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LETABA CATCHMENT RESERVE DETERMINATION STUDY – GROUNDWATER REPORT FINAL FEBRUARY 2006

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Letaba Catchment Reserve Determination Groundwater Report i

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1. INTRODUCTION

1.1 BACKGROUND

The Directorate: Resource Directed Measures has identified the Letaba catchment as a stressed river catchment where Reserve determinations are required at a comprehensive level in order to comply with licensing requirements mandated by the National Water Act of 1998.

The National Water Act of 1998 places emphasis on the protection of water resources for their sustainable utilization. This is reflected in the subsequent development of Resource Directed Measures (RDM), which consists of three important aspects, namely: classification; the reserve; and resource quality objectives.

The purpose of this report is to undertake a determination of the groundwater component of the RDM at a desk top level and to develop a Terms of Reference for a more comprehensive Reserve determination based on these preliminary findings.

It is generally accepted that groundwater plays a role in the ecological Reserve determination if there is a direct hydraulic connection between groundwater and surface water bodies that jointly sustains the aquatic ecosystems. In such situations the often complex role of groundwater (in terms of water level, volume, and water quality), in supporting the ecosystem and human population, has to be ascertained, so that groundwater is not subsequently misallocated. Where aquifers have minimal connection with the aquatic ecosystems, the groundwater component of Reserve would refer to the Basic Human Needs component (25 l/d/person multiplied by the number of people using the groundwater supply in the area).

As a core concept of the RDM, the Reserve covers both Basic Human Needs (BHN) and Ecological Reserve (ER), however, this study focuses primarily on the ER and existing and planned groundwater usage.

The methodology employed is the seven step process identified in the project K5/1090-92 entitled “Towards the Resource Directed Measures: Groundwater Component”, sponsored by the Water Research Commission (WRC). The Programme started on January 1st, 1999 and was published in 2003.

1.2 SCOPE OF WORK

WSM (Pty) Ltd was appointed to undertake a scoping level understanding of the role of groundwater in the Reserve and to compile a terms of reference for a comprehensive determination of the groundwater component of the Reserve. The following tasks were identified:

- Determine the importance of groundwater in terms of current and future groundwater use;
- Utilize desktop study information from the RDM office to initially delineate groundwater resource units;
- Determine groundwater contribution to baseflow and provide a reconnaissance level understanding of the contribution of groundwater to the ecosystem functioning of rivers and wetlands in the catchment;
- Determine the degree of groundwater stress;

- Compile a terms of reference for conducting a comprehensive determination of the groundwater component of the reserve stating all tasks as well as a monitoring program.

In order to undertake these tasks it will be necessary to:

- Identify groundwater regions;
- Identify groundwater response units;
- Identify groundwater management units;
- Characterize groundwater conditions under unimpacted conditions and current conditions in each unit;
- Determine present status of resource units in terms of ecological relevance, resource quality and water uses;
- Determine importance of groundwater resource units in terms of ecological relevance, social and economic importance;
- Determine the level of protection required for the groundwater contribution to the low flows;
- Quantify the groundwater contributions to baseflow;
- Identify criteria for Resource Quality Objectives.

2. CLASSIFICATION

2.1 OBJECTIVES

Objectives of the classification component of the RDM process is to provide a framework for resource protection and assessment within which the groundwater component of the Reserve and RQO occurs. Classification includes:

- Delineating groundwater units for which the groundwater component of the reserve is set;
- Determining reference conditions of aquifers;
- Determining an appropriate classification based on importance, sensitivity and economic value of the resource;
- Identifying management units.

Classification delineates groundwater management units as either Protected, Good, Fair, Severely Modified, which imply different levels of resource protection and impact acceptable to stakeholders. The different classes represent the degree of modification from natural conditions existing at present and the degree of risk of irreversible damage.

2.2 GEOGRAPHIC EXTENT OF THE RESOURCE

2.2.1 Location

The Letaba River catchment is 13400 km^2 and falls within the Luvubu and Letaba Water Management Area (WMA), WMA no. 2 on the 1: 2 000 000 Map, showing the WMA of South Africa (DWAF, 2000). WMA no. 2 includes the following main river systems: Mutale, Luvuvhu and Letaba Rivers. For the purposes of this assessment only the Letaba River catchment in WMA 2 will be considered, including the secondary catchments, B81 to B83. The towns of Tzaneen, Dan, Middelwater, Buffelshoek, Olifantshoek and Giyani are included in the Letaba catchment (secondary catchments B81 to B83, as depicted on Figure 1).

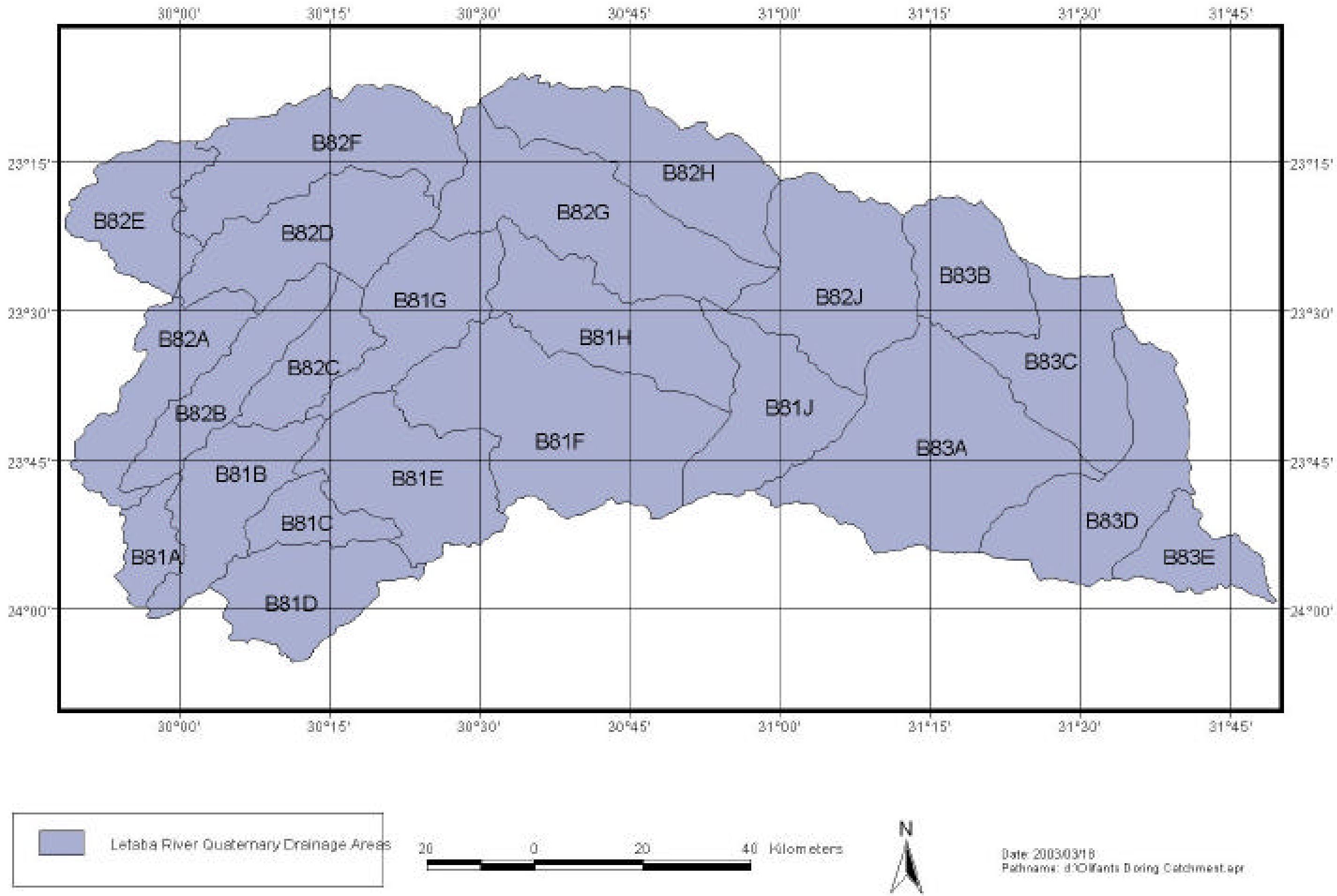

Figure 1: The Letaba Catchment and Quaternary Catchments

2.2.2 Geology

The study area is underlain by 8 major stratigraphic groups. From oldest to youngest they are:

- Goudplaats and Makhutswi Basement Gneisses
- The Giyani, Pietersburg and Gravelotte Groups of the Murchison Sequence
- The Bandolierskop Complex
- Mafic and Ultramafic Complexes
- The Rooiwater Complex
- Younger Granite Intrusives
- The Schiel Complex
- The Wolkberg Group
- The Timbavati Gabbro
- The Karoo SuperGroup
- Quarternary Deposits

(i) The Goudplaats and Makhutswi Gneisses form the basement on which all other existing lithologies were deposited and preserved. They consist of biotite gneiss, migmatite and re-melted granitic mobilizate and underlay more than 50% of the catchment.

(ii) The Murchison Sequence is ancient supra-crustal rocks preserved in the basement gneisses. Three occurrences are present in the study area. The Giyani Group is a varied assemblage of volcano-sedimentary rocks consisting of ultra mafic schists, amphibolite, banded iron formation, acid meta lavas, garnetiferous schists, quartzite, dolomite, calc-silicate rocks and granulites. It outcrops primarily in the catchment of the middle reaches of the Klein Letaba, stretching SW to the Molotsi. The Gravelotte Group is only partially presented in the study area in the south. The green schist sequences consist of acid meta-lavas, andesite, chlorite schists, banded iron formation, mafic meta lavas and ultra mafic schists. It outcrops only on the southern margin of the Groot Letaba, where it forms the Murchison Range. The Pietersburg Group consists of amphibolites, quartzites and ultramafic schists. It is present as isolated outcrops in the Duiwelskloof region.

(iii) The Bandolierskop Complex is a highly metamorphosed body infolded into the basement rocks consisting of amphibolites, mafic granulites, metapelites, metaquartzites, magnetites, pyroxenite and calc-silicates. It occurs as isolated outcrops in the upper to middle reaches of the Klein Letaba.

(iv) Small outcrops of Swazian age intrusive serpentinite, ultramafic schists and metapyroxenite occur in the basement rocks and the Murchison Sequence.

(v) The Rooiwater Complex is a layered intrusive ultra-mafic body in contact with the Gravelotte Group lithologies in the south. The contact is structural and is thought to be due to thrusting.

(vi) Younger Granite Intrusives of Randian to Vaalian age intrude the basement complex. The more significant granite bodies are; The Lekker Smaak Granite, Willie Granite, Baderouke Granite and the Maranda Granite. They are all essentially leucocratic muscovite, biotite granites.

(vii) The Schiel Complex is of younger than the above granite intrusives and consists of a porphyritic hypersthene syenite and hornblende granite. It underlies the middle reaches of the Klein Letaba.

(viii)The Wolkberg Group consist of shale quartzite and basalt and occurs in the upper reaches of the Groot Letaba where they form a watershed.

(ix) The Timbavati Gabbro is a non-linear ultra-mafic dyke of varying width (can be larger than 1 km) which strikes in a general north/south direction. It consists of olivine gabbro. Of similar age and composition are a series of NE trending diabase dykes that occur as swarms primarily in the western half of the catchment.

(x) The Letaba Formation of the Karoo Supergroup occurs along the eastern part of the study area. It consists of a thick layer of N-S striking basalt lava. The mountain range which forms the Lebombo range is made up Tshokwane Granophyre and Jozini Formation rhyolite. A small outcrop of N-S striking Clarens Formation sandstone of hydrogeological significance occurs on the western margin of the basalts.

(xi) Quaternary age alluvium is preserved in broad shallow depressions and in the valleys of the study area. These deposits are made up of sand, river terrace, gravel, high level gravels and scree.

A geological map of rock types is shown in Figure 2. The distribution of lithologies in each Quaternary catchment is given in Table 1.

Table 1: Distribution of Lithologies

Quaternary catchment	Area (km2)	Geology
B81A	169	Goudplaats-2% Pietersburg-2% Granite intrusives-96%
B81B	481	Goudplaats-2% Pietersburg-2% Granite intrusives-96%
B81C	208	Goudplaats-40% Granite intrsuives-60%
B81D	479	Goudplaats-10% Gravelotte-10% Rooiwater-30% Granite intrsives-50%
B81E	665	Goudplaats – 35% Rooiwater-20% Granite intrusives-40% Gravelotte-5%

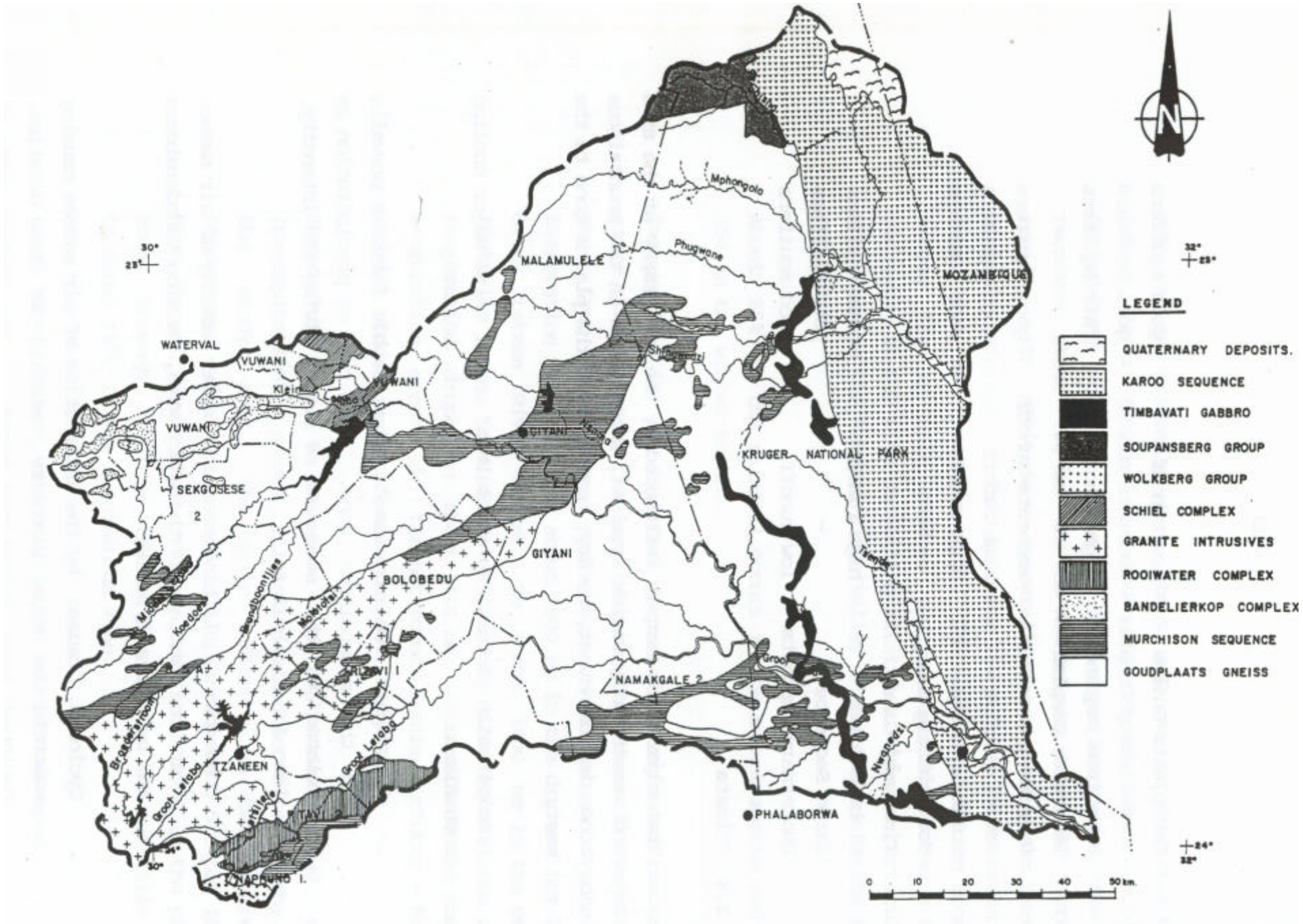

Figure 2: Geology

Quaternary catchment	Area (km2)	Geology
B81F	1201	Goudplaats-82% Gravelotte-5% Pietersburg-1% Rooiwater-5% Granite intrusives-7%
B81G	513	Goudplaats-52% Granite intrusives-45% Giyani -3% Pietersburg-1%
B81H	668	Goudplaats-75% Giyani-10% Granite intrusives-15%
B81J	568	Goudplaats-80% Gravelotte-15% Granite intrusives-5%
B82A	467	Goudplaats-92% Bandolierskop-5% Pietersburg-3%
B82B	406	Goudplaats-85% Pietersburg-5% Granite intrusives-10%
B82C	300	Goudplaats-75% Pietersburg-<1% Granite intrusives-25%
B82D	632	Goudplaats-93% Giyani-1% Bandolierskop-4% Schiel -2%
B82E	423	Goudplaats-95% Bandolierskop-5%
B82F	760	Goudplaats-65% Bandolierskop-10% Schiel -25%
B82G	921	Goudplaats-65% Giyani-25% Granite Intrusives-10% Swazian mafic and ultramafics-<1%
B82H	749	Goudplaats-53% Giyani-45% Swazian mafic and ultramafics-1% Granite intrsuives-1%
B82J	795	Goudplaats-96% Giyani-1% Swazian mafic and ultramafics-1% Granite intrusives-<1% Timbavati-2%
B83A	1252	Goudplaats-90% Gravelotte-4% Granite Intrusives-3% Timbavati-3%
B83B	439	Goudplaats-80% Timbavati-4% Clarens-1% Letaba-15%
B83C	592	Goudplaats-20% Clarens-2% Gravelotte-1% Granite intrusives1% Alluvium-1% Letaba-75%

Quaternary catchment	Area (km2)	Geology
B83D	784	Goudplaats-25% Timbavati-3% Clarens-1% Swazian Mafic and ultramafics-1% Letaba-63% Thsokwane and Jozini-5% Alluvium-2%
B83E	312	Letaba-84% Thsokwane and Jozini-15% Clarens-1%

2.3 GROUNDWATER REGIONS AND RESPONSE UNITS

The catchment can be largely classified as Crystalline igneous and metamorphic basement rocks of Swazian to Randian age underlying the Lowveld region. Aquifers are predominantly secondary, with the exception of the alluvial deposits. The land surface has been dissected by erosion beginning in the early Cretaceous along the Escarpment which forms the western watershed to the early Miocene in the east.

The hydrogeology of the Letaba catchment is characterized by secondary or fractured aquifers formed by mainly metamorphic basement rocks of the Goudplaats Gneiss, Giyani and Gravelotte Greenstone belts, Igneous rocks of the Lebombo Granite, Makhutzi Granite, various younger granitoid intrusions of the Vorster Suite and gabbroic intrusions of the Rooiwater Suite Timbavati Gabbro. Intergranular aquifers (unconsolidated to semi-consolidated materials, with primary porosity) occurs on the Letaba River, mainly inside the Kruger Park.

The climate of the Letaba catchment varies from wet and humid in the mountainous zone to dry and hot on the plains zone (DWAF, 1990). The mean annual precipitation (MAP) varies gradually from approximately 450 mm in the south-east to approximately 700 mm at the Drakensberg foothills in the vicinity of Tzaneen. The MAP precipitation rises rapidly to more than 2000 mm in the south-western corner of the catchment as a result of the increasing altitude of the Transvaal Drakensberg. Conversely, evaporation increases from approximately 1500 mm in the Tzaneen area to 2100 mm in the south-eastern corner of the Letaba catchment (DAWF, 1990).

Temperatures vary considerably across the region from moderately warm to hot in the mountainous region to hot and very hot in the plains region.

The catchment can be divided into several hydrogeological regions (see Figure 3):

- Drakensberg Escarpment
- Drakensberg Foothills and valleys
- Bandolierskop
- Giyani-Gravelotte
- The Plains
- Lebombo
- Alluvium

2.3.1 Escarpment Zone

This zone forms the south-western part of the catchment and constitutes the Transvaal Drakensberg mountain range. The Escarpment zone consists primarily of Vaalian age granites with scattered xenoliths of ultramafic schists, amphibolite and magnetite quartzite of the Pietersburg Group. Numerous north-east, south-west striking dykes have also intruded the area.

Rainfall exceeds 1000 mm/a, except in the upper Kudus and Middle Letaba valleys where rainfall is 600 mm/a due to the rain shadow effect of the Duiwelskloof mountains. The main aquifers are associated with fractured dyke contact zones and lithological contact zones (DWAF, 1990). Although they may be highly permeable, storage in these fractured aquifers is very limited, especially where a deep overlying weathered zone is absent. As a result they may provide high initial yields, which decline rapidly as the larger joints and fractures are dewatered.

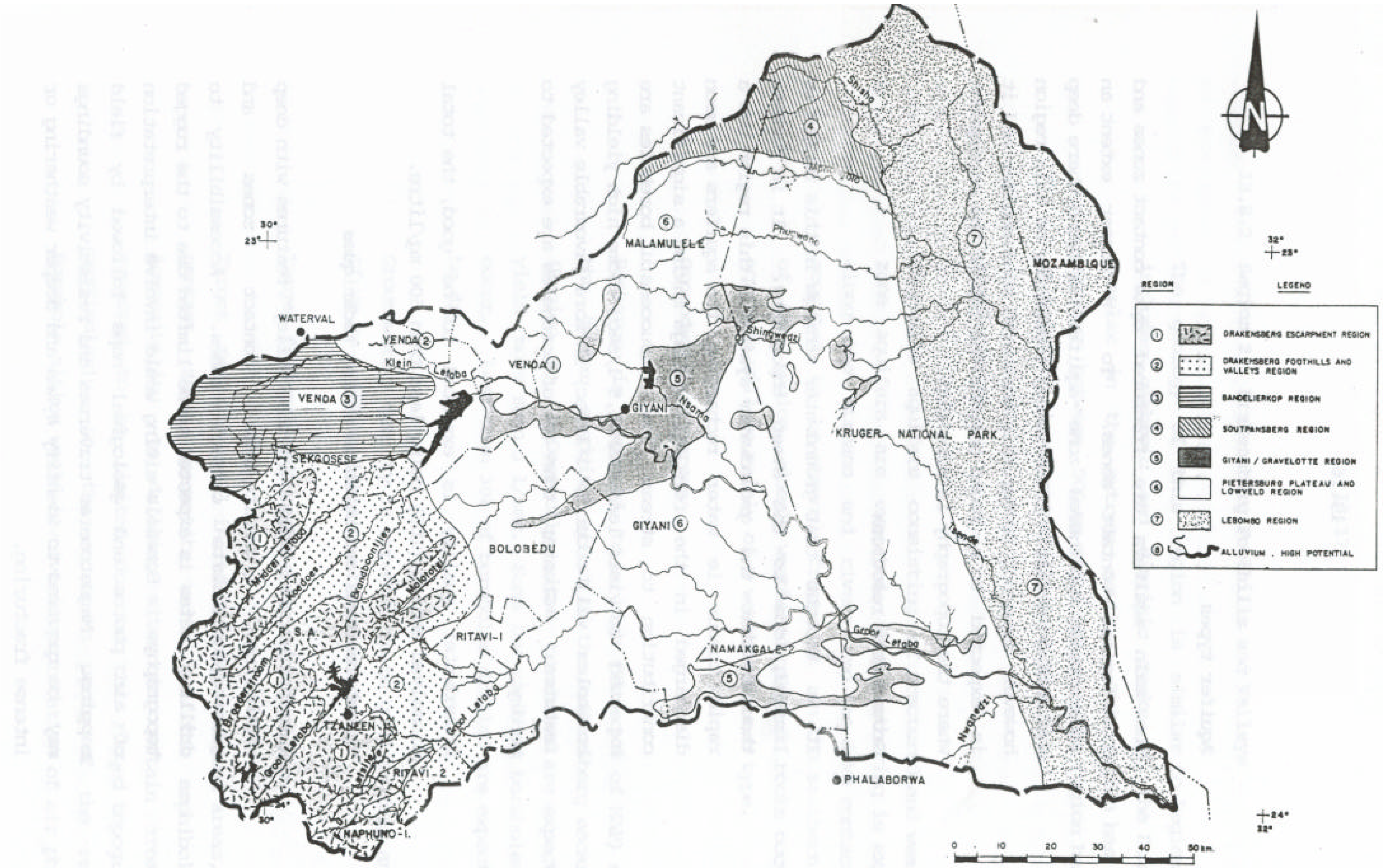

Figure 3: Hydrogeological Regions

On the steep slopes that generally exceed 15^{o}, recharge to these aquifers is rapidly discharged in the forms of springs, which provide baseflow to the rivers that may exceed 200 mm/a, however, these resources are not directly exploitable by the regional aquifers that occur in the valley bottoms. As a result, a large fraction of recharge cannot be directly exploited through boreholes.

To a lesser extent, as a result of the steep topography, an intermittent weathered zone aquifer is found where deep weathering occurs. The steep topography generally inhibits deep weathered profiles, hence weathered zone aquifers are generally found only at the top of the escarpment where the Pietersburg plateau exists, or in valley bottoms. Where these weathered zones exist they provide storage of groundwater, which feeds the underlying fractured aquifer when it is subjected to pumping.

Groundwater yields typically vary between 0.5 and 1.5 l/s and groundwater quality is expected to be good, with TDS being less than 500 mg/l. Groundwater generally occurs in fractures situated on average 10 m below the static water level.

Although recharge is high, up to 40% of boreholes are dry, indicating that the bulk of recharge does not enter the regional fractured aquifer, but is shed as baseflow from shallow fractures above the regional water level. Furthermore, it should be noted that groundwater has a rapid turn-over time in the aquifers and is soon discharged in the form of springs, contributing significantly to stream flow. Spring yields vary between 1 and 3 l/s.

2.3.2 Drakensberg Foothills and Valleys

In the Drakensberg foothills and valleys the geology is similar to the Escarpment zone, except that gabbroic and dioritic rocks of the Rooiwater Complex intrude the Vaalian age granitoid rocks in the extreme south. Rainfall is 500-1000 mm and slopes are generally flat to moderate, with slopes generally less than 15%.

The aquifers are of a composite type, consisting of fractured zone and overlying weathered zone aquifers (DWAF, 1990). Deep weathering occurs along rivers and streams and dyke contact zones are highly fractured. The Rooiwater aquifer is deeply weathered and is generally of the weathered type.

Scientifically sited boreholes yield more than 3 l/s and approximately 30% of all boreholes drilled are expected to be dry. Groundwater quality is good to fair and TDS of up to 1000 mg/l are expected.

During the period 1995 to 2001, approximately 3000 rural water supply boreholes were installed in the Letaba catchment to supply the basic human need requirements of the communities living in the catchment. A fair proportion of these boreholes are situated in the granite aquifer. Boreholes had yields ranging between 0.5 to 3.0 l/s and less than 30% were dry.

As a result of the lack of sanitation facilities, elevated nitrate concentrations commonly occur in groundwater. The hardness of granites and consequent shallow depth of weathering aggravates the impact of contamination of granite aquifers in the absence of adequate sanitation systems and uncontrolled animal grazing, both of which are part of the rural population's lifestyle.

The Granite Aquifers seem to be a very good groundwater resource, provided that good aquifer management practices are applied and low yielding hand pumps are installed to meet the ever growing Basic Human Need requirement for hundreds of thousands of people living in informal settlements in the area around Tzaneen, Letsitele and environs.

These aquifers are very vulnerable and sensitive to changes in rainfall patterns during droughts. During times of drought, boreholes dry out if not managed properly. Extensive forestry and agricultural activities in and around Tzaneen also impacts on the volumes and quality of groundwater flowing back to the Letaba River as baseflow.

In the above-mentioned areas, water resources are scarce commodities and conjunctive surface and groundwater use in times of drought is a solution to the high water demands in the area. An investigation into agricultural practices and their associated water demands, in particular in times of drought, is recommended. Irrespective of the nitrate contents of the groundwater in the Granite Aquifer, groundwater development meets the water demands of the people living in this rural area. Hand pumps are commonly selected as the preferred water supply option for widespread, low income, rural communities.

2.3.3 Bandelierskop

The geology of this region consists of mafic volcanic and politic rocks infolded into basement gneisses, as well numerous NE trending diabase dykes. Significant faulting is also evident. The regional MAP is 500-1000 mm. The region is hilly and has slopes of 5-15^{o}.

Fractures and faults formed by the various deformational phases and dykes are thought to constitute the main aquifers as a result of deeper weathering. A considerable number of water supply boreholes were installed in this aquifer to meet the basic human need requirements of several rural communities during the period 1995 to 2001. Borehole yields are generally less than 1.5 l/s, however higher yields are associated with faults.

2.3.4 Giyani-Gravelotte

This greenstone belt region includes highly metamorphosed ultramafic to mafic schist, amphibolite, mafic metalava, quartzitic schist, quartzite and ironstone. Local fractured aquifers dominate this region as a result of the intense folding and associated fracturing. Rainfall varies from 500-600 mm/a and the topography is generally flat, except where steep ridges where quartzite and ironstone formations outcrop.

Borehole yields typically vary between 2 and 5 l/s, with the highest yields occurring in brittle quartzites. Large-scale groundwater abstraction currently takes place at Giyani (0.1 to 1.0 million m3) for domestic purposes. Localized low yielding boreholes (0.5 to 3.0 l/s) are also in use by various rural communities to meet their basic human need requirements.

2.3.5 The Plains

This region is covers over 50% of the catchment. This aquifer underlies the largest part of the plains of the central Letaba catchment from north of Polokwane in the east to Tzaneen past Phalaborwa, to approximately the Kruger Park boundary.

These aquifers are composed of fractured gneissoid rocks with xenoliths of undifferentiated metamorphic rocks and meta-arenaceous rocks (quartzite, gneiss and migmatite). In the north the gneisses have been intruded by syenites and granites of the Schiel Complex, which has a low groundwater potential. In the east the Timbavati Gabbro and numerous diabase dykes are intrusive.

Rainfall varies from 500-600 mm/a and groundwater yields generally vary between 0.5 and 2.0 l/s, with localized zones where yields range between 2.0 and 5.0 l/s and occasionally more than 5 l/s.

Groundwater development for irrigation purposes takes place on a large scale from this aquifer at Letsitele (1 to 2 million m^3), Mooketsi (2 to 5 million m^3) and Levubu (1 to 2 million m^3). From Levubu right through to Louis Trichardt (which falls outside the Letaba catchment), large-scale groundwater abstraction takes place for irrigation purposes. Very few intrusive hydrogeological investigations have been carried out to conceptualize and quantify groundwater flow, recharge and the water balance to enable long-term aquifer management.

Large-scale irrigation of permanent crops, i.e. citrus, mango, avocado, banana, litchi and macadamia nuts takes place at Letsitele and Mooketsi to the east and north of Tzaneen, conjunctively using surface and groundwater. The 1000 ha large tea plantations of SAPICO are situated on the plateau. The sole reliance of farmers on permanent crops makes agriculture, which is the most important economic activity in the greater Tzaneen area, very sensitive and highly dependent on the water supply conditions. Farmers should be advised to generate a substantial amount of their income from cash crops in order to survive the ‘dry’ years. There is also a tendency amongst farmers to expand their permanent crop capacity in ‘wet’ years as a result of water savings realized by employing more water efficient irrigation systems. In general, large-scale irrigation and agricultural activities reduce considerably towards the ‘drier’ east.

Groundwater levels are generally below stream level, hence baseflow is unlikely to be generates. In general, all aspects surrounding the groundwater/surface water interaction need to be investigated further. No intrusive studies have been carried out to date.

In addition to the above, localized groundwater use for domestic and game watering purposes is widespread at the various game farms in the area from Phalaborwa to Hoedspruit and various rural water supply boreholes exist with yields ranging between 0.5 and 3.0 l/s.

Hundreds of thousands of people living in rural communities on this aquifer rely on groundwater supply for basic human need requirements. In particular, large-scale groundwater use takes place north of Phalaborwa and Tzaneen to meet this basic need. Some of the communities to the east of Tzaneen, that are dependent on groundwater to meet their basic human need requirements, are Letsitele, Letaba Estates, Nkowakow, Lenyenye and Ritavi and in the northern part of the Letaba catchment, Giyani, Bolobedu and Namakgate. In all the above-mentioned rural communities there is a huge potential for expansion of groundwater use. Associated with the rural community lifestyle is increased nitrate and organic contamination as a result of uncontrolled animal grazing along riverbeds and lack of sanitation systems, all resulting in poorer quality groundwater baseflow reaching the Letaba River. Furthermore, there is an urgent requirement for the monitoring of the Groot and Klein Letaba River systems in terms of flow and quality.

Localized use of granite aquifers for domestic and game watering purposes in granite aquifers also takes place on private game farm property to the east. Several boreholes have been drilled in the Kruger Park and are utilized by private game reserves in the vicinity. Although the Park obtains most of its domestic supplies from surface water, there is a concern that private game reserves might overexploit groundwater resources to supplement game viewing water holes. In the light of this, a fear exists that the park is not in a position to manage their groundwater resources.

2.3.6 Lebombo

This region is situated in the east and underlies the Kruger Park. The geology consists of a thin basal sequence of Clarens Formation sandstone overlain by basalts and rhyolites. The MAP is less than 500 mm. Borehole yields are generally less than 0.5-1.5 l/s and a large fraction are dry.

2.3.7 Alluvium

Primary aquifers, consisting of saturated alluvium, are often present along major river drainage systems and are composed of unconsolidated clayey silts to coarse gravels and boulders. The highest yielding aquifer of this type is present in the south-eastern and eastern regions of the Letaba catchment, mostly in the Kruger Park. In the middle and upper reaches of the Klein Letaba and Molotsi rivers alluvial deposits of up to 150 m wide and 8m thick are present.

These aquifers extending along the river course can be up to 500 m in width and up to 10 m thick. The average borehole yield of this aquifer is more than 5 l/s. During the rainy season, up to 20 l/s per borehole can be abstracted. However, the yield diminishes during the dry season if the volume of storage is limited or if there is no recharge from the host rock.

Groundwater quality in these aquifers is highly variable and a decrease in yield in the dry season is normally accompanied by an increase in salinity.

Alluvial aquifers form isolated local aquifers along major river courses and are recharged during periods of high streamflow and discharge once again to the river once stream stage drops. Since they are recharged by surface water rather than conventional direct groundwater recharge, their maintenance depends on ensuring periods of high flow to replenish bank storage.

They are considered major aquifers and exist in delicate equilibrium with surface water and ecosystems present along the river course. In terms of the future exploitation potential of these aquifers, surface water/groundwater interactions, and the sensitivity of ecosystems along the Letaba River to a drop in water table resulting from a change in the flow regime need to be evaluated. A high confidence groundwater reserve determination is therefore proposed.

2.4 REFERENCE CONDITIONS AND PRESENT STATE

2.4.1 Groundwater Harvest Potential

The Ground Water Harvest Potential (Seward and Seymour, 1996) was used as the basis for the evaluation. The Harvest Potential is defined as the maximum volume of groundwater that is available for abstraction without depleting the aquifer systems, and takes into account recharge, storage and drought periods.

It is however not possible to abstract all the ground water available. This is mainly due to economic and/or environmental considerations. The main contributing factor is the hydraulic conductivity or transmissivity of the aquifer systems. As no regional information is available, a qualitative evaluation has been done using available borehole yield information, as there is a good relationship between borehole yield and transmissivity.

The average borehole yield was determined for each quaternary catchment using information available from the National Ground Water Database and the borehole database of the Chief Directorate Water Services. Where no information was available, the average of the tertiary catchment was used. The Harvest Potential was then reduced by an exploitation factor, determined from borehole yield data, to obtain an exploitation potential, i.e. the portion of the Harvest Potential which can practically be exploited (Table 2).

2.4.2 Groundwater Use

The existing groundwater use was determined by Baron and Seward 2000 (Table 3). Information was then verified at a workshop held in the WMA by the Water Resources Situation Assessment team. This provided local input to the groundwater use numbers provided by Baron and Seward which were then adjusted accordingly.

2.4.3 Groundwater Baseflow

Three tabulations of baseflow were obtained: from the Pitman Model as used to calculate the groundwater component of river flow on the Map of the Groundwater Resources of South Africa, from the Hughes SARES Model, which uses a digital filter to separate baseflow from the Virgin Runoff Hydrograph, and from Schultz and Barnes (2001), as calculated by the ACRU model. The Schultz Figures diverge significantly from the Pitman and Hughes figures due to a different definition of baseflow. Schultz considers baseflow to be the portion of ground water which contributes to the low flow of streams originating from the regional groundwater body, hence baseflow can therefore be regarded as that portion of the total water resource that can either be abstracted as ground water or surface water. The Pitman and Hughes interpretation of baseflow includes all water, which migrates through the subsurface, hence it includes seepage from perched aquifers, high lying springs and interflow. A large fraction of this water never reaches the regional aquifer, hence does not form part of the groundwater resources included in the concept of Harvest Potential. For this reason, this investigation utilized the Schultz baseflow figures to determine groundwater contributions to rivers. The baseflow in this study is defined as the annual equivalent of the average low flow that is equaled or exceeded 75% of the time during the 4 driest months of the year.

2.4.4 Groundwater-Surface Water Interaction

The exchange of water between groundwater and surface water was quantified by evaluating the base flow or more specifically the contribution of Harvest Potential to the base flow (Table 4). The Schultz baseflow figures were divided by Harvest Potential to obtain a Baseflow Factor. Where baseflow factors were greater than 1, such as in the escarpment region, it was assumed that a large fraction of baseflow originates from springs, throughflow or perched water tables where percolating water never reaches the regional groundwater. In such cases baseflow factors were corrected to 1.0 to obtain an estimate of baseflow from the regional groundwater body.

This groundwater contribution can be seen as water which can either be abstracted as groundwater or surface water. From this, the extent to which groundwater abstraction will impact on surface water has been qualitatively evaluated and the following arbitrarily chosen classification was done (Table 5):

- where the groundwater contribution is 0 the impact will be negligible
- where the contribution is ≤ 30% of the baseflow the impact will be low
- where the contribution is 30% - 80% of the baseflow, the impact will be moderate
- high impact has been evaluated where the contribution to baseflow is > 80%.

The groundwater balance then compares existing groundwater use to Harvest and Exploitation Potential to determine the extent to which the groundwater resources are utilized, i.e. if total use was greater than the Harvest Potential, the catchment was considered over-utilized, if the total use was greater than the exploitation potential but less than the Harvest Potential, the catchment was considered heavily utilized, if the total use was more than 66% of the Exploitation Potential the catchment was considered moderately-utilized and if the total use was less than 66% of the exploitation potential the catchment was considered under-utilized.

2.4.5 Groundwater Quality

The water quality has been evaluated in terms of TDS and potability. The information was obtained from WRC Project K5/841 (M Simonic 2000). The mean TDS together with the highest value, lowest value and range is given for each catchment where analyses were available. Where no analyses were available an estimate of the mean was made using Vegters Maps (Vegter, 1995). The potability evaluation done by Simonic (M Simonic, 2000) was based on the evaluation of chloride, fluoride, magnesium, nitrate, potassium, sodium, sulphate and calcium using the Quality of Domestic Water Supplies, Volume I (DWAF, 1998).

The portion of the ground water resources considered potable has been calculated as that portion classified as ideal, good and marginal (Class 0, 1 and 2) and according to Quality of Domestic Water Supplies, Volume I (DWAF, 1998). Water classified as poor and unacceptable (Class 3 and 4) has been considered not potable (See Table 5).

Data on historic groundwater levels and water quality variations are not available.

2.4.6 Impacts on Groundwater

Due to the limited storage in the fractured aquifer, it is likely that over abstraction would result in rapid dewatering, hence declining water levels would have an immediate impact on abstraction. Declining baseflow may be attributable to afforestation in the Escarpment and Foothills region. This would probably result in reduced baseflow from throughflow and perched aquifers, but would not impact on the regional valley bottom aquifers to the same extent. A qualitative summary of groundwater present status and predicted impacts are given in Tables 6-8.

The following impacts on water levels were considered :

- limited duration: water level recovery < 2 years
- medium duration: recovery 2-10 years
- None: No or insignificant use (<1% of exploitation potential)

- Low: total use is <10% of exploitation potential
- Moderate: total use is 10-30% of exploitation potential
- High: total use > 30% of exploitation potential

Impacts on baseflow were considered as arising from Streamflow Reduction Activities including afforestation, alien invasive vegetation, and groundwater abstraction in excess of the difference between groundwater baseflow and Harvest Potential. The Hughes figures for baseflow were utilized since Stream Flow Reduction Activities generally impact on high lying springs and perched aquifers, which generate baseflow in the high lying regions above the regional aquifer. Afforestation and, alien vegetation area, and streamflow reduction volumes were obtained from WSAM. It was assumed that water consumption by afforestation and alien invasives was entirely at the expense of baseflow. This is considered to be an overestimation, since a fraction of this consumptive use would be from water which would discharge during hydrograph peaks.

Table 2: Harvest and Exploitential Potential of Quaternary Catchments

	AREA (km^2)	HARVEST POTENTIAL (m^3/km^2/a)	HARVEST POTENTIAL (mm)	HARVEST POTENTIAL (X10^6 m^3/a)	AVERAGE YIELD BOREHOLES (l/s, 8hrs/d)	AVERAGE YIELD BOREHOLES (l/s, 24hrs/d)	EXPLOITATION FACTOR	EXPLOITATION POTENTIAL (m^3/km^2/a)	EXPLOITATION POTENTIAL (mm)	EXPLOITATION POTENTIAL (X10^6 m^3/a)
B81A	169	16041	16.0	2.71	0.06	0.02	0.3	4812	4.8	0.81
B81B	481	16040	16.0	7.72	2.17	0.72	0.6	9624	9.6	4.63
B81C	208	16000	16.0	3.33	0.35	0.12	0.4	6400	6.4	1.33
B81D	479	16281	16.3	7.80	1.80	0.60	0.6	9769	9.8	4.68
B81E	665	13445	13.4	8.94	1.22	0.41	0.5	6723	6.7	4.47
B81F	1201	12000	12.0	14.41	1.90	0.63	0.6	7200	7.2	8.65
B81G	513	13119	13.1	6.73	1.80	0.60	0.6	7871	7.9	4.04
B81H	668	12000	12.0	8.02	4.49	1.50	0.7	8400	8.4	5.61
B81J	568	11372	11.4	6.46	3.43	1.14	0.7	7960	8.0	4.52
B82A	467	15771	15.8	7.37	0.80	0.27	0.5	7886	7.9	3.68
B82B	406	16000	16.0	6.50	0.85	0.28	0.5	8000	8.0	3.25
B82C	300	15854	15.9	4.76	1.00	0.33	0.5	7927	7.9	2.38
B82D	632	15993	16.0	10.11	3.28	1.09	0.7	11195	11.2	7.08
B82E	423	15152	15.2	6.41	3.10	1.03	0.7	10606	10.6	4.49
B82F	760	15856	15.9	12.05	2.31	0.77	0.6	9514	9.5	7.23
B82G	921	11968	12.0	11.02	2.96	0.99	0.6	7181	7.2	6.61
B82H	749	11309	11.3	8.47	1.01	0.34	0.5	5654	5.7	4.24
B82J	795	8071	8.1	6.42	2.64	0.88	0.6	4842	4.8	3.85
B83A	1252	9648	9.6	12.08	2.56	0.85	0.6	5789	5.8	7.25
B83B	439	8000	8.0	3.51	2.73	0.91	0.6	4800	4.8	2.11
B83C	592	8000	8.0	4.74	3.25	1.08	0.7	5600	5.6	3.32
B83D	784	9297	9.3	7.29	2.28	0.76	0.6	5578	5.6	4.37
B83E	312	9281	9.3	2.90	1.00	0.33	0.5	4641	4.6	1.45

Table 3: Groundwater use by Quaternary Catchment

QUAT	NO OF BORES WITH YIELD DATA	SUM OF YIELDS (l/s)	SUM OF BOREHOLE YIELDS (X106 m3/annum)	THEORETICAL NO OF PRODUCTION BOREHOLES	MUNICIPAL USE (X106 m3/a)	RURAL USE (X106 m3/a)	LIVESTOCK USE (X106 m3/a)	IRRIGATION USE (X106 m3/a)	TOTAL USE FACTOR	TOTAL USE (X106 m3/a)	TOTAL USE (mm/a)
B81A	1	0.06	0.00	623.10	0.00	0.00	0.01	0.38	1.00	0.39	2.33
B81B	3	6.50	0.07	118.35	0.00	0.00	0.06	6.68	0.40	2.70	5.60
B81C	4	1.38	0.01	14.01	0.00	0.04	0.02	0.00	1.00	0.05	0.24
B81D	75	134.90	1.42	358.95	0.00	3.71	0.00	14.38	0.38	6.79	14.17
B81E	16	19.54	0.21	0.72	0.00	0.00	0.01	0.00	1.00	0.01	0.01
B81F	20	38.07	0.40	30.47	0.00	0.61	0.00	0.00	1.00	0.61	0.51
B81G	18	32.38	0.34	56.70	0.00	1.07	0.00	0.00	1.00	1.07	2.09
B81H	9	40.43	0.42	12.71	0.00	0.60	0.00	0.00	1.00	0.60	0.90
B81J	5	17.17	0.18	4.42	0.00	0.15	0.01	0.00	1.00	0.16	0.28
B82A	24	19.18	0.20	161.14	0.00	0.03	0.00	1.77	0.75	1.35	2.90
B82B	3	2.56	0.03	0.49	0.00	0.00	0.00	0.00	1.00	0.00	0.01
B82C	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
B82D	75	246.33	2.59	122.19	0.00	4.11	0.00	0.11	1.00	4.22	6.68
B82E	165	510.86	5.37	63.67	0.00	2.01	0.00	0.06	1.00	2.07	4.90
B82F	13	30.02	0.32	46.92	0.00	0.92	0.00	0.22	1.00	1.14	1.50
B82G	12	35.47	0.37	20.05	0.00	0.62	0.00	0.00	1.00	0.62	0.68
B82H	16	16.21	0.17	15.21	0.00	0.16	0.00	0.00	1.00	0.16	0.22
B82J	13	34.33	0.36	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
B83A	30	76.85	0.81	0.07	0.00	0.00	0.00	0.00	1.00	0.00	0.00
B83B	32	87.23	0.92	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
B83C	22	71.45	0.75	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
B83D	33	75.24	0.79	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
B83E	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00

Table 4: Groundwater Baseflow

QUAT	MEAN ANNUAL RUNOFF	BASE FLOW INDEX	BASE FLOW SCHULTZ	BASE FLOW PITTMAN	BASE FLOW HUGHES	BASE FLOW SCHULTZ	BASE FLOW FACTOR	CORRECTED BASE FLOW FACTOR	CONTRIBUTION TO BASE FLOW	CONTRIBUTION TO BASE FLOW
	(X106 m3/a)		(mm/annum)	(mm/annum)	(mm/annum)	(X106 m3/annum)			(X106 m3/annum)	(mm/annum)
B81A	69.01	0.36	148.11	199.40	231.17	25.03	9.23	1.00	2.71	16.04
B81B	164.05	0.35	119.51	148.90	189.28	57.48	7.45	1.00	7.72	16.04
B81C	16.83	0.12	9.81	18.50	31.99	2.04	0.61	0.61	2.04	9.81
B81D	55.18	0.23	27.06	81.70	83.16	12.96	1.66	1.00	7.80	16.28
B81E	29.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B81F	18.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B81G	16.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B81H	7.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B81J	5.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B82A	23.03	0.04	2.06	7.20	15.75	0.96	0.13	0.13	0.96	2.06
B82B	18.04	0.04	1.92	7.00	14.17	0.78	0.12	0.12	0.78	1.92
B82C	13.93	0.05	2.10	7.10	15.14	0.63	0.13	0.13	0.63	2.10
B82D	16.39	0.06	1.52	5.00	8.74	0.96	0.09	0.09	0.96	1.52
B82E	13.33	0.05	1.70	5.90	10.57	0.72	0.11	0.11	0.72	1.70
B82F	27.43	0.05	1.73	6.10	11.68	1.32	0.11	0.11	1.32	1.73
B82G	14.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B82H	10.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B82J	13.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83A	12.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83B	8.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83C	7.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83D	9.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83E	4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5: Groundwater Resources and Surface-Subsurface Impacts

QUAT	HARVEST POT. - BASEFLOW (X106 m3/a)	EXPLOITABLE PORTION Of Harvest pot.- baseflow (X106 m3/a)	HARVEST POT. – TOTAL USE (X106 m3/a)	EXPLOITATION POT. - USE (X106 m3/a)	EXPLOITATION POTENTIAL DIVIDED BY TOTAL USE (X106 m3/a)	ESTIMATED EXTENT OF GROUND WATER UTILISATION	IMPACT OFGROUND WATER ABSRTACTION ON SURFACE WATER	PORTION POTABLE	MAX UTILISABLE GROUND WATER (X106 m3/annum)
B81A	0	0.00	2.32	0.42	2.07	UNDER-UTILISED	HIGH	0.70	0.57
B81B	0	0.00	5.02	1.93	1.72	UNDER-UTILISED	HIGH	0.50	2.31
B81C	1.29	0.52	3.28	1.28	26.20	UNDER-UTILISED	MODERATE	1.00	1.33
B81D	0	0.00	1.01	-2.11	0.69	HEAVILY-UTILISED	HIGH	0.96	4.47
B81E	8.94	4.47	8.93	4.46	482.44	UNDER-UTILISED	NEGLIGABLE	0.92	4.10
B81F	14.41	8.65	13.80	8.04	14.18	UNDER-UTILISED	NEGLIGABLE	0.76	6.54
B81G	6.73	4.04	5.66	2.97	3.77	UNDER-UTILISED	NEGLIGABLE	0.80	3.22
B81H	8.02	5.61	7.42	5.01	9.35	UNDER-UTILISED	NEGLIGABLE	0.45	2.55
B81J	6.46	4.52	6.30	4.36	28.31	UNDER-UTILISED	NEGLIGABLE	0.40	1.81
B82A	6.40	3.20	6.01	2.33	2.72	UNDER-UTILISED	LOW	0.55	2.04
B82B	5.72	2.86	6.49	3.24	738.18	UNDER-UTILISED	LOW	0.59	1.90
B82C	4.13	2.06	4.76	2.38		UNDER-UTILISED	LOW	1.00	2.38
B82D	9.15	6.40	5.89	2.86	1.68	UNDER-UTILISED	LOW	0.76	5.37
B82E	5.69	3.98	4.34	2.41	2.17	UNDER-UTILISED	LOW	0.60	2.69
B82F	10.73	6.44	10.91	6.09	6.35	UNDER-UTILISED	LOW	0.83	6.03
B82G	11.02	6.61	10.40	5.99	10.62	UNDER-UTILISED	NEGLIGABLE	0.75	4.96
B82H	8.47	4.24	8.31	4.07	26.14	UNDER-UTILISED	NEGLIGABLE	0.67	2.82
B82J	6.42	3.85	6.42	3.85		UNDER-UTILISED	NEGLIGABLE	1.00	3.85
B83A	12.08	7.25	12.08	7.25	3814.40	UNDER-UTILISED	NEGLIGABLE	1.00	7.25
B83B	3.51	2.11	3.51	2.11		UNDER-UTILISED	NEGLIGABLE	0.89	1.87
B83C	4.74	3.32	4.74	3.32		UNDER-UTILISED	NEGLIGABLE	1.00	3.32
B83D	7.29	4.37	7.29	4.37		UNDER-UTILISED	NEGLIGABLE	0.85	3.70
B83E	2.90	1.45	2.90	1.45		UNDER-UTILISED	NEGLIGABLE	0.50	0.72

Table 6: Impacts on Groundwater Levels

Quaternary	Water Levels			
	Reference condition (mbgl)	**Impacting uses**	**Nature, extent , duration and significance of impact**	**Present status**
B81A	15-30	Irrigation	Drawdown, localized, limited, High	Fair
B81B	5-25	Irrigation	Drawdown, localized, limited, High	Fair
B81C	15-35	Rural	Drawdown, localized, limited, Low	Good
B81D	15-35	Irrigation/rural	Drawdown, widespread, medium, High	Poor
B81E	10-30		None	Natural
B81F	10-20	Rural	Drawdown, localized, limited, Low	Good
B81G	10-20	Rural	Drawdown, localized, limited, Moderate	Fair
B81H	10-20	Rural	Drawdown, localized, limited, Moderate	Fair
B81J	10-20	Rural	Drawdown, localized, limited, Low	Good
B82A	15-35	Irrigation/rural	Drawdown, localized, limited, High	Fair
B82B	5-25		None	Natural
B82C	5-25		None	Natural
B82D	40-50	Irrigation/rural	Drawdown, localized, limited, High	Fair
B82E	15-35	Irrigation/rural	Drawdown, localized, limited, High	Fair
B82F	20-30	Irrigation/rural	Drawdown, localized, limited, Moderate	Fair
B82G	20-30	Rural	Drawdown, localized, limited, Low	Good
B82H	20-30	Rural	Drawdown, localized, limited, Low	Good
B82J	10-20		None	Natural
B83A	10-20		None	Natural
B83B	10-20		None	Natural
B83C	10-20		None	Natural
B83D	10-20		None	Natural
B83E	10-20		None	Natural

Table 7: Baseflow Reduction in the Letaba

Quaternary	Baseflow (mm)	Area (km2)	Baseflow Mm^3/a	Streamflow reduction from afforestation Mm^3/a	Streamflow reduction from alien vegetation Mm^3/a	Exploitable Groundwater not linked to surface water Mm^3/a	Total abstraction Mm^3/a	Baseflow reduction by abstraction Mm^3/a	Total baseflow reduction Mm^3/a
B81A	246.42	169.10	41.67	16.11	3.07	0.00	0.39	0.39	19.57
B81B	201.84	481.20	97.13	31.98	7.94	0.00	2.70	2.70	42.62
B81C	32.42	208.40	6.76	0.49	1.80	1.29	0.05		2.29
B81D	83.16	478.80	39.82	5.12	3.59	0.00	6.79	6.79	15.50
B81E	0.00	664.90	0.00	1.08	0.18	8.94	0.01		1.26
B81F	0.00	1199.70	0.00	0.00	0.08	14.41	0.61		0.08
B81G	0.00	512.40	0.00	0.23	0.03	6.73	1.07		0.26
B81H	0.00	667.70	0.00	0.00	0.02	8.02	0.60		0.02
B81J	0.00	567.00	0.00	0.00	0.01	6.46	0.16		0.01
B82A	15.75	466.60	7.35	0.41	0.40	6.40	1.35		0.81
B82B	14.17	406.30	5.76	0.86	0.47	5.72	0.00		1.33
B82C	14.85	299.70	4.45	1.38	0.86	4.13	0.00		2.24
B82D	8.74	631.70	5.52	0.60	0.43	9.15	4.22		1.03
B82E	10.36	423.40	4.39	0.66	0.00	5.69	2.07		0.66
B82F	11.68	759.80	8.87	0.36	0.06	10.73	1.14		0.42
B82G	0.00	920.10	0.00	0.00	0.04	11.02	0.62		0.04
B82H	0.00	748.60	0.00	0.00	0.02	8.47	0.16		0.02
B82J	0.00	793.70	0.00	0.00	0.02	6.42	0.00		0.02
B83A	0.00	1250.00	0.00	0.00	0.00	12.08	0.00		0.00
B83B	0.00	438.80	0.00	0.00	0.00	3.51	0.00		0.00
B83C	0.00	591.40	0.00	0.00	0.00	4.74	0.00		0.00
B83D	0.00	712.80	0.00	0.00	0.01	7.29	0.00		0.01
B83E	0.00	266.60	0.00	0.00	0.00	2.90	0.00		0.00

The impacts of streamflow reduction activities on baseflow are shown in Table 8.

The following impacts on baseflow were considered :

- Low: total use is <10% of baseflow
- Moderate: total use is 10-30% of baseflow
- High: total use > 30% of baseflow

Approximately 80% of baseflow is generated from 8% of the catchment (B81A, B81B, B81D). These are the sub-catchments most significantly impacted, accounting for 88% of the total baseflow reduction. In total, baseflow has been reduced by nearly 40%, primarily due to afforestation in the headwater regions.

Table 8: Impacts on Baseflow

Quaternary	Baseflow Reduction			
	Reference condition (m^3 x 10^6 /a)	Impacting uses	Significance of impact	Present status
B81A	41.67	Afforestation, alien invasives, irrigation	High	Poor
B81B	97.13	Afforestation, alien invasives, irrigation	High	Poor
B81C	6.76	Alien invasives, afforestation	High	Poor
B81D	39.82	Irrigation, afforestation, alien invasives	High	Poor
B81E	0.00	Afforestation, alien invasives	No significance	Good
B81F	0.00		None	Good
B81G	0.00		None	Good
B81H	0.00		None	Good
B81J	0.00		None	Good
B82A	7.35	Afforestation, alien invasives	Moderate	Fair
B82B	5.76	Afforestation, alien invasives	Moderate	Fair
B82C	4.45	Afforestation, alien invasives	High	Poor
B82D	5.52	Afforestation, alien invasives	Moderate	Fair
B82E	4.39	Afforestation,	Moderate	Fair
B82F	8.87	Afforestation, alien invasives	Low	Good
B82G	0.00		None	Good
B82H	0.00		None	Natural
B82J	0.00		None	Natural
B83A	0.00		None	Natural
B83B	0.00		None	Natural
B83C	0.00		None	Natural
B83D	0.00		None	Natural
B83E	0.00		None	Natural

2.5 IMPORTANCE OF SOURCE

2.5.1 Ecological Importance

Baseflow to maintain instream flows can be attributed to discharge from the regional aquifers, or from subsurface discharge with a rapid turnover time originating from shallow fractures outcropping on steep slopes, perched water tables, throughflow through the weathered zone, or highland springs above the regional valley bottom aquifer. The ecological significance of the regional aquifer used a groundwater resource is related to the connectivity of groundwater to the river reaches, and the degree to which the aquifer maintains baseflow.

Impacts on groundwater baseflow can occur when abstraction exceeds groundwater losses other than to discharge to the river, resulting in a diminished baseflow, or flow reversals of streamflow into the aquifer. This situation is most prevalent when tracts of alluvium exist, allowing the infiltration of large volumes of streamwater into the alluvium in response to dropping groundwater levels. In addition, dropping water levels in alluvial systems may impact on groundwater dependent riverine vegetation. Impacts on ecological systems are shown in Table 9.

The Following impacts on groundwater baseflow and vegetation were considered:

- Insignificant: total baseflow reduction is localized and not numerically significant (<1%)
- Low: total baseflow reduction is <10% of baseflow, or total use is <10% of the difference between harvest potential and groundwater baseflow
- Moderate: total baseflow reduction is 10-30% of baseflow, or total use is 10-30% of the difference between harvest potential and groundwater baseflow
- High: total baseflow reduction > 30% of baseflow, or total use is > 30% of the difference between harvest potential and groundwater baseflow.

Total reduction in groundwater baseflow is approximately 10 Mm^3/a, however, in many cases this impact is significantly larger in dry years when irrigators rely more strongly on boreholes due to reduced streamflow. During dry years depletion of baseflow and losses into the aquifer can reach 21.5 Mm^3/a. This can be as high as 85% of baseflow originating from the regional aquifer.

Table 9: Impacts of Groundwater use on Ecological Systems

Quaternary	**Groundwater Baseflow**			
	Reference condition (m^3 x 10^6 /a)	**Impacting uses**	**Impact on baseflow, Significance of impact**	**Present status**
B81A	2.71	Irrigation	-0.39 Mm3/a, moderate	Poor
B81B	7.72	Irrigation	-2.7 Mm^3/a, high	Poor
B81C	2.04	Rural	Low	Good
B81D	7.80	Irrigation	-6.79 Mm^3/a, high	Poor
B81E	0.00		Insignificant	Good
B81F	0.00	Rural	Low	Good
B81G	0.00	Rural	Moderate	Fair
B81H	0.00	Rural	Low	Good
B81J	0.00	Rural	Low	Good
B82A	0.96	Irrigation	Moderate	Fair
B82B	0.78		Insignificant	Good
B82C	0.63		Insignificant	Good
B82D	0.96	Rural	High	Poor
B82E	0.72	Rural	High	Poor
B82F	1.32	Rural	Low	Good
B82G	0.00	Rural	Low	Good
B82H	0.00	Rural	Low	Good
B82J	0.00		None	Natural
B83A	0.00		None	Natural
B83B	0.00		None	Natural
B83C	0.00		None	Natural

Quaternary	Groundwater Baseflow			
	Reference condition (m^3 x 10^6 /a)	Impacting uses	Impact on baseflow, Significance of impact	Present status
B83D	0.00		None	Natural
B83E	0.00		None	Natural

2.5.2 Social and Economic Importance

The importance of groundwater to the regional economy can be assessed by assessing the use of groundwater for irrigation, livestock, and rural water supply in terms total combined surface and ground water use for each of these functions. Groundwater usage for irrigation was based on drought usage rather than average annual, to highlight the importance of this resource during dry years. The results are shown in Table 10.

Table 10: Significance of Groundwater Usage

Quaternary	Irrigation usage	Livestock usage	Rural Usage	Total use	Significance
B81A	57%	14%	0%	36%	High
B81B	43%	45%	0%	42%	High
B81C	0%	47%	13%	1%	Low
B81D	43%	0%	65%	46%	High
B81E	0%	31%	0%	0%	Insignificant
B81F	0%	0%	11%	7%	Low
B81G	0%	0%	23%	23%	Moderate
B81H	0%	0%	24%	24%	Moderate
B81J	0%	21%	24%	3%	Low
B82A	25%	0%	19%	25%	Moderate
B82B	0%	0%	0%	0%	Insignificant
B82C	0%	0%	0%	0%	Insignificant
B82D	25%	0%	50%	49%	High
B82E	25%	0%	52%	50%	High
B82F	25%	0%	13%	14%	Moderate
B82G	0%	0%	31%	5%	Low
B82H	0%	0%	6%	3%	Low
B82J	0%	0%	0%	0%	Insignificant
B83A	0%	0%	0%	0%	Insignificant
B83B	0%	0%	0%	0%	Insignificant
B83C	0%	0%	0%	0%	Insignificant
B83D	0%	0%	0%	0%	Insignificant
B83E	0%	0%	0%	0%	Insignificant

2.5.3 Importance to Wetlands

Few wetlands exist in the catchment and only two are recorded:

- Soutini/Baleni in catchment B82H
- Eiland in catchment B81F

These wetlands are zones of groundwater discharge. Since both are located in catchments were groundwater usage is low, neither wetland is presently at risk.

2.6 VULNERABILITY OF GROUNDWATER

2.6.1 Groundwater vulnerability

A map of the risk to aquifers by faecal contamination was prepared for the Luvuvhu/Letaba WMA based on the DRASTIC approach.

Aquifer vulnerability is low in the western Escarpment region of the catchment due to the presence of moderate to deep clayey loam soils overlying the granites. In the Foothills the aquifer is highly vulnerable to contamination due .the sandy loam texture of the soil. In the Giyani-Gravelotte region the aquifer is moderately vulnerable due to depth of the water table. In the plains the aquifer is overlain by sandy soils, hence is moderately vulnerable to contamination, however, the region overlying basalt, is underlain by clayey soils and has a low vulnerability.

2.6.2 Overexploitation

The groundwater resources of the Letaba are underutilized, with the exception of B81D, the catchment of the Letsitele. In this catchment abstraction for irrigation is 145% of the exploitation potential, and as a result significant depletion of baseflow generated in the headwaters of the catchment occurs.

2.6.3 Drought

Aquifers can be prone to drought stress when water demand is large in relation to harvest potential, rainfall variability is high and storage is limited.

Vulnerability was assessed by comparing maximum abstraction during dry years to aquifer storage (Table 11). Aquifer storage was determined from aquifer thickness, an assumed storativity of 0.005 and the exploitation factor (Table 2) to correct storage in terms of the abstractable proportion. Since water strikes are generally within 8 m of the static water level the aquifer in the Escarpment region, and within 15-20 within the plains region, the aquifer can be considered to have a thickness of 8 and 17 m respectively.

Table 11: Aquifer Vulnerability to Drought

Quaternary	Aquifer thickness (m)	Aquifer storage (Mm^3)	Abstraction as % of storage	MAP (mm)	Vulnerability
B81A	7	1.78	22%	1194	Moderate
B81B	7	10.11	67%	1163	High
B81C	7	2.92	2%	880	Low
B81D	7	10.05	180%	832	High
B81E	7	11.64	0%	667	Insignificant
B81F	17	61.18	1%	544	Low
B81G	7	10.76	10%	627	Low
B81H	7	16.36	4%	510	Low
B81J	17	33.74	0%	502	Insignificant
B82A	7	8.17	22%	721	Moderate
B82B	7	7.11	0%	702	Insignificant
B82C	7	5.24	0%	712	Insignificant
B82D	7	15.48	27%	623	Moderate

Quaternary	Aquifer thickness (m)	Aquifer storage (Mm^3)	Abstraction as % of storage	MAP (mm)	Vulnerability
B82E	7	10.37	20%	656	Moderate
B82F	7	15.96	7%	676	Low
B82G	17	46.93	1%	524	Low
B82H	17	31.82	1%	516	Low
B82J	17	40.48	0%	540	Insignificant
B83A	17	63.75	0%	515	Insignificant
B83B	17	22.38	0%	596	Insignificant
B83C	17	35.19	0%	539	Insignificant
B83D	17	36.35	0%	552	Insignificant
B83E	17	11.33	0%	587	Insignificant

2.7 PRESENT STATE AND PROPOSED LEVEL OF GROUNDWATER RESERVE DETERMINATION

The management of the groundwater component of the Reserve for the Letaba should be based largely on protecting baseflow, due to the implications on downstream users of current baseflow reduction activities in the headwater regions. Existing activities which pose a risk to the depletion of the groundwater component of the Reserve, and suggested groundwater Reserve determination levels to manage these risks are given in Table 12.

Table 12: Present State and Required Reserve Determination Levels

Quaternary	Region	Groundwater Response Unit	Activity/Hazards	Present State	Recommended Reserve determination
B81A	Escarpment	Granite, high baseflow	Afforestation, alien invasives, irrigation / perched and groundwater baseflow reduction	Fair	Comprehensive
B81B	Escarpment	Granite, high baseflow	Afforestation, alien invasives, irrigation / perched and groundwater baseflow reduction, drought vulnerability	Fair	Comprehensive
B81C	Escarpment	Granite and gneiss basement, moderate baseflow	Afforestation, alien invasives / perched baseflow reduction	Fair	Intermediate
B81D	Escarpment	Granite and gneiss basement, moderate baseflow	Afforestation, alien invasives, irrigation / perched and groundwater baseflow reduction, aquifer vulnerability, overexploitation, drought vulnerability	Fair	Comprehensive
B81E	Foothills	Granite and gneiss basement,	Afforestation/ aquifer vulnerability	Good	Intermediate
B81F	Plains	Basement gneiss	Rural water / aquifer vulnerability	Good	Intermediate
B81G	Plains	Basement gneiss	Afforestation, rural/ groundwater baseflow reduction, aquifer vulnerability	Good	Intermediate
B81H	Plains	Basement gneiss	Rural/ aquifer vulnerability	Good	Intermediate
B81J	Giyani-Gravelotte	Basement gneiss, gravelotte greenstones	Rural/aquifer vulnerability	Good	Intermediate
B82A	Escarpment	Basement gneiss, low baseflow	Afforestation, alien invasives, irrigation rural / perched and groundwater baseflow reduction, aquifer vulnerability, drought vulnerability	Fair	Comprehensive
B82B	Escarpment	Basement gneiss,	Afforestation , alien invasives /	Good	Intermediate

Quaternary	Region	Groundwater Response Unit	Activity/Hazards	Present State	Recommended Reserve determination
		low baseflow	perched baseflow reduction		
B82C	Escarpment	Basement gneiss, low baseflow	Afforestation , alien invasives / perched baseflow reduction	Fair	Comprehensive
B82D	Foothills	Basement gneiss, low baseflow	Irrigation, rural, afforestation, alien invasives / perched and groundwater baseflow reduction, aquifer vulnerability	Fair	Comprehensive
B82E	Bandolierskop	Basement gneiss, bandolierskop, low baseflow	Rural, afforestation, irrigation / perched and groundwater baseflow reduction, aquifer vulnerability	Fair	Comprehensive
B82F	Bandolierskop	Basement gneiss, Bandolierskop, low baseflow	Rural, afforestation, irrigation / perched and groundwater baseflow reduction, aquifer vulnerability	Fair	Comprehensive
B82G	Giyani-Gravelotte	Basement gneiss, Giyani greenstones	Rural / Aquifer vulnerability	Good	Rapid
B82H	Giyani-Gravelotte	Basement gneiss, Giyani greenstones	Rural / Aquifer vulnerability	Good	Rapid
B82J	Plains	Basement gneiss		Protected	Rapid
B83A	Plains	Basement gneiss		Protected	Rapid
B83B	Plains	Basement gneiss		Protected	Rapid
B83C	Lebombo	Letaba basalt		Protected	Rapid
B83D	Lebombo	Letaba basalt		Protected	Rapid
B83E	Lebombo	Letaba basalt		Protected	Rapid

In the fractured Basement Aquifers of the Escarpment and Foothills regions a high confidence level groundwater reserve determination is required based on streamflow reduction activities, the surface water groundwater interaction, existing and future groundwater abstraction, impact of large-scale agricultural activities on return water quality, high basic human need requirement and interrelationships between surface and groundwater. There is a need to conceptualize the aquifer systems and quantify groundwater recharge in relation to rainfall patterns and frequencies.

In the fractured basement and granitoid aquifers of the Plains region a high confidence level groundwater reserve determination is required in view of the large basic human need requirement, aquifer vulnerability and contamination as a result of lack of sanitation facilities, existing and future groundwater use, surface water/groundwater interaction and ecological sensitivity and the importance of several existing springs. This is even more important should the conjunctive use of surface and groundwater materialize, as is envisaged as a feasible option to meet the water demands in the area in the near future. An understanding of the contribution and importance of the groundwater component in the regional water balance is important.

This is even more important in order to understand the contribution and importance of the groundwater component in the regional water balance, should the conjunctive use of surface and groundwater materialize. Surface and groundwater use is envisaged as a feasible option for the water demands in this area in the future. An urgent investigation into the agricultural activities in the area in relation to crop water demands in times of drought, is recommended.

Very little intrusive hydrogeological investigations have been carried out to conceptualize and quantify groundwater flow, recharge and the water balance in order to enable long-term aquifer management.

In the greenstones underlying the Giyani-Gravelotte District, due to existing groundwater use from the aquifer, future expansion potential and basic human need requirements, a rapid to intermediate level groundwater reserve determination is proposed.

Alluvial aquifers along the major Letaba River course, mainly in the Kruger Park, are considered major aquifers and exist in delicate equilibrium with surface water and ecosystems present along the river course. These aquifers are recharged by surface water during periods of high flow. In terms of the potential for future exploitation of these aquifers, and for the modification of the river flow regime, surface water/groundwater interactions need to be quantified and the sensitivity of ecosystems along the Letaba River to a dropping water table needs to be evaluated. A high confidence groundwater reserve determination is therefore proposed.

Right through the Letaba catchment, the basic human need requirements for various rural settlements pose huge challenges both in terms of primary water supply and also in protecting the quality of groundwater resources from increasing nitrate values in the absence of adequate sanitation systems. In addition to the above, uncontrolled animal grazing in river beds and the utilization of the major river course itself for washing purposes will have a profound water quality impact in the long term.

3. GROUND WATER AND THE THE ECOLOGICAL RESERVE

The contribution of groundwater to the ecological reserve is dependent on the natural contribution of subsurface water to streamflow, desired management class and Instream Flow Requirements.

Groundwater contributions cannot be simply equated to recharge, since recharge may be lost in steeply areas before reaching the regional aquifer through interflow through the weathered zone, seepage of percolating water outcropping fractures, springs draining perched water tables, artesian springs, evapotranspiration, or by conventional discharge into effluent streams. Therefore, it is not the recharge term that is significant to quantifying discharge of subsurface water into streams; it is the natural discharge. This component must be subdivided into discharge, which emerges in high lying areas not connected to the regional groundwater body and therefore not accessible by boreholes, and into groundwater discharge.

In the Letaba catchment, regional groundwater levels are generally below the level of the river, hence conventional groundwater baseflow is limited. Baseflow is sustained by rainfall in the highlying Escarpment and foothills regions, which seeps through the shallow soils and emerges from fractured granite and gneiss above the regional aquifer as mountain springs. For this reason, recharge calculated based on rainfall and soil zone percolation is significantly different than the Harvest Potential of the regional aquifer.

To calculate groundwater contribution to the Reserve, Streamflow Reduction Activities were subtracted from baseflow calculated by Hughes based on streamflow Hydrographs. This incorporates discharge from perched systems as well as groundwater baseflow.

Abstraction from boreholes must be subtracted from Harvest Potential, which represents recharge to the regional groundwater body. When abstraction exceeds the difference between Harvest Potential and groundwater baseflow, an impact on baseflow is assumed. This method may be overly simplistic since it does not take into account where abstraction takes place.

Abstraction in the vicinity of the river would have a much more significant impact on groundwater discharge than the same abstraction some distance away from the river. Since the location of abstraction is not known, an attempt to correct for abstraction location was made by assuming that 50% of abstraction occurs in the vicinity of streams and was subtracted directly from groundwater discharge. The remaining 50% was subtracted only from Harvest Potential and would impact on baseflow only if abstraction exceeds the difference between Harvest Potential and baseflow.

In some cases negative flows arise due to water use in excess of available water. Such situations were permitted as water deficits could be made up from the infiltration of river water into bank storage.

Estimated present day perched and groundwater baseflow was compared to IFR baseflow requirements in DWAF (1994) of 70 Mm^3/a. This baseflow volume represents 31.5% of virgin baseflow, hence 31.5% of virgin groundwater and perched discharge was considered to be the ecological reserve. Differences in the water quality and timing of discharge from these two sources may be of significance for ecological purposes hence it is important to maintain proportions between the two sources.

Calculations of groundwater contributions to the Reserve are given in Table 13. Figures underlined represent catchments where abstraction exceeds the ecological reserve under maximum groundwater abstraction conditions. For the catchment as a whole, baseflow exceeds the Reserve, however, much of the baseflow generated in the headwater regions is abstracted from the river for irrigation, hence baseflow requirements downstream are not met.

Table 13: Calculation of the Groundwater Component of the Reserve

	Total Virgin Baseflow Mm^3/a	Virgin G'water Baseflow Mm^3/a	Virgin Perched Baseflow Mm^3/a	Forestry Water use Mm^3/a	Alien invasive Water use Mm^3/a	Present Perched baseflow Mm^3/a	G'water Abstract. Mm^3/a	Harvest Potential - Baseflow Mm^3/a	Present G'water Baseflow Mm^3/a	Max. G'water Abstract. Mm^3/a	Present G'water Baseflow Mm^3/a	Reserve G'water baseflow Mm^3/a	Reserve Perched Baseflow Mm^3/a
B81A	41.67	2.71	38.96	16.11	3.07	19.78	0.39	0.00	2.32	0.39	2.32	0.86	12.30
B81B	97.13	7.72	89.41	31.98	7.94	49.49	2.70	0.00	5.02	6.74	0.98	2.44	28.23
B81C	6.76	2.04	4.72	0.49	1.80	2.43	0.05	1.29	2.02	0.06	2.01	0.64	1.49
B81D	39.82	7.80	32.02	5.12	3.59	23.31	6.79	0.00	1.01	18.09	-10.29	2.46	10.11
B81E	0.00	0.00	0.00	1.08	0.18	-1.26	0.01	8.94	0.00	0.01	0	0.00	0.00
B81F	0.00	0.00	0.00	0.00	0.08	-0.08	0.61	14.41	0.00	0.61	0	0.00	0.00
B81G	0.00	0.00	0.00	0.23	0.03	-0.26	1.07	6.73	0.00	1.07	0	0.00	0.00
B81H	0.00	0.00	0.00	0.00	0.02	-0.02	0.60	8.02	0.00	0.6	0	0.00	0.00
B81J	0.00	0.00	0.00	0.00	0.01	-0.01	0.16	6.46	0.00	0.16	0	0.00	0.00
B82A	7.35	0.96	6.39	0.41	0.40	5.58	1.35	6.41	0.28	1.8	0.06	0.30	2.02
B82B	5.76	0.78	4.98	0.86	0.47	3.65	0.00	5.72	0.78	0	0.78	0.25	1.57
B82C	4.45	0.63	3.82	1.38	0.86	1.58	0.00	4.13	0.63	0	0.63	0.20	1.21
B82D	5.52	0.96	4.56	0.60	0.43	3.53	4.22	9.15	-1.15	4.22	-1.15	0.30	1.44
B82E	4.39	0.72	3.67	0.66	0.00	3.01	2.07	5.69	-0.32	2.07	-0.32	0.23	1.16
B82F	8.87	1.32	7.55	0.36	0.06	7.13	1.14	10.73	0.75	1.14	0.75	0.42	2.39
B82G	0.00	0.00	0.00	0.00	0.04	-0.04	0.62	11.02	0.00	0.62	0	0.00	0.00
B82H	0.00	0.00	0.00	0.00	0.02	-0.02	0.16	8.47	0.00	0.16	0	0.00	0.00
B82J	0.00	0.00	0.00	0.00	0.02	-0.02	0.00	6.42	0.00	0	0	0.00	0.00
B83A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.08	0.00	0	0	0.00	0.00
B83B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.51	0.00	0	0	0.00	0.00
B83C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.74	0.00	0	0	0.00	0.00
B83D	0.00	0.00	0.00	0.00	0.01	-0.01	0.00	7.29	0.00	0	0	0.00	0.00
B83E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.90	0.00	0	0	0.00	0.00
TOTAL		**25.64**	**196.07**	**59.28**	**19.03**	**117.76**	**21.94**	**144.11**	**11.34**	**37.74**	**-4.23**	**8.10**	**61.90**

4. GUIDELINES FOR TERMS OF REFERENCE

Further Investigations of the groundwater component of the Reserve should focus on maintaining the required volume and quality of baseflow to meet the IFR.

The scope of work performed shall include but not necessarily be limited to:

- Delineation of aquifer units and their boundary conditions in a format whereby flows across boundary can be quantified under natural and modified scenarios
- Development of a conceptual model of groundwater recharge and discharge
- Estimation of recharge and its variations in time
- Quantification of groundwater abstraction and baseflow reduction from Streamflow Reduction activities
- Quantification of water demand for the Basic Human Need
- Determination of groundwater levels and hydraulic gradients in the vicinity of the river courses to determine natural and modified conditions
- Evaluation of the relationship between abstraction rates, distance from water courses, and impacts on baseflow
- Setting of Resource Quality Objectives and an associated monitoring programme that focuses on maintaining the required volume and quality of baseflow to meet the IFR.

Since baseflow is generated only in the Escarpment, Foothills and Bandolierskop regions, investigations for maintaining the groundwater component of the Reserve need to focus on these regions. The setting of Resource Quality Objectives for these regions include :

- Groundwater monitoring systems should be put in place in the vicinity of the stream channel relate groundwater levels in the regional aquifer to groundwater baseflow and to evaluate minimum groundwater levels to maintain the Reserve.
- Localized groundwater dependent ecosystems and springs need to be identified;
- Irrigation demand from groundwater during drought periods needs to be quantified
- Water use by plantations and the impact on recharge to the regional aquifer needs to be quantified
- Surface water/groundwater interaction and perched and groundwater discharge needs to be quantified;
- The environmental impact of groundwater abstraction needs to be quantified;
- A regional aquifer management system needs to be designed, including water quality and quantity;
- Monitoring of the Groot and Klein Letaba River systems (flow and quality) needs to be carried out; and
- Thorough agricultural analysis needs to be carried out in accordance with regional water management and an integrated water management plan, including suggested agricultural practices prepared for the Letaba catchment.

In the Plains and Giyani-Gravelotte Districts groundwater does not contribute directly to the ecological Reserve, and groundwater abstraction for domestic purposes is the main water use. However, it is possible that river reaches may be influent, resulting in transmission losses. Resource Quality Objectives for the region include the following:

- Groundwater monitoring systems should be put in place to ensure that groundwater levels do not drop and groundwater quality does not deteriorate;

- Surface water/groundwater interaction needs to be quantified.
- Resource quality objectives for the Alluvial Aquifers are as follows:
- Groundwater monitoring systems should be put in place to ensure that abstraction does not result in significant leakage and baseflow depletion.
- Aquifer recharge needs to be quantified;
- Surface water/groundwater interaction in needs to be quantified;
- The extent of existing and future groundwater use from this aquifer needs to be determined.

5. REFERENCES

DWAF Report No PB800/00/1590, 1990: Water Resources Planning of the Letaba River Basin, Study of development potential and management of the Water Resources, Basin Study Report: Annexure 13 Groundwater Resources.

DWAF, 2000. 1: 2 000 000 Map, Water Management Areas of the Republic of South Africa.

Nelspruit Hydrogeology Map 2530, 1: 500 000, Department of Water Affairs and Forestry.

Phalaborwa Hydrogeological Map2330, 1: 500 000, Department of Water Affairs and Forestry.