

THUKELA WATER PROJECT DECISION SUPPORT PHASE

RESERVE DETERMINATION STUDY GROUNDWATER SCOPING REPORT

April 2003

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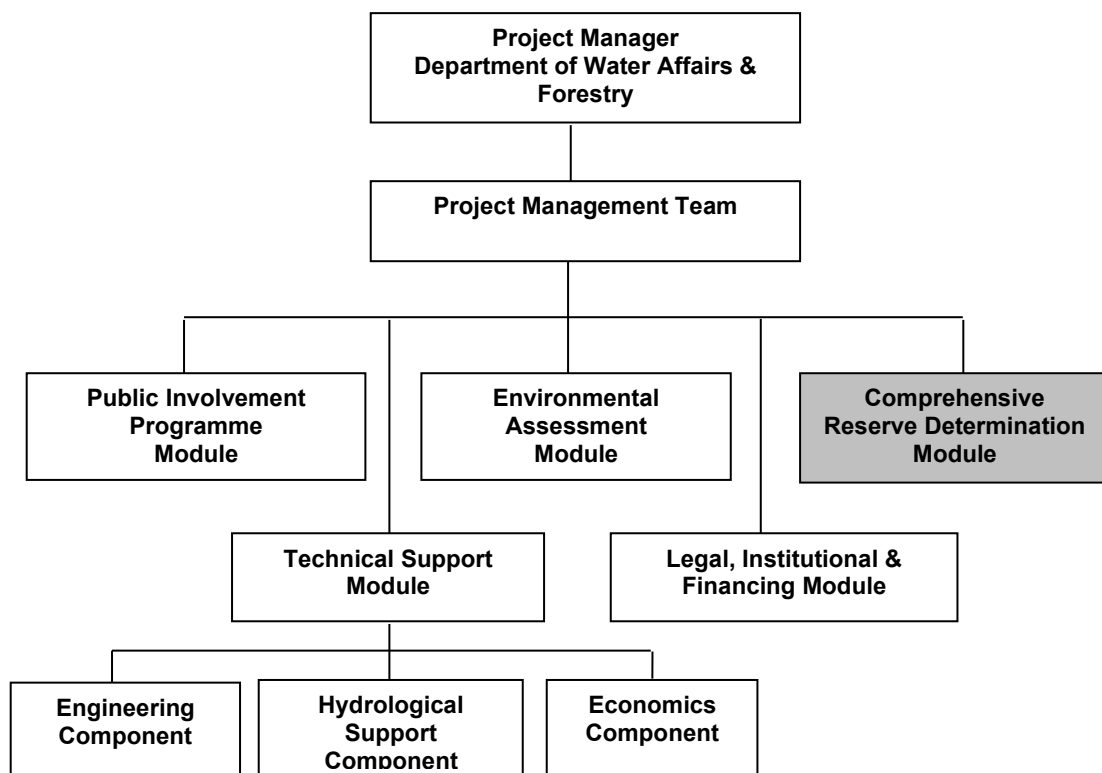
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STRUCTURE OF DECISION SUPPORT PHASE



**DEPARTMENT OF WATER AFFAIRS & FORESTRY
DIRECTORATE WATER RESOURCES PLANNING**

**THUKELA WATER PROJECT DECISION SUPPORT PHASE
RESERVE DETERMINATION STUDY
GROUNDWATER SCOPING REPORT**

IWR SOURCE-TO-SEA

APRIL 2003

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EXECUTIVE SUMMARY

Previous geohydrological work in the Thukela River catchment focussed on developing groundwater supplies for rural communities. None considered the role of groundwater in the functioning of the hydrological system, nor possible impacts should groundwater contributions be reduced. A scoping study was hence commissioned to assess the role of groundwater in sustaining the Reserve in the Thukela River catchment. The desk-based study aimed to:

- Describe prevailing geohydrological characteristics.
- Assess the role of groundwater in meeting basic human needs and contribution to baseflow.
- Identify further work requirements.

The Thukela River catchment covers an area of 29 000km² and has a largely rural-based population of 1 570 000. Groundwater is a key source of water and has played a major part in meeting basic water needs in the catchment. The Thukela River has its source in the Drakensberg Mountains and flows eastwards toward the sea, discharging some 90km north of Durban. Rainfall, which has a strong correlation with relief, falls mainly during summer months with little falling in the cold winter months.

Sediments of the Karoo Supergroup underlie much of the catchment. Older rocks of the Natal Group and Barberton Sequence outcrop in the eastern parts of the catchment while Jurassic-aged dolerites cap the escarpment in the west. The catchment is dominated by weathered and fractured hard rock aquifers. Borehole yields are generally low, but yields in excess of 2P/s are obtained in places. Groundwater quality is generally good, but deteriorates slightly in the direction of flow (south-eastwards). These characteristics result in the aquifers being classified as minor aquifers with moderate to low vulnerability to anthropogenic impacts. Though the aquifers are thought to be in near-pristine condition, potential sources of contamination include coalmines and lack of sanitation in unserved rural communities.

Using information from the KwaZulu-Natal groundwater mapping project, recharge was conservatively estimated to be 620 MCM/a. This equates to some 2.6% of MAP. Total groundwater use in the catchment was estimated at 35 MCM/a, half of which is used for rural water supply. It was further estimated about 6 000 boreholes are operational in the study area. Neither recharge nor groundwater quality are considered limiting factors in developing groundwater resources for rural water supply. Because the rate of abstraction is low, is generally widespread and only amounts to about 5% of recharge, it is not expected groundwater abstracted for this purpose poses a threat to aquatic ecosystems.

In addition to sustaining terrestrial ecosystems and riverine vegetation, groundwater contributes to baseflow and sustains pools and shallow subsurface water bodies critical to aquatic ecosystems during dry periods. However, since implementing the concept of the Reserve, it has become more and more clear that not all baseflow is derived from groundwater. In addition to inconsistent use of terminology, confusion stems from baseflow separation procedures only considering stormflow and baseflow and not recognising the contribution from stormflow, *interflow* and groundwater. Traditional baseflow separation techniques indicate groundwater could contribute as much as 40% of MAR. However, this far exceeds estimates of recharge. Analysis during the current study suggests the groundwater contribution to baseflow may equate to about 10% MAR. This aspect requires further attention.

Though abstraction in the Thukela River catchment is unlikely to impact the role played by groundwater in sustaining the ecological Reserve, local abstraction adjacent to rivers may have an impact. It was considered prudent, therefore, that generic groundwater management guidelines be compiled to manage groundwater resources (particularly those

adjacent to sensitive ecosystems) and guide allocations at a local scale. Other recommendations from this scoping study include:

- Determine the groundwater component of the Reserve at a rapid level for each quaternary catchment.
 - Undertaking a catchment-wide recharge study to facilitate better quantification of the groundwater component of the Reserve.
 - Determination of the groundwater contribution to baseflow using river flow data, groundwater level data and expert hydrological and geohydrological judgement.
 - Identify groundwater dependant ecosystems in order that sensitive systems can be protected from anthropogenic impacts.
 - Inclusion of geohydrological expertise in the Reserve determination process to facilitate a better understanding of the hydrological system and the provision of specific insights or inputs when required.
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LIST OF ACRONYMS

DWAF	Department of Water Affairs and Forestry
EC	Electrical conductivity
GDP	Gross Domestic Product
GGP	Gross Geographical Product
IFR	Instream flow requirement
Ma	Million years
MAP	Mean annual precipitation
MAR	Mean annual run-off
MCM/a	Million cubic metres per annum
m ³ /s	Cubic metres per second
m ² /d	Metres squared per day
mm/a	Millimetres per annum
mS/m	Millsiemens per metre
NGDB	National Groundwater Database
RDP	Reconstruction and Development Programme
T	Transmissivity
TWP	Thukela Water Project
VAPS	Vaal Augmentation Planning Study

GLOSSARY OF TERMS

Aquifer: Strata or a group of interconnected strata comprising of saturated earth material capable of conducting groundwater and of yielding usable quantities of groundwater to borehole(s) and/or springs (a supply rate of 0.1P/s is considered as a usable quantity). Latin: *aqua* water and *ferre* to carry.

Baseflow: That part of stream flow which is contributed by either water temporarily stored in the vadose zone or groundwater discharged from the saturated zone, water discharged into rivers days to months after a rainfall event.

Basic human need: The least amount of water required to satisfy basic water requirements, this is currently set at 25 P/p/d.

Exploitation potential: The rate at which groundwater can be withdrawn from a catchment without causing any detrimental impacts, calculated by dividing the harvest potential by a borehole factor.

Groundwater: All subsurface water occupying voids within a geological stratum.

Groundwater allocation: The rate at which groundwater can be withdrawn without resulting in a significant regional drop of groundwater levels in a catchment over the long-term, without inducing a deterioration of groundwater quality or without causing any other detrimental impact.

Harvest potential: Maximum amount of groundwater that can be abstracted per square kilometre per annum without depleting the aquifers.

Recharge: Process of the addition of water to the groundwater system by natural or artificial processes.

Reserve: The quantity and quality of water required to supply basic needs of people to be supplied with water from that resource, and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources.

Transmissivity: The rate at which a volume of water of the prevailing kinematic viscosity is transmitted through a unit width of aquifer under a unit hydraulic head (m^2/d).

1 INTRODUCTION

1.1 BACKGROUND

In 1994 the Department of Water Affairs and Forestry (DWAF) initiated the Vaal Augmentation Planning Study (VAPS) to determine the respective merits of alternative water resource development options to augment supplies to the Vaal River. These options are to follow implementation of Phases 1A and 1B of the Lesotho Highlands Water Project. The subsequent Thukela Water Project (TWP) feasibility study was initiated in 1997 to confirm the VAPS results. A number of investigations have since been undertaken to investigate the feasibility of various water supply options (BKS, 2001), including a series of instream flow requirement (IFR) assessments (DWAF, 2000). However, none of the work undertaken to date considered the role of groundwater in the functioning of the hydrological system, nor possible impacts should groundwater contributions be reduced.

Geohydrological investigations undertaken in the Thukela River catchment have focussed on developing groundwater supplies for rural communities (Hobbs, 1993; E.Martinelli and Associates, 1994, 1995; Davies Lynn and Partners, 1995; Groundwater Consulting Services, 1995; Steffen Robertson and Kirsten, 1995; VSA Earth Science Consultants, 1995; King, 1997). Issues such as borehole yield and groundwater quality in terms of fitness-for-use have been addressed, but little attempt has been made to quantify recharge, groundwater flow directions, and contribution to stream flow or environmental dependencies.

The study area addressed by this report includes the third largest river in South Africa and the largest river not subject to water demands and rights from other countries. Lack of previous investigations into surface – groundwater interaction and the preliminary nature of this investigation prevent a detailed assessment of the role of groundwater in the general catchment. Much of the assessment provided in this report was based on first principles and an understanding of prevailing geohydrological and hydrological conditions. Further, the sheer size of the catchment required a number of generalisations be made.

1.2 TERMS OF REFERENCE

A scoping study was required to assess the role of groundwater in sustaining the Reserve of the Thukela River and consider the need for more detailed geohydrological assessment. The study aimed to describe prevailing geohydrological characteristics and assess the role of groundwater in meeting basic human water needs and its contribution to base flow. The findings of the scoping exercise were to be documented in a short report. Further work requirements were also to be documented in the report. The project outcome was to be based on available information.

The project was not required to quantify the groundwater component of the Reserve. As the purpose of the scoping exercise was to identify the role of groundwater in the Thukela River catchment, it was also not required to develop a comprehensive understanding of the hydrogeology of the catchment.

The following tasks were undertaken during the groundwater scoping exercise:

- Collection of available maps of the study area.
- Collection of available geohydrological reports of the area.
- Visit DWAF geohydrologists responsible for the study area.
- Discuss baseflow characteristics with project hydrologist.
- Assess available information.
- Preparation of a short report documenting the findings of the scoping exercise.
- Discussion with project team regarding further work requirements.

1.3 REPORT STRUCTURE

After describing the proposed Thukela Water Project (Section 2) and the catchment in terms of physiography, climate, drainage and geology (Section 3), the report describes prevailing geohydrological conditions (Section 4). Based on this, the contribution of groundwater in meeting Basic Human Needs (Section 5) and sustaining baseflow (Section 6) is assessed. The findings of the investigation are discussed in Section 7 and conclusions and recommendations presented in Section 8.

2 DESCRIPTION OF PROPOSED THUKELA WATER PROJECT

The proposed Thukela Water Project is described in detail by BKS (2001) and only a brief background summary is presented below. Water from the Thukela River plays an important role in supplying water to KwaZulu-Natal and the Vaal River System. About 23m³/s is currently transferred out of the catchment.

Water was transferred from the Mooi River into the Mgeni River as an emergency scheme during severe drought in the 1980s. This scheme was mothballed when the drought broke. However, the scheme has since been recommissioned and is to be used as a permanent transfer scheme to transfer some 4m³/s for use by Pietermaritzburg and Durban.

Richards Bay obtains water from the transfer of water from the lower Thukela River into the Goedertrouw Dam on the Mhlatuze River (Middledrift Transfer Scheme). This scheme currently transfers water at a rate of 1.2m³/s, but may be increased to 8m³/s in the future (Thukela Basin Consultants, 2000).

Water is transferred from the upper Thukela River via Woodstock Dam and Kilburn Dam into Sterkfontein Dam from where it is transported into the Vaal River System via the Wilge River. The average rate of transfer of the Drakensberg Pumped Storage Scheme is 17m³/s. The Vaal River System supplies water to six provinces, which produce more than 50% of the country's gross domestic product (GDP).

Transfer from Zaaihoek Dam on the Slang River (a tributary of the Buffalo River) to the Majuba Power Station and the Grootdraai Dam in the Vaal River System also takes place. Current rate of transfer is low (0.06m³/s), but is likely to increase to 0.9m³/s.

It was proposed that the Jana Dam south-west of Ladysmith and the Mielietuin Dam between Weenen and Escourt be investigated further. The aim of building these dams and the ancillary water transfer network would be to supplement the current Thukela - Vaal Transfer Scheme (BKS, 2001). It is planned that the Jana and Mielietuin dams be built on the Thukela River and the Bushmans River. Water will be pumped up to the Kilburn Dam and linked to the current transfer scheme. It is estimated the proposed scheme will supplement the Vaal River System by a further 15m³/s.

3 DESCRIPTION OF STUDY AREA

3.1 LOCATION

The Thukela River catchment is located on the eastern seaboard of South Africa. The catchment drains some 29 000km² and discharges into the Indian Ocean 90km north of Durban. The proposed dams are to be built in the uThukela Region, which essentially comprises the western part of the greater Thukela River catchment. The region covers an area of 11 000km².

3.2 PHYSIOGRAPHY

The Thukela River has its source in the Drakensberg Mountains near Bergville. These mountains attain elevations in excess of 3 000 m. From the steep mountain slopes in the northern and western headwaters, the topography flattens eastwards toward the coast.

King (1997) describes the western portion of the catchment as high mountains while the northern area is described as low mountains. The area east of the confluence of the Thukela River, Bushmans River and the Buffalo River is also described as low mountains. The central parts of the catchment were described by King (1997), as moderately undulating plains and mountains and lowlands. These terrain morphology classifications were based on slope, relief, drainage density and stream frequency.

3.3 CLIMATE

The catchment experiences a wide range of climatic conditions. Summers are generally hot with temperatures often exceeding 35°C. Winters are cold, particularly in the west and north where temperatures fall below freezing and frost occurs regularly. Along the coast conditions are generally more temperate.

Mean annual precipitation (MAP) in the Thukela River catchment is some 830mm/a (Vegter and Pitman, 1996). However, rainfall varies significantly throughout the catchment and exhibits a strong correlation with relief. Rainfall in excess of 1 000mm/a occurs along the escarpment, but drops to less than 600mm/a east of Weenen. Much of the central part of the Thukela basin receives between 600 and 800mm/a. The coastal parts of the study area also receive in excess of 1 000mm/a.

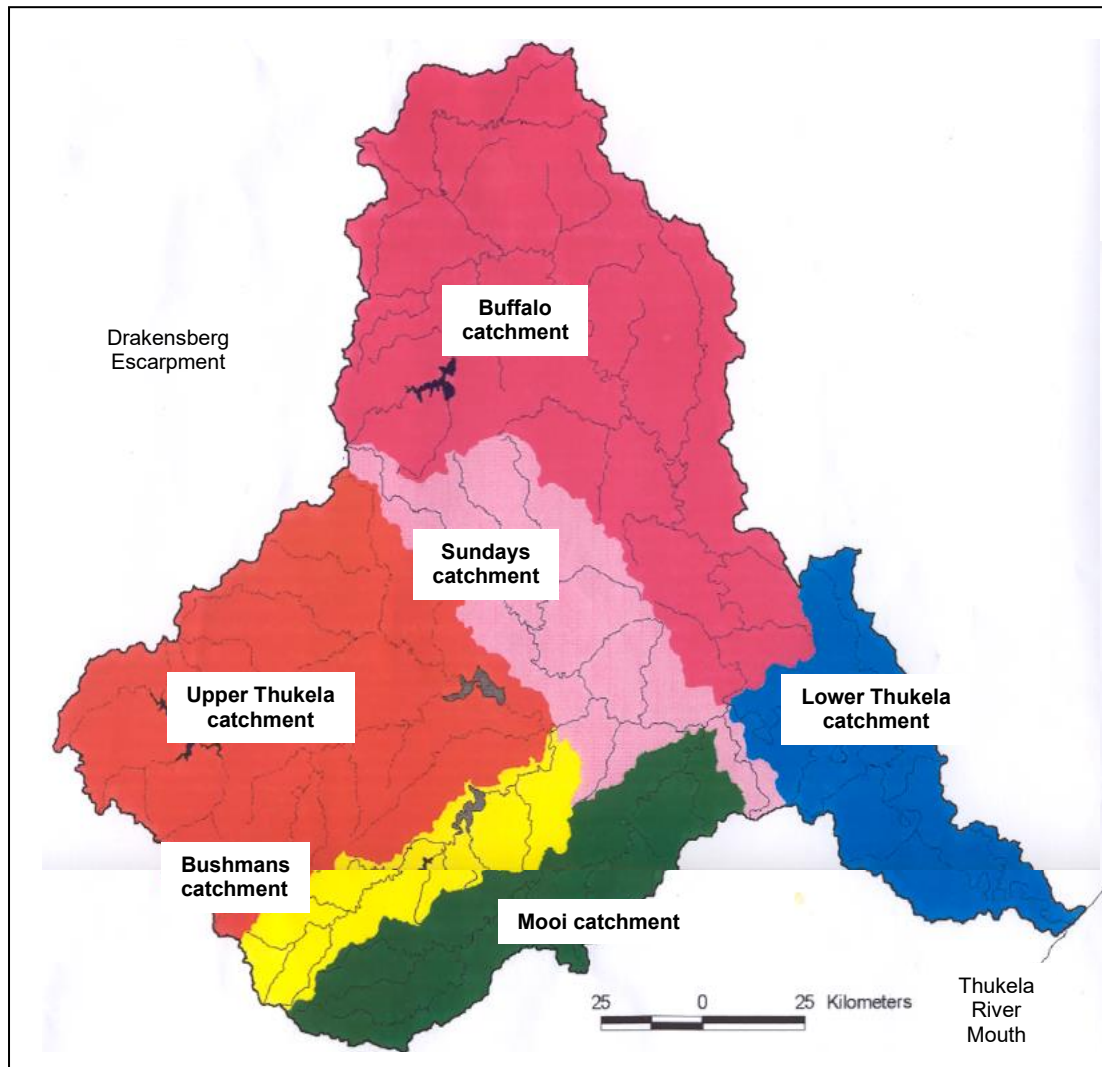
Most rainfall occurs in summer months, particularly between December and March. Little rainfall occurs during the cold winter months. Snow falls on the higher lying Drakensberg Mountain peaks, but melts fairly rapidly. BKS (2001) reported rainfall in the catchment is erratic and years of prolonged drought are followed with very wet periods.

Evaporation increases from the coast westwards. At the coast, evaporation amounts to about 1 200 mm/a and increases to 1 500mm/a in the central part of the study area. Evaporation along the escarpment range between 1 300 and 1 400mm/a.

3.4 DRAINAGE

Rivers in the catchment are steeply graded and flow from west to east. The Thukela River is the major river to drain the study area and has a length of 512km. Major tributaries include the Mooi River, the Bushmans River, the Bloukrans River, the Little Thukela River, the Klip River, the Sundays River and the Buffalo River (Figure 3.1). Estimated naturalised mean annual run-off (MAR) of the Thukela River catchment ranges between 3 850 and

Fig. 3.1 Sub-catchments in the Thukela River catchment



4600 MCM/a (DWAF, 1995; Alcock, 1999) with 4 300 MCM/a appearing a reasonable average. Peak flows occur in wet summer months while baseflows occur during June, July, August and September. Baseflow accounts for about 19.3% of total flow (Vegter and Pitman, 1996). This equates to about 3.2% of MAP.

Highest surface run-off occurs along the steep sloped escarpment and generally decreases eastwards toward the coast. Construction of a number of water supply and farm dams in the catchment has modified surface flows. Major dams in the catchment include the Wagendrift Dam (Bushmans River), Spioenkop Dam (Thukela River), the Chelmsford Dam (Buffalo River) and Woodstock Dam (Thukela River). Dams proposed as part of the Thukela Water Project are the Jana Dam on the Thukela River south-west of Ladysmith and the Mielietuin Dam on the Bushmans River between Weenen and Escourt.

DWAF have permitted a large number of smaller farm dams, most of which are found in the upper reaches of main rivers. Thukela Basin Consultants (2000) estimated total storage of farm dams may be in the order of 338 MCM which is sufficient to have a significant impact on flow regimes, particularly in the upper parts of the catchment.

3.5 GEOLOGY

3.5.1 Lithostratigraphy

Rocks in the Thukela River catchment represent almost the entire geological sequence (Table 3.1), with a younging sequence observed as one moves north-westwards ie. the rocks become progressively younger as one moves north-westwards (Figure 3.2). Small outcrops of granites of the Barberton Sequence occur west of Tugela Ferry. These are some of the oldest rocks known and date in excess of 3 000 Ma. Similarly, the Natal Metamorphic Province include rocks of some 1 000 Ma, but their extent is limited to the south-eastern part of the catchment between Kranskop and Mandini. The extent of the Natal Group is also limited to the area south east of Kranskop

Much of the Thukela River catchment comprises rocks of the Karoo Supergroup. These rocks were deposited between 280 and 180 Ma ago in a variety of depositional environments. The older Dwka Group was deposited during a polar climate while the younger Clarens Formation was deposited under arid conditions. Karoo volcanism during the Jurassic period some 180 Ma ago marked the end of this Supergroup.

Outcrop of Dwka Group tillite is limited to the area around Kranskop. Sediments of the Ecca Group are found in the eastern part of catchment and underlie much of the Sundays River and Buffalo River catchments, with rocks of the Vryheid Formation underling much of the area. These rocks comprise mainly of sandstones and are relatively resistant to erosion, resulting in relatively narrow and deeply incised river channels. The lower Beaufort Group (Adelaide Subgroup) predominates in the western part of the catchment. These rocks are finer grained and comprise most shales and mudstones, with subordinate sandstone horizons. As a result, they are less resistant to erosion, resulting relatively flat, wide valleys. Larger water courses are characterised by large alluvial floodplains with relatively abundant fine-grained alluvial deposits (BKS, 2001).

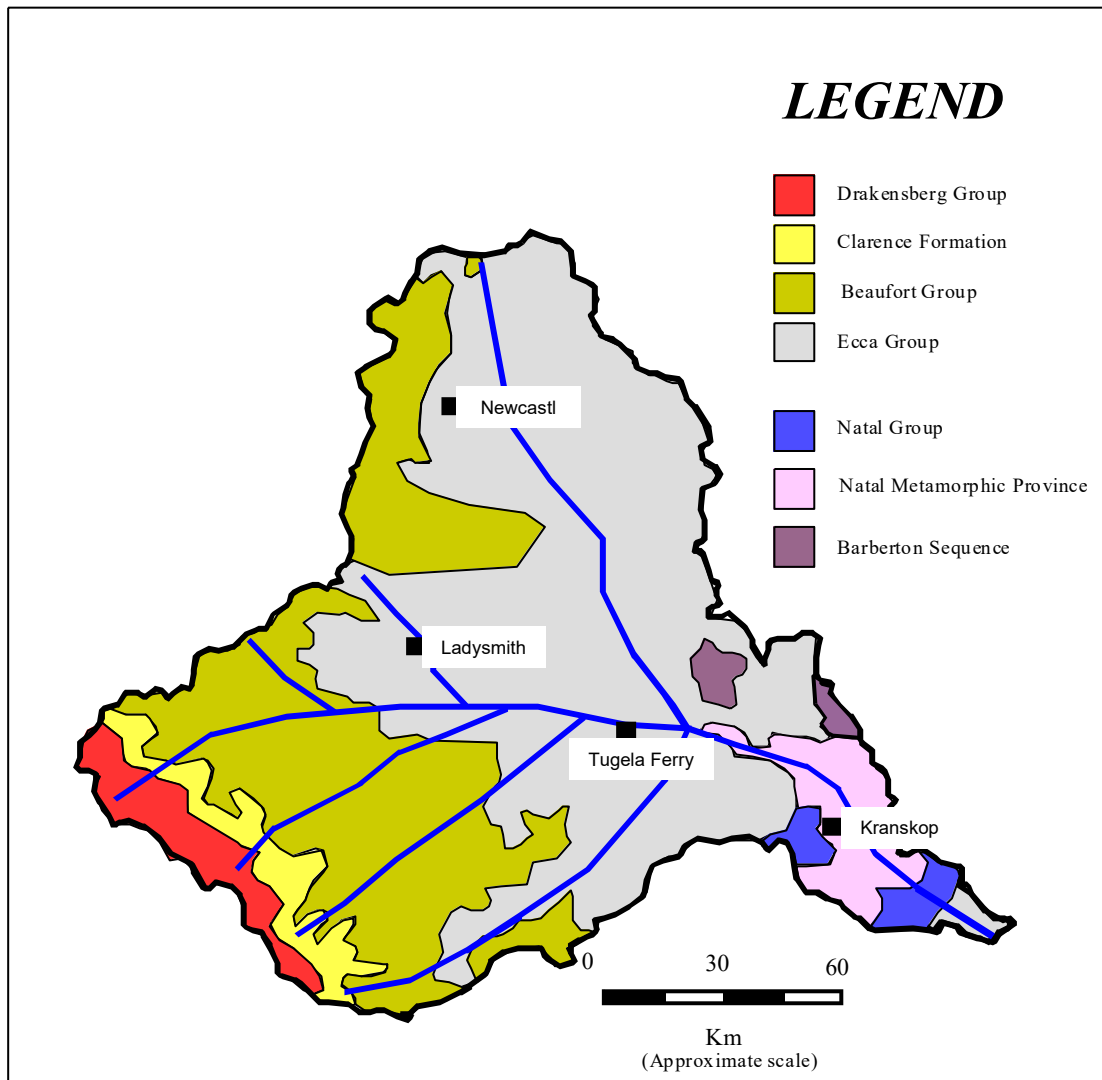
Post Beaufort Group sedimentary rocks are found at the base of the escarpment, which is capped by Karoo-aged basalts. Extrusion of these basalts was linked to the breakup of Gondwana. These rocks are found in the mountains along the western edge of the study area and form an impressive escarpment along the Drakensberg mountain range. Dolerite dykes and sills of Jurassic age are found extensively throughout the study area up-gradient of Kranskop. These features play an important role in the geohydrology of the area and significantly enhance the water-bearing properties of the more arenaceous geological units.

Table 3.1 Stratigraphy of the Thukela River catchment

Age (Ma)	System	Supergroup	Group	Formation	Lithology	
65	Quaternary Tertiary		Maputaland		Calcareous sands	
	Cretaceous		Zululand		Marine siltstones, sandstones and some conglomerates	
140	Jurassic	Karoo	Drakensberg		Basalt	
195			Lebombo	Jozini Letaba	Rhyodactite and rhyolite Basalt	
				Clarens Elliot Nyoka Ntabene Molteno	Sandstone Sandstone and mudstone Mudstone interbedded with sandstone Sandstone with subordinate mudstone Sandstone, mudstone and shale	
	Triassic			Tarkastad Adelaide Emakwenzini Normandien	Sandstone with mudstone Mudstone alternating with sandstone Sandstone alternating with shale and mudstone Sandstone interbedded with shale	
				Ecca	Volsrust Vryheid Pietermaritzburg	Shale and siltstone Sandstone with some shale Shale
345	Permian Carboniferous			Dwka		Tillite, diamictite
	Devonian Silurian Ordovician		Natal		Conglomerates, arkosic sandstone, quartz-arenite and subordinate shale	
570 1180	Cambrian	Natal Metamorphic Province			Mafic metavolcanic rocks with subordinate metasediments	
3 100		Pongola	Nsuze		Tuffs, black sandstones, dactites and rhyolites, quartzites and shales, basalts and andesites, greywackes, conglomerates and shales	
3 200		Barberton Sequence	Swazian granites		Granite and granite gneiss	

(After King, 1997)

Fig. 3.2 Simplified geological map of the Thukela River catchment.



Younger unconsolidated sands are limited to the coastal area and are only of significance in the immediate vicinity of the estuary. King (1997) indicates the presence of localised, but significant alluvial sand deposits throughout the Thukela River catchment. Some deposits reach a thickness of almost 40m.

3.5.2 Structure and Tectonics

A well-defined area roughly parallel to the coast and extending some 70 km inland has been extensively faulted. This has resulted in development of tilted block faults and horst and graben structures southeast of Kranskop. These structures are of post Karoo age and are confined to the lower reaches of the Thukela River.

Two extensive west - east trending faults occur in the study area. The southern Tugela Fault played a prominent role in defining the position and morphology of the Thukela River as the river flows along the fault in the central parts of the study area.

Geological structural lineaments throughout KwaZulu-Natal were mapped by von Vey (cited by King, 1997). These features have east-north-east, west-north-west and north-south orientations and were caused by the break up of Gondwanaland. They are relatively

extensive throughout the catchment and play an important role in the water-bearing properties of prevailing aquifers.

3.6 POPULATION

The total population of the Thukela River catchment is approximately 1 570 000 and is largely in rural areas, but urban/rural population ratios vary significantly throughout the catchment. The rural population is extremely poor with the GDP well below the provincial average (BKS, 2001).

In addition to the main urban centres such as Utrecht, Newcastle, Dundee, Ladysmith, Bergville, Colenso, Escourt, Tugela Ferry, Kranskop and Mandini, large rural communities are found south of Utrecht, along the base of the escarpment in the vicinity of Cathedral Peak and Giants Castle and in the central part of the basin east of Ladysmith through to the coast.

3.7 LAND USES

Manufacturing makes the largest contribution to gross geographical product (GGP). Agriculture contributes a relatively small amount to the GGP (8.1%) while mining and quarrying is insignificant (0.4%).

Agriculture includes forestry, sugar cane plantations, stock farming and game farming. Approximately 42 000 ha are under irrigation with the potential to expand this by a further 18 000 ha (Quinn and Whitfield, 2001).

The Vryheid Formation of the Ecca Group contains coal seams, which have been extensively mined in the past. Most mining activity has taken place in the Klip River coalfield between Newcastle, Dundee and Ladysmith, the Vryheid coalfield and Utrecht coalfield.

4 GEOHYDROLOGY

4.1 DATA SOURCES

A number of data sources were used to assess geohydrological conditions in the Thukela River catchment. Historically, groundwater was generally not considered an important source of water in the catchment. The KwaZulu-Natal groundwater mapping project initiated by DWAF provided the first comprehensive geohydrological description of KwaZulu-Natal (Hobbs, 1993). The mapping project was divided into 11 hydrogeological mapping units, with the Thukela River catchment falling within hydrogeological mapping units 1, 2, 5, 8, 9 and 11. The Thukela River estuary falls in mapping unit 6. The provincial mapping project was followed by an assessment by King (1997), which was based on earlier work and various data collected during drought relief and Reconstruction and Development Programme (RDP) water supply projects. DWAF (1999b) compiled a set of maps related to rural water supplies and groundwater supplies. As a result of these mapping and characterisation initiatives, good quality geohydrological data sets are available for assessing the groundwater component of the Reserve, should it be required.

These studies were supported by national scale mapping initiatives by Vegter (1995), Seymour et al (1998), Parsons and Conrad (1998) and Haupt (2001). Data was also abstracted from the National Groundwater Database (NGDB) for this review. The national and regional maps provide important references regarding the nature and extent of aquifers in the catchment.

4.2 AQUIFER TYPES

The Thukela River catchment is dominated by weathered and fractured hard rock aquifer systems. Primary aquifers are generally confined to the narrow strip along the coast and localised deposits in the middle reaches of the Thukela River, Sundays River and Buffalo River. These deposits appear to have limited importance in a regional context. The primary aquifer in the immediate vicinity of the estuary provides a source of moderate quality water to the estuary during periods of low flow.

In very general terms, the lower Thukela catchment comprises older and highly fractured aquifers associated with rocks of the Natal Metamorphic Province. The Sundays catchment and the Buffalo catchment are dominated by weathered (or intergranular) and fractured aquifers comprised of rocks of the Ecca Group (mainly present as the Vryheid Formation). The Upper Thukela catchment, the Bushmans catchment and western part of the Mooi catchment are underlain by younger weathered and fractured aquifers composed of Beaufort Group sediments.

Parsons and Conrad (1998) classified aquifers in the study area as minor aquifers with moderate to low vulnerability to anthropogenic impacts. Except in the coastal area around the estuary, aquifers in the Thukela River catchment are classified as minor aquifers. These aquifers have a moderate water supply potential and are capable of supplying sufficient water to support 1 250 people per km² at a basic level of service (i.e. 25P/p/d). The more competent Natal Group rocks in the vicinity of Kranskop have a higher groundwater supply potential and are capable of supporting about 3 000 people per km² (DWAF, 1999b)

4.3 BOREHOLE YIELDS

Based on the work of King (1997) and others, borehole yields in KwaZulu-Natal are generally low (Table 4.1). A high percentage of boreholes are dry while few boreholes yield more than 2P/s. Fracturing was identified as a critical requirement for drilling successful boreholes (yield greater than 0.1P/s). Contacts between different lithologies were also seen to be important drilling targets. It must be noted, however, that much of the King (1997) data

related to rural water supply projects where high yields were not important and drilling positions constrained by settlement position and not necessarily governed by geohydrological criteria.

Higher borehole yields can be obtained in some localities. Juxtaposition of sandstone horizons to dolerite, major structural features such as faults and fractures and more competent Natal Group quartzites and sandstones have all produced borehole yields in excess of 2P/s. The likelihood of obtaining yields in excess of 2P/s, however, is less than 30% while few boreholes yield more than 3 P/s.

Table 4.1 Borehole yields obtained during KwaZulu-Natal rural water supply projects

Aquifer type	No. of boreholes	Dry (%)	< 0.5P/s (%)	< 1.0P/s (%)	> 2.0P/s (%)
Quaternary sediments					
- paleochannels	7	15	22	29	35
- fine sand	18	28	35	95	0
- contact with Zululand GP	12	58	0	0	0
Dolerite					
- dolerite	85	15	88	95	5
- contact with Karoo	21	55	75	100	0
- argillaceous	12	60	0	100	0
- contact Eccla	17	55	95	100	0
- contact Vryheid					
Karoo – argillaceous	24	28	81	95	0
Karoo – arenaceous	38	15	80	85	8
Eccla	26	0	71	93	4
Vryheid	43	25	65	73	16
Dwyka – fractured	43	35	75	85	5
Natal	143	30	80	88	10
Natal Metamorphic Province	206	30	80	90	5

(After King, 1997)

Note: Excluding the Dwyka Group and Vryheid Formation, King (1997) grouped all Karoo aged sedimentary rocks into a single group.

4.4 GROUNDWATER LEVELS

A good, spatially distributed data set of groundwater level measurements is available for the study area. However, because of prevailing topography, depth to groundwater varies significantly over short distances and little correlation with surface elevation is obtained when assessed at a small scale. Reported depth to groundwater ranges from near surface to more than 50m in places.

A detailed re-examination of all available groundwater level data is required to facilitate a better understanding of surface – groundwater interactions in the Thukela River catchment. This will require reliable depth to groundwater measurements and accurate surface elevation data. Ongoing population of the NGDB is crucial while elevation data can be obtained from topographical survey data and digital terrain models of the study area.

Groundwater contour maps indicate groundwater flow directions mimic that of slope. Flow in the vicinity of the Thukela River is generally eastwards while that in the Buffalo River catchment is generally southwards.

4.5 GROUNDWATER QUALITY

Good quality groundwater with a CaMg-HCO₃ character is found in the western part of the catchment along the escarpment. This chemical characteristic is typical of younger groundwater in close proximity to the recharge area. As one moves eastwards, groundwater quality deteriorates in the direction of flow and assumes a more dominant Na-Cl character. This is a result of groundwater – rock interaction. Nonetheless, the prospects of finding groundwater with a quality suitable for drinking exceed 80% throughout much of the catchment (Simonc, 2001), but lower prospects are found in the eastern part of the catchment. These are associated with lower rainfall and older basement rocks.

The majority of Karoo Supergroup rocks, particularly the argillaceous units, produce relatively poor quality groundwater with high levels of Na and Cl (King, 1997). The Natal Metamorphic Province schists also produce elevated Na, Cl and F concentrations, but the crystalline and arenaceous units generally exhibit good quality groundwater. Some groundwater quality statistics presented by King (1997) are recorded in Table 4.2.

Table 4.2 Mean groundwater quality sampled during rural water supply projects in KwaZulu-Natal

Aquifer type	pH	EC (mS/m)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Cl (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F (mg/L)
Quaternary sediments									
paleochannels	7.9	428	132	564	3	922	162	1.3	0.9
fine sand	7.5	113	17	127	6	217	24	0.7	0.3
- contact Zululand	6.8	557	193	109	35	1758	265	1.4	0.1
Dolerite									
dolerite	7.9	180	37	277	5	414	39	4.1	0.8
contact Karoo (arg)	8.1	262	54	425	11	664	62	8.1	0.7
contact Ecca	7.9	565	14	95	4	86	8	1.3	0.3
contact Vryheid	8.2	85	20	117	3	112	13	4.8	1.0
Karoo – argillaceous	8.0	351	60	548	8	994	40	9.2	1.5
Karoo – arenaceous	8.0	678	121	1316	21	2102	202	12.3	1.1
Ecca	8.0	194	49	320	9	454	39	3.6	0.4
Vryheid	7.6	144	32	227	5	354	24	2.3	0.8
Dwyka – fractured	7.5	82	23	106	5	145	12	2.5	0.6
Natal	7.3	63	16	79	5	118	17	1.1	0.4
Natal Met. Province	7.8	68	24	78	5	62	15	4.0	0.8

(After King, 1997)

During the KwaZulu-Natal groundwater mapping project it was observed that good quality groundwater is found in the mountain headwaters, with quality deteriorating in the direction of flow. Poorer quality groundwater is found in the lower reaches of the Upper Thukela, Bushmans and Mooi catchments, probably reflecting the influence of the argillaceous sediments in this part of the study area (Figure 3.2). In general, groundwater quality seldom limits the use of water for domestic supply, but some localised groundwater quality issues are apparent. Instances of elevated fluoride were reported in the western part of the catchment. Anthropogenic impacts on groundwater quality are addressed in Section 4.8.

4.6 GROUNDWATER POTENTIAL

4.6.1 Introduction

King (1997) reported competent rocks of the Natal Group and Natal Metamorphic Province and the karstic Uloa Formation of the Maputaland Group have the best overall potential for water supply. Karoo Supergroup sediments have moderate potential, with the argillaceous rocks having the lowest potential of the Karoo rocks, while contacts between Ecca Group shales and sandstones have the best potential of this stratigraphic unit.

Fractures clearly enhance the groundwater potential of most hydrolithologies in KwaZulu-Natal. Fractured Dwyka Group tillites were rated by King (1997) as one of the best drilling targets, despite the generally poor water-bearing characteristics associated with this unit. Dolerite contacts with competent Natal Group rocks also prove successful drilling targets. However, contacts with other rock types generally have poor development potential (King, 1997). Highly faulted and fractured rocks in the Lower Thukela catchment also make attractive drilling targets.

4.6.2 Recharge

No detailed recharge studies have been undertaken in the study area. The KwaZulu-Natal groundwater mapping project based their assessments either on baseflow or on a percentage of rainfall reaching the water table.

It is widely accepted that baseflow provides a measure of minimum recharge. However, it is also recognised baseflow separation techniques are arbitrary and only recognise stormflow and baseflow components. They do not address interflow which can contribute to both run-off and groundwater discharge into rivers. As a result, the actual contribution of groundwater to baseflow is often not appreciated or understood. Vegter and Pitman (1996) estimated baseflow of the entire Thukela River catchment (Drainage Region V) at 3.2% MAP and 19.3% MAR.

The six mapping units covering the Thukela River catchment used an average of 3.7% MAP to quantify recharge. In addition to baseflow considerations, estimates were based on historic practises and work of Kircher *et al.* (1991). While these estimates of recharge are applicable in drier areas underlain by aquifers of the Karoo Supergroup, the relatively high rainfall in the study area suggests recharge may be in the order of 5 – 10% MAP.

Considering the outcome of the KwaZulu-Natal groundwater mapping project, the total recharge of the Thukela River catchment was calculated to be 620 MCM/a. Accepting MAP is 830 mm/a, this equates to about 2.6% MAP and 14.4% MAR.

Because recharge plays such an important role in quantifying the groundwater allocation (DWAF, 1999) and helping to understand surface – groundwater interaction, it is strongly recommended a regional recharge study of the Thukela River catchment be commissioned. Though such a study is required as part of the Reserve determination project, this information will also be valuable for quantifying available groundwater resources and guiding groundwater management in the region.

4.6.3 Harvest Potential

Baron *et al.* (1998) reported effective storage rather than recharge dictated the potential of aquifer systems in the study area. They set the Harvest Potential for the Thukela River catchment at 520 MCM/a.

4.6.4 Exploitation Potential

Using the same data set, Haupt (2001) defined the Exploitation Potential of the catchment as 230 MCM/a. He adjusted the Harvest Potential on the basis that low borehole yields prevent the full Harvest Potential being realised. He based his reduction on an average borehole yield of 0.85 P/s.

4.6.5 Implications for Thukela River Reserve Determination Project

The widespread occurrence of good quality groundwater suggests groundwater will continue to play a crucial role in satisfying basic human needs in the catchment. A lack of quantified

recharge data, however, will prevent any groundwater-related Reserve assessments from being of medium to high confidence. It is generally expected higher rainfall (as experienced in the catchment) results in higher recharge. However, estimates presented above are low and are probably conservative. Because quantification of the groundwater component of the Reserve is essentially based on an estimate of recharge and the contribution of groundwater to baseflow, it is imperative recharge in the Thukela River catchment be better quantified if a medium to high level of confidence in the Reserve determination is to be obtained.

4.7 GROUNDWATER USE

Traditionally, groundwater has not been considered a significant source of water in the KwaZulu-Natal region. Limited groundwater was abstracted for domestic and irrigation purposes. However, much of the rural population relied on groundwater in the form of springs and seeps (Huggins, 2001).

The KwaZulu-Natal groundwater mapping project confirmed groundwater plays a critical role in supplying water to much of the rural population. Some instances of groundwater being used by villages, towns, agriculture and mines were reported, but these were generally few and far between. Examples of towns using groundwater for domestic supply include Newcastle, Nottingham Road and Tugela Ferry. Groundwater is generally used to supplement surface water supplies during times of drought.

It was also reported groundwater plays little role in supporting agriculture in the Thukela River catchment. In addition to wind pumps used for stock-watering, some groundwater is used for irrigation. However, irrigation is predominantly surface water based. Based on a survey by Braune and Coetzer (1992) and agricultural surveys in 1976 and 1981, less than 500 ha are thought to be irrigated using groundwater. This equates to about 5 MCM/a.

A number of authors expressed concern about the potential impact of afforestation on groundwater (E.Martinelli and Associates, 1994;1995). No attempt was made to quantify the impact and use of groundwater by plantations in the study area is not known. As afforestation covers a relatively minor part of the catchment, impacts are expected to remain localised. However, such impacts could have significant impact on meeting Basic Human Need requirements and groundwater contribution to streamflow in some instances. Potential impacts of afforestation on groundwater must be considered when assessing the Reserve in areas adjacent to forested areas.

Following democratisation in South Africa in 1994, implementation of the RDP resulted in a formal programme to develop groundwater resources for the rural poor. Most rural communities in the Thukela River catchment currently do not have adequate access to potable water supplies (DWAF, 1999b). Advantages of developing groundwater for rural water supply (as opposed to surface water) include its general availability, its relatively low unit cost, its ability to overcome supply problems to dispersed rural communities in hilly KwaZulu-Natal catchments and its ability to yield water during periods of drought. Groundwater now plays a critical role in meeting basic human water needs in the Thukela River catchment and in many cases is the only means of supplying water to some rural communities in the catchment.

Boreholes used for community water supply are generally low yielding ($< 0.3\text{P/s}$) and are unlikely to have any impact on groundwater levels. Abstraction is hence unlikely to affect the contribution of groundwater to the ecological component of the Reserve. Reworking data collected during the groundwater mapping project showed some 7 100 boreholes exist in the catchment. Of these, more than 4000 boreholes were operational. Given the water supply efforts of the RDP between 1994 and 2001, it is possible more than 6 000 boreholes are now used in the Thukela River catchment.

Based on a hydrocensus of water sources in the Traditional Authority Areas within the catchment, preliminary estimates suggest the rural population use about 13 MCM/a of groundwater (Jennings, *pers.comm.*, 2002). Of this, 3.5 MCM/a is abstracted from 3 000 operational boreholes and 9.5 MCM/a from 6 000 springs. A further 1 500 non-operational boreholes were identified during the hydrocensus.

Work by Haupt (2001) suggested total groundwater use in the Thukela River catchment amounts to about 14 MCM/a. This equates to 6% of the conservatively estimated 230 MCM/a exploitable groundwater resource and less than 2.5% of total estimated recharge (620 MCM/a). Estimates of groundwater use made during the KwaZulu-Natal groundwater mapping project suggested use in the Thukela River catchment amounts to about 35 MCM/a, at least half of which is used for rural water supply. As groundwater use is only about 5% of estimated recharge, most aquifer systems in the Thukela River catchment are in pristine or near-pristine state and would be assigned an "A" present status class.

It is of interest to note groundwater accounts for about 10% of all water used in the Thukela River catchment. Total water use was estimated by Thukela Basin Consultants (2000) to be 348 MCM/a, excluding the estimated 26 MCM/a used by forestry.

Groundwater already plays a crucial role in addressing basic human needs in the Thukela River catchment. Further development of groundwater to satisfy this need is expected. Because of the widespread nature of groundwater abstraction, low borehole yields and small volumes of groundwater abstracted (in relation to recharge), it is unlikely groundwater abstraction will impact the contribution of groundwater to river flow. Localised abstraction of large volumes of groundwater adjacent to rivers, however, must be controlled.

4.8 GROUNDWATER CONTAMINATION

In addition to potential groundwater contamination in urban areas (waste and sewage disposal, underground storage tanks, chemical spills etc.), a number of potential sources of groundwater contamination exist in the study area. These include:

- Mines (acid rock drainage).
- Agriculture (irrigation return flows, fertilizers and pesticides, feedlots).
- Rural communities (sanitation).

Groundwater contamination is generally difficult to assess at a regional scale, with impacts only apparent at a local scale. Seepage of acid rock drainage from coal dumps and slurry dams could have a significant impact on river quality, particularly during drier months. As coal mining is limited to areas underlain by the Vryheid Formation of the Ecca Group, this potential problem is only relevant in the northern Buffalo River and Sundays River catchments (Figure 3.1) and hence needs to be considered when assessing instream flow requirements at IFR7, IFR8, IFR13 and IFR14.

No significant groundwater quality impacts associated with agriculture were identified. As the application of fertilizers and pesticides result in non-point source pollution, these impacts are difficult to detect. Cognisance of potential groundwater contamination impacts by farming must be taken when assessing the Reserve.

Pit latrines and unserviced areas provide a widespread, but probably a low risk source of groundwater contamination. DWAF (1999b) reported more than 75% of the rural population in the uThukela Region required sanitation systems. Elsewhere in the catchment this need was set at between 25% and 50%. No information is available regarding the impact of sanitation systems – or the lack thereof – on groundwater quality. This impact needs to be addressed at a local scale and may have to be considered at most IFR sites.

5 BASIC HUMAN NEEDS

Groundwater plays a critical role in meeting the basic water needs of rural communities in the Thukela River catchment. Historically, springs and seeps were the only available source of water for settlements away from rivers and streams. More recently, boreholes have been drilled as part of the RDP, drought relief programmes and foot and mouth alleviation efforts. It was estimated about 18 MCM/a of groundwater is used for rural water supply (Section 4.7).

The abstraction of groundwater for rural water supply is not expected to pose a threat to the resource. Recharge is not considered a limiting factor, while the rate of abstraction is generally very low. Much of the challenge with developing groundwater for rural water supply relates to getting drilling rigs to the point of need and drilling boreholes in positions that will satisfy distance specifications of the RDP i.e. a potable water point within 200m of the home.

Poor sanitation, or the lack thereof, poses a threat to groundwater being developed to meet rural water needs. This aspect received close attention during the RDP. Regular groundwater quality testing should continue to form part of rural water supply management.

In general, it is not expected groundwater abstracted for rural water supply purposes poses any threat to the aquatic ecosystem component of the Reserve (Section 4.7). Localised abstraction of large volumes of groundwater adjacent to rivers, however, must be controlled. Setting abstraction limitations in buffer zones adjacent to a river is an effective means of achieving this.

6 SURFACE – GROUNDWATER INTERACTION

6.1 PREAMBLE

Methods to quantify the role of groundwater in sustaining the Reserve were developed by DWAF (1999). Unfortunately, a lack of a clear understanding of surface – groundwater interaction restricts the ability to adequately assess and quantify this. In addition to sustaining terrestrial and riverine vegetation, groundwater plays two key roles:

- Contributing to baseflow during dry periods; and
- sustaining pools and shallow subsurface water bodies critical to ecosystems during dry periods.

During dry periods, groundwater is the sole source of water to rivers. Though groundwater's contribution to river flow may be numerically small, the timing of contributions result in the importance of groundwater's role being far more significant than flow volumes indicates.

Since implementing the concept of the Reserve, it has become more and more clear that not all baseflow is derived from groundwater. In addition to inconsistent use of terminology, confusion stems from baseflow separation procedures only considering stormflow and baseflow and not recognising the contribution from stormflow, interflow and groundwater (Section 4.6.2).

Most rivers on the eastern seaboard of South Africa are perennial, with perennality supported by a constant discharge of groundwater into rivers during dry winter months. Vegter and Pitman (1996) estimated baseflow in the Thukela River catchment to amount to 19.3% MAR. Hughes and Munster (2000) determined baseflow indices of between 0.31 and 0.53 for quaternary catchments in the study area. The average baseflow index was 0.37.

Assuming MAR to be 4 300 MCM/a and using Vegter and Pitman (1996) and Hughes and Munster (2000) assessments of baseflow, respective baseflow estimates of 830 MCM/a and 1 490 MCM/a were obtained. These are significantly higher than the estimated recharge of 620 MCM/a (Section 4.6.2). In addition to recharge estimates for the study area being considered conservative, the baseflow index clearly does not only provide a measure of the groundwater contribution to baseflow, but also includes contributions from interflow.

6.2 LOW FLOW ASSESSMENT

In an attempt to investigate the groundwater contribution to baseflow, daily flow data measured at various points in the catchment were reassessed (Figure 6.1). Based on the understanding that only groundwater contributes to baseflow in the driest months (i.e. no storm run-off or contributions from interflow) and groundwater discharge cannot vary significantly over time, lowest daily flows recorded in a month at a particular gauging station were plotted (Figure 6.2). Focussing on flow data measured prior to dam construction, low flows during dry periods could be determined.

Three gauging stations on the Sundays River were selected to illustrate the method (Figure 6.2). In the upper parts of the catchment, minimum flows are low (V6H006). Minimum flows during the 1970s suggest the groundwater contribution to river flow could be about 0.1m³/s, while minimum flows further down the river are in the order of 0.3m³/s. At V6H002, minimum flow is in the order of 5m³/s. Converting these flows to annual volumes and comparing them to estimates of baseflows calculated using indices

Fig. 6.1 Position of gauging stations used to assess groundwater contribution to baseflow

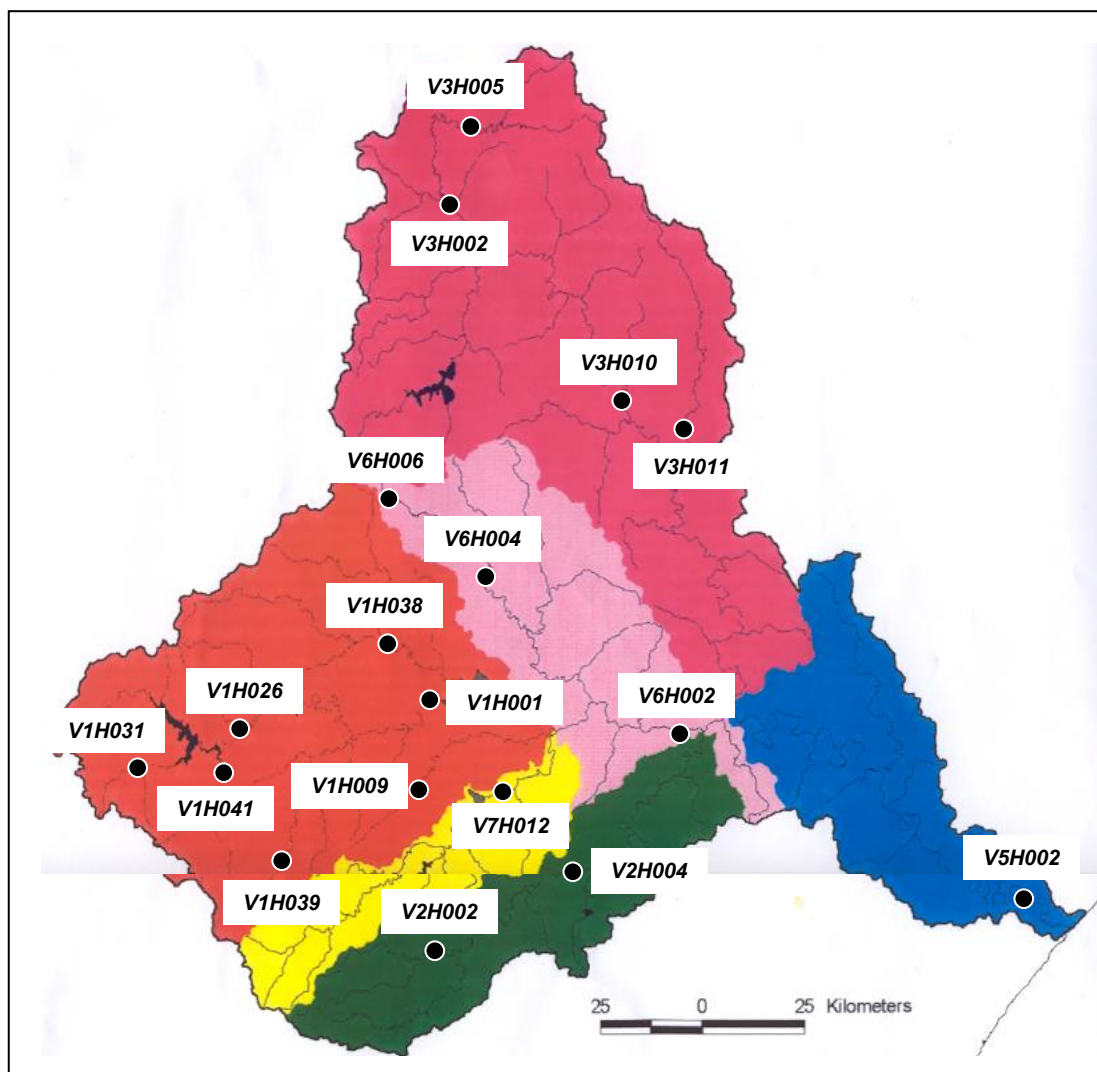
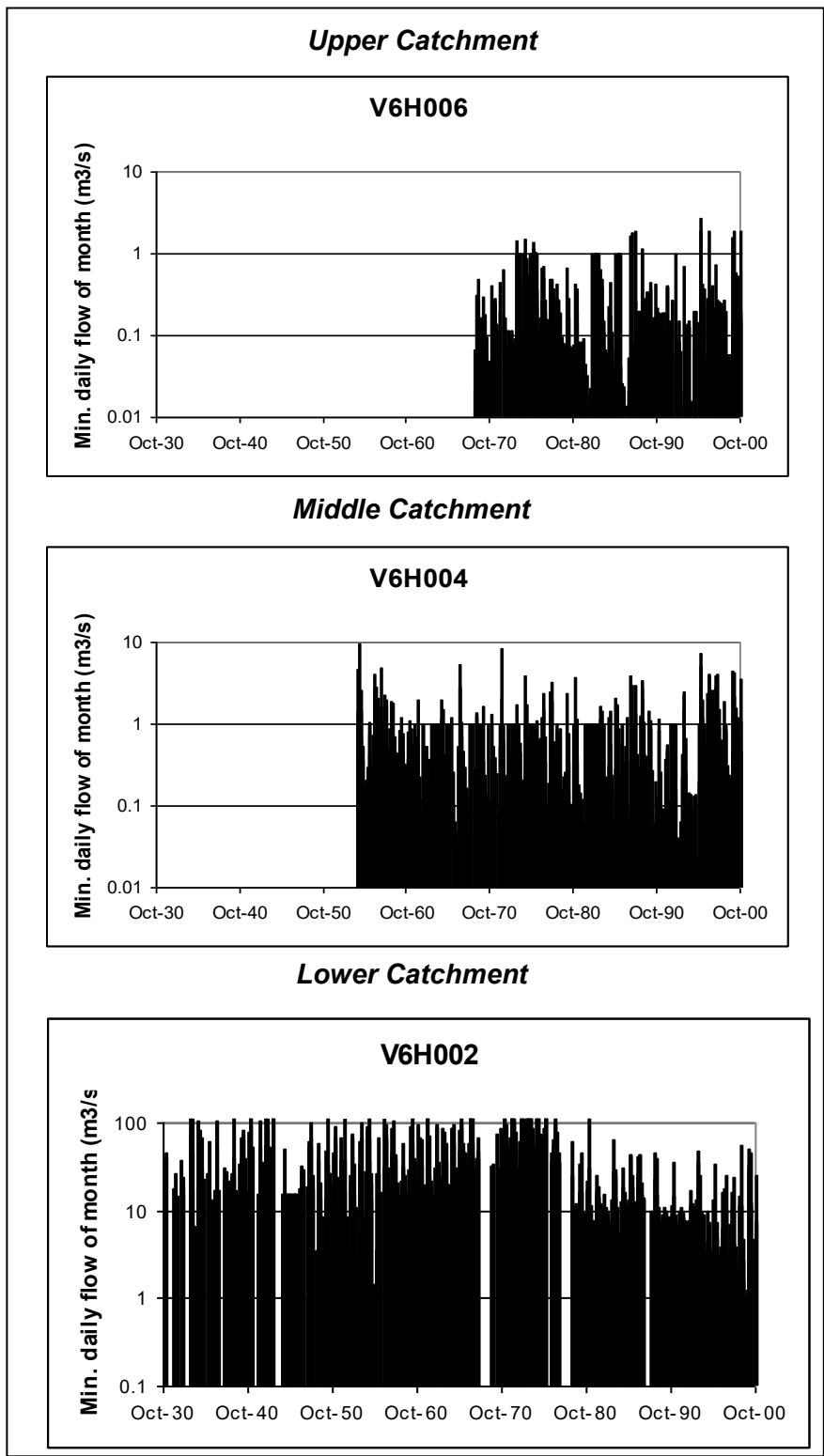


Fig. 6.2 Lowest daily flow recorded in a particular month for three gauging stations in the Sundays River catchment



presented by Hughes and Munster (2000) suggests the groundwater contribution to baseflow is in the order of 43%, 24% and 18% respectively (see Table 6.1).

Calculating the groundwater contribution to baseflow for other gauging stations elsewhere in the catchment indicates the Sundays River, Bushmans River and Mooi River behave in

asimilar manner while the Upper Thukela River and Buffalo River have similar groundwater contribution to baseflow characteristics (Table 6.1).

It was interesting to note the groundwater contribution to baseflow at two gauging stations in the lower parts of the catchment (V6H002 and V5H002) yielded almost identical contributions of about 18%. Electrical conductivity (EC) data presented by Archibald (in Quinn and Whitfield, 2001) measured at weir V5H002 showed clear seasonal variation of water quality in the Thukela River. During wet summer months, EC dropped to between 10 and 15 mS/m, but steadily increased to 30 and 40mS/m during dry winter months. These chemical patterns are often the result of an increasing proportion of groundwater in the river. This data hence confirms the important contribution groundwater makes during dry periods. In turn, this suggests the timing of the groundwater contribution may be more important than the volume of the contribution. Groundwater abstraction adjacent to rivers during low flow periods thus needs to be carefully considered.

Table 6.1 Estimation of groundwater contribution to baseflow using low flow assessment

Gauging station	Position in catch	Min. Daily flow (m ³ /S)	Baseflow from Gwater (MCM/a)	MAR (MCM/a)	BFI	Baseflow (MCM/a)	Baseflow from Gwater (%)	MAR from Gwater (%)
Upper Thukela								
V1H026	upper	1.0	32	740	0.32	237	13.3	4.3
V2H031	upper	0.0	1	15	0.32	5	19.7	6.3
V1H038	middle	0.1	4	231	0.36	83	4.9	1.8
V1H002	lower	1.2	38	1952	0.37	722	5.2	1.9
Buffalo								
V3H005	upper	0.2	6	116	0.37	43	14.7	5.4
V3H002	upper	0.2	6	121	0.37	45	14.1	5.2
V3H010	middle	0.6	19	580	0.38	220	8.6	3.3
Mooi								
V2H002	upper	1.4	44	259	0.40	104	42.6	17.0
V2H004	middle	0.7	22	267	0.39	104	21.2	8.3
Sundays								
V6H006	upper	0.1	3	19	0.38	7	42.9	18.4
V6H004	middle	0.3	9	104	0.38	40	23.9	9.1
V6H002	lower	5.0	158	2 428	0.37	898	17.6	6.5
Bushmans								
V7H012	upper	0.1	3	31	0.39	12	26.1	10.2
Estuary								
V5H002	lower	9.5	300	3 748	0.45	1 687	17.8	8.0

6.3 DARCIAN CALCULATIONS

As a means of checking the validity of the above approach, an attempt was made to calculate the volume of groundwater flow into rivers. This was done using a Darcian approach and coarse regionalised parameters. Transmissivity (T) was estimated using borehole data provided by King (1997) and the following approximation:

$$T = 10Q$$

where Q = borehole yield (P/s)

Given that the median yield of boreholes drilled in the different lithologies ranged between 0.3 and 0.6P/s, an average T of 5m²/d was used for modelling purposes (Table 6.2). Hydraulic gradient for each quaternary catchment was inferred from topography while the length of the main channel was measured on topographical maps.

Table 6.2 Estimation of groundwater contribution to baseflow using a Darcian approach

CATCHMENT			DARCIAN APPROACH				BASEFLOW SEPERATION	
Gauging station	Area (km ²)	MAR (MCM/a)	T (m ² /d)	I	W (km)	Baseflow From Gwater (MCM/a)	Baseflow From Gwater (MCM/a)	
V1H001	4200	1126	5	0.006	420	9	135	
V1H009	195	21	5	0.011	25	1.0	1.6	
V1H039	233	158	5	0.100	25	9.1	12	
V1H041	434	247	5	0.035	40	5.1	19	
V3H011	543	65	6	0.015	40	2.6	3.9	

Comparison of the modelled discharge with that estimated using a baseflow separation technique that incorporated the principles described in Section 6.2 indicates a degree of similarity in the two approaches (Table 6.2). It was only in the case of a large catchment that poor correlation was obtained (V1H001). For the rest, the groundwater contribution, as calculated using both methods, was of a similar order of magnitude.

As the Darcian approach yielded a very small contribution to baseflow at V1H001, groundwater discharge from each individual quaternary catchment upstream of the gauge was estimated and the results added together. This yielded a groundwater contribution to baseflow of 65 MCM/a, which is about half that estimated using a baseflow separation technique. Given that only the length of the main channel was used and not that of all the tributaries, it is possible more comparable results could be obtained if more accurate input data were used. However, the scope and budget of the project prevented a more detailed assessment using the Darcian approach. Nonetheless, results obtained using the Darcian approach supported the quantification of the groundwater contribution to baseflow presented in Section 6.2.

6.4 MANAGEMENT AND PROTECTION

Though the low flow assessment method used to quantify the groundwater contribution to baseflow is yet not properly developed and the assessments performed are only preliminary, results conform to the current conceptual understanding of surface – groundwater interaction in the Thukela River catchment. Accepting that groundwater contributes about 20% of baseflow (or about 7.5% of MAR), then the total groundwater contribution of 320 MCM/a is about half the estimated recharge in the catchment. Other groundwater losses include subsurface discharge into adjacent catchments, evapotranspiration and abstraction.

Conventional estimates determined using baseflow separation techniques (which implicitly assume most baseflow is derived from groundwater) suggest groundwater supplies about 40% of MAR in the Thukela River. More conservative approaches described above indicated the groundwater contribution is more likely to be about 10% of MAR. Similar discrepancies have emerged during Reserve determination projects elsewhere (Pienaars River, Hex River) and have highlighted the lack of understanding of surface – groundwater interaction. This lack of understanding has emerged in response to implementation of the National Water Act (Act No. 36 of 1998) and requires urgent attention through appropriate research.

Because of limited groundwater abstraction in the catchment, the ability of groundwater to continue discharging into rivers is not threatened. However, at a local scale, large-scale abstraction adjacent to rivers could significantly reduce flows. VSA Earth Science Consultants (1995), for example, reported on a caisson system directly adjacent to the Buffalo River used to abstract 'groundwater' at Vant's Drift. These - and other more conventional high yielding boreholes adjacent to rivers – can result in a reduction of flow in rivers. Clear guidelines need to be developed to ensure boreholes adjacent to rivers are managed in such a way that they do not impact river flow significantly. Such guidelines need to take account of the rate of abstraction and local groundwater conditions.

Discharge of springs and seeps and shallow groundwater levels away from rivers results in groundwater supporting aquatic ecosystems throughout the catchment. The role of springs in meeting basic human needs was addressed in Section 4.7 and Section 5. The role of groundwater in sustaining ecosystems and protection mechanisms cannot be addressed at a catchment scale. Rather, clear protection policy and guidelines are required for implementation at a local scale.

7 DISCUSSION

Groundwater clearly plays a number of important roles in the Thukela River catchment. In addition to providing water for the rural population (and thereby allowing basic human needs to be addressed), groundwater sustains river flow and aquatic ecosystems during dry winter months, particularly between June and September. As groundwater abstraction is widespread, generally takes place at low rates, and volumes abstracted are relatively small in comparison to estimates of recharge, the ability of groundwater to continue to support the Reserve on a catchment scale is generally not threatened.

Significant development of groundwater for rural water supplies has taken place in the study area since democratisation of South Africa in 1994. This has been supported by a number of drought relief programmes and foot and mouth eradication programmes. It was estimated some 6 000 boreholes are now operational in the study area. Current groundwater use amounts to about 35 MCM/a, of which about half is used to meet the basic water requirements of the rural population. The relatively small volume of groundwater abstracted (in relation to recharge) indicates prevailing aquifer systems are in pristine or near-pristine condition. Much of the study area, hence, will be assigned an "A" present status class.

It was estimated recharge in the Thukela River catchment is 620 MCM/a while the groundwater contribution to baseflow is 320 MCM/a. This equates to about 7.5% of MAR. Though this contribution may appear low, the timing of the contribution during dry months is crucial to the functioning of the river system.

Recharge is poorly quantified and surface – groundwater interaction in the Thukela River catchment poorly understood. This is not unique to this catchment, but applies to many catchments in the country. This inadequacy has emerged as a result of the implementation of the National Water Act (Act 36 of 1998), which requires an integrated approach to water resource management. Because recharge plays such an important role in quantifying the groundwater component of the Reserve, it is considered that a better assessment of recharge in the entire catchment will be required as part of the Reserve determination.

Similarly, as the groundwater component of the Reserve is based on low maintenance baseflows and these flows are likely to exceed total recharge in the catchment (Section 6), the actual contribution of groundwater needs to be better quantified. Failure to do so is likely to create conflict between maintaining the groundwater contribution during low flow periods and the need to abstract groundwater for basic human needs.

As no tools are currently available to adequately assess the groundwater contribution to baseflow, support should be given to a national research programme that will result in tools being developed to quantify the groundwater contribution to rivers. ***Until such time as the required tools are available, the project hydrologist and geohydrologist will have to consider all available baseflow data and, using expert judgement, make an assessment of the volume of groundwater discharged into rivers during periods of low flow.*** Because of this, any assessment of the groundwater component of the Reserve is unlikely to be done at a confidence that exceeds a medium level.

It is at a local level that geohydrological expertise is most required. For example, groundwater abstraction directly adjacent to rivers or wetlands could impact the contribution of groundwater to river flow. Local scale management measures need to be put into place to ensure the supporting role played by groundwater is not impacted. Similarly, coal mining and the lack of sanitation potentially threaten the quality of groundwater discharged into streams. This is particularly true when assessing IFR7, IFR8, IFR13 and IFR14. The setting of Resource Quality Objectives, placing limits or restrictions on groundwater abstraction near rivers, streams and wetlands and controlling potential contamination will be effective protection measures. However, all need to be implemented at a local level.

Because of the above considerations, the groundwater component of the Reserve needs to be included in the Thukela Reserve Module. Development of generic groundwater abstraction guidelines and use of local geohydrological expertise should be considered as a means of achieving integration of the groundwater component into the overall Reserve determination process.

8 WAY FORWARD

Given the findings of this scoping report and the need for additional work, the following recommendations are made with respect to further work requirements:

- At this stage, it is not recommended that a comprehensive Reserve determination of the groundwater component be carried out. Rather, rapid Reserve determinations should be undertaken for all quaternary catchments in the study area. The rapid Reserve determinations should be based on brief reconnaissance visits and inputs from local experts. This will provide an indication to DWAF officials of the allocatable groundwater resources in each quaternary catchment (which is the outcome of the groundwater component of the Reserve determination).
- A catchment-wide recharge study of the Thukela River catchment should be commissioned. Such a study will allow for better quantification of recharge (a key parameter for determining the groundwater component of the Reserve), promote a better understanding of surface – groundwater interaction and also allow for better quantification of groundwater resources in the catchment. To facilitate the Reserve determination at a rapid level, recharge to each quaternary catchment must be determined.
- In addition to supporting research to develop tools to quantify surface – groundwater interaction, a project should be commissioned to better quantify the contribution of groundwater to baseflow. As traditional methods are clearly flawed, such a study needs to be based on available river flow data, groundwater level data and expert judgement. Both hydrological and geohydrological skills are required for this. Such a study will greatly contribute to assessing the role of groundwater in sustaining low maintenance baseflow and defining the level of groundwater dependence.
- Groundwater dependant ecosystems in the catchment need to be mapped and sensitive systems identified. This will allow for better protection of these systems. Input from the Reserve team (hydrologists, water quality specialists, ecologists, wetland specialists etc.) is required for this. More detailed investigation may be required in some cases.
- Generic groundwater management guidelines are required to manage the groundwater resources and guide allocations at a local scale. Such guidelines should address buffer zones adjacent to rivers and sensitive aquatic ecosystems and allowable abstraction within the zone. The guidelines also need to consider groundwater monitoring requirements, particularly in sensitive areas or in instances of large-scale abstraction.

As a result of the National Water Act (Act 36 of 1998) recognising a unitary hydrological cycle, a number of deficiencies in knowledge regarding recharge estimation and surface – groundwater interaction have emerged. It is hence argued geohydrological expertise is needed in any Reserve determination to facilitate a better understanding of the hydrological system and provide specific insights or inputs when required. Further, these deficiencies need to be made known to water resource and research managers so actions can be implemented to improve current knowledge in this regard.

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