### Determination of Water Resources Class, Reserve and Resource Quality Objectives for Secondary Catchments A5 – A9 and Secondary Catchment B9

Internal Draft Report submitted to Myra Consulting



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#### 1. GROUNDWATER STATUS QUO

#### 1.1. APPROACH TO STATUS QUO ASSESSMENT

#### 1.1.1. Overview and Data Sources

The delineation of groundwater resource units depends on the hydrogeological characteristics of the area (amongst other factors), and it is practical to consider the status quo for groundwater resources in respect of groundwater resource units. As such, the hydrogeological characteristics of the area, the delineation of resource units (or rather groundwater units of analysis) and status quo of groundwater units (of analysis) are presented together in this report. Section 1.2 includes an overview of the geology and hydrostratigraphy of the study area, followed by the delineation of groundwater resource units (GRUs) (1.3). The groundwater status quo assessment (section 1.4) includes a description of key groundwater characteristics (recharge, discharge, groundwater use and groundwater quality) across the groundwater resources units, followed by a detailed status quo and trend analysis of groundwater level and groundwater quality per groundwater resource unit (section 0 onwards).

All available point data (borehole geology, abstraction, groundwater level, groundwater quality) was collated (Refer to Information & Gap Analysis Report), and interrogated for the trend analysis, and points with sufficient time-series including recent data are analysed to provide a current status quo. Sources of data used to populate the tables included in the trend analysis per GRU include:

- National Groundwater Archive
- GRIP data (2011)
- HYDSTRA database
- WMS datasets
- WARMS data
- Point data extracted from various reports assessing the response to bulk abstraction (i.e. municipal monitoring reports)
- Data from DWS project All Towns Reconciliation project
- Various reports

The trend analysis (section 0 onwards) is presented in a standard table format per groundwater resources unit (GRU). The datasets collated contain long term DWS-owned monitoring boreholes. These boreholes are dispersed, and are capable of illustrating the background trends in particular locations or aquifers. Given the predominance of disperse abstraction, this data is likely to be sufficient for an indication of regional trends and typical water levels and water qualities in particular aquifers and locations. This will form a valuable basis for future phases of the project. The existence of additional data not yet incorporated in the trend analysis is mentioned in the status quo assessment where this is known. Additional monitoring data (i.e. illustrating the response to bulk point abstraction at municipal wellfields) will be sought where necessary for prioritised GRUs.

#### 1.1.2. Theoretical background for groundwater level trend analysis

Under natural conditions an aquifer is in a state of dynamic equilibrium: wet and dry years balance out, aquifer discharge equals the recharge, and the groundwater levels (equivalent to the stored volume) are constant over the long-term. When an aquifer is pumped this equilibrium is disturbed, and "water withdrawn artificially from an aquifer is derived from a decrease in storage in the aquifer, a reduction in the previous discharge from the aquifer, an increase in the recharge, or a combination of these changes" (Theis, 1940). On pumping, water levels will therefore decline, natural discharge may decline, and recharge may increase. Over time (and with the same rate of pumping), a new dynamic equilibrium will form in response to the changes fluxes (i.e. new discharge mechanisms to abstraction, reduced



discharge and or enhanced recharge). Once the new dynamic equilibrium is formed, there is no further loss from storage i.e. groundwater levels no longer decline in response to abstraction.

The time taken to reach this new dynamic equilibrium (the "response time") can vary from relatively short to hundreds of years, depending on the aquifer parameters and location of abstraction compared to aquifer boundaries (Sophocleous 2000; Bredehoeft and Durbin, 2009). The magnitude of storage depletion (water level change before new equilibrium is met), is also dependent on the aquifer parameters and location of abstraction.

If the abstraction can be met by changes in the aquifer fluxes (reduced discharge, enhanced recharge) and a new equilibrium can be established (halting water level decline), then the abstraction can be considered maintainable (note, not sustainable) (Delvin and Sophocleous, 2005; WRC, 2016). If "sustainable groundwater use" is defined as groundwater use that is socially, environmentally (ecologically), and economically acceptable, then abstraction of a maintainable yield is not necessarily sustainable. A critical step from quantification of a maintainable aquifer yield to quantification of sustainable groundwater use, is to determine the volume contribution from each source under the new dynamic equilibrium (projected reduced discharge, enhanced recharge, impact on storage / groundwater levels), and then take a socio-economic-environmental decision as to whether this is acceptable (Sophocleous, 2000, Alley and Leake, 2004, WRC, 2016). Projection of the impact of pumping on storage / water levels can be completed (for simple situations) with analytical models that derive a characteristic water level decline over time when pumped ("pump curves", Kruseman and de Ridder, 1991). Determination of the impact on natural discharge or enhanced recharge generally requires a numerical model to be setup for the aquifer in question to simulate the abstraction and impacts on flow regime.

Not all abstraction can be maintained. Abstraction from groundwater without an active flow regime (fossil groundwater) simply harvests stored groundwater and groundwater levels continue to fall. "Runaway" drawdown, in which the rate of decline of groundwater level increases over time, is an indication that the abstraction rate cannot be met by changes in the aquifer fluxes (it is not maintainable).

The above-mentioned theory is relevant to the status quo trend analysis. Water level decline is to be expected in response to pumping. Groundwater level decline (alone) is not an indication of abstraction rates being too high or not maintainable, and certainly not an indication of un-sustainability (using the definition of sustainable groundwater use mentioned above). Water level decline is simply a reflection of the aquifer transitioning to a new dynamic equilibrium after commencement of pumping. Water level analysis using numerical / analytical equations to determine whether abstraction yields are maintainable, and to determine the maximum drawdown that is to be expected under the abstraction conditions, is not possible within this regional study. Barring this level of detail, some comments on monitored water level decline and what it might represent are nevertheless possible through comparing the shape of the water level decline by eye to characteristic pump curves, and through consideration of rainfall changes.

#### **1.2. DESCRIPTION OF STUDY AREA**

#### 1.2.1. Location and Drainage Regions

The Limpopo and the small northern section of the Olifants WMAs, catchments A5-9 and B9, occupies the northwestern part of the Limpopo Province, forming the project area. The Limpopo River watercourse forms the northern boundary of the WMA, and indeed of the country (DWAF, 2003a). The major tributaries, from the upstream end, are the Matlabas River, Mokolo River, Lephalala River, Mogolakwena River, Sand River and the Nzhelele, Nwanedi, Mutale, Levuvhu and Shinhwedzi Rivers (Figure 1). All of these rivers flow towards the Limpopo River in the north. The Limpopo River flows eastwards and eventually mouths in the Indian Ocean in Mozambique.



The WMA's do not include the total catchment area of the Limpopo River, since the upper tributaries (the Marico and Crocodile Rivers) are included in the Crocodile West and Marico WMA. The study area includes a total of 76 quaternary catchments.

Table 1 lists the sub-areas (secondary drainage area) tertiary drainages, quaternary catchments together with the main tributaries for the Limpopo WMA.

WMA	Sub-Area	Tertiary Drainage	Quaternary Catchments	Description
			A50A,B,C,D,E,F	Lephalala (Upper)
	Lephalala (A5)	A50	A50G,H	Lephalala (Lower)
			A50J	Soutkloof
			A61A,B,C	Nyl (Upper)
		AC1	A61D,E	Nyl (Middle)
		AOI	A61F,G	Mogalakwena (Upper)
	Mogalakwona (A6)		A61H,J	Sterk
	wogulukwellu (Ab)	A62	A62A,B,C,D,E,F,G,H,J	Mogalakwena (Middle)
Limnono			A63C	Doringfonteintjiespruit
сшироро		A63	A63A,B,D	Mogalakwena (Lower)
			A63E	Којоре
		A71	A71A,B,C,D	Sand (Upper)
	Sand (A7)		A71E,F,G	Hout
			А71Н,Ј,К	Sand (Lower)
			A71L	Kongoloops/Soutsloot
		A72	А72А,В	Brak
	Nzhololo (A9)	480	A80A,B,C	Nzhelele (Upper)
	NZITETETE (AO)	Aðu	A80D,E,F,G	Nzhelele (Lower)
	Nwanedi (A8)	A80	A80H,J	Nwanedi
	Mutale (A9)	A92	A92A,B,C,D	Mutale
			A92A,B, C,D	Upper Levuvhu
Olifants	Levuvhu (A92)	A92	A92E,F,G	Middle Levuvhu
Omants			А92Н,Ј,К	Lower Levuvhu
			B90A,B,C,D	Upper Shingwedzi
	Shingwidzi (B9)	B90	B90E,F,G	Middle Shingwedzi
			В9ОН,Ј,К	Lower Shingwedzi

#### Table 1. Drainage description of the project area.

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Figure 1. Regional secondary drainage region of the study area.



#### 1.2.2. Topography

The study area is characterised by mostly flat laying terrain with elevations of approximately 800 mamsl. Local granitic inselburgs occur due to the more resistant Matlala, Mashashane and Moletsi granite intrusions with elevation ups to 1300mamsl. The Waterberg in the south and Soutpansberg in the north-east form topographical elevated mountainous areas with elevation up to 1700mamsl. The average altitude in the central part of the study area is between 400 and 800 m and between 1 200 and 2 000 m along the Soutpansberg, Blouberg and Waterberg mountain ranges(refer to Figure 1).

#### 1.2.3. Climate

The climate is typically of South African Bushveld and Highveld, characterised by warm wet summers month between October and march with most rainfall occurring as thundershowers, and cool dry winters with cold nights and mist occurring at the mountainous areas. Some orogenic rainfall does occur as cloud area accreted onto the Soutpansberg and Tzaneen mountain range. In terms of climate, the study area is characterised by semi-arid temperatures in the south becoming arid in the northern portions. The mean annual temperature ranges between 16°C in the south to more than 22°C in the north with an average of 20°C for the catchment as a whole. Seasonal rainfall is characteristic of the area with mean annual rainfall of 300 mm to 700 mm per annum (mm/a) (DWAF, 2003b) with the greatest part of the study area receiving only 300mm/a. The Soutpansberg and Blouberg mountains experience precipitation of between 500 and 600mm/a with the escarpment up to 1000mm/a. In general, the rainfall decreases from the southern part of the study area to the drier northern parts, where the lowest MAP of about 350 mm occurs along the lower part of the Limpopo River valley (Figure 2). The mean annual evaporation varies from 1400 to 1700 mm/a, exceeding more than half of the amount of precipitation.

#### 1.2.4. Geology

The geomorphology features found in the study area are the results of geological evolution of the Swazian aged Greenstone belts and granites forming the Kaapvaal Craton, collision between the Kaapvaal and Zimbabwean cratons forming the Limpopo Mobile Belt, granite and basaltic intrusions, sedimentary deposition forming the Blouberg, Waterberg, Soutpansberg and Karoo groups. The study area is delineated by the Archaean Basement rocks, Bushveld Complex, Karoo Supergroup, and the Waterberg, Blouberg and Soutpansberg groups. The geological sequencing is shown in Table 2 and illustrated in Figure 3.

Era	Lithostratigraphy Unit	Rock Types		
Cenozoic (<65 Ma)	Quaternary deposits	Sand, soil, alluvial, calcrete		
Mesozoic (250 – 65 Ma)	Karoo Supergroup	Sandstone, shale, mudstone, coal, intrusive dolerite		
	Plouborg Formation	Sandstone, feldspathic granulestone, breccia, conglomerate,		
Makalian (2050 1000 Ma)	Blouberg Formation	quartzite and gneiss		
	Waterberg Group	Granulestone, conglomerate and sandstone		
	Soutpansberg Group	Basalt, andesite, shale, greywacke, conglomerate and lava		
Vaalian (2650 - 2050 Ma)	Bushveld Igneous Complex	Gabbro norite		
vaaliali (2030 – 2030 ivia)	Transvaal Supergroup	Quartzite, dolomite, chert,		
	Archaean Granitiods Intrusion	Granitic rock		
Swazian (S2100 Ma)	Archagan Groonstong Bolt	Gneiss, schist, quartz-carbonate rock, amphibolite, komatiite		
	Archaean Greenstone Beit	and basalt		
	Goudplaats-and Houriver gneiss	Gneiss (basement rock)		

#### Table 2. Geological sequences in the region.

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Figure 2. Regional precipitation of the project area.



#### 1.2.4.1. Basement rocks from the Limpopo Mobile Belt

The term Kalahari Craton was recently introduced (Johnson et al, 2006) for the discussion of the Kaapvaal and Zimbabwean Craton together with the Limpopo Mobile Belt (LMB), a gneissic zone, as a whole formational event describing the evolutionary stages of the Limpopo Mobile belt welded onto the stable Kaapvaal and Zimbabwean Craton creating a large stable region on which various geological events and features occurred. The evolution of Southern Africa can be regarded as subsequence of accretion onto the stable Kaapvaal Craton during both extensional and compression tectonic periods (Patridge and Maud, 1987). With the occurrence of the accretion of the Limpopo Mobile Belt onto the Kaapvaal craton (approximately 3.1 Ga) and Zimbabwean Craton, the study area is characterized by granitoid-greenstone rock formations together with rocks of sedimentary an volcanic origin. The study area falls within the southern marginal zone of the Limpopo Mobile belt in the north-eastern section of the Kaapvaal Craton and is mostly underlain by Precambrian crystalline basement rocks (granite, gneiss, greenstones, etc.). Typical characterisation of the gneisses is that they are either fine grained to Pegmatoidal, and homogenous or layered (Brandl, 1986, 1987; Du Toit et al., 1983; Anhaeusser,1992; Brandl and Kröner, 1993). All these formations are consequently overlain by quaternary deposits formed from erosional sequences of the pre-existing formations.

Towards the northeast the study area is underlain by the mega shear zone known as the Limpopo Mobile Belt, which strikes east to northeast and separates the Kaapvaal Craton from the Zimbabwean Craton. The resulting Limpopo Mobile Belt consists of three main crustal zones, namely the Northern Marginal Zone, the Central Zone and the Southern Marginal Zone, which lie parallel to one another in an ENE direction.

The Southern Marginal Zone is bounded by down faulted basins containing upper Karoo strata and the Soutpansberg Mountains consisting of Soutpansberg Group rocks, while to the south the northward dipping Hout River Shear Zone forms the boundary of the Limpopo Mobile Belt. To the southwest the Limpopo Mobile belt is truncated by large E-W trending faults with younger Waterberg Group strata and the northern lobe of the Bushveld Complex on the down faulted side of the faults (e.g. Melinda Fault). The associated Palala Shear zone is regarded as the southern boundary of the Central zone of the Limpopo Mobile Belt.

The LMB consists of gneissic, granites, granulites, serpentenites, metapelites and horneblende gneisses with infolded supra crustal rocks such as the Houtriver-Goudplaats gneisses and the Beit Bridge Complex, which have undergone high grade granulite metamorphism. The Beit Bridge Complex consists of metaquartzites, calcsilicates, amphibolite, metapelites and pink hornblende gneisses The Bandelierskop Complex is infolded into the basement of the Houtriver-Goudplaats gneisses and consists of ultramafic peridotite, pyroxenite lavas, mafic granulite, amphibolite, metapelite, pelitic gneisses, magnetite, quartzite and meta quartzite). A number of massive, unfoliated granite intrusions occur as batholiths, plutons and stocks in the study area. These granitic intrusions form prominent topographical features that can be seen north of Polokwane. The Rhenosterkoppies and Pietersburg Greenstone Belts occur towards the southwest and north of Polokwane. They are composed largely of extrusive mafic and, to lesser extents, ultramafic and felsic rock.

#### 1.2.4.2. Diabase dykes and sills

Tre number of diabase dykes and sills are found throughout the project area. Dyke swarms crop more densely in the north-eastern domain of the Kaapvaal than elsewhere on the craton and northeast-trending diabase dykes are dominant in the project area. Due to their orientation and these northeast-trending dykes are associated with 2.7 Ga Ventersdorp Supergroup trends (Uken & Watkeys, 1997), which formed either in response to the Limpopo orogeny (Burke et al.) or by crustal extension due to mantle plume activity (Hatton, 1995). Later Karoo dolerites sporadically cut through the older dykes, but usually follow the same intrusion paths as their Archaean predecessors. The Houtrivier Shear Zone was probably one of the controls of the dyke emplacement in the area, because many more dykes are observed north of the Hout River Shear(in the South Marginal Zone) than south of it.



#### 1.2.4.3. Bushveld Complex

The study area is also bounded by the northern limb of the Bushveld Complex. This intrusive complex is intruded into basement rocks and comprises of the lower Rustenburg Layered suite and the Lebowa Granite Suite above. The layered rocks of the Bushveld Complex are believed to be the result of slow cooling during crystallization (gravitational crystals settling) of magma. Bowen (1928) described these as accumulative rocks. These accumulative rocks consists of two classes of materials; cumulus grains that form from settling and become packed and intercumulus liquid filling up the spaces between the cumulus grains that cements them together (Jackson, 1967). These rocks are characterised by large homogenous rocks with igneous lamination. The formation of the rocks in the Bushveld Intrusive Complex is formed through the processes of fractional crystallization and mineralization in a magma chamber, which follows Bowen's reaction series. Gabbro Norite rocks characterise Bushveld Complex.

#### 1.2.4.4. Southpansberg, Waterberg and Blouberg formations

The Soutpansberg formation forms the large east-west trending mountain range in the project area. The Blouberg and Waterberg formation are located south, west and north in the study area where they form local recharge areas. The Soutpansberg, Waterberg and Blouberg formations are considered to be between 1700 and 2000 Ma old, forming part of the Palaeoproterozoic age (Barker et al., 2006). The Blouberg Formation consists completely of clastic sedimentary rocks deposited nonconformably over the granulite-grade gneisses of the Limpopo Mobile Belt with a maximum thickness of 1400m (Jansen, 1975; Bumby et al., 2001a). However, only sequences of less than 300 metres are found at outcrop. The Blouberg formation consists of two members, a lower and upper member. The 600 metre thick lower member consists of cross-bedded coarse arkoses and stone and channel fills of feldspathic granulestone (Wentworth, 1922) in association with depositional events in braided river and stream systems. The upper member consists of coarse, feldspathic sedimentary breccia and conglomerate. The cobbles and boulders consist of quartzite and foliated feldspathic gneiss. The formation event of this upper layer is interpreted as the deposition of alluvial fans. The sediments of the Blouberg Formation are characterised by overturned sediments with steeply dipping bedding planes dipping in a northerly direction (Bumby et al., 2001a). However, the lower member of the formation is characterised by southwards dipping planes. The sandstones are often feldspathic, consisting of subangular grains of quartz with minor K-feldspar and opaque minerals. The Soutpansberg Formation rests unconformably on the Archaean granulite-grade gneiss as well as on the Blouberg formation with a maximum thickness of 5000 m (Barker, 1979 and Brandl, 1999). According to Barker (1979) the Soutpansberg formation comprises of both volcanic basalt and andesites and sedimentary rock successions that is subdivided onto six successions.

#### 1.2.4.5. Other geological formations (Transvaal and Karoo Supergroup)

A small extent (area) of the study area is charactered by the Transvaal and Karoo supergroups. The Transvaal Super Group rocks occur in the south central part of the study area with the strata dipping towards the Bushveld Complex. The most significant lithology in terms of groundwater potential is the Chuniespoort Group consisting of cherts, dolomites and subordinate limestone. Karoo Super Group rocks consisting of shale, shaley sandstone conglomerate with coal in places, occur in several localities throughout the Limpopo WMA but are prominent west of Lephalale and north of Alldays.



Figure 3. Regional geology.



#### 1.2.5. Aquifer Types

Some of the greatest groundwater needs in South Africa occur in the Limpopo and Olifants WMAs and groundwater is the only dependable source of water for many users. Groundwater is available and widely used throughout the study area, but in varying quantities depending upon the hydrogeological characteristics of the underlying aquifer. The study area is dominated by Intergranular and fractured aquifer systems with borehole yields between 0.1 and > 5 l/s (Figure 4) (Du Toit, 2003). The dominant rock types in the study area are the Goudplaats-, Hout River-, Alldays- and Sand River Gneiss as well as the Beit Bridge complex including the number of granitic intrusions. These rocks form the major subgroups of the Basement Crystalline Complex as they form part of the Achaean eon 3.1 to 2.5 Ga. Aquifers are developed within the weathered overburden and fractured bedrock of these hard crystalline or re-crystallised rocks of igneous or metamorphic origin. Crystalline rocks are characterised by very low primary porosity (fresh or unweathered crystalline rocks contain virtually no water), and almost all groundwater movement and storage in these rocks takes place via fractures, faults, weathered zones and other secondary features that enhance the aquifer potential only locally. Intrusive batholiths and fractured contact zones can displace the host rocks during intrusion in order to create space for the ascending magma. These 10 to 100 metres wide zones are highly productive and can yield in boreholes in excess of 30 l/s (Du Toit, 2001).

A number of exceptionally high yielding areas within the crystalline basement aquifer system occur in the Dendron (Mogwadi), Vivo, Baltimore and Tolwe regions (Figure 4). These aquifers have provided for large scale irrigation for the last few decades.

The southwest of the study area is dominated by the Waterberg Group sandstones and the Karoo Super Group rocks which are classified as a fractured aquifer with expected borehole yields between 0.1 and > 2 l/s (Figure 4). Primary aquifers (or intergranular aquifers) occur throughout the study area and exist in the vicinity of drainage channels where alluvial material overlies or replaces the weathered overburden creating a distinct intergranular aquifer type. The elongated alluvial aquifers follow rivers (so called valley trains), sand rivers or drainage lines with limited width and depth, which typically vary according to the topography and climate.

The mountainous area east of Mokopane are also of special interest as far groundwater is concerned as this area consists primarily of dolomite and has considerable groundwater resources. The karst aquifer with excepted yields of more than > 51/s is however heavily exploited, within quaternary catchment A61F (DWAF, 2004)

Three main types of aquifer occur within the study area, namely

- Intergranular (alluvial aquifer),
- Intergranular ("primary" or weathered sandy aquifers) and fractured ("secondary" aquifers), and
- Karst aquifer system.



Figure 4. Aquifer type and yield.



#### Intergranular aquifer (alluvial aquifer)

An alluvial aquifer is described as "an aquifer comprising unconsolidated material deposited by water, typically occurring adjacent to rivers and buried palaeochannels." (DWS, 2011). The distribution of alluvial deposits (aquifers) is determined by the river gradient, geometry of the channel, fluctuation of stream power as a function of decreasing discharge downstream due to evaporation and infiltration losses, as well as rates of sediment input due to erosion (Moyce et al., 2006). The most predominant alluvial aquifer system is the Limpopo River. The geomorphology of the Limpopo River is characterised by 100 m to 66 500 m wide alluvial deposits ranging in thickness between 5 and 10 m, as well as rocky outcrops and floodplains in the upper and middle reaches and extensive floodplains further downstream (Boroto and Görgens, 2003). The aquifers comprise mainly unconsolidated Quaternary sequences of clay, sand and gravel beds (CSIR, 2003; Gomo and van Tonder, 2013), and are sources of groundwater abstraction for multiple communities due to their high permeabilities (Owen and Madari, 2010) and good water quality (CSIR, 2003; Moyce et al., 2006). The alluvial aquifers along the Limpopo River are considered to have the potential for high yields, whereas those along tributaries such as the Luvuvhu River display much lower potential due to limited aquifer extent and less than optimum hydraulic characteristics (CSIR, 2003)

#### Intergranular and fractured aquifer system

An aquifer system in crystalline material such as the norites and pyroxenites of the Bushveld Igneous Complex as well as the Basement Complex rocks comprise of (a) an in-situ weathered overburden or saprolite (often collectively with the soil zone referred to as regolith), partially replaced or overlain by alluvial or hill wash material, (b) an unweathered and intact rock matrix with negligible matrix porosity and permeability, and (c) planes of discontinuity in the rock matrix, including layers/reefs, faults and joint planes (collectively here referred to as fractures in the hydrogeological meaning). The fractured bedrock comprising of the intact rock matrix and fractures is commonly referred to as saprock. The degree/intensity of chemical weathering or more specifically the spatial and depth variations thereof, control the geometry of the shallow weathered aquifer profile. The weathered overburden is considered to have low to moderate transmissivity, but high storativity. The weathered aquifer is recharged by rainfall or by leakage from perennial and non-perennial surface water drainages and dams. Direct recharge from rainfall is limited, as the mafic rocks of the BIC tend to weather to a swelling clay rich soil (black turf), which has low permeability and considered to reduce infiltration unless preferential flow paths are opened by vertical desiccation cracks. The dominant rock types in the study area are the Goudplaats-, Hout River-, Alldays- and Sand River Gneiss as well as the Beit Bridge complex including the number of granitic intrusions.

With the presence of the Karoo Supergroup located in the weathered zone of the Karoo sediments hosts the unconfined or semi-confined shallow weathered Karoo aquifer or hydro-stratigraphic zone. Due to direct rainfall recharge and dynamic groundwater flow through the unconfined aquifer in weathered sediments, the water quality is expected to be generally good, but in the absence of an overlying confining layer also vulnerable to pollution. Localised perched aquifers may occur on clay layers or lenses. Water intersections in the weathered aquifer are mostly above or at the interface to fresh bedrock (sandstone or sills), where less permeable layers of weathering products and capillary forces limit the vertical percolation of water and promote lateral water movement. Groundwater flow is governed by secondary porosities like faults, fractures, joints, bedding planes or other geological contacts (including coal seams), while the rock matrix itself is considered impermeable. Geological structures are generally better developed in competent rocks like sandstone, which subsequently show better water yields than the less competent silt- or mudstones and shales. Not all secondary structures are water bearing due to e.g. compressional forces by the neotectonic stress field overburden closing the apertures.

#### **Karst aquifer**

The kart / dolomitic aquifer consists of chert-rich dolomite and chert breccias with boreholes yields exceeding 5 l/s. Water bearing properties of the dolomite stem from carbonate dissolution along structural and lithological



discontinuities (such as faults, fractures, and joints). Storativity of South African dolomite aquifers generally vary between 1 and 5 % but this property depends greatly on the extent of weathering and dissolution. Transmissivities can be several hundred m<sup>2</sup>/day or more. The aquifer can be regarded as a water-table aquifer with mostly unconfined conditions. Groundwater levels varies, however typically shallow in natural conditions, and generally show an immediate response to rainfall. The karst aquifer system is limited to the Malmani Dolomites found around Mokopane area (DWS and WGS, 2011).

#### 1.2.6. Transboundary Aquifers (TBAs)

Two international transboundary aquifers<sup>1</sup> occur in the study area namely the AF9 – Tuli Karoo Sub-Basin and the AF8 – Limpopo Basin and the (Figure 5). A summary of the characteristics of the aquifers is provided below:

- AF9 Tuli Karoo Sub-Basin
  - The predominant lithology is crystalline rocks volcanic and basement rocks with sedimentary rocks sandstones and extensive sands alluvial deposits along the major drainage channels.
- AF8 Limpopo Basin
  - The predominant lithology is crystalline rocks granitic basement.

A comprehensive description of the Limpopo TBAs is generally lacking due to the lack of data from adjacent countries. These two specific TBAs have generally low transmissivities with a slow rate of groundwater movement. In addition groundwater occurs within disconnected "pockets" determined by geology and weathering processes (e.g. basement aquifers) (Cobbing et al., 2008). The impression of a large interconnected and high yielding shared aquifer resources are, therefore not the case for these two TBAs. However, the Limpopo River alluvial aquifer might be of more importance to the four countries sharing the resource. The seasonal flow regime of the Limpopo River is characterised by wet season runoff that recharges the alluvial aquifer; surface flows decline during the dry winter months, reducing to dislocated pools of standing water connected by sub-surface flows. At this stage the AF8 and AF9 TBAs is not believed to be at risk of competition for water between South African and neighbouring countries. In addition these TBAs north of the Limpopo River will be excluded from the study area purely based on the basis and methodology applied to delineate of the groundwater resource units.



Figure 5. Transboundary aquifers of the study area.

<sup>&</sup>lt;sup>1</sup> Transboundary Water Assessment Programme (TWAP) – www.geftwap.org



#### 1.2.7. Strategic Water Source Areas – Groundwater (SWSA-gws)

There are 57 nationally strategic SWSA-gw which cover about 11% of South Africa, with 37 of these being nationally strategic (Le Maitre, et al., 2019). Groundwater source area can therefore be defined as an area with high groundwater availability and where this groundwater forms an important resource. A strategic groundwater source area can therefore be defined as an area with a high source of groundwater and where this groundwater forms a nationally important resource. The study area hosts 6 SWSA-gw areas (Figure 6) of which all except the Blouberg groundwater resource area is considered of National importance.

#### 1.3. DELINEATION OF GROUNDWATER RESOURCE UNITS

#### 1.3.1. Overview

It is practical to consider the status quo for groundwater resources in respect of groundwater resource units (termed groundwater units of analysis or GUAs). As such, the hydrogeological characteristics of the area, the delineation of groundwater units of analysis, and status quo of GUAs are presented together in this report.

Quaternary catchments are used as the primary delineation of water resource units in RDM assessments. The delineation of groundwater resource units depends on the hydrogeological characteristics of the area (e.g. aquifer types and flow regimes), and due to the nature of groundwater flows, hydraulic boundaries for groundwater flow are often different to that of surface water systems. Although the hydraulic boundaries may differ, the delineation should consider that a Class, Reserve and RQOs must be set for each unit, and therefore linkages with other components have to be considered, and each unit will have to be managed. The delineation of GUAs presented in this section therefore considers the following physical, management and functional criteria together:

- Surface water divides on a quaternary and secondary level
- > Geological structures (i.e. fault, hydrostratigraphy or lithological contact zones)
- River systems
- Recharge and discharge zones and groundwater flow regimes
- Zones of groundwater use
- Groundwater management (size and extent of units)

#### 1.3.2. Groundwater regions

The groundwater divisions as proposed by Vegter (2000) are primarily based on geology and not hydraulic units as such. As a result the delineated regions group similar geological rocks that has uniform water bearing properties. A comparison of the borehole information of the groundwater regions within the study area after Vegter (2000) is provided in Table 3. The regions were adapted in this study to isolate the Nyl River Flats more distinctly from the larger Waterberg regions Figure 7. In addition the dolomites found at Mokopane (in the old Eastern Bankenveld) was renamed as Mokopane dolomites. From the results, the variability between delineated groundwater regions is clear. As expected the Mokopane dolomite region have above average transmissivity and yields, while lower transmissivities and yields are associated with the Karoo- and Soutpansberg Strata. The variability in groundwater potential is also evident between the crystalline basement complexes, where the Houdenbrak Granulite-Gneiss has higher average yields compared to the Limpopo Granulite-Gneiss Belt.

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Figure 6. SWSA-gw for the study area.



Crowndwater Design	Info	BH Depth	Water Level	Water Strike	Transmissivity	Rec. Yield	Blow Yield
Groundwater Region	Into		(mbgl)		(m²/day)	(I/s for 24hrs)	(I/s)
	Ν	1050	1136	278	149	76	208
Cremulita Craisa Distanu	Min	-	<1	<1	0.1	0.02	< 0.01
Granulle-Gheiss Plateau	Max	250	78.5	160	960	12	40
	Mean	59.5	15.2	37.3	39.7	1.3	3.2
	Ν	1363	1567	430	255	97	299
Usudashark Crawlite Craise	Min	-	<1	<1	0.3	0.01	< 0.01
Houdenbrak Granulite-Gheiss	Max	300	93.6	204	640	11	99
	Mean	61.8	24.8	43.1	33.4	1.2	2.5
	Ν	274	204	183	40	65	88
	Min	-		2	0.2	0.05	< 0.01
Koedoesrand Bushveld Cpx	Max	290.5	115	289	527	7	27
	Mean	54.4	18.0	50.2	51.7	1.0	2.1
	Ν	1443	1297	654	93	79	355
	Min	<1	<1	<1	0.1	0.04	< 0.01
Limpopo Granulite-Gneiss Belt	Max	335	200	306	387	15	30
	Mean	50.5	24.0	49.4	37.5	1.1	1.7
	N	338	201	165	1	1	100
	Min	<1	<1	6	12.4	0.8	< 0.01
Limpopo Karoo Basin	Max	259	66	259	12.4	0.8	0.7
	Mean	34.6	17.4	43.2	12.4	0.8	1.1
	N	195	172	130	20	21	94
	Min	<1	2	5	4	0.05	0.1
Mokopane Dolomites	Max	238	122	149	500	6.6	36
	Mean	59.6	20.1	41 7	112 3	1.6	8.2
	N	118	99	121	none	none	102
	Min	<1	<1	4	none	none	< 0.01
Northern Lebombo	Max	137.5	54	114	none	none	15
	Mean	45.9	13.7	29.9	none	none	1.9
	N	610	580	244	124	57	133
	Min	<1	<1	2	0.1	0.01	< 0.01
Northern Limb Bushveld Cpx	Max	204	92	150	380	11.0	15
	Mean	54.4	15.5	42.8	52.8	1.0	17
	N	526	405	299	14	13	194
	Min	<1	<1	<1	0.4	0.06	<0.01
Nyl River Flats	Max	281	90	192	68	3.6	28
	Mean	57.8	15.8	44.2	24.1	1 4	2.1
	N	777	664	399	80	58	264
	Min	<1	<1	<1	0.2	0.02	<0.01
Soutpansberg Hinterland	Max	340	137	266	925	15	60
	Mean	64.1	22.5	47.8	68.2	1.2	3.0
	N	792	746	263	154	64	214
	Min	<1	<1	200	0.2	0.02	<0.01
Soutpansberg Trough	Max	340	140	340	428	11	49
	Mean	63 /	15 1	44.6	16.6	0.8	27
	N	52	27	61	10.0	none	2.7
	Min	<1 <1	6	3	none	none	<0.01
Waterberg Karoo Coal Basin	May	300	160	258	none	none	0.01
	Mean	60.0	2/ /	230	nono	nono	9
	N	1005	770	00.9 EGO	122	FO	0.7
	Min	1005	//ð	00C	0.1	0.02	∠6ŏ
Waterberg Plateau	Max	201	220	2	0.1	0.02	<u>\U.U</u> 00
	Moor	291	10.0	237	000	0.3	3ð 1 c
	iviean	64.3	19.6	51.0	43.1	0.5	1.6

#### Table 3: Comparison of hydrogeological parameters for the delineated groundwater regions.

NOTE: Borehole depth and water levels based on integrated GRIP and NGA databases. Min value not statistical meaningful, reported as <1mbgl). Water Strike and Blow Yield based on NGA database.

Transmissivity and Rec. Yield based on GRIP database.

Major River based on perennial river flow as indicated on the report maps.



Figure 7. Groundwater regions (adapted from Vegter, 2000).



#### 1.3.3. Delineation results

Due to the size of the project area, it is not feasible to determine a Groundwater Reserve for the entire area. In addition, the first step in the RDM Classification process as outlined under Chapter 3 of the NWA, is the demarcation of the units of analysis (UA), of which is to be classified, a Reserve assessment undertaken and Resource Quality Objectives (RQOs) set.

In this study the quaternary catchments were used as the primary delineation, while the GUAs were based on a single or a combination of quaternary catchments. The following aspects were considered:

- Although surface water and groundwater divides do not always correspond, groundwater must be considered in terms of an integrated water resource.
  - The study area is drained by 8 major rivers flowing into the Limpopo River. As a result the study area is easily divided into 8 sub-catchments. Considering that the groundwater component of the (ecological) Reserve is determined by calculating the groundwater contribution to baseflow it makes sense to follow the hydrological approach.
  - Regionally the groundwater mimics the surface topography. Figure 8 shows the very good correlation (R<sup>2</sup>=1.0) between absolute surface and groundwater table elevations in metres above mean sea level (mamsl) for the project area.
    - The data presented is based on water levels obtained from the GRIP and NGA dataset.
- Identification and recognition of aquifer type and groundwater regimes within each sub-catchment.



Figure 8. Correlation between surface topography and groundwater elevations for the study area.

A summary of the delineated GUA within each sub-catchment is provided in Table 4. All GUAs coincide with the subcatchments except for A63/A71-3, which straddle the Mogalakwena- and Sand River sub-catchments. The tributaries draining the associated quaternary catchments drain directly into the Limpopo River. These catchments also straddle the Limpopo Karoo Basin, so as a result they were delineated as a single GUA.



The delineated resource units generally combine a couple of quaternary catchments so that the integration of surface water and groundwater systems can be achieved (Figure 9).

Drainage system	GUA	Nr of Quats.	Catchments	Name	Geology
	A50-1	6	A50A,B,C,D,E,F	Upper Lephalala	Waterberg Group
Lephalala	A50-2	1	A50G	Middle Lephalala	Bushveld Complex
	A50-3	1	A50H	Lower Lephalala	Basement Complex
	A61-1	5	A61A,B,C,D,E	Nyl River Valley	Bushveld Complex, Lebombo Group
Upper	A61-2	2	A61H,J	Sterk	Bushveld Complex, Waterberg Group
Mogalakwena	A61-3	3	A61F,G	Upper Mogalakwena	Bushveld- and Basement Complex, Dolomites
	A62-1	3	A62A,B,C,D	Klein Mogalakwena	Bushveld Complex, Waterberg Group
Middle- and	A62-2	2	A62E,F	Matlala	Bushveld- and Basement Complex,
Lower	A62-3	3	A62G,H,J	Steilloop	Waterberg Group
Mogalakwena	A63-1	3	A63A,B,D	Lower Mogalakwena	Basement Complex, Karoo Super Group, Lebombo Group
	A71-1	2	A71A,B	Upper Sand	Basement Complex, Alluvium
Upper Sand	A71-2	3	A71C,D,H	Middle Sand	Basement Complex
	A71-3	4	A71E,F,G	Hout	Basement Complex
	A71-4	2	A71J, A72B	Sandbrak	Basement Complex, Karoo Super Group, Lebombo Group
Lower Salid	A71-5	1	A71K	Lower Sand	Basement Complex, Karoo Super Group
Limpopo Tributary	A63- 3/A71-6	2	A63E, A71L	Limpopo Tributary	Basement Complex, Karoo super Group
Kalkpan	A50- 4/A63-2	2	A63C, A50J	Kalkpan/Maasstroom	Basement Complex
Nzhelele	A81-1	6	A80A, B,C,D,E,F	Nzhelele	Soutpansberg Group, Karoo Super Group, Lebombo Group, Basement Complex
Lower Nzhelele	A81-2	1	A80G	Lower Nzhelele	Soutpansberg Group, Karoo Super Group, Basement Complex
Nwanedi	A81-3	2	A80H,J	Nwanedi	Soutpansberg Group, Karoo Super Group, Basement Complex
Upper Luvuvhu	A91-1	7	A91A,B,C,D,E,F,G	Upper Luvuvhu	Soutpansberg Group, Basement Complex
Mutale /Luvuvhu	A91-2	7	A91H,J,K, A92A,B,C,D	Mutale /Luvuvhu	Soutpansberg Group, Basement Complex
Shingwedzi	B90-1	8	A90A,B,C,D,E,F,G,H	Shingwedzi	Basement Complex, Soutpansberg Group

#### Table 4. Description of delineated groundwater units of analysis.

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Figure 9. Delineated groundwater units of analysis.



#### **1.4. REGIONAL GROUNDWATER DESCRIPTION**

#### 1.4.1. Groundwater levels and flow direction

Average water levels for the study area are 20 metres below groundwater level (mbgl). The deepest average water strikes are observed within the Waterberg Karoo Coal Basin, i.e. 89 mbgl, with all other geological setting similar with an average of approx. 40 mbgl (Table 3). This is also reflected in the groundwater levels, as the Waterberg Karoo Coal Basin has an average water level of 34 mbgl, whereas the other geological setting of approx. 15-20 mbgl. The deeper water recorded water strikes and water levels may be as a result of deep drilling into the underlying confined Waterberg Group strata. The reflection of shallow water levels and water strikes observed at the other geological setting could imply that the weathered aquifer system is targeted, rather than the deeper aquifer systems.

Based on the hydrographs (obtained from the HYDSTRA data) majority of groundwater levels indicate a decrease in groundwater levels. Recharge events are observed for most monitoring boreholes, with groundwater levels recovering to long-term average levels (during periods of above average rainfall). Aecom (2015) provided a series of groundwater level heat maps for certain periods from 1960 to present which shows the areas affected by (over) abstraction over the Limpopo WMA over time.

A large scale groundwater contour map based on the latest HYDSTRA groundwater levels is shown in Figure 10. Regionally groundwater levels mimic surface topography and shallow groundwater flow is from higher lying ground towards surface drainages. The main flow direction is towards (and along) the Limpopo River towards the north and northeast.

#### 1.4.2. Recharge

The nationally available recharge dataset, GRAII (DWAF, 2004) is shown in in Figure 10, and summed in Table 5 (per GUA). The recharge distribution is largely controlled by the precipitation distribution, which in turn is related to the topography. At the broadest scale, areas of high rainfall largely correspond (at least in the theoretical datasets) to areas of high recharge. In certain areas the correlation is not direct and the underlying geology, and aquifer type, influences the recharge.

A study from Sorensen et al., (2021) investigated statically the response of groundwater levels over time (hydrographs) with geomorphological conditions within the Mogalakwena and Sand River catchments (see chapters 1.1, 2.3, 1.1 and 2.5). The study found rainfall and aridity are driving factors for groundwater level responses with either a string or subdued reflection from rainfall (recharge) with seasonal fluctuations observed, however some boreholes only showed rainfall response to large recharge events. Groundwater abstraction has an impact on correlation of rainfall, recharge and groundwater responses such as at clustered groundwater abstraction sites (well fields) used for large scale water supply and should be taken with consideration within such areas.



Figure 10. Regional groundwater levels and flow direction.



Figure 11. Groundwater recharge per quaternary catchment.

	_	Area	GR	Vegter (1995)	
Description	GUA	(km²)	(Wet) Mm <sup>3</sup>	(Dry) Mm <sup>3</sup>	Mean Mm <sup>3</sup>
Upper Lephalala	A50-1	2 704	62.6	44.5	140.4
Middle Lephalala	A50-2	821	9.2	6.3	3.2
Lower Lephalala	A50-3	1 943	15.1	9.9	2.6
Nyl River Valley	A61-1	2 333	62.1	44.7	113.2
Sterk	A61-2	1 403	42.4	30.7	54.6
Upper Mogalakwena	A61-3	1 716	43.2	30.9	28.4
Klein Mogalakwena	A62-1	2 125	42.0	29.5	62.8
Matlala	A62-2	1 240	17.8	12.2	12.2
Steilloop	A62-3	2 428	31.6	21.6	13.4
Lower Mogalakwena	A63-1	4 751	43.5	29.4	10.8
Maasstroom	A63-2	1 318	8.1	5.3	4.5
Upper Sand	A71-1	2 026	26.7	18.3	10.9
Middle Sand	A71-2	3 235	27.9	19.0	17.2
Hout	A71-3	4 359	35.4	24.2	18.7
Sandbrak	A71-4	2 716	21.9	14.5	5.4
Lower Sand	A71-5	1 669	9.5	6.1	0.9
Limpopo Tributaries	A63- 3/71-3	3 750	23.3	15.0	3.0
Kalkpan	A50- 4/A63-2	2 572	16.98	11.24	29.00
Nzhelele	A81-1	1 837	71.7	52.7	116.2
Lower Nzhelele	A81-2	1 228	11.8	7.8	1.7
Nwanedi	A81-3	1 133	15.2	10.5	10.2
Upper Luvuvhu	A91-1	2 098	170.2	131.9	451.1
Mutale/Luvuvhu	A91-2	3 838	113.5	83.7	94.8
Shingwedzi	B90-1	5 301	70.5	48.4	40.4

#### Table 5. Groundwater recharge estimates per GUA.

#### 1.4.3. Discharge

One groundwater discharge mechanism is through discharge to surface water, as groundwater contribution to baseflow (river baseflow, springs and seeps). The available baseflow information for the region is a national dataset derived from the GRAII assessment at quaternary catchment scale (DWAF, 2004), shown in (Figure 12). The distribution of groundwater contribution to baseflow closely correlates with the distribution of recharge. Rainfall has a dominant control on recharge, and aquifers with high recharge, can also be reasonably expected to have high groundwater discharge, given a state of dynamic equilibrium in the long term.

This dataset is often the only or major (natural) discharge considered from groundwater. It is simply the only one for which there is a spatial dataset available. Interflow between aquifers, direct evapotranspiration, are discharge mechanisms for which there is not readily available spatial data at regional scale. A widely applied equation for groundwater availability equates availability to recharge minus use (existing abstraction and groundwater contribution to baseflow) minus the reserve. This equation simply yields un-quantified groundwater discharge. All natural discharge (and some enhanced recharge) may be available, or only a small portion of it, depending on the ability to capture this yield (section 1.1.2).

# A92D A91K A91J



7 30°0'E

Figure 12. Baseflow distribution, per quaternary catchment.

28°0'E



#### 1.4.4. Groundwater use

The sum of registered groundwater use (WARMS) per GUA is shown in Table 6 and to assess the current exploitation of the units the volumes was compared to recharge as well as the harvest and exploitation potential.

#### Groundwater Availability (DWAF, 2004b GRA II)

The volume of water that may be abstracted from a groundwater resource based on the concept of an 'exploitability factor' and yield (borehole) distribution which relates to the **Groundwater Exploitation Potential (GEP)**. The volume of water that may be abstracted from a groundwater resource may

ultimately be limited by anthropogenic, ecological and/or legislative considerations, which ultimately is a management decision that will reduce the total volume of groundwater available for development – referred to as the **Utilisable Groundwater Exploitation Potential (UGEP)**, which accounts for the Reserve by prescribing a fixed-level below which the groundwater level may not decline.

The **Groundwater Harvest Potential** is aimed at providing estimates on a national scale of the annual maximum volume of groundwater that can be abstracted from a unit area on a sustainable basis.

A map showing the distribution of registrations is in Figure 13. This map also illustrates a density function which sums the groundwater registration (I/s) per km<sup>2</sup>, emphasising clustered use and high registrations. The three largest groundwater use sectors are large scale irrigation from farmlands, water services to communities and towns/cities and mining, as illustrated in Table 7.

Groundwater use in terms of distribution, is significantly higher along the Nyl river system, following downgradient northwards the sand river system. Large clusters of groundwater use is observed at the Bela-Bela/Modimolle towns, Polokwane and downgradient from Albasini dam (farm land irrigation). Widespread groundwater use is mostly associated with local communities and irrigation use. Groundwater use clustering is less in the central west and far east (Kruger National park). Using the present groundwater utilisation data and comparing it with the exploitable volumes shows that the Lephalala (A50-3), Upper Mogalakwena (A61-3), Upper Sand (A71-1; A71-2), Sandbrak (A71-4), Nzhelele (A81-2), Nwanedi (A81-3) and Levuvhu (A91-1) GUAs are heavily exploited while the Lower Sand and Limpopo Tributaries (comprising of abstraction from the Limpopo Alluvial Aquifers) exceed the exploitation potential.

## $\Delta h$



Figure 13. Map showing distribution of registered groundwater abstraction (points) and groundwater use >0.3 L/s/km<sup>2</sup> shaded.



Drainage system	GUA	Groundwater Use (Mm³/a)	Harvest Potential (Mm <sup>3</sup> /a)	Groundwater Exploitation Potential (Mm <sup>3</sup> /a)	Utilisable Groundwater Exploitation Potential (Mm <sup>3</sup> /a)	Exploit % (Use vs. GEP)
	A50-1	0.71	34.35	249.83	40.83	0.3%
Lephalala	A50-2	1.29	5.82	11.30	6.06	11.4%
	A50-3	11.55	12.17	20.77	10.30	55.6%
Unnor	A61-1	15.17	42.01	102.19	15.93	14.8%
Mogalakwona	A61-2	4.14	20.37	94.69	8.94	4.4%
wogalakwena	A61-3	12.49	10.85	18.15	8.07	68.8%
Middle and	A62-1	1.75	26.03	193.56	26.77	0.9%
lower	A62-2	3.82	14.30	29.93	15.35	12.7%
Mogalakwona	A62-3	1.01	21.48	140.09	48.07	0.7%
wogalakwella	A63-1	15.98	37.48	73.42	33.99	21.8%
	A71-1	37.65	21.11	45.27	11.46	83.2%
Upper Sand	A71-2	40.63	31.10	74.53	25.81	54.5%
	A71-3	44.82	46.68	119.67	16.95	37.5%
Sandbrak	A71-4	19.39	17.41	27.73	14.25	69.9%
Lower Sand	A71-5	13.97	5.32	8.33	4.21	167.7%
Limpopo Tributaries	A63-3/71-3	46.97	16.87	19.89	9.35	236.1%
Kalkpan	A50-4/A63-2	5.83	27.79	27.15	15.77	21.5%
Nahalala	A81-1	8.40	14.76	55.13	33.61	15.2%
Nzhelele	A81-2	5.50	5.24	9.81	5.68	56.0%
Nwanedi	A81-3	5.97	5.01	11.92	6.40	50.1%
Levuvhu	A91-1	61.10	27.15	102.65	66.75	59.5%
Mutale /Levuvhu	A91-2	3.70	27.65	82.35	49.14	4.5%
Shingwidzi	B90-1	2.24	47.32	82.22	31.89	2.7%

#### Table 6. Groundwater use (WARMS) compared to the exploitation potential of the GUA.

Table 7. Groundwater use (WARMS) per groundwater use sector.

Groundwater Use Sector	Registered Use (Mm³/a)				
Agriculture: Aquaculture	0.35				
Agriculture: Irrigation	284.01				
Agriculture: Wearing Livestock	2.13				
Industry (Non-Urban)	5.41				
Industry (Urban)	4.89				
Mining	19.99				
Power Generation	0.004				
Recreation	0.06				
Schedule 1	0.60				
Water Supply Service	46.66				
TOTAL	364.09				

#### 1.4.5. Groundwater quality

The median groundwater quality for selected parameters was calculated for each GUA, as shown in Table 8. Even though the groundwater quality will be discussed in more detail in the following sections, a short discussion is provided here. Approximately 2100 groundwater quality samples were collated from the available databases (e.g. GRIP and WMS). Major elements (pH, EC, Ca, Mg, Na, K, SO<sub>4</sub> Cl, NO<sub>3</sub> as N and F) were compared to the water quality guidelines for acceptable drinking water specified by the Department of Water and Sanitation, inclusive of three water quality classes. The most noticeable elements of concern for water consumption is nitrate (measured as nitrogen (N), with some exceedances observed for fluoride, and sodium.

According to Marais (1999), the single most important reason for groundwater sources in South Africa being declared unfit for drinking is nitrate levels exceeding 10 mg/l (as N). The main inputs of nitrate to groundwater in rural environments are derived from anthropogenic activities such as inappropriate on-site sanitation and wastewater



treatment, improper sewage sludge, drying and disposal, and livestock concentration at watering points near boreholes. However, the extensive occurrence of nitrate in groundwater in uninhabited regions may suggest non-anthropogenic sources possibly related to evaporative enrichment of dry and wet deposition, biogenic point sources through N-fixing organisms, or to a geogenic origin (Tredoux and Talma, 2006). Several samples show major ion concentrations (i.e. Na and F) with elevated salts. This can mostly be related to evaporative concentration of elements in discharge areas or due to low recharge values as well as long residence times for selected samples. The occurrence of fluoride is primarily controlled by geology and climate. Therefore, there are no preventative measures under the given spatial limits of water supply to avoid contamination.

The spatial distribution of the collated (last analysed) Electrical Conductivity (EC) concentrations (in mS/m) is shown in Figure 14. While it may not reflect a specific point in time it does provide an overall indication of the salt loads for comparison purposes. The EC intervals is based on the DWAF (1996) domestic use water quality classification/guideline. Most notable hotspots occur in the Steilloop GUA as well as Lower Lephalala GUA, Upper Mogalakwena GUA, Hout GUA along the Brak River and the Mutale/Luvuvhu GUA.



GUA	GUA	Parameter	рН	EC (mS/m)	TDS	Ca	Mg	Na	к	SO4	CI	NO₃ as N	F
DWAF Class I			5-6 or 9-9.5	70-150	450-1000	80-150	30-70	100-200	-	200-400	100-200	6-10	0.7-1
DWAF Class II			4-5 or 9.5-10	150-370	1000-2000	150-300	70-100	200-600	-	400-600	200-600	10-20	1-1.5
DWAF Class III			3.5-4 or 10-10.5	370-520	2000-3000	>300	100-200	600-1200	-	600-1000	600-1200	20-40	1.5-3.5
Lephalala	A50-1	Median	7.8	143.0	738.2	90.5	38.0	170.1	2.8	25.7	175.9	0.6	1.6
		N	5	5	4	5	5	5	5	5	5	1	5
	A50-2	Median	8.1	127.0	993.7	72.0	48.7	137.8	2.9	39.4	157.8	115.1	1.2
		N	61	65	56	67	67	67	67	67	67	11	64
	A50-3	Median	8.1	125.2	952.5	69.3	58.5	103.2	9.0	30.5	107.0	48.9	1.0
		N	45	45	33	47	47	47	47	47	47	13	45
Upper Mogalakwena	A61-1	Median	7.8	37.5	133.8	28.2	11.5	34.7	1.3	11.2	16.8	0.9	0.3
		N	19	20	7	21	21	21	21	17	20	13	20
	A61-2	Median	8.1	58.0	469.5	51.8	19.0	24.2	1.2	12.1	21.3	-	0.4
		N	5	5	5	5	5	5	5	5	5	0	4
	A61-3	Median	8.1	106.7	865.8	60.0	69.6	60.3	2.0	30.2	75.3	76.0	0.3
	100.1	N	132	124	121	135	134	134	128	130	124	12	123
	A62-1	Median	8.1	109.5	/61.0	/4.4	39.2	89.7	1.9	12.1	123.9	63.5	0.6
	462.2	N	130	143	131	153	152	153	150	136	153	21	14/
Meddle and Lawrence	A62-2	Median	8.1	124.5	943.4	54.9	38.0	149.0	8.7	26.5	1/2.2	59.1	0.6
Middle- and Lower	462.2	N	143	137	144	155	155	154	154	155	155	11	148
wogalakwena	A62-3	Iviedian	8.1	116.0	865.6	57.3	47.1	130.9	8.5	24.6	164.0	35.9	0.4
	462.1	Madian	155	138	149	1/0	1/1	1/1	1/1	169	110.1	18	150
	A03-1	wedian	8.1	120.6	122	70.6	58.8	97.8	2.5	25.3	119.1	83.4 1E	122
	471.1	Madian	9.1	97.6	125 6E0.9	140	159	140 96 F	157 6.2	26.1	141 69 F	24.0	152
Upper Sand	A/1-1	N	0.1	120	167	204	201	202	202	109	204	24.9	170
	471.2	Modian	Q 1	125.2	962.7	572	54.4	1205	203	24.9	122.7	44.0	0.2
	R/1-2	N	156	1/13	136	164	165	164	164	150	122.7	20	1/12
	A71-3	Median	81	109.6	826.0	17.8	16.4	111 5	10.0	27.7	140.5	23.8	0.3
	R/1-5	N	320	322	347	389	387	386	385	384	389	39	287
	Δ71-4	Median	77	110.0	541 5	66.1	45.0	99.1	2.8	30.1	109.0	34.7	0.5
Sandbrak and Lower Sand	7014	N	3	3	2	3	3	3	3	3	3	1	3
	A71-5	Median	8.2	177 5	1330.0	102.0	82.0	159.4	51	104.8	223.8	36.2	0.8
	7010	N	4	4	3	4	4	4	4	4	4	1	4
Limpopo Tributaries	A63-3/71-3	Median	8.1	131.4	964.6	95.4	79.6	37.6	1.6	41.0	76.7	-	0.5
		N	2	2	2	2	2	2	2	2	2	0	2
Kolope	A50-4/A63-2	Median	7.4	102.0		75.6	60.9	69.2	10.1	16.9	74.5	81.4	0.2
		N	1	1	0	1	1	1	1	1	1	1	1
Nzhelele	A81-1	Median	7.8	54.7	409.9	29.6	25.3	30.4	0.7	7.9	34.6	3.1	0.2
		Ν	142	141	132	146	145	142	120	104	137	10	106
	A81-2	Median	8.0	177.0	1178.1	73.9	63.1	140.0	1.3	60.3	208.2	-	0.4
		Ν	15	15	14	15	15	15	15	15	15	0	15
Nwanedzi	A81-3	Median	7.8	70.0	485.9	18.3	20.2	54.9	1.5	16.8	57.0	16.6	0.2
		Ν	52	53	45	53	54	53	51	40	52	7	47
Levuvhu	A91-1	Median	8.0	56.3	453.7	42.0	29.2	23.7	1.0	7.3	29.4	10.9	0.2
		Ν	288	275	262	329	332	329	282	265	328	62	221
Mutale /Levuvhu	A91-2	Median	7.9	49.1	378.0	24.1	20.0	38.4	0.9	7.1	38.0	8.4	0.2
		Ν	228	239	213	257	254	251	227	179	257	28	174
Chinewidei	B90-1	Median	8.1	121.1	939.6	67.8	59.6	103.1	2.2	14.3	102.4	71.5	0.4
SIIIIgwidzi		N	150	138	124	159	161	160	156	151	161	36	134



Figure 14. Spatial distribution of groundwater EC concentration (GRIP dataset).


# 2. GUA STATUS QUO ASSESSMENT

### 2.1. LEPHALALA RIVER

The upper Lephalala River is relatively undeveloped and travers's large wilderness areas. The runoff originates in the upper reaches, and most of the surface water use is found in these upper catchments, where the large number of farm dams supports a significant amount of irrigation. Lower down in the catchment irrigators make use of water from alluvial aquifers. The only other significant water use is the rural water use, and it is assumed that this is sourced from groundwater. Communities in the catchment are located in the lower reaches and they rely mainly on the groundwater resource. In this assessment four GUAs have been delineated for the Lephalala drainage area, namely A50-1 (Figure 16), A50-2 (Figure 17), A50-3 (Figure 18) and A50-4 (Figure 19). A summary of the borehole information for the region is shown in Table 9.

Description	GUA	Info	BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (I/s for 24hrs)	Blow Yield (I/s)
Upper Lephalala	AEO 1	Ν	355	214		2	174
	A30-1	Mean	68.0	24.4		1.1	1.6
	A50-2	Ν	208	159	31	52	72
wilddie Lephalaia		Mean	51.1	18.2	60.3	0.9	2.6
	A50-3	Ν	455	404	60	73	154
Lower Lephalala		Mean	64.5	24.8	40.4	1.1	2.0
Kallunan	A50-	Ν	768	641	1	1	149
καικματι	4/A63-2	Mean	42.4	23.2	14.7	0.4	1.75

#### Table 9. Borehole information for the Lephalala drainage region.

### 2.1.1. Groundwater recharge

The low and variable rainfall together with evaporation rates considerably exceeding rainfall result in a low expectation of natural recharge to groundwater over most of the area. As a result the recharge vary spatially from as high as 18 mm/a in the higher lying areas to less than 2 mm/a in the lower parts of the catchment. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 10.

Description	GUA	Quat	MAP (mm)	Area	GR	Vegter (1995)	
		Quat		(km²)	(Wet)	(Dry) Mm <sup>3</sup>	Mean
Linner Lenhalala		A50A	65/11	208	11 25	8.28	12 16
	A50-1		500.0	406	12.05	9.64	42.10
		ASUB	599.0	400	12.05	0.04	29.51
		A50C	593.0	362	10.36	7.40	24.96
		A50D	558.2	637	12.57	8.89	17.86
		A50E	517.0	629	10.95	7.63	13.61
		A50F	495.8	372	5.35	3.70	12.51
Middle Lephalala	A50-2	A50G	435.3	821	9.20	6.26	3.19
Lower Lephalala	A50-3	A50H	407.2	1945	15.11	9.91	2.56
Kalkpan	A50-	A50J	391.1	1255	8.84	5.91	4.09
	4/A63-2	A63C	377.7	1323	8.14	5.32	4.54

#### Table 10. Recharge estimation (Lephalala).

### 2.1.2. Groundwater Use

The groundwater use for the Lephalala GUAs is summarised in Table 11. The present WARMS groundwater use data was compared to the 2015 Limpopo (WMA) North Reconciliation Strategy (LNRS) estimated 2020 use. The majority of groundwater use is lower down the catchment closer to the confluence of the Limpopo River (i.e, A50-3 and A50-40).

GMA Description	GUA	Quat	WARMS: Use Mm <sup>3</sup>	LNRS 2020 Mm <sup>3</sup>
		A50A	0.107	0.159
		A50B	0.115	0.199
Linner Lenhalala	AEO 1	A50C	0.235	0.193
Opper Lephalala	A30-1	A50D	0.108	0.303
		A50E	0.122	0.255
		A50F	0.136	0.106
Middle Lephalala	A50-2	A50G	1.290	3.120
Lower Lephalala	A50-3	A50H	11.552	3.786
	A50-4	A50J	4.254	1.009
Kalknan	A50-			
Ναικματι	4/A63-	A63C		0.502
	2		1.579	

Table 11. Groundwater use (per annum) as registered per catchment for each Lephalala GUA.

### 2.1.3. Groundwater quality

Regional water quality in the Upper Lephalala is subject to considerable variation due to the extensive use of groundwater, various lithologies and groundwater-surface water interaction. Groundwater samples indicate a variety of water types (e.g. Ca/Mg-HCO<sub>3</sub>, Na-HCO<sub>3</sub> and Na-Cl) (Figure 15). A high percentage of samples relate to a fresh recharge type (Ca/Mg-HCO<sub>3</sub>) water, while cation and anion exchange process may be occurring within the strata hence Na-Cl and Ca/Mg-Cl type water present.



Figure 15. Piper diagram for the Upper Lephalala drainage region.



Groundwater quality in the Lephalala is considered to be acceptable to marginal water quality. The most notable elements of concern include NO<sub>3</sub> as N and fluoride with average concentrations above the recommended drinking limit (Table 12).

GUA		рН	EC	TDS	Са	Mg	Na	к	SO4	CI	NO₃as N	F
DWAF Cla	ss I	5-6 or 9- 9.5	70-150	450- 1000	80- 150	30- 70	100- 200	-	200- 400	100- 200	6-10	0.7-1
DWAF Cla	ss II	4-5 or 9.5-10	150-370	1000- 2000	150- 300	70- 100	200- 600	-	400- 600	200- 600	10-20	1-1.5
DWAF Cla	ss III	3.5-4 or 10-10.5	370-520	2000- 3000	>300	100- 200	600- 1200	-	600- 1000	600- 1200	20-40	1.5-3.5
A50-1	Ν	5	5	4	5	5	5	5	5	5	1	5
	Median	7.7	143	738	90.5	38.0	170.1	2.7	25.6	175.9	0.57	1.6
A50-2	Ν	61	65	56	67	67	67	67	67	67	11	64
	Median	8.0	127	993	72.0	48.7	137.7	2.9	39.4	157.76	115.1	1.2
A50-3	Ν	45	45	33	47	47	47	47	47	47	13	45
	Median	8.1	125	952	69.2	58.5	103.19	8.9	30.4	107.00	48.9	0.9
A50- 4/A63-2	Ν	1	1	0	1	1	1	1	1	1	1	1
	Median	7.4	102	-	75.6	60.9	69.20	10.1	16.8	74.48	81.4	0.2

Table 12. Groundwater quality for the Lephalala region (All units in mg/l, EC in mS/m) (red text exceeds Class III)

### 2.1.4. Groundwater contribution to baseflow

Effluent conditions are expected in the upper reaches while seasonal alternating effluent / influent conditions can occur along the lower reaches of the Lephalala River. It is expected that surface-groundwater exchange between the alluvium and the Lephalala River occurs on a far shorter time scale in comparison to the interaction between the regional and alluvial aquifers. Regional aquifers of the lower catchment show marginal gradients towards the Lephalala River course and exchange water with the river only indirectly via the alluvial deposits. However, in the upper reaches of the catchment a higher gradient towards the River course is observed and where the alluvium is lacking the surface-groundwater exchange is directly from the regional aquifer to the River. Comparison of groundwater contribution to baseflow estimates for the Lephalala drainage region are summarised in Table 13.

Description	GUA	Quat	Hughes Mm³/a	Shultz Mm³/a	Pitmann Mm³/a	GRA II (WR2005) Mm <sup>3</sup> /a	Maint. Low flow Mm³/a
		A50A	11.19	3.48	8.97	4.22	3.01
		A50B	11.81	3.87	10.72	5.44	3.07
the set of the late	A50-1	A50C	10.27	3.42	9.45	4.82	1.25
Opper Lephanana		A50D	6.71	0.36	2.87	2.12	2.98
		A50E	4.86	0.33	2.58	1.88	0.42
		A50F	2.39	0.18	1.49	1.04	0.23
Middle Lephalala	A50-2	A50G	-	-	-	-	0.02
Lower Lephalala	A50-3	A50H	-	-	-	-	0.04
	A50-	A50J	-	-	-	-	0.72
Kalkpan	4/A63- 2	A63C	-	-	-	-	0.84

Table 13. Groundwater contribution to baseflow estimates.

#### 2.1.5. Summary

The following tables provide a summary for each of the GUA, as illustrate in Table 14, Table 15, Table 16 and Table 17.



# Table 14. Summary information for GUA: A50-1.

Description         The main aquifer types include are the factured Waterberg Group aquifers (Predominately) and Intergranular and aquifers. The Waterberg Group aquifers is associated with steep topography and shows generally poor capability to produce huge amounts of groundwater. Richtrage to the aquifer, and the discharged on the steep slope, provides baseflow to the inverse. A weathered zone aquifer is found only where deep weathering occurs and provides groundwater storage that feeds the underlying fractured aquifer. Allwivial aquifers are recharged during the rannel bushed Complex, forming type (additional feedback) and the lower reaches of the tephalable River with a thickness of approximately 5 m. the GUA lower lying areas is characterised by rocks from the Karoo underlying fractured aquifer. Allwivial aquifers steep slope, provides baseflow to the water ow with infligation, schedule 1, recreational and livestock watering use.           Astor         Astor         Agon, B_C, D, F.F           Mag         The flag to the approximately 5 m. the GUA lower lying areas is characterised by recomplex to the steep slope, provides baseflow to the karoo underlying flag to the steep slope, provide baseflow to the karoo underlying flag to the steep slope, provide baseflow to the steep slope, provide baseteslope slope slope slop	GUA	Upper Leph	alala A50-1						
Alluvia aquifers. The Waterberg formation, located from Weigeveden northwest to Berglowsch inderburg proc. capability to produce huge anounts of groundwater. Recharge to the aquifer (fet discharged on the steep slopes, provides baseflow to the river. A weathered zone aquifer is found only where deep veathering occurs and provides groundwater storage that feeds during protocal on the steep slopes. The weathered is the underlying fractured aquifer. Alluvial aquifers are recharged during periods of high stream-flows as well as during the rainfal season. The alluvium appears to be better developed along the lower reacters of the Lephabia were with a hickness of approximately 5 m. The GUA lower (hug areas is characterised by rocks from the Karoo supergroup and Bushedel Complex, forming typical fractured aquifer systems. The groundwater use is associated with firigations, schedule 1, recreational and livestock watering use.         Catchment       ASO, B, C, D, F.         Map       Together and the steep slopes and the steep slope slope another steep slope and the steep slope and th	Description	The main a	auifer types includ	e are the fra	ctured Waterbe	erg Group aquifers (	Predominately) a	nd Intergranular	
ares, is associated with steep "opegraphy" and shows generally poor capability to produce huge amounts of groundwater. Richarge on the steep slope, provides baseflow to her werk. A weathered zone aquifer is found only where deep weathering occurs and provides groundwater uses as well as during the rainfall season. The alluvium appears to be better developed along the lower reaches of the Lephalala River with a thickness of approximately 5 m. The GUA lower lying areas is characterised by trods from the Karoo uppergoup and bushveld Complex, forming typical fractured aquifer system. The groundwater use is associated with imgation, schedule 1, recreational and livestod watering use.         AsoNa, B.O.F.F         Mar         Viet Level         Optimized Status         AsoNa, B.O.F.F         Mar         Viet Level         Optimized Status         Optimized Status         AsoNa, B.O.F.F         Mar         Viet Level         Optimized Status         Mark Status         Optimized Status         Optimized Status         Optimized Status         Optimized Status		Alluvial aqu	ifers. The Waterbe	rg formation	located from	Welgevoden northwe	est to Berglus-Or	skuld-Indenburg	
groundwater. Recharge to the aquifer, often discharged on the steep slopes, provides parallelis to the aquifer. Altuvial aquifers are recharged during periods of high stream-flows as well as during the rainfall season. The alluvium appears to be better developed along the lower reaches of the tephalab River with a litchness of approximately 5m. The GUA lower lying areas is characterised by rocks from the Karoo supergroup and Bushveld Complex, forming typical fractured aquifer systems. The groundwater use is associated with irrigations, schedule 1, recreational and livestock watering use.         Catchments       ASOA,B,C,D,E,F         Mar       Mar         Mar       AsoA,B,C,D,E,F         Mar       Mar		area, is ass	ociated with steer	topography	and shows ge	nerally poor capabili	ty to produce h	uge amounts of	
weathered zone aguifer is found only where deep weathering occurs and provides groundwater storage that feeds the underlying fractured aquifer. Aluvial aquifers are recharged during periods of high stream-flows as well as during the rainfall season. The alluvian appears to be better developed along the lower reaches of the Lephalaba River with a thickness of approximately 5 m. The GUA lower lying areas is characterised by rocks from the Karoo supergroup and Buskveld Complex, forming typical fractured aquifer systems. The groundwater use is associated with irrigation, schedule 1, recreational and livestock watering use.         Aston.ec.       Aston.ec.O.E.F         Man       Massing Complex, forming typical fractured aquifer systems. The groundwater use is associated with irrigation, schedule 1, recreational and livestock watering use.         Mark Schenker       Aston.ec.O.E.F         Mark Schenker       Massing Complex, forming the Schenker Mark Sch		groundwate	er. Recharge to the	e aquifer, ofte	n discharged or	n the steep slopes, p	rovides baseflow	to the rivers. A	
the underlying fractured aquifer. Alluvial aquifers are recharged during periods of high stream-flows as well as during the rainfall season. The alluvium appears to be better developed along the lower reaches of the Lephalal River with a linkensos of approximately 5 m. The GUA lower lying areas is characterised by rocks from the Karoo supergroup and Bushveld Complex, forming typical fractured aquifer systems. The groundwater use is associated with irrigation, schedule 1, recreational and livestock watering use.  Eatchments ASOA.B.C.D.E.F  Mo		weathered	zone aquifer is foun	d only where	deen weatherir	ng occurs and provide	s groundwater st	orage that feeds	
during the rainfall season. The alluvium appears to be better developed along the lower reaches of the Lephalaid River with a thickness of approximately 5 m. The GUA lower king areas is characterised by rocks from the Karoo supergroup and Buskveld Complex, forming tryptical fractured aufler systems. The groundwater use is associated with irrigation, schedule 1, recreational and livestock watering use. <b>4500.B.C.O.E.F</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>Total</b> <b>T</b>		the underly	ing fractured aquif	er Alluvial a	quifers are rech	harged during period	s of high stream-	flows as well as	
Biver with a thickness of approximately 50 mode betwee developed along the characterised by rocks from the Karoo superroup and Bushveld Complex, forming typical factured aquifer systems. The groundwater use is associated with irritation, schedule 1, recreational and livestok watering use.         Catchments       ASOA, B, C, D, E, F         Map       Image and Bushveld Complex, forming typical and livestok watering use.         Legend       Jone Study 1, and 1, an		during the r	ainfall season The	alluvium anr	pars to be bett	er developed along th		of the Lenhalala	
Note while the match of the Boldow and Provide Match of the Match		River with a	thickness of annre	vimately 5 m		er lying areas is chara	ic lower reaches	from the Karoo	
Subjective of a local contract of only as (yind) in a water or and investor water ing use.         Catchments         ASOA, B, C, D, E, F         Map         Image: Contract of the state of the sta			and Ruchvold Com	play forming	typical fracture	a aquifor systems. The	ho groundwater i		
Catchment       ASDR.B.C.D.E.F         Map       Legend         Water Lowel       ASDR.B.C.D.E.F         Map       Schment       Legend         Water Lowel       ASDR.B.C.D.E.F         Map       Schment       Legend         Water Lowel       ASDR.B.C.D.E.F         Map       Schment       Schment         Water Study Area       Asord       Schment         Geodale       Man Rivers       Schment         Man Rivers       Schment Area       Schment Mark         Bobasse       Mark Schedel       1 1000         WetLINGTON       Scheder Mark       Scheder Mark         Waterbag GRP       WetLINGTON       Scheder Mark         Scheder State       Mark Scheder Mark       Scheder Mark         Waterbag GRP       WetLINGTON       Scheder Mark         Scheder State       Mark Scheder Mark       Scheder Mark         Scheder State       Mark Scheder Mark       S		supergroup	and Bushveld Com	piex, iorning	ivostock waterin	a aquiler systems. In	ne groundwater t	ise is associated	
Catchments       P30A,B,C,D,C,F,F         Map       Isgend       Legend         Viater Level       Advouted Topics         Geologic       Water Study Avag       1000         VMS Geosite       Water Study Avag       1000         WMS Geosite       1000       100 000         Catchment       Catchment       1000         Geologic       1000       100 000         Catchment       1000       100 000         Catchment       1000       100 000         Catchment       1000       100 000         Catchment       1000       100 000         Start Date       Well NGTON       100 000         Start Date       For Date       Councers       1000         ModaLakeword       Viater User Schemes (stort WK 2015, Reco Study)       1       1000         Sterie Softer DWAF, 2015, Reco Study       Astore Study       Astore Study       Astore Study         Scheme Name       Vilage/Settlement       Catchment       Astore Manual         Model Marce Supply       Farms Modinolle IM       Astore Manual       Astore Manual         Scheme Name       Vilage/Settlement       Catchment       Astore Manual         ModaLakwey Supply       Farms Modinolle IM </th <th>Catabasanta</th> <th></th> <th></th> <th></th> <th></th> <th>ig use.</th> <th></th> <th></th>	Catabasanta					ig use.			
Map         Legend       Legend       Legend       Legend         With Care Lawel       Application       100       1000       1000       1000       1000       0000       Schedule 1 (m3)       1       1000       Schedule 1 (m3)       1       1000       0000       1       1000       0000       Schedule 1 (m3)       1       0000       1       1000       0000       Schedule 1 (m3)       1       1000       0       1000000       1       1000000       10000000       1       1000000       10000000       1       1000000       10000000       1       1000000       10000000       1       1000000       10000000       1       1000000       10000000       10000000       1       1000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       10000000       100000000       100000000       100000000	Catchments	A50A,B,C,D,	E,F						
Legend Geologic Water Level Geologic Min Rivers       Advector Figure Market Geologic Min Rivers       Advector Figure Market Ma									
Water Lavel Geostia       Water Supply (m3)         HYDRSTRA Geostia       HYDRSTRA Geostia         WMS Geostia       Hydrs Study Area Cathment Geostia         Cathment Geostia       Cathment Geostia         Geostia       Hydrs Study Area Cathment Geostia         WELLINGTON       SwartRANP WELLINGTON         SwartRANP Welcharker       Hydrs Geostia         Welcharker       Hydrs Geostia         Water Step Ger       Hydrs Geostia <th>Legend</th> <th>A5</th> <th>0H A5N0016</th> <th></th> <th></th> <th></th> <th></th> <th>egend</th>	Legend	A5	0H A5N0016					egend	
Water Level       Water Supply (m3)       I         HyDRSTRA       HYDRSTRA       I 000 000         MMS Geosite       I 000 000         MMR Rivers       Schedule 1 (m3)       I 000 000         Main Rivers       I 000 000       Schedule 1 (m3)       I 000 000         Catchment       Geology       I 000 000       I 000 000         Babase       I 000 000       I 000 000       I 000 000         Schedule 1 (m3)       I 000 000       I 000 000       I 000 000         Marking GBP       WelLINGTON       I 000 000       I 000 000         Swens Study Area       I 000       I 000 000       I 000 000         Marking GBP       WelLINGTON       I 000 000       I 000 000         Waterberg GBP       WelLINGTON       I 100       I 000 000         Waterberg GBP       Wellebrorg GBP       I 100       I 000 000         Waterberg GBP       Waterberg GBP       I 100       I 000 000         Waterberg GBP       Waterberg GBP       I 100       I 000 000         CLEREMONT       Bustrowid Complex       I 100       I 000 000         Scheene Safet DWAF, 2015, Recon Study       Asige       Asige       Asige         Scheene Name       Village/Settlement	3-11			50G			· · ·		
Celositie       - 1 00         WMS Geositie       - 1 000 000         WMS Geositie       - 1 000 000         Schedule 1 (m3)       - 1 000 000         Catchment       - 0 000 000         Geositie       - 0 000 000         WMS Geositie       - 0 000 000         WMS Geositie       - 0 000 000         Catchment       - 0 000 000         Geology       - 0 000         UMATERNARY       - 0 00000         Dabases       - 0 00000         Karoo SGBP       - 0 00000         Weither Geology       - 0 00000         Watherberg GRP       - 0 00000         ModGaLakwenA       - 1 00         Watherberg GRP       - 0 00000         ModGaLakwenA       - 0 00000         ModGaLakwenA       - 0 00000	Water Leve	el	A since in				Water Sup	ply (m3)	
HyDRS1RA       HyDRS1RA         HyDRS1RA       HyDRS1RA         MMR Kvers       Hydrs1RANT         Roobsrg GBP       Hydrs2RNARY         Will Mass       Hydrs2RNARY         Will Hydrs2RNARY       Hydrs2RNARY         Walker Hydrs2NNARY       Hydrs2NNARY         Modimolie LM Farmy	Geosite	. 13	C	The star start			• • 1		
WMS Geosite       1000000         Main Rivers       Schedule1 (m3)         Reverse Study Area       1000000         OutTERNARY       000000         OutTERNARY       000000         WellLINGTON       SwartTRANT         Rooker GGP       000000         WellLINGTON       SwartTRANT         Rooker GGP       000000         WellAWATER       000000	Geosite	A	A4N0504	CARLEN AV CAR	°	A62D	A62 • 1 000		
Minite Views       Schedule 1 (m3)         Rivers Study Area       0 00000         QUATERNARY       0 00000         QUATERNARY       0 00000         Bibabas       0 000000         Schedule 1 (m3)       0 00000         Diabas       0 000000         Schedule 1 (m3)       0 000000         Diabas       0 0000000         Schedule 1 (m3)       0 000000         Diabas       0 0000000         Schedule 1 (m3)       0 000000         Diabas       0 0000000         Mark Rivers       0 0000000         Mark Rivers       0 000000         Mark Ris Rivers       0 000000 </th <th>WMS Geos</th> <th>sito D</th> <th><b>2:</b></th> <th>ASNO</th> <th></th> <th></th> <th>A6No 0 1 000</th> <th>000</th>	WMS Geos	sito D	<b>2:</b>	ASNO			A6No 0 1 000	000	
Automation       1         Automation       1         Catchment       100         Goldgy       100         Wellington       1000         Wellington       1000         Wellington       1000         Wellington       1000         Wellington       1000         Wellington       1000	A Main River	's	ASOF ON			A Startes	Schedule *	l (m3)	
Scheme Name       Village/Settlement         Volume       Village/Settlement         Volum       Village/Settlement      <	Bivers Stur	dy Area	1 Det	ASOE	25-1.	° f • f ••	2 0 1		
Geology       000000000000000000000000000000000000	Catchment					1220 100 100	100		
UATERNARY Dibbase Karoo SQP       Wining (m3) 1 1 000 10 000 00 10 000 00 10 000 00 10 000 00	Geology	Set.				PL DAVS	5 100 C	00	
Outboundstream       I 000         WELLINGTON       1000         WELLINGTON       1000         WARTRANT       1000         Roolberg GBP       1000         WARTRANT       1000         Roolberg GBP       1000         WARTRANT       1000         WARTRANT       1000         Roolberg GBP       1000         WARTRANT       1000         MAKGABENG       1000         WARTRANT       1000         MAKGABENG       1000         Waterberg GRP       1000         Waterberg GRA       1000         Retrobox       1000         Waterberg GRA       1000         Retrobox       1	OUATERN		· · ·		1	LL S	Mining (m3	3)	
Karoo SGGP         100 000           WELLINGTON         100 000           SWARTRANT         100 000           Rooleg GBP         100 000           WALLINGTON         100 000           WALLINGTON         100 000           WELLINGTON         100 000           WALMATER         100 000           WALMATER         100 000           WALMATER         100 000           WALMATER         100 000           Waterberg GRP         440507           WALMATER         100 000           Waterberg GRANITE         100 000           Waterberg         Waterberg           Water Use Schemes (after DWAF, 2015, Recon Study)         100 000           Scheme Name         Village/Settlement         AS08           Rietbokvalley Supply         Rietbokvalley         AS08           Rietbokvalley Supply         Rietbokvalley         AS08           Avallable monitoring locations for trend analysis - Water Level         Min water level         Mean water           Name         Start Date         End Date         Count         Max water         Invel (mbgl)           Astolota         2008/02/21         2021/09/17         3425         0.12         3.72         10.33	Diabase					. 0. 0. S.S.S.S.S.	• 1 000		
Wellington         0 000 000           SWARTRANT         10 000 000           Rooberg GBP         10 000 000           Rooberg GRP         10 000 000           MAKGABENG         1 000 000           KRANSBERG         1 000 000           Waterberg GRP         1000 000           MAKGABENG         1 000 000           KRANSBERG         1 000 000           Waterberg GRP         1 1000           Waterberg GRP         1 000 000           Waterberg GRP         1 000 000           Waterberg GRP         1 000 000           Scheme Name         Village/Settlement         Catchment           Modinolle LM Farms Supply         Farms Modinolle LM         A508           Rietbolvailey Supply         Farms Modinolle LM         A508           Rietbolvailey Supply         Rietbolvailey         A508	Karoo SGBP		10000		A500 8		• 100 0	00	
SWARTRANT         Roolberg GBP         Roolberg GRP         MAKGABENG         Waterberg GRP         MOGALAKWENA         CLEREMONT         Bushveld Complex         NEBO GRANITE         Waterberg         Village/Settlement         Catchment         Modimolle LM Farms Supply         Rietbokvalley Supply         Rietbokvalley Supply         Rietbokvalley Supply         Rietbokvalley Supply         Rietbokvalley Supply         Astonia         Name       Start Date         End Date       Count         Max water       (mbgl)         (mbgl)       (min-max) (m)         Astonia       2005/02/21         2021/09/17       3425       0.12       3.72         Astonia       2002/03/26       2021/09/14       3672       12.76	WELLINGT	TON	DALL P		<u>Q</u>		10 00	0 000	
Roolberg GBP       I <t< th=""><th>SWARTRA</th><th>NT</th><th>54</th><th></th><th></th><th>0</th><th>6No588</th><th>Irban (m3)</th></t<>	SWARTRA	NT	54			0	6No588	Irban (m3)	
Notice         Constrained         Constrained <t< th=""><th>Rooiberg GBP</th><th>1345</th><th><i>m</i></th><th>SA</th><th>0 - 00 0</th><th></th><th></th><th></th></t<>	Rooiberg GBP	1345	<i>m</i>	SA	0 - 00 0				
Notification       Notification       10000       100000       1000000       1000000       1000000       1000000 </th <th>POOIBER</th> <th>C Poer</th> <th>se Lo</th> <th><u>.</u></th> <th>- 24 - 21</th> <th>1459 m</th> <th>1.000</th> <th>•</th>	POOIBER	C Poer	se Lo	<u>.</u>	- 24 - 21	1459 m	1.000	•	
MackadBeng NackadBeng NackadBeng NackadBeng NogaLakWeNA CLEREMONT Bushveld Complex NeBo GRAINTE       A Nosof Nate of erg Nate of erg	Waterberg GRP	0 150	(do			A62A	1 000	000	
Walchool         Olige Settlement         Modimolic LM Farms Supply         Farms Modimolic LM         Max water level         Max water level         Max water level (mbgl)         Mean water level (mbgl)         Rietbokvalley Supply       Rietbokvalley         Asign colspan="2">Start Date       End Date       Count       Max water level (mbgl)       Mean water level (mbgl)       Fluctuation (min-max) (m)         Asign colspan="2">Asign colspan="2">Catchment         Max dot colspan="2">Catchment         Max dot colspan="2">Catchment         Max dot colspan="2">Max water level (mbgl)       Mean water level (mbgl)         Asign colspan="2" <th co<="" th=""><th>MAKGABE</th><th>NG</th><th>1</th><th></th><th>· · · · · · · · · · · · · · · · · · ·</th><th></th><th></th><th></th></th>	<th>MAKGABE</th> <th>NG</th> <th>1</th> <th></th> <th>· · · · · · · · · · · · · · · · · · ·</th> <th></th> <th></th> <th></th>	MAKGABE	NG	1		· · · · · · · · · · · · · · · · · · ·			
New WalkWater SETLAOLE MOGALAKWENA CLEREMONT Bushveid Complex NEBO GRANTE Water berg         Nebo GRANTE O       AkNosof D         Nebo GRANTE O       Nebo GRANTE D         Nebo GRANTE O       AkNosof D         Nebo GRANTE O       AkNosof D         Nebo GRANTE O       AkNosof D         Nebo GRANTE O       Village/Settlement         Scheme Name       Village/Settlement         Scheme Name       Village/Settlement         Modimolle LM Farms Supply       Farms Modimolle LM         Astokalley Supply       Rietbokvalley         Asidable monitoring locations for trend analysis - Water Level       Min water level (mbgl)       Mean water fluctuation (min-max) (m)         Astolo 13       2008/02/21       2021/09/17       3425       7.95       3.92       6.56       4.03         Astolo 14       2007/10/26       2021/09/17       3425       7.95       3.92       6.56       4.03         Astolo 1	KRANSBE	RG A4Nos	07		1:1-74		Livestrock	(m3)	
Structure       Image:		FR		6	A5N0015	AsoB	• 1	and the second se	
WOGALAKWENA CLEREMONT Bushveid Complex       Image for the reg Water berg         Figure 16 Map showing the GUA A50-1 with geology, groundwater use and geo-sites.       Image for the reg Water berg       Image for the reg Water berg       Image for the reg Water berg         Scheme Name       Village/Settlement       Catchment A50B         Modimolle LM Farms Supply       Farms Modimolle LM       A50B         Rietbokvalley Supply       Rietbokvalley       A50B         Available monitoring locations for trend analysis - Water Levels       Max water level (mbgl)       Min water level (mbgl)       Mean water (min-max) (m)         A5N0013       2008/02/21       2021/09/17       3425       7.95       3.92       6.56       4.03         A5N0014       2007/10/26       2021/09/29       2801       10.45       0.12       3.72       10.33         A5N0015       2009/03/26       2021/09/14       3672       12.76       7.88       9.47       4.88	SETLAOLE			i	Asoc -		• 100		
Water being of the bind	MOGALAK	WENA		Noro6	\***; <i>7_</i>	2.37		000	
Water berg       Water berg       1       1       1       1       1       100000000000000000000000000000000000		DNT		4140500		A5N0014	Irrigation (r	n3)	
Image: Start Date       End Date       Count       Max water       Min water level       Mean water       Fluctuation         Name         Start Date       End Date       Count       Max water       Min water level       Mean water       Fluctuation         Associated a sological data water         Associated a sological data water         Mane       Start Date       End Date       Count       Max water       Min water level       Mean water       Fluctuation         Associated a sological data water       Sological data water       Min water level       Mean water       Fluctuation         Mare Start Date       End Date       Count       Max water       Min water level       Mean water       Fluctuation         Associate 2009/03/26       2021/09/17       3425       7.95       3.92       6.56       4.03         Associate 2009/03/26       2021/09/14       3672       12.76       7.88       9.47       4.88	Bushveld Compl	lex Wa	aterberg	Dwarsrivier			1800 m • 1		
Village/Settlement         Catchment           Modimolle LM Farms Supply         Farms Modimolle LM         A50B           Rietbokvalley Supply         Rietbokvalley         A50A, B           Available monitoring locations for trend analysis – Water Levels         Min water level (mbgl)         Min water level (mbgl)         Fluctuation (min-max) (m)           A5N0013         2008/02/21         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0014         2007/10/26         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0015         2009/03/26         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0014         2007/10/26         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0015         2009/03/26         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0015         2009/03/26         2021/09/29         2801         10.45         0.12         3.72         10.33           A5N0015         2009/03/26         2021/09/14         3672         12.76         7.88         9.47         4.88	NEBO GR	ANITE	2 6 5 4	~	L		• 1 000		
Village/Settlement       Catchment         Mare Schemes (after DWAF, 2015, Recon Study)         Scheme Name       Village/Settlement       Catchment         Modimolle LM Farms Supply       Farms Modimolle LM       A50B         Rietbokvalley Supply       Rietbokvalley       Max water       Min water level       Mean water       Fluctuation         Name       Start Date       End Date       Count       Max water       Min water level       Mean water       Fluctuation         A50013       2008/02/21       2021/09/17       3425       7.95       3.92       6.56       4.03         A50014       2009/03/26       2021/09/14       3672       12.76       7.88       9.47       4.88	N	1	2 2 -/		teuingspail	A50A	10 00	0 000	
Mame         Village/Settlement         Catchment           Mare Isology groundwater use and geo-sites.           Mater Use Schemes (after DWAF, 2015, Recon Study)           Scheme Name         Village/Settlement         Catchment           Modimolle LM Farms Supply         Farms Modimolle LM         A50B         A50A, B           Rietbokvalley Supply         Rietbokvalley         Mater Use         Mater Use Start Date         Fluctuation (min-max) (m)           A5N0013         2008/02/21         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0014         2007/10/26         2021/09/29         2801         10.45         0.12         3.72         10.33           Mater Lavel Graphs         2021/09/14         3672         12.76         7.88         9.47         4.88	13 A 12	in the second	989783a	lwater	ararivuos	•	· ·····		
Scheme Name         Village/Settlement         Catchment           Modimolle LM Farms Supply         Farms Modimolle LM         A50B           Rietbokvalley Supply         Rietbokvalley         A50A, B           Astalable monitoring locations for trend analysis – Water Level         Mane         Start Date         End Date         Max water level (mbgl)         Min water level (mbgl)         Mean water (mbgl)         Fluctuation (min-max) (m)           A5N0013         2008/02/21         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0014         2007/10/26         2021/09/29         2801         10.45         0.12         3.72         10.33           Motionale zones         2009/03/26         2021/09/14         3672         12.76         7.88         9.47         4.88	Y-A	withstroom		nset	- strater		Sillin		
20 Kilometers         End Date       Catchment         Scheme Start Date       Village/Settlement       Catchment         Modimolle LM Farms Supply       Farms Modimolle LM       AS0B         Rietbokvalley Supply       Rietbokvalley       Mark Start Date       End Date       Count       Max water level (mbgl)       Min water level (mbgl)       Mean water level (mbgl)       Fluctuation (min-max) (m)         ASN0013       2008/02/21       2021/09/17       3425       7.95       3.92       6.56       4.03         Max water level (mbgl)       Min water level (mbgl)       Mean water level (mbgl)       Fluctuation (min-max) (m)         ASN0013       2008/02/21       2021/09/17       3425       7.95       3.92       6.56       4.03       ASN0014       2007/10/26       2021/09/17       3425       7.95       3.92       6.56       4.03         ASN0013       2009/03/26	Nord	51		900	21	A.	61HJ	AGAES	
Figure 16 Map showing the GUA A50-1 with geology, groundwater use and geo-sites.         Water Use Schemes (after DWAF, 2015, Recon Study)         Scheme Name       Village/Settlement       Catchment         Modimolle LM Farms Supply       Farms Modimolle LM       A50B         Rietbokvalley Supply       Rietbokvalley       Rietbokvalley       A50A, B         Available monitoring locations for trend analysis – Water Levels       Min water level (mbgl)       Mean water level (mbgl)       Fluctuation (min-max) (m)         A5N0013       2008/02/21       2021/09/17       3425       7.95       3.92       6.56       4.03         A5N0014       2007/10/26       2021/09/29       2801       10.45       0.12       3.72       10.33         A5N0015       2009/03/26       2021/09/14       3672       12.76       7.88       9.47       4.88		20 Kilometer	s and the second	102312	the states	Isn, NASA, NGA USGS, EsroSouth	Affrea, Esri, HERE, Gaistin, FAQ	MPTIANASA, USGS	
Figure 16 Map showing the GUA A50-1 with geology, groundwater use and geo-sites.         Water Use Schemes (after DWAF, 2015, Recon Study)         Scheme Name       Village/Settlement       Catchment         Modimolle LM Farms Supply       Farms Modimolle LM       Farms Modimolle LM       A50B         Rietbokvalley Supply       Rietbokvalley       Rietbokvalley       A50A, B         Available monitoring locations for trend analysis – Water Levels       Max water level (mbgl)       Min water level (mbgl)       Mean water level (mbgl)       Fluctuation (min-max) (m)         A5N0013       2008/02/21       2021/09/17       3425       7.95       3.92       6.56       4.03         A5N0014       2007/10/26       2021/09/29       2801       10.45       0.12       3.72       10.33         A5N0015       2009/03/26       2021/09/14       3672       12.76       7.88       9.47       4.88	Les Maria	A. O. U.S. 18	1.201.2.01.3	Station 1	- 111625 - 140				
Water Use Schemes (after DWAF, 2015, Recon Study)         Scheme Name       Village/Settlement       Catchment         Modimolle LM Farms Supply       Farms Modimolle LM       A50B         Rietbokvalley Supply       Rietbokvalley       Rietbokvalley       A50A, B         Available monitoring locations for trend analysis – Water Levels       Max water       Min water level (mbgl)       Mean water level (mbgl)       Fluctuation (min-max) (m)         A5N0013       2008/02/21       2021/09/17       3425       7.95       3.92       6.56       4.03         A5N0014       2007/10/26       2021/09/29       2801       10.45       0.12       3.72       10.33         A5N0015       2009/03/26       2021/09/14       3672       12.76       7.88       9.47       4.88	Figure 16 Map	showing the	GUA A50-1 with g	geology, grou	undwater use	and geo-sites.			
Scheme NameVillage/SettlementCatchmentModimolle LM Farms SupplyFarms Modimolle LMFarms Modimolle LMA50BRietbokvalleyRietbokvalleyRietbokvalleyKietbokvalleyA50A, BAvailable monitoring locations for trend analysisWater LevelsMax waterMin water levelMean waterFluctuationNameStart DateEnd DateCountMax waterMin water levelMean waterFluctuationA5N00132008/02/212021/09/1734257.953.926.564.03A5N00142007/10/262021/09/29280110.450.123.7210.33A5N0152009/03/262021/09/14367212.767.889.474.88	Water Use Schem	nes (after DW	AF, 2015, Recon Stu	dy)					
$ \begin{array}{ c c c c c c } \hline Modimolle LM Farms Supply & Farms Modimolle LM & Farms Modimolle LM & Farms Modimolle LM & A50B \\ \hline Rietbokvalley $$$ variable monometry for the text of the text of the text of the text of tex$	Scheme Name		Village/Settlemer	nt				Catchment	
RietbokvalleyRietbokvalleyA50A, BAvailable monitoring locations for trend analysis – Water LevelsNameStart DateEnd DateCountMax water level (mbgl)Min water level (mbgl)Mean water level (mbgl)Fluctuation (min-max) (m)A5N00132008/02/212021/09/1734257.953.926.564.03A5N00142007/10/262021/09/29280110.450.123.7210.33A5N00152009/03/262021/09/14367212.767.889.474.88	Modimolle LM F	arms Supply	Farms Modimolle	LM				A50B	
Available monitoring locations for trend analysis – Water Levels           Name         Start Date         End Date         Count         Max water level (mbgl)         Min water level (mbgl)         Mean water level (mbgl)         Fluctuation (min-max) (m)           A5N0013         2008/02/21         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0014         2007/10/26         2021/09/29         2801         10.45         0.12         3.72         10.33           A5N0015         2009/03/26         2021/09/14         3672         12.76         7.88         9.47         4.88	Rietbokvalley Supply Rietbokvalley A50A, B								
Name         Start Date         End Date         Count         Max water level (mbgl)         Min water level (mbgl)         Mean water level (mbgl)         Fluctuation (min-max) (m)           A5N0013         2008/02/21         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0014         2007/10/26         2021/09/29         2801         10.45         0.12         3.72         10.33           A5N0015         2009/03/26         2021/09/14         3672         12.76         7.88         9.47         4.88	Available monito	ring locations	for trend analysis -	- Water Levels	5				
A5N0013         2008/02/21         2021/09/17         3425         7.95         3.92         6.56         4.03           A5N0014         2007/10/26         2021/09/29         2801         10.45         0.12         3.72         10.33           A5N0015         2009/03/26         2021/09/14         3672         12.76         7.88         9.47         4.88	Name	Start Date	End Date	Count	Max water	Min water level	Mean water	Fluctuation	
ASNO013         2003/02/21         2021/03/17         342.5         7.55         3.52         0.50         4.03           ASN0014         2007/10/26         2021/09/29         2801         10.45         0.12         3.72         10.33           ASN0015         2009/03/26         2021/09/14         3672         12.76         7.88         9.47         4.88	A5N0012	2008/02/21	2021/00/17	3/125	7 05	3 07	656	<u>λ</u> μσ	
ASNO014         2007/10/20         2021/09/23         2001         10.45         0.12         3.72         10.33           ASN0015         2009/03/26         2021/09/14         3672         12.76         7.88         9.47         4.88		2000/02/21	2021/05/17	2423	10.75	0.10	0.00	4.03	
ADIVUUTD 2009/03/20 2021/09/14 30/2 12./6 /.88 9.4/ 4.88	A5N0014	2007/10/26	2021/09/29	2601	10.45	0.12	3.72	10.33	
	ASINUU15	2009/03/26	2021/09/14	3072	12.70	/.88	9.47	4.88	





The observed hydrographs for each of the three stations show a fluctuation of between 4 and 10 m. A significant response in water levels can be attributes to groundwater recharge events is observed for boreholes in the upper Lephalala catchment (A50A), while a more subtle response is observed at stations lower down the catchment (A50C and A50E). The overall trend indicates a slight lowering of groundwater levels.

The nitrate concentration graph show significant fluctuations in observations, however an overall increasing trend is observed since 2008. The groundwater signature is dominated by Cl-anion water facies, indicating mineralised (evolved) groundwater. Only one long term DWS groundwater quality monitoring station is active for the GUA.



# Table 15. Summary information for GUA: A50-2.

GUA	Middle Leph	alala A50-2					
Description	The main ac	uifer types include	intergranular	and fractured	aquifer system from	the Bushveld Com	plex. The middle
	reaches of	the Lephalala drai	nage area is	underlain by I	ngenious rock that c	omprise of deepe	er fractured (i.e.
	secondary)	aquifers overlain b	y a weathere	d horizon of v	ariable thickness. Th	nick, weathered a	quifer zones are
	expected in	areas where the	bedrock has	been subjected	d to intense fracturin	ng. The Lephalala	River section is
	characterise	d by intergranular	Alluvial aquife	ers. Alluvial aqu	ifers are recharged d	uring periods of hi	igh stream-flows
	as well as d	uring the rainfall se	ason. The all	luvium appears	to be better develop	ed along the lowe	er reaches of the
	Lephalala R	iver with a thickne	ss of approxi	mately 5 m. Gr	roundwater use is as	sociated with Irrig	gation, industrial
	(urban) and	recreations use.					
Catchments	A50G						
Мар							
Legend	0	•.			•••••		brend
Logona	1. A.						
Water Level Geosite			•.	l andeherg	· (,	Rercreation	(m3)
HYDRSTRA		Morukhurukhung	• :	Landsberg		• 10	
Geosite		St Catherina A50H	ArNoo	AI AI	exanderfontein	• 100	
WMS Geosite	•••		Kitty	Melinda		● 10 000	0
Rivers Study	Area		89790	•		Ventersdraa Industrial U	rban (m3)
Catchment	Alea			•		- 1	•
Geology					-	• 1 000	
	RY	1	N. N. N. N.		1105/m 1195/m	1 000	000
Diabase			R K Z	·		Irrigation (m	13)
Karoo SPGRP		1 11:00		Ga-Maeteletsa		• 1	
SWARTRAN		× × × ×	Mokurwanyane 1			s • 1 000	-
Regiber GRR		X X X X GOD				10 000	000 000
ROOIBERG	100 C			Bangalong	a b a b a b a b a b a b a b a b a b a b	4mg)	
<sup>m</sup> Waterberg GRP		Skaapkraal			A STATES		
SETLAOLE	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0				40 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 -	PieternA62	G
MAKGABEN	G		GarM	nyeki araparan	Smitswinke	2.	
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Busyheld Complex	Ver 1		Matadi	and the the the			
GABBRO-			Phahladira				
ANORTHOSI	TE Pretoria	1000 00 00 00 00 00 00 00 00 00 00 00 00	E A A Y ANA Y A A A Y	and the state of t		Marken	Vian
Transvaal SPGRP		• Act values	0.14.0	1	• • • •		
PRETORIA	1.			1.			23.5
Limpopo Belt	0			ý .	1.1.50	A621	
BANDELIER	KOP			Overvesel	and a second		and a company
PALALA GRA	ANITE 1186 m	- A59.6	gue .	Lephan	AsoE	Kirster	ibos
RASHOOP GRANOPHY		A (Nora)	5 /	(R)	Klein Denteren	A CAR	· (
		VA4100504	11	ASN	N0013		
0 5	10 Kilometers	5	\$89789	7	Esri, NASA, NGA, USGS Esri	South Africa, Esri, HERE, Garmin, N	VIETI/NASA, USGS
5-13-		5.		1 7 2	1 4. T	$(\cdot)$	R2
Figure 17 Map	showing GU	A A50-2 with geol	ogy, ground	water use and	geo-sites.		
Water Use Schem	nes (after DW/	AF, 2015, Recon Stu	dy)				
Scheme Name		Village/Settlemer	nt				Catchment
Mmaletswai RW	S	Dipompopong, Di	taung, Ga-Ma	eteletsa, Ga-M	ocheko, Hlagalakwer	a, Keletse le Mm	a, A50G, H
		Kiti, Mmaletswa	ai, Mokurua	inyane Abbot	tspoort, Mokuruar	yane Martinique	e,
		Mokuruanyane Ne	eckar, Motswe	ding, Reabetsw	ve		
Ga-Phahladira Cl	uster	Ga-Phahladira Set	tlement				A50G
Available monitor	ring locations	for trend analysis -	Water Levels	<b>.</b>			
News	Chart Data	End Data	Count	Max water	Min water level	Mean water	Fluctuation
Name	Start Date	End Date	Count	level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)
A5N0016	2010/11/11	2021/09/17	4634	17.64	11.34	13.80	6.31
Water Level Grap	hs	•					







### Table 16. Summary information for GUA: A50-3.

GUA	Lower Lephalala A50-3							
Description	The main aquifer types include the intergranular and fractured aquifer system from the Basement	Complex and						
	Intergranular Alluvial aquifers. The lower reaches of the Lephalala drainage area, from Melinda-Alex	anderfontein						
	area north to Tom-Burke-Limpopo River, is underlain by basement aquifers that comprise of deeper f	fractured (i.e.						
	secondary) aquifers overlain by a weathered horizon of variable thickness. Thick, weathered aquit	fer zones are						
	expected in areas where the bedrock has been subjected to intense fracturing. Recharge to the a	aquifer, often						
	discharged on the steep slopes, provides baseflow to the rivers. A weathered zone aquifer is found onl	y where deep						
	weathering occurs and provides groundwater storage that feeds the underlying fractured aquifer. All	uvial aquifers						
	are recharged during periods of high stream-flows as well as during the rainfall season. The ground	dwater use is						
	associated with irrigation, industrial, recreation and schedule I water use.							
Catchments	A50H							
Мар								
Legend	AsNoo17	· · · ]						
Water Level	Sakadula 1 (m2)							
Geosite		000						
Geosite		n-urban (m3)						
WMS Geosite	1142m A5dJ 100 000 • 1 000	D						
Rivers Study Area	Rercreation (m3)	000						
Geology	A5N0012 • 10 Irrigation (m	3)						
QUATERNARY								
Karoo	• • • • • • • • • • • • • • • • • • •	000						
CLARENS BOSBOKPOORT								
EENDRAGTPAN		B0886						
GREENWICH	A03A	<b>•</b>						
LISBON	AşoH AşoH	••						
Waterberg								
GROOTEGELUK								
Soutpansberg		3.5						
FRIPP								
MADZARINGWE		723						
Bushveld Complex	- ASN0009							
VILLA NORA	89790							
GABBRO- ANORTHOSITE	A62J							
Limpopo Belt	1195 m							
MALALA DRIFT		· · ····						
BANDELIERKOP		- 5						
GUMBU								
MOUNT DOWE	N A50G •• A62G	100						
MESSINA								
WILLIES FOOK	A5Nooi6							
	20 Kilometers Esri, NASA, NGA, USOS. Esri Soud Matrix Mean, HERE, Gommin, FARODAEDU/	NASA, USOS						
Figure 10 Man	showing CIIA AEO 2 with goology groundwater use and goo sites	400						
Water Use Schem	es (after DWAF 2015, Recon Study)							
Scheme Name	Village/Settlement	Catchment						
Ga-Seleka RWS	Botshabelo, Ga – Seleka, Kauletsi, Lebu, Madibaneng, Moong, Monwe, Mothlasedi,	A50H						
	Sefithlogo, Tom Burke, and Tshelamfake	7.0011						
Marnitz Supply	lv Marnitz A50H							
Witpoort RWS	Botsalanong, Kgobagodimo, Kopanong, Lerupurupurung, Letlora, Mongalo, Segale	A50H						
	Sencela, Thabo Mbeki, Tlapa le Borethe and the Witnoort CRD							
Tom Burke Suppl	v Tom Burke	A50H						
Mmaletswai RW9	Dipompopong, Ditaung, Ga-Maeteletsa, Ga-Mocheko, Hlagalakwena, Keletse le Mma	A50. H						
	Kiti. Mmaletswai. Mokuruanyane Abbottspoort. Mokuruanyane Martinique							
	Mokuruanyane Neckar, Motsweding, Reabetswe							
Available monitor	ing locations for trend analysis – Water Levels	l						

Available monitoring locations for trend analysis – water Levels									
Name Start I	Start Data	End Date	Count	Max water	Min water level	Mean water	Fluctuation		
	Start Date			level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)		
A5N0009	2006/06/28	2021/09/17	2867	13.72	9.76	11.84	3.96		
A5N0012	2008/02/20	2021/08/18	2525	16.42	7.55	13.43	8.87		





#### Comments

The observed hydrographs for each of the two stations show a fluctuation of between 4 and 9m. A subtle response in water levels as a result of groundwater recharge is observed for boreholes in the Lower Lephalala catchment (A50H). Apart from the seasonal fluctuations in groundwater levels, the overall trend suggest a lowering of the water table. However, a distinct recharge period in the last year or so years have resulted in an increase of the water levels.

The nitrate concentration graph show a strong fluctuation in observations, especially during beginning of 2000, however an overall slight increase in nitrate concentrations are observed at station 89757. The groundwater signature is dominated by both HCO<sub>3</sub> and Cl-anion water facies, indicating freshly recharged groundwater undergoing mineralisation.



### Table 17. Summary information for GUA: A50-4/A63-2.

GUA	Kalkpan A50	-4/A63-2					
Description	The GUA is u	underlain by basem	ent aquifers, f	from Orleans-Ca	lifornia area north to	the Limpopo Riv	er, that comprise
	of deeper fra	actured (i.e. second	ary) aquifers c	overlain by a wea	athered horizon of var	iable thickness.	Thick, weathered
	aquifer zone	s are expected in a	areas where the	ne bedrock has	been subjected to int	ense fracturing.	Recharge to the
	aquifer, ofte	n discharged on th	e steep slope	s, provides base	flow to the rivers. A	weathered zone	e aquifer is found
	only where	deep weathering o	ccurs and prov	/ides groundwat	er storage that feeds	the underlying f	fractured aquifer.
	Alluvial aqui	fers are recharged	during period	s of high strear	n-flows as well as du	ring the rainfall	season. Borehole
	yields generation	ally range between	0.1 – 2 l/s. Hy	/drogeological fi	ndings by Bush (1989	) in the Swartwa	ter area revealed
	that 66 % of	boreholes surveyed	d had yields be	elow 1 l/s. Vegte	r (2000) indicated tha	t only 19 % of bo	oreholes recorded
	yielded more	e than 1 l/s in an a	rea east of Be	auty. The groun	dwater use is associa	ted with irrigation	on and schedule I
	use.						
Catchments	A50J						
Мар							
		N		12	2		
Leg	ena	Â					
Water Le	vel Geosite	A					A63E
💛 💛 WMS Ge	osite		and the second second		077 m	1.1.1	A6No583
🔷 HYDRST	RA Geosite		20 Kilometer	S	57711		
2- Main Rive	ers					Strain 1	3
2 Rivers St	udy Area				Limpono Rivel	1 - C2 & A	
Catchme	nt			1.4.1		2 7 2 2 2	
Geology	ansas -					-1	
QUATER	NARY				A6No <u>589</u>		
Alluvium			1				
Soutpansberg G	RP	A	6N0594		and the second second	5	
		A	N. C. C.	A			
	CNEISS	6.3	18 a the	· · · · · · · · · · · · · · · · · · ·		A6No595	A6gD
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	DGE	Qter.	Z Z			1072 m	
						Schedule 1 (r	n3) •
	DRIFT			-4	A	63B• 1	
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	• • A5N0012			)		2 . 0 100 00	0 🦉
	AsoH		A5N0018	1 10 10	A63A	Irrigation (m3	)
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	1.					• 1 000	Ť
					Esri, NASA, NGA, USGS. Esri South A	rica Esri, HE 🔵 10 000	000
57		00.			• •	ADE	
Figure 19 Ma	p showing GUA	A50-4 with geolo	ogy, groundw	ater use and g	eo-sites.		
Water Use Sche	emes (after DWA	F, 2015, Recon Stud	ly)				
Scheme Name		Village/Settlemen	t				Catchment
Zwartwater Su	pply	Zwartwater					A50J
Maasstroom S	upply	Maasstroom					A63C
Available moni	toring locations f	or trend analysis –	vvater Levels				<b></b>
Name	Start Date	End Date	Count	Max water	Min water level	Mean water	Fluctuation
	eta.t bute		count	level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)
A5N0017	2012/02/23	2021/08/18	3996	15.53	11.09	12.78	4.44
A5N0018	2012/05/23	2021/09/30	4011	36.84	32.65	34.59	4.19
A6N0583	2007/10/22	2021/08/19	3718	10.67	5.56	8.74	5.11
A6N0589	2007/10/04	2021/08/19	3457	14.19	8.31	11.75	5.88
A6N0594	2007/08/29	2021/09/30	2920	14.81	4.34	6.95	3.00

A6N0594 2007/08/29 2021/09/30
Water Level Graphs





Comments

The observed hydrographs for each of the two stations show a fluctuation of approx. 4 m. No clear response from groundwater recharge events or surface-groundwater interaction is observed for stations A5N0017 and A5N0018, showing limited fluctuations overtime. However, stations A6N0583, A6N0589 and A6N0594 indicate strong seasonal and recharge events. The overall trend indicates a decrease in groundwater levels overtime.

The nitrate concentration graph shows significant fluctuations in observations; however, an overall decreasing trend is observed. The nitrate concentrations are highly elevated for stations 89748 and 184422. Stations 89775 and 89777 is well below any target values. The groundwater signature is dominated by both HCO₃ and Cl-SO₄ anion water facies, indicating freshly recharged groundwater undergoing mineralisation with potential anthropogenic impacts or reflection from the river systems.



### 2.2. NYL AND UPPER MOGALAKWENA

The Mogalakwena River is known as the Nyl River in its upper reaches. The Nyl River originates north of Bela-Bela at an altitude of about 1 500 m. At Mokopane the name changes and it becomes the Mogalakwena River (DWA, 2003a). The river flows northwards and joins the Limpopo River at an altitude of about 625 m. The upper Mogalakwena catchment is densely populated. As a result groundwater resource development occurred mainly to allow irrigation and to meet domestic and urban water needs. Several Platinum mines were developed and utilise local groundwater resources and limited surface water resources. Numerous well-fields were developed to meet consumers' needs. Two Subterranean government water control areas occur within the upper Mogalakwena drainage region namely, Nyl River Valley and Dorpsrivier. The groundwater resource had been and still is extensively utilised in the region for municipal, irrigation and mining purposes. The Nylsvley wetland in the upper reaches of the Mogalakwena River catchment is home to a large number of bird species and is a registered RAMSAR site. The 16,000-ha Nyl River Flood-plain that stretches over 70 km from Modimolle to Mokopane forms part of South Africa's largest flood-plain.

In this assessment three GUAs have been delineated for the Upper Mogalakwena drainage area, namely A61-1 (Figure 21), A61-2 (Figure 22) and A61-3 (Figure 23). A summary of the borehole information for the region is shown in Table 18. According to the pumping tests conducted in the Upper Mogalakwena, there are vast differences in the transmissivities of the groundwater UA's. Most notably is the high transmissivities observed in the Dorps River Valley A61-3 GUA. A number of large yielding aquifers including the Chuniespoort Group dolomites occur within the Upper Mogalakwena drainage region.

Description	GUA	Info	BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (I/s for 24hrs)	Blow Yield (I/s)
Nyl River Valley	A61-1	Ν	673	530	16	16	218
		Mean	56.6	16.0	22.2	0.95	2.1
Stork	101 0	Ν	252	152	4	6	119
Sterk	A01-2	Mean	57.1	16.5	6.6	0.25	1.8
Upper Mogalakwena	A61-3	Ν	535	554	121	58	168
		Mean	59.5	16.3	65.9	0.6	4.3

 Table 18. Borehole information for the Upper Mogalakwena drainage region.

### 2.2.1. Groundwater recharge

Mean annual precipitation varies from 600 mm in the Nyl River valley and Mokopane to about 450 mm north of Doorndraai dam (**Error! Reference source not found.**). The Upper Mogalakwena ranges from 12 mm/a to more than 20 mm/a. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 19.

Description	GUA	Quat	МАР	Area	GR	Vegter (1995)	
	GUA	Quat	(mm)	(km²)	(Wet) Mm <sup>3</sup>	(Dry) Mm³	Mean Mm <sup>3</sup>
Nyl River		A61A	629.1	381	11.86	8.57	27.75
	A61-1	A61B	629.1	362	10.89	7.86	24.86
		A61C	632.7	587	16.44	11.83	18.57
valley		A61D	630.2	456	12.37	8.91	22.27
		A61E	624.6	547	10.57	7.57	19.76
Stork	AC1 2	A61H	636.0	585	18.94	13.74	29.66
Sterk	A01-2	A61J	630.7	818	23.46	17.01	24.97
Upper	AC1 2	A61F	597.2	789	22.40	16.07	14.08
Mogalakwena	A01-3	A61G	584.8	927	20.80	14.82	14.28



# 2.2.1. Groundwater Use

The groundwater use for each of the GUA associated with the Nyl and Upper Mogalakwena River system is summarised in Table 20. The present WARMS groundwater use data was compared to the 2015 Limpopo (WMA) North Reconciliation Strategy (LNRS) estimated 2020 use.

GMA Description	GUA	Quat	WARMS: Use Mm <sup>3</sup>	LNRS 2020 Mm <sup>3</sup>
		A61A	1.384	2.650
Nyl River Valley		A61B	0.274	0.644
	A61-1	A61C	2.449	3.219
		A61D	2.930	3.705
		A61E	8.137	9.401
Storle	AC1 2	A61H	2.785	2.616
Sterk	A01-2	A61J	1.564	1.777
Upper Mogalakwena	A61-3	A61F	3.222	5.082

Table 20. Groundwater use (per annum) as registered per catchment for each GUA

# 2.2.2. Regional groundwater quality

Regional water quality in the Nyl and Upper Mogalakwena is subject to considerable variation due to the extensive use of groundwater, various lithologies and groundwater-surface water interaction. Groundwater samples indicate a variety of water types (e.g. Ca/Mg-HCO<sub>3</sub>, Na-HCO<sub>3</sub> and Na-Cl) (Figure 20). A high percentage of samples relate to a fresh recharge type (Ca/Mg-HCO<sub>3</sub>) water, while cation and anion exchange process may be occurring within the strata hence Na-Cl and Ca/Mg-Cl type water present.



Figure 20. Piper diagram for the Nyl and Upper Mogalakwena drainage region.



Groundwater quality in the Nyl and Upper Mogalakwena is considered to be acceptable to marginal water quality. The most notable elements of concern include NO<sub>3</sub> as N with average concentrations above the recommended drinking limit (Table 21).

GUA		рН	EC	TDS	Са	Mg	Na	к	SO4	CI	NO₃ as N	F
DWAF Class I		5-6 or 9- 9.5	70-150	450- 1000	80-150	30-70	100- 200	-	200- 400	100- 200	6-10	0.7-1
DWAF Class I	I	4-5 or 9.5-10	150-370	1000- 2000	150- 300	70- 100	200- 600	-	400- 600	200- 600	10-20	1-1.5
DWAF Class I	II	3.5-4 or 10-10.5	370-520	2000- 3000	>300	100- 200	600- 1200	-	600- 1000	600- 1200	20-40	1.5- 3.5
AC1 1	Ν	19	20	7	21	21	21	21	17	20	13	20
A01-1	Median	7.8	37	133	28.1	11.5	34.7	1.3	11.2	16.7	0.9	0.31
A61 2	Ν	5	5	5	5	5	5	5	5	5	0	4
A61-2	Median	8.1	58	469	51.8	19.0	24.2	1.2	12.1	21.2	-	0.39
AC1 2	Ν	132	124	121	135	134	134	12	130	124	12	123
A01-2	Median	8.1	106	865	59.9	69.6	60.3	1.9	30.2	75.3	75.9	0.80

Table 21. Groundwater quality for the Nyl and Upper Mogalakwena region (All units in mg/l, EC in mS/m) (red text exceeds Class III)

### 2.2.3. Groundwater contribution to baseflow

The Upper Mogalakwena River stretch can be classified into a continuous interaction bedrock system (Waterberg Group) in the upper reaches, while the middle (Nyl River Valley) and low reaches (Dorps River Valley) can be classified as a porous media (alluvial sediments). The Nyl river valley can be regarded as a gaining river while in the lower reaches seasonal alternating effluent / influent conditions can be experienced.

Apart from exceptionally wet periods, flow in the river is sustained mainly by groundwater. Groundwater is generally toward the main River channel; however, intermittency implies local inversions from effluent to influent conditions by secondary permeability variations in the underlying lithology. Numerous seasonal and some perennial springs occur in the dolomitic formations, which contribute significantly, to the baseflow component of the Dorps River (A61G). However, some springs occurring in the lower Dorps River catchment have been effected by the abstraction from boreholes. Comparison of groundwater contribution to baseflow estimates for the Upper Mogalakwena drainage region are summarised in Table 22.

Description	GUA	Quat	Hughes Mm³/a	Shultz Mm³/a	Pitmann Mm³/a	GRA II (WR2005) Mm <sup>3</sup> /a	Maint. Lowflow Mm <sup>3</sup> /a
Nyl River Valley		A61A	6.98	1.80	6.48	3.77	0.89
		A61B	5.84	1.20	5.43	2.83	0.50
	A61-1	A61C	8.31	1.11	7.63	3.37	0.54
		A61D	6.54	1.11	5.47	3.08	1.27
		A61E	7.30	1.11	6.56	3.25	0.61
Stork	A61-2	A61H	11.99	6.12	10.76	6.83	1.72
Sterk		A61J	15.95	7.74	14.97	9.15	2.28
Upper	A61 2	A61F	6.51	2.64	6.15	5.16	1.57
Mogalakwena	A61-3	A61G	7.17	2.97	7.05	4.87	1.69

Table 22. Groundwater contribution to baseflow estimates.

### 2.2.4. Summary

The following tables provide a summary for each of the GUA, as illustrate in Table 23, Table 24 and Table 25.



#### Table 23. Summary information for GUA: A61-1.





Modmindie Orban (NP3)       Modemindie Orba	Mapela RWSDanisane, Ditlotswane, Ga-Chokoe, Ga-Magongoa, Ga-Mokaba, Ga-Molekana, Ga- Pila Sterkwater, Ga-Tshaba, Hans, Kgobudi, Kwakwalata, Lelaka, Maala Parekisi, Mabuela, Mabusela, Mabusela Sandsloot, Machikiri, Magope, Malokongskop, Masahleng, Masenya, Masoge, Matlou, Matopa, Mesopotania,, Millenium Park, Mmahlogo, Mmalepeteke, Phafola, Ramorulane, Rooiwal, Seema, Sekgoboko Sekuruwe, Skimming, Tshamahansi, Witrivier, Fothane, Mohlotlo Ga-Malebana, Mohlotlo Ga-PukaModimolle Urban RWSModimolle (previously called Nylstroom), the outlying informal settlement area of								
Mogalakwena         LM         Farms         Farms Mogalakwena LM         A61E           Supply         Mogwadi Wurthsdorp GWS         Matima, Ga-Madikana, Koniggratz, Mogwadi, Mohodi, Wurthsdorp         A61E, A71E, A71G, A72A           Mokopane RWS         Madiba, Madiba         East, Mzumbana         North, Mzumbana         South, Maribashoop/Oorlogsfontein plots, Masodi, Madiba, Madiba East, Mzumbana         South, Maribashoop/Oorlogsfontein plots, Masodi, Madiba, Ga-Mangou, GaMatipa, Glen Roy, Jupiter, Mandela Park, Manyapye, Mapateng, Malaleng, Maune, Mohonong, Montwane 1, Montwane 2, Moshate, Naledi, Ngopane, Sebora, Sefahlane, Segoahleng, Sepanapudi, Utjane, Chebeng, Doornspruit, Ga-Mapangula, Makweya, Newlands, Paz College, Sengatane, Setotolwane College, Vaalkop 1 and Vaalkop 3 Venus and Waterplaats         A61F.           Mookogophong RWS         Mookogopong (Naboomspruit), Mookogopong Phomolong, Phomolong Squatter Settlement and Rietbokvalley         Mean           Name         Start Date         End Date         Count         Max water level (mbgl)         Min water level (mbgl)         Mean           A680053         1970/11/24         2021/09/20         513         12.86         2.52         8.05         10.34           A6800550         1989/01/06         2021/09/16         11515         15.06         1.96         8.78         13.10           A680053         1993/07/05         2021/09/16         1515.06         1.96         8.78 <t< td=""><td></td><td>, Kokanja Retiremen</td><td>nt Village and</td><td>d</td></t<>		, Kokanja Retiremen	nt Village and	d					
Mogwadi Wurthsdorp GWS         Matima, Ga-Madikana, Koniggratz, Mogwadi, Mohodi, Wurthsdorp         A61E, A71E, A71	Mogalakwena LM Farms Farms Mogalakwena LM Supply								
Mokopane RWS       Madiba, Madiba, Madiba       East, Mzumbana       North, Mzumbana       South, Maribashoop/Oorlogsfontein plots, Masodi, Madiba, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Oorlogsfontein plots, Masodi, Madiba, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Oorlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Oorlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Oorlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba, East, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba, East, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba, East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba East, Mzumbana North, Mzumbana South, Maribashoop/Ourlogsfontein plots, Masodi, Madiba East, Mzumbana North, Mzumbana North, Mzumbana North, Mzumbana North, Mzumbana South, Maribashoo/Posting Cast Manne, Seconding Nontwane 1, Nontwane 2, Moshate, Ndoshate, Ndoshoo Posting Cast Mapangula, Makweya, Newlands, Pax College, Sengature, Setotolwort Souther North Weenen North Weenen North Weenen South North Weenen South North Weenen North Weenen North Weenen North Maribasho Postex Verere Weenen South North North Weenen North Weenen	Mogwadi Wurth	sdorp GWS	Matima, Ga-Madika	na, Koniggrat:	z, Mogwadi, Mo	hodi, Wurthsdorp		A61E, A71E, A71G, A72A	
Moletje South GWS       Boetse, Diana, Ga-Kgasha, Ga-Maibia, Ga-Mangou, GaMatlapa, Glen Roy, Jupiter, Mandela Park, Manyapye, Mapateng, Matlaleng, Maune, Mohlonong, Montwane 1, Montwane 2, Moshate, Naledi, Ngopane, Sebora, Sefahlane, Segoahleng, Sepanapudi, Utjane, Chebeng, Doornspruit, Ga-Mapangula, Makweya, Newlands, Pax College, Sengataue, Setotolware College, Vaalkop 1 and Vaalkop 3 Venus and Vaalko	Mokopane RWS		Madiba, Madiba Maribashoop/Oorlo North, Mzumbana Sekgakgapeng	Mzumbana ots, Masodi, N aribashoop/Oor	North, Mzumba 1adiba, Madiba Eas logsfontein plots,	ana South t, Mzumban Masodi, and	n, A61E,F,G,H,J a d		
Mookgophong RWS         Mookgopong (Nabomspruit), Mookgopong Phomolong, Phomolong, Phomolong, Squatter Settlement and Rietbkvalley         A61C, D           Weenen Supply         Weenen         Weenen         A61F           Adilable monitoring locations for trend analysis of trend analys	Moletje South G	ws	Boetse, Diana, Ga-k Mandela Park, Many Montwane 2, Mo Sepanapudi, Utjane Pax College, Sengat Waterplaats	gasha, Ga-Ma yapye, Mapat oshate, Nale , Chebeng, D ane, Setotolw	adiba, Ga-Mang eng, Matlaleng, di, Ngopane, oornspruit, Ga vane College, Va	gou, GaMatlapa, Glei Maune, Mohlonong, Sebora, Sefahlane, Mapangula, Makwe aalkop 1 and Vaalkoj	n Roy, Jupiter , Montwane 1 Segoahleng ya, Newlands o 3 Venus and	r, A61F,G,A62E,F ., , A71E, F ., ., d	
Weenen Supply         Weenen         A61F           Available monitoring locations for trend analysis – Water Levels         Mannel Start Date         End Date         Max water Level (mbgl)         Min water level (mbgl)         Mean (mbgl)         Fluctuation (minmax) (m)           A6N0023         1970/11/24         2021/09/20         513         12.86         2.52         8.05         10.34           A6N0059         1975/09/29         2021/09/20         15128         30.64         0.30         8.13         30.34           A6N0550         1989/01/06         2021/09/16         11515         15.06         1.96         8.78         13.10           A6N0553         1993/07/20         2021/09/16         3698         4.71         0.000         0.90         4.71           A6N0585         2007/01/30         2021/09/16         14416         43.74         13.84         23.65         29.90           A6N0611         2006/07/18         2021/09/16         14416         43.74         13.84         23.65         29.90	Mookgophong R	WS	Mookgopong (Nab Settlement and Riet	r A61C,D					
Available monitoring locations for trend analysis – Water Levels           Name         Start Date         End Date         Count         Max water level (mbgl)         Min water level (mbgl)         Mean water level (mbgl)         Fluctuation (min- max) (m)           A6N0023         1970/11/24         2021/09/20         513         12.86         2.52         8.05         10.34           A6N0059         1975/09/29         2021/09/20         15128         30.64         0.30         8.13         30.34           A6N0550         1989/01/06         2021/09/16         11515         15.06         1.96         8.78         13.10           A6N0553         1993/07/20         2021/09/16         3698         4.71         0.00         0.90         4.71           A6N0585         2007/01/30         2021/09/16         14416         43.74         13.84         23.65         29.90           A6N0611         2006/07/18         2021/05/25         4125         12.56         7.82         9.72         4.74	Weenen Supply		Weenen					A61F	
Name         Start Date         End Date         Count         Max water level (mbgl)         Min water level (mbgl)         Mean water (mbgl)         Fluctuation (min- max) (m) (mbgl)           A6N0023         1970/11/24         2021/09/20         513         12.86         2.52         8.05         10.34           A6N0059         1975/09/29         2021/09/20         15128         30.64         0.30         8.13         30.34           A6N0550         1989/01/06         2021/09/16         11515         15.06         1.96         8.78         13.10           A6N0553         1993/07/20         2021/09/16         3698         4.71         0.00         0.90         4.71           A6N0585         2007/01/30         2021/09/16         14416         43.74         13.84         23.65         29.90           A6N0611         2006/07/18         2021/05/25         4125         12.56         7.82         9.72         4.74	Available monito	ring locations	for trend analysis – \	Nater Levels	I		1		
A6N0023         1970/11/24         2021/09/20         513         12.86         2.52         8.05         10.34           A6N0059         1975/09/29         2021/09/20         15128         30.64         0.30         8.13         30.34           A6N0550         1989/01/06         2021/09/16         11515         15.06         1.96         8.78         13.10           A6N0553         1993/07/20         2021/09/16         3698         4.71         0.00         0.90         4.71           A6N0585         2007/01/30         2021/09/20         4059         55.71         12.01         19.26         43.70           A6N0603         2011/06/22         2021/09/16         14416         43.74         13.84         23.65         29.90           A6N0611         2006/07/18         2021/05/25         4125         12.56         7.82         9.72         4.74	Name	Start Date	End Date	Count	Max water level (mbgl)	Min water level (mbgl)	Mean water level (mbgl)	Fluctuation (min- max) (m)	
A6N0059         1975/09/29         2021/09/20         15128         30.64         0.30         8.13         30.34           A6N0550         1989/01/06         2021/09/16         11515         15.06         1.96         8.78         13.10           A6N0553         1993/07/20         2021/09/16         3698         4.71         0.00         0.90         4.71           A6N0585         2007/01/30         2021/09/20         4059         55.71         12.01         19.26         43.70           A6N0603         2011/06/22         2021/09/16         14416         43.74         13.84         23.65         29.90           A6N0611         2006/07/18         2021/05/25         4125         12.56         7.82         9.72         4.74	A6N0023	1970/11/24	2021/09/20	513	12.86	2.52	8.05	10.34	
A6N0550         1989/01/06         2021/09/16         11515         15.06         1.96         8.78         13.10           A6N0553         1993/07/20         2021/09/16         3698         4.71         0.00         0.90         4.71           A6N0585         2007/01/30         2021/09/20         4059         55.71         12.01         19.26         43.70           A6N0603         2011/06/22         2021/09/16         14416         43.74         13.84         23.65         29.90           A6N0611         2006/07/18         2021/05/25         4125         12.56         7.82         9.72         4.74	A6N0059	1975/09/29	2021/09/20	15128	30.64	0.30	8.13	30.34	
A6N0553         1993/07/20         2021/09/16         3698         4.71         0.00         0.90         4.71           A6N0585         2007/01/30         2021/09/20         4059         55.71         12.01         19.26         43.70           A6N0603         2011/06/22         2021/09/16         14416         43.74         13.84         23.65         29.90           A6N0611         2006/07/18         2021/05/25         4125         12.56         7.82         9.72         4.74	A6N0550	A6N0550 1989/01/06 2021/09/16 11515 15.06 1.96 8.78							
A6N0585         2007/01/30         2021/09/20         4059         55.71         12.01         19.26         43.70           A6N0603         2011/06/22         2021/09/16         14416         43.74         13.84         23.65         29.90           A6N0611         2006/07/18         2021/05/25         4125         12.56         7.82         9.72         4.74	A6N0553	A6N0553 1993/07/20 2021/09/16 3698 4.71 0.00						4.71	
A6N0603         2011/06/22         2021/09/16         14416         43.74         13.84         23.65         29.90           A6N0611         2006/07/18         2021/05/25         4125         12.56         7.82         9.72         4.74	A6N0585	2007/01/30	7/01/30 2021/09/20 4059 55.71 12.01 19.26						
A6N0611 2006/07/18 2021/05/25 4125 12.56 7.82 9.72 4.74	A6N0603	2011/06/22	2021/09/16	14416	43.74	13.84	23.65	29.90	
	A6N0611	2006/07/18	3 2021/05/25	4125	12.56	7.82	9.72	4.74	





The observed hydrographs for each of the three stations show a fluctuation of between 4 and 30 m. Since the high recharge event during 1997 a slight decrease in groundwater levels is observed. Station A6N0603 show a less pronounced recharge effect with a strong decreasing trend. A larger number (relative to the GUA) of registered groundwater users is observed in close approximation of station A6N0603. There are two main interrelated factors which control the general trend of groundwater-level fluctuations in the area, namely recharge and abstraction. A well-identified seasonal water-level fluctuation is observed over most stations.

The nitrate concentration graph show some fluctuation however is generally at low levels. Station 90124 shows the highest level of nitrate values, however recordings have ceased since 2001. The groundwater signature is dominated by both HCO<sub>3</sub> water facies, indicating freshly recharged groundwater that had limited time for mineralisation to occur.



### Table 24. Summary information for GUA: A61-2.

GUA	Sterk A61-2						
Description	The GUA is o	characterised by th	e Waterberg	g Plateau (m	ountainous region)	from the Wate	rberg Group, from
	Paardeplaats	northeast to Koelm	nansrus and r	north to Leyd	en areas, comprising	g of sedimentar	y and metamorphic
	rocks, with a	ssociated elevation	n up to 180	0 mamsl. A	weathered zone a	quifer is found	only where deep
	weathering of	ccurs and provides	groundwater	storage that	feeds the underlyin	g fractured aqui	fer. Rocks form the
	Bushveld Con	nplex and Limpopo	Belt is found	d in the far n	ortheaster areas of	the GUA. The g	groundwater use is
	associated wit	th irrigation, livesto	ck watering,	industrial and	l water supply uses.		
Catchments	A61H,J						
Мар							
	Lanand		123- 1.	Mogolakwena	× ·	• A	6N 0599
	Legend			7 A62B	· · · · · · · · · · · · · · · · · · ·	182748	A62E
• Water Level Geosite	Diabase	SKILPAE	KOP	A CONTRACTOR	12		
HYDRSTRA	KUNDERG GRP	SNEK GLENTIC	BIOER S				V A71E
Geosite		.OOF Busvheld Com	plex	A Starting Press	A 61	6.2	
2- Main Rivers	Waterberg GRP	NEBO G	RANITE		i za la ale	0.0	
2- Rivers Study	Area	Limpopo Belt	P • • /	• 😵 🖇	LAS /	• •	1 121 · 1
CL Catchment	MAKGABE	NG GRANOF	HYRE	1. C.	C. Mees	8 · · ·	
Geology	AASVOëL	KOP		:		185543	Roo
QUALERINA	A5N0015	124 18			A6No534	A6N0083	87.00
	AsõC	54	•		Con Co		A6N0560
1		3.2	• 14	-	Sy Cal	AGN	A6N0581
	4 (m /	1		A01	C.		ane
Dwarsrivier		ASNO0	14				
N. The second se	Lev	/ 3 ~~	• 57	No.		2)8. 1.	1 24 1 77
1	m	(Aron)	• 24.	0000			ALL AND AL
	Heungsprut		≥ M∧j	A6N0610	100	1	
aller un or	Parsriviar	• •					TRANS
selo	The start			14		A6N0059	12
× ×	AN		₹.●∕ ≯	And		Legend	-
	S.J.	5-2-2-	ABNO	02	Water Supp	oly (m3)	1 000 000
1 series	Contra and		A61H 9 9:	and a	• 1	Lives	strock (m3)
N	A4N0516				• 1 000	•	1
			10151 C	Tobiasspruit- Co.	Industrial U	Jrban (m3)	100
Sec. Sec.	1814m				• 1		100 000
222	R. S. W. S. W.		· · · · · · ·	A62D	• • 1 000	Irriga	tion (m3)
W/om				90124	1 000	000	1 000
s. 1936	31 -34		1		No585 Industral no	on-urban (m3)	10 000 000
0 5 10	20 Kilometers	A 5 a D 41522 m	A610	A A	Esri, NASA, NGA, L • 1 000		
[ HI HIL		MOID	24 1				
Figure 22 Map	showing GUA A6	1-2 with geology	, groundwat	ter use and g	geo-sites.		
Water Use Scher	nes (after DWAF, 2	015, Recon Study)					
Scheme Name		Village/Settlement					Catchment
Bakenberg RWS		Bakenberg Basoga	di, Bakenbe	erg Kwanaite	e, Bakenberg Matl	aba, Bakenber	g A61G, A61J,
		Mautjana, Bakenbe	rg Mmotong	, Bakenberg N	/lothwathwase, Bast	erspad, Bohwid	i, A62A, A62B,
		Buffelhoek, Clarem	iont, Dikgok	gopeng, Diph	ichi, Galakwenastro	oom, Ga-Masipa	a, A62C, A62F
		Good Hope, Harma	nsdal, Jakkals	skuil, Kabeane	e, Kaditshwene, Kgo	peng, Kromkloo	f,
		Lesodi, Leyden, Lus	aka Ngoru, M	labuladihlare	1,Makekeng, Malap	ila, Mamatlakala	ı <i>,</i>
		Marulaneng, Mate	ebeleng, Mp	helelo, Nell	y, Paulos, Pudiyal	kgopa, Raadslic	l,
		Ramosesane, Rantl	akane, Sepha	irane, Skilpad	skraal,Skrikfontein A	A, Skrikfontein E	в,
		Taolome, Van Wyks	pan, Vlakfon	tein, Vlakfont	ein 2, Wydhoek and	Good Hope Eas	t
Mokopane RWS	i	Madiba, Madib	a East,	Mzumbana	North, Mzur	nbana South	, A61E, A61F,
		Maribashoop/Oorlo	ogsfontein pl	ots, Masodi,	Madiba, Madiba I	East, Mzumban	a A61G, A61H,
		North, Mzumbana	South, M	aribashoop/C	orlogstontein plot	s, Masodi, an	a A61J
Augulation		sekgakgapeng	4 a u 1 1				
Available monito	oring locations for t	rena analysis – Wa	ter Levels	N.4			
				IVIAX	Minwator	Moonweter	Eluctuation (min
Name	Start Date	End Date	Count	water	win water level	iviean water	
				(mbgl)	(igam)	ievei (mbgi)	max) (m)
	l			(11561)		1	





The observed hydrographs for each of the two stations show a fluctuation of between 8 and 10 m. A significant response in water levels as a result of seasonal fluctuations and recharge events are observed for the monitoring boreholes. Station A6N0602 shows an overall increase in groundwater levels, especially from 2013 to 2015.

The nitrate concentration graph (of station 90121) show significant fluctuations in observations. Station 90122 show low levels of nitrate concentrations. The groundwater signature is dominated by HCO<sub>3</sub> anion water facies, indicating freshly recharged groundwater.



# Table 25. Summary information for GUA: A61-3.

GUA	Upper Mogalakwena A61-3										
Description	The GLIA is characterised by the Waterberg Plateau (mountainous region) from the Bushveld, Ba	sement complex									
Description	and Transvaal Supergroup comprising of ingenuous cedimentary dolomitic and metamor	abic rocks with									
	and mansvaal supergroup comprising of ingendous, sedimentary, doionnuc and metamor										
	associated elevation up to 1500 mamsi. Fractured rocks of the Bushveid complex owe th	eir groundwater									
	otential largely to fracturing. Its groundwater potential is generally good with water occurring in deeply (up to 55 1 in places) weathered and fractured basins occurring in these mafic rocks. A weathered zone aquifer is found										
	in places) weathered and fractured basins occurring in these mafic rocks. A weathered zone aquifer is found now where deep weathering occurs and provides groupdwater storage that feeds the underlying fractured										
	nly where deep weathering occurs and provides groundwater storage that feeds the underlying fractured										
	quifer. Alluvial aquifers are recharged during periods of high stream-flows as well as during the rainfall season.										
	ne total alluvial thickness varies from 10 to 24 m and is used in conjunction with the underlying weathered and										
	ictured bedrock aquifers. Due to its limited extent and saturated thickness these aquifers are also vulnerable to										
	over-abstraction during periods of drought when there is little or no recharge. Higher rec	harge rates are									
	characterised with the alluvial system, being a intergranular aquifer system, and karst aquifer	r, relative to the									
	fracture aquifers from the Waterberg group system. Borehole vields generally range betwee	en 0.1 - > 5 l/s									
	however are much larger within the karts aquifer system (>51/s). The karst aquifer system is used	for water supply									
	to Mokonane and surrounding water users. The groundwater use is associated with irrigation liv	estock watering									
	water supply schedule I mining and industrial uses. A large number of village (schemes) occur wi	thin the GUA									
Catchmonts											
Man	(110)										
IVIAP											
Le	egend A62F	• (• • • •									
Water Level	KLAPPERKOP	A71F									
Geosite											
HYDRSTRA Geosite	MAGALIESBERG										
9 WMS Geosite											
2- Main Rivers											
Rivers Study Area		anue .									
Catchment		a)									
QUATERNARY		1									
Alluvium		AZIA									
Diabase		A7N0620									
Rooiberg GRP		<b>A</b>									
Waterberg GRP											
SWAERSHOEK											
<ul> <li>Bushveld Complex</li> </ul>											
MEBO GRANITE	GRANITE GRANITE	60									
NORITE		0.7									
MOLENDRAAI	LUNSKLIP										
GABBRO	GRANITE GRANITE	2000 m									
Z ZOETVELD	GRANITE AND CONTRACT OF CONTRACT.	89683									
Transvaal SPGRP	PIETERSBURG										
BLACK REEF	RASHOOP GRANOPHYRE	B5N0011									
DUITSCHLAND	MOTHIBA N	IC-IN-									
AsoA		1.18									
	Stort . Mar All All All All All	A FRANCE									
		B5N0013 010 Kilometers									
•	A6No610	<u> </u>									
s Water Supply (m2)	Schodulo 1 (m2) Industral non-urban (m2) Livestrock (m2) Irrigation (m2)										
0 1											
• 1 000	● 100 ● 100 000 ● 1000 ● 1000 ● 1000 ● 1000	1									
0 1 000 000	100 000 000 000 000 000 000 E, Garmin, FAO,	METI/NASA, USGS									
		1									
Figure 23 Map sho	owing GUA A61-3 with geology, groundwater use and geo-sites.										
Water Use Schemes	(after DWAF, 2015, Recon Study)										
Scheme Name	Village/Settlement	Catchment									
Bakenberg RWS	Bakenberg Basogadi, Bakenberg Kwanaite, Bakenberg Matlaba, Bakenberg	A61G, A61J,									
	Mautjana, Bakenberg Mmotong, Bakenberg Mothwathwase, Basterspad, Bohwidi,	A62A, A62B,									
	Buffelhoek, Claremont, Dikgokgopeng, Diphichi, Galakwenastroom, Ga-Masipa,	A62C, A62F									
	Good Hope, Harmansdal, Jakkalskuil, Kabeane, Kaditshwene, Kgopeng, Kromkloof										
	Lesodi, Levden, Lusaka Ngoru, Mabuladihlare 1 Makekeng, Malanila, Mamatlakala										
	Marulaneng Mateheleng Mnhelelo Nelly Paulos Pudiyakgona Raadslid										
	Ramocesane Rantlakane Senharane Skilnadskraal Skrikfontein A Skrikfontein D										
	Taolome Van Wyksnan Vlakfontein Vlakfontein 2 Wydhoek and Good Hone East										
1	radiome, van wykspan, viakiontein, viakiontein 2, wydnoek and 6000 hope Last										



Mokopane RW	okopane RWS Madiba, Madiba E Maribashoop/Oorlogsfont North, Mzumbana Sout Sekgakgapeng			Mzumbana plots, Masodi Maribashoop/	a North, N i, Madiba, Madi Oorlogsfontein	Mzumbana Sou iba East, Mzumba plots, Masodi, a	th, A61E, A61F, ina A61G, A61H, nd A61J
Available monit	oring locations fo	r trend analysis –	Water Levels				
Name	Start Date	End Date	Count	Max water level (mbgl)	Min water lev (mbgl)	vel Mean water level (mbgl)	Fluctuation (min- max) (m)
A6N0044	1980/11/02	2021/06/08	3258	15.69	5.68	8.97	10.01
A6N0069	1977/03/08	2021/06/09	13435	54.34	19.53	36.92	34.81
A6N0079	1980/01/10	2021/06/08	3252	11.96	2.13	3.63	9.83
A6N0083	1985/01/17	2020/10/14	5792	24.59	11.11	14.50	13.48
A6N0534	1977/03/02	2021/06/08	7546	25.02	2.22	8.21	22.80
A6N0560	1993/01/06	2021/02/10	3270	7.96	2.09	4.19	5.87
A6N0581	2006/11/07	2021/06/09	20067	34.77	10.68	20.77	24.09
A6N0587	2005/10/04	2021/06/09	4698	27.14	10.66	12.53	16.48
Water Level Gra	phs						
10- (m) 20- (m) 30- 40- 50-	1980	1990			2010	2020	★       A6N0044         ★       A6N0069         ★       A6N0079         ★       A6N0083         ★       A6N0534         ★       A6N0581         ★       A6N0587
Available monit	oring locations fo	r trend analysis -\	Vater Quality	(Chemistry)			
Name	Start Date	End Date	Count	NO <sub>3</sub> +NO <sub>2</sub> conc. (mg/L)	Min NO <sub>3</sub> +NO <sub>2</sub> conc. (mg/L)	Median NO <sub>3</sub> +NO <sub>2</sub> conc. (mg/L)	Exceed Drinking Water guideline
89685	1997/05/26	2017/09/11	38	2.11	0.03	0.29	No
182748	2000/05/04	2017/09/13	34	16.06	0.19	3.97	Yes
Water Quality G	raph and Piper Pl	ot					



The observed hydrographs for each of the stations show a fluctuation of between 6 and 35 m. A significant response in water levels is observed at station A6N0069. Station A6N0069 is located within the karts aquifer system and could indicate strong correlation with groundwater recharge events, such as rainfall, associated with the high recharge zones of the dolomitic rocks. Apart from the observed seasonal fluctuations decreasing trend is observed up to 1997 followed by an increase up to 2016. Since 2017 the a slight decreasing groundwater level trend have been observed.

The nitrate concentration graph (of station 182748) indicate elevated nitrate with a distinct decrease since 2005. Low levels of nitrate concentrations are observed at station 89685. The groundwater signature is dominated by both HCO<sub>3</sub> and Cl-anion water facies, indicating freshly recharged groundwater undergoing mineralisation.



# 2.3. MIDDLE AND LOWER MOGALAKWENA

The Middle- and Lower Mogalakwena catchment have limited surface water resources but large groundwater resources which have already been extensively exploited by the irrigation sector. High rural population densities occur in the middle part of the Mogalakwena catchment which should be able to source their water from groundwater while larger requirements may require transfers in from the Olifants WMA since there is little scope for further development of the local surface water resources.

In this assessment five GUAs have been delineated for the Middle and Lower Mogalakwena drainage area, namely A62-1 (Figure 25), A62-2 (Figure 26), A62-3 (Figure 27), and A63-1 (Figure 28). There are vast differences in the transmissivities of the GUA's (Table 26). Most notably is the high transmissivities observed in A62-2 and A63-1. The high yielding boreholes associated with A62-2 is located along the contact zones of the batholiths which intruded the older Hout River Gneiss. In GUA A63-1, Tolwe and Baltimore is known for its large scale irrigation from boreholes.

Description	GUA	Info	BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (I/s for 24hrs)	Blow Yield (l/s)
Klain Magalakwana	A62 1	Ν	470	405	80	50	150
Kielii wogalakwella	A02-1	Mean	62.0	17.4	50.4	0.4	1.4
Matiala	AC2 2	Ν	395	413	65	47	43
Wallala	A02-2	Mean	59.0	13.6	75.8	1.3	2.2
Staillaan	AC2 2	Ν	509	393	67	56	128
Stellloop	A02-3	Mean	65.1	17.5	27.3	0.8	2.0
Lower Mogalakwena	AC2 1	N	973	877	108	57	255
	A03-1	Mean	59.2	24.2	59.9	1.2	2.9

 Table 26. Borehole information for the Middle and Lower Mogalakwena drainage region.

# 2.3.1. Groundwater recharge

Mean annual precipitation varies from 600 mm in the south to less than 400 mm in the north (**Error! Reference source not found.**). In lower lying areas the low and variable rainfall together with evaporation rates (2 000 mm) considerably exceeding rainfall result in a low expectation of natural recharge to groundwater. Recharge vary spatially from as high as 18 mm/a in the Waterberg region to less than 3 mm/a at the confluence with the Limpopo River. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 27.

Description	CUA	Quet	МАР	Area	GR	A II	Vegter (1995)
Description	GUA	Quat	(mm)	(km²)	(Wet) Mm <sup>3</sup>	(Dry) Mm <sup>3</sup>	Mean Mm <sup>3</sup>
		A62A	610.2	428	11.07	7.98	24.85
Klein	AC2 1	A62B	528.7	710	14.20	9.96	14.94
Mogalakwena	A62-1	A62C	478.3	385	6.53	4.50	11.30
		A62D	488.8	603	10.15	7.02	11.71
Madala.	A62-2	A62E	460.4	621	8.59	5.88	5.64
watiala		A62F	478.1	620	9.18	6.33	6.58
		A62G	437.3	627	8.25	5.63	4.60
Steilloop	A62-3	A62H	439.3	871	10.94	7.45	5.25
		A62J	450.1	930	12.44	8.50	3.59
Lower		A63A	433.1	1928	18.20	12.36	1.81
	A63-1	A63B	393.9	1505	11.35	7.61	4.29
wogalaKwena		A63D	412.3	1319	13.99	9.43	4.72

Table 27. Recharge estimation (Middle- and Lower Mogalakwena).



# 2.3.2. Groundwater Use

The groundwater use for each of the GUA associated with the Middle and Lower Mogalakwena River system is summarised in Table 28. The present WARMS groundwater use data was compared to the 2015 Limpopo (WMA) North Reconciliation Strategy (LNRS) estimated 2020 use.

GMA Description	GUA	Quat	WARMS: Use Mm <sup>3</sup>	LNRS 2020 Mm <sup>3</sup>
		A62A	0.577	0.866
Klain Magalakwana	462.1	A62B	0.523	1.685
Kieln wogalakwena	A02-1	A62C	0.001	0.693
		A62D	0.648	1.208
Matiala	A62.2	A62E	0.106	2.214
Walldia	A02-2	A62F	3.709	5.672
		A62G	0.003	1.199
Steilloop	A62-3	A62H	0.798	2.941
		A62J	0.211	1.057
		A63A	11.003	20.900
Lower Mogalakwena	A63-1	A63B	1.171	2.793
		A63D	3.808	4.952

Table 28. Groundwater use (per annum) as registered per catchment for each GUA.

### 2.3.3. Groundwater quality

Groundwater samples in the Middle and Lower Mogalakwena drainage region indicate a variety of water types (e.g.  $Ca/Mg-HCO_3$ , Na-HCO<sub>3</sub> and Na-Cl) (Figure 24). A high percentage of samples relate to a fresh recharge type (Ca/Mg-HCO<sub>3</sub>) water, while cation and anion exchange process may be occurring within the strata hence Na-Cl and Ca/Mg-Cl type water present.



Figure 24 Piper diagram for the Middle- and Lower Mogalakwena drainage region.



Groundwater quality in the Middle- and Lower Mogalakwena region is considered to be moderate to poor. The most notable elements of concern include NO<sub>3</sub> as N with average concentrations above the maximum allowable recommended drinking limit (Table 29). In addition, high (not exceeding thought) ion concentrations (e.g. Mg and Cl) and subsequently electric conductivities (EC) beyond acceptable limits. This can mostly be related to evaporative concentration of elements in discharge areas or due to low recharge values as well as long residence times for selected samples.

GUA		рН	EC	TDS	Са	Mg	Na	к	SO4	CI	NO₃ as N	F
DWAF Class	I	5-6 or 9- 9.5	70-150	450- 1000	80-150	30-70	100- 200	-	200- 400	100- 200	6-10	0.7-1
DWAF Class	II	4-5 or 9.5-10	150-370	1000- 2000	150-300	70- 100	200- 600	-	400- 600	200- 600	10-20	1-1.5
DWAF Class	111	3.5-4 or 10-10.5	370-520	2000- 3000	>300	100- 200	600- 1200	-	600- 1000	600- 1200	20-40	1.5- 3.5
AC2 1	Ν	130	143	131	153	152	153	150	136	153	21	147
A02-1	Median	8.0	109	760	74.4	39.2	89.7	1.9	12.1	123.9	63.4	0.62
AC2 2	Ν	143	137	144	155	155	154	154	155	155	11	148
A02-2	Median	8.1	124	943	54.8	38.02	149.0	8.7	26.5	172.1	59.0	0.61
AC2 2	Ν	155	158	149	170	171	171	171	169	170	18	150
A62-3	Median	8.1	116	865	57.2	47.10	130.9	8.5	24.5	163.9	35.9	0.36
A62 1	Ν	127	128	123	140	139	140	137	127	141	15	132
A02-1	Median	8.08	120.60	884 79	70 60	58 80	97 83	2 54	25 31	119 07	83.4	0 44

Table 29. Groundwater quality for the Middle- and Lower Mogalakwena region (All units in mg/l, EC in mS/m). (red text exceeds Class III).

# 2.3.4. Groundwater contribution to baseflow

The Middle Mogalakwena River stretch can be classified into a localized interacting weathered hard rock system (Bushveld Complex) in the upper reaches, while the Waterberg Group will be in continues interaction with the river and probability of baseflow is regarded as high. In the lower reaches alluvium replaces the weathered material and can be classified as a porous media with a semi-pervious layer. In both cases seasonal alternating effluent / influent conditions can be experienced. Comparison of groundwater contribution to baseflow estimates for the Middle- and Lower Mogalakwena drainage region are summarised in Table 30.

Description	GRU	Quat	Hughes Mm³/a	Shultz Mm³/a	Pitmann Mm <sup>3</sup> /a	GRA II (WR2005) Mm <sup>3</sup> /a	Maint. Low flow Mm³/a
		A62A	8.24	3.72	7.58	4.52	3.46
Klein	AG2 1	A62B	4.71	0.48	2.27	2.44	1.27
Mogalakwena	A62-1	A62C	1.82	0.27	1.12	1.11	0.49
		A62D	3.08	0.39	1.75	1.82	1.45
Madala	A62-2	A62E	-	-	-	-	0.34
IVIALIAIA		A62F	0.02	-	-	-	0.41
	A62-3	A62G	-	-	-	-	0.14
Steilloop		A62H	0.01	-	-	-	0.40
		A62J	0.05	-	-	-	0.24
		A63A	0.08	-	-	-	0.03
Lower	A63-1	A63B	-	-	-	-	0.02
Mogalakwena		A63D	-	-	-	-	0.37

Table 30. Groundwater contribution to baseflow estimates.

### 2.3.5. Summary

The following tables provide a summary for each of the GUA, as illustrate in Table 31, Table 32, Table 33 and Table 34.



# Table 31. Summary information for GUA: A62-1

GUA	Klein Mogalakwena A62-1					
Description	The main aquifer types include the Fractured aquifers associated with the Waterberg Formation, ranging from					
	Duikerfontein north to Kirstenbos, and Granitic Intrusive rocks, northern extent of the GUA at Marken. area The					
	Waterberg formation is associated with steep topography and shows generally poor capability to produce huge					
	amounts of groundwater. Recharge to the aquifer, often discharged on the steep slopes, provides baseflow to the					
	rivers. A weathered zone aquifer is found only where deep weathering occurs and provides groundwater storage					
	that feeds the underlying fractured aquifer. The Bushveld rocks, located towards the east of the GUA at					
	Gooedehoop area, forms fractured aquifers owing their groundwater potential largely to fracturing. Intergranular					
	Alluvial aquifers (limited to the main river stems) recharge during periods of high stream-flows as well as during the					
	rainfall season. The groundwater use is associated with irrigation, water supply, livestock watering, industrial and					
	some aquacultural use. A large number of villages (schemes) are associated with the GUA.					
Catchments	A62A,B,C,D,E					
Мар						
	Maning Maning					
Legend						
Water Leve	Water Supply (m3)					
Geosite						
HYDRSTR/	A 1000					
Geosite						
VIVIS Geos	Año Industrial Urban (m3)					
Pivore Stud	A62C					
Catchment	A6No6o4 • 1 000					
Geology						
QUATERNA	ARY Livestrock (m3)					
Diabase						
Rooiberg GRP						
KWAGGAS	NEK					
ROOIBERG	B Irrigation (m3)					
SCHRIKKL						
Waterberg GRP						
KRANSBER	RG ASOD S 10 000 000					
MOGALAK	WENA Aquaculture (m3)					
SETLAOLE	A6Nos033					
CLEREMO						
MAKGABE						
Bushveld Comple						
NEBO GRA						
MOLENDR						
GABBRO	Arec N - 2 - 3					
MAPELA G	ABBRO- A6Noo15 A A6Noo587					
NORITE						
Limpopo Belt						
GRANOPH	YRE					
Figure 25 Man	showing GUA A62-1 with geology, groundwater use and geo-sites					
Water Use Schem	es (after DWAF, 2015, Recon Study)					

water ose schemes (arter owar, 2015, Recon Study)					
Scheme Name	Village/Settlement	Catchment			
Aganang East GWS	Chloe A, Chloe B, Damplats, Eerste Geluk, Ga-Ngwetsana, GaRamoshwane, Kgabo Park,	A62E A62H			
	Preezburg, Ramatlwane, Rampuru, Rapitsi, Ga-Mmabasotho, Ga-Modikana, Ga-Phago,				
	Ga-Piet, GaRankhuwe, Kalkspruit 1, Lehlohlong, Vischkuil, Wachtkraal and Ga-Nonyane				
Bakenberg RWS	Bakenberg Basogadi, Bakenberg Kwanaite, Bakenberg Matlaba, Bakenberg Mautjana,	A61G A61J			
	Bakenberg Mmotong, Bakenberg Mothwathwase, Basterspad, Bohwidi, Buffelhoek,	A62A A62B			
	Claremont, Dikgokgopeng, Diphichi, Galakwenastroom, Ga-Masipa, Good Hope,	A62C A62F			
	Harmansdal, Jakkalskuil, Kabeane, Kaditshwene, Kgopeng, Kromkloof, Lesodi, Leyden,				
	Lusaka Ngoru, Mabuladihlare 1,Makekeng, Malapila, Mamatlakala, Marulaneng,				
	Matebeleng, Mphelelo, Nelly, Paulos, Pudiyakgopa, Raadslid, Ramosesane, Rantlakane,				
	Sepharane, Skilpadskraal, Skrikfontein A, Skrikfontein B, Taolome, Van Wykspan,				
	Vlakfontein, Vlakfontein 2, Wydhoek and Good Hope East				
Bakone GWS	Bakone, Boratapelo, Dibeng, Ga-Ramakara, Madietane, Manamela 2, Mpone Ntlolane 1,	A62E A62F			
	Mpone Ntlolane 3, Nokayamatlala, Ntlolane 2, Phetole, Phofu, Ramalapa 1, Semaneng				



		and Taung.						
Biesjeskraal W	/S	Moepelfarm					A62D	
Daggakraal W	S	Daggakraal					A50D A62B	
Ga Mokobodi	GWS	Ga-Lepadima, Ga-	Mokobodi, Ga	a-Phaka, Ga-Rar	nakadi-Kadi, Goedgev	onden, Hwibi, Jun	o, A62E A62F	
		Moetagare, Scho	Moetagare, Schoongelegen, Tibana, Ga-Mabitsela, Ga-Ramotlokana, Leokaneng,					
		Mamehlabe, Pinki	e, Rozenkranz	and Ngwanalle	la			
Ga Rawesi GV	VS	Uitkyk 2, Mesehle	eng 1, Meseh	leng 2, Mokud	ung, Kgokonyane, No	nono, Setlaole, Ga	a- A62E A62G	
		Masekwa, Rotlok	wa, Ga-Rawe	si, Murasie, Ga	-Letswalo, Lekiting,	Aurora, Ga-Ngwep	e A62H A72A	
	and Schoongezicht							
Glen Alpine G	WS	Mattanau, Breda,	Duren, Galak	wena, Ga-Tlha	ko, Khala, Lennes, M	onte Christo, Polei	n, A62D A62G	
		Preezburg, Rebon	e, Setuphulan	e, Sodoma, Tau	eatswala, Thabalesho	ba, Tipeng, Uitzich	t, A62H A62J	
		Sterkwater						
Houtrivier RW	/S	Koloti, Kamape 1	, Komape 2, I	Komape 3, Mat	oukelele, Madikote, N	/lamadila, Moshate	e, A62E A62H	
		Ramagaphota, Ci	ristiana, Ga-k	(goroshi, GaSe	tshaba, Helena, Kall	kspruit, Magongo	a, A71E A71F	
		Vlaklaagte and Wa	aschbank					
Mapela RWS		Danisane, Ditlots	wane, Ga-Cho	okoe, Ga-Magoi	ngoa, Ga-Mokaba, Ga	a-Molekana, Ga-Pi	a A61F A61G	
		Sterkwater, Ga-Ts	shaba, Hans,	Kgobudi, Kwaky	walata, Lelaka, Maala	Parekisi, Mabuel	a, A62B A62F	
		Mabusela, Mabu	isela Sandslo	oot, Machikiri,	Magope, Malokon	gskop, Masahlen	g, A71B	
		Masenya, Masoge, Matlou, Matopa, Mesopotania,, Millenium Park, Mmahlogo,						
		Mmalepeteke, Phatola, Ramorulane, Rooiwal, Seema, Sekgoboko Sekuruwe, Skimming,						
		Ishamahansi, Wit	rivier, Fothane	e, Mohlotlo Ga-	Malebana, Mohlotio (	ja-Puka		
Marken Suppl	у Онис	Marken					A62D	
Moletje South	n GWS	Boetse, Diana, Ga-Kgasha, Ga-Madiba, Ga-Mangou, GaMatlapa, Glen Roy, Jupiter,						
		Mandela Park, Manyapye, Mapateng, Matialeng, Maune, Mohlonong, Montwane 1,						
		Nontware Z, Nosnate, Naleol, Ngopane, Sebora, Setaniane, Segoanieng, Sepanapudi,						
		Sengatane Setotolwane College Vaalkon 1 and Vaalkon 3 Venus and Waterolaats					2,	
Dahara DM/C		Bavaria Breda Blinkwater Chinana Dinere Duren Ga-Chere Galakwena Galalia Ga						
Rebone RWS		Bavaria, Breda, Bilnkwater, Chipana, Dipere, Duren, Ga-Chere, Galakwena, Galelia, Ga-						
		ivionare, Ga-iviusni, Ga-ivong, Ga – Tikako, Grasviel, Ham I, Hiogoyanku, Khala,						
		Leknureng, Lennes, Makobe, Matnekga, Matjitjileng, Mattanau, Monte Christo, Polen,						
		Preezburg, Mosnuka, Kidikitiana, Kebone, Kapadi, Segole 1, Segole 2, Selfappes, Senita,					, ,	
		Tinong Hitzicht M	Joina, Sterkw	Vianna			5,	
Llitsnan Sunnl	Llitenan Supply			A62D				
	itoring locations	for trend analysis -	- Water Level				AUZD	
			Water Level	Max water	Min water level	Mean water	Fluctuation	
Name	Start Date	End Date	Count	level (mbgl)	(mhgl)	level (mbgl)	(min-max) (m)	
A6N0588	2007/01/30	2021/09/13	2360	5.85	3,30	4.54	2.55	
A6N0597	2008/07/17	2021/09/13	6444	13,69	4,21	11.39	9.48	
A6N0604	2010/10/06	2021/09/13	3205	17.42	14.00	16.12	3.42	
Water Level G	ranhs	1021,00,10	5205	27112	1.000	10.12	0.12	





of recharge observed for these monitoring boreholes. Apart from the observed seasonal fluctuations decreasing trend is observed up to 2016 followed by an increase up to 2021. Station A6N0588 is located close to a non-perennial river bed, and could explain the shallow groundwater table associated with the borehole observations. A prominent groundwater recharge events is clearly observed during 2014/15.



## Table 32. Summary information for GUA: A62-2

GUA	Matlala A62-2					
Description	The GUA is characterised by intergranular alluvial aquifers, recharged during periods of high stream-flows as well as					
•	during the rainfall season. The igneous and metamorphic rocks occurring in the eastern portions of the Matlala area					
	especially the Hout River Gneiss have good water bearing potential. Thick, weathered aquifer zones are expected in					
	areas where the bedrock has been subjected to intense fracturing. The Basement is represented in the eastern					
	sector of the Mogalakwena drainage region. Ground water is entrapped in small relatively shallow, locally developed					
	basing and troughs revealing that mechanical and chemical weathering appear to be associated with surface					
	drainage channels. The basement aquifer system (Limpono Belt) is located to the east of the GUA, range from Ga-					
	Manou north to Ga-Bamela area, whereas the fractured aquifer form the Bushveld rocks in located towards the west					
	of the GIIA. The groundwater use is associated with irrigation and industrial uses					
Catchments						
Man						
Legend	Legend					
Material area	Ga-Phag					
Geosite	Industrial Orban (m3)					
HYDRSTR						
Geosite	A A A A A A A A A A A A A A A A A A A					
💛 💛 WMS Geos						
2- Main Rivers	s Industral non-urban (m3)					
Rivers Stud	ty Area					
Catchment						
Geology						
QUATERN.	ARY					
Diabase						
Waterberg GRP	1 000					
• MAKGABE						
Bushveld Compl						
GABBRO						
MAPELA G	ABBRO-					
NORITE						
NEBO GRA						
Transvaal SPGR						
PRETORIA	A6No597 A7No635					
MALMANI						
Limpopo Belt						
GNEISS						
LUNSKLIP	N Ga Mabusela					
GRANITE	A71F					
MATLALA	A61G					
A GRANITE	0 5 10 Kilopreters GarMargou Manyapie A71A					
Leyden	sepharane Mesopotamia 182743					
Figuro 26 Man	showing GUA A62-2 with goology groundwater use and goo-sites					
Water Use Schem	es (after DWAF 2015 Recon Study)					

Cabama Nama		Catabasant
Scheme Name	Village/Settlement	Catchment
Aganang East GWS	Chloe A, Chloe B, Damplats, Eerste Geluk, Ga-Ngwetsana, GaRamoshwane, Kgabo Park,	A62E A62H
	Preezburg, Ramatlwane, Rampuru, Rapitsi, Ga-Mmabasotho, Ga-Modikana, Ga-Phago,	A71E A71F
	Ga-Piet, GaRankhuwe, Kalkspruit 1, Lehlohlong, Vischkuil, Wachtkraal and Ga-Nonyane	
Bakenberg RWS	Bakenberg Basogadi, Bakenberg Kwanaite, Bakenberg Matlaba, Bakenberg Mautjana,	A61G A61J
	Bakenberg Mmotong, Bakenberg Mothwathwase, Basterspad, Bohwidi, Buffelhoek,	A62A A62B
	Claremont, Dikgokgopeng, Diphichi, Galakwenastroom, Ga-Masipa, Good Hope,	A62C A62F
	Harmansdal, Jakkalskuil, Kabeane, Kaditshwene, Kgopeng, Kromkloof, Lesodi, Leyden,	
	Lusaka Ngoru, Mabuladihlare 1,Makekeng, Malapila, Mamatlakala, Marulaneng,	
	Matebeleng, Mphelelo, Nelly, Paulos, Pudiyakgopa, Raadslid, Ramosesane, Rantlakane,	
	Sepharane, Skilpadskraal, Skrikfontein A, Skrikfontein B, Taolome, Van Wykspan,	
	Vlakfontein, Vlakfontein 2, Wydhoek and Good Hope East	
Bakone GWS	Bakone, Boratapelo, Dibeng, Ga-Ramakara, Madietane, Manamela 2, Mpone Ntlolane 1,	A62E A62F
	Mpone Ntlolane 3, Nokayamatlala, Ntlolane 2, Phetole, Phofu, Ramalapa 1, Semaneng	
	and Taung.	



13.18

4.43

Ga Mokobodi	GWS	Ga-Lepadima, Ga-Mokobodi, Ga-Phaka, Ga-Ramakadi-Kadi, Goedgevonden, Hwibi, Juno, A62E A62F						
		Moetagare, Schoongelegen, Tibana, Ga-Mabitsela, Ga-Ramotlokana, Leokaneng, A6						
		Mamehlabe, Pinki	Mamehlabe, Pinkie, Rozenkranz and Ngwanallela					
Ga Rawesi GV	VS	Uitkyk 2, Mesehle	eng 1, Meseh	leng 2, Mokud	ung, Kgokonyane, No	nono, Setlaole, G	a- A62E A62G	
		Masekwa, Rotlok	wa, Ga-Rawe	si, Murasie, Ga	-Letswalo, Lekiting,	Aurora, Ga-Ngwer	e A62H A72A	
		and Schoongezich	t					
Aganang LM F	arms supply	Farms Aganang LN	Λ				A62F	
Houtrivier RW	/S	Koloti, Kamape 1	, Komape 2, I	Komape 3, Mat	oukelele, Madikote, N	/Jamadila, Moshat	e, A62E A62H	
		Ramagaphota, Ci	ristiana, Ga-k	(goroshi, GaSe	tshaba, Helena, Kall	kspruit, Magongo	a, A71E A71F	
		Vlaklaagte and Wa	aschbank	-				
Mapela RWS		Danisane, Ditlots	wane, Ga-Cho	okoe, Ga-Magoi	ngoa, Ga-Mokaba, Ga	a-Molekana, Ga-Pi	la A61F A61G	
		Sterkwater, Ga-Ts	shaba, Hans,	Kgobudi, Kwakv	walata, Lelaka, Maala	Parekisi, Mabuel	a, A62B A62F	
		Mabusela, Mabu	isela Sandslo	oot, Machikiri,	Magope, Malokon	gskop, Masahlen	g, A71B	
		Masenya, Masog	ge, Matlou,	Matopa, Meso	potania,, Millenium	Park, Mmahlog	0,	
		Mmalepeteke, Ph	afola, Ramoru	ulane, Rooiwal,	Seema, Sekgoboko Se	ekuruwe, Skimmin	g,	
		Tshamahansi, Witrivier, Fothane, Mohlotlo Ga-Malebana, Mohlotlo Ga-Puka					-	
Moletje South	n GWS	Boetse, Diana, Ga-Kgasha, Ga-Madiba, Ga-Mangou, GaMatlapa, Glen Roy, Jupiter,						
-		Mandela Park, Manyapye, Mapateng, Matlaleng, Maune, Mohlonong, Montwane 1,						
		Montwane 2, Moshate, Naledi, Ngopane, Sebora, Sefahlane, Segoahleng, Sepanapudi,						
		Utjane, Chebeng, Doornspruit, Ga-Mapangula, Makweya, Newlands, Pax College,						
		Sengatane, Setoto	, lwane College	e, Vaalkop 1 and	l Vaalkop 3 Venus and	l Waterplaats		
Rebone RWS		Bavaria, Breda, Blinkwater, Chipana, Dipere, Duren, Ga-Chere, Galakwena, Galelia, Ga-						
		Monare, Ga-Mushi, Ga-Nong, Ga – Tlkako, Grasvlei, Ham 1, Hlogoyanku, Khala,						
		Lekhureng, Lennes, Makobe, Mathekga, Matjitjileng, Mattanau, Monte Christo, Polen, A6						
		Preezburg, Moshuka, kidikitlana, Rebone, Rapadi, Segole 1, Segole 2, Seirappes, Senita,						
		Setophulane, Sodoma, Sterkwater, Taueatswala, Tennerif, Thabaleshoba, Tiberius,					S,	
Tipeng, Uitzicht, Vergenoeg and Vianna								
Available mon	itoring locations	for trend analysis -	- Water Levels	S				
Namo	Start Date	End Data	Count	Max water	Min water level	Mean water	Fluctuation	
Name	Start Date	Ellu Date	Count	level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)	
A6N0584	2006/12/07	2021/09/13	7246	35.39	27.28	30.35	8.11	
A6N0599	2007/09/05	2021/06/10	1879	24.14	22.10	23.07	2.04	
A6N0612	2007/10/18	2021/06/10	3805	15.46	7.17	9.79	8.29	







							1
				conc. (mg/L)	conc. (mg/L)	conc. (mg/L)	Water guideline
				none			
Water Quality	Water Quality Graph and Piper Plot						
				none			
Comments							
The observed to significant	hydrographs for or recharge events	each of the four are observed fo	stations show a r stations A6N	a fluctuation of 10584, A6N0623	between 2 and 8 and A6N0612. I	m. Seasonal fluctuati However station A6N0	ons and a response )599 shows limited

fluctuations. Station A6N0599 is located close to the Tlhapsana river system whereas the other station are not in close approximation of a perennial river and could explain difference in water level response. Stations A6N0584 and A6N0612 shows a decline in groundwater levels.



# Table 33. Summary information for GUA: A62-3

GUA	Steilloop A6	2-3					
Description	The igneous	and metamorphi	c rocks occurring in the e	astern portions of the	e GUA especially the mafic r	ocks (gabbro,	
	norite, etc.)	of the Bushvel	d Complex and the Hou	t River Gneiss have	good water bearing pote	ntial. Thick,	
	weathered	aquifer zones are	expected in areas where	e the bedrock has be	en subjected to intense fra	cturing. The	
	Basement is	s represented in t	he eastern sector of the	Mogalakwena draina	ge region. Ground water is	entrapped in	
	small relativ	ely shallow, loca	lly developed basins and	troughs revealing th	at mechanical and chemica	al weathering	
	appear to be	e associated with	surface drainage channel	s. The fractured aqui	ers associated with the Bus	hveld rocks is	
	located at t	he south and cent	tral part of the GUA wher	eas the Waterberg G	roup at the western portion	n of the GUA.	
	The GUA is	characterised by i	ntergranular alluvial aqui	fers, recharged durin	g periods of high stream-flo	ws as well as	
	during the i	he rainfall season. The groundwater use is associated with irrigation, industrial and water supply uses. A					
	large numbe	er of villages (sche	mes) are associated with	the GUA.			
Catchments	A62G,H,J						
Мар							
N.		9886	A6N0582		Logand	]	
ANAE8	• •		) which is		Legend	•	
•	0 00 1/1			Bosen Water S	Supply (m3) Industral non-	urban (m3)	
	1 A634	Iometers		•••••••••	• 1	1	
			Line P. (	· · · · ·			
	3.	CE RET.		Industri	al Urban (m3)		
	· ·	and the first		• 1	Irrigation (m3)	1	
		A62J <sup>2</sup>		• 1	000 • 1 000		
	698840	The second	Winner		000 000	00 4	
Азон		A6N'0578	( we all		10 000 0		
		4-10:4-1					
· · · ·				- 1 - 1			
					AGNOGOS	•	
A6No	98			CASH AND A CONTRACT OF A	· · · · · · · · · · · · · · · · ·	:	
6				AN A	A BAY YOLY		
1.00		A62G		AD2H	THE WAY THE	• •	
4.50			the strategy of the strategy o		Y Y Y Y Y Y Y		
A500		$\sim$ $?$		• • \ • • • • • • • • • • • • • • • • •			
				Mattala	Y Y Y Y Y Y		
		m.		A start theme	· · · · · · · · · · · · · · · · · · ·		
	, P	2		Same	· · · · · · · · ·	A71E	
		25 ·V?	agond			· · · ·	
			egenu		A62E V V V	Hen	
Water Leve	1.27	Catchment	MOGALAKWENA	NEBO GRANITE			
Geosite	Geo	logy	SETLAOLE	Limpopo Belt			
Geosite	4	QUATERNARY	Bushveld	BANDELIERKOP	•		
WMS Geos	ite	Diabase	MAPELA GABBRO-	HOUT RIVER		× ×	
2 Main Rivers	Wate	erberg GRP		GINEISS MATLALA	23.2	• / •	
Rivers Stud	y Area	KRANSBERG	MAGNETITE	GRANITE		LIMF	
		MAKGABENG	GABBRO		South Africa, Esri, HERE, Garmin, FAS, METI/	A71F	
Element 27 Mars	-hi CU				<u> </u>		
Figure 27 Map	snowing GU	A A62-3 with ge	ology, groundwater us	e and geo-sites.			
water Use Schem	es (after DWA	AF, 2015, Recon S	tudy)			<b>.</b>	
Scheme Name	16	Village/Settlem	ent D. Damalata, Fanata Calul	Co Novetore Col	New Strategy Reals and		
Aganang East GW	15	Chioe A, Chioe I	B, Damplats, Eerste Geluk	k, Ga-Ngwetsana, Gar	Ramoshwane, Kgabo Park,	A62E A62H	
		Preezburg, Ram	atiwane, Rampuru, Rapit	si, Ga-ivimabasotno,	Ga-Modikana, Ga-Phago,	A/1E A/1F	
		Ga-Piet, GaRank	nuwe, Kalkspruit 1, Lehio	niong, Vischkuil, Wac	ntkraal and Ga-Nonyane		
Aganang North G	W	Ga-Maboth, Ga	-Mantihodi, Ga-Mosehloi	ng, Ga-Motlakgomo,	Kanana, Mohlajeng, Ga-	A62H A/1E	
		Kolopo, Ga-Mar	ibana, Ga-Phagodi, Maro	we, Modderput, Sek	uruwe 2, Ga-Moropa, Ga-	A/2A	
		Mankgodi, Gake	etse, Ga-Dikgale, Uitkyk a	ind Terbrugge			
Blouberg LM Farr	ns Supply	Blouberg LM Fai	ms Supply			A62J	
Ga Mokobodi GV	/S	Ga-Lepadima, G	a-Mokobodi, Ga-Phaka, G	ia-Ramakadi-Kadi, Go	edgevonden, Hwibi, Juno,	A62E A62F	
		Moetagare, Sc	hoongelegen, Tibana,	Ga-Mabitsela, Ga-R	amotlokana, Leokaneng,	A62G A62H	
		Mamehlabe, Pir	KIE, Rozenkranz and Ngw	anallela			
Ga Rawesi GWS		Uitkyk 2, Mese	nieng 1, Mesehleng 2, M	lokudung, Kgokonyar	ne, Nonono, Setlaole, Ga-	A62E A62G	
		Masekwa, Rotlo	okwa, Ga-Rawesi, Murasi	e, Ga-Letswalo, Leki	ting, Aurora, Ga-Ngwepe	A62H A72A	
		and Schoongezie	cht				



Glen Alpine GWS	Mattanau, Breda, Duren, Galakwena, Ga-Tlhako, Khala, Lennes, Monte Christo, Polen, A				
	Preezburg, Rebone, Setuphulane, Sodoma, Taueatswala, Thabaleshoba, Tipeng, Uitzicht,	A62H A62J			
	Sterkwater				
Houtrivier RWS	Koloti, Kamape 1, Komape 2, Komape 3, Mabukelele, Madikote, Mamadila, Moshate,	A62E A62H			
	Ramagaphota, Cristiana, Ga-Kgoroshi, GaSetshaba, Helena, Kalkspruit, Magongoa,	A71E A71F			
	Vlaklaagte and Waschbank				
Lephalale LM Farms Supply	Farms Lephalale LM	A62J			
Rebone RWS	Bavaria, Breda, Blinkwater, Chipana, Dipere, Duren, Ga-Chere, Galakwena, Galelia, Ga-	A62C A62D			
	Monare, Ga-Mushi, Ga-Nong, Ga – Tlkako, Grasvlei, Ham 1, Hlogoyanku, Khala,	A62F A62E			
	Lekhureng, Lennes, Makobe, Mathekga, Matjitjileng, Mattanau, Monte Christo, Polen,	A62G A62H			
	Preezburg, Moshuka, kidikitlana, Rebone, Rapadi, Segole 1, Segole 2, Seirappes, Senita,				
	Setophulane, Sodoma, Sterkwater, Taueatswala, Tennerif, Thabaleshoba, Tiberius,				
	Tipeng, Uitzicht, Vergenoeg and Vianna				
Silwermyn / Kirstenspruit	Driekoppies, Silwermyn, De Villiersdale 1, De Villiersdale 2, Swarts, Non-Parella, Mons,	A62H A62J			
GWS	De Villiersdale, Thabanantlhana, De La Roche, Kirstenspruit, Grootdraai, Vergelegen, Ga-	A63A A72A			
	Mankgodi, Papegaai, Sebotlana, Madibeng, Ga-Ntshireletsa and Nieuwe Jerusalem				
Taaiboschgroet	Simpson, Grootpan, Sais, Slaaphoek, Donkerhoek, Voorhout, Royston, Juniorsloop,	A63A A63B			
	Berseba, Wegdraai, Ga-Raphokola, Gideon, Thlonasedimong, Eldorado, Fonteine Du	A63D A72A			
	Champ, Esaurinca, Louisenthaal, The Grange, Longden, Taaiboschgroet, De Vrede,				
	Kromhoek, Pax, Johannesburg, Lovely, Burgerregt, Edwinsdale, The Glen and				
	Glenferness				
Available monitoring locations for trend analysis – Water Levels					

				-			
Name Start Date	End Data	Count	Max water	Min water level	Mean water	Fluctuation	
	Start Date	Ella Date	Count	level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)
A6N0578	2006/03/17	2021/09/17	3824	14.95	6.17	9.81	8.87
A6N0586	2006/03/09	2021/09/13	3509	8.23	3.50	5.33	4.73
A6N0598	2008/02/06	2021/09/17	4713	28.40	16.20	21.58	12.2
A6N0605	2010/09/30	2021/09/13	1801	17.16	15.30	15.98	1.86
Material C	ua ua la a						





# Table 34. Summary information for GUA: A63-1

GUA	Lower Mogalakwena A63-1						
Description	The GUA is characterised by intergranular alluvial aquifers, recharged during periods of high stream-flows as well						
	as during the rainfall season. The igneous and metamorphic rocks, basement rocks form the Limpopo Belt,						
	occurring in the northern portions of the Lower Mogalakwena area especially gneiss from the and the Alldays						
	Gneiss have good water bearing potential. Thick, weathered aquifer zones are expected in areas where the						
	bedrock has been subjected to intense fracturing. Ground water is entrapped in small relatively shallow, locally						
	developed basins and troughs revealing that mechanical and chemical weathering appear to be associated with						
	surface drainage channels. The weathered and fractured aquifer systems associated with the Soutpansberg						
	mountainous area, associated with basalts, are associated with the Beerkraal area, Waterberg sedimentary rocks						
	at the Papagaai area and Blouberg sedimentary rocks associated with the Blouberg Mountains form the southern						
	portion of the GUA . The Karoo Supergroup rocks, located in a small portion close to Doornfontein, Towle and						
	Wegdraai areas, central part of the GUA, form intergranular and fractured aquifer systems with high groundwater						
	yields. The groundwater use is associated with irrigation, water supply, livestock watering and schedule I uses.						
	Large number of communities rely on groundwater as main water use.						
Catchments	A63A,B,D						
Мар							
a la la catalan	Legend						
• Water Level Geosite	Soutpansberg GRP 0 5 10 20 30 Kilometers AGN/0582						
HYDRSTRA	MADZARINGWE						
WMS Geosite	KLOPPERFONTEIN						
2- Main Rivers	Waterberg GRP						
2- Rivers Study Ar	ea KRANSBERG						
Geology	MAKGABENG						
QUATERNARY	Limpopo Belt						
Alluvium	ALLDATS GNEISS BANDELIERKOP A63C						
Diabase	GUMBU						
KAROO DOLEI	RITE HOUT RIVER						
LETABA	MALALA DRIFT						
KAROO	MESSINA 2 46N0606 463B						
RED ROCKS	MOUNT DOWE						
BOSBOKPOOF							
SOLITUDE	SYENITE						
Blouberg GRP	Gapriloogn A6Not79						
BLOUBERG	CAGNO550						
ALNOOTA							
89756	645N0672						
	757 Mountain						
• / • • • • •	740924 A7N0034 A7N0659						
	A72A						
	A6No586						
A5	oH						
	• • • • • • • • • • • • • • • • • • •						
	A5N0000						
** \$A50G	ADINO5787 ADINO5787 ADINA AVAILA USAN AVAILA A						
Figuro 29 Man	showing GUA A63-1 with goology groundwater use and goo-sites						

rigare 20 Map showing don'nos 1 with geology, groundwater use and geo sites.						
Water Use Schemes (after DWAF, 2015, Recon Study)						
Scheme Name	Village/Settlement					
Alldays BS	Alldays BS	A63D A63E				
Archibald GWS	Archibald, Genua, Letswatla, Borwalathoto, Thorp	A63A				
		A63B				
Avon GWS	Avon, Bul Bul, Dantzig 2, Ga-Kibi, Indermark, Innnes, Puraspan, Sewale North and The	A63D				
	Glade	A72A				
Baltimore Supply	Baltimore	A63A				
Gorkum GWS	Berg-en-Dal, Ga-Mamoleka, Gorkum, Varedig, Sekhung and Morotsi	A63A				
		A63B				
		A72A				
Silwermyn / Kirstenspruit	Driekoppies, Silwermyn, De Villiersdale 1, De Villiersdale 2, Swarts, Non-Parella, Mons,	A62H A62J				



GWS		De Villiersdale, Thabanantlhana, De La Roche, Kirstenspruit, Grootdraai, Vergelegen,							
Ga-Mankgodi, Papegaai, Sebotlana, Madibeng, Ga-Ntshireletsa and Nieuwe Jerusa					Vieuwe Jerusalem	A72A			
Taaiboschgro	et	Simpson, Grootpa	an, Sais, Slaa	aphoek, Donker	hoek, Voorhout, Ro	yston, Juniorsloop	, A63A		
		Berseba, Wegdraai, Ga-Raphokola, Gideon, Thlonasedimong, Eldorado, Fonteine Du							
		Champ, Esaurinca, Louisenthaal, The Grange, Longden, Taaiboschgroet, De Vrede,							
		Kromhoek, Pax, Johannesburg, Lovely, Burgerregt, Edwinsdale, The Glen and					I A72A		
		Glenferness							
Thalahane GWS		Kgatalala, Buffelshoek and Thalahane							
		1					A63D		
							A72A		
Ga-Hlako RWS	S	Bodie, Brodie Hill, Dithabaneng, Ga-Hlako, Ga-Mabeba, GaMaboth, Gamakgwata, Ga-					- A72A		
		Malokela, Ga-Mar	npote, Ga-Ma	aselela, Ga-Moko	opane, Kobe, Kutump	a, Kwaring, Manye	, A63A		
Manye extension, Miltonduff 1, Mokumuru, Mongalo, Sesalong, Udney 1, Werden									
Available mon	Available monitoring locations for trend analysis – Water Levels								
Nama	Start Data	End Data	Count	Max water	Min water level	Mean water	Fluctuation		
INdifie	Start Date	End Date	Count	level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)		
A6N0580	2007/11/20	2021/09/30	6801	34.21	24.15	28.26	10.06		
A6N0582	2007/01/25	2020/12/18	3924	24.47	14.28	22.25	10.19		
A6N0590	2007/08/29	2021/08/13	9259	49.52	26.12	34.44	7.00		
A6N0595	2008/02/20	2019/04/16	2956	20.38	15.96	18.49	4.42		
A6N0606	2011/11/03	2021/08/19	6461	46.31	38.78	42.36	7.53		
A6N0579	2005/09/08	2020/12/15	7548	70.11	49.25	56.21	20.86		
A6N0592	2007/09/04	2021/09/20	2133	5.49	2.44	4.34	3.05		
A6N0608	2010/02/15	2018/01/22	7421	37.74	26.34	31.59	11.41		
Water Level G	Water Level Graphs								
0-									
					A A A A A A A A A A A A A A A A A A A				
		Ŷ							
20-									



2005		2010		2015		2020				
			Da	te						
Available monitoring locations for trend analysis -Water Quality (Chemistry)										
Name	Start Date	End Date	Count	Max NO <sub>3</sub> +NO	2 Min NO <sub>3</sub> +NO <sub>2</sub>	Median NO <sub>3</sub> +NO <sub>2</sub>	Exceed Drinking			
				conc. (mg/L)	conc. (mg/L)	conc. (mg/L)	Water guideline			
89885	1996/06/11	2017/09/20	39	29.70	3.92	19.83	Yes			
89886	1997/06/04	2017/09/20	37	109.00	1.80	66.15	Yes			
89870	1996/06/11	2017/09/12	42	70.62	0.47	39.17	Yes			
90039	1996/06/05	2017/04/10	38	152.15	7.80	68.35	Yes			
Water Quality Graph and Piper Plot										

Water level (m)

60-





Comments

The observed hydrographs for each of the stations show a fluctuation of between 3 and 21 m. The overall trend for most monitoring stations indicate a decrease in water levels. A significant decrease of approx. 21 m is observed at station A6N0579. Monitoring stations A6N0592, A6N0595 and A6N0582 show limited water level fluctuations and an overall increasing trend.

Nitrate concentrations is elevated for all monitoring stations. The nitrate concentration graph show significant fluctuations at stations 89886 and 90039. Stations 89885 and 89870, indicate fairly constant nitrate concentrations over the time period.

The groundwater signature is dominated by both HCO₃ and Cl-anion water facies, indicating freshly recharged groundwater undergoing mineralisation.


# 2.4. UPPER SAND

The Sand River originates south of Polokwane and drains the eastern part of the Limpopo WMA. The River traverses semi-arid terrain before passing through the gorge at the Soutpansberg mountains. The catchment has exceptional groundwater reserves which have been heavily exploited. The water requirements are large compared to the rest of the study area, with irrigation the largest water user. One Subterranean government water control areas occur within the drainage region namely, Dendron-Vivo (Houdenbrak). In this assessment three GUAs have been delineated for the Upper Sand drainage area, namely A71-1 (Figure 30), A71-2 (Figure 31) and A71-3 (Figure 32). The area is characterised by high transmissivities and as a result has good groundwater potential (Table 35).

Drainage system	GUA	Info	BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (I/s for 24hrs)	Blow Yield (l/s)
Linner Cond	A71-1	Ν	454	565	105	59	121
Opper Sand		Mean	53.4	16.0	32.4	1.4	4.9
Middle Cond	A71-2	Ν	777	633	126	53	222
winddie Sand		Mean	54.6	25.7	32.0	1.3	2.4
llout	A71-3	Ν	736	1004	175	80	163
поц		Mean	66.3	25.1	52.7	1.5	2.8

### 2.4.1. Groundwater recharge

The climate of the Upper Sand is semi-arid with mean annual rainfall spatially varying between 350 mm and 700 mm (Error! Reference source not found.). The flat and almost featureless plateau can be described as an extremely old erosion surface underlain by crystalline bedrock into which several mature rivers have incised themselves. Low and variable rainfall together with evaporation rates (2000 mm) considerably exceeding rainfall result in a low expectation of natural recharge to groundwater. Recharge vary from approximately 10 mm/a to less than 3 mm/a north of Mogwadi. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 36.

CD4A	CUA	Quet	МАР	Area	GR	Vegter (1995)	
GWA	GUA	Quat	(mm)	(km²)	(Wet) Mm <sup>3</sup>	(Dry) Mm <sup>3</sup>	Mean Mm <sup>3</sup>
Upper Sand	A 71 1	A71A	468.3	1144	16.71	11.48	5.18
	A/1-1	A71B	450.4	882	9.99	6.81	5.70
	A71-2	A71C	417.8	1331	10.43	7.04	4.95
Middle Sand		A71D	390.0	892	2.39	1.60	3.33
		A71H	490.8	1012	15.07	10.40	8.91
		A71E	420.8	893	6.38	4.31	4.86
llout	A71-3	A71F	400.2	683	4.29	2.88	3.67
Hout		A71G	427.2	875	4.80	3.26	4.59
		A72A	464.5	1908	19.96	13.72	5.55

Table 36. Recharge estimation (Upper Sand).

### 2.4.2. Groundwater Use

The groundwater use for each of the GUA associated with the Upper Sand River system is summarised in Table 37. The present WARMS groundwater use data was compared to the 2015 Limpopo (WMA) North Reconciliation Strategy (LNRS) estimated 2020 use.

GMA Description	GUA	Quat	WARMS: Use Mm <sup>3</sup>	LNRS 2020 Mm <sup>3</sup>	
Linney Cand	A 71 1	A71A	32.032	47.470	
Opper Sand	A/1-1	A71B	5.620	13.217	
		A71C	18.898	25.263	
Middle Sand	A71-2	A71D	6.510	6.000	
		A71H	15.210	3.762	
		A71E	9.705	8.723	
Hout	471.2	A71F	6.294	7.752	
HOUL	A/1-3	A71G	12.571	11.127	
		A72A	16.248	24.017	

### Table 37. Groundwater use (per annum) as registered per catchment for each GUA.

# 2.4.3. Groundwater quality

Groundwater samples in the Upper Sand region vary from a Na-HCO<sub>3</sub> to a Na-Mg-HCO<sub>3</sub> and Na-Cl water type. A high percentage of samples relate to a fresh recharge type (Ca/Mg-HCO<sub>3</sub>) water, while cation and anion exchange process may be occurring within the strata hence Na-Cl type water present (Figure 29).



Figure 29. Piper diagram for the Upper Sand drainage region.

Groundwater quality in the Upper Sand region is considered to be marginal to poor with the most notable elements of concern include NO<sub>3</sub> as N with average concentrations above the maximum allowable recommended drinking limit in the (Table 38). In addition, some samples showed elevated major ion concentrations (e.g. Cl). This can mostly be related to evaporative concentration of elements in discharge areas or due to low recharge values as well as long residence times for selected samples.



GUA		рН	EC	TDS	Са	Mg	Na	к	SO₄	Cl	NO₃ as N	F
DWAF Cla	ss I	5-6 or 9-	70-150	450- 1000	80-150	30-70	100- 200	-	200- 400	100- 200	6-10	0.7-1
DWAF Class II		4-5 or 9.5- 10	150-370	1000- 2000	150- 300	70- 100	200- 600	-	400-600	200- 600	10-20	1-1.5
DWAF Cla	ss III	3.5-4 or 10-10.5	370-520	2000- 3000	>300	100- 200	600- 1200	-	600- 1000	600- 1200	20-40	1.5- 3.5
A 71 1	Ν	178	180	167	204	201	203	203	198	204	32	179
A/1-1	Median	8.1	87	650	40.9	35.6	86.4	6.2	26.0	68.4	24.9	0.4
A71 0	Ν	156	143	136	164	165	164	164	150	166	29	142
A/1-2	Median	8.0	125	962	57.2	54.4	129.5	7.6	34.8	122.7	44.9	0.3
471.2	Ν	320	322	347	389	387	386	385	384	389	39	287
A/1-3	Median	8.1	109	826	47.7	46.4	111.4	9.9	27.6	140.4	23.8	0.3

#### Table 38. Groundwater quality for the Upper Sand region (All units in mg/l, EC in mS/m). (red text exceeds Class III)

# 2.4.4. Groundwater contribution to baseflow

Alluvium is present to various degrees in all the major surface water drainage courses grading from clay through sand to pebbles and in places is covered superficially by deposits of calcrete. In general, the thickness and lateral extent of the alluvium increases down-gradient towards the north. The porous nature of the alluvium makes this a natural repository for groundwater recharged periodically from ephemeral flows in the drainage courses. However, the natural groundwater-surface water interaction has been modified by the artificial recharge of treated sewage effluent that is continuously being discharged from the municipal sewage treatment works into the Sand River. This effluent is either abstracted directly from the Sand River by some riparian farmers downstream for irrigation purposes or it serves as a source of recharge of the groundwater stored in the alluvium. Comparison of groundwater contribution to baseflow estimates for the Upper Sand drainage region are summarised in Table 39.

Description	GRU	Quat	Hughes Mm <sup>3</sup> /a	Shultz Mm³/a	Pitmann Mm <sup>3</sup> /a	GRA II (WR2005) Mm <sup>3</sup> /a	Maint. Low flow Mm³/a
Upper	A 71 1	A71A	0.13	-	-	-	0.03
Sand	A/1-1	A71B	0.01	-	-	-	0.42
Middlo	A71-2	A71C	0.01	-	-	-	0.24
Sand		A71D	-	-	-	-	0.12
Sanu		A71H	0.19	-	-	-	0.75
		A71E	-	-	-	-	0.37
Hout	A 71 0	A71F	-	-	-	-	0.23
поис	A71-5	A71G	-	-	-	-	0.02
		A72A	0.34	-	-	-	0.06

#### Table 39. Groundwater contribution to baseflow estimates.

### 2.4.1. Summary

The following tables provide a summary for each of the GUA, as illustrate in Table 40, Table 41 and Table 42.



# Table 40. Summary information for GUA: A71-1

GUA	Upper Sand A71-1										
Description	The GUA is characteri	sed by intergranular	and fractured aqui	fer system associated	with the Limpopo Mobile Belt.						
-	The groundwater pote	ntial of the Hout Rive	r Gneiss is in genera	al moderate to good v	vith yield between 0.5 to 2.0 L/s.						
	High yielding boreholes in the Hout River Gneiss appear to be related to pegmatite occurrences in the area.										
	Groundwater in the gneisses is also obtained in deep basins of weathering and transitional zones between										
	weathered and solid g	weathered and solid gneiss. The groundwater potential of granite intrusive (batholiths), forming distinct inselbergs is									
	generally poor, howey	generally noor however horeholes located along the contact zones of these hatholiths provide the highly productive									
	boreholes. Associated	with the Sand River	is a intergranular a	alluvial aquifer system	n. Due to its limited extent and						
	saturated thickness th	ese aquifers are also	vulnerable to over	-abstraction during n	eriods of drought when there is						
	little or no recharge	The river section is	characterised by a	two-lavers intergran	ular and fractured aquifer with						
	groundwater vield ab	ove 51/s The group	dwater is associate	d with irrigation wa	ater supply schedule I mining						
	industrial livestock wa	itering and aquacultur	ral uses		iter supply, seneduce i, mining,						
Catchmonts											
Man	A71A,B										
Iviap											
A=5.0		Legend	••	A7N0698	Legend						
Water Supply (m3)	Mining (m3)	Industral non-urban (m3)	Irrigation (m3)								
• 1	• 1 000	• 1	• 1		Water Level Geosite						
o 1 000	• 100 000	• 1 000	• 1 000	Aller and a L	HYDRSTRA Geosite						
O 1 000 000	10 000 000	1 000 000	10 000 000		Main Rivers						
	Industrial Urban (m3)	Livestrock (m3)	Aquaculture (m3)		Rivers Study Area						
100	• 1	• 1	• 1 000		• Catchment						
100,000	• 1 000	100	<ul> <li>10 000</li> <li>100 000</li> </ul>		Geology						
A72 E	1 000 000	100 000			QUATERNARY						
		V V WWW	STATA O		Diabase						
		Y Y Y Y Y Y Y Y Y Y Y Y Y	A7N0653	182773	Transvaal SPGRP						
	0.00	V V		- 69	WOLKBERG						
			6654 8 V V A7N0633		Limpopo Belt						
P			v) vev	Y	GOUDPLAATS GNEISS						
	IPOPO		v v v		HOUT RIVER GNEISS						
A62E A/10035	Aindess Ai	V0642 Y Y Y Y Y Y			LUNSKLIP GRANITE						
· · · ·	V V AA7N0637	A7N0586 - A A7N0525			MOLETSI GRANITE						
		A7Ngo2g									
	A A A A A A A A	AZNOBATION	AV2B		PIETERSBURG						
1.9											
• •/ •/ •		Polokwane		+++							
N D. A A		lo549 A7No636									
A V S COURT A											
X X X A A											
289685 A7N0639											
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	m /	nies	1 million	Esri, NASA, NGA, USGS. Esri South Afri 2046.	ca, Esri, HERE, Garmin, FAO, MEH/NASA, USGS m						
		13	and the second	The States States							
Figure 30 Man	showing GIIA A71-1 w	ith geology, ground	iwater use and ge	en-sites.							

Water Use Schemes (after DW)	AF, 2015, Recon Study)	
Scheme Name	Village/Settlement	Catchment
Badimong RWS	Badimong, Bergvley, Ga-kole, Ga-Mailula, Ga-Makgoba, GaMamphaka, Ga-Moropo, Ga-	A71B
	Silwane, Katzenstren, Kgatla, Kgwara, Komaneg, Lebowa, Leswane, Masealama,	
	Melkboom, Mongwaneng, Moshate, Thema, Thune, Tsware	
Laaste Hoop RWS	Laaste Hoop Ward 7, Maboi, Manthorwane, Mogoloe, Tsatsaneng	A71B
Mankweng RWSS	Ga-Magowa, Ma-Makanye, Ga-Ramogale, Ga-Thoka, Makgwareng, Mankweng A,	A71B
	Mankweng B, Mankweng C, Mankweng D, Mankweng unit E, Mankweng unit F,	
	Mankweng unit G, Moshate, Tsatsaneng, University of the North	
Mapela RWS	Danisane, Ditlotswane, Ga-Chokoe, Ga-Magongoa, Ga-Mokaba, Ga-Molekana, Ga-Pila	A61F A61G
	Sterkwater, Ga-Tshaba, Hans, Kgobudi, Kwakwalata, Lelaka, Maala Parekisi, Mabuela,	A62B A62F
	Mabusela, Mabusela Sandsloot, Machikiri, Magope, Malokongskop, Masahleng,	A71B
	Masenya, Masoge, Matlou, Matopa, Mesopotania,, Millenium Park, Mmahlogo,	
	Mmalepeteke, Phafola, Ramorulane, Rooiwal, Seema, Sekgoboko Sekuruwe, Skimming,	



		Tshamahansi, Witrivier, Fothane, Mohlotlo Ga-Malebana, Mohlotlo Ga-Puka									
Moletje Ea	ast Regional	Chokoe, Ga-Mabotsa, Hlahla, Kobo, Mabitsela, Mabotsa 1, Mabotsa 2, Makibelo,									
Groundwater	SS	Mashita, Masobohleng, Matikireng, Ramongwane 1, Ramongwane 2, Semenya, Setati									
Mothapo RWSS Cottage, Ga-Mothiba, Makotopong 1, Makotopong 2, NobodyMothapo, Nobody-											
		Mothiba and Ntsh	nichane								
Olifants-Sand	RWSS	Bloedrivier, Bergnek Greenside, Kgohlwane, Mabotsa, Makgove, Mokgokong,									
		Pietersburg, Seshego, Sepanapudi, Toska, Mashinini, Seshego, Toska Mashinini, Zone 6,									
		Perskebult Ext 1&2, Polokwane, Montinti Park, Dalmada S/H, Doornbult S/H, Elmadal									
		S/H, Geluk S/H, I	vydale, Mooifo	ontein S/H, Myr	igenoeg S/H, Palmieti	fontein S/H A, B &	С,				
		Tweefontein S/H,	Roodepoort S	/H, Polokwane	SDA3						
Segwasi RWS	S	Jack and Mohlake	ng				A71B				
Available mon	itoring locations	for trend analysis -	- Water Level	s							
Name	Start Date	End Date	Count	Max water	Min water level	Mean water	Fluctuation				
	otartoate			level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)				
A7N0029	1985/04/15	2021/09/13	2597	8.41	1.70	6.16	6.71				
A7N0525	1975/05/07	2021/09/23	2871 34.13 13.74 22.03		22.03	20.39					
A7N0538	1973/11/12	2021/09/13	4866	30.63	3.31	5.42	27.32				
A7N0539	1973/11/13	2021/09/13	4656	20.71	1.89	4.39	18.82				
A7N0549	1971/11/05	2021/09/13	6521	21.09	2.07	7.15	19.02				
A7N0561	1973/11/12	2021/02/15	3746	16.74	2.57	7.65	14.17				
A7N0586	1989/06/05	2021/09/13	9169	20.48	1.69	7.39	18.79				
A7N0629	2007/07/31	2021/09/23	4028	19.56	4.01	12.23	15.55				
A7N0631	2005/03/14	2018/02/08	2038	3.47	1.08	2.65	2.39				
A7N0632	2005/06/20	2018/06/18	1890	4.13	1.83	3.08	2.30				
A7N0633	2006/03/13	2021/09/17	7429	19.96	12.21	15.44	7.74				
A7N0636	2005/02/25	2017/04/21	6964	11.11	4.08	7.59	7.03				
A7N0637	2005/07/14	2018/04/03	8691	14.49	5.11	9.07	9.38				
A7N0639	2006/07/04	2021/06/08	3541	34.08	28.25	30.20	5.83				
A7N0642	2007/11/10	0 2021/09/17 5612 16.81 10.47 13.45									
A7N0646	2006/10/10	2021/09/13	4240	10.05	4.16	6.09	5.89				
A7N0647	2006/08/10	2021/09/23	3804	8.42	2.25	4.24	6.16				
A7N0653	2008/03/11	2021/09/23	4654	19.63	12.75	15.62	6.88				
A7N0654	2008/04/16	2021/09/15	14951	48.03	26.76	34.95	21.27				
A7N0655	2008/06/11	2021/09/17	8195	37.34	12.83	18.78	24.51				

# Water Level Graphs







						•••••••••••••••••••••••••••••••••••••••						/
	Name	Start Date	End Date	Count	Max	NO <sub>3</sub> +NO <sub>2</sub>	Min	NO <sub>3</sub> +NO <sub>2</sub>	Median	NO <sub>3</sub> +NO <sub>2</sub>	Exceed	Drinking
					conc.	(mg/L)	conc.	(mg/L)	conc. (mg/l	.)	Water gui	deline
	89692	1997/05/26	2004/04/30	15	3.203		0.09		0.25		No	
	89693	1997/09/15	2017/09/18	34	11.80		0.03		1.85		Yes	
												-



#### Comments

The observed hydrographs for each of the stations show a fluctuation of between 2 and 27 m. Declining groundwater levels is observed at specific monitoring stations e.g. A7N0586 and A7N0549, overall groundwater levels appear to have recovered back to long term averages due to above average rainfall in late 1990s and early 2000's.

The nitrate concentration graph (89693) show a significant increase (> 10 mg/l) in observations during from 2008 to 2010 followed by a decreasing trend to around 2 mg/l, currently.

The groundwater signature is dominated by HCO<sub>3</sub> anion water facies, indicating freshly recharged groundwater that had limited time to undergo mineralisation.



## Table 41. Summary information for GUA: A71-2

GUA	Middle Sand A71-2									
Description	The groundwater potential of the Hout River Gneiss, Limpopo Mobile Belt, is high with yielding values > 5 l/s. The									
	thickness of the regolith is typically between 15 and 50 metres below surface. Alluvial aquifers are recharged during									
	periods of high stream-flows as well as during the rainfall season. Due to its limited extent and saturated thickness									
	these aquifers are also vulnerable to over-abstraction during periods of drought when there is little or no recharge.									
	Borehole yields generally range between $0.1 - > 5$ l/s fir the GUA. Fractured rocks associated with the Karoo									
	unergroup is located furthest reaches towards the north of the GIIA close to the Sandsloot River. The groundwater									
	use is associated with irrigation, water supply, industrial, schedule I, mining and livestock watering.									
Catchments										
Man										
Legend	A8eF Legend									
Water Level G	Sensite 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000 000 1 000									
	ABOBIOURANSERG WOUNTAIN 0 1 Industral non-urban (m3)									
WMS Geosite										
2 Main Rivers										
Rivers Study										
Catchment	A <sup>7</sup> Nv533 100 Livestrock (m3)									
Geology										
QUATERNAR	Y A7N644 ANN6571 100 100									
Alluvium										
Diabase	7667 A7N0667									
Karoo SPGRP										
KAROO										
Limpopo Belt										
BANDELIER										
GNEISS										
HOUT RIVER										
LUNSKLIP G										
MATOK GRAN	NITE BRN0510									
MOTHIBA	BBNotas									
PALMIETFON										
SIBASA	ATTNODGING AND									
GRANITE										
TSHIFHEFHE										
TURFLOOP O	GRANITE 0558 A7N0661 A7N0661 N									
WYLLIES PO										
ZANDRIVIER	SPOORT Greater Letaba									
	0 5 10 20 30 Kilo Bearly 5 <sup>85</sup>									
LIME	Ag1B Ean, NASA-NGA, USGS, Ean South Africe, Ean, HERE, Garnin, FAO, METI/NASA, USGS B8N0514									
Eigung 21 Mars	chewing the distribution of CUA A71. 2 with geology wate use and geo sites									
rigure 31 Map	snowing the distribution of GUA A / 1-2 with geology, wate use and geo-sites									

water Use Schemes (after DWAF, 2015, Recon Study)								
Scheme Name	Village/Settlement	Catchment						
Alexandra Scheme	Alexandra Scheme /							
Bandelierkop Supply	Bandelierkop Supply	A71D						
Botlokwa GWS	Ga-Phasha, Makgato, Mangata, Matseke, Mphakane, Ramatjowe, Sekakene, St	A71C						
	Brendans Mission School							
Makhado Air Force Base	Makhado Air Force Base	A71D A71H						
Supply								
Makhado RWSS Tshikota, Louis Trichardt, Tshikota Squatter								
Molemole LM Farms Supply	Molemole LM Farms Supply	A71D						
Nthabiseng RWS	Capricorn Park, LCHMorebeng, Nthabiseng	A71C						
Ramakgopa GWS	Eisleben, Mokganya, Ramakgop	A71C						
Rietgat GWS	Rietgat (ZZ2)	A71C						
Sinthumule/Kuta ma RWSS	Diiteleni, Midorini, Tshikhodobo, Dzumbathoho, Zamenkom, Tshikwarani B, Makhita,	A71D A71G						
Tshikwarane, Raphalu, Ha-Manavhela, Muduluni, Muraleni Block B, Muraleni Block C,								
Ha-Madonga, Ravele, Ha Mamburu, Gogobole, Tshiozwi, Ha-Ramahantsha, Ramakhuba,								
Madombidzha Zone 1, Madombidzha Zone 2, Madombidzha Zone 3, Rathidili, Ha-								
	Magau, Mutavhani, Raliphaswa, Siyawoodza, Moebani and Mutayhani							



Available monitoring locations for trend analysis – Water Levels											
Name	Start Data	End Data	Count	Max water	Min water level	Mean water	Fluctuation				
	Start Date	End Date	Count	level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)				
A7N0019	1983/05/17	2021/07/12	10010	16.02	4.00	10.91	12.02				
A7N0041	1989/09/20	2021/09/23	3361	14.99	3.63	6.05	11.36				
A7N0593	1993/08/10	2021/09/16	2054	37.11	27.64	30.67	9.47				
A7N0638	2006/09/12	2018/05/30	2399	21.47	19.05	20.37	2.41				
A7N0643	2007/06/27	2021/09/23	10817	38.07	23.61	28.85	14.46				
A7N0656	2010/09/20	2021/09/20	4308	26.84	21.04	22.67	5.80				
A7N0657	2011/11/02	2021/09/14	998	45.39	43.01	43.54	2.38				
A7N0663	2018/09/18	2021/09/14	10	26.67	25.15	26.11	1.52				

#### Water Level Graphs



Available monitoring locations for trend analysis -Water Quality (Chemistry) Max NO<sub>3</sub>+NO<sub>2</sub> Min NO<sub>3</sub>+NO<sub>2</sub> Median NO<sub>3</sub>+NO<sub>2</sub> Exceed End Date Name Start Date Count conc. (mg/L) conc. (mg/L) conc. (mg/L) Water guideline 90081 1995/06/23 2017/04/19 40 18.80 0.03 6.56 Yes



#### Comments

The observed hydrographs for each of the stations show a fluctuation of between 2 and 15 m. A response in water levels as a result of recharge events is observed for these monitoring boreholes. The majority of water levels are deeper than 20 m. A decrease in groundwater levels have been observed up to the late 1900's, following a recharge event resulting in a slight recovery of the groundwater levels. An overall decrease in the groundwater levels since the recharge event can be observed. The nitrate concentration graph show extreme fluctuations from 2012 to 2017 (exceeding 10 mg/l). The groundwater signature is dominated by HCO<sub>3</sub> anion water facies, indicating freshly recharged groundwater that had limited time to undergo mineralisation.

Drinking



# Table 42. Summary information for GUA: A71-3

GUA	Hout A71-3								
Description	Borehole yields generally range between $0.1 - 5$ l/s The groundwater potential of the Hout River Gneiss is in								
	general moderate to good yielding > 5 l/s. High yielding boreholes in the Hout River Gneiss appear to be related to								
	pegmatite occurrences in the area. Water in the gneisses is also obtained in deep basins of weathering and								
	transitional zones between weathered and solid gneiss. Deep weathering in excess of 40m is not uncommon in the								
	gneiss. The thickness of the regolith in the generally extends to between 15 and 50 metres below surface. Below the								
	weathered zone is a zone of fracturing, which according to geohydrological studies done by Dziembowski (1976) and								
	Jolly (1986) in the Dendron/Mogwadi area may extend to depths greater than 120 m. The groundwater potential of								
	granite intrusive (batholiths), forming distinct inselbergs is generally poor, however boreholes located along the								
	contact zones of these batholiths provide the highly productive boreholes. Intergranular and fractured rocks from								
	the Karoo supergroup is located in the west, close to Bodi are, with yields below 2L/s. The Blouberg Mountains.								
	Soutpansberg and Waterberg Group form the sedimentary rocks towards the north of the GUA, with yields ranging								
	from 0.5L/s to above 5L/s. The groundwater use is associated with irrigation, water supply, schedule I, industrial and								
	livestock watering.								
Catchments	A71E,F,G,A72A								
Мар									
Legend	A63B A62B Legend								
• Water Level Geosi	te A63D. A6N8573								
HYDRSTRA Geos	e								
A Main Rivers									
2- Rivers Study Area	2057/m/								
Catchment	0 A7/NODD9 A7/NOD09 A7/NO								
QUATERNARY	A6N8582 00 100 100 100 100 100 100 100 100 100								
Diabase	A7N0648 A7N0670 A7N0667 A7N0667 A7N0664								
Karoo SPGRP	4 000								
CLARENS	Mining (m3)								
BOSBOKPOORT									
TSHIPISE	Industrial Urban (m3)								
Blouberg GRP									
Soutpansberg GRP									
FRIPP	A62H								
Waterberg GRP	a <u>Angle</u> a Angle a Constant of Angle a Consta								
KRANSBERG	62G								
MAKGABENG									
SETLAOLE     Transvaal SPGRP	At a Livestrock (m3)								
BLACK REEF									
Limpopo Belt	6604 A7No683 100 000								
GOUDPLAATS	ATTION ATTI								
GNEISS									
HUGOMOND GRA	ATN05350 0 45N0597								
LUNSKLIP GRANI									
	E AJNgo29 A72B								
UITLOOP GRANIT	E Abin0599 - A Abin0599 - Abin0599 - A Abin0599 - Ab								
WYLLIES POORT									
ZANDRIVIERSPO	ORT								
C CIDNON	A61J								
Figure 32 Map	showing GUA A71-3 with geology, groundwater use and geo-sites.								

Water Use Schemes (after DWAF, 2015, Recon Study)								
Scheme Name	Village/Settlement	Catchment						
Aganang East GWS	Chloe A, Chloe B, Damplats, Eerste Geluk, Ga-Ngwetsana, GaRamoshwane, Kgabo Park,							
	Preezburg, Ramatlwane, Rampuru, Rapitsi, Ga-Mmabasotho, Ga-Modikana, Ga-Phago,							
	Ga-Piet, GaRankhuwe, Kalkspruit 1, Lehlohlong, Vischkuil, Wachtkraal and Ga-Nonyane							
Aganang North GWS	Ga-Maboth, Ga-Mantlhodi, Ga-Mosehlong, Ga-Motlakgomo, Kanana, Mohlajeng, Ga-	A62H A71E						
	Kolopo, Ga-Maribana, Ga-Phagodi, Marowe, Modderput, Sekuruwe 2, Ga-Moropa, Ga-	A72A						
	Mankgodi, GaKeetse, Ga-Dikgale, Uitkyk and Terbrugge							
Buysdorp Scheme	Buysdorp Scheme	A71G A72A						
Houtrivier RWS	Koloti, Kamape 1, Komape 2, Komape 3, Mabukelele, Madikote, Mamadila, Moshate,	A62E A62H						
	Ramagaphota, Cristiana, Ga-Kgoroshi, GaSetshaba, Helena, Kalkspruit, Magongoa,	A71E A71F						
	Vlaklaagte and Waschbank							



Makgalong A & B GWS Makgalong A and Makgalong B					A71E					
Mogwadi Wu	thsdorp GWS	Fatima, Ga-Madik	ana, Koniggra	tz, Mogwadi, Mo	ohodi, Wurthsdorp		A61E A71E			
							A71G A72A			
Molemole W	est Individual	Ga-Mollele, Sche	llenburg A, S	Schellenburg B,	, Ga-Broekmane, Ga	Mokwele, Brillian	t, A71G A72A			
GWS		Koekoek, Ga-Poo	pedi, Bouwlus	st, Brussels, Ga-	Mokgehle, Schoonve	ld 1, Schoonveld 2	2,			
		Reinland, Ga-Kga	re, Ga-Sako,	Sakoleng, Ove	rdijk West, Ga-Mad	ikana, Wurthsdor	D,			
		Mogwadi, Fatima,	Iogwadi, Fatima, Mohodi and Koniggratz							
Moletje Ea	ast Regional	Chokoe, Ga-Mab	okoe, Ga-Mabotsa, Hlahla, Kobo, Mabitsela, Mabotsa 1, Mabotsa 2, Makibelo,							
Groundwater	SS	Mashita, Masobol	nleng, Matikir	eng, Ramongwa	ne 1, Ramongwane 2	, Semenya, Setati	A71F			
Moletje North	n Groundwater	Ditengteng, Kgoro	shi (Mphela),	Kgoroshi (Thans	sa), and Mahwibitswa	ne, Manamela	A71E A71F			
SS	0.1.10									
Moletje South	GWS	Boetse, Diana, G	ia-Kgasha, Ga	i-Madiba, Ga-N	langou, GaMatlapa,	Glen Roy, Jupite	r, A61F A61G			
		Mandela Park, M	lanyapye, Ma	pateng, Matial	eng, Maune, Monior	iong, Montwane	L, A62E A62F			
		Wontwane Z, Wo	Shate, Naledi,	, Ngopane, Seb	ora, Setaniane, Segoa	anieng, Sepanapud anda Day Callag	I, A/IEA/IF			
		Songatano Sototo	, Doornsprun	i, Ga-iviapangu Maalkon 1 and	ld, Makweyd, Newi	dilus, Pax College	=,			
Olifants-Sand	R/W/SS	Bloedrivier Berg	mak Greens	ide Kaohlwar	Mahotsa Mak	n water plaats	τ Λ71Λ Λ71B			
Oniants-Sand	110035	Diotorshurg Sosh	ano Senanani	ide, Rgonwan idi Toska Masi	hinini Sechego Tock	Mashinini Zona (	5, A/1A A/1D			
		Perskehult Fxt 18	2 Polokwane	Montinti Park	Chalmada S/H Doo	rnhult S/H Flmad				
		S/H Geluk S/H Iv	vdale Mooifo	ontein S/H Myn	genoeg S/H Palmiett	ontein S/H A B &(	<u>-</u>			
		Tweefontein S/H.	Roodepoort S	/H. Polokwane S	SDA3		-,			
Sinthumule/K	uta ma RWSS	Diiteleni. Midorin	i. Tshikhodob	o. Dzumbathoł	no. Zamenkom. Tshik	warani B. Makhita	a. A71D A71G			
		Tshikwarane, Rap	, halu, Ha-Man	avhela, Mudulu	uni, Muraleni Block E	, Muraleni Block (	, A71H			
		Ha-Madonga, Ravele, Ha Mamburu, Gogobole. Tshiozwi. Ha-Ramahantsha. Ramakhuba.								
		Madombidzha Zo	Madombidzha Zone 1, Madombidzha Zone 2, Madombidzha Zone 3, Rathidili, Ha-							
		Magau, Mutavhar	ni, Raliphaswa	, Siyawoodza, M	loebani and Mutayha	ni				
Available moni	toring locations	for trend analysis –	Water Levels	5						
Name	Start Date	End Date	Count	Max water	Min water level	Mean water	Fluctuation			
Hume	Start Bate		count	level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)			
A7N0524	1965/09/10	2021/09/14	2547	35.35	21.21	31.29	14.14			
A7N0634	2004/12/01	2021/09/20	8866	37.79	23.18	27.28	14.62			
A7N0635	2006/03/09	2021/06/10	1899	11.85	6.03	7.06	5.82			
A7N0641	2007/06/27	2021/09/16	5204	41.22	19.26	29.71	21.96			
A7N0644	2007/05/31	2021/02/08	4226	82.68	77.01	78.69	5.67			
A7N0648	2005/01/18	2021/09/23	5677	15.53	7.94	10.66	7.59			
A7N0658	2012/02/20	2021/09/16	4625	14.59	9.77	12.04	4.82			
A7N0659	2010/09/29	2021/09/21	7158	47.05	35.27	39.02	11.78			
A7N0661	2012/05/07	2021/09/15	6943	14.36	5.79	10.34	8.57			
A7N0662	2013/08/13	2021/09/15	2842	72.67	62.45	66.01	10.22			
A/N0664	2018/09/18	2021/09/14	8	67.87	61.03	63.31	6.84			
A/N0665	2018/09/21	2021/09/15	10	62.72	58.57	60.41	4.15			
A/N0666	2018/09/18	2021/09/15	9	19.74	19.00	19.30	0.74			
A/N066/	2018/09/18	2021/09/15	481	54.23	51.78	51.99	2.45			
A/N0669	2018/09/18	2021/09/14	306	58.59	50.31	57.63	8.28			
A/N06/0	2018/09/21	2021/05/20	241	30.80	35.//	35.90	1.09			
A/N06/1	2018/09/18	2021/09/14	2851	58.14	35.16	48.14	22.98			
A/NU6/2	2018/09/18	2021/09/15	1940	/0.31	44.19	68.3U	26.12			
A/NU6/3	2018/09/18	2021/09/14	10	44.57	32.94	30.91	11.03			
A/NU6/4	2018/09/21	2021/05/20	481	39.67	38.20	39.12	1.4/			
10V01 (10V01 (1)	auns									







#### Comments

The observed hydrographs for each of the stations show a fluctuation of between 1 and 26 m. Station A7N0524 has the longest available data since 1956 and indicates show an overall decline in groundwater levels. Groundwater recharge events are evident during the 1980's and early 2000's, resulting in a recovery of the groundwater levels. The other stations indicate similar groundwater levels trends as A7N0524, however with a subdued reflection. A decline in groundwater levels is further observed at specific monitoring stations e.g. A7N0586 and A7N0549, overall groundwater levels appear to have recovered back to long term averages due to above average rainfall in late 1990s and early 200's. A well-identified seasonal groundwater level fluctuation is observed over most stations.

The nitrate concentration graph show a sudden increase in early 2008 (exceeding 10 mg/l). A gradual decrease in this trend was observed since 2010 to concentrations of around 4 mg/l.

The groundwater signature shows a mixed anion signature, indicating freshly recharged groundwater undergoing mineralisation with potential anthropogenic impacts.



# 2.5. LOWER SAND AND LIMPOPO TRIBUTARIES

The Lower Sand River passes through the gorge at the Soutpansberg Mountains before flowing north-east towards its confluence with the Limpopo River. Smaller urban centres (e.g. Musina) and numerous mining activities (e.g. Venetia diamond Mine) obtain water supplies from locally developed groundwater sources along the Limpopo River. Quaternary catchment A63E and A71L do not drain towards the Sand River but towards the Limpopo River via a number of smaller tributaries. Quaternary catchment A71L has the lowest rainfall and highest MAE of all of the catchments in the Sand River drainage area (tertiary catchment A71). The majority of water usage comes from the primary aquifer or directly from river flow. Numerous coalfields are being explored along the Limpopo River and north of the Soutpansberg. In this assessment the Lower Sand River have been delineated in two GUAs, namely A71-4 and A71-5, while quaternary catchment A71L have been grouped with A63E to form a separate GUA, namely A63/71-3 (Table 43).

Drainage system	GUA	Info	BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (I/s for 24hrs)	Blow Yield (I/s)
Condhuak	A 71 A	Ν	360	240	3	4	150
Sanubrak	A71-4	Mean	59.4	27.0	3.3	0.3	1.3
Lower Cond	Δ71 Γ	Ν	290	166	3	3	114
Lower Sand	A71-5	Mean	46.9	(mbgl)         (m²/day)         (l/s for 24h           240         3         4           27.0         3.3         0.3           166         3         3           24.5         3.5         0.7           348         2         2           19.6         38.2         1.4	0.7	1.4	
	A63-3/71-	Ν	562	348	2	2	161
Limpopo Tributaries	3	Mean	39.1	19.6	38.2	1.4	1.3

 Table 43. Borehole information for the Lower Sand and Limpopo Tributary drainage region

## 2.5.1. Groundwater recharge

The Lower Sand receives on average 350 mm rainfall per annum making it one of the arid areas in the Limpopo WMA (Error! Reference source not found.). Recharge are considered to be low over most of the area however, recharge can be slightly higher in the fault zones, and significantly higher in the alluvial area where no surface runoff is evident. Recharge vary from approximately 8 mm/a to less than 2 mm/a in the northeast. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 44.

<b>Fable 44. Recharge estimation</b>	(Lower Sand and	Limpopo	Tributary).
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GNA	GUA	Quat	МАР	Area	GR	A II	Vegter (1995)
GIVIA	GUA	Quat	(mm)	(km²)	(Wet) Mm <sup>3</sup>	(Dry) Mm³	Mean Mm <sup>3</sup>
Sandbrak	A71-4	A71J	396.1	1162	12.80	8.57	3.23
Saliubrak		A72B	343.9	1554	9.05	5.96	2.14
Lower Sand	A71-5	A71K	304.7	1668	9.47	6.12	0.95
Limpopo	A63-	A63E	357.9	1992	13.72	8.99	2.17
Tributaries	3/71-3	A71L	287.8	1765	9.57	6.02	0.86

### 2.5.2. Groundwater Use

The groundwater use for each of the GUA associated with the Lower and Limpopo River system is summarised in Table 45. The present WARMS groundwater use data was compared to the 2015 Limpopo (WMA) North Reconciliation Strategy (LNRS) estimated 2020 use.

GMA Description	GUA	Quat	WARMS: Use Mm <sup>3</sup>	LNRS 2020 Mm <sup>3</sup>
Condhuol	A71 A	A71J	13.921	16.519
Sanubrak	A71-4	A72B	5.472	3.622
Lower Sand	A71-5	A71K	13.970	4.877
Limnono Tributorios	A63-3/71-	A63E	24.340	4.931
Limpopo indutaries	3	A71L	22.631	0.589

Table 45. Groundwater use (per annum) as registered per catchment for each GUA.

### 2.5.3. Groundwater quality

A limited number of groundwater samples are available for the Lower Sand drainage region. Based on the piper diagram the main water types vary from a Ca/Mg-HCO<sub>3</sub>, to a Na-Cl dominance (Figure 33). Na-Cl water type is a result of prolonged residence and fluid-rock interaction times in the subsurface in areas of discharge (i.e. alluvium along rivers) or areas of low recharge.



Figure 33. Piper diagram for the Lower Sand and Limpopo Tributary drainage region.

Groundwater quality in the Lower Sandriver and Limpopo Tributary region is considered to be marginal to poor with the the most notable elements of concern include NO<sub>3</sub> as N with average concentrations above the allowable recommended drinking limit (Table 46). In addition, several samples show elevated salt content and ion concentrations (e.g. Mg and EC) beyond acceptable limits. This can mostly be related to evaporative concentration of elements in discharge areas or due to low recharge values as well as long residence times for selected samples. It should be noted, a limited number of water sample (statistical population) was available for interpretation.



GUA Para-meter		рН	EC	TDS	Са	Mg	Na	к	SO4	CI	NO₃ as N	F
DWAF Class	I	5-6 or 9- 9.5	70-150	450- 1000	80-150	30-70	100- 200	-	200- 400	100- 200	6-10	0.7-1
DWAF Class II		4-5 or 9.5-10	150-370	1000- 2000	150-300	70- 100	200- 600	-	400- 600	200- 600	10-20	1-1.5
DWAF Class III		3.5-4 or 10-10.5	370-520	2000- 3000	>300	100- 200	600- 1200	-	600- 1000	600- 1200	20-40	1.5- 3.5
A71-4	Ν	3	3	2	3	3	3	3	3	3	1	3
A71-4	Median	7.7	110	541	66.1	45.0	99.1	2.7	30.1	109.0	34.70	0.46
A71 E	Ν	4	4	3	4	4	4	4	4	4	1	4
A/1-5	Median	8.1	177	1329	102.0	81.9	159.3	5.1	104.7	223.8	36.19	0.8
A63-3/71-	Ν	2	2	2	2	2	2	2	2	2	0	2
3	Median	8.1	131	964	95.3	79.6	37.5	1.6	41.0	76.6		0.5

## Table 46. Groundwater quality for the Lower Sand region (All units in mg/l, EC in mS/m).

### 2.5.4. Groundwater contribution to baseflow

The Lower Sand and Limpopo Tributaries have a low probability of groundwater contribution to baseflow. According to baseflow data in the GRA II dataset groundwater baseflow to surface water courses does not exist in the area, hence, natural recharge must be lost through riverine vegetation and spring discharge.

## 2.5.4.1.1.Summary

The following tables provide a summary for each of the GUA, as illustrate in Table 47, Table 48 and Table 49.



# Table 47. Summary information for GUA: A71-4

GUA	Sandbrak A71-4									
Description	The main aquifer types include the Fractured aquifers associated with the Soutpansberg Group and Karoo									
	Supergroup. The Soutpansberg Group does not possess any primary porosity and groundwater occurrences are controlled by geological structures. In general groundwater yields are low. The stratified rocks of the Karoo can									
	generally be regarded as being of low groundwater potential away from structures with the inter-bedded sandstones having a moderate potential. Intergranular Alluvial aquifers (Limited to the main river stems) are recharged during parieds of high stream flows as well as during the rainfall season. The dopths of the alluvium generally decrease									
	periods of high stream-flows as well as during the rainfall season, The depths of the alluvium generally decrease away from the river. Intergranular and fractured associated with the Beit Bridge Complex cover large parts of the area with moderate groundwater potential and boreholes yield between 0.5 and 2 l/s. Ground water is entrapped in small relatively shallow, locally developed basins and troughs revealing that mechanical and chemical weathering appear to be associated with surface drainage channels. Although dykes have intruded the host rock extensively they are generally poor water suppliers. The groundwater use is associated with irrigation, water supply, schedule l,									
	recreation, mining, industrial and livestock uses.									
Catchments	A71J and A72B									
Man										
Legend										
	A7No650									
Water Level Ge	eosite									
🛛 💡 HYDRSTRA G										
💡 WMS Geosite	• 0 • 5 • 40 • 20 Kilometers									
2- Main Rivers										
Rivers Study A	rea AGNo593									
Catchment										
Geology										
QUATERNARY										
Alluvium	Recreation (m3)									
Diabase										
Karoo SPGRP										
KAROO	Not 592 and the second s									
KAROO DOLE	RITE 0 000 11 10 000 000 000 000 000 000 00									
LETABA	A0.20 . 100.000									
BOSBOKPOO	RT 10 and and									
RED ROCKS										
TSHIPISE	industrial Urban (m3)									
Soutpanberg GRP										
FRIPP	ATNOS									
SOLITUDE										
MADZARINGV	VE No668									
KLOPPERFON										
Limpopo Belt										
WYLLIES POC										
MOUNT DOW	E Irrigation (m3)									
MESSINA	1580 m 1580 m 1									
MALALA DRIF										
HOUT RIVER	GNEISS									
GUMBU	A727									
Z Z ALLDAYS GNE	EISS / A7No669 A716 34									
NZHELELE	A7N0659									
SIBASA	A7No644 370 A7No67Esri, N/SA, NGA, USGS. Esri South Africa, Esri, HERE, Garmino FAO, ME7I/MABA Clags									
SIBASA	howing GUA A71-4 with geology, groundwater use and geo-sites.									

Water Use Schemes (after DWAF, 2015, Recon Study)								
Scheme Name	Village/Settlement	Catchment						
Mapela RWS	Danisane, Ditlotswane, Ga-Chokoe, Ga-Magongoa, Ga-Mokaba, Ga-Molekana, Ga-Pila Sterkwater, Ga-Tshaba, Hans, Kgobudi, Kwakwalata, Lelaka, Maala Parekisi, Mabuela, Mabusela, Mabusela Sandsloot, Machikiri, Magope, Malokongskop, Masahleng, Masenya, Masoge, Matlou, Matopa, Mesopotania,, Millenium Park, Mmahlogo, Mmalepeteke, Phafola, Ramorulane, Rooiwal, Seema, Sekgoboko Sekuruwe, Skimming, Tshamahansi, Witrivier, Fothane, Mohlotlo Ga-Malebana, Mohlotlo Ga-Puka	A61F A61G A62B A62F A71B						
Musina LM Farms Supply	Farms Musina LM	A71J						
Waterpoort Supply	Waterpoort	A71H A71J						
Available monitoring location	ns for trend analysis – Water Levels							



				Maxwetan		Magazia	Fluetuation
Name	Start Date	End Date	Count	Max water	Iviin water level	Mean water	Fluctuation
				level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)
A7N0651	2007/10/18	2021/09/22	1 4236	40.17	33.35	36.76	6.82
A7N0652	2007/10/23	2021/09/22	1 16696	76.91	40.12	50.31	36.79
A7N0660	2010/09/29	2021/09/20	7400	54.89	43.87	48.63	11.02
Water Level O	Graphs						
0- 20- 04ter level (m)				A			Name A7N0651 A7N0652 A7N0660
	2010		:	2015	2	020	
			Da	ite			
Available mo	nitoring locations	for trend analy	sis -Water Qual	ity (Chemistry)			
Name	Start Date	End Date	Count	Max NO <sub>3</sub> +NO <sub>2</sub>	Min NO <sub>3</sub> +NO <sub>2</sub> Me	dian $NO_3 + NO_2$	Exceed Drinking
			count	conc. (mg/L)	conc. (mg/L) con	c. (mg/L)	Water guideline
				none			
Water Quality	y Graph and Pipe	Plot					
				none			
Comments							
The observed	hydrographs for	each of the stat	ions show a flu	ctuation of betw	een 2 and 36 m. Sta	tions A7N0652 and	d A7N0660 show a

The observed hydrographs for each of the stations show a fluctuation of between 2 and 36 m. Stations A7N0652 and A7N0660 show a declining groundwater level trend since the onset of monitoring in 2007. Some response in water levels as a result of recharge is evident. The average groundwater levels depths range from to 40 to 50 mbgl.



## Table 48. Summary information for GUA: A71-5

GUA	Lower Sand A	71-5							
Description	The main aq	The main aquifer types include with the Intergranular and fractured associated with the Beit Bridge Complex cover							
	large parts o	f the area with mo	derate ground	dwater potentia	al and boreholes yield	between 0.5 a	nd 2 l/s. Ground		
	water is entr	apped in small rela	tively shallow	, locally develo	ped basins and trough	s revealing that	mechanical and		
	chemical wea	athering appear to b	be associated w	vith surface dra	iinage channels. Althou	gh dykes have i	ntruded the host		
	rock extensiv	ely they are genera	lly poor water	suppliers. The	Fractured aquifers asso	ociated Soutpan	sberg Group and		
	Karoo Super	group. The Soutpan	sberg Group	does not posse	ss any primary porosit	y and groundw	ater occurrences		
	are controlle	d by geological stru	ictures. In gen	eral groundwat	ter yields are moderate	e, ranging from	0.5L/s to 2.0L/s.		
	Alluvial aquit	fers (Limited to the	e main river s	tems) are rech	arged during periods of	of high stream-	flows as well as		
	during the ra	infall season, The d	epths of the al	luvium generall	y decrease away from t	the river.			
Catchments	A71K								
Мар									
		Limps	po	and the second s	V V	1			
Legend				K	1 per	ant	Legend		
Water Level G	Geosite		• • • •	200 0000		Water Supp	bly (m3)		
📍 🎈 HYDRSTRA (	Geosite	3 5	. 0	NOTRING.	Beitbridge	0 1			
💛 💛 WMS Geosite	-	_1 ?	. 1 .			• 100	D		
- C- Main Rivers		stor)	52.	: • 0		0 100	000 000		
Rivers Study	Area		<	1. 1		Schedule 1	(m3)		
Catchment	2	ATAL S	· _ only	75. 00%.	A7N	10628 0 1			
Geology	7.	1.4 2	•	A7N0649		0 100			
QUATERNAR	Y / •	$\sim$ $) / \cdot$	1 1		Mulsing	100	000		
Alluvium		0: 1. m	1		10	• Mining (m3	)		
Karoo SPGRP		V		·		×//••• 100	D S		
KAROO	5.	A7No650		THE WEAR		• 100	000		
RED ROCKS				Se Me Pa		10 0	00 000		
				A THINK	A alt - said at the +	Industrial U	rban (m3)		
Soutpappherg GPP		• 100 n			A Ser HTD	• 1			
FRIPP	$\leq$			- 11 AM		• 100	o 🖌		
KLOPPERFO	NTEIN	all les				1 00	0000		
Limpopo Belt									
WYLLIES PO	ORT	ANT A	B			. 1			
x x SAND RIVER	GNEISS	· · · · · · · · · · · · · · · · · · ·	A71			• 100			
MOUNT DOW	/E	:				100	000		
MESSINA	•	uller and	1+++++++++++++++++++++++++++++++++++++	A7N0645		River Irrigation (n	23)		
MALALA DRI	FT B	and send			- MZ	A8Nd Ingation (I	13)		
GUMBU		7N0651	57		······	. 100	See of the second secon		
BULAI GNEIS	is i	1	00	A Pri	· · · · · · · · · · · · · · · · · · ·	10.0			
ZZ ALLDAYS GN	EISS	$\cdot \rangle \cdot \cdot \langle \langle$	.< V. 70	<u></u>			3 A80H		
SOLITUDE	* *		=	· / e		• N* • • •	5 5		
SIBASA		A7aJ .			5		204		
10		. 5		A'80F •	· · · · · · · ·	hembe			
1.	• • •	a			BN0513	ASPCIN	20 Kilometers		
••••			1.1.16.1.1	haspruite	EsA & A95 DEGA DEGS. Esro South A	frica, Esri, HERE, Garmin, FA	D. METI/NASA LISCS		
•	· · · · · ·		• • •	A8òE	A80B	EN ST.	A92A		
Figure 35 Map	showing GUA	A71-5 with geolog	gy, groundwa	ater use and g	eo-sites.				
Water Use Scheme	es (after DWAF	, 2015, Recon Stud	y)						
Scheme Name		Village/Settlemen	t				Catchment		
Mopane Supply	pane Supply Mopane A71K								
Musina RWS Musina (Messina), Harper, Harper Industrial, Lost City (Cambell), Musina Military Base, A71K A71L									
		Nancefield	. , ,			, -	A80G		
Available monitor	ing locations fo	or trend analysis – \	Nater Levels						
				Max water	Min water level	Mean water	Fluctuation		
Name	Start Date	End Date	Count	level (mhøl)	(mhøl)	level (mhøl)	(min-max) (m)		
A7N0628	2006/05/10	2021/06/00	6328	22.24	1 01	8/6	18 20		
A7N0645	2000/05/15	2021/00/03	10652	<u> </u>	73 20	36.12	16 9/		
Water Level Grant	15	2021/03/21	10032	40.14	23.30	50.16	10.04		





The observed hydrographs for each of the stations show a fluctuation of between 16 and 18 m. Groundwater level monitoring stations show a significant response to recharge events with variable (and seasonal) fluctuations.

The nitrate concentration graph show a sudden increase in observations during 2012 followed by a decreasing trend to around 2 mg/l, currently. The groundwater signature is dominated by a mix between  $HCO_3$ , Cl and  $SO_4$  anion water facies, indicating groundwater undergoing mineralisation.



# Table 49. Summary information for GUA: A63-3/71-3

GUA	Limpopo Trib	utary Sand A63-3/7	'1-3							
Description	The main aqu	uifer types include	the Fractured	aquifers associ	ated with the Karoo	Supergroup and	Soutpansberg			
	Group. The st	Group. The stratified rocks of the Karoo and Soutpansberg can generally be regarded as being of low groundwater								
	potential awa	potential away from structures with the inter-bedded sandstones having a moderate potential, with yield ranging								
	from 0.1L/s to	o 2.0L/s. Intergran	ular Alluvial ac	uifers from the	Limpopo River are re	charged during p	eriods of high			
	stream-flows	stream-riows as well as during the rainfall season and is associated with high yielding potential, above 5L/s. The								
	deptns of the	depths of the alluvium generally decrease away from the river. Intergranular and fractured associated with the								
	between 0 5	and 2 1/s. Groundw		e area with mo	rightion water supply	potential and bt	ing industrial			
	and livestock	watering uses	valer use is as		igation, water supply	, schedule i, min	ing, industrial			
Catchments		watering uses.								
Man	AUSE, ATE									
		-	~		6	Limpopo	5 1			
N		N		pustimpo	00 - 20 - C	Company				
		LIMPOPORTive,	1 cm	AL OCH	P P REAL		Sea River			
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A63C	6-32	AGNO		11/11/	· ···		in m			
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Joz	1 C.		V V. P.	· · ·		Legend				
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	3			·	+ HYDRSTRA Geo	osite RED F	ROCKS			
· · / .(	AGNOS	169869 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	<u>.</u>		🍼 🕴 WMS Geosite	SOLIT	UDE			
1	••• (•• *	Legend	• •• 0		Main Rivers	TSHIF	ISE			
and and and a set of		Legend			Rivers Study Are	a Soutpansber	g GRP			
Water Supply (m3)	) Mining	(m3)	Livestrock (m3)		Geology		PERFONTEIN			
• • 1	0	1000	• 100	1.	QUATERNARY	Limpopo Bel				
0 1 000 000		10,000,000			Alluvium	× × BULA	GNEISS			
Schedule 1 (m3)	Inductor	al pop urban (m2)	Irrigation (m2)		A7No Diabase	GUME	iu 🖡			
1	•	1	• 1	•	Karoo SPGRP	MALA	LADRIFT			
100	•	1 000	• 1 000		BOSBOKPOOR	MESS				
100 000		1 000 000	10 000 000	000			AYS GNEISS			
	101103790			21			MOUNTAIN			
Figure 36 Map	showing GUA	A63/71-3 with ge	eology, groun	dwater use an	d geo-sites.					
Water Use Schen	nes (after DWAF	, 2015, Recon Stud	y)							
Scheme Name		Village/Settlemen	t				Catchment			
Alldays BS		Alldays	_				A63D A63E			
Makhado LM Fa	rms Supply	Farms Makhado LN	VI				A63E			
Musina RWS		Musina (Messina),	, Harper, Harp	per Industrial, L	ost City (Cambell), N	/lusina Military	A/1K A/1L			
	uine le cetiene fe	Base, Nancefield					A80G			
Available monito	oring locations fo	or trend analysis – V	water Levels				Eluctuatio			
Namo	Start Data	End Data	Count	Max water	Min water level	Mean water	riuctuatio			
ivalite	Start Date	Enu Date	Count	level (mbgl)	(mbgl)	level (mbgl)	max) (m)			
A6N0591	2007/00/00	2021/06/00	2079	13.00	10 11	12 55	2 00			
A6N0503	2007/06/08	2021/00/09	2079	13.00 21.67	10.11	20.06	2.09			
Δ7ΝΩ6/0	2007/07/03	2021/05/20	7027	10.12	1 0/1	£ 0.00	9.10 9.10			
Δ7Ν0650	2007/06/23	2021/00/09	7357 2727	10.15 22 <i>I</i> /7	1.04	10.21	5.09			
Water Level Gran	ohs	2021/03/21	2121	23.77	17.40	13.43	5.55			





show a decreasing trend during poor recharge seasons.

The nitrate concentration graph show a some fluctuations exceeding 10 mg/l but are for most part around 2 mg/l. The groundwater signature is dominated by a mix between HCO<sub>3</sub>, Cl and SO<sub>4</sub> anion water facies, indicating groundwater undergoing mineralisation.



# 2.6. NZHELELE

The Nzhelele River comprises a perennial reach upstream of the Nzhelele Dam with considerable water abstraction. The upper reaches, which flow through forestry areas and steep mountainous areas, have several red data species. The waterfalls along several of the river reaches in the mountainous areas create breaks which prevent migration of fish species. Numerous flow dependent species occur in the upper Nzhelele and its tributaries. Although the groundwater is used extensively in certain areas, any additional water requirements for domestic use will have to be sourced from groundwater and groundwater still has potential for future use. In this assessment the Nzhelele have been delineated in two GUA, namely A81-1 (Figure 38) and A81-2 (Figure 39).

Drainage system	GUA	Info	BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (I/s for 24hrs)	Blow Yield (I/s)
Nzhelele	A81-1	Ν	387	293	72	38	138
		Mean	61.9	19.8	14.2	0.7	2
	A81-2	Ν	190	122	14	13	106
Lower inzhelele		Mean	50.9	18.6	7.1	0.6	1.5

### Table 50. Borehole information for the Nzhelele drainage region.

### 2.6.1. Groundwater recharge

The upper reaches of the drainage region drains the mountainous region to the south and has a relatively high rainfall (**Error! Reference source not found.**). For a small portion in the Soutpansberg the MAP is 1 000 mm and higher. In comparison the plains north of the Soutpansberg have a relatively low rainfall of only 300 mm per annum. Recharge vary from approximately 18 mm/a to less than 2 mm/a in the northeast. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 51.

CNAA	CUA	Quat	МАР	Area	GRA II		Vegter (1995)
GWA	00/1	Quut	(mm)	(km²)	(Wet) Mm <sup>3</sup>	(Dry) Mm³	Mean Mm <sup>3</sup>
	A81-1	A80A	938.0	287	26.11	20.40	48.27
		A80B	659.3	251	12.11	8.85	18.22
Nahalala		A80C	576.3	294	11.26	8.00	13.48
Nzhelele		A80D	621.9	128	4.59	3.30	16.30
		A80E	622.3	247	9.79	7.01	16.23
		A80F	388.1	630	7.78	5.18	3.70
Lower Nzhelele	A81-2	A80G	332.6	1230	11.84	7.76	1.72

#### Table 51. Recharge estimation (Nzhelele).

#### 2.6.1. Groundwater Use

The groundwater use for each of the GUA associated with the Nzhelele River system is summarised in Table 52. The present WARMS groundwater use data was compared to the 2015 Limpopo (WMA) North Reconciliation Strategy (LNRS) estimated 2020 use.

GMA Description	GUA	Quat	WARMS: Use	LNRS 2020
•		-	Mm³	Mm³
		A80A	1.282	0.388
	401.1	A80B	1.471	0.407
Nahalala		A80C	1.477	0.317
NZHEIEIE	A01-1	A80D	0.030	0.455
		A80E	1.235	1.563
		A80F	2.901	0.843
Lower Nzhelele	A81-2	A80G	5.495	3.151

## Table 52. Groundwater use (per annum) as registered per catchment for each GUA.

# 2.6.2. Groundwater quality

Based on the piper diagram the main water types for the Nzhelele region vary from a Ca/Mg-HCO<sub>3</sub>, to a Na-Cl dominance (Figure 37). A number of samples relate to a fresh recharge type (Ca/Mg-HCO<sub>3</sub>) water, while cation and anion exchange process may be occurring within the strata hence Na-Cl and Ca/Mg-Cl type water present.



Figure 37. Piper diagram for the Nzhelele drainage region.

Groundwater quality in the Nzhelele region is considered to be acceptable for drinking water with limited exceedances observed (Table 53). Some elevated salts (chloride) are observed for the Nwanedi region.



GUA		рН	EC	TDS	Ca	Mg	Na	к	SO4	Cl	NO₃ as N	F
		5-6 or 9-	70 150	450-	00 1E0	20 70	100-		200-	100-	6 10	071
DWAF Class	1	9.5	70-150	1000	80-130	5 50-70	200	-	400	200	6-10	0.7-1
DWAF Class II		4-5 or	150 270	1000-	150-	70-	200-		400-	200-	10.20	115
		9.5-10	150-570	2000	300	100	600	-	600	600	10-20	1-1.5
DWAF Class III		3.5-4 or	270 520	2000-	>200	100-	600-		600-	600-	20.40	1 5 2 5
		10-10.5	570-520	3000	>300	200	1200	- 1000	1000	1200	20-40	1.5-5.5
AQ1 1	Ν	142	141	132	146	145	142	120	104	137	10	106
A01-1	Median	7.8	54	409	29.6	25.3	30.4	0.6	7.8	34.5	3.1	0.2
N N		15	15	14	15	15	15	15	15	15	0	15
A81-2	Median	7.9	177	1178	73.8	63.0	139.9	1.3	60.3	208.2		0.3

### Table 53. Groundwater quality for the Nzhelele zi region (All units in mg/l, EC in mS/m).

# 2.6.3. Groundwater contribution to baseflow

In the upper catchments groundwater contributes to base flow via sub surface seepage and springs. The probability of baseflow diminishes down-gradient towards the northeast. Comparison of groundwater contribution to baseflow estimates for the Nzhelele drainage region are summarised in Table 54.

Description	GUA	Quat	Hughes Mm³/a	Shultz Mm³/a	Pitmann Mm³/a	GRA II (WR2005) Mm <sup>3</sup> /a	Maint. Low flow Mm³/a
		A80A	15.60	2.62	8.90	2.30	4.80
	A81-1	A80B	4.66	1.23	3.31	1.98	1.24
Nabalala		A80C	3.18	0.96	2.70	1.81	0.38
NZHEIEIE		A80D	1.98	0.57	1.43	0.99	0.52
		A80E	3.86	1.14	2.77	1.84	1.01
		A80F	-	-	-	-	0.01
Lower Nzhelele	A81-2	A80G	-	-	-	-	0.02

## Table 54. Groundwater contribution to baseflow estimates.

### 2.6.4. Summary

The following tables provide a summary for each of the GUA, as illustrated in Table 55 and Table 56.



# Table 55. Summary information for GUA: A81-1

GUA	Nzhelele A81-1						
Description	The Souptpansberg Mountain range forms prominent elevated topography, associated with higher recharge in						
	comparison the lower laying areas. The main aquifer types include the Fractured aquifers from the Soutpansberg						
	Group and Karoo Supergroup. The Soutpansberg Group does not possess any primary porosity and groundwater						
	occurrences are controlled by geological structures. In general groundwater yields are moderate with yields up to						
	5L/s. The Karoo supergroup, located towards the north, has low groundwater potential with yield up 0.5L/s. to The						
	Intergranular and fractured associated with the Limpopo Belt, granite-gneissic rocks, cover the central and southern						
	portion of the GUA with moderate groundwater potential and boreholes yield between 0.5 and 2 l/s. Alluvial						
	aguifers is mainly bound to the main river systems and the depths of the alluvium generally decrease away from the						
	river The groundwater use is associated with irrigation water supply schedule L recreation industrial and livestock						
	watering uses						
Catchments							
Man							
Legend	Legend						
Water Supply (m3)	Water Lovel Goosite						
	Water Lever Geostie						
o 1 000	Asharar						
0 1 000 000	A/IL A7No645 AND A						
Schedule 1 (m3)	Rivers Study Area						
1	Catchment						
- 🔵 100	Geology Geology						
100 000	QUATERNARY						
Rercreation (m3)	Alluvium						
● 10	Ale						
IO0	Karoo SPGRP						
- 🔵 10 000							
Industrial Urban (m3)	AMASTA RED ROCKS						
• 1							
• 1 000							
1 000 000							
Industral non-urban (	m3) De						
• 1							
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1 000 000							
<sup>26</sup> Livestrock (m3)							
100	A MUSEKWA BASALT						
100	Agin 配価は AgiA Agin Agin Agin Agin Agin Agin Agin						
Irrigation (m3)							
1 000	AgaC AgaC SibasA						
	Limpopo Belt						
	Agail Agail Device Poor 1 20 Kildmeters CLIMPU						
A710							
	A9N0021						
Figure 38 Map	showing GUA A81-1 with geology, groundwater use and geo-sites.						
Water Use Schem	es (after DWAF, 2015, Recon Study)						
Scheme Name	Village/Settlement Catchment						

Scheme Name	Village/Settlement	Catchment
Alexandra Scheme	Alexandra	A71H A80D
Matshavhawe / Kunda RWS	Khunda, Matshavhawe, Manyuwa, Piesanghoek	A80A A80B
Mutale Main RWS	Dzamba Tshiwisa, Dzata Ruins, Dzumbama, Fefe, Gogogo, Goma, Gundani,	A80A A80B
	Gwagwathini, Ha-Mabila, Helala, Khakhu Thondoni, Luheni, Madatshitshi, Madzororo,	A80C A80G
	Mafhohoni, Mafhohoni, Mafhohoni South, Maname, Mavhode, Mavhuwa, Mazwimba,	A80H
	Mphagane, Mufongodi, Mufulwi, Ngalavhani, Mufulwi, Ngalavhani, Sheshe, Thonoda	
	Lusidzana, Thononda, Tsaanda, Tsaanda 2 Tshiedeulu Thembaluvhilo, Tshiendeulu,	
	Tshilimbane, Tshilovi, Tshitandani, ZTshixwandza and Tshumulungwi.	
Nzhelele North RWS	Afton, Dolidoli, Garasite, Khomela, Maangani, Makushu, Mangwele, Maranikhwe,	A80B A80C
	Mudimeli, Musekwa, Musekwa Korporasi, Natalie, Ndouvhada, Ngonavhanyai,	A80E A80F
	Pfumembe, Pfumembe Tsha Fhasi, Phembani, Sane, Straighthardt, Tshitwi	A80G A80H
		A80J
Nzhelele RWS	Divhani, Domboni, Dopeni, Dzanani, Fondwe, Ha Matsa, HaFunyufunyu, Ha-Makatu, Ha-	A80A A80B



		Mandiwana Dza	nani, Ha-Ma	anngo, Ha-Maj	ohaha, Ha-Mapila,	Ha-Matidza, H	a- A80E A80F	
		Matshareni, HaMphaila, Ha-Rabali, Khalavha, Lutomboni, Luvhalani, Magoloni,						
		Makanga, Makhavhani, Makungwi, Malamba, Mamuhohi, Mamuhoyi, Mamvuka,						
		Maname Paradise	e, Mandala A	A, Mandala B,	Mandala Tshantha,	Manyii, Manyuw	a,	
		Mapakophele, Ma	atanda Zone	2, Matsa, Mat	sa A, Matsa B, Ma	tserere, Maulum	a,	
		Mavhunga, Mba	avhunga, Mbadoni, Mudunungu, Musanda Thondoni, Mutavhani, Posaito,					
		Raliphaswa, Ram	avhoya, Shar	nzha, Siloam, S	Siyawoadza, Themba	luvhilo, Thondor	ni,	
		Tshatharu, Tshav	/halovhedzi,	Tshiheni, Tshil	khalani, Tshikhalani	East, Tshikhud	0,	
		Tshikuwi, Tshirolv	ve Ext 2, Tshii	rolwe Ext1, Tshi	sinisa, Tshiswenda, T	shitasini, Tshithu	ni	
		Tshafhasi, Tshith	uthuni, Tshi	tuni, Tshituni	B, Tshituni Tshar	itha, Tshivhamb	e,	
		Tshivhilidulu, Vhutuwangazebu						
Tshifire Muru	nwa RWS	Dzumbathoho, Phadzima, Mazhazhani, Mazuwa, Gudumabama, Maelula, Vuvha, A80/						
		Matakani, Mazhazhani, Mazuwa, Murunwa, Tshedza Tshihalwe, Tshifudi B, Tshifudi A,						
		Tshidzini Tshifudi, Tshidzini, Phaswana, Mutshetshe, Mushiru, Mushiro Mahagala,						
		Musenga, Mubvumoni South, Mubvomoni North, Masiwane, Manzemba, Lukalo, Ha-						
		Lambani Tshantha	, Tshitavha, B	egwa, Buluni, Di	mani			
Available monitoring locations for trend analysis – Water Levels								
Neree	Chart Data	Find Data	Courst	Max water	Min water level	Mean water	Fluctuation	
Name	Start Date	End Date	Count	level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)	
A8N0507	2006/05/19	2020/08/18	7049	12.01	4.72	7.38	7.30	
A8N0508	2005/07/19	2021/05/25	2350	5.18	2.64	4.41	2.54	
A8N0509	2005/03/16	2021/05/25	2121	3.35	0.62	2.41	2.73	
A8N0513	2007/06/21	2021/09/22	2021/09/22 3811 11.25 7.41 9.42					
A8N0515	2006/09/20	2021/05/25	2075	10.58	3.55	5.50	7.03	

Water Level Graphs



Water Quality Graph and Piper Plot



The nitrate concentration graph show significant fluctuation but values remain less than 1 mg/l.

The groundwater signature is dominated by HCO<sub>3</sub>-anion water facies, indicating freshly reached groundwater with limited time to undergo mineralisation.



# Table 56. Summary information for GUA: A81-2

Description       The main aquifier types include the Fractured aquifiers from the Soutpansberg Group and Karoo Supergroup. The Soutpansberg Group does not possess any primary porosity and groundwater occurrences are controlled by geological structures. In general groundwater yields are moderate with yields up to 5U.5. The Karoo supergroup, located towards the north, has low groundwater potential with yield up 0.5U.5. The Karoo supergroup, located towards the north, has low groundwater potential with yield up 0.5U.5. The Karoo supergroup, located towards the north, has low groundwater potential with yield up 0.5U.5. The Karoo supergroup, located towards the main river stems) are recharged during periods of high stream-flows as well as during the rainfall season. It is an important local, major aquifer and exists in equilibrium with surface water, adjacent groundwater potential and boreholes yield between 0.5 and 2.16. Stream-low sare, sans doreate with surface drainage channels. The groundwater use is associated with inrigation, water supply, industrial and livestock watering uses.         Catchments       A80G         Map       Map         Image Channels. The groundwater use is associated with inrigation, water supply, industrial and livestock watering uses.         Map       Map         Image Channels. The groundwater use is associated with inrigation on the more than information on the supergroup. The same during the recent lives and the same during the recent lives to addite the more during the recent lives to addite t	GUA	Nzhelele A81-2
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Belogical structures. In general groundwater yields are moderate with yield up 0.5L/s. The lintergranular Alluvial aupliers Limited to the main river stems) are recharged during periods of high stream-flows as well as during the rainfall season. It is an important local, major aquifer and exists in equilibrium with surface water, adjacent groundwater yotentian due obscycts. The depths of the alluvium generally decrease away from the river. The intergranular and fractured associated with the Limpopo Belt, granite-greissic rocks, has moderate groundwater yotentian due borchelos yield between 0.5 and 2 /s. Ground water is entrapped in small relatively shallow, locally developed basins and troughs revealing that mechanical and chemical weathering appear to be associated with surface drainage channels. The groundwater yet is associated with irrigation, water supply, industrial and livestock watering uses.           Catchemits         ABOC           Man         May           Viewer obscience         Agord           Viewer obscience         May           Viewer obscience         Agord           Viewer obscience         May           Viewer obscience         Agord		Soutpansberg Group does not possess any primary porosity and groundwater occurrences are controlled by
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Returned       United to the main river stems) are recharged during periods of high stream-flows as well as during the rainfall season. It is an important local, major aquifer and exists in equilibrium with surface water, adjacent groundwater systems and ecosystems along the rivers. The depths of the alluvium generality decrease away from the river. The Integranular and fractured associated with the Limpopo Belt, granite-gnessic roots, has moderate groundwater use is associated with the relational and borcholes yield between 0.5 and 21/s. Ground water is entrapped in small relatively shallow, locally developed basins and troughs revealing that mechanical and chemical weathering appear to be associated with surface drainage channels. The groundwater use is associated with irrigation, water supply, industrial and livestock watering uses.         Catchment       ABOE         Map       The function of the stream of the		located towards the north, has low groundwater potential with yield up 0.5L/s. The Intergranular Alluvial aquifers
season. It is an important local, major aquifer and exists in equilibrium with surface water, adjacent groundwater systems and ecosystems along the rivers. The depths of the alluvium generally decrease away from the river. The integranular and fractured associated with the impopo Belt, granite-gneissic rocks, has moderate groundwater watering uses. Catchments ABO Mathematical and chemical watchmical watchering appear to be associated with surface drainage channels. The groundwater use is associated with irrigation, water supply, industrial and livestock watering uses. Mathematical and chemical watchering appear to be associated with surface drainage channels. The groundwater use is associated with irrigation, water supply, industrial and livestock watering uses. Mathematical and chemical watchering appear to be associated with surface drainage channels. The groundwater use is associated with irrigation, water supply, industrial and livestock watering uses.		(Limited to the main river stems) are recharged during periods of high stream-flows as well as during the rainfall
systems and ecosystems along the rivers. The depths of the alluvium generally decrease away from the river. The intergranular and fractured associated with the Limpopo Belt, granite-gneissic rocks, has moderate groundwater potential and boreholes yield between 0.5 and 21/6. Ground water is entrapped in small relatively shallow, locally surface drainage channels. The groundwater use is associated with irrigation, water supply, industrial and livestock watering uses.           Catchments         A80G           Map         Image: Comparison of the diverse of the allow of the diverse of the		season. It is an important local, major aquifer and exists in equilibrium with surface water, adjacent groundwater
Intergranular and fractured associated with the Limpopo Belt, granite-gneissic rocks, has moderate groundwater protential and horeholes yield between 0.5 and 2 l/s. Ground water is entraped in small relatively shallow, locally developed basins and troughs revealing that mechanical and chemical water image and to associated with surface drainage channels. The groundwater use is associated with irrigation, water supply, industrial and livestock watering uses. <b>Catchments</b> A80G <b>Tem</b> <b>Legend</b> <b>Under Under Genetic PHORER Reverses</b> <b>Number Content</b> <b>Legend</b> <b>Under Under Genetic PHORER Reverses</b> <b>Catchments</b> <b>Legend</b> <b>Under Under Genetic PHORER Reverses</b> <b>Legend</b> <b>Under Under Genetic PHORER Reverses</b> <b>Legend</b> <b>Under Under Genetic PHORER Reverses</b> <b>Legend</b> <b>Under Under Genetic PHORER Reverses</b> <b>Legend</b> <b>Under Under Genetic PHORER Reverses</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Legend</b> <b>Leg</b>		systems and ecosystems along the rivers. The depths of the alluvium generally decrease away from the river. The
potential and boreholes yield between 0.5 and 2 l/s. Ground water is entrapped in small relatively shallow, locally developed basins and troughs revealing that mechanical and chemical weathering appear to be associated with surface drainage channels. The groundwater use is associated with irrigation, water supply, industrial and livestock watering uses. A 80G Map United Level Geostie 0. UNITERNARY 0. UN		Intergranular and fractured associated with the Limpopo Belt, granite-gneissic rocks, has moderate groundwater
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surface drainage channels. The groundwater use is associated with irrigation, water supply, industrial and livestock watering uses.		developed basins and troughs revealing that mechanical and chemical weathering appear to be associated with
watering uses.     o     o     o       Catchments     ASOC       Map       Users     Users       <		surface drainage channels. The groundwater use is associated with irrigation, water supply, industrial and livestock
Catchments       A80G         Map       Legend         Usend       Legend         Water Level Goods       Musina         With Cases       Legend         Water Level Goods       Legend         Main Rives       Legend         Diabase       Legend         Rancos SPGRP       Antrik       Outreation and main         Lindon SPGRP       Antrik       Outreation and main         Lindon SPGRP       Basks       Antrik       Outreation and main         Lindon SPGRP       Basks       Basks       Basks       Basks         Endland SR       Basks       B		watering uses.
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Logend       Logend         Witter Lavel Geosite       Purce         HYRTS RA Geosite       Purce         Witter Study Area       0         Mark Rivers       1000         Mark Rivers       100000         Mark Rivers	Man	
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<ul> <li>Water Level Geosite</li> <li>Water Study Area</li> <li>Rivers Study Area</li> <li>Rivers Study Area</li> <li>Conclument</li> <li>Geology</li> <li>Additional for the study of th</li></ul>	Legend	Pande Legend
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WWS Geodele WWS Geodele WWS Geodele Wester Geodery Catchment	HYDRSTRA G	Twilight Twi
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Rivers Study Availa       Lest Diff       Industrial Urban (m3)         Catchment       0000         Geology       1000         QUATERNARY       Arak         Multium       0000         Diabase       1000         KAROO       0000         KAROO DOLERITE       00000         Soltaansberg GRP       1000         Rivers Study Availa       0000         KAROO DOLERITE       00000         Diabase       1000         KAROO TUE       Borsokep         BOSBOKPOORT       Bunnekep         Soltaansberg GRP       Bunnekep         KLOPPERFORTEIN       Bunnekep         BULLAI GNEISS       0         BULLAI GNEISS       0         BULLAI GNEISS       0         BULLAI GNEISS       0         MALALADRIFT       Asof	2- Main Rivers	
Catchment Geology ULATERNARY Alkulum Debases Karoo SPGRP KAROO DOLERITE LETABA RED ROCKS SOLITUDE Solutionsherg GRP Solutionsherg GRP Solutionsherg GRP Filipp Filipp Filipp Filipp Solutionsherg GRP Solutionsherg GRP Solutionsher	Rivers Study Ar	ea Lost City Industrial Urban (m3)
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Allowing Diabases Karoo SPGRP KAROO DOLERITE LETABA Reno SOCKS Solution Reno Socks Solutionsberg GRP FRIPP FRIPP FRIPP FRIPP Solutionsberg GRP FRIPP Solutionsberg GRP FRIPP Solutionsberg GRP FRIPP Solutionsberg GRP FRIPP Solutionsberg GRP FRIPP Solutionsberg GRP FRIPP Solutionsberg GRP FRIPP Solutionsberg GRP Solutionsberg GRP FRIPP Solutionsberg GRP Solutionsberg GRP Solutions		
Diabase Karoo SPGRP Karoo SPGRP Karoo SPGRP LETABA RED ROCKS SolUTIUDE BOSBOKPOORT BISHIPISE SolUTAISE SOLUTAISE SOLUTAISE SOL	Alluvium	
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KAROD DOLERTRE       I 000 000         LETABA       RED ROCKS         Solutiude       B0580KPOORT         B0580KPOORT       I 000 000         Solutiansberg GRP       I 000 000         FRIPP       I 000 000         KLOPPERFONTEIN       I 000 000         SIBASA       I 000 000         SIBASA       I 000 000         Image: Sibular Strappendic GRN       I 0 000 000         Image: Sibular Strappendic	KAROO	Reinwaler
CELEBOR CELEBOR CELEBOR CSE SOLITUDE BOSBOKPOORT Binnewkop FRIP FRIP FRIP FRIP FRIP FRIP FRIP FRIP SIBASA S	KAROO DOLEI	
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BOSBOKPOORT Stiffender FRIPP FURDUDZI KLOPPERFONTEIN SIBASA SIBASA STAYT TSHIDZI Limpopo Belt BULAI GNEISS GUMBU JEROME GRANITE MALALA DRIFT MALALA DRIFT M	SOLITUDE	
Soutpansberg GRP FRIPP FUNDUDZI KLOPPERFONTEIN SIBASA SIB	BOSBOKPOOF	
Soutpansberg GRP FRIPP FRIPP FRIPP FRIPP SIBASA	TSHIPISE	Blaauwkop
<ul> <li>FNUFP</li> <li>FUNDUDZI</li> <li>KLOPPERFONTEIN</li> <li>SIBASA</li> <li>STAYT</li> <li>TSHIDZI</li> <li>Limpopo Belt</li> <li>BULAI GNEISS</li> <li>GUMBU</li> <li>JEROME GRANITE</li> <li>MALALA DRIFT</li> <li>MALALA DRIFT</li> <li>MALALA DRIFT</li> <li>MALALA DRIFT</li> <li>MALALA DRIFT</li> <li>MASING</li> <li>MALALA DRIFT</li> <li>MALALA DRIFT</li></ul>	Soutpansberg GRP	
KLOPPERFONTEIN SIBASA STAYT TSHIDZI Limpopo Belt BULAI GNEISS GUMBU JEROME GRANITE MALALA DRIFT MALALA DR	FUNDUDZI	
SIBASA STAYT TSHIDZI Limpopo Belt GUMBU JEROME GRANITE MALALA DRIFT MALALA DRIFT MA	KLOPPERFON	
STAYT TSHIDZI Limpopo Belt BULAI GNEISS GUMBU JEROME GRANITE MALALA DRIFT MALALA DRIFT ABOF MOUNT DOWE MESSINA SAND RIVER GNEISS WYLLIES POORT ABOB	SIBASA	
TSHIDZI Limpopo Belt BULAI GNEISS GUMBU JEROME GRANITE MALALA DRIFT MALALA DRIFT MA	STAYT	
BULAI GNEISS GUMBU JEROME GRANITE MALALA DRIFT MOUNT DOWE MESSINA SAND RIVER GNEISS WYLLIES POORT A80B	TSHIDZI	
GUMBU JEROME GRANITE MALALA DRIFT MOUNT DOWE MESSINA SAND RIVER GNEISS WYLLIES POORT A80B	BULAI GNEISS	
JEROME GRANITE MALALA DRIFT MOUNT DOWE MESSINA SAND RIVER GNEISS WYLLIES POORT A8NO <sub>513</sub> A80B	GUMBU	
MALALA DRIFT MOUNT DOWE MESSINA SAND RIVER GNEISS WYLLIES POORT A80B A80B A80B A80B A90C A90	a JEROME GRAI	
MOUNT DOWE MESSINA SAND RIVER GNEISS WYLLIES POORT MSCHOOL ABNO513 ABOB MSCHOOL MSCHO	MALALA DRIFT	A8oF A92BAuloo
MESSINA SAND RIVER GNEISS WYLLIES POORT 0 5 10 Kilometers Agroody Agroup Agro	MOUNT DOWE	Starlight Wheembo
WYLLIES POORT		aneirs 0 10 kilometers Agac Agac AgazA
A86B)	WYLLIES POO	RT VARNOS13
		A86B

Figure 39 Map showing the distribution of GUA A81-2	with geology, wate	use and geo-sites
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Water Use Schemes (after DWAF, 2015, Recon Study)							
Scheme Name	Village/Settlement	Catchment					
Musina RWS	Musina (Messina), Harper, Harper Industrial, Lost City (Cambell), Musina Military Base,	A71K A71L					
	Nancefield	A80G					
Mutale Main RWS	Dzamba Tshiwisa, Dzata Ruins, Dzumbama, Fefe, Gogogo, Goma, Gundani,	A80A A80B					
	Gwagwathini, Ha-Mabila, Helala, Khakhu Thondoni, Luheni, Madatshitshi, Madzororo,	A80C A80G					
	Mafhohoni, Mafhohoni, Mafhohoni South, Maname, Mavhode, Mavhuwa, Mazwimba,	A80H					
	Mphagane, Mufongodi, Mufulwi, Ngalavhani, Mufulwi, Ngalavhani, Sheshe, Thonoda						
	Lusidzana, Thononda, Tsaanda, Tsaanda 2 Tshiedeulu Thembaluvhilo, Tshiendeulu,						
	Tshilimbane, Tshilovi, Tshitandani, ZTshixwandza and Tshumulungwi.						



Nzhelele North RWS Afton, Dolidoli, Garasite, Khomela, Maangani, Makushu, Mangwele, Maranikhwe, A80B A8						ve, A80B A80C		
Mudimeli, Musekwa, Musekwa Korporasi, Natalie, Ndouv					uvhada, Ngonavhany	ai, A80E A80F		
	Pfumembe, Pfumembe Tsha Fhasi, Phembani, Sane, Straighthardt, Tshitwi						A80G A80H	
							4801	
Tchinico Poc	ort Supply	Tchinico Pocor					1805	
Tshipise Kest		TSHIPISE RESET		•-			Abug	
Available moi	nitoring locations	for trend analys	is – Water Leve	IS	T		T =	
Name	Start Date	End Date	Count	Max water	Min water lev	vel Mean water	Fluctuation	
	2005/02/16	2021/00/22	2451	level (mbgl)	(mbgl)	level (mbgl)	(min-max) (m)	
A8N0505	2005/02/16	2021/09/22	2 2451	15.01	8.34	9.55	6.67	
ASNUSIU	2000/00/15	2021/06/24	+ 3742	9.64	3.10	7.19	0.48	
water Lever C	irapiis							
Name A ANOSOS ANOSOS ANOSOS ANOSOS ANOSOS ANOSOS ANOSOS ANOSOS ANOSOS ANOSOS ANOSOS								
Available mol	Available monitoring locations for trend analysis -vvaler Quality (chemistry)							
Name	Start Date	End Date	Count	IVIAX $NO_3 + NO_2$	$V_1 V_1 NO_3 + NO_2$	Iviedian $NO_3 + NO_2$	Exceed Drinking	
	conc. (mg/L) conc. (mg/L) Water guideline							
				none				
Water Quality	Water Quality Graph and Piper Plot							
	none							
Comments								
The observed	The observed hydrographs for each of the three stations show a fluctuation of approx. 6m A strong seasonal fluctuation is observed							

especially seen at station A8N0505. A slight decreasing groundwater level trend is observed for station A8N0505.



# 2.7. NWANEDI

The Nwanedi River catchment is a small catchment in the north-eastern corner of the Limpopo WMA. The drainage region has high rainfall in the upper reaches of the catchment and is semi-arid in the central and lower reaches of the catchment. Although the groundwater is used extensively in certain areas, any additional water requirements for domestic use will have to be sourced from groundwater and groundwater still has potential for future use. In this assessment the Nwanedi drainage region have been delineated as A81-3 (Figure 41).

## Table 57. Borehole information for the Nwanedi drainage region

Drainage system	GUA	Info	BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (I/s for 24hrs)	Blow Yield (l/s)
Neurope all	4.01.2	Ν	142	115	5	33	60
Nwanedi	A81-3	Mean	60.9	15.3	114.3	1.0	3.4

# 2.7.1. Groundwater recharge

Recharge vary from approximately 18 mm/a to less than 2 mm/a in the northeast. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 51.

### Table 58. Recharge estimation (Nwanedi).

GNA	CUA	Quat	MAP	Area	GRA II		Vegter (1995)
GIVIA	GUA	Quat	(mm)	(km²)	(Wet)	(Dry)	Mean
					IVIM <sup>®</sup>	IVIM <sup>®</sup>	ivim <sup>2</sup>
Nuuanadi	A 0 1 - 2	A80H	620.6	266	10.75	7.72	8.90
iswanedi	A91-3	A80J	292.1	870	4.43	2.82	1.26

### 2.7.2. Groundwater Use

The groundwater use for each of the GUA associated with the Nwanedi River system is summarised in Table 52. The present WARMS groundwater use data was compared to the 2015 Limpopo (WMA) North Reconciliation Strategy (LNRS) estimated 2020 use.

### Table 59. Groundwater use (per annum) as registered per catchment for each GUA.

GMA Description	GUA	Quat	WARMS: Use Mm <sup>3</sup>	LNRS 2020 Mm <sup>3</sup>
Nuceedi	401 0	A80H	4.848	0.064
wanedi	A81-3	A80J	1.121	1.375

### 2.7.3. Groundwater quality

Based on the piper diagram the main water types for the Nwanedi region vary from a Ca/Mg-HCO<sub>3</sub>, to a Na-Cl dominance (Figure 40). A number of samples relate to a fresh recharge type (Ca/Mg-HCO<sub>3</sub>) water, while cation and anion exchange process may be occurring within the strata hence Na-Cl and Ca/Mg-Cl type water present.





Figure 40. Piper diagram for the Nwanedi drainage region.

Groundwater quality in the Nwanedi region is considered to be poor with the most notable elements of concern include  $NO_3$  as N with average concentrations above the recommended drinking limit (Table 53).

GUA		рН	EC	TDS	Са	Mg	Na	к	SO₄	Cl	NO₃as N	F
DWAF CI	ass I	5-6 or 9-	70-	450-	80-150	30-70	100-	-	200-	100-	6-10	0 7-1
		9.5	150	1000	00 150	30 / 0	200		400	200	0 10	0.7 1
		4-5 or	150-	1000-	150 200	70-	200-		400-	200-	10.20	1 1 E
DWAF CI	d55 11	9.5-10	370	2000	150-500	100	600	-	600	600	10-20	1-1.5
	III	3.5-4 or	370-	2000-	× 200	100-	600-		600-	600-	20.40	1.5-
DVVAF CI	dss III	10-10.5	520	3000	>300	200	1200	-	1000	1200	20-40	3.5
10.2	Ν	52	53	45	53	54	53	51	40	52	7	47
A0-3	Median	7.8	69	485	18.2	20.2	54.8	1.4	16.7	57.0	16.6	0.25

Table 60. Groundwater quality for the Nwanedi region (All units in mg/l, EC in mS/m).

## 2.7.4. Groundwater contribution to baseflow

In the upper catchments groundwater contributes to base flow via sub surface seepage and springs. The probability of baseflow diminishes down-gradient towards the northeast. Comparison of groundwater contribution to baseflow estimates for the Nwanedi drainage region are summarised in Table 54.

Description	GUA	Quat	Hughes Mm³/a	Shultz Mm³/a	Pitmann Mm³/a	GRA II (WR2005) Mm <sup>3</sup> /a	Maint. Low flow Mm³/a
Nucesodi	A 0 1 - 2	<sup>1</sup> A80H	9.00	2.91		2.41	1.08
wanedi	A81-3	A80J					0.01

Table 61. Groundwater contribution to baseflow estimates.

# 2.7.5. Summary

The following tables provide a summary for each of the GUA, as illustrate in Table 62.



# Table 62. Summary information for GUA A80-3.

GUA	Nwanedi A81-3
Description	The main aguifer types include the Fractured aguifers from the Soutpansberg Group. The main aguifer types include
	the Fractured aquifers from the Southansberg Group and Karoo Supergroup. The Southansberg Group does not
	assess any primary parasity and groundwater or assurences are controlled by goldarial structures. In general
	possess any primary porosity and groundwater occurrences are controlled by geological structures. In general
	groundwater yields are moderate with yields up to 2L/s. The Intergranular Alluvial aquifers (Limited to the main river
	stems) are recharged during periods of high stream-flows as well as during the rainfall season. It is an important
	local, major aquifer and exists in equilibrium with surface water, adjacent groundwater systems and ecosystems
	along the rivers. The depths of the alluvium generally decrease away from the river. The Intergranular and fractured
	associated with the Limnono Belt, granite-greissic rocks, has moderate groundwater potential and horeholes yield
	between 0.5 and 21/6. Created water is entraneed in small relatively challes, lead between 0.5 and the starting of the startin
	between 0.5 and 2 //s. Ground water is entrapped in small relatively shallow, locally developed basins and troughs
	revealing that mechanical and chemical weathering appear to be associated with surface drainage channels. The
	groundwater use is associated with irrigation, water supply, industrial and livestock watering uses
Catchments	LH08A
Мар	
Lagand	- Danda
Legend	0 5 10 Kilometers
Water Level G	eosite
🕴 🕴 HYDRSTRA G	beosite
💛 WMS Geosite	
2- Main Rivers	ARNOSID Store
Rivers Study A	
ACT Catchment	
Geology	AppD AgNooo5 apage
QUATERNAR'	Y Riverview / Gao / Gao Gao Gao Gao Missie Marshart Gao
Alluvium	Accel and a second se
Diabase	AgNoo16 Tshamutavha
Karoo SPGRP	Skirbeen Mute
KAROO	
KAROO DOLE	RITE
LETABA	
RED ROCKS	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
SOLITUDE	AgNoo12
TSHIPISE	Ag2C Ag2C
BUSBOKPOO	RT Tshirkhongweni
Soutpansberg GRP	AgNooo1 Legend
	Shakadza
MARILICIA/E	
MUSEKWA B	
Limpono Belt	AgNoo27 AgNo 100
WYLLIES POO	
MESSINA	
GUMBU	ANNOOLS ) Irrigation (m3)
MALALA DRIF	AgNgo26 AgNgo28 GTshitavha 1
• • • • • • • • •	Ag2A AgNoo2g 1000
Mutungud	Esri NASA, NGA, USGS: Esri South Africa, Es
	Noot your Again Tourn.

Figure 41 Map showing the distribution of GUA A81-3 with geology, groundwater use and geo-sites. Water Use Schemes (after DWAF, 2015, Recon Study)

Scheme Name	Village/Settlement	Catchment		
Luphephe / Nwandedzi	Bale, Bale North, Malale, Mapakoni, Masea, Matshakatini, Matshena, Tshamutumbu	A80J		
North	Police Station and Tshiungani.			
Luphephe / Nwanedi Main	Folovhodwe, Gumela, Musunda, Muswodi Dipeni, Muswodi Tshisimani, Nwanedi Nature	80H A80J		
RWS	Resort, Tshikotoni and Tshitanzhe.			
Mutale Main RWS	Dzamba Tshiwisa, Dzata Ruins, Dzumbama, Fefe, Gogogo, Goma, Gundani, Gwagwathini,			
	Ha-Mabila, Helala, Khakhu Thondoni, Luheni, Madatshitshi, Madzororo, Mafhohoni,	A80C A80G		
	Mafhohoni, Mafhohoni South, Maname, Mavhode, Mavhuwa, Mazwimba, Mphagane,	A80H		
	Mufongodi, Mufulwi, Ngalavhani, Mufulwi, Ngalavhani, Sheshe, Thonoda Lusidzana,			
	Thononda, Tsaanda, Tsaanda 2 Tshiedeulu Thembaluvhilo, Tshiendeulu, Tshilimbane,			
	Tshilovi, Tshitandani, ZTshixwandza and Tshumulungwi.			
Nzhelele North RWS	Afton, Dolidoli, Garasite, Khomela, Maangani, Makushu, Mangwele, Maranikhwe,	A80B A80C		
	Mudimeli, Musekwa, Musekwa Korporasi, Natalie, Ndouvhada, Ngonavhanyai,	A80E A80F		



	Pfumembe, Pfumembe Tsha Fhasi, Phembani, Sane, Straighthardt, Tshitwi A80G A80H							
		<u> </u>					A80J	
Available mo	nitoring locations	for trend analys	sis – Water Level	S				
Name	Start Date	End Date	Count	Max water level (mbgl)	Min water level (mbgl)	Mean water level (mbgl)	Fluctuation (min-max) (m)	
A8N0504	2006/06/14	2021/06/24	6894	14.86	5.97	10.71	8.89	
A8N0506	2006/03/16	2021/09/22	2 5067	23.25	17.56	19.93	5.69	
A8N0514	2007/03/27	2019/10/18	3 2815	2.87	0.00	1.67	2.87	
Water Level G	iraphs							
0- 5- (m) 10- 10- 15- 20-							Name A8N0504 A8N0506 A8N0514	
		2010	Date	2015	:	2020		
Available me	itoring locations	for trand and		v (Chomistry)				
Available Mol	intoring locations	Tor trend analys					Excood Drinking	
Name	Start Date	End Date	Count	conc. (mg/L)	conc. (mg/L) con	c. (mg/L)	Water guideline	
none								
Water Quality	Water Quality Graph and Piper Plot							
none								
Comments								
The observed	he observed hydrographs for each of the three stations show a fluctuation of between 3 and 9 m. A significant response in water levels							

as a result of recharge/rainfall is observed for station A8N0504 and A8N0514, while a more subtle response is observed at station A8N0506. A decreasing trend in the groundwater levels are observed (at station A8N0504 and A8N0506) which is more pronounced at A8N0506.



# 2.8. UPPER LUVUVHU

The Upper Luvuvhu Rivers originate in the northern extremity of the Great Escarpment, flowing from the Nzhelele Nature Reserve thought the Albasini dam down into the Lower Luvuvhu River stretch. The drainage region has high rainfall in the upper reaches of the catchment and is semi-arid in the central and lower reaches of the catchment. The Luvuvhu/Mutale sub-area of the Luvuvhu/Letaba WMA forms part of the Limpopo River Basin, which is shared by South Africa, Botswana, Zimbabwe and Mozambique.

Groundwater use in the region is dominated by large scale irrigation and water supply services to local communities. Downstream of the Albasini Dam are high clustering of groundwater abstraction. Substantial quantities of groundwater are abstracted for irrigation purposes in the upper Luvuvhu River Catchment. In this assessment the Upper Luvuvhu drainage region have been delineated as A91-1 (Figure 43).

### Table 63. Borehole information for the Upper Luvuvhu drainage region

Drainage system	GUA	Info	BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (I/s for 24hrs)	Blow Yield (l/s)
Upper Luvuvhu	401.1	Ν	576	552	152	56	137
	A91-1	Mean	61.8	16.4	17.2	0.9	2.9

# 2.8.1. Groundwater recharge

The upper reaches of the drainage region drains the mountainous region in the central section of thee GUA has a relatively high rainfall, with a MAP up to 1 500 mm and higher. In comparison the far east and west of the GUA relatively lower rainfall of only 450 mm per annum. Recharge vary from approximately 21 mm/a to less than 12 mm/a. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 64.

Table 64	. Recharge	estimation	(Upper	Luvuvhu).
rabie o r	· ····································	countation	Copper	Bararnaji

GMA	GUA	Quat	MAP (mm)	Area (km²)	GI	Vegter (1995)	
					(Wet) Mm <sup>3</sup>	(Dry) Mm³	Mean Mm <sup>3</sup>
Upper Luvuvhu	A91-1	A91A	696	232	11.1	8.3	13.4
		A91B	620	275	8.0	5.8	14.8
		A91C	866	250	20.1	15.5	20.9
		A91D	1287	132	23.0	19.1	12.6
		A91E	1078	223	26.3	20.9	19.7
		A91F	662	580	14.6	10.5	22.7
		A91G	950	406	67.1	51.8	26.1

# 2.8.2. Groundwater Use

The groundwater use for each of the GUA associated with the Upper Luvuvhu River system is summarised in Table 65.

GMA Description	GUA	Quat	WARMS: Use Mm <sup>3</sup>
		A91A	6.374
		A91B	11.689
		A91C	27.926
Upper Luvuvhu	A91-1	A91D	10.445
		A91E	2.116
		A91F	1.770
		A91G	0.793

Table 65. Groundwater use as registered per catchment for each GUA.



# 2.8.3. Groundwater quality

Based on the piper diagram the main water types for the Nzhelele and Nwanedi region vary from a Ca/Mg-HCO<sub>3</sub>, to a Na-Cl dominance (Figure 42). A number of samples relate to a fresh recharge type (Ca/Mg-HCO<sub>3</sub>) water, while cation and anion exchange process may be occurring within the strata hence Na-Cl and Ca/Mg-Cl type water present.



Figure 42. Piper diagram for the Upper Luvuvhu drainage region.

Groundwater quality in the Upper Luvuvhu region is considered to be acceptable to poor with some exceedances observed for  $NO_3$  as N with average concentrations above the recommended drinking limit (Table 66).

GUA		рН	EC	TDS	Ca	Mg	Na	к	SO4	CI	NO₃ as N	F
DWAF Cla	ss I	5-6 or 9- 9.5	70- 150	450- 1000	80-150	30-70	100- 200	-	200- 400	100- 200	6-10	0.7-1
DWAF Cla	ss II	4-5 or 9.5-10	150- 370	1000- 2000	150-300	70- 100	200- 600	-	400- 600	200- 600	10-20	1-1.5
DWAF Class III		3.5-4 or 10-10.5	370- 520	2000- 3000	>300	100- 200	600- 1200	-	600- 1000	600- 1200	20-40	1.5- 3.5
A91-1	Ν	288	275	262	329	332	329	282	265	328	62	221
	Median	7.9	56	453	41.9	29.1	23.7	0.9	7.2	29.3	10.8	0.2

Table 66. Groundwater quality for the Upper Luvuvhu region (All units in mg/l, EC in mS/m).


## 2.8.4. Groundwater contribution to baseflow

The Luvuvhu drainage region more specifically the Upper Luvuvhu stretch can be classified as a continuous interaction bedrock system (Great Escarpment rocks) with some trenches being porous media underlain by a semi-pervious layer. Along the lower reaches where the alluvium thinness or don exist at all the River stretch can be classified as localized interacting weathered hard rock system. The Great Escarpment Mountain range is an important area for groundwater recharge and drainage base flow. In the upper catchments groundwater contributes to base flow via sub surface seepage and springs. The probability of baseflow diminishes down-gradient towards the northeast. Comparison of groundwater contribution to baseflow estimates for the Upper Luvuvhu drainage region are summarised in Table 67.

Description	GUA	Quat	Hughes Mm³/a	Shultz Mm³/a	Pitmann Mm³/a	GRA II (WR2005) Mm <sup>3</sup> /a
		A91A	8.9	4.6	8.9	2.8
	A91-1	A91B	6.9	3.9	8.2	3.1
Unnor		A91C	20.7	10.9	20.6	2.9
Upper		A91D	23.6	11.6	18.0	1.1
Luvuvnu		A91E	28.7	14.5	24.0	1.9
		A91F	6.5	1.1	3.1	3.0
		A91G	71.5	33.1	65.2	2.9

#### 2.8.5. Summary

The following tables provide a summary for each of the GUA, as illustrate in Table 68.



#### Table 68. Summary information for GUA: A91-1.

GUA	Upper Luvu	nu A91-1					
Description	The main aq	ifer types include the F	ractured aquife	rs associated with	the Soutpansberg. The	Soutpansk	perg Group,
	forming the	elevated high and rechar	ge region for he	GUA, does not po	ossess any primary por	osity and gr	roundwater
	occurrences	are controlled by geolo	gical structures	. In general grou	Indwater vields are low	w. howeve	r structural
	dominated a	nuifers systems associate	ed with lineam	ents vield high val	ues (>51/s) The Interg	ranular and	d fractured
	Limnono Be	rocks consisting of gran	ite-gneissic roc	ks has a moderate	e groundwater notentia	al and hore	holes vields
	botwoon 0 5	and 2 1/s. Ground water	ic optropped in	small rolativoly s	ballow locally dovelop	and basing a	and troughs
	between 0.2	anu z 1/s. Grounu water	is entrapped in	a appear to be	accepted with surface		
	revealing th		incal weatherin	ig appear to be		Le urainage	e channels.
	Intergranula	. The groundwater ruse	is associated wi	th water supply, s	schedule I, recreations,	mining, inc	Justrial and
	irrigation us	S.					
Catchments	A91A,B,C,D,	,F,G					
Мар							
		Legend	32 6	TA	1232	AgN0027	A9N0011
		Logona		180H	1105 m 🔥	A9N0025	AgNoo24
Water Level G	eosite	Diabase	OUDPLAATS	8No514	AgNoo26	A DO P	8-2.5
🕴 HYDRSTRA G	eosite Soutpa	nsberg GRP	INCISS	1	AgNoo28	1920	80.86
WMS Geosite	0				SOUTPANS		-A9N0030
2- Main Rivers	20-	SHIFHEFHE	HIRINDI GRANITE		···· ··· · · · · · · · · · · · · · · ·		
- Rivers Study A	rea 5	SIBASA E		A92A	Mowed.		Agin
Catchment	Limpo	o Belt	RANITE	AgNooog		3 -8	
Geology			ALMIETFONTEIN	12073	A91.69	A SNOOT	
QUATERNAR		E E	NTABENI GRANITE			000	
Alluvium		+ J	EROME GRANITE		and all other of a sol	002	
Lilling?		6-1511-1-1-1	Nzhorie	0		0 2 02	В90В
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	12000000	1583 m				0 <sup>2</sup> <sup>2</sup> 0 <sup>2</sup> 0	-Changeligh
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Porprivier • An	00000		AgNoo13	<b>4</b>	B9Nooo	2	>
A71H	, (C.)	z 2 - 0 0 0 z 0 0 z 0	8 000 m	0 2 0 2 0 2 2 2 2	200 2.2	- BgoF	-va:
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		B8N0521	Contraction of the	B9N0007 B9N00	06	-1	
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gai z	- Wet to	Water Supply (	m3)	100 000	10 000 000	• 1 000	
AnNonin	N Klein Les	Nwandi 0 1	Rerci	eation (m3)	Industrial Urban (m3)	1 000 000	
	A	• 1 000 • 1 000 00	•	10	• 1	rrigation (m3)	
A7N0657	N	Schedule 1 (m3	o)	100	• 1000	• 1	
0 5	10	0 Kilometers	· •	10 000	1 000 000	• 1 000	
2-1 ++++	TI I I IT	100	Minin	g (m3)	Industral non-urban (m3)	10 000 000	
	B8N0524	12-12-01		100 000	• 1		
A710	1 1 - 1 - 3	albore		/		1 8	
Figure 43 Map s	howing GUA	A91-1 with geology, g	roundwater u	se and geo-sites	5.		
Water Use Scheme	es (after DWA	, 2015, Recon Study)					
Scheme Name		Village/Settlement					Catchment
Elim/Vleifontein F	RWS	Elim/Vleifontein					A91B,C
Matshavhawe / K	unda RWS	Matshavhawe / Kunda					A91A
Mutale Mukuya R	WS	Mutale Mukuya					A91D,E,F
Tshifire Murunwa	RWS	Tshifire Murunwa					A91A,D,G
Levubu CBD		Levubu CBD					A91C,D
Middle Letaba RV	VS : Majosi	Majosi					A91B
Valdezia RWS	-	Valdezia					A91B.C

Vondo RWS Vondo A91E,F Makhado RWS A91A,B,C Makhado Available monitoring locations for trend analysis – Water Levels Min water level Fluctuation Max water Mean water Name Start Date End Date Count level (mbgl) level (mbgl) (min-max) (m) (mbgl) A9N0007 2005/09/21 2021/09/21 5295 28.28 3.12 25.16 11.88 A9N0008 2005/09/01 2021/06/08 7100 16.51 2.45 6.19 14.06





The observed hydrographs for each of the stations show a fluctuation of between 9 and 25 m. Apart from the seasonal fluctuations in groundwater levels, an overall decreasing trend is observed since 2013.

Nitrate concentrations trend over the last few years seem to have stabilised below 5 mg/l. The groundwater signature is dominated by HCO<sub>3</sub>-anion water facies, indicating fresher groundwater with limited evolution time to cause mineralisation in the groundwater signature.



## 2.9. MUTALE AND LOWER LUVUVHU

The Mutale and Lower Luvuvhu Rivers drains the most north-eastern part of the study area. The Mutale River originates at the Sacred Lake Funduzi and flows into the Luvuvhu River, which ends up in confluence with the Limpopo River. The Luvuvhu Rivers, flowing in an easterly direction through the Kruger National Park and into Mozambique before discharging into the Indian Ocean. In this assessment the Mutale and Lower Luvuvhu drainage region have been delineated as A91-2 (Figure 45).

Drainage system	GUA	Info	BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (I/s for 24hrs)	Blow Yield (I/s)
Mutale / Luvuvhu	401.2	Ν	391	380	89	52	94
	A91-2	Mean	73.4	14.2	17.6	0.9	3.6

#### Table 69. Borehole information for the Mutale and Lower Luvuvhu drainage region

#### 2.9.1. Groundwater recharge

The higher elevation / mountainous area of the drainage region has a relatively high rainfall, with a MAP up to 1 000 mm and higher. In comparison the far north and east, lower laying in elevation, relatively lower rainfall of only 200 mm per annum. Recharge vary from approximately 16 mm/a to less than 3 mm/a. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 70.

#### Table 70. Recharge estimation (Mutale and Lower Luvuvhu).

Child	CUA	Quat MAP		Area	GR	A II	Vegter (1995)
GIVIA	GUA	Quat	Quat (mm)		(Wet) Mm <sup>3</sup>	(Dry) Mm³	Mean Mm <sup>3</sup>
	A91-2	A91H	722	450	15.94	11.65	22.17
		A91J	450	570	7.49	5.12	4.32
Mutalo and		A91K	373	669	4.00	2.53	2.48
		A92A	997	329	51.34	39.63	40.68
		A92B	711	565	25.43	18.56	19.54
		A92C	423	455	6.79	4.59	4.38
		A92D	301	805	2.47	1.58	1.22

#### 2.9.2. Groundwater Use

The groundwater use for each of the GUA associated with the Mutale and Lower Luvuvhu River system is summarised in Table 71.

Table 71. Groundwater use as registered per catchment for each GRU

GMA Description	GUA	Quat	WARMS: Use Mm <sup>3</sup>
		A91H	0.439
		0.092	
		A91K	-
Iviutale and Lower	A91-2	A92A	0.223
Luvuviiu		A92B	1.163
		A92C	1.599
		A92D	0.188



## 2.9.3. Groundwater quality

Based on the piper diagram the main water types for the Mutale/Lower Luvuvhu region vary from a Ca/Mg-HCO<sub>3</sub>, to a Na-Cl dominance (Figure 44). A number of samples relate to a fresh recharge type (Ca/Mg-HCO<sub>3</sub>) water, while cation and anion exchange process may be occurring within the strata hence Na-Cl and Ca/Mg-Cl type water present.



Figure 44. Piper diagram for the Mutale/Lower Luvuvhu drainage region.

Groundwater quality in the Mutale/Lower Luvuvhu region is considered to be acceptable water quality (Table 53).

GUA		рН	EC	TDS	Са	Mg	Na	к	SO4	Cl	NO₃ as N	F
DWAF Clas	5 I	5-6 or 9- 9.5	70-150	450- 1000	80-150	30-70	100- 200	-	200- 400	100- 200	6-10	0.7-1
DWAF Clas	s II	4-5 or 9.5-10	150-370	1000- 2000	150-300	70- 100	200- 600	-	400- 600	200- 600	10-20	1-1.5
DWAF Clas	s III	3.5-4 or 10-10.5	370-520	2000- 3000	>300	100- 200	600- 1200	-	600- 1000	600- 1200	20-40	1.5- 3.5
401.2	Ν	228	239	213	257	254	251	227	179	257	28	174
A91-2	Median	7.9	49	378	24.1	20.0	38.4	0.9	7.0	38.0	8.4	0.2

Table 72. Groundwater quality for the Nzhelele and Nwanedi region (All units in mg/l, EC in mS/m).

## 2.9.4. Groundwater contribution to baseflow

In the upper catchments groundwater contributes to base flow via sub surface seepage and springs. The probability of baseflow diminishes down-gradient towards the northeast. Comparison of groundwater contribution to baseflow estimates for the Mutale and Lower Luvuvhu drainage region are summarised in Table 73.

Table 73. Groundwater contribution to baseflow estimates.
---

Description	GUA	Quat	Hughes Mm³/a	Shultz Mm <sup>3</sup> /a	Pitmann Mm³/a	GRA II (WR2005) Mm <sup>3</sup> /a
Mutale		A91H	7.9	0.7	3.2	2.1
	A91-1	A91J	-	-	-	-
		A91K	-	-	-	-
and Lower		A92A	60.4	27.1	56.1	2.5
Luvuvhu		A92B	9.4	0.9	4.0	2.6
		A92C	-	-		
		A92D	-	-	-	-

2.9.5. Summary

The following tables provide a summary for each of the GUA, as illustrate in Table 74.



## Table 74. Summary information for GUA: A91-2.

GUA	Mutale and Lo	wer Luvuvhu A91-	-2				
Description	The main aqui	ifer types include t	he Fractured a	aquifers associat	ed with the Karoo Gr	oup and Soutpans	sberg Group. The
	stratified rock	s of the Karoo car	n generally be	regarded as bei	ng of low groundwat	er potential away	/ from structures
	with the inter-	-bedded sandston	es having a mo	oderate potentia	al ranging from . Inter	granular Alluvial	aquifers (Limited
	to the main riv	ver stems) are rec	harged during	periods of high	stream-flows as well	as during the rair	nfall season. It is
	an important	local, major aquif	er and exists	in equilibrium w	ith surface water, a	diacent groundwa	ater systems and
	ecosystems al	long the rivers. Th	e depths of th	ne alluvium gene	erally decrease away	from the river. T	, he Intergranular
	and fractured	l (basement aquif	fers form the	Limpopo Belt)	consisting of granit	e-gneissic rocks	has a moderate
	groundwater	notential and hor	eholes vields	hetween 0.5 an	d 2 1/s Ground wate	e grieissie roeks er is entranned ir	small relatively
	shallow local	ly developed basi	ns and trough	between 0.5 an	t mochanical and ch	omical weatherin	ng appear to be
	sitaliow, local	ty developed basi	ns and troug	ns revealing that	ic mechanical and ci	irrigation and wat	tor supply uses
Catalan anta		In surface drainage	e channels. The	e groundwater u	ise is associated with	ingation and wai	ter supply uses.
Catchments	A91H,J,K,A92A	4,В,С,D					
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0 0	00	Catchment		KAROO	FUNDUDZI	WYLLIE	S POORT
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Figure 45 Ma	n showing GUA A	A91-2 with geolo	gy, groundw	ater use and g	eo-sites.		
Available monit	oring locations for	r trend analysis –	Water Levels	g and g			
				Max water	Min water level	Mean water	Eluctuation
Name	Start Date	End Date	Count	level (mhal)	(mhal)	level (mbgl)	(min-max) (m)
A9N0001	2004/11/17	2021/00/22	8011	18 24	15.22	30.01	37.86
ASNOUL	2004/11/1/	2021/03/22	1700	40.24	10.00	30.01	52.00

				( 07	1 01	( 0/	· · · · · ·
A9N0001	2004/11/17	2021/09/22	8911	48.24	15.38	30.01	32.86
A9N0002	2005/09/06	2021/09/29	4738	26.50	18.85	22.07	7.64
A9N0003	2005/05/18	2020/07/14	5259	13.43	7.61	11.48	5.82
A9N0004	2005/05/18	2020/07/14	3861	14.48	10.06	12.15	4.42
A9N0005	2005/05/18	2021/05/26	4560	37.92	0.30	15.23	37.62
A9N0006	2005/05/18	2018/04/01	5209	55.23	0.01	14.75	55.22
A9N0009	2006/02/02	2021/03/12	13757	23.54	1.94	19.14	21.61
A9N0010	2006/04/03	2021/09/29	4192	13.82	6.88	8.66	6.95
A9N0011	2006/03/15	2021/09/16	13198	17.51	1.04	13.32	16.46
A9N0012	2005/05/19	2021/09/22	11444	22.97	8.54	16.88	14.43
A9N0013	2006/03/15	2020/10/29	14537	60.95	14.23	31.48	46.72
A9N0016	2004/11/11	2021/06/24	2785	14.56	8.84	11.09	5.72



A9N0017	2007/03/27	2016/05/11	4024	35.63	30.62	33.65	5.01
A9N0020	2012/08/14	2021/09/29	3569	17.26	10.29	15.41	6.97
A9N0025	2013/04/18	2021/09/16	3943	8.29	4.16	6.81	4.13
A9N0028	2018/09/19	2021/09/16	12	9.83	1.65	8.07	8.18
A9N0030	2016/08/31	2021/06/22	19	17.49	8.91	14.37	8.58
Mator Loval Cr	anha						



Water Quality Graph and Dinor Dist	
90131 1998/04/29 2017/	09/05

1997/07/14

2017/10/23

37

16

36.09

5.76

0.14

0.02

7.09

0.06

90086

Yes

No





Comments

The observed hydrographs for each of the three stations show a fluctuation of between 4 and 55 m. A well-identified seasonal as well as response to significant recharge events (i.e. 2012) can be inferred from the groundwater level fluctuation observations. Since this recharge event the overall trend is slightly decreasing with a recent rapid increase inf groundwater levels suggesting another significant recharge event.

The nitrate concentration graph show a some fluctuations exceeding 10 mg/l at station 90086 in the early 2000's but has since decreased to below 10 mg/l apart from the latest measurement. The nitrate concentrations at the other stations are low, with no noticeable fluctuation or exceedances over the monitoring period. The groundwater signature is dominated by both a HCO $_3$  and Cl-anion water facies, indicating freshly recharged groundwater undergoing evolution (mineralisation) in the groundwater and rock interactions.



## 2.10. Shingwedzi

The Shingwedzi sub-area is a head-water catchment, which drains into Mozambique. It is situated almost entirely within the Kruger National Park. The drainage region has high rainfall in the upper reaches of the catchment and is semi-arid in the central and lower reaches of the catchment. Limited number of groundwater users are observed for the Shingwedzi drainage region, mostly due to the large coverage of the Kruger National Park. In this assessment the Shingwedzi drainage region have been delineated as B90-1 (Figure 47).

#### Table 75. Borehole information for the Shingwedzi drainage region

Drainage system	system GUA In		BH Depth (mbgl)	Water Level (mbgl)	Transmissivity (m²/day)	Rec. Yield (l/s for 24hrs)	Blow Yield (I/s)
Shingwedzi	B90-1	Ν	356	365	86	43	144
		Mean	61.5	16.3	20.5	0.6	1.6

#### 2.10.1. Groundwater recharge

The drainage region 's MAP ranges from up to 650 mm to as low as 400mm. Recharge vary from approximately 12 mm/a to less than 3 mm/a. Groundwater recharge volumes for each of the quaternaries constituting the unit of analysis and are summarised in Table 76.

#### Table 76. Recharge estimation (Shingwedzi).

Chan	GUA	Quat	MAP (mm)	Area	GR	Vegter (1995)	
GMA				(km²)	(Wet) Mm <sup>3</sup>	(Dry) Mm³	Mean Mm <sup>3</sup>
	B90-1	B90A	465	693	7.32	5.01	4.03
		B90B	470	754	8.54	5.88	6.99
		B90C	498	535	6.28	4.36	6.17
Shingwadzi		B90D	471	447	4.57	3.14	3.77
Shingwedzi		B90E	466	474	4.49	2.94	3.73
		B90F	539	819	11.37	7.99	6.96
		B90G	535	698	12.67	8.89	4.41
		B90H	538	890	15.26	10.18	4.30

2.10.1. Groundwater Use

The groundwater use for each of the GUA associated with the Shingwedzi River system is summarised in Table 77.

Table 77. Groundwater use (per annum) as registered per catchment for each GUA.

GMA Description	GUA	Quat	WARMS: Use Mm <sup>3</sup>
Shingwedzi		B90A	-
		B90B	1.614
	B90-1	B90C	0.205
		B90D	-
		B90E	-
		B90F	0.422
		B90G	-
		B90H	-



## 2.10.2. Groundwater quality

Based on the piper diagram the main water types for the Shingwedzi region vary from a Ca/Mg-HCO<sub>3</sub>, to a Na-Cl dominance (Figure 46). A number of samples relate to a fresh recharge type (Ca/Mg-HCO<sub>3</sub>) water, while cation and anion exchange process may be occurring within the strata hence Na-Cl and Ca/Mg-Cl type water present. Some samples indicate sulphate enrichment as dominant anion water facies.



Figure 46. Piper diagram for the Shingwedzi drainage region.

Groundwater quality in the Shingwedzi region is considered to be poor with the most notable elements of concern include  $NO_3$  as N with average concentrations above the recommended drinking limit (Table 53).

GUA		рН	EC	TDS	Ca	Mg	Na	к	SO4	Cl	NO₃ as N	F
DWAF CI	ass I	5-6 or 9- 9.5	70-150	450- 1000	80-150	30-70	100-200	-	200- 400	100- 200	6-10	0.7-1
DWAF CI	ass II	4-5 or 9.5-10	150-370	1000- 2000	150-300	70- 100	200-600	-	400- 600	200- 600	10-20	1-1.5
DWAF CI	ass III	3.5-4 or 10-10.5	370-520	2000- 3000	>300	100- 200	600- 1200	-	600- 1000	600- 1200	20-40	1.5-3.5
DOO 1	Ν	150	138	124	159	161	160	156	151	161	36	134
B90-1	Median	8.0	121	939	67.8	59.5	103.1	2.2	14.3	102.4	71.4	0.3

 Table 78. Groundwater quality for the Shingwedzi region (All units in mg/l, EC in mS/m). (red text exceeds Class III)

## 2.10.3. Groundwater contribution to baseflow

The Shingwedzi GUA have a low probability of groundwater contribution to baseflow and no sustainable yield is derived from surface flow in the Shingwedzi catchment (DWA, 2014).



## 2.10.4. Summary

# The following tables provide a summary for each of the GUA, as illustrate in Table 79.

GUA	Shingwedzi	Shingwedzi B90-1								
Description	The main aq	uifer types include	the Intergran	ular and fracture	ed aquifer systems fro	om the Karoo Sup	ergroup (Letaba			
	Group) and	fractured basemer	nt aquifer ass	ociated with th	ne Limpopo Belt as v	vell as the Inter	granular Alluvial			
	aquifer. The	e stratified rocks of	f the Karoo s	upergroup can	generally be regarde	d as being of lo	w to moderate.			
	ranging from	n 0.51/s to 2.01/s. li	ntergranular A	lluvial aquifers	(limited to the main r	iver stems) are r	echarged during			
	neriods of h	periods of high stream-flows as well as during the rainfall season. The depths of the alluvium generally decrease								
	away from	away from the river. The Intergranular and fractured (basement aguifers form the Limpopo Belt) consisting of								
	away nom	granite-gneissic rocks has a moderate groundwater notential and horeholes vields between 0.5 and 2.1/s. The								
	granite-grief	grande-greissie rocks has a moderate groundwater potential and potenties yields between 0.5 dfld 2 1/5. The								
- · · ·	groundwate									
Catchments	B90A, B,C,D	,E,F,G								
Мар										
Legend		9N0012 89767	A92D.	2 3	1 Sust	100	Legend			
A	2	AgNobol	AgNoo10	L	A91K	RIOGO	Legend			
Water Level	Geosite	gar i i i	1	Ant Mato	· ···	Irrigation (m	13)			
WMS Geosit	Geosite	A9	N0023	ST	······································	• • 1				
2 Main Rivers		A92B	1		0.02	• 1 000	)			
Rivers Study	Area	AgN0027 AgN0024	A9N0011 5		004 004	10 00	000 000			
Catchment	105 m	• A9N0013	AgaH 5	2-520m	BaoA a	100	liau			
Geology	A9N0026	AgNoo25	BoN	Menthenge		R A	Rio			
QUATERNA	RY BERG MO	AgNoo28 AgNoo3	30	5.	9- F- 0 4 C 4 C	30.0				
Diabase			B	9N0004		9 4 0 9				
Karoo SPGRP	- M	bille di La	· · · · · · · · · · · · · · · · · · ·	07 2 0 0 0 0	Car De Cors	Ŷ 0.0 Ŷ 0				
KAROO DOL	ERITE	A9N0014	0 000 00	GoB		0° 0° 0° 0° 0°	516 m			
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Limpopo Belt			BooF o	Shingw	idzi z z - 1/z 0900	0.000000				
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		XM	B8No	503	Nwa		a of the			
TSHIFHEFH										
TSHOKWAN	E									
GRANOPHY	RE 0 5		30 Kilometers		Esri, NASA, NGA, USGS. Esri South	Africa, Esri, HERE, Galanio, FAC	METWINASA, USGS			
WYLLIES PO	JORI				ash	apu				
Figure 47 Ma	p showing GUA	A B90-1 with geol	ogy, ground	water use and	geo-sites.					
Water Use Sche	mes (after DWA	AF, 2015, Recon Stu	idy)							
Scheme Name	me Name Village/Settlement Catchment									
Malamulele W	MalamuleleB90F									
North Malamu	lele East RWS	Malamulele					B90A,B			
Giyani System	A/B & F1/F2	Giyani					B90F			
Available monit	oring locations	for trend analysis –	- Water Levels	3						
Name	Start Data	End Data	Count	Max water	Min water level	Mean water	Flux (min-			
ivame	Start Date	End Date	Count	level (mbgl)	(mbgl)	level (mbgl)	max) (m)			
B9N0001	2005/09/01	2020/06/19	4407	17.85	8.96	13.96	8.89			
B9N0002	2005/09/01	2021/06/08	3097	12.11	7.14	8.95	4.97			





The observed hydrographs for each of the stations show a fluctuation of between 4 and 11 m. Apart from the seasonal fluctuations in groundwater levels, the overall trend shows a decrease in groundwater levels.

The nitrate concentration graph show a strong fluctuation in observations While an increase in nitrate concentrations are observed the levels are still below 2 ng/l. The groundwater signature is indicate a mix between HCO<sub>3</sub> and Cl-anion water facies, indicating freshly recharged groundwater undergoing mineralised (evolved groundwater).



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