REPORT No. P 12000/00/0101

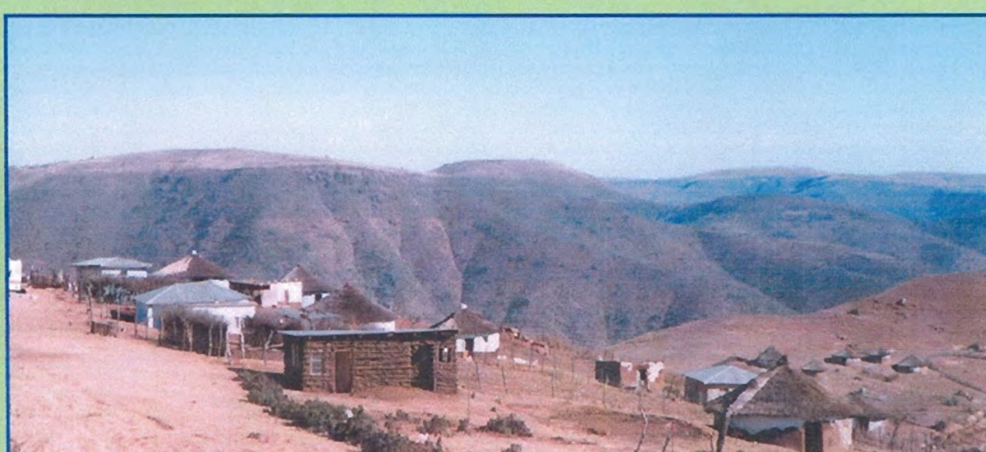
DEPARTMENT: WATER AFFAIRS AND FORESTRY

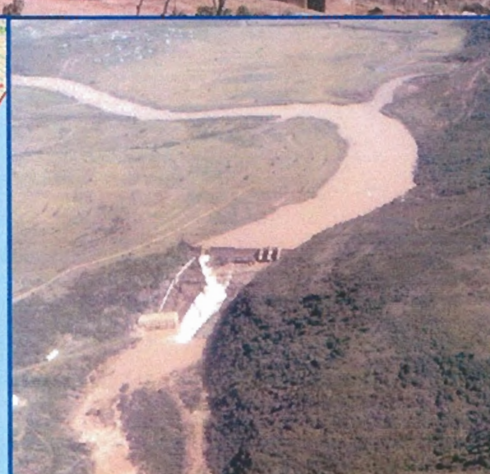
Directorate: Water Resources Planning

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

MAIN REPORT: VOLUME 1
JULY 2002





COMPILED BY:

NINHAM SHAND
CONSULTING ENGINEERS

Title	:	**Mzimvubu to Kieskamma Water Management Area : Water Resources Situation Assessment - Main Report - Volume 1 of 2**
Authors	:	R Blackhurst, A Spinks, J N Rossouw and authors of standard texts provided by DWAF
Project Name	:	Water Resources Situation Assessment
DWAF Report No.	:	P 12000/00/0101
Status of Report	:	Final
First Issue	:	June 2002
Final Issue	:	July 2002

Approved for Study Team :

....
M J SHAND
Ninham Shand (Pty) Ltd

DEPARTMENT OF WATER AFFAIRS AND FORESTRY

Directorate : Water Resources Planning

Approved for the Department of Water Affairs and Forestry by :

....
F A STOFFBERG
Chief Engineer
(Project Manager)

....
J A VAN ROOYEN
Director

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

MAIN REPORT

OVERVIEW

The water resources of South Africa are vital to the health and prosperity of its people, the sustenance of its natural heritage and to its economic development. Water is a national resource that belongs to all the people who should therefore have equal access to it, and although the resource is renewable, it is finite and distributed unevenly both spatially and temporally. The water also occurs in many forms that are all part of a unitary and inter-dependent cycle.

The National Government has overall responsibility for and authority over the nation's water resources and their use, including the equitable allocation of water for beneficial and sustainable use, the redistribution of water and international water matters. The protection of the quality of water resources is also necessary to ensure sustainability of the nation's water resources in the interests of all water users. This requires integrated management of all aspects of water resources and, where appropriate, the delegation of management functions to a regional or catchment level where all persons can have representative participation.

This report is based on a desktop or reconnaissance level assessment of the available water resources and quality and also patterns of water requirements that existed during 1995 in the Mzimvubu to Keiskamma Water Management Area, which occupies a portion of the Eastern Cape Province and a small portion of the Kwa-Zulu Natal Province. The report does not address the water requirements beyond 1995 but does provide estimates of the utilisable potential of the water resources after so-called full development of these resources, as this can be envisaged at present. A separate national study has been conducted to consider future scenarios of land use and water requirements and the effects of water conservation and demand management measures on these requirements and to identify alternative water resource developments and water transfers that will reconcile these requirements with the supplies.

The main purpose of this report is to highlight the principal water related issues, to identify existing water shortages, to provide information that is necessary to formulate future strategies such as the national water resources strategy and catchment management strategies and to stimulate initial actions to ensure the best overall sustainable utilisation of the water, with minimal waste and harm to the aquatic ecosystems.

The National Water Act (No. 36 of 1998), requires that a national water resources strategy (NWRS) be established that sets out the policies, strategies, objectives, plans, guidelines and procedures and the institutional arrangements for the protection, use, development, conservation, management and control of water resources for the country as a whole, and establish and define the boundaries of water management areas taking into account catchment boundaries, socio-economic development patterns, efficiency considerations and communal interests. This strategy is binding on all authorities and institutions exercising powers or performing duties under the National Water Act.

The national water resources strategy will, *inter alia*, provide for at least the requirements of the Reserve, international rights and obligations, actions required to meet projected future water needs and water use of strategic importance. Furthermore, it will contain estimates of present and future water requirements, set out principles relating to water conservation and demand management, give the total quantity of water available within each water management area, state the surpluses or deficits, provide for inter-catchment water transfers required to balance the supply with the requirements and state the objectives in respect of water quality to be achieved through the classification system to be provided for the water resources.

A catchment management agency established in terms of the National Water Act (No. 36 of 1998), must progressively develop a catchment management strategy, objectives, plans, guidelines and procedures for the protection, use, development, conservation, management and control of water resources within its water management area. Such a strategy must not be in conflict with the national water resources strategy, must take into account the class of water resource and resource quality objectives, the requirements of the Reserve and any applicable international obligations, the geology, land use, climate, vegetation and waterworks within its water management area. The strategy shall contain water allocation plans, take account of any relevant national or regional plans prepared in terms of any other law; enable public participation and take into account the needs and expectations of existing and potential water users. This report provides the initial baseline data that can be used by the catchment management agency to develop its catchment management strategy, objectives, plans, guidelines and procedures for the protection, use, development, conservation, management and control of the water resources in its area of responsibility.

The national water resources strategy will be reviewed and published at five-yearly intervals, with Addenda being issued in the interim, when required. The strategy will give guidance to the Department of Water Affairs and Forestry in respect of the protection, use, development, conservation, management and control of water resources and will also serve as a very important means of communication with all the stakeholders. The overall responsibility for the compilation of the national water resources strategy rests with the Directorate: Strategic Planning of the Department of Water Affairs and Forestry, while the Directorate: Water Resources Planning is responsible for :

- Identification of water resources to meet particular requirements
- Identification of international rights and obligations
- Identification of water use of strategic importance
- Calculating water balances
- Developing plans to reconcile water requirements and resources.

A number of inter-related studies have therefore been included by the Directorate: Water Resources Planning of the Department of Water Affairs and Forestry in the national future scenario study that will supply the information required for formulating the strategies, as given above.

The main objective of this water resources situation assessment has been to determine the water requirements of all the user sectors (including those of the riverine and estuarine ecosystems) and the ability of the available water resources to supply these requirements. However, other aspects such as water quality, legal and institutional aspects, macro-economics, and existing infrastructure have also been addressed. This report outlines the 1995 water resources situation, using information obtained from previous study reports to identify the main water related issues of concern. The large body of information available in the Department of Water Affairs and Forestry and from other sources has also been collated and presented in this assessment. This has been collected on a catchment basis at the quaternary catchment level of resolution. The levels of confidence that can be attached to the data on land use, water requirements and surface water and groundwater resources have however, been found to vary considerably because of the desktop nature of the study. This has therefore also provided a basis for identifying where improvements need to be made to the data in future and to prioritise such studies. It is also important to note that where information on land and water use and sensitive ecosystems is not given, this could be due to the fact that it does not exist or because it has not been documented in a format or source that is readily accessible.

The larger inter-related studies that have supported this water resources situation assessment have been the following:

- Development of a computerised database

  Data collected in this water resources situation assessment has been used to populate the database of the Chief Directorate: Planning of the Department of Water Affairs and Forestry. The database design has mainly been based on the requirements of a water balance model that has been developed to compare the water requirements with the available water resources.

- Demographic study

  An important part in the development of the national water resources strategy is the future scenarios. Since water use is mainly driven by the requirements of the various socio-economic groupings of the population, a national demographic study was initiated. An important part of the study was an estimate of the base year (1995) population. The study has also associated the population with defined water user categories to facilitate estimating existing and future water requirements. These categories have *inter alia* been defined on the basis of reports on urban water supplies and questionnaires completed by local authorities.

- Macro-economic study

  Economic activity and its effects on the spatial distribution of the population and vice versa is an important determinant of water use. With the ever-increasing need for water for domestic use and protection of the water resources, water availability is already becoming a limiting factor in various regions of the country. The economic viability of continuing to supply water for existing sectors, such as irrigation and also of expanding such activities to satisfy socio-economic aspirations will need careful consideration. A national macro-economic study has therefore been undertaken to provide basic economic data for use in the demographic study and to provide macro-economic overviews for each water management area.

- Formulation and development of a water situation assessment model

  The primary function of the water situation assessment model is to reconcile water supply and water requirements by quantifying the surplus or deficit per catchment area. Water balances are compiled from the quaternary catchment level of resolution of the data, which can then be aggregated to suite any desired predetermined catchment boundaries. The water situation assessment model is nevertheless only a coarse planning tool and does not replace the detailed hydrological studies that are required for basin studies or project investigations.

- Water requirements for the ecological component of the Reserve

  The National Water Act (No. 36 of 1998) requires that water be provided for the Reserve, which is the quantity and quality of water required to satisfy basic human needs and to protect the aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant resource. The ecological sensitivity and importance of the rivers in South Africa and the present ecological status class was therefore established at the quaternary catchment level of resolution, using available data and local knowledge. At the same time the results of previous field assessments of the water requirements of the aquatic ecosystems at selected sites in South Africa were used in a separate study to develop a model for estimating the water required for the ecological component of the Reserve for various ecological management classes that correspond to those determined previously for the rivers throughout the country.

SYNOPSIS

1. INTRODUCTION

1.1 PURPOSE OF THE STUDY

The National Water Act No. 36 of 1998 requires the Minister of Water Affairs and Forestry to establish a national water resource strategy for the protection, use, development, conservation, management and control of water resources. To enable the strategy to be established, information on the present and probable future situations regarding water requirements and water availability is required, that is, a national water resources situation assessment providing information on all the individual drainage basins in the country.

The Department of Water Affairs and Forestry (DWAF) has appointed consulting engineers to undertake Water Resources Situation Assessments for the purpose of gathering information and using it to reconcile the present water requirements of all the user sectors with the presently available water resources. The information produced by all the studies will be consolidated by DWAF into a national database which will be used to establish the National Water Resource Strategy. Scenarios of future water requirements and availability are being dealt with in a separate study. These scenarios will be taken up in the National Water Resource Strategy and will be reported on separately for each water management area.

As a component of the National Water Resource Strategy, the Minister of Water Affairs and Forestry has established water management areas and determined their boundaries.

The information gathered in the Water Resources Situation Assessments has been presented in the form of a separate report on each water management area (WMA). This report is in respect of the Mzimvubu to Keiskamma Water Management Area.

1.2 APPROACH TO THE STUDY

The study was carried out as a desktop investigation using data from reports and electronic databases, or supplied by associated studies, local authorities and DWAF. The study considered conditions as they were in the year 1995 and did not make projections of future conditions. Data at reconnaissance level of detail was collected on land-use, water requirements, water use, water related infrastructure, water resources and previous investigations of water supply development possibilities. Relevant data was used to calculate the yield of the water resources at development levels as they were in 1995, and the maximum yield that could be obtained from future development of these resources. The water balance (the relationship between water requirements and water availability) at selected points in each water management area was also calculated.

Information on urban water use and water related infrastructure was obtained from reports on urban water supplies and from questionnaires filled in by local authorities. The collected data on urban water use was supplied to consultants appointed to carry out a separate national demographic study, in relation to water requirements.

In that study, data from the 1996 census, and other sources, was used to derive demographic information for the whole country for the year 1995. In addition, the information on urban water use that was supplied by the water resources situation assessment studies, was analysed in the demographic study to derive typical unit water requirements. These were used, in conjunction with the demographic data, to estimate water requirements in 1995 for urban areas for which no recorded data was available.

Both the demographic data and the estimated water requirements in 1995, as supplied for the Mzimvubu to Keiskamma WMA by the national demographic study (DWAF, 2000b), are presented in this report. In addition to the separate studies on the water balance model and demography referred to above, separate studies were carried out to provide information on a national basis on :

- Macro-economic aspects
- Legal aspects of water resource management
- Institutional arrangements for water supply
- Effects of alien vegetation on runoff
- Groundwater resources
- Bacteriological contamination of water resources
- Water requirements for irrigation
- Ecological classification of rivers
- Water requirements for the ecological component of Reserve
- Effects of afforestation on runoff
- Storage-yield characteristics of rivers

Information from all the above studies, that is relevant to the Mzimvubu to Keiskamma Water Management Area, is included in the appropriate sections of the report.

2. CHARACTERISTICS OF THE WMA

The main characteristics of the Mzimvubu to Keiskamma WMA, as determined from the information gathered in this situation assessment, are listed below :

Physical Characteristics

- The Mzimvubu to Keiskamma WMA covers an area of 66 211 km^2 in which the mean annual precipitation ranges from 450 mm in the north-western interior to more than 1 200 mm along the coast in the north-east. Rainfall occurs throughout the year in the WMA, but is highest during the summer months.

- The north-western portion of the WMA, making up 6% of its total surface area, lies within the KwaZulu-Natal Province. The rest of the WMA is in the Eastern Cape Province.

- The geology of the WMA consists mainly of Karoo sediments with a narrow band of sandstones, quartzites and conglomerates of the Cape Supergroup along the northern coast.

- The rivers of the northern coastal catchments are of high to very high ecological importance and sensitivity, and have largely natural present ecological status classes. Consequently they have high ecological flow requirements. Most of the other rivers are of moderate ecological importance and sensitivity, have moderately modified to largely modified present ecological status classes, and have correspondingly lower ecological flow requirements.

Development Status

- The population of the WMA in 1995 was approximately 4 521 000 people. Some 60 % of the population lived in the portion to the north-east of the Great Kei River Basin, and 26 % of the total population lived in the towns of the WMA. About 1,5% of the population lived in the KwaZulu-Natal Province.

- Much of the economic activity is concentrated in the south-western portion of the WMA, with the East London/King William's Town area (now Buffalo City) contributing 56 % of the GGP in 1997. The GGP of the whole WMA was R62 billion in 1997, with the most important economic sectors, in terms of their contributions to GGP, being Government (30,8 %), Manufacturing (20,4 %), and Trade (14,7 %). Agriculture contributed only 6% to the GGP. The economy is depressed with 48% of the labour force being unemployed in 1994, and all economic sectors except electricity showing negative growth between 1967 and 1997.

Land-use

- Land-use is predominantly for rough grazing for livestock. Some 268 km^2 or 0,4 % of the surface area of the WMA is used for irrigated crops, but only about 187 km^2 of land is irrigated in average years, with larger areas irrigated occasionally when rainfall is favourable in the drier areas. Afforestation, mainly in the north-eastern interior, covers some 1 678 km^2, and 159 km^2 of land consists of nature reserves. Alien vegetation other than the afforestation covered an equivalent condensed area of 730 km^2 in 1995.

- There were about 7 900 000 head of livestock in the WMA in 1995. Sheep and goats made up 74 % of the livestock numbers, with sheep predominating.

Water Related Infrastructure

- Water related infrastructure is well developed, particularly in the south-western half of the WMA, while developments in the north-eastern portion, although generally less extensive, include four hydro-power stations.

- Town bulk water supply schemes were generally adequate in 1995, but the requirements of many of the smaller towns were approaching their capacities and supplies are likely to require augmentation soon. Additional raw water supplies are generally available from local sources, but the necessary infrastructure needs to be developed. The water supply to the bigger urban area of Queenstown will need to be augmented in the near future and water may need to be imported from some distance away. The water requirements of the East London/King William's Town area (Buffalo City) exceed the yield of the local resources, but the infrastructure to import water from adjacent catchments has been provided and the supply should suffice to about the year 2010.

- About 20% of the rural population received water from regional potable water supply schemes in 1995. The majority of the rest of the rural population had inadequate water supplies.

- The existing allocations of water from Waterdown Dam under the Klipplaat River Government Water Scheme for urban use and irrigation cannot be supported at an acceptable level of assurance. In contrast, the yields of eight dams constructed in the former Republics of Transkei and Ciskei for the supply mainly of irrigation water, are under-utilised, with the result that a total of 64 million m^3/a of yield from these dams was not used in 1995.

Water Requirements

- Water requirements in 1995 were estimated to total 1 168 million m^3/a, excluding the requirements of the ecological Reserve, but including water use by afforestation and alien vegetation. The major water user sector was hydro-power generation, which required 570 million m^3/a, or 49 % of the total consumptive requirement (i.e. excluding the ecological Reserve). The next biggest water user was agriculture, at 18 % of the total consumptive requirement, followed by afforestation (14%), urban and rural domestic requirements (10 %), alien vegetation (8%), and bulk supplies to industry (1%). The estimate of water use by alien vegetation is at a low level of confidence. With the requirements of the ecological Reserve added, the total water requirement becomes 2 656 million m^3/a.

- The equivalent water requirement at 1:50 year assurance, with the requirements of the ecological Reserve and water use by alien vegetation and afforestation all included as impacts on yield, was 797 million m^3/a. The estimates of the impacts on yield are at a low level of confidence.

Water Resources

- The natural MAR of the Mzimvubu to Keiskamma WMA was 7 240 million m^3/a and the yield utilised from surface water resources in 1995 was 749 million m^3/a at 1:50 year assurance. Some 33 % of the utilised yield was from farm dams and run-of-river abstractions, and 67 % from major dams. In addition, boreholes with an estimated yield of 21 million m^3/a had been developed, bringing the total utilised yield in 1995 to 770 million m^3/a at 1:50 year assurance.

- In the north-eastern part of the WMA, the full available run-of-river yield is not utilised because there is insufficient demand for the water. As the requirements of the ecological Reserve impact on the full available run-of-river yield, it was necessary to take it into account in the yield balance. The unutilised portion of the available run-of-river yield in 1995 was estimated (at a low level of confidence) to be 406 million m^3/a, which, when added to the utlised yield in 1995 of 770 million m^3/a, brings the total available yield to 1 176 million m^3/a.

- The maximum potential utilisable yield of the water resources of the WMA is estimated to be 3 263 million m^3/a, which is 2 087 million m^3/a more than the available yield in 1995 of 1 176 million m^3/a. The reliability of this estimate is uncertain because of a lack of reliable information on the ecological flow requirements of the estuaries, and on the availability of suitable dam sites in some areas.

- The natural quality of groundwater and of surface water base flows in the WMA is variable, with elevated salinities in some areas. Therefore, the viability of developing the full potential yield may be adversely affected by water quality.

- In the catchments of the Buffalo and Nahoon Rivers water quality has been adversely affected by urban development and gives cause for concern.

- The Mtata River is heavily polluted by flows of untreated sewage from the Umtata urban area and the pollution is a health threat to rural communities downstream who use the untreated river water for household purposes.

- There is a high risk of microbial contamination of both suface water and groundwater in most parts of the densely populated tribal areas of the WMA, and this poses a health threat to those rural communities who rely on untreated supplies of potable water.

Water Balance

- Comparison of the equivalent 1:50 year assurance water requirements of 797 million m^3/a with the available yield 1 176 million m^3/a, shows a surplus of 379 million m^3/a. Re-usable return flows of 255 million m^3/a increase the surplus to 634 million m^3/a.

- The greater part of the surplus, amounting to 634 million m^3/a, occurs in the area to the north-east of the Great Kei River Basin. There are also overall surpluses in the remaining areas of the WMA, comprising the Amatole Region and the Great Kei River Basin. Localised deficits occur in the latter area in the Klaas Smits and Thomas River catchments. These are attributable to equivalent irrigation requirements at 1:50 year assurance exceeding the 1:50 year yield.

Costs of Water Resources Development

- The capital cost of developing the full potential yield of the water resources of the WMA was estimated to be approximately R20 300 million at year 2000 prices. However, the viability of developing the full potential yield may be affected by water quality as well as the high cost of constructing dams and the demand for water, and it is likely that only a portion of this yield could be fully developed.

- The estimate of the cost of developing the potential water resources was based solely on surface water development, but the limited development of groundwater may be more economical in some areas.

3. CONCLUSIONS AND RECOMMENDATIONS

It is concluded from the above that :

- The Mzimvubu to Keiskamma WMA is a water rich area in which the water resources have not been fully developed. The water requirements within the WMA are much less than the potential yield and are likely to continue to be so for the foreseeable future.

- It is only in a few areas such as the urban areas of Buffalo City and Queenstown, and parts of the Great Kei Basin where irrigated agriculture is well developed, that water requirements exceed the yields of the local resources and water needs to be imported from adjacent catchments. (Studies to investigate ways of providing for the future needs of the affected urban areas have been carried out since 1995 or are planned for the future).

- The issues relating to deteriorating water quality are cause for concern :
  - The water quality problems in the Buffalo City area have been investigated in detail and the actions required to address them have been identified.
  - The pollution by raw sewage in the Mtata River can only be addressed by improving the sewerage reticulation in the Umtata urban area, improving sewage treatment facilities, and implementing effective water conservation and demand management to reduce the volume of flow in the sewerage system.
  - The threat of microbial pollution of water resources in the rural areas needs to be countered by the provision of effective sanitation systems in conjunction with safe potable water supplies. Major initiatives in this regard have been underway for some years and are continuing.

It became apparent in the course of carrying out this assessment that the available data on the following aspects is inadequate :

- Ecological flow requirements of both rivers and estuaries and their impact on the available yield of the water resources.
- The impacts of alien vegetation and afforestation on the yield of the water resources.
- The distribution, types and areas of crops irrigated from "private" sources (e.g. boreholes, small dams, small streams) and their water requirements.
- The capacities of the raw water supplies to some of the towns. (This data should be obtained for information on urban water supply infrastructure to be comprehensive, but is not of high priority and should be available from the water services development plans prepared by the towns.)
- The numbers and types of game in the WMA and verification of livestock numbers in areas that fall within the former Republics of Transkei or Ciskei. (This is not of high priority because the changes in the overall water requirements in the WMA are likely to be small. Nevertheless, the information should be obtained for completeness of the data on the water requirements of livestock and game.)

Ideally, all the information referred to above should be available to facilitate the efficient management of the water resources of the Mzimvubu to Keiskamma WMA and the planning of their further development. However, a considerable amount of work will be required to obtain all the information, and it is unlikely that the task could be completed in a short time. Therefore, a phased approach is suggested, in which the required information is collected for particular areas as it becomes necessary to address water resources problems, or as the Reserve is implemented.

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DIAGRAMS

ABBREVIATIONS AND ACRONYMS

AEMC	Suggested Ecological Management Class
CMA	Catchment Management Agency
DBSA	Development Bank of Southern Africa
DEMC	Default Ecological Management Class
DESC	Default Ecological Status Class
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
E Cape	Eastern Cape Province
EISC	Ecological Importance and Sensitivity Class
GGP	Gross Geographic Product
GIS	Geographical Information System
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MD	Magisterial District
MSL	Mean sea level
NWA	National Water Act (Act No. 36 of 1998)
PESC	Present Ecological Status Class
TDS	Total Dissolved Salts
TLC	Transitional Local Council
TRC	Transitional Rural Council
WMA	Water Management Area
WRSA	Water Resources Situation Assessment
WSAM	Water Situation Assessment Model
ha	hectare
km^2	square kilometres
ℓ/c/d	litres per capita per day
m^3	cubic metre
mg/ℓ	milligram per litre
Mℓ	Megalitres
Mℓ/d	Megalitres per day
%	percent
$t/km^2.a$	tonnes per square kilometre per annum
10^6 m^3/a	million cubic metres per year

GLOSSARY OF TERMS

ASSURANCE OF SUPPLY	The reliability at which a specified quantity of water can be provided, usually expressed either as a percentage or as a risk. For example "98% reliability" means that, over a long period of time, the specified quantity of water can be supplied for 98% of the time, and less for the remaining 2%. Alternatively, this situation may be described as a "1 in 50 year risk of failure" meaning that, on average, the specified quantity of water will fail to be provided in 1 year in 50 years, or 2% of time.
BASIN	The area of land that is drained by a large river, or river system.
BIOTA	A collective term for all the organisms (plants, animals, fungi, bacteria) in an ecosystem.
CONDENSED AREA	The equivalent area of alien vegetation with a maximum concentration/density that represents the more sparsely distributed alien vegetation that occurs over a large area.
CATCHMENT	The area of land drained by a river. The term can be applied to a stream, a tributary of a larger river or a whole river system.
COMMERCIAL FARMING	Large scale farming, the products of which are normally sold for profit.
COMMERCIAL FORESTS	Forests that are cultivated for the commercial production of wood or paper products.
DAM	The wall across a valley that retains water, but also used in the colloquial sense to denote the lake behind the wall.
DEFICIT	Describes the situation where the availability of water at a particular assurance of supply is less than the unrestricted water requirement.
DEFAULT ECOLOGICAL MANAGEMENT CLASS	Default Ecological Management Class (A-D). A class indicating the ecological importance and sensitivity of an area, as it is likely to have been under natural (undeveloped) conditions, and the risks of disturbance that should be tolerated. Values range from ClassA (highly sensitive, no risks allowed) to ClassD (resilient systems, large risk allowed).
DRAINAGE REGION	The drainage regions referred to in this document are either single large river basins, or groups of contiguous catchments or smaller catchments with similar hydrological characteristics. They follow the division of the country into drainage regions as used by the Department of Water Affairs and Forestry.

ECOSYSTEM	A unit made up of all the living and non-living components of a particular area that interact and exchange materials with each other.
ECOSYSTEM HEALTH	An ecosystem is considered healthy if it is active and maintains its organisation and autonomy over time, and is resilient to stress. Ecosystem health is closely related to the idea of sustainability.
ECOLOGICAL IMPORTANCE	A measure of the extent to which a particular species, population or process contributes towards the healthy functioning of an ecosystem. Important aspects include habitat diversity, biodiversity, the presence of unique, rare or endangered biota or landscapes, connectivity, sensitivity and resilience. The functioning of the ecosystem refers to natural processes.
EDAPHIC	Pertaining to the influence of soil on organisms, OR Resulting from or influenced by factors inherent in soil rather than by climatic factors.
ENDANGERED SPECIES	Species in danger of extinction and whose survival is unlikely if the causal factors bringing about its endangered status continue operating. Included are species whose numbers have been reduced to a critically low level or whose habitat has been so drastically diminished and/or degraded that they are deemed to be in immediate danger of extinction.
ENDEMIC	Occurring within a specified locality; not introduced.
ENDOREIC	Portion of a hydrological catchment that does not contribute towards river flow in its own catchment (local) or to river flow in downstream catchments (global). In such catchments the water generally drains to pans where much of the water is lost through evaporation.
ENVIRONMENTALLY SENSITIVE AREA	A fragile ecosystem which will be maintained only by conscious attempts to protect it.
EPHEMERAL RIVERS	Rivers where no flow occurs for long periods of time.
FORMAL IRRIGATION SCHEME	The term applies to a scheme where water for irrigation purposes is stored in a dam controlled by DWAF or an Irrigation Board and supplied in pre-determined quotas to irrigators registered under the scheme.
HISTORICAL FLOW SEQUENCE	A record of river flow over a defined period and under a defined condition of catchment development in the past, calculated from a record of observed flow corrected for inaccuracies, or from records of observed rainfall, or a combination of the two.

HYDROLOGICAL YEAR — The twelve-month period from the beginning of October in one year to the end of September in the following year.

INVERTEBRATE — An animal without a backbone - includes insects, snails, sponges, worms, crabs and shrimps.

IRRIGATION QUOTA — The quantity of water, usually expressed as m^3/ha per year, or mm per year, allocated to land scheduled under the scheme. This is the quantity to which the owner of the land is entitled at the point at which he or she takes delivery of the water and does not include conveyance losses to that point.

LOTIC — Pertaining to fast running aquatic habitats such as fast flowing streams or rivers.

MEAN ANNUAL RUNOFF — Frequently abbreviated to MAR, this is the long-term mean annual flow calculated for a specified period of time, at a particular point along a river and for a particular catchment and catchment development condition. In this report, the MARs are based on the 70-year period October 1920 to September 1990 inclusive.

OPPORTUNISTIC IRRIGATION — Irrigation from run-of-river flow, farm dams, or compensation flows released from major dams. As storage is not provided to compensate for reduced water availability in dry years, areas irrigated generally have to be reduced in dry years.

PRESENT ECOLOGICAL STATUS CLASS — A class indicating the degree to which present conditions of an area have been modified from natural (undeveloped) conditions. Factors that are considered in the classification include the extent of flow modification, inundation, water quality, stream bed condition, riparian condition and proportion of exotic biota. Values range from ClassA (largely natural) to ClassF (critically modified).

QUATERNARY CATCHMENT — The basic unit of area resolution used in the WR90 series of reports published by the Water Research Commission and also in this report. The primary drainage regions are divided into secondary, tertiary and quaternary catchments. The quaternary catchments have been created to have similar mean annual runoffs : the greater the runoff volume the smaller the catchment area and vice versa. The quaternary catchments are numbered alpha-numerically in downstream order. A quaternary catchment number, for example R30D, may be interpreted as follows : the letter R denotes Primary Drainage Region R, the number 3 denotes secondary catchment 3 of Primary Drainage Region R, the number 0 shows that the secondary catchment has not, in this case, been sub-divided into tertiary catchments, and the letter D shows that the quaternary catchment is the fourth in sequence downstream from the head of secondary catchment R30.

RARE	Species with small or restricted populations, which are not at present endangered or vulnerable, but which are at risk. These species are usually localised within restricted geographical areas or habitats, or are thinly scattered over a more extensive range. These may be species which are seldom recorded but may be more common than supposed, although there is evidence that their numbers are low.
RED DATA BOOK	A book that lists species that are threatened with extinction. The concept was initiated by the International Union for the Conservation of Nature, and has since become adopted by many countries. The "Red" stands for "Danger". The categories reflect the status of the species only within the area under review, and it is sometimes the case that species which are threatened in one region may have secure populations in other areas.
RELIABILITY OF SUPPLY	Synonymous with assurance of supply.
RESERVE	The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997) for people, who are now or who will, in the reasonably near future, be (i) relying upon; (ii) taking water from; or (iii) being supplied from, the relevant water resource; and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource as indicated in the National Water Act (Act No. 36 of 1998).
RESERVOIR	The lake formed behind a dam wall. In this report the colloquial term dam is generally used for reservoir.
RESILIENCE	The ability of an ecosystem to maintain structure and patterns of behaviour in the face of disturbance or the ability to recover following disturbance.
RESOURCE QUALITY	The quality of all the aspects of a water resource including : (a) the quantity, pattern, timing, water level and assurance of instream flow; (b) the water quality, including the physical, chemical and biological characteristics of the water; (c) the character and condition of the instream and riparian habitat; and (d) the characteristics, condition and distribution of the aquatic biota.
RESOURCE QUALITY OBJECTIVE	Quantitative and verifiable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection.
RIVER SYSTEM	A network of rivers ranging from streams to major rivers and, in some cases, including rivers draining naturally separate basins that have been inter-connected by man-made transfer schemes.

SCHEDULED LAND	Irrigable land to which a water quota has been allocated.
SPATIO - TEMPORALLY ROBUST	Does not change significantly with time in relation to spatial distribution.
SUB-CATCHMENT	A sub-division of a catchment.
SUBSISTENCE FARMING	Small-scale farming where almost all produce is consumed by the farmer's household or within the local community.
SUGGESTED ECOLOGICAL MANAGEMENT CLASS	A class of water resource indicating the suggested management objectives of an area which could possibly be attained within 5 years. Values range from Class A (largely natural) to Class D (largely modified).
VADOSE ZONE	Relating to or resulting from water or solutions that are above the permanent groundwater level.
VULNERABLE	Species believed likely to move into the endangered category in the near future if the causal factors continue operating. Included are species of which all or most of the population are decreasing because of over-exploitation, extensive destruction of habitat, or other environmental disturbance. Species with populations which have been seriously depleted and whose ultimate security is not yet assured, and species with populations that are still abundant but are under threat from serious adverse factors throughout their range.
WATER IMPORTS	Water imported to one drainage basin or secondary sub-catchment from another.
WATER TRANSFERS	Water transferred from one drainage basin or secondary sub-catchment to another. Transfers in are synonymous with water imports.
YIELD	The maximum quantity of water obtainable on a sustainable basis from a dam in any hydrological year in a sequence of years and under specified conditions of catchment development and dam operation.

CHAPTER 1: INTRODUCTION

1.1 PURPOSE OF THE STUDY

The National Water Act No. 36 of 1998 requires the Minister of Water Affairs and Forestry to establish a national water resource strategy for the protection, use, development, conservation, management and control of water resources. To enable the strategy to be established, information on the present and probable future situations regarding water requirements and water availability is required, that is, a national water resources situation assessment providing information on all the individual drainage basins in the country.

The Department of Water Affairs and Forestry (DWAF) has appointed consulting engineers to undertake Water Resources Situation Assessments for the purpose of gathering information and using it to reconcile the present water requirements of all the user sectors with the presently available water resources. The information produced by all the studies will be consolidated by DWAF into a national database which will be used to establish the National Water Resource Strategy. Scenarios of future water requirements and availability are being dealt with in a separate study. These scenarios will be taken up in the National Water Resource Strategy and will be reported on separately for each water management area.

As a component of the National Water Resource Strategy, the Minister of Water Affairs and Forestry has established water management areas and determined their boundaries. The National Water Act provides for the delegation of water resource management from central government to the regional or catchment level by establishing catchment management agencies. It is intended that the documents produced in this study as well as in the subsequent scenario studies referred to above should, in addition to contributing to the establishment of the National Water Resource Strategy, provide information for collaborative planning of water resources development and utilisation by the central government and the future catchment management agencies.

In order to facilitate use by future catchment management agencies, the information has been presented in the form of a separate report on each water management area (WMA). This report is in respect of the Mzimvubu to Keiskamma Water Management Area, which occupies a portion of the Eastern Cape Province and a small portion of the Kwa-Zulu Natal Province. A provincial water resources situation assessment can be derived by assembling the provincial data from each of those reports that describe the water management areas that occupy the province.

1.2 APPROACH TO THE STUDY

The study was carried out as a desktop investigation using data from reports and electronic databases, or supplied by associated studies, local authorities and DWAF. The study considered conditions as they were in the year 1995 and did not make projections of future conditions. Data at reconnaissance level of detail was collected on land-use, water requirements, water use, water related infrastructure, water resources and previous investigations of water supply development possibilities. Relevant data was used in a computerised water balance model, developed in a separate study (DWAF, 2000a) to calculate the yield of the water resources at development levels as they were in 1995, and the maximum yield that could be obtained from future development of these resources. The water balance (the relationship between water requirements and water availability) at selected points in each water management area was also calculated.

Information on urban water use and water related infrastructure was obtained from reports on urban water supplies and from questionnaires filled in by local authorities. The collected data on urban water use was supplied to consultants appointed to carry out a separate national demographic study, in relation to water requirements.

In that study, data from the 1996 census, and other sources, was used to derive demographic information for the whole country for the year 1995. In addition, the information on urban water use, that was supplied by the water resources situation assessment studies, was analysed in the demographic study to derive typical unit water requirements. These were used, in conjunction with the demographic data, to estimate water requirements in 1995 for urban areas for which no recorded data was available.

Both the demographic data and the estimated water requirements in 1995, as supplied for the Mzimvubu to Keiskamma Water Management Area by the national demographic study (DWAF, 2000b), are presented in this report. In addition to the separate studies on the water balance model and demography referred to above, separate studies were carried out to provide information on a national basis on :

- Macro-economic aspects
- Legal aspects of water resource management
- Institutional arrangements for water supply
- Effects of alien vegetation on runoff
- Groundwater resources
- Bacteriological contamination of water resources
- Water requirements for irrigation
- Ecological classification of rivers
- Water requirements for the ecological component of Reserve
- Effects of afforestation on runoff
- Storage-yield characteristics of rivers

Information from all the above studies, that is relevant to the Mzimvubu to Keiskamma Water Management Area, is included in the appropriate sections of this report.

1.3 REPORT LAYOUT AND CONTENT

The findings of the study in respect of the Mzimvubu to Keiskamma Water Management Area are presented in the nine chapters that make up the main body of this report, and a number of appendices containing mainly statistics for the quaternary hydrological sub-catchments that make up the water management area. (The system used to divide the area into hydrological sub-catchments is explained in Section 2.1 of the report).

The chapter headings are :

Chapter 1 : Introduction
Chapter 2 : Physical Features
Chapter 3 : Development Status
Chapter 4 : Water Related Infrastructure
Chapter 5 : Water Requirements

Chapter 6 : Water Resources
Chapter 7 : Water Balance
Chapter 8 : Costs of Water Resources Development
Chapter 9 : Conclusions and Recommendations

Chapters 2, 3 and 4 describe climatic and physical features, and land-uses that affect water resources or water supply. Chapter 5 describes the various water user sectors and their requirements. It includes information on water allocations, water conservation and demand management, and water losses and return flows. Chapter 6 describes the groundwater and surface water resources of the water management area, and Chapter 7 compares water requirements with the available resource. In Chapter 8, rough estimates are given of the cost of developing the portion of the total water resource that was not developed by 1995, and the conclusions and recommendations arising from the study are presented in Chapter 9.

CHAPTER 2: PHYSICAL FEATURES

2.1 THE STUDY AREA

The study area comprises the whole of the Mzimvubu to Keiskamma Water Management Area which is shown on Figure 2.1.1. It consists of three large drainage basins and the catchments of a number of smaller rivers that lie between the major drainage basins and the Indian Ocean. The major drainage basins are the Great Kei (Drainage Region S), the Mbashe (part of Drainage Region T), and the Mzimvubu (part of Drainage Region T).

The Mzimvubu to Keiskamma WMA is bounded in the west by the Fish to Tsitsikamma WMA, the Upper Orange WMA and Lesotho in the north, the Mvoti to Umzimkulu WMA in the north-east, and the Indian Ocean in the south-east.

The topography is hilly to mountainous throughout the WMA with the high mountains of the Drakensberg along the north-eastern boundary (see Figure 2.1.2). The rivers are deeply incised in the coastal strip.

For purposes of assessing water requirements and the available water resources, the water management area has been divided into quaternary catchments (see Figure 2.1.3). These are the basic unit of area used in the report on the Surface Water Resources of South Africa, 1990 (Midgley *et al*, 1994), which is the main source of the hydrological data used in this study.

In this system, drainage regions throughout the country are divided into secondary, tertiary and quaternary catchments. The quaternary catchments have been selected to have similar runoffs : the greater the runoff volume, the smaller the catchment area and vice versa. The quaternary catchments are numbered alpha-numerically in downstream order. A quaternary catchment number, for example T34C, may be interpreted as follows. The letter T denotes Drainage Region T (sometimes referred to as a primary catchment). The number 3 denotes secondary catchment 3 of Drainage Region T. The number 4 shows that the secondary catchment has, in this case, been sub-divided into tertiary catchments and that the tertiary catchment is the fourth in sequence downstream from the head of secondary catchment T3. The letter C shows that the quaternary catchment is the third in sequence downstream from the head of tertiary catchment T34.

The Mzimvubu to Keiskamma WMA consists of Drainage Regions R and S and a large portion of Drainage Region T. It contains a total of 194 quaternary catchments from these drainage regions.

In the description of features of the area that follows, references to quaternary catchments are shown in brackets to assist in locating the approximate positions of the features on Figure 2.1.3. Many of the features themselves are not shown on the figure because the scale of mapping is too small.

The total area of the WMA is some 66 211 km^2. For purposes of describing its physical features it may conveniently be sub-divided into the drainage areas referred to above.

- Drainage Region R, known as the Amatole Region, consists of the catchments of the Keiskamma River (R10A to R10M), the Buffalo River (R20A to R20G), the Nahoon (R30E, R30F) and the Gqunube (R30C, R30D) Rivers, and several smaller rivers along the coast from the western boundary of the WMA to the catchment of the Great

Kei River to the north-east. The area is generally mountainous, with the rivers flowing in deeply incised valleys.

- The catchment of the Great Kei River is designated Drainage Region S. It extends from the northern and north-western edges of the WMA to the coast. The main tributaries of the Great Kei River are the Black Kei River (S31, S32), the White Kei River (S10A to S10J), with its tributary, the Indwe River (S20A to S20D), the Tsomo River (S50A to S50H), and the Thomas (S40A to S40E), Kubusi (S60A to S60E) and Zilinxa (S70C to S70E) Rivers.

- The whole of the central and north-eastern portions of the WMA lie within Drainage Region T, which extends into the Mvoti to Mzimkulu WMA. The topography of this area consists of the high mountains of the Drakensberg in the interior with the rugged foothills of the mountains falling to a hilly central plateau which is bounded along its south-eastern edge by a coastal strip consisting of steep grassy hills separated by numerous deeply incised valleys. The portion of Drainage Region T within the Mzimvubu to Keiskamma WMA contains the catchments of :

  - The Mbashe River (T11, T12, T13) which rises in the mountains of the southern Drakensberg (T11A, T11B), where the peaks rise to altitudes of about 2 300 m above mean sea level, and flows across a plateau in the central portion of its catchment, before entering an area of deeply incised and tortuous valleys for the last 60 km (T13C, T13D, T13E) of its route to the sea.

  - The Mtata River (T20A to T20G) which rises at an altitude of about 1 600 m above mean sea level in the foothills of the Drakensberg (T20B), before flowing across the central plateau (T20B, T20C, T20D) and through the rugged topography of the 60 km wide coastal strip (T20E, T20F, T20G) to the sea.

  - The Mzimvubu is the largest undeveloped river in South Africa and its basin (T31 to T36) covers an area of some 20 000 km^2. The Mzimvubu River itself, and three of its four main tributaries, rise in the Drakensberg Mountains along the border with Lesotho, where the mountain peaks rise to altitudes of more than 2 800 m above mean sea level. The tributaries are the Tsitsa River (T35A to T35M), the Tina River (T34A to T34K) and the Kinira River (T33A to T33G). The Kinira River joins the upper portion of the main stem of the Mzimvubu River (T31A to T31J) at the south-western edge of the central plateau, and the Tina and Tsitsa Rivers join it further downstream at the edge of the coastal strip (T36A). The fourth major tributary is the Mzintlava River (T32A to T32H), which rises in the Ngele Mountains (T32A, T32B, T32C) and flows along the eastern edge of the Mzimvubu River Basin to join the Mzimvubu River at the inland edge of the coastal strip (T32H). The Mzimvubu River flows in deep and spectacular gorges through the coastal strip (T36A, T36B) to the sea at Port St Johns.

  - The catchments of smaller rivers (T7, T8, T9) situated between the catchments of the main rivers and the coast. These rivers generally have unspoiled estuaries that are of high conservation value.

  - The catchments of the small rivers of the Pondoland area (T60A to T60K) which rise in the coastal strip between the Mzimvubu River Basin and the north-eastern boundary of the WMA. Both the rivers and the estuaries in this area are of high conservation value.

For purposes of describing the characteristics of the WMA, it was divided into a number of key areas. These are either the catchments of the main rivers within the WMA, or groupings of several minor catchments. The key areas are listed in Table 2.1.1, where reasons for selecting them are also included.

TABLE 2.1.1: KEY AREAS WITHIN THE MZIMBUBU TO KEISKAMMA WMA

CATCHMENT					REASON FOR SELECTION
PRIMARY		SECONDARY/TERTIARY		TERTIARY/ QUATERNARY	
No.	Description	No.	Area	No.	
R	Amatole Region	R5	Southern Coastal Catchments	R50A, R50B	Catchments of Mpekweni, Mgwalana and Bira Rivers
		R1	Keiskamma	R10A to R10M	Entire catchment of Keiskamma River
		R4	Amatole Coastal Catchments	R40A to R40C	Catchments of coastal rivers between the Keiskamma and Buffalo River Catchments
		R2	Buffalo	R20A to R20G	Entire catchment of Buffalo River
		R3	Nahoon, Gqunube	R30A to R30F	Nahoon River and adjacent coastal catchments
S	Great kei	S1	White Kei	S10A to S10J	Catchment of White Kei River upstream of its confluence with the Great Kei River
		S2	Indwe	S20A to S20D	Catchment of Indwe River upstream of its confluence with the Whtie Kei River
		S31	Klaas Smits	S31A to S31G	Catchment of Klaas Smits River upstream of its confluence with the Black Kei River
		S32	Black Kei	S32A to S32M	Incremental catchment of the Black Kei River upstream of its confluence with the Great Kei River
		S4	Thomas	S40A to S40F	Catchment of Thomas River and mainstem of Great Kei River upstream of its confluence with the Tsomo River
		S5	Tsomo	S50A to S50J	Catchment of Tsomo River at its confluence with the Great Kei River
		S6	Kubusi	S60A to S60E	Catchment of the Kubusi River upstream of its confluence with the Great Kei River
		S7	Great Kei and Xilinxa	S70A to S70F	Incremental catchment of the Great Kei River downstream of its confluence with the Tsomo River
T	Transkei	T1	Mbashe	T11A to T11G T12A to T12G T13A to T13E	Entire catchment of the Mbashe River
		T2, T7, T8	Mtata	T20A to T20G T70A to T70G T80A to T80D	Catchment of Mtata River and smaller coastal rivers between the Mbashe and Mzimvubu River catchments
		T31, T33 (part)	Upper Mzimvubu	T31A to T31K T33H to T33K	Incremental catchment of the Mzimvubu River upstream of its confluences with the Tina, Tsitsa and Mzintlava Rivers
		T32	Mzintlava	T32A to T32H	Catchment of Mzintlava River upstream of its confluence with the Mzimvubu River
		T33 (part)	Kinira	T33A to T33G	Catchment of the Kinira River upstream of its confluence with the Mzimvubu River
		T34	Tina	T34A to T34K	Catchment of the Tina River upstream of its confluence with the Tsitsa River.
		T35	Tsitsa	T35A to T35M	Catchment of the Tsitsa River upstream of its confluence with the Mzimvubu River
		T36	Lower Mzimvubu	T36A, T36B	Incremental catchment of the Mzimvubu River downstream of its confluence with the Tina and Tsitsa Rivers
		T6	Pondoland Coastal Catchments	T60A to T60K	Catchments of Msikaba, Mtentu, Mzumba Rivers and adjacent smaller rivers
		T9	Southern Wild Coast	T90A to T90G	Coastal catchments between the Kei and Mbashe catchments

2.2 CLIMATE

2.2.1 Temperature

The mean annual temperature ranges between 20ºC along the coast and 8ºC on the border with Lesotho, with an average of 16,1ºC for the WMA as a whole. Maximum temperatures are experienced in January and minimum temperatures usually occur in July. The following Table summarises temperature data for the WMA for these two months (Schulze *et al*, 1997).

TABLE 2.2.1: TEMPERATURE DATA

MONTH	TEMPERATURE (ºC)	AVERAGE	RANGE
January	Mean temperature	21	12 - 26
	Maximum temperature	24	17,2 - 32,7
	Minimum temperature	12	2,8 - 19,7
	Diurnal range	13,7	6,3 - 18,7
July	Mean temperature	10,6	-0,3 - 16,8
	Maximum temperature	16	8,2 - 22,3
	Minimum temperature	2	-8,8 - 11,6
	Diurnal range	14,2	9,8 - 17

Frost occurs in the inland areas in winter, typically over the period from mid-May to late August and snowfalls occur on the mountains in the winter.

2.2.2 Rainfall

Rainfall in the Mzimvubu to Keiskamma WMA occurs mainly in summer, but the winter months are not completely dry and about 30% of the annual rainfall occurs between April and September.

There is a great variation of the quantity of rainfall throughout the WMA. The mean annual precipitation (MAP) along the coastal region ranges from a low of 600 mm in the west to a high of 1 208 mm in the east, and varies from 400 mm to 1 200 mm in the central plateau and along the northern edge of the WMA. The rainfall is generally higher in the east than in the west.

2.2.3 Humidity and Evaporation

The relative humidity in the WMA is higher in summer than in winter. It is generally highest in February (the daily mean ranges from 60% in the north-west to 82% in the south-east) and lowest in July (the daily mean ranges from 50% in the north-west to 72% in the south-east).

Average potential mean annual gross evaporation (MAE) (as measured by Symons-pan) for the WMA ranges from 1 700 mm in the north-west to less than 1 200 mm in the south-eastern parts.

2.3 GEOLOGY

The geology of the Mzimvubu to Keiskamma WMA is shown on Figure 2.3.1. The predominant strata are shales, mudstones, and sandstones of the Karoo Sequence that have been intruded by dolerite dykes and sills. Basaltic lavas of the Drakensberg Formation occur in a small area (T33B, T34A to T34C, T34E and T35A). Dwyka Tillite occurs in the lower part of the Mzimvubu catchment (T36B) and in the central portion of the Pondoland Coastal Catchments (T60A, T60C, T60G, T60J, T60K).

Along the coast from Port St Johns (T70B) to the north-eastern edge of the WMA (T60A), the strata consist of sandstones of the Natal Group of the Cape Supergroup.

2.4 SOILS

Figure 2.4.1 shows a generalised soils map of the WMA based on some sixteen broad soil groupings. The figure was obtained from the report on the Water Resources of South Africa, 1990 (Midgley *et al*, 1994). The 16 groupings were derived by the Department of Agricultural Engineering of the University of Natal using a national base map which was divided into 82 soil types. These soil types were then analysed according to features most likely to influence hydrological response, viz. depth, texture and slope.

The following soil types occur in the Mzimvubu to Keiskamma Water Management Area :

- Moderately deep to deep clayey loams in undulating to steep terrain along the south-western coast of the WMA (between R50B and T70D).
- Moderately deep to deep sandy loams in steep terrain in the south-western part (R10G, R10H, R10J) of the Keiskamma River catchment and in the valley of the Great Kei River (between S32M and S70B).
- Moderately deep to deep clayey loams on the steep slopes of the foothills of the Drakensberg in the northern part of the WMA.
- Moderately deep to deep clayey soils on the steep slopes of the Drakensberg along the Lesotho border.
- Moderately deep to deep sandy loam in undulating terrain in the rest of the WMA.

2.5 NATURAL VEGETATION

2.5.1 Introduction

Some 20 000 different plant species occur throughout South Africa. These are, however, not randomly distributed within the region but are organised into distinct communities, largely dependent on the prevailing climatic (especially rainfall) and edaphic (soil) conditions. For the purposes of identifying and managing the heterogenous arrangement of vegetation within South Africa it is necessary to be able to recognise relatively homogenous vegetation groups or types. Furthermore, for the recognised groups to be meaningful, it is essential that they are readily apparent and spatio-temporally robust.

Acocks (1988) introduced the concept of "Veld Type", which he defined as: "*a unit of vegetation whose range of variation is small enough to permit the whole of it to have the same farming potentialities"*. Acocks (1988) identified a total of 70 veld types in South Africa (see Table 2.5.1.1), including 75 variations. These 70 veld types fall into 11 broad categories, ranging from various forest types to sclerophyllous (Fynbos) types (Table 2.5.1.1). These "simplified" Acocks veld type categories are used for the purposes of this report, and accordingly the description of the natural vegetation types occurring within the Water Management Area (WMA) is rather broad.

TABLE 2.5.1.1: A LIST OF THE DETAILED AND SIMPLIFIED ACOCKS VELD TYPES (Acocks, 1988)

DETAILED VELD TYPES	NO.	SIMPLIFIED VELD TYPE
Coastal Forest and Thornveld	1	**Coastal Tropical Forest**
Alexandria Forest	2	
Pondoland Coastal Plateau Sourveld	3	
Knysna Forest	4	
›Ngongoni Veld	5	
Zululand Thornveld	6	
Eastern Province Thornveld	7	
North-eastern Mountain Sourveld	8	**Inland Tropical Forest**
Lowveld Sour Bushveld	9	
Lowveld	10	**Tropical Bush and Savanna**
Arid Lowveld	11	
Springbok Flats Turf Thornveld	12	
Other Turf Thornveld	13	
Arid Sweet Bushveld	14	
Mopani Veld	15	
Kalahari Thornveld	16	
Kalahari Thornveld invaded by Karoo	17	
Mixed Bushveld	18	
Sourish Mixed Bushveld	19	
Sour Bushveld	20	
False Thornveld of eastern Cape	21	**False Bushveld**
Invasion of Grassveld by *Acacia karroo*	22	
Valley Bushveld	23	**Karoo and Karroid**
Noorsveld	24	
Succulent Mountain Scrub	25	
Karroid Broken Veld	26	
Central Upper Karoo	27	
Western Mountain Karoo	28	
Arid Karoo	29	
Central Lower Karoo	30	
Succulent Karoo	31	
Orange River Broken Veld	32	
Namaqualand Broken Veld	33	
Strandveld	34	
False Arid Karoo	35	**False Karoo**
False Upper Karoo	36	
False Karroid Broken Veld	37	
False Central Lower Karoo	38	
False Succulent Karoo	39	
False Orange River Broken Karoo	40	
Pan Turf Veld invaded by Karoo	41	
Karroid *Merxmuellera* Mountain Veld replaced by Karoo	42	
Mountain Renosterveld	43	

DETAILED VELD TYPES	NO.	SIMPLIFIED VELD TYPE
Highland Sourveld and Dohne Sourveld	44	**Temperate and Transitional Forest and Scrub**
Natal Mist Belt ›Ngongoni Veld	45	
Coastal Renosterveld	46	
Coastal Fynbos	47	
Cymbopogon - Themeda Veld	48	**Pure Grassveld**
Transitional *Cymbopogon - Themeda* Veld	49	
Dry *Cymbopogon - Themeda* Veld	50	
Pan Turf Veld	51	
Themeda Veld or Turf Highveld	52	
Patchy Highveld to *Cymbopogon - Themeda* Veld Transition	53	
Turf Highveld to Highland Sourveld Veld Transition	54	
Bakenveld to Turf Highveld Transition	55	
Highland Sourveld to *Cymbopogon - Themeda* Veld Transition	56	
North-eastern Sandy Highveld	57	
Themeda - Festuca Alpine Veld	58	
Stormberg Plateau Sweetveld	59	
Karroid *Merxmuellera* Mountain Veld	60	
Bankenveld	61	**False Grassveld**
Bankenveld to Sour Sandveld Transition	62	
Piet Retief Sourveld	63	
Northern Tall Grassveld	64	
Southern Tall Grassveld	65	
Natal Sour Sandveld	66	
Pietersburg Plateau False Grassveld	67	
Eastern Province Grassveld	68	
Fynbos	69	**Sclerophyllous Bush**
False Fynbos	70	**False Sclerophyllous Bush**

2.5.2 Natural Vegetation Types within the Mzimvubu to Keiskamma WMA

The Mzimvubu to Keiskamma WMA is mostly located within the Eastern Cape Province, and the vegetation within this province is typically dominated by Coastal Tropical Forest Types, Karoo and Karroid Types, Temperate and Transitional Forest and Scrub Types, and Pure Grassveld Types. False Bushveld and False Grassland Types also occur. The veld types occurring within the Mzimvubu to Keiskamma WMA are described in more detail below and illustrated on Figure 2.5.2.1.

Coastal Tropical Forest

A broad band of Coastal Tropical Forest veld type occurs adjacent to the entire coastline of the Mzimvubu to Keiskamma WMA. This veld type is typically confined to the coastal area or immediate vicinity, and includes area of forest, thornveld and bushveld. There is considerable turnover in species composition between forest patches. Rainfall is typically higher than that for Temperate and Transitional Forest and Scrub, ranging from 900 to 1 500 mm per annum. Coastal Tropical Forest occurs at any altitude from sea level to 450 m above mean sea level (MSL). This veld type exhibits a long history of anthropogenic effects.

False Bushveld
The False Bushveld veld type occurs along the western boundary of the Mzimvubu to Keiskamma WMA, and continues into the adjacent Fish to Tsitsikamma WMA. This veld type has a very localised distribution within South Africa, and is restricted to the Eastern Cape Province. False Bushveld is typically dominated by *Acacia karoo*, and is characterised as a thorn-bushclump veld which is invading grassveld. Rainfall is moderate, ranging from 400 to 650 mm per annum.

Karoo and Karroid
Isolated patches of this veld type occur throughout the Mzimvubu to Keiskamma WMA, and are largely restricted to the margins of various river courses. The flora is characteristically low, typically less than 1 m in height, and includes scrub, bushes, dwarf trees and a few grasses. Rainfall within this vegetation type typically ranges between 150 and 500 mm per annum, but does reach a maximum of up to 900 mm per annum in some of the river valleys. Karoo and Karroid veld type occurs at any altitude from sea level to 1700 m MSL.

Temperate and Transitional Forest and Scrub
This veld type dominants the central and northern regions of the Mzimvubu to Keiskamma WMA, and occupies some 50 to 60% of the WMA. A large patch of this vegetation type occurs towards the north-eastern boundary of the Mzimvubu to Keiskamma WMA. As the name implies this veld type is typical of relatively temperate habitats. This general veld type includes areas of forest, grassland and fynbos. Temperate and Transitional Forest and Scrub occurs from sea level to up to 1350 m above mean sea level. Rainfall is typically high ranging from 650 to 1150 mm per annum, although it may be somewhat lower within the coastal renosterveld and fynbos elements of this veld type, where it typically ranges from 300 to 500 mm per annum.

Pure Grassveld
Isolated patches of this veld type occur along the western and northern boundaries of this WMA. This type represents the true grassveld, and occurs on the upper plateau and the mountain tops, at altitudes ranging from 1 050 to over 3 050 m above MSL, in regions which are too dry and/or experience frost too regularly for the development of any kind of forest. Rainfall typically ranges from 400 to 750 mm per annum. Much of this veld type has been impacted by farming activities.

False Grassveld
Six patches of False Grassveld occur in the central reaches of the Mzimvubu to Keiskamma WMA, and like the Karoo and Karroid types, are largely restricted to the margins of various river courses. False Grassveld occurs on either sandy or stoney soils at altitudes ranging between 800 and 1 750 m above MSL. Rainfall ranges between 550 and 1 150 mm per annum, typically falling in summer. Much of this veld type has been impacted by farming activities.

2.6 ECOLOGICALLY SENSITIVE SITES

2.6.1 Sensitive Ecosystems

The conservation of living resources is essential for sustaining development by: maintaining the essential ecological processes and life support systems, preserving genetic diversity and ensuring that utilisation of species and ecosystems is sustainable. However, for conservation to succeed it should be underpinned by two basis principles, namely the need to plan resource management (including exploitation) on the basis of an accurate inventory and the need to implement proactive protective measures to ensure that resources do not become exhausted. Accordingly, a vital component of ensuring sustainable conservation practices is the identification of conservation worthy habitats or sensitive ecosystems.

In terms of section 2(1) of the Environment Conservation Act (No. 73 of 1989), South Africa's schedule of protected areas was published in the Government Gazette 15726 in May 1994 (Notice 449 of 1994). This classification identifies the following sensitive or protected areas: Scientific and Wilderness Areas, National Parks and Equivalent Reserves, Natural Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas and Protected Land/Seascapes, based on their location and the functions they fulfill.

South Africa has also recognised the importance of its wetlands as sensitive ecosystems which require conservation, and accordingly has become a signatory to the international *Convention on Wetlands of International Importance especially as Waterfowl Habitat* or RAMSAR Convention. In terms of this convention signatories undertake to include wetland conservation considerations in their national land-use planning, and as far as possible to ensure the wise use of wetlands within their territory.

Before moving on to discuss ecosystems of concern to the study area it would be prudent to give some consideration to the definition of aquatic ecosystems, especially with respect to the National Water Act (No. 36 of 1998). In general terms, an ecosystem may be defined as a community of organisms and their physical environment interacting as an ecological unit. Hence, aquatic ecosystems encompass the aquatic community and water resources necessary to sustain its ecological integrity. Within the National Water Act, the water resource requirements of aquatic ecosystems are recognised and protected by the introduction of the concept of an ecological reserve *viz.* the water required to protect the aquatic ecosystem of the water resources. The Reserve refers to both the quantity and quality of the resource. Accordingly, development must take cognisance not only of the sensitivity of the receiving ecosystem but also of the resource requirements or ecological reserve of the aquatic communities it supports.

2.6.2 River Classification

The water resources of South Africa are to be protected in terms of the National Water Act (No. 36 of 1998). This will be accomplished by classifying each water resource, setting the resource quality objectives and determining the Reserve. This process had not yet been completed and therefore it was necessary to determine the present condition or present ecological status class (PESC) of the water resources so as to estimate the quantities of water required to maintain them in this condition for the purpose of the 1995 water resources situation assessment.

The water resources situation assessment has been performed at the quaternary catchment scale of resolution as described in Section 2.1. However, the delineation of these quaternary catchments was not based on ecological principles. In order to provide some ecological basis for the estimates of water requirements to maintain a particular class of river it was decided to base estimates of water requirements on an index of the ecological importance and sensitivity class (EISC) of the rivers in the quaternary catchment of concern. The ecological importance and sensitivity class of the rivers was used to derive the default ecological management class (DEMC), which relates to a default ecological status class (DESC). The default ecological status class and the present ecological status class (PESC) have been used to arrive at a suggested future ecological management class

(AEMC) to be considered for the water resources. The default ecological status class would normally be assigned to a water resource on the basis of ecological sensitivity and importance. This methodology is based on the assumption that the ecological importance and sensitivity of a river would generally be closely associated with its default ecological management class and that its current ecological status and potential to recover from past ecological damage will determine the possibility of restoring it to a particular ecological management class.

This section describes the procedures and methods adopted to estimate the various status and management classes of the rivers that will be used to estimate the corresponding quantities of water required for that component of the Reserve that is necessary to protect the aquatic ecosystems according to the designated class.

The procedure that has been followed to determine the various classifications is illustrated in Diagram 2.6.2.1. The descriptions of the various ecological importance and sensitivity classes (EISC), default ecological management classes (DEMC), default ecological status classes (DESC), present ecological status classes (PESC) and the suggested future ecological management class (AEMC) are given in Diagram 2.6.2.2.

Individual assessors familiar with the ecology of a particular area or a comparable area were engaged in discussions and workshops during which a number of biotic and habitat determinants, considered important for the determination of ecological importance and sensitivity, were quantified or scored. The procedure that was followed was considered to be suitable for the situation where the delineation of the quaternary catchment units was not based on ecological considerations. The approach may however, have a low ecological sensitivity because of the absence of an ecological typing framework. The median of the scores assigned by the assessors was calculated to derive the ecological importance and sensitivity class. The assessors were then required to compare this with their overall estimation of the ecological importance and sensitivity class of the mainstem river of the quaternary catchment of concern near its outlet.

The assessors were required to record and be able to substantiate their assessments to a reasonable degree for possible review in future.

The ecological importance and sensitivity classes were either assessed during meetings or at a workshop held during 1998. This was followed by a second workshop during 1999 that was primarily concerned with the assessment of the present ecological status class, the potential to improve the ecological status class and the suggested future management class. The second workshop however, also involved an overall review of the ecological importance and sensitivity assessments determined during the original workshop.

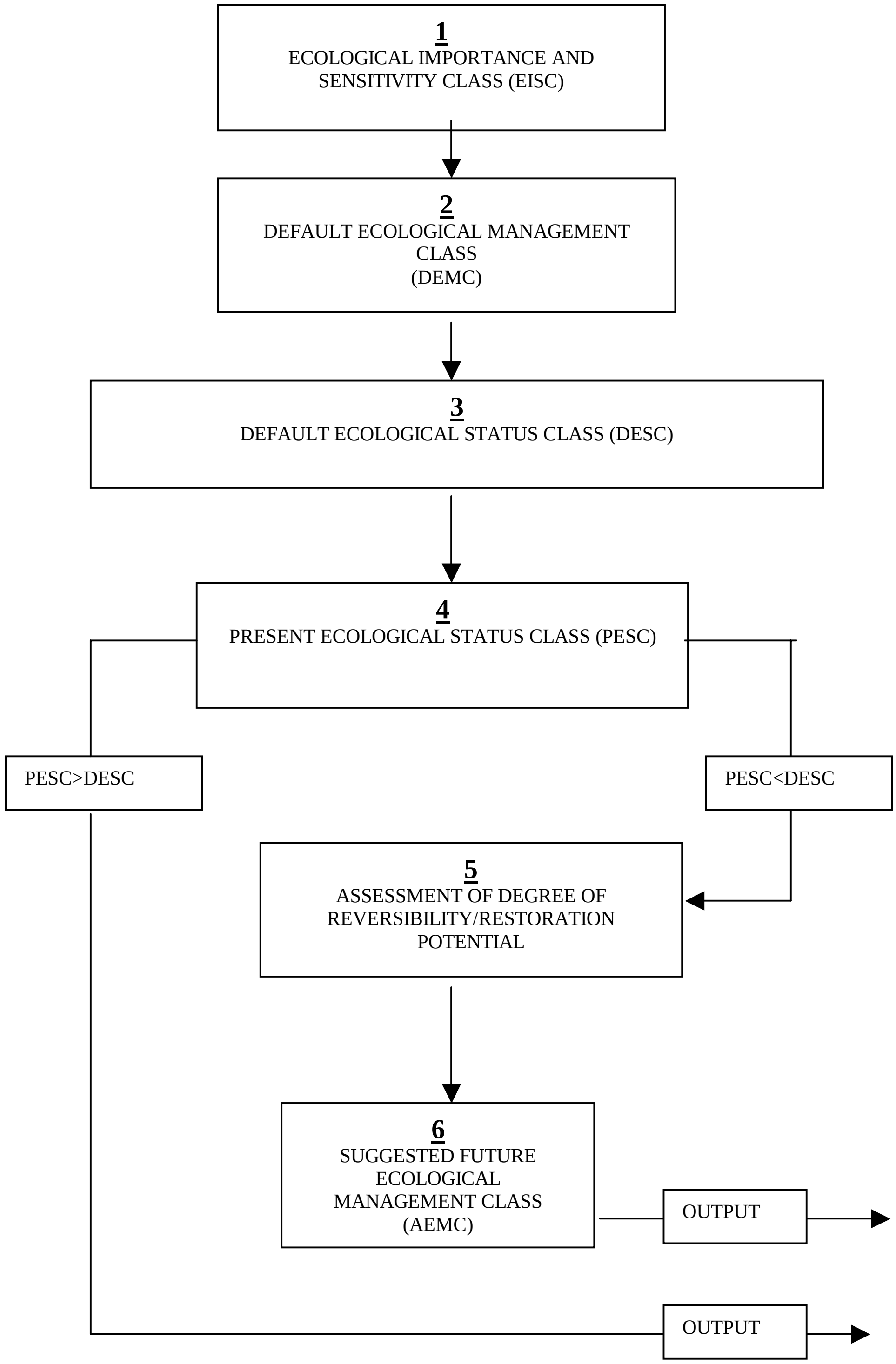


Diagram 2.6.2.1: Procedure followed to determine the river classifications

EISC

Very high → No human induced hazards

High → Small risk allowed

Moderate → Moderate risk allowed

Low/marginal → Large risk allowed

DEMC and DESC

→Class A: Unmodified natural

→Class B: Largely natural

→Class C: Moderately modified

→Class D: Largely modified

PESC

Class A: Unmodified natural

Class B: Largely natural

Class C: Moderately modified

Class D: Largely modified

Class E: Seriously modified

Class F: Critically modified

PESC: SUGGESTED ATTAINABLE IMPROVEMENT

Acceptable range of AEMC:

Class A: Unmodified natural

Class B: Largely natural

Class C: Moderately modified

Class D: Largely modified

Class E: Seriously modified

Class F: Critically modified

→: indicates relationship.

——▶: indicates possible direction of desirable change.

Diagram 2.6.2.2: Descriptions of EISC, DEMC DESC, PESC and AEMC

The procedure that was adopted to classify the rivers was qualified in the following respects:

- Only lotic systems (i.e. streams and rivers and associated habitats such as lotic wetlands) can be classified and the procedure is not meant to be applied to lakes, pans, impoundments or estuaries. Although several of the components considered in this assessment may be generally applicable, the application of the procedure to systems other than rivers and streams was not attempted.

- Where a quaternary catchment contained an estuary, this procedure was only applied to the riverine part of the catchment.

- Only the mainstem river in a quaternary catchment was considered in the assessment and therefore the management class must not be applied to any tributary streams in the quaternary catchment. These tributaries and their associated water requirements do however, become relevant when a water resources situation assessment is conducted at a sub-quaternary level.

- In cases where a dam wall was present at or relatively close to the outlet of a quaternary catchment, the assessments for that quaternary catchment were based on the river upstream of the dam (i.e. upstream of the backwater effect of the dam).

- In cases where degradation has occurred along certain sections of the mainstem of a quaternary catchment, but where there are still substantial less disturbed sections, the classification was based on those less disturbed areas. The intention of this was to ensure that the ecological component of the Reserve would provide for these less disturbed sections as if they were situated at the outlet of the quaternary catchment, where the ecological component of the Reserve will be estimated for the water resources situation assessments.

- The classifications were fundamentally considered from an instream and riparian zone perspective. Although the catchment in itself plays a major role in the condition and functioning of the rivers and streams in the catchment, the purpose of this procedure was not to provide an overall assessment of the condition of each catchment.

- The riparian zone has broadly been regarded as that part of the river bordering on the river channel. Usually characteristic plant species and/or vegetation structure provided an indication of the extent of the riparian zone.

The specific aspects that were considered when classifying the rivers are described below.

Ecological Importance and Sensitivity Class (EISC)
The following ecological aspects were considered for the estimation of the ecological importance and sensitivity class :

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, species intolerant to changes in flow regime or water quality and also species diversity were taken into account for both the instream and riparian components of the river.

- Habitat diversity was also considered. This included specific habitats and river reaches with a high diversity of habitat types such as pools, riffles, runs, rapids, waterfalls and riparian forests.

- The importance of the particular river or stretch of river in providing connectivity between different sections of the river, i.e. whether it provides a migration route or corridor for species.

- The presence of conservation or relatively natural areas along the river section serving as an indication of ecological importance and sensitivity.

- The ecological sensitivity (or fragility) of the system to environmental changes. Both the biotic and abiotic components were included.

The ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and broader scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its resilience or capability to recover from a disturbance that has occurred.

The present ecological status was not considered when determining the ecological importance and sensitivity *per se*. The ecological importance and sensitivity that has been established for the water resources situation assessments is a general and unrefined estimate. It is strongly biased towards the potential importance and sensitivity of the mainstem river of the quaternary catchment under close to unimpaired conditions.

Present Ecological Status Class (PESC)

Habitat integrity i.e. ecological integrity, condition and change from the natural condition, was regarded as a broad preliminary indicator of present ecological status for the purpose of the water resources situation assessments.

The above attributes that were used to estimate the present ecological status were each scored, from which the mean was calculated. This mean was used to assign a present ecological status class to the mainstem river in the vicinity of the outlet of the quaternary catchment.

Suggested Future Ecological Management Class (AEMC)

The potential to improve the ecological conditions was assessed only in terms of the present flow regime. Degradation of the system purely because of non-flow related changes was ignored.

The practicality of improving an existing modified ecological system to arrive at the suggested future ecological management class was assessed on the basis of the changes that have occurred, by comparing the difference between the present ecological status class and the default ecological status. For the purpose of these water resources situation assessments restoration was accepted to be the "…re-establishment of the structure and function of an ecosystem, including its natural diversity". Generally, structure is the native or natural species diversity of the ecosystem, while function is its productivity in terms of growth of plant biomass as the basis for food webs and the functions of hydrology, trophic structure and transport. Restoration is to reverse the decline of the health of a degraded ecosystem towards its historic structure. In contrast, reclamation and rehabilitation are usually more local and site-specific, while habitat creation refers to the establishment of new habitat, without regard to historical conditions.

The water resources situation assessment is, *inter alia*, concerned with the quantity of water, and therefore particular emphasis was placed on flow modification. Where the impact on the biota and the habitats of the estimated present flow modification was less than can be inferred from the present ecological status, this was taken into account and specifically highlighted (emphasised or flagged). It is obvious that such a state of affairs needs more specific attention. This situation arose only in a limited number of cases and has been indicated in the assessment of both the present ecological status class and the suggested future ecological management class, but needs more specific attention in future.

2.6.3 Aquatic Ecosystems of Concern to the Study

It is important to recognise that within the context of the current report sensitive ecosystems refer specifically to ecosystems which are sensitive with respect to possible changes in water quantity and quality. Other sensitive ecosystems, specifically protected areas, are discussed in Section 2.6.4 below and shown on Figure 2.6.3.2.

The Mzimvubu to Keiskamma WMA derives its name from the Mzimvubu and Keiskamma Rivers, both of which occur within the WMA. Other major rivers within this WMA include the Mbashe, the Great Kei and its tributaries, the Buffalo and the Mtata.

The ecological significance/conservation importance of the river systems falling within the Mzimvubu to Keiskamma WMA, as exemplified by their Ecological Importance and

Sensitivity Classes (EISC), is summarised in terms of associated ecological management or status classes in Figures 2.6.3.1 to 2.6.3.3. These show, respectively for each quaternary catchment, the default ecological management class, the present ecological status class, and the suggested future ecological management class. As outlined in Section 2.6.2, the EISC of a river is an expression of its importance to the maintenance of ecological diversity and functioning on a local and wider scale, as well as the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The EISC leads to the DEMC shown on Figure 2.6.3.1. As evident from Figure 2.6.3.1, the river reaches within the Mzimvubu to Keiskamma WMA exhibit the full range of EISCs from "low" to "very high" and associated DEMCs ranging from Class A : unmodified natural, to Class D : largely modified. Reaches of the Black Kei (*e.g.* S31A-F, S32A-M) and White Kei Rivers (*e.g.* S10A-J), typically exhibit "moderate" to "low" EISCs, corresponding to DEMCs of Class C : moderately modified, and Class D: largely modified. These are indicative of their manipulated/degraded condition. In contrast, the reaches of the Keiskamma River (R10A-M) exhibit a "high" to "very high" EISC, corresponding to DEMCs of Class B : largely natural, and Class A : unmodified natural, and should be protected from irresponsible and unregulated development. The Mzimvubu River and its tributaries exhibit the entire gambit of anthropogenic manipulations. Accordingly, the upper reaches of the Mzimvubu and its tributaries (T33A-F) exhibit DEMCs of Class B : largely natural, whilst their middle to lower reaches (*e.g.* T33G, T33H, T33J, T33k, T36A, T36B) exhibit DEMCs of Class C : moderately modified.

This overview of the ecological significance and conservation importance of the river systems within the Mzimvubu to Keiskamma WMA is of necessity superficial. However, the assessment of the EISC and Default Ecological Management Classes for the various quaternary catchments (outlined in Section 2.6.2) involved the consideration of a range of ecological determinants, including: rare and endangered biota, unique biota, intolerant biota, species richness, diversity of habitats types or features, refuge value of habitat types, sensitivity to flow changes, sensitivity to water quality changes, migration route/ corridor for instream and riparian biota and presence of conservation or natural areas. This information is summarised within DWAF's EcoInfo database (DWAF, 1999a), and accordingly this database should be consulted as a matter of course at the onset of any water utilisation and development project, to provide insight into the ecological sensitivity of the environment which is likely to be impacted by the proposed project, particularly with respect to sensitive habitats and rare and endangered species.

The ecological sensitivity of aquatic systems other than rivers, including lakes, wetlands and groundwater systems, has to date not been assessed within the Mzimvubu to Keiskamma WMA. Similarly, the estuarine systems are generally not well studied, but could be ecologically important and sensitive to reduced flows and changes in water quality, especially salinity. Accordingly, it is imperative that if any significant future development of the water resources in the Mzimvubu to Keiskamma WMA is considered, a comprehensive study of these other aquatic systems is undertaken to ascertain the environmental acceptability of the development.

2.6.4 Natural Heritage Sites, Proclaimed Game and Nature Reserves and Wilderness Areas

As previously alluded to, the sensitive ecosystems outlined above only include those relevant to aquatic ecosystems. However, in addition to these ecosystems the Mzimvubu to Keiskamma WMA contains other protected areas which may be impacted directly or indirectly upon by development activities associated with water resources. These protected areas include Natural Heritage Sites as well as those areas listed in

Section 2.6.1, *viz.* Scientific and Wilderness Areas, National Parks and Equivalent Reserves, Natural Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas and Protected Land/Seascapes.

Table 2.6.1 contains a list of the protected areas within the Mzimvubu to Keiskamma WMA. All water resource development and utilisation should take cognisance of these sites and it is the developer's responsible to identify the exact proximity of activities to any of these sites, and to ensure that activities do not threaten the integrity of these sites. This consideration is particularly pertinent where water resource development activities impact on the supply of water resources to these areas and hence their long-term ecological sustainability.

The aforementioned list of protected areas should be regarded as dynamic, since other protected areas are likely to be identified within this WMA in the future. Accordingly, it is the developer's responsibility to ensure he is familiar with the most recent status of protected areas within the Mzimvubu to Keiskamma WMA.

TABLE 2.6.1: PROTECTED NATURAL AREAS AND NATURAL HERITAGE SITES WITHIN THE MZIMVUBU TO KEISKAMMA WMA

AREA NAME	CATEGORY	GRID REFERENCE
Altydgedacht	South African Natural Heritage Sites	30º 55'S 30º 18'E
Amalinda Nature Reserve	Habitat and Wildlife Management Areas	32º 59'S 27º 51'E
Amasundu Pheszulu	South African Natural Heritage Sites	30º 55'S 30º 18'E
Bellevue Lodge	South African Natural Heritage Sites	30º 55'S 30º 18'E
Benghoil and Bushy Park	South African Natural Heritage Sites	32º 19'S 27º 02'E
Blackwoods	South African Natural Heritage Sites	31º 09'S 28º 10'E
Bruce=s Valley	South African Natural Heritage Sites	30º 38'S 29º 23'E
Carnarvon Estates	South African Natural Heritage Sites	31º 36'S 26º 43'E
Dacu State Forest	Habitat and Wildlife Management Areas	32º 24'S 27º 33'E
Driebos	Habitat and Wildlife Management Areas	32º 23'S 27º 27'E
East London Coast Nature Reserve	Habitat and Wildlife Management Areas	33º 00'S 27º 55'E
Enon Forest	South African Natural Heritage Sites	30º 11'S 29º 47'E
Estoril	South African Natural Heritage Sites	30º 55'S 30º 18'E
Fearnly	South African Natural Heritage Sites	30º 08'S 29º 14'E
Fort Pato Nature Reserve	Habitat and Wildlife Management Areas	33º 00'S 27º 40'E
Frederika Nature Reserve	South African Natural Heritage Sites	30º 55'S 30º 19'E
Hlatini	South African Natural Heritage Sites	30º 55'S 30º 18'E
Hogsback	South African Natural Heritage Sites	32º 35'S 27º 01'E
iGxalingenwa Nature Reserve	Habitat and Wildlife Management Areas	30º 00'S 29º 39'E
Isidenge State Forest	Habitat and Wildlife Management Areas	32º 38'S 27º 15'E
Kubusi State Forest	Habitat and Wildlife Management Areas	32º 33'S 27º 18'E
Malekgonyane Wildlife Reserve	Habitat and Wildlife Management Areas	30º 28'S 28º 15'E
Mhoge	South African Natural Heritage Sites	32º 08'S 26º 59'E
Minnehaha Vulture Colony	South African Natural Heritage Sites	30º 39'S 30º 15'E
Mkambati Wildlife and marine Reserve	Habitat and Wildlife Management Areas	31º 15'S 30º 00'E
Mt. Currie Nature Reserve	Habitat and Wildlife Management Areas	30º 31'S 29º 25'E
Ngele Nature Reserve	Habitat and Wildlife Management Areas	30º 39'S 29º 37'E
Ngoningoni Forest	Habitat and Wildlife Management Areas	29º 55'S 29º 50'E
Ngwangwane Forest	Habitat and Wildlife Management Areas	30º 03'S 29º 42'E
Nthabathemba Tribal Reserve	Habitat and Wildlife Management Areas	32º 06'S 26º 30'E
Ocean View Guest Farm	South African Natural Heritage Sites	32º 38'S 28º 06'E
Patchwood	Habitat and Wildlife Management Areas	32º 25'S 27º 27'E
Phinda Resource Reserve	South African Natural Heritage Sites	32º 20'S 27º 50'E
Prentjiesberg Nature Reserve	South African Natural Heritage Sites	31º 08'S 28º 10'E
Qacu Nature Reserve	Habitat and Wildlife Management Areas	32º 37'S 27º 17'E

AREA NAME	CATEGORY	GRID REFERENCE
Roelton Blue Swallow Site	South African Natural Heritage Sites	30º 07'S 29º 59'E
Rush Valley Pan	South African Natural Heritage Sites	30º 50'S 28º 12'E
Umziki Pan	South African Natural Heritage Sites	32º 19'S 28º 01'E

2.7 CULTURAL AND HISTORICAL SITES

The purpose of this section is to highlight the need to take cognisance of any cultural or historical sites which may be present within the Mzimvubu to Keiskamma WMA and accordingly could influence the further development and utilisation of water resources. Cultural and historical sites can be broadly defined as natural or manmade areas that are associated with human activity and history, and which carry social, cultural, religious, spiritual or historic significance. Furthermore, sites of palaeontological significance contain fossilised human or animal remains. The National Heritage Resources Act (No. 25 of 1999) provides automatic protection for palaeontological, archaeological and historical sites and materials older than 60 years, and a permit is required before any alterations can be made to such artefacts.

No general listing of the sites of palaeontological, archaeological and historical significance within the Mzimvubu to Keiskamma WMA is available. The South African Heritage Resources Agency (formerly the National Monuments Council) does possess a database of National Monuments within each province, but this is only of limited use since it only lists National Monuments (as declared within the Government Gazette), and the vast majority of these occur within urban areas which are unlikely to be impacted upon by water utilisation and development projects. Accordingly, it is the responsibility of the developer to liaise with the South African Heritage Resources Agency and South African Museum to establish whether they are aware of any sites of cultural/ historical/ archaeological interest within any area earmarked for development. Moreover, it is the developer's responsibility to ensure that the development area is surveyed for archaeological sites or artefacts, and that necessary steps are taken to conserve them if they are present. To this end, the developer should be familiar with the relevant sections of the National Heritage Resources Act and any other relevant legislation (*e.g.* National Parks Act (No. 57 of 1975)), and should consult with the South African Heritage Resources Agency on discovering sites or artefacts of palaeontological, archaeological or historical significance.

CHAPTER 3: DEVELOPMENT STATUS

3.1 HISTORICAL DEVELOPMENT OF WATER RELATED INFRASTRUCTURE

The early development of water related infrastructure in the Mzimvubu to Keiskamma WMA was in the form of small water supply schemes implemented by local authorities for town water supplies which relied mainly on run-of-river flow or boreholes. It was only in the late 1950s that the State began to construct dams to supply water for irrigation.

As the populations of the towns grew, it became necessary to improve the reliability of the early run-of-river water supply schemes by constructing dams. The oldest registered dam in the WMA is Amalinda Dam which, with a capacity of 0,45 million m^3, was constructed by East London Municipality in 1883 for the water supply to the town. The construction of Bongola Dam for the Municipality of Queenstown was completed in 1908, and the Borough of King William's Town commissioned the construction of Maden Dam, which was completed in 1909.

The continuing growth of East London and King William's Town necessitated the construction of the small off-channel Umzoniana Dam by East London Municipality in 1922, and the much larger Laing Dam in 1949. This was followed by the completion of Rooikrantz Dam by DWAF in 1951 for the water supply of King William's Town and surrounding rural areas.

The development of the water resources of the East London/King William's Town area continued with the construction of Nahoon Dam in 1966 to supply water to a large textile factory, the construction of Bridle Drift Dam by East London Municipality in 1969, and the construction of Wriggelswade Dam by DWAF in 1991.

The first major dam constructed to supply water for irrigation as well as urban use was Waterdown Dam which was completed by DWAF in 1957. It also provides water for the towns of Queenstown, Sada and Whittlesea. Since then, some 20 dams designed primarily to provide water for irrigation schemes have been constructed either by DWAF or by the former Government of Ciskei or the former Government of Transkei. Many of the irrigation schemes were not successful and the infrastructure has fallen into disrepair. DWAF is currently investigating the financial viability of rejuvenating these schemes.

With the steady increase in population that occurred in the tribal areas, the traditional sources of water (springs and streams) of the villages in these areas became inadequate and a number of regional rural water supply schemes relying on dams and extensive distribution pipelines were constructed in the 1970s and 1980s and are continuing to be constructed today. In addition, numerous standpipe water supply schemes supplied from boreholes equipped with pumps driven by windmills were constructed for individual villages. The maintenance of these schemes proved to be difficult and many of them fell into disrepair. However, since the former Republics of Ciskei and Transkei were re-incorporated into South Africa, an intensive programme to re-furbish these schemes and implement new schemes has been underway with the objective of providing safe and adequate water supplies to the whole population of the WMA.

3.2 DEMOGRAPHY

3.2.1 Introduction

A national study (Schlemmer *et al*, 2001) to develop water use projections to the year 2025 was undertaken for the Department of Water Affairs and Forestry by a team of specialists, in order to support the development of the National Water Resource Strategy. This included the development of baseline 1995 population estimates. The work commenced well before the results of the 1996 census became available, and a number of sources were used to develop the baseline data set. The database developed was subsequently reconciled with the results of the census in areas where the census had provided superior information.

The study focused on so-called functional urban centres having or likely to have reticulated water supply systems in the future. In a number of instances areas on the fringe of urban centres and classified as rural in the 1996 census were incorporated with the functional urban centres defined in the study, and urban populations identified in this study therefore differed from the urban populations enumerated in the census. The regional weighting of census counts to compensate for undercounts was also identified as a factor distorting some urban populations in smaller centres reported in the census.

3.2.2 Methodology

Functional urban areas were identified within magisterial districts. Estimates were made of the 1995 population in these centres, while the populations outside of these urban areas were grouped together as a so-called rural remainder. The urban populations were further categorised in order to provide a basis for developing estimates of urban water use for the entire country (see Section 5.3).

A number of sources and approaches were used to obtain baseline population data for the year 1995. These included projections and estimates made by the following institutions:

- The Development Bank of Southern Africa.
- The Demographic Information Bureau.
- The Bureau for Market Research.
- Local authority estimates, where available.

The data from the above sources were compared with extrapolations and estimates based on the following:

- Household counts from the sampling database held by one of the participating consultants.
- Previous census results from 1970 onwards, including former homeland censuses.
- Estimates obtained from very large surveys such as that of the SAARF.
- The database of villages of the Directorate: Water Services of the Department of Water Affairs and Forestry.

Discrepancies were reconciled on the basis of local knowledge and special enquiries directed at local authorities. The results of the 1996 census became available after this had been completed, and was used as an additional check on the database. Where discrepancies were significant these were investigated, and the database was revised where the 1996 census provided improved information.

As an overall check the population distribution database for 1995 that was developed as part of this study was projected for one year on the basis of a ruling population growth rate of 1,9%. An effective population of 42 379 000 persons in 1996 was arrived at in this way, which is only 1% above the 1996 census population of 41 945 000 persons.

A reasonable estimate of the distribution of the rural population was made, using the census results for the rural population as a guideline, to develop a spatially distributed database.

3.2.3 Historical Population Growth Rate

Accurate historical population data for the WMA as a whole is not readily available. The reason for this is that the main sources of data are the national population censuses for which published data are available in terms of magisterial districts. As the boundaries of the latter do not coincide with the boundaries of the WMA, the population of the WMA can only be roughly estimated. Nevertheless, this information can be used to obtain an indication of trends in population growth.

It appears from data extracted from population censuses and published by the Development Bank of Southern Africa (DBSA, 1991), that the average growth rate of the population in the area between 1980 and 1990 was about 2,0% per annum. There were, however, significant differences in growth rates within the WMA : in Transkei it was 2,4% per annum, reducing to 1,8% per annum in Ciskei, and 1,75% per annum in the remainder of the WMA. In general, both urban and rural populations increased. The exceptions were the Elliot, Molteno and Wodehouse magisterial districts (see Figure 3.4.9.1) where both urban and rural populations decreased and the Indwe, Cathcart, Queenstown, Komga and Butterworth magisterial districts where the rural populations decreased by between 1% and 2% per annum.

3.2.4 Population Size and Distribution in 1995

In 1995, approximately 4 520 000 people lived in the WMA. About 1 170 000 (26%) of these lived in urban or peri-urban areas, and the remaining 74% in rural areas. The distribution of the population is shown in Table 3.2.4.1 and on Figure 3.2.4.1. About 60% of the population lives in the catchments of Drainage Region T, 18% in the Great Kei Basin (Drainage Region S) and 22% in the Amatole Catchments (Drainage Region R). Approximately 580 000 people, or 50% of the urban population lives in the East London/King William's Town urban complex (now called Buffalo City).

The north-western corner of the WMA falls within KwaZulu Natal. As a result, approximately 69 200 people, or 1,5% of the population lives in KwaZulu Natal.

3.3 MACRO-ECONOMICS

3.3.1 Introduction

The purpose of this section is to provide an economic overview of the salient features of the Mzimvubu to Keiskamma Water Management Area (WMA) in terms of the following aspects:

TABLE 3.2.4.1: POPULATION IN 1995

CATCHMENT					POPULATION IN 1995		
PRIMARY		SECONDARY		TERTIARY/QUATERNARY	URBAN	RURAL	TOTAL
No.	Description	No.	Description	No.			
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	0	31 100	31 100
		R1	Keiskamma (all E Cape)	R10A to R10M	17 650	147 078	164 728
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	0	32 799	32 795
		R2	Buffalo (all E Cape)	R20A to R20G	578 200	114 747	692 947
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	10 150	42 379	52 529
		TOTAL IN AMATOLE REGION (all E Cape)			606 000	368 099	974 099
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	0	143 888	143 838
		S2	Indwe (all E Cape)	S20A to S20D	12 200	65 073	77 273
		S3	Klaas Smits (all E Cape)	S31A to S31G	56 050	10 160	66 210
			Black Kei (all E Cape)	S32A to S32M	58 100	74 681	132 781
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			126 350	293 802	420 152
		S4	Thomas (all E Cape)	S40A to S40F	8 000	27 212	35 212
		S5	Tsomo (all E Cape)	S50A to S50J	18 750	156 814	175 564
		S6	Kubusi (all E Cape)	S60A to S60E	26 700	18 060	44 760
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	6 300	149 606	155 906
		TOTAL IN GREAT KEI BASIN (all E Cape)			**186 100**	**645 494**	**831 594**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	16 700	329 694	346 394
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	193 700	514 020	975 530
		T3	Upper Mzimvubu in Kwa-Zulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	1 550 23 250	34 400 140 383	35 950 163 633
			Mzintlava in Kwa-Zulu-Natal Mzintlava in E Cape	T32A to T32H	19 550 14 450	10 400 136 456	29 950 150 706
			Kinira in Kwa-Zulu-Natal Kinira in E Cape	T33A to T33G	4 000 5 250	9 300 189 150	13 300 194 400
			Tina((all E Cape)	T34A to T34K	12 050	148 078	160 128
			Tsitsa (all E Cape)	T35A to T35M	13 350	190 597	203 947
			Lower Mzimvubu (all E Cape)	T36A to T36B	12 050	47 940	59 990
		Total in Mzimvubu in KwaZulu-Natal			25 100	54 100	79 200
		Total in Mzimvubu in E Cape			340 650	1 914 078	2 254 728
		Total Mzimvubu			365 750	1 968 178	2 333 928
		T6	Pondoland Coastal Catchments	T60A to T60K	14 300	366 930	381 230
		T9	Southern Wild Coast	T90A to T90G	50 050	217 760	
		Total in Transkei Region in KwaZulu-Natal			25 100	54 100	79 200
		Total in Transkei Region in E Cape			354 950	2 281 008	2 635 958
		TOTAL IN TRANSKEI REGION			**380 050**	**2 335 108**	**2 715 158**
TOTAL IN WMA IN KWAZULU-NATAL					25 100	54 100	79 200
TOTAL IN WMA IN E CAPE					1 147 050	3 294 602	4 441 652
TOTAL IN WMA					**1 172 150**	**3 348 702**	**4 520 852**

- The present economic development of the Mzimvubu to Keiskamma WMA on a sectoral basis, taking into account the context of economic development in South Africa.
- The comparative advantages of the Mzimvubu to Keiskamma WMA.

Selected graphs are included to illustrate the text and additional supporting information is given in Appendix B.1.

3.3.2 Data Sources

The information presented has been derived from a database of macroeconomic indicators that was prepared by Urban-Econ: Development Economists from a number of sources, including the Development Bank of Southern Africa. Appendix B.2 contextualises each WMA economy in terms of its significance to the national economy, as derived from the national economic database. Only gross geographic product (GGP) and labour data are analysed. A brief description of the database of macro-economic indicators and associated economic information system is given in Appendix B4.

Gross geographic product is the total value of all final goods and services produced within the economy in a geographic area for a given period. GGP is the most commonly used measure of total domestic activity in an area and is also the basis for the national account. Changes in the local economy can therefore be expressed as an increase in GGP. Base GGP data for 1972, 1975, 1978, 1981, 1984, 1988, 1991, 1993 and 1994 were obtained from Statistics South Africa. Data for unknown years between 1972 and 1994 were interpolated applying a compound growth formula. The interpolated data was balanced with national account figures. Data for 1995 to 1997 is based on weighted least squares estimates of the long-term trend, taking into account the change in electricity consumed. The projected data was balanced with national account figures. The major limitation of GGP figures is that activities in the informal sector are largely unmeasured.

The **labour** distribution provides information on the sectoral distribution of formal economic activities, as do the GGP figures, but in addition, information is provided on the extent of informal activities, as well as dependency. Dependency may be assessed from unemployment figures, as well as by determining the proportion of the total population that is economically active. *Total economically active* population consists of those employed in the formal and informal sectors, and the unemployed. *Formally employed* includes employers, employees and self-employed who are registered taxpayers. *Unemployment figures* include people who are actively looking for work, but are not in any type of paid employment, either formal or informal. *Active in informal sector* includes people who are employers, employees or self-employed in unregistered economic activities, i.e. businesses not registered as such. The labour data was obtained directly from the Development Bank of Southern Africa (DBSA). The DBSA has utilised the 1980 and 1991 population censuses as the basis but has also updated the figures utilising the 1995 October Household Surveys of Statistics South Africa (Central Statistical Services statistical release P0317 for South Africa as a whole and P0317.1 to P0317.9 for the nine provinces).

The GGP and labour statistics are disaggregated into the following major economic sectors:

- Agriculture
- Mining
- Manufacturing

- Electricity
- Construction
- Trade
- Transportation
- Finance
- Government and Social Services (Community Services).

Separate GDP figures for government and social services are available. However, in the labour market these figures are combined into the community services sector. The nature and composition of each sector are described in Appendix B.3.

3.3.3 Methodology

Each sector of the economy was dealt with in an appropriate way to reflect a reasonable approximation of the spatial distribution of production and labour:

Agriculture
The digitised geographic layer of WMAs was merged with the Magisterial District (MD) boundaries, and the surface area for each of the newly generated polygons was determined. The proportion of the surface area of each of the MD, which falls within each WMA, was calculated, and that proportion was used to allocate the part of a GGP figure that falls on each side of a WMA-boundary.

Trade and Community Services
To take account of the subdivision of local authority areas by MD or WMA boundaries, the number of enumerator areas (EAs) falling within each subdivision of a local authority area, as a proportion of the total number of EAs in a local authority area, was determined. This proportion was applied to the latest population figure (1996 census) of each local authority area. As EAs are of approximately equal population size, these proportions were used to calculate the approximate population for that part of a local authority area which falls within each MD, as they are subdivided by WMA boundaries. The population of each MD segment, as a proportion of the total MD population, was used to calculate the proportion of a GGP figure which should be allocated to each segment of a MD, so that theses figures could be totalled up within the WMA boundaries.

Other Sectors
Historical factors such as the relocation of certain segments of the population to non-productive areas, and the immigration of mainly Mozambicans, especially to Mpumalanga and the Northern Province, had to be taken into account when allocating the GGP figure to the WMAs. Subsequently, for all the sectors apart from those discussed above, only the Caucasian population was used to perform the calculations as described above. Economic activities in these sectors are less dependent on population *per se*, but are dependent on the same factors which affect the kind of population distribution that is not distorted by government intervention or other external factors. The Caucasian population has typically not been influenced by the latter factors, and its distribution is therefore a better guide for determining the distribution of economic activities in these sectors.

3.3.4 Status of Economic Development

The GGP of the Mzimvubu to Keiskamma WMA was R62bn in 1997. The most important magisterial districts in terms of contribution to GGP in this WMA are shown below:

- East London 35,4%
- Mdantsane 8,9%
- Zwelitsha 6,2%
- King William's Town 5,4%
- Queenstown 5,0%
- Other 39,1%

Economic Profile

The composition of the Mzimvubu to Keiskamma WMA economy is shown in Diagram 3.3.4.1. The most important sectors in terms of contribution to GGP are shown below:

- Government 30,8%
- Manufacturing 20,4%
- Trade 14,7%
- Finance 11,4%
- Other 22,7%

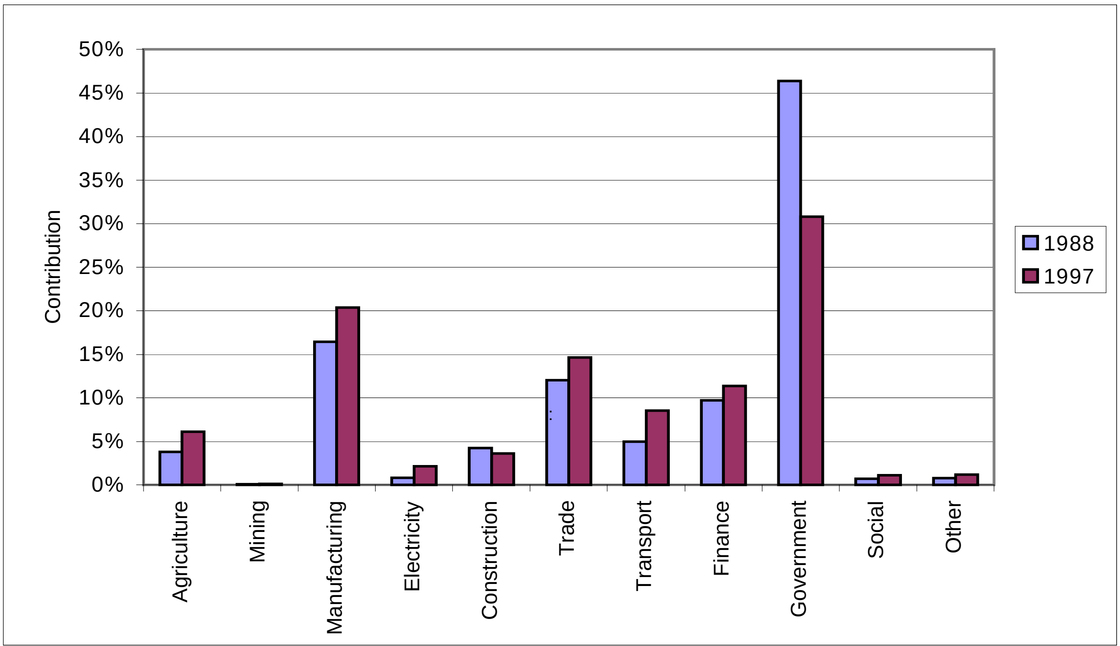


Diagram 3.3.4.1: Contribution by sector to economy of Mzimvubu to Keiskamma Water Management Area, 1988 and 1997 (%)

The manufacturing sector is dominated by the textile and clothing industry. In East London, Da Gama Textiles, which manufactures polyester-cotton fabrics, is one of the largest of its kind in the country. The second largest industry is the automotive industry, which consists, amongst others of Mercedes Benz and First National Batteries on East London's West Bank and August Laepple body panel manufacturers in Berlin. Mercedes Benz South Africa (MBSA) is Africa's largest truck horse manufacturer and is also the third largest Mercedes Benz manufacturing plant outside Germany. The food industry is also large and the country's largest pineapple processing plants are operating in the East London area.

Trade is an important element of the activities around the East London harbour. Agricultural produce of the region is stored and exported via the harbour. Tourism is also active along the coast at places like Port St Johns and Coffee Bay along the Wild Coast, and in places like Hogsback in the Amatola mountains.

The government sector contributes a large share of the GGP. One of the factors contributing to the importance of this sector is the presence of government services in the capital of the former Transkei, namely Umtata, and the capital of the former Ciskei, Bisho, which now houses the provincial legislature. It can be expected that some of these activities will decline as East London plays an increasingly important role in accommodating the Eastern Cape provincial government offices.

Sheep and cattle farming provide a living for the rural subsistence farmers in the former Transkei and Ciskei. Citrus is grown under irrigation in the Keiskamma River basin. Commercial forestry is extensive in the upper parts of the Buffalo, Kei, Mbashe, Mtata and Mzimvubu catchments. Near East London are areas which are considered some of the best pineapple-growing areas in the world. This area is also one of the few places in the country where chicory is grown. There is also potential for growing sugar beet.

Economic Growth

The average annual economic growth by sector is shown in Diagram 3.3.4.2. Between 1987 and 1997, the only sector with a positive average growth rate was the utilities (electricity, gas, water) sector, with a growth rate of 2,7%. All other sectors recorded negative growth rates.

Growth in the electricity sector only and most in activities such as construction and manufacturing suggest that expansion in the electricity sector was not driven by production demand, but rather by increased electricity consumption related to new electrification projects, such as in previously disenfranchised areas.

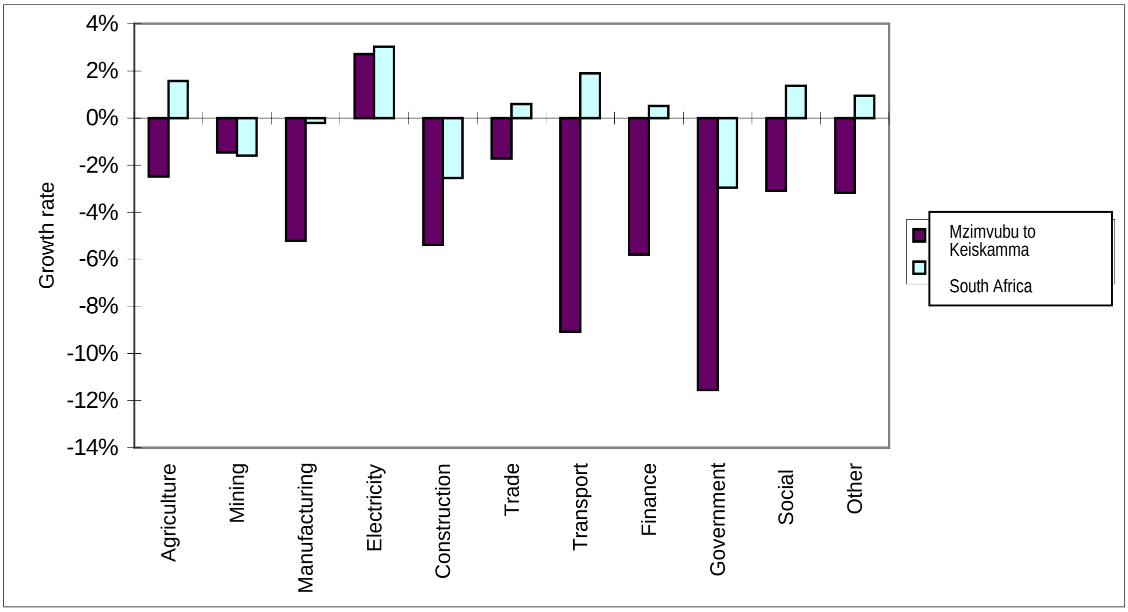


Diagram 3.3.4.2 : Average annual economic growth by sector of Mzimvubu to Keiskamma Water Management Area and South Africa, 1988-1997

Labour

Of the total labour force of just over 1 million persons in 1994, 48.1% were unemployed, which is higher than the national average of 29,3%. Forty one percent (41,6%) are active in the formal economy. Forty percent (40,4%) of the formally employed labour force are active in the community services sector, i.e. government and social services, while 16,6%, are involved manufacturing and 16,3% in agriculture.

During the period 1980 – 1994 employment growth was recorded in the mining sector (although this growth is in the number of migrant labourers working in mines outside the area); financial services (0,8% per annum); the community services sector (2,3% per annum); and manufacturing (1,0% per annum).

3.3.5 Comparative Advantages

A comparative advantage of a particular region indicates that the economy poses a relatively more competitive production function for a specific product or service than other regions in the aggregate economy (e.g. South Africa). A comparative advantage may be measured by means of a location quotient, which compares the economic sector's share in gross geographic product (GGP) with its percentage share in some basic aggregate, such as gross national product (GNP). A value of more than one implies that the region has a comparative advantage in a specific production function *vis-à-vis* the rest of South Africa.

Diagram 3.3.5.1 shows the location quotients for the Mzimvubu to Keiskamma WMA. The Figure shows that, based on the location quotients for 1997, the Mzimvubu to Keiskamma WMA economy is relatively more competitive than the remainder of South Africa in the following economic activities:

- Agriculture : 1,3
- Construction : 1,2
- Transport : 1,1
- Government : 2,0

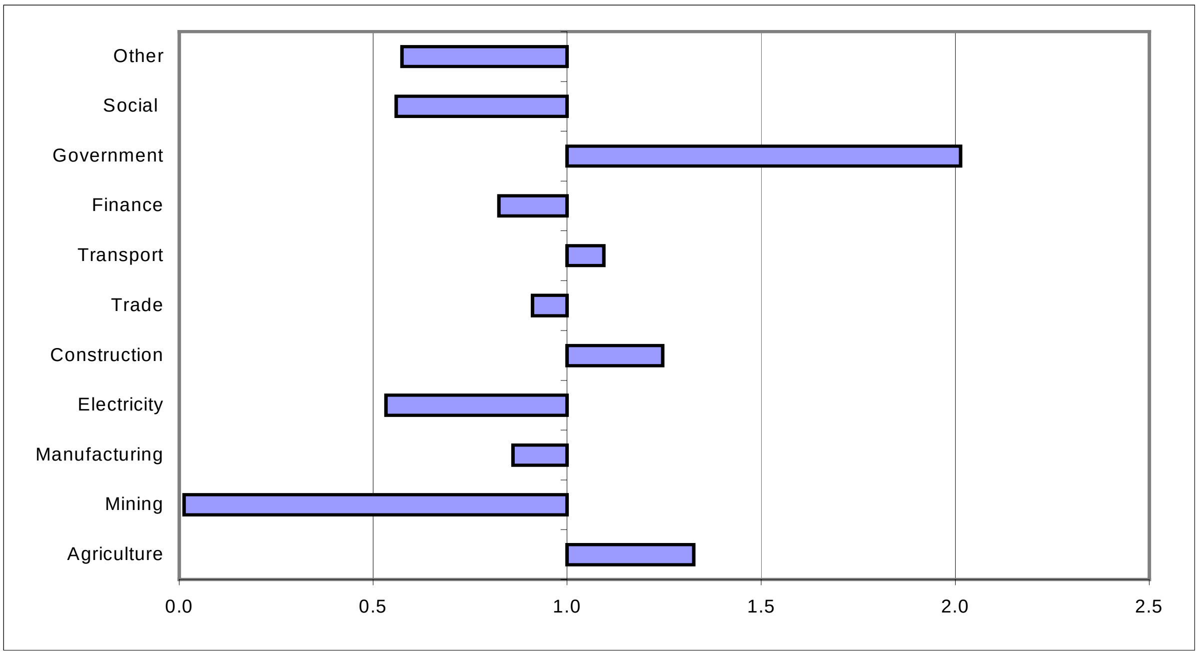


Diagram 3.3.5.1: Mzimvubu to Keiskamma gross geographic product location quotient by sector, 1997

The comparative advantage of the agricultural sector can be attributed to the variety of products produced in this area. Some of the agricultural activities include inland fish hatcheries, abalone, pineapples, chicory, wheat and forestry in the high-lying areas such as the Amatola mountains.

The comparative advantage identified in the construction industry could be ascribed to the numerous housing projects initiated in the area.

The transport sector also has a comparative advantage in national context. This could be ascribed to the transport activities and facilities in this WMA. The East London harbour and airport are major assets in this sector. The Mutate airport has capacity for all large passenger aircraft, except 747-size aircraft. East London also has the country's only river port.

One of the factors that contribute to the comparative advantage of the government sector is the presence of government services not only in the former Eastern Cape area, but also in the former homelands.

Although the transport and manufacturing sectors do not have a comparative advantage in National Context, the East London/Mdantsane development corridor might strengthen the comparative advantage of the transport sector and could possibly improve the manufacturing sector location quotient.

3.4 LEGAL ASPECTS AND INSTITUTIONAL ARRANGEMENTS FOR WATER SUPPLY

3.4.1 Past History

The history of settlement in southern Africa is linked to the availability and supply of fresh water. From early times South African water law was based on the needs of white settlers who in colonising the land promulgated a water law in which domestic and agriculture needs and later industrial needs played the major role (*res publica)* and the government had the function to regulate the use of water (*dominus fluminis*).

Initially Roman and Roman Dutch law had a strong influence in the shaping of South African water law and water running in rivers was regarded as common property. This changed in the latter half of the 19^{th} century, after the occupation of the Cape by the British. The judges trained by the British introduced the principle that owners of property riparian to a river became entitled to water from that river.

The first codification of water law in South Africa was in the Irrigation and Conservation of Waters Act of 1912. The emphasis was still on irrigation and carried down the riparian principle. This Act was repealed by the Water Act of 1956, which also placed a major emphasis on the use of water for irrigation, although other water uses, such as domestic, urban and industrial, also received recognition.

This remained the situation until the National Water Act (Act No. 36 of 1998) (NWA) was assented to by the President on 20 August 1998. As from 1 October 1999 the whole of the NWA came into full effect and is now the only Act dealing with water law.

3.4.2 National Water Act

The NWA does away with and introduces some far-reaching concepts. These concepts have both economic and social features. The former to address water management by conservation and pricing strategy and the latter by ensuring that past discriminatory principles are not continued in the NWA. The most important of these can be summarised as follows:

- The riparian principle is done away with. The nation's water resources become common property, belonging to the nation as a whole. Therefore the previous concept of private ownership in water is done away with;
- The national government, through the Minister of Water Affairs and Forestry, becomes responsible as the public trustee of all water resources to ensure that water resources are protected and water allocated equitably and used beneficially in the public interest. Therefore the NWA reflects the constitutional right of access to sufficient water (Section 27 of the Constitution);
- All right to use water derives from the NWA;
- Water must be available for the Reserve. The Reserve is a new concept and consists of two legs, namely the quantity and quality of water required to satisfy basic human needs as prescribed by the Water Services Act (Act No 108 of 1997) for people who now or will in future require water and to protect the aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource. Thus environmental considerations are anchored in the NWA;
- Setting out in the purposes of the Act that institutions which have appropriate community, racial and gender representation must be developed to give effect to the NWA;
- Shifts the emphasis from the traditional "supply management" approach towards "demand management", that is conservation of the nation's water resources by lessening the demand and providing for an innovative pricing system.
- Providing for extensive public participation. Virtually no decision can be made without public participation;
- The abolishment of the Water Courts and introducing a Water Tribunal where administrative final decisions can be appealed to; and
- Recognition of international obligations.

3.4.3 Strategies

The NWA makes provision for establishment of two water management strategies. These are the National Water Resource Strategy and the Catchment Management Strategy. The National Water Resource Strategy is binding on the Minister of the Department of Water Affairs and Forestry, other organs of State and all water management institutions for anything contained therein, while the catchment management strategy is binding on the relevant catchment management agency and is more on a local level.

Water resource management will in future be based on the management strategies and the classification system for the protection of water resources provided for in the NWA. The contents of the National Water Resource Strategy are wide and included therein are the principles relating to water conservation and water demand management; the objectives in respect of water quality to be achieved through the classification system, as well as having to establish the future water needs. The National Water Resource Strategy will also provide for international rights and obligations.

3.4.4 Environmental Protection

Chapter 3 of the NWA deals with protection of the water resources.

The Minister must classify the nation's water resources and then determine the class and resource quality objectives for each class. This will establish clear goals for resource protection and at the same time provide for a balance between the need to protect and sustain one's water resources and the need to develop and use them on the other hand.

An important function is for the Minister to determine the Reserve, which as stated above, is closely linked to the Water Services Act (Act No. 108 of 1997).

Section 19 of the NWA provides *inter alia* that any person who is in control of land over which pollution is taking place or who causes pollution or potential pollution to take place, must take the necessary steps to prevent this from continuing. Should this not be done, the Minister shall have the right to take the necessary steps to recover the cost from the responsible person.

3.4.5 Recognition of Entitlements

The NWA abolishes the historical distinction between public and private water. There is no ownership in water and all water is subject to a licensing system, except for the following:

- Water use that is set out under Schedule 1 of the NWA;
- General authorisations issued under Section 39 of the NWA; and
- Existing lawful use recognised under the NWA until such time as the person is required to apply for a licence.

The statutory difference between water resources within an area proclaimed as a government water control area in terms of the Water Act of 1956 and areas outside a government water control area has now been done away with. In actual fact the whole of the country is a government water control area.

3.4.6 Licensing

Whereas the Water Act of 1956 divided water into different categories, in the NWA all water has the same status. Section 21 of the NWA sets out what is regarded as water use. These include, amongst other uses, taking water from a water resource, storage of water, diverting water, discharging waste into a watercourse, disposing of waste in a manner that may detrimentally impact on a water resource and recreational use.

Two new concepts of water use are created. The first is that the Minister can declare any activity to be a stream flow reduction activity, if that activity reduces the availability of water. Afforestation has already been declared a stream flow reduction activity. The second new concept is that the Minister can declare any activity to be a controlled activity if that activity impacts on a water resource. Activities such as irrigation on any land with waste, recharging of an aquifer are examples of activities that are already controlled activities.

All water use requires a licence unless it falls into a Schedule 1 use (this deals with the *de minimus* use, such as water for reasonable domestic use, small gardening and animal watering (excluding feedlots); or was permissible as an existing lawful use (water use permitted under previous laws and which were exercised during the period of two years before the date that Section 32 came into effect; namely 1 October 1998); and under a general authorisation.

An important innovation is that a licence can only be for a maximum period of 40 years and is subject to a review period, which may not be at intervals of more than five years. A licence can be increased at each review period but not for more than the review period. This is known as the "revolving licence".

If a person who has an existing lawful use applies for a licence under Section 43 of the NWA (compulsory licensing), and the application has been refused or has been granted for a lesser amount which results in severe economic prejudice, the applicant may claim compensation. Compensation cannot be claimed if the reduction is to provide for the Reserve, rectify a previous over-allocation or a previous unfair allocation.

Compensation must be claimed from the Water Tribunal.

The Minister has the right to attach conditions to any licence as well as to make regulations on various topics set out in section 26 of the NWA.

It is important to note that although the Water Services Act (Act No. 108 of 1997) deals with water services, the actual water use is controlled under the NWA.

3.4.7 Other Legislation

The NWA is aligned with other laws in order to prevent, for example, duplication of applications, unnecessary expenses and where possible, a "one stop" can be issued. Specific examples are as follows :

- Environment assessments in terms of the Environmental Conservation Act of 1989 can be taken into account by the responsible authority when issuing a licence;
- If a licence is issued under other acts that meet the purpose of the NWA, the responsible authority can dispense with the issuing of a licence for water under the NWA; and
- Provisions in the Constitution of the Republic of South Africa must be complied with.

Further, there is a close connection between the Water Services Act (Act No. 108 of 1997) and the NWA.

The Abolition of Racially Based Land Measures Act repealed laws that previously restricted black persons from owning or occupying land. These acts had the effect of preventing black persons from having any water rights or under certain circumstances, limited water entitlements.

Notwithstanding the NWA there are other acts to which a water user and indeed the State must comply.

These Acts are the following :

Physical Planning Act (Act No. 125 of 1991)
Under this act no land use, development or subdivision may be permitted unless in accordance with an approved plan.

Development Facilitation Act (Act No. 67 of 1995)
This act prescribes the set of principles with which all development projects and all land use and land use planning should comply, and which will serve as guidelines for the administration of land use and development schemes.

Restitution of Land Rights (Act No. 22 of 1994)
This act is aimed at the restitution of land to those who have been deprived thereof in terms of discriminatory laws. Claims are lodged with the Land Claims Commission. It is because of this act that when a transfer of water entitlements is approved in terms of the NWA an indemnity is required from the transferor that a claim was not lodged against the land in terms of the Restitution of Land Rights Act.

Environmental Conservation Act (Act No. 73 of 1989)
This act provides for the effective protection and control of the environment. It makes provision for the declaration of an environmental conservation policy.

In terms of this act the state has a responsibility to act as trustee of the natural environment and to consider all activities which may have an influence on the environment.

Activities, which may have a detrimental effect on the environment, have been published in terms of Section 21 of this act. To undertake any of these activities, authorisation is required, which can only be obtained from the Minister of Environmental Affairs and Tourism after the prescribed procedure has been complied with. The construction of various forms of water works (dams, water diversions, water transfer schemes, etc.) are subject to the new process.

Through a consultative process a White Paper for Sustainable Coastal Development in South Africa was prepared. In terms thereof it is the joint responsibility of the Departments of Water Affairs and Forestry and of Environmental Affairs and Tourism to protect the in-shore marine environment.

In terms of this act the Department of Environmental Affairs and Tourism is responsible for issuing waste permits under this act and has published a Government Notice 1986 of 24 August 1990 relating to the identification of waste. This government notice needs drastic amendment to bring it in line with the NWA.

In May 2000 the Department of Environmental Affairs and Tourism published a White Paper on Integrated Pollution and Waste Management for South Africa. Aspects included water pollution; diffuse water pollution, marine pollution; and land pollution.

National Environmental Management Act (Act No. 107 of 1998)
This act lays a new foundation for environmental management. The act includes 20 principles that serve as a general framework within which environmental management and implementation plans must be formulated and guide any other law concerned with the protection or management of the environment. Environment is defined as the natural environment and the physical chemical, aesthetic and cultural properties of it that influence human well being.

To give effect to these principles this act creates the National Environmental Forum and the Committee for Environmental Co-ordination and defines the procedure for the establishment of a Coastal Management Subcommittee of the Committee for

Environmental Co-ordination in order to achieve better inter-governmental co-ordination of coastal management.

This act provides for the drawing up of environmental implementation plans by certain scheduled national Government Departments and the Provinces. In addition, environmental management plans are to drawn up by certain national Departments. The two sets of plans do not have to be drawn up by the private sector and may be consolidated. The purpose of the plans is set out in detail and must co-ordinate and harmonise environmental policies, plans, decisions of the three spheres to prevent duplication; give effect to co-operative governance and enable monitoring the achievement.

Chapter 7 of this act relates to environmental damage, duty of care, emergencies and remediation.

Conservation of Agriculture Resources Act (Act No. 43 of 1983)
This act is to provide for control over the utilisation of the natural agricultural resources in order to promote the conservation of the soil; the water resources and vegetation and the combating of weeds and invader plants. Except for weeds and invader plants, this act does not apply to land in an urban area.

3.4.8 Institutions Created Under the National Water Act

The NWA creates various institutions, some of which are listed below.

The first are Catchment Management Agencies (CMA) and one CMA will be established in each of the Water Management Areas that have been promulgated by Government Notice 1160 of 1 October 1999 (19 in total). These will have various functions either delegated or assigned to them, thus bringing the management of water resources to the regional or catchment level. A CMA will operate via a board along the lines set out in Schedule 4 to the NWA. The composition of the board is recommended by an Advisory Committee that is established by the Minister and has the important task to recommend to the Minister proposed members who are racially, gender and community representative.

A second institution, is that of Water User Associations (WUA) that will operate on a restricted local level and are in effect cooperative associations of individual water uses who wish to undertake related water activities for a mutual benefit. Irrigation Boards established under the Water Act of 1956 had until 29 February 2000 to transform into a WUA. All WUAs must have a constitution based on the lines set out in Schedule 5 to the NWA, which must be approved by the Minister. The policy of the Department of Water Affairs and Forestry is that these must also as far as possible be racially, gender and community representative.

A third institution is a body to implement international agreements. This can only be established by the Minister in consultation with the Cabinet.

A fourth body that the Minister can establish is Advisory Committees. These committees may be established for a particular purpose but can also have powers delegated to it by the Minister.

Lastly the NWA establishes a Water Tribunal where appeals against administrative decisions by the Department of Water Affairs and Forestry and CMAs can be heard. The question of compensation for loss of entitlements to use water is also to be heard in this Tribunal. Appeals on questions of law from the Tribunal are heard in the High Court.

3.4.9 Institutions Responsible for Community Water Supplies

The Water Services Act, No. 108 of 1997, deals with the provision of water supply services and sanitation services in a manner consistent with the broader goals of water resource management. The institutional structure provided for in the Act includes, in addition to the National Government, represented by the Department of Water Affairs and Forestry, the following bodies :

(i) Water Services Authorities, which are municipalities, including district or rural councils, that are responsible for ensuring access to water services.

(ii) Water Boards, which may be established by the Minister of Water Affairs and Forestry, after due consultation with stakeholders, for the primary purpose of providing water services to other water services institutions.

(iii) Water Services Committees, which may be established by the Minister of Water Affairs and Forestry to provide water services to communities within their own service areas where the Water Services Authorities having jurisdiction in the areas in question are unable to provide water services effectively.

(iv) The Provincial Government, which may take over the functions of a Water Services Committee or a Water Board, if requested to do so by the Minister of Water Affairs and Forestry.

(v) Advisory Committees, which may be appointed by the Minister of Water Affairs and Forestry to provide advice on matters falling within the scope of the Act.

The municipalities are the Water Services Authorities responsible for water services in the WMA. The municipalities were restructured in the year 2000. As this report deals with the period prior to that, mainly the institutional arrangements prior to the re-structuring are reported on here.

In the Mzimvubu to Keiskamma WMA most of the transitional local councils had the resources and the technical skills to be Water Services Authorities. Therefore, they became the Water Service Authorities responsible for the water and sanitation services of their own towns. The areas of jurisdiction of the transitional local councils are shown on Figure 3.4.9.2.

The areas that did not fall within the jurisdiction of the transitional local councils fell under the transitional regional councils that are also shown on Figure 3.4.9.2. Where these areas are nature reserves or privately owned farmland, the owners of the land are responsible for their own water supplies. In these areas, neither the transitional regional councils nor the district councils were Water Services Authorities.

In the areas of the WMA where there is tribal land that was part of the former Republic of Ciskei or Transkei, DWAF took over the responsibility for community water supplies, and was the Water Services Authority until the year 2001, when the responsibility passed to the new district municipalities

The boundaries of the supply area of the Amatola Water Board, which provides water services mainly in the Amatole Region (Drainage Region R) are shown on Figure 3.4.9.2 as they were in 1995. They have recently been extended to include the whole of the Great Kei River Basin (Drainage Region S) and some of the adjoining catchments. The Amatola Water Board provides bulk water supplies to the Water Services Authorities in the area.

The district councils provided other services such as roads and clinics. The boundaries of the areas of jurisdiction of the district councils are shown on Figure 3.4.9.1, which also shows magisterial districts. The magisterial districts are generally sub-divisions of the district councils for general administrative purposes, but they can also fall within more than one district council and have no connection with water supplies.

Only the Kei District Council area fell fully within the Mzimvubu to Keiskamma WMA, the other five extending across the boundaries. Similarly, several of the magisterial districts extend outside the WMA.

The district council areas were :

The Amatola District Council
The Drakensberg District Council
The Indlovu District Council
The Kei District Council
The Stormberg District Council
The Wild Coast District Council

3.5 LAND-USE

3.5.1 Introduction

Analysis of satellite images of the area (CSIR, 1999) has shown that land use is predominantly for rough grazing for livestock, with some 51 800 km^2, or 78% of the surface area of the WMA being used for this purpose. It is estimated that there were approximately 7 700 000 head of livestock in the WMA in 1995, of which 68% were sheep or goats. The satellite images show that 8 929 km^2, or 13% of the surface area of the WMA is used for dryland cultivation of crops, but this is probably an over-estimate because the satellite images do not distinguish areas of uncultivated land within large blocks of cultivated land.

Irrigated lands occupy about 268 km^2 which is 0,4% of the area of the WMA and afforestation 1 678 km^2, or 2% of the area. Nature reserves cover about 159 km^2 (0,2% of the surface area of the WMA), and urban areas and rural villages together occupy 2 134 km^2, which is 3% of the surface area of the WMA.

Statistics on the main categories of land use are shown in Table 3.5.1.1 for the key areas, and the distribution of those categories of land use that are directly associated with water requirements is shown per key area on Figure 3.5.1.1.

Land use per province and per district council area is shown in Table 3.5.1.2 where it can be seen that 94% of the WMA lies in the Eastern Cape Province, the remainder being in KwaZulu Natal.

TABLE 3.5.1.1: LAND USE BY KEY AREAS (PAGE 1 OF 2)

CATCHMENT					IRRIGATION (1) (km^2)	DRYLAND SUGAR CANE (km^2)	OTHER (2) DRY LAND CROPS (km^2)	AFFORES-TATION (3) (km^2)	INDIGENOUS FORESTS (3) (km^2)	ALIEN (4) VEGETATION (km^2)	NATURE (5) RESERVES (km^2)	URBAN AND RURAL VILLAGE AREAS (km^2)	ROUGH (7) GRAZING AND OTHER (km2)	TOTAL (8) AREA (km^2)
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY										
No.	Description	No.	Description	No.										
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	4,22	0,00	92	0,00	0,00	18,01	0,00	17,75	675,02	807
		R1	Keiskamma (all E Cape)	R10A to R10M	10,13	0,00	219	68,45	29,04	46,11	0,00	124,75	2 199,52	2 697
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	10,06	0,00	102	4,81	0,00	28,40	12,68	27,70	668,35	854
		R2	Buffalo (all E Cape)	R20A to R20G	6,77	0,00	98	74,87	0,00	14,64	12,54	152,97	926,21	1 286
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	28,82	0,00	136	0,78	0,00	8,37	12,94	40,18	2 064,91	2 292
		TOTAL IN AMATOLE REGION			**60,00**	**0,00**	**647**	**148,91**	**29,04**	**124,93**	**37,80**	**363,35**	6 524,97	**7 936**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	6,13	0,00	427	1,91	0,00	0,00	27,24	79,87	2 382,85	2 925
		S2	Indwe (all E Cape)	S20A to S20D	12,98	0,00	295	0,01	0,00	0,00	0,00	51,23	1 247,78	1 607
		S3	Klaas Smits (all E Cape)	S31A to S31G	52,60	0,00	6	0,00	0,00	0,00	2,14	35,96	2 555,30	2 652
			Black Kei (all E Cape)	S32A to S32M	50,81	0,00	86	20,99	0,00	5,48	36,63	72,19	3 980,90	4 253
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			122,52	0,00	814	22,90	0,00	5,48	66,01	239,25	10 166,84	11 437
		S4	Thomas (all E Cape)	S40A to S40F	20,96	0,00	38	9,56	0,00	150,72	0,75	9,68	1 939,33	2 169
		S5	Tsomo (all E Cape)	S50A to S50J	3,09	0,00	455	32,98	0,00	0,00	0,00	143,66	2 798,27	3 433
		S6	Kubusi (all E Cape)	S60A to S60E	13,62	0,00	34	147,22	40,35	148,52	0,00	14,25	890,04	1 288
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	4,35	0,00	340	0,00	0,00	2,65	0,01	125,16	1 685,83	2 158
		TOTAL IN GREAT KEI BASIN (all E Cape)			**164,54**	**0,00**	**1 681**	**233,84**	**40,35**	**307,37**	**66,77**	**532,00**	17 459,13	**20 485**

TABLE 3.5.1.1: LAND USE BY KEY AREAS (PAGE 2 OF 2)

CATCHMENT					IRRIGATION (km²)	DRYLAND SUGAR CANE (km²)	OTHER DRY LAND CROPS (km²)	AFFORES-TATION [3] (km²)	INDIGENOUS FORESTS [3] (km²)	ALIEN [4] VEGETATION (km²)	NATURE [5] RESERVES (km²)	URBAN AND RURAL VILLAGE AREAS (km²)	ROUGH [7] GRAZING AND OTHER (km²)	TOTAL [8] AREA (km²)
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY										
No.	Description	No.	Description	No.										
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	4,70	0,00	1 338	219,34	6,64	5,64	0,00	277,96	4 200,72	6 053
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	2,93	0,00	1 071	289,72	33,82	47,88	0,00	434,54	3 646,11	5 526
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	9,23 0,00	0,00 0,00	135 510	10,10 4,62	0,00 0,00	14,15 57,87	0,14 0,00	1,38 91,21	2 511,14 1 395,16	2 681 2 059
			Mzintlava in KwaZulu-Natal Mzimtlava in E Cape	T32A to T32H	26,15 0,00	0,00 0,00	9 30	6,44 19,05	0,00 18,23	41,64 32,67	24,96 0,00	5,17 48,02	1 260,64 1 428,03	1 374 1 576
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	0,00 0,00	0,00 0,00	22 515	0,27 6,70	0,00 0,00	2,16 42,35	0,00 0,00	4,10 123,38	55,47 2 537,57	84 3 225
			Tina (all E Cape)	T34A to T34K	0,00	0,00	749	76,05	6,44	27,36	0,00	63,23	2 274,92	3 197
			Tsitsa (all E Cape)	T35A to T35M	0,00	0,00	418	606,05	1,69	6,24	29,46	126,55	3 741,01	4 929
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,12	0,00	128	0,00	0,00	1,54	0,00	9,96	587,38	727
		Total in Mzimvubu in KwaZulu-Natal			35,38	0,00	166	16,81	0,00	57,95	24,96	10,65	3 827,25	4 139
		Total in Mzimvubu in E Cape			0,12	0,00	2 350	703,42	26,36	168,03	29,46	462,35	11 963,26	15 713
		Total Mzimvubu			35,50	0,00	2 516	730,23	26,36	225,98	54,42	473,00	15 790,51	19 852
		T6	Pondoland Coastal Catchments	T60A to T60K	0,00	11,00	1 157	29,45	1,23	10,62	0,00	25,38	2 498,32	3 733
		T9	Southern Wild Coast	T90A to T90G	0,00	0,00	508	26,36	8,90	7,96	0,00	27,70	2 047,08	2 626
		Total in Transkei Region in KwaZulu-Natal			35,38	0,00	166	16,81	0,00	57,95	24,96	10,65	3 827,25	4 139
		Total in Transkei Region in E Cape			7,75	11,00	6 424	1 278,30	76,94	240,13	29,46	1 227,93	24 345,49	33 651
		TOTAL IN TRANSKEI REGION			**43,13**	**11,00**	**6 590**	1 295,11	**76,94**	**298,08**	**54,42**	**1 238,58**	28 182,74	**37 790**
TOTAL IN WMA IN KWAZULU-NATAL					**35,38**	**0,00**	**166**	16,81	**0,00**	**57,95**	**24,96**	**10,65**	3 827,25	**4 139**
TOTAL IN WMA IN E CAPE					**232,29**	**11,00**	**8 752**	1 661,05	**146,33**	**672,43**	**134,03**	**2 123,28**	48 339,59	**62 072**
TOTAL IN WMA					**267,67**	**11,00**	**8 918**	**1 677,86**	**146,33**	**730,38**	**158,99**	**2 133,93**	**52 166,84**	**66 211**

1. From CSIR land-use maps (CSIR, 1999) in conjunction with listed areas obtained from DWAF Eastern Cape Regional Office. Values are the estimated maximum land areas irrigated.
2. Total cultivated areas from CSIR 1999 less irrigated areas derived as explained in Note 1.
3. From *A Handy Reference Manual on the Impacts of Timber Plantations on Runoff in South Africa* (CSIR, 1995). An area of 9 km² of indigenous forest falls within nature reserves and is not included in the "Total Area" column because the nature reserve area is included.
4. WRC, 1998.
5. Measured off DWAF GIS coverage of nature reserve boundaries.
6. Built up areas from CSIR land-use maps (CSIR, 1999). Areas include rural villages in tribal areas as well as towns and smallholdings.
7. Remaining land after all other land-uses in this table had been allocated.
8. WSAM database.

NOTE : Values are reported to two decimal places for purposes of cross-checking with other values in this report. This does not mean that the values are accurate to this level.

TABLE 3.5.1.2: LAND USE BY PROVINCE AND DISTRICT COUNCIL AREA

TYPES OF LAND USE	AREAS IN EASTERN CAPE PROVINCE						AREAS IN KWA ZULU NATAL	TOTAL AREA (km^2)
	AMATOLA DISTRICT COUNCIL (km^2)	DRAKENSBERG DISTRICT COUNCIL (km^2)	STORMBERG DISTRICT COUNCIL (km^2)	KEI DISTRICT COUNCIL (km^2)	WILD COAST DISTRICT COUNCIL (km^2)	TOTAL FOR EASTERN CAPE (km^2)	INDLOVU DISTRICT COUNCIL (km^2)	
Irrigation	104	5	116	8	0	233	35	268
Dryland Sugar Cane	0	0	0	0	11	11	0	11
Other Dryland Crops	1 982	555	883	2 652	2 680	8 752	166	8 918
Afforestation	372	550	64	548	127	1 661	17	1 678
Indigenous Forest	78	0	0	42	26	146	0	146
Nature Reserves	63	30	41	0	0	134	25	159
Alien Vegetation	444	2	6	61	159	672	58	730
Urban Areas and Rural Villages	721	51	305	714	332	2 123	11	2 134
Other	15 622	4 756	8 975	8 849	10 138	48 340	3 827	52 167
TOTAL AREA	**19 386**	**5 949**	**10 390**	**12 874**	**13 473**	**62 072**	**4 139**	**66 211**

3.5.2 Irrigation

Irrigation Areas

Estimates of irrigated areas and the types of crops grown under irrigation are shown for each key area in Table 3.5.2.1 and a map depicting the extent of irrigated land in each key area is shown on Figure 3.5.1.1.

The sources of data were the following :

- The Ciskei National Water Development Plan (HKS, 1991) for portions (R1, R4, R5) of the Amatole Region.
- The Amatole Water Resources System Analysis (DWAF, 1994; DWAF, 1999c) for portions (R2, R3) of the Amatole Region and the Kubusi River catchment (S6).
- The Upper Kei Basin Study (DWAF, 1993) for the Black Kei and White Kei catchments (S1, S2, S3).
- A report with the title *Marketing Potential for Irrigation Crops in Region D : Final Report* (Kassier *et al*, 1988) for areas in the catchment of the Great Kei River for which other data were not available.
- The Mbashe Basin Study (Stephenson & Associates, 1988) for the Mbashe River catchment (T1).
- The Mtata River Basin Study (DWAF, 2002) for the Mtata and adjacent coastal catchments (T2, T7, T8).
- The Vaal Augmentation Planning Study (DWAF, 1995) for the Mzimvubu Basin (T3).
- Transkei Development Information (DBSA, 1987) for portions of Drainage Region T for which other data were not available.

The level of confidence in the reliability of the data varies. In those areas covered by basin studies or system analyses the accuracy is considered to be good. In other areas the accuracy is low. With the exception of the portion of Drainage Region T covered by the recent Mtata River Basin Study (T2, T7, T8), the data for that area is at a low level of confidence. Most of the irrigation in the portion of the WMA falling within Drainage Region T is in KwaZulu Natal. The data on irrigated areas was obtained from the Vaal Augmentation Planning Study and was based on estimates made by the Provincial Department of Agriculture. While the estimate of the total area irrigated may be reliable, the allocation to quaternary catchments is at a low level of confidence.

In consultation with officials of the DWAF Eastern Cape Regional Office in Cradock, some minor adjustments were made to the areas obtained from the sources described above to obtain the maximum irrigated areas in the column headed "Total Irrigated Land Area" in Table 3.5.2.1. These values are estimates of the maximum areas irrigated when sufficient water is available in the rivers and dams. Because of the high variability of rainfall over parts of the Mzimvubu to Keiskamma WMA, the volume of water required to irrigate the total area of land developed for irrigation is not available every year.

The section of Table 3.5.2.1 headed "Land Area Irrigated in Average Years" shows estimates, made in conjunction with officials of the DWAF Eastern Cape Regional Office in Cradock, of the average total areas of land irrigated in each key area in the "Total" column on the right hand edge of the table. The other columns show the approximate areas of different types of crops grown. These values were derived using information on crop mixes contained in the references listed above, and should be regarded as being only indicative of the true situation.

TABLE 3.5.2.1: IRRIGATION LAND USE

CATCHMENT					TOTAL (1) IRRIGATED AREA (km²)	LAND AREA HARVESTED IN AVERAGE YEARS (km²)							
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY		LUCERNE	MAIZE	VEGETABLES	PASTURE	CITRUS	WHEAT	MIXED (3) CROPS	TOTAL
No.	Description	No.	Description	No.									
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	4,22	-	-	1,48	1,23	-	-	-	2,71
		R1	Keiskamma (all E Cape)	R10A to R10M	10,13	-	-	4,80	-	-	-	0,99	5,79
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	10,06	-	-	3,88	2,59	-	-	-	6,47
		R2	Buffalo (all E Cape)	R20A to R20G	6,77	-	-	2,00	2,71	-	-	-	4,71
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	28,82	2,80	1,60	11,92	3,00	-	-	-	19,32
		TOTAL IN AMATOLE REGION (all E Cape)			**60,00**	**2,80**	**1,60**	**24,08**	**9,53**	**-**	**-**	**0,99**	**39,00**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	6,13	1,00	3,34	1,00	-	-	-	-	5,34
		S2	Indwe (all E Cape)	S20A to S20D	12,98	5,27	1,80	-	1,80	-	-	-	8,87
		S3	Klaas Smits (all E Cape)	S31A to S31G	52,60	8,00	8,00	-	15,98	-	-	-	31,98
			Black Kei (all E Cape)	S32A to S32M	50,81	15,00	5,00	0,22	5,00	-	-	-	25,22
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			122,52	29,27	18,14	1,22	22,78	-	-	-	71,41
		S4	Thomas (all E Cape)	S40A to S40F	20,96	5,00	5,00	-	10,00	-	-	-	20,00
		S5	Tsomo (all E Cape)	S50A to S50J	3,09	-	1,24	-	-	-	-	1,24	2,48
		S6	Kubusi (all E Cape)	S60A to S60E	13,62	-	1,70	1,70	3,46	-	-	-	6,86
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	4,35	-	1,00	-	1,25	-	-	2,00	4,25
		TOTAL IN GREAT KEI BASIN (all E Cape)			**164,54**	**34,27**	**27,08**	**2,92**	**37,49**	**-**	**-**	**3,24**	**105,00**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	4,70	-	2,40	2,30	-	-	-	-	4,70
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	2,93	-	-	2,91	-	0,02	-	-	2,93
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	9,23 0,00	- -	- -	1,50 0,00	7,73 0,00	- 0	- -	- -	9,23 0,00
			Mzintlava in KwaZulu-Natal Mzintlava in E Cape	T32A to T32H	26,15 0,00	- -	- -	4,15 0,00	22,00 0,00	- -	- -	-	26,15 0,00
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	0,00 0,00	- -	- -	- -	- -	-	- -	-	0,00 0,00
			Tina (all E Cape)	T34A to T34K	0,00	-	-	-	-	-	-	-	0,00
			Tsitsa (all E Cape)	T35A to T35M	0,00	-	-	-	-	-	-	-	0,00
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,12	-	-	0,12	-	-	-	-	0,12
		Total Mzimvubu in KwaZulu-Natal			35,38	-	-	5,65	29,73	-	-	-	35,38
		Total Mzimvubu in E Cape			0,12	-	-	0,12	0,00	-	-	-	0,12
		Total Mzimvubu			35,50	-	-	5,77	29,73	-	-	-	35,50
		T6	Pondoland Coastal Catchments	T60A to T60K	0,00	-	-	-	-	-	-	-	0,00
		T9	Southern Wild Coast	T90A to T90G	0,00	-	-	-	-	-	-	-	0,00
		Total in Transkei Region in KwaZulu-Natal			35,38	-	-	5,65	29,73	0,00	-	-	35,38
		Total in Transkei Region in E Cape			7,75	-	2,40	5,33	0,00	0,02	-	-	7,75
		TOTAL IN TRANSKEI REGION			**43,13**	**-**	**2,40**	**10,98**	**29,73**	**0,02**	**-**	**-**	**43,13**
TOTALS IN WMA IN KWAZULU-NATAL					**35,38**	**0,00**	**0,00**	**5,65**	**29,73**	**0,00**	**-**	**0,00**	**35,38**
TOTAL IN WMA IN E CAPE					**232,29**	**37,07**	**31,08**	**32,33**	**47,02**	**0,02**	**-**	**4,23**	**151,75**
TOTAL IN WMA					**267,67**	**37,07**	**31,08**	**37,98**	**76,75**	**0,02**	**-**	**4,23**	**187,13**

1. Maximum areas irrigated when sufficient water is available.
2. Estimates of the average areas of land irrigated were made in consultation with officials of the DWAF Eastern Cape Regional Office. The estimates are at a low level of confidence.
3. No information on the crop mix was found. It is likely to be a mixture of maize and green vegetables.

It can be deduced from Table 3.5.2.1 that the area of land irrigated in average years is about 70% of the total area that is irrigated when there is sufficient water. It has been assumed that in the Amatole Region and the Great Kei Basin the average area irrigated is about 65% of the total area developed for irrigation, whereas the area irrigated in the Transkei Region, where water is more plentiful, remains constant from year to year.

Irrigation Methods

Irrigation methods vary widely throughout the WMA. Descriptions of irrigation practices in the various areas of the WMA follow.

The Amatole Region

There is very little irrigation in the Southern Coastal Catchments which occupy the area between the western boundary of the WMA and the Keiskamma River Catchment. Isolated patches of irrigation of mainly vegetables occur in alluvial soils close to the rivers. The maximum area irrigated is estimated to be 422 ha. Flood irrigation is generally practised.

In the Keiskamma River Catchment (R1), land is used mainly for rough grazing for cattle sheep and goats, and dryland cultivation of staple crops. Several dams on the upper reaches of the Keiskamma River supply water for irrigation. These are the Cata, Mnyameni and Sandile Dams (all in R10B) and the Pleasant View and Binfield Park Dams (both in R10G). The dams were designed to supply water to 1 900 ha of irrigated land, but in 1995 a maximum area of only about 1 100 ha was irrigated (R10B, C, G, H). The crops grown are mainly vegetables under flood irrigation.

There are no large irrigation schemes in the catchments of the Buffalo (R2), Nahoon (R30E, F) and Gqunube (R30C, D) rivers and the smaller coastal rivers (R30A, B, R40A, B, C) between the Great Kei and the Keiskamma River Basins, but diffuse irrigation occurs along all the rivers and the total maximum diffuse irrigated area is estimated to be about 4 500 ha. The Horseshoe Irrigation Scheme (R20B) uses water pumped from the Buffalo River to irrigate 56 ha of land farmed by small scale farmers who grow mainly vegetables. Crops grown in the area as a whole are vegetables (65%), pasture (25%), and lucerne and maize (10%), mainly under sprinkler irrigation.

The Great Kei River Basin

Land-use is mainly for rough grazing for sheep, cattle and goats, but it is estimated that about 16 000 ha of land is irrigated in the basin, and 23 000 ha is afforested.

The irrigation is generally diffuse, but there are concentrations of irrigated land in the vicinity of Queenstown (S31E, F, G) where groundwater is extensively used, and along the Black Kei River (S32G, K, H) where water is supplied from Waterdown Dam (S32E). Irrigation in these areas is mainly by sprinkler.

A number of dams have been constructed on the upper tributaries of the Kei River to supply water for irrigation. These include Mitford (S32B), Tentergate (S32B), Thrift (S32A), Oxkraal (S32G) and Bushmanskrantz (S32F) Dams which were planned to irrigate 2 025 ha of land. In 1995, about 980 ha was irrigated, the remaining 1 085 ha having either fallen into disuse or not been developed.

Another dam is Xonxa (S10E) which was constructed to irrigate 4 900 ha of land along the White Kei River (S10H). It was subsequently found that much of the land was not suitable for irrigation and only 1 643 ha of land was developed. Most of this fell into disuse, and by 1995, only 60 ha was irrigated.

Lubisi Dam (S20C) was completed in 1966 to supply water to small scale farmers under the Qamata Irrigation Scheme (S20D). Original planning was for development of 3 574 ha of land, but only 2 600 ha was, in fact, developed. It was reported (Department of Agriculture and Land Affairs, 1996) that only about 650 ha were cropped in 1995.

Thus, these dams and their associated infrastructure were developed to irrigate 6 268 ha of land of which only about 1 690 ha was irrigated in 1995.

Crops grown under irrigation in the Great Kei Basin are lucerne (32%), maize (26%), pasture (36%) and smaller areas (6%) of other crops, mainly vegetables. Irrigation is generally by sprinkler.

The Transkei Region

Land-use in the area of the WMA to the east of the Great Kei River catchment is predominantly for subsistence agriculture, except in the vicinities of Kokstad and Matatiele in the north-eastern portion of the area (T31A-J, T32A to D) where farmland is high developed, and in the vicinity of Maclear (T35A, T35C, T35F, T35G).

Crops grown under irrigation in the north-eastern part, where about 3 500 ha of land are irrigated, are pasture (84%) and vegetables (16%). The application of water is generally by sprinkler.

Nearly all the irrigation in the Mbashe River catchment occurs in the Ncora Irrigation Scheme (T12C). The scheme was developed in 1978, when 2 162 ha were put under irrigation. Subsequently, an additional 838 ha were developed, bringing the total area of irrigated land to 3 000 ha. Dairy produce, maize and vegetables are produced. Because of disagreements between stakeholders in the scheme, it has not prospered in recent years and it was reported (Department of Agriculture and Land Affairs, 1996) that only a small part of the irrigable land was cultivated in 1995. For the purposes of this assessment it has been assumed that the irrigated area was 470 ha.

In the catchments of the Mtata (T2) and Mngazi (T70A, T70B) Rivers, 293 ha of land are irrigated. Crops consist mainly of vegetables. In addition, 2 ha of citrus orchards and a very small area of pecan nuts are irrigated.

Areas of irrigated land elsewhere in the Transkei Region are negligible.

3.5.3 Dryland Farming

An area of 11 km^2 of sugarcane is grown in catchment T60A (CSIR, 1999). The area of dryland cultivation of other crops in the WMA is estimated to be 8 918 km^2, of which about 8 000 km^2 is on land used for subsistence farming. This estimate was derived from satellite images (CSIR, 1999) and is at a low level of confidence. The distribution of this total area amongst the key areas is shown in Table 3.5.1.1. No detailed information on the types of dryland crops was obtained in this study.

3.5.4 Livestock and Game Farming

Data on the numbers of different categories of livestock per magisterial district were obtained from the 1994 national livestock census (Department of Agriculture, 1994). The areas of land that fell within the former Republics of Ciskei and Transkei were not included in the livestock census. The data from the census was converted from numbers per magisterial district to numbers per key area by assuming the distribution of livestock to be proportional to land area. The results are shown in Table 3.5.4.1, but are incomplete for those key areas that fall partially or completely within the boundaries of the former Republics of Ciskei or Transkei. Data on livestock numbers for Ciskei in 1981 were obtained from the Ciskei National Water Development Plan (HKS, 1991) and for Transkei from the publication *Transkei Development Information* (DBSA, 1987). The data for Transkei were for the year 1982. These data were not readily available in terms of key areas. Therefore, they have been used only for the totals in the Transkei Region and the totals for the WMA shown in Table 3.5.4.1.

It is recommended that the information on livestock numbers should be reviewed when the next national livestock census, which should include the Ciskei and Transkei areas, becomes available.

It can be deduced from Table 3.5.4.1 that sheep and goats account for 68% of the estimated total of approximately 7 700 000 head of livestock in the WMA. Cattle make up 26% of the total numbers, and horses, mules, donkeys and pigs the remainder of 6%.

Equivalent large stock units (ELSU) are used to measure the water requirements of livestock. Each ELSU is assumed to represent a water requirement of 45 ℓ/day. For example, one ELSU is equivalent to 0,85 head of cattle, or 1 horse, or 6,5 sheep, or 4 pigs. A detailed table for use in converting mature livestock and game populations to ELSU is included in Appendix D. Values of ELSU per quaternary catchment are available from the report on the Eastern Cape Water Resources Situation Assessment (DWAF, 1999b) and were used to derive the values of ELSU per key area shown in Table 3.5.4.1. These include the livestock in Ciskei and Transkei.

TABLE 3.5.4.1: LIVESTOCK

CATCHMENT					NUMBERS OF LIVESTOCK [1]					
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	CATTLE	HORSES AND DONKEYS	SHEEP	GOATS	PIGS	NO. OF ELSU [5]
No.	Description	No.	Description	No.						
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	(4)	(4)	(4)	(4)	(4)	14 795
		R1	Keiskamma (all E Cape)	R10A to R10M	(4)	(4)	(4)	(4)	(4)	79 391
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	14 687	272	1 469	1 206	1 552	13 942
		R2	Buffalo (all E Cape)	R20A to R20G	9 722	115	11 583	1 073	632	13 333
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	79 595	928	51 252	9 384	4 700	41 218
		TOTAL IN AMATOLE REGION (all E Cape)			-	-	-	-	-	**162 679**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	6 344 [2]	205 [2]	17 946 [2]	3 091 [2]	600 [2]	65 875
		S2	Indwe (all E Cape)	S20A to S20D	6 932	211 [2]	39 273 [2]	1 067 [2]	768 [2]	36 408
		S3	Klaas Smits (all E Cape)	S31A to S31G	28 928	865	110 214	22 359	1 708	43 044
			Black Kei (all E Cape)	S32A to S32M	65 169	695	203 651	41 748	4 972	76 591
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			-	-	-	-	-	
		S4	Thomas (all E Cape)	S40A to S40F	18 615	320	31 050	17 957	892	44 505
		S5	Tsomo (all E Cape)	S50A to S50J	9 797 [2]	251 [2]	65 383 [2]	1 450 [2]	1 248 [2]	130 533
		S6	Kubusi (all E Cape)	S60A to S60E	9 674	300	79 586	10 115	1 196	22 709
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	16 708 [2]	123 [2]	11 687 [2]	2 970 [2]	388 [2]	92 116
		TOTAL IN GREAT KEI BASIN (all E Cape)			-	-	-	-	-	**511 781**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	(4)	(4)	(4)	(4)	(4)	506 296
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	(4)	(4)	(4)	(4)	(4)	495 000
		T3	Upper Mzimvubu in KwaZulu-Natal	T31A to T31J T33H to T33K	72 716	1 434	153 419	750	825	110 920
			Upper Mzimvubu in E Cape		(4)	(4)	(4)	(4)	(4)	146 914
			Mzintlava in KwaZulu-Natal	T32A to T32H	41 544	750	86 071	430	471	63 058
			Mzintlava in E Cape		(4)	(4)	(4)	(4)	(4)	94 951
			Kinira in KwaZulu-Natal	T33A to T33G	2 350	42	4 900	26	26	3 571
			Kinira in E Cape		(4)	(4)	(4)	(4)	(4)	203 531
			Tina (all E Cape)	T34A to T34K	(4)	(4)	(4)	(4)	(4)	219 138
			Tsitsa (all E Cape)	T35A to T35M	38 177 [3]	740 [3]	12 784 [3]	122 [3]	146 [3]	354 990
			Lower Mzimvubu (all E Cape)	T36A to T36B	(4)	(4)	(4)	(4)	(4)	14 806
		Total in Mzimvubu in KwaZulu-Natal			116 610	2 226	244 390	1 206	1 322	177 549
		Total in Mzimvubu in E Cape			(4)	(4)	(4)	(4)	(4)	1 034 330
		Total Mzimvubu			-	-	-	-	-	1 211 879
		T6	Pondoland Coastal Catchments	T60A to T60K	(4)	(4)	(4)	(4)	(4)	70 610
		T9	Southern Wild Coast	T90A to T90G	(4)	(4)	(4)	(4)	(4)	215 103
		Total in Transkei Region in KwaZulu-Natal			116 610	2 226	244 390	1 206	1 322	177 549
		Total in Transkei Region in E Cape			(4)	(4)	(4)	(4)	(4)	2 321 339
		TOTAL IN TRANSKEI REGION			-	-	-	-	-	**2 498 888**
TOTAL IN WMA IN KWAZULU-NATAL					**116 610**	**2 226**	**244 390**	**1 206**	**1 322**	**177 549**
TOTAL IN WMA IN E CAPE					**1 897 594**	**114 419**	**3 096 790**	**1 915 065**	**287 393**	**2 995 799**
TOTAL FOR WMA [6]					**1 770 584**	**102 577**	**3 707 926**	**2 137 903**	**194 709**	**3 173 348**

(1) Numbers were derived from the 1994 Agricultural Census for all areas except those falling within the former Republics of Ciskei and Transkei. Values of ELSU for the latter areas are available from the 1999 report on the Eastern Cape Water Resources Situation Assessment but the breakdown of categories of livestock in the form required for this table are not readily available. Therefore, numbers of livestock in sub-areas of the former Republics of Ciskei and Transkei are not included in this table, but the number of ELSU take account of the livestock in those areas.

(2) These numbers are incomplete as they do not include livestock in the former Republic of Ciskei (see Note 1).

(3) These numbers are incomplete as they do not include livestock in the former Republic of Transkei (see Note 1).

(4) These areas were fully within the former Republics of Ciskei and Transkei and data is not readily available (see Note 1).

(5) Derived from the report on the Eastern Cape Water Resources Situation Assessment (DWAF, 1999b). ELSU given in DWAF 1999b for the Transkei Region were multiplied by a factor of 1,52 to bring them in line with the total livestock numbers in the Transkei Region given in this table.

(6) These include totals for Ciskei and Transkei derived from the Ciskei National Water Development Plan (HKS, 1991) and Transkei Development Information (DBSA, 1987).

3.5.5 Afforestation

The areas of indigenous forests and commercial timber plantations are shown in Table 3.5.5.1 and on Figure 3.5.1.1.

The total area of commercial timber plantations in 1995 was 1 678 km^2, of which 730 km^2, or 44% was in the catchment of the Mzimvubu River, mainly in the vicinity of Ugie (T35C, T35F, T35G). Table 3.5.1.1 also shows 146 km^2 of indigenous forest which occurs in numerous parts of the WMA.

TABLE 3.5.5.1: AREAS OF AFFORESTATION AND INDIGENOUS FOREST

CATCHMENT					AREA OF AFFORESTATION (km^2)	AREA OF INDIGENOUS FOREST (km^2)
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY		
No.	Description	No.	Description	No.		
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	0,00	0,00
		R1	Keiskamma (all E Cape)	R10A to R10M	68,44	29,04
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	4,81	0,00
		R2	Buffalo (all E Cape)	R20A to R20G	74,87	0,00
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	0,78	0,00
		TOTAL IN AMATOLE REGION (all E Cape)			**148,91**	**29,04**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	1,91	0,00
		S2	Indwe (all E Cape)	S20A to S20D	0,01	0,00
		S3	Klaas Smits (all E Cape)	S31A to S31G	0,00	0,00
			Black Kei (all E Cape)	S32A to S32M	20,99	0,00
		Total : Black Kei and White Kei (S1, S2, S3) (all E Cape)			22,90	0,00
		S4	Thomas (all E Cape)	S40A to S40F	9,56	0,00
		S5	Tsomo (all E Cape)	S50A to S50J	32,98	0,00
		S6	Kubusi (all E Cape)	S60A to S60E	147,22	40,35
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	0,00	0,00
		TOTAL IN GREAT KEI BASIN (all E Cape)			**233,84**	**40,35**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	219,34	6,64
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	289,72	33,82
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	10,10 4,62	0,00 0,00
			Mzintlava in KwaZulu-Natal Mzintlava in E Cape	T32A to T32H	6,44 19,05	0,00 18,23
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	0,27 6,70	0,00 0,00
			Tina (all E Cape)	T34A to T34K	76,05	6,44
			Tsitsa (all E Cape)	T35A to T35M	606,05	1,69
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,00	0,00
		Total in Mzimvubu in KwaZulu-Natal			16,81	0,00
		Total in Mzimvubu in E Cape			703,42	26,36
		Total Mzimvubu			730,23	26,36
		T6	Pondoland Coastal Catchments	T60A to T60K	29,45	1,23
		T9	Southern Wild Coast	S90A to S90G		
		Total in Transkei Region in KwaZulu-Natal			16,81	0,00
		Total in Transkei Region in E Cape			1 278,30	76,94
		TOTAL IN TRANSKEI REGION			**1 295,11**	**76,94**
TOTAL IN WMA IN KWAZULU-NATAL					**16,81**	**0,00**
TOTAL IN WMA IN E CAPE					**1 661,05**	**146,33**
TOTAL IN WMA					**1 677,86**	**146,33**

3.5.6 Alien Vegetation

The impacts of the widespread infestations by alien plants in South Africa are increasingly recognised. The total incremental water use of invading alien plants was estimated at 3 300 million m^3/a by Le Maitre *et al*. (1999) but this estimate is not widely recognised by the water resources planning community. This estimate is almost twice as high as the estimate for stream flow reduction resulting from commercial afforestation. Le Maitre *et al* (1999) estimate that the impact of alien vegetation will increase significantly in the next 5 to 10 years, resulting in the loss of much, or possibly even all, of the available water in certain catchment areas. Again, this is a debatable point requiring more research to verify these statements.

Much of the infested areas are in the riparian zones where the degree of infestation is largely independent of the rainfall in the surrounding areas. The acacias, pines, eucalyptus, and prosopis species and melia azedarachs are among the top ten invading aliens, which account for about 80% of the water use.

Commercial afforestation has been one of the major sources of alien vegetation in South Africa, largely as a result of poor past forestry management practices. The results of a recent national scale study (Nel *et al*, 1999) showed that about 44% of the area invaded by plantation trees (pine, eucalyptus and black wattle) overlaps with areas affected by commercial afforestation practices. The new commercial afforestation plantations generally tend to be well-managed, maximising benefits of forestry and minimising environmental impacts.

Alien vegetation infestations across South Africa were mapped under supervision of a CSIR (Environmentek) team using a "best expert knowledge" approach, supplemented by existing detailed localised maps and Geographic Information System (GIS) data sets obtained from certain specific authorities. The expert knowledge was gathered through workshops in different regions and mapped directly onto overlays on 1:250 000 scale topographic maps. Data capture procedures were designed to standardise the approach and terminology and to ensure consistency and comparability in the inputs made by the wide range of people involved.

Areas invaded by alien vegetation were mapped as independent polygons with each polygon accompanied by attribute data regarding species and density. All polygons and attribute data were captured in a GIS (Arc/Info).

The following shortcomings and limitations of the CSIR database on alien vegetation infestation have been highlighted by Görgens (1998):

- The quality of data gathered is known to be variable as it depended on the level of expert knowledge available, the nature of the terrain and the extent and complexity of the actual invasion.

- Mapping of alien vegetation ending very abruptly (and artificially) along some or other administrative boundary.

- Mapping of riparian infestations along rivers at the coarse scale of the available GIS coverages (generally, 1:500 000 with 1:250 000 for some areas) could have led to significant under-estimates of river lengths and, therefore, of infested riparian areas.

For example, a pilot comparison by the CSIR of 1:50 000 scale (a suitable scale) and 1:500 000 scale maps yielded a river length ratio of 3,0 and greater.

- Riparian infestation identification in a particular catchment with the simple statement: "all rivers are invaded". In these cases, all the river lengths appearing in the particular coverages were assigned a uniform infested "buffer" strip of specific width, say 20m.

- Small rivers not reflected on the smaller scale mapping were not accounted for and therefore infestation along these particular rivers was not mapped or quantified.

Estimated areas of alien vegetation are shown in Table 3.5.6.1 and diagrammatically for each key area on Figure 3.5.6.1. The values are for condensed areas, which are the equivalent areas that the alien vegetation would occupy if it were condensed to provide completely closed canopy cover.

TABLE 3.5.6.1: INFESTATION BY ALIEN VEGETATION

CATCHMENT					CONDENSED AREA OF ALIEN VEGETATION (km^2)
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	
No.	Description	No.	Description	No.	
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	18,01
		R1	Keiskamma (all E Cape)	R10A to R10M	46,11
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	28,40
		R2	Buffalo (all E Cape)	R20A to R20G	14,64
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	8,37
		TOTAL IN AMATOLE REGION (all E Cape)			**124,93**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	0,00
		S2	Indwe (all E Cape)	S20A to S20D	0,00
		S3	Klaas Smits (all E Cape)	S31A to S31G	0,00
			Black Kei (all E Cape)	S32A to S32M	5,48
		Total : Black Kei and White Kei (S1, S2, S3) (all E Cape)			**5,48**
		S4	Thomas (all E Cape)	S40A to S40F	150,72
		S5	Tsomo (all E Cape)	S50A to S50J	0,00
		S6	Kubusi (all E Cape)	S60A to S60E	148,52
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	2,65
		TOTAL IN GREAT KEI BASIN (all E Cape)			**307,37**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	5,64
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	47,88
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	14,15 57,87
			Mzintlava in KwaZulu-Natal Mzintlava in E Cape	T32A to T32H	41,64 32,67
			Kinira in Natal Kinira in E Cape	T33A to T33G	2,16 42,35
			Tina (all E Cape)	T34A to T34K	27,36
			Tsitsa (all E Cape)	T35A to T35M	6,24
			Lower Mzimvubu (all E Cape)	T36A to T36B	1,54
		Total in Mzimvubu in KwaZulu-Natal			57,95
		Total in Mzimvubu in E Cape			168,03
		Total Mzimvubu			225,98
		T6	Pondoland Coastal Catchments	T60A to T60K	10,62
		T9	Southern Wild Coast	S90a to S90G	7,96
		Total in Transkei Region in KwaZulu-Natal			57,95
		Total in Transkei Region in E Cape			240,13
		TOTAL IN TRANSKEI REGION			**298,08**
TOTAL IN WMA IN KWAZULU-NATAL					**57,95**
TOTAL IN WMA IN E CAPE					**672,43**
TOTAL IN WMA					**730,38**

3.5.7 Urban Areas

The data on urban areas was obtained from the CSIR land-use maps (CSIR, 1999). The total urban area in the WMA is 504 km^2, which is 0,8% of the area of the WMA. The Buffalo City urban complex covers approximately 100 km^2.

Rural villages cover an additional 1 630 km^2, or 2,5% of the area of the WMA. The combined urban and rural village areas per key area are shown in Table 3.5.1.1.

3.6 MAJOR INDUSTRIES AND POWER STATIONS

The major industries in the WMA are all situated in the East London/King William's Town area. The only industry not supplied via the municipal distribution systems is Da Gama Textiles which has plants at Zwelitsha and near East London with individual supplies. There are hydro-power stations at Ncora Dam, on the Mbashe River at Collywobbles, and at two points on the Mtata River. Details are shown in Table 3.6.1.

TABLE 3.6.1: POWER STATIONS

QUATERNARY CATCHMENT	NAME	TYPE	GENERATING CAPACITY (MW)	OWNER
T13D	Collywobbles	Hydro-electric	43,5	Eskom
S50E	Ncora	Hydro-electric	2,1	Eskom
T20D	Mtata 1st Falls	Hydro-electric	6,0	Eskom
T20E	Mtata 2nd Falls	Hydro-electric	11,0	Eskom

3.7 MINES

There are no mines in the WMA. However, major titanium deposits are known to exist on the Transkei Coast, and development of these has been under consideration for some time.

3.8 WATER RELATED INFRASTRUCTURE

The water supply infrastructure of the cities and the bigger towns is well developed, but most of the smaller towns and rural villages had inadequate water supply schemes in 1995. The existing water related infrastructure is described in detail in Chapter 4.

CHAPTER 4: WATER RELATED INFRASTRUCTURE

4.1 OVERVIEW

Even though irrigated agriculture is not well developed throughout the WMA, some 26 700 ha of crops are irrigated and the water required to do this constitutes the largest consumptive (i.e. excluding the requirements of the ecological Reserve) water requirement in the WMA. About 5 400 ha of the irrigation uses water from Government Water Schemes and the other 21 300 ha relies on water from farm dams, run-of-river flow, or boreholes.

The Government Water Schemes were intended to provide water to about 12 300 ha of land, but much of the land is not used. DWAF is in the process of determining the reasons for this and identifying those schemes that can be rejuvenated.

The principal characteristics of the Government Water Schemes that provide water for irrigation are summarised in Table 4.1.1 and the schemes are described in more detail in Section 4.4. Their locations are shown in Figure 4.1.1.

There are more than fifty potable water supply schemes in the WMA. Many of these are regional schemes that provide water to the main urban centres and the surrounding areas, or regional rural water supply schemes providing water to villages in the tribal areas of the WMA. In addition, many of the towns have their own individual potable water supply schemes and many villages have individual borehole or protected spring schemes.

Information on all the schemes has not been obtained for this study. This applies particularly to the individual village schemes. Details of the supplies to the majority of the towns, and of the regional rural water supply schemes are summarised in Table 4.1.2. It is estimated that the combined capacity of the schemes in 1995 was about 114 million m^3/a, and that they provided water to about 1 840 000 people. Thus, the schemes listed provided water to only 43% of the total population of the WMA in 1995 of 4 520 000 people. The majority of the people not receiving water from the schemes listed in Table 4.1.2 live in the rural areas and have inadequate water supplies.

The regional potable water supply schemes are described in more detail in Section 4.2, and the schemes supplying single towns in Section 4.3.

The controlled irrigation schemes and many of the regional potable water supply schemes rely on surface water resources as their source of raw water, and more than 40 dams have been constructed to regulate the flow in the rivers for this purpose. These dams are listed in Table 4.1.3. They have a combined capacity of 1 077 million m^3 and an estimated 1:50 year yield of 500 million m^3/a. In addition, there are some 105 farm dams in the WMA with a combined storage capacity of 33 million m^3.

The approximate allocations of the 1:50 year yields of the dams to domestic supplies, irrigation and, where applicable, hydro-power, are shown in Table 4.1.3. In most cases, the actual allocations from the dams are at lower assurances of supply than the 1:50 year assurance shown in the table. Consequently, in cases where the yields of the dams are fully allocated, the quantity of water allocated is greater than the 1:50 year yield. In Table 4.1.3, these cases have been dealt with by giving priority to the domestic requirements and showing the balance of the 1:50 year yield as the portion of the yield allocated to irrigation or hydro-power, as applicable.

TABLE 4.1.1: CONTROLLED IRRIGATION SCHEMES IN THE MZIMVUBU TO KEISKAMMA WMA IN 1995

SCHEME NAME	SCHEDULED AREA (ha)	IRRIGATED AREA IN 1995 (ha)	PRODUCE	SUPPLY SOURCE	AVAILABLE WATER (1) (million m^3/a)	PRESENT AVERAGE ANNUAL USE (million m^3/a)	CATCHMENT NO.
Zanyokwe Irrigation Scheme	47 (1)	90	Vegetables	Sandile Dam	5,18	1,0	R10C, D
Keiskamma Irrigation Scheme	854	744	Dairy products	Mnyameni and Cata Dams	9,86	6,02	R10B
Tyume Irrigation Scheme	231	114	Citrus	Binfield Park Dam	17,36	0,7	R10G, H
Klipplaat Govt Water Scheme	1 905	1 820	Lucerne, maize, pasture	Waterdown Dam	7,2	18	S32G, H S31G S32K, M
Oxkraal Irrigation Scheme	0 (2)	0	None	Oxkraal Dam Shiloh Dam	7,9 0,4	1,7 (2)	S32G
Nthabethemba Irrigation Scheme	1 200	720	Maize, vegetables	Thrift, Limietskloof, Tentergate, Mitford, Glenbrock Dams and White Kei River	2,52	Not known	S32A, B, C
Zweledinga Irrigation Scheme	239	239	Maize	Bushmanskrantz Dam	2,26	Not known	S32F
Qamata Irrigation Scheme	2 600	650	Maize, lucerne, vegetables	Lubisi Dam	30,5	Not known	S20D
Ncora Irrigation Scheme	3 000	750	Dairy, vegetables, maize	Ncora Dam	35	Not known	T12C, T12D
Xonxa Irrigation Scheme	1 643	60	Maize, vegetables, lucerne	Xonxa Dam	33	Not known	S10H
Doring River	180	180	Lucerne, maize, pasture	Doring River Dam	1,8	1,8	S20B
TOTALS	12 323	5 367			152,98		

(1) Available water at 1:10 year risk of failure.

(2) 566 ha was planned under the Oxkraal Scheme but has not been developed. The dam releases water for irrigators under the Klipplaat Government Water Scheme.

TABLE 4.1.2: POTABLE WATER SUPPLY SCHEMES IN 1995

SCHEME NAME	RAW WATER SOURCE	POPULATION SUPPLIED	SCHEME CAPACITY			CATCHMENT NO.
			10^6 m^3/a	ℓ/c/d	Limiting Factor	
Amatole System	Wriggleswade, Nahoon, Bridle Drift, Laing, Rooikrantz, Maden, Gubu Dams	725 000	57,0	215	Treatment capacity	R20A, B, C, D, E, F, G R30E, F R30D
Komga	Boreholes, Kei River	5 100	0,50	268	Treatment capacity	S70A
Butterworth	Xilinxa Dam	36 450	5,45	188	Treatment capacity	S70E
Willowvale	Weir on river	2 000	0,11	150	Treatment capacity	T90C
Centane	Borehole and river	1 400	0,05	97	Source	T90G
Tsomo	River sump	2 050	0,12	160	Treatment capacity	S50J
Idutywa	Local dams	12 000	0,30	68	Treatment capacity	T90A
Nqamakwe	Boreholes	2 050	0,05	66	Source	S50J
Cathcart	Sam Meyer Dam	8 000	0,50	172	Source	S40A
Mgwali Heckel Scheme	Boreholes	4 500	0,42	255	Source	S60D
Wartburg Scheme	Boreholes	5 000	0,27	148	Source	S60C
Kwelera Scheme	Boreholes	18 000	0,88	133	Source	R30B, D
Mooiplaas Scheme	Boreholes	30 000	0,60	55	Source	R30A, B
Alice (Tyume Valley Scheme)	Binfield Park Dam	15 300	1,1	195	Treatment capacity	R10H
Debe Regional Water Supply Scheme	Debe Dam	29 000	0,45	43	Treatment capacity	R10E, J, K
Keiskammahoek Water Supply Scheme	Mnyameni Dam	12 000	0,88	200	Treatment capacity	R10B
Wesley Regonal Water Supply Scheme	Keiskamma River	700	1,15	N/A	Treatment capacity	R10M R50A, B
Sandile Regional Water Supply Scheme	Sandile Dam	104 000	5,4	142	Treatment capacity	R10D, E, K R20C, D
Hamburg	Boreholes	1 700	Not known			R10M
Indwe	Doring River Dam	6 350	0,35	151	Treatment capacity	S20A
Cala	Tsomo River and boreholes	13 350	0,55	111	Treatment capacity	S50A
Elliot	Thompson Dam	11 050	0,44	98	Source	T11A
Ugie	Weir on river	4 000	0,24	165	Treatment capacity	T35F
Maclear	Maclear Dam	4 700	0,22	128	Source	T35D
Queenstown	Waterdown Dam; Bongolo Dam	50 450	8,9	483	Source	S31F
Sada/Whittlesea	Waterdown Dam	50 400	3,4	185	Treatment capacity	S32G/H
Yonda/Mbekweni	Bushmanskrantz Dam	9 200	0,10	30	Treatment capacity	S32F, G
Cacadu Rural Water Supply Scheme	Macubeni Dam	64 000	1,06	45	Treatment capacity	S20A S10F, G
Hewu Groundwater Scheme	Boreholes and springs	48 000	0,53	30	Source	S32C, F
Ilinge Scheme	Boreholes	13 000	1,3	274	Source	S32J
Tsojana Scheme	Tsojana Dam	5 000	0,14	79	Treatment capacity	S50H
Libode Regional	Mlanga Dam	60 000	0,78	36	Source	T20D, E; T70A, B, C , E
Corana	Corana Dam	47 000	0,22	13	Treatment capacity	T20B, D, E
Mhlahlane	Mabeleni Dam	28 000	0,26	25	Treatment capacity	T20A, B
Umtata Town	Umtata Dam	175 000	13,9	218	Treatment capacity	T20B, C, D
Mtangana	Mtangana Dam, springs, boreholes	16 000	0,14	24	Source	T12E, F, G
Qumbu Town	Boreholes	4 650	0,04	20	Source	T35K
Port St Johns	Lower Bulolwa Dam	12 050	0,33	76	Source/ Treatment capacity	T36B T70B
Ngqeleni	Dam and boreholes	6 050	0,07	30	Treatment capacity	T70F
Mqanduli	Weir on river	4 650	0,05	32	Treatment capacity	T20F
Elliotdale	Weir on river	2 000	0,06	83	Treatment capacity	T80C
Tsolo	Weir on river	4 650	0,16	94	Source	T35K
Engcobo	Two streams and borehole	5 650	0,21	101	Source	T12B
Belfort Scheme	Belfort Dam	5 000	0,30	166	Treatment capacity	T33A
Kwa Bhaca	Ntenetyana Dam	59 000	0,33	15	Treatment capacity	T33G, H, T34H, J
Lusikisiki	Xura River Weir	50 000	0,57	32	Treatment capacity	T60F, G, H, J
Mnceba	Weir on river	29 000	0,63	60	Treatment capacity	T31J, T32F, T33H
Flagstaff Town	Boreholes and dam	7 650	0,18	65	Treatment capacity	T32H
Mt Ayliff Town	Weir on stream	6 600	0,04	18	Source	T32F
Mt Fletcher Town	Boreholes	12 050	0,05	12	Source	T34D

SCHEME NAME	RAW WATER SOURCE	POPULATION SUPPLIED	SCHEME CAPACITY			CATCHMENT NO.
			10^6 m³/a	ℓ/c/d	Limiting Factor	
Tabankulu Town	Dam	23 250	0,25	30	Treatment capacity	T33H
Kokstad	Crystal Springs Dam	19 550	2,00	280	Source	T32C
Matatiele	Mountain Dam, Borehole	4 500	1,23	749	Source	T33A
	TOTALS	1 876 050	114,01	170		

TABLE 4.1.3: MAIN DAMS IN THE MZIMVUBU TO KEISKAMMA WMA

NAME	LIVE CAPACITY (million m³/a)	YIELD *					OWNER	CATCHMENT NO.
		DOMESTIC SUPPLIES (million m³/a)	IRRIGATION (million m³/a)	HYDRO-POWER (million m³/a)	SURPLUS/ OTHER (million m³/a)	TOTAL (million m³/a)		
Xilinxa	14,5	9,4	0,00	0	0	9,4	DWAF	S70C
Gcuwa	0,9						DWAF	S70D
Gubu	8,8	2,27	0,63	0	0,1	2,9	DWAF	S60A
Wriggleswade	91,2	16,9	3,00	0	5,5 **	25,4	DWAF	S60B
Nahoon	20,7	5,6	1,30	0	0,9 ***	7,8	DWAF	R30E
Maden	0,22	3,1	0,00	0	0	3,1	King William's Town TLC	R20A
Rooikrantz	4,90						DWAF	R20A
Laing	21,0	14,9	0,00	0	0	14,9	DWAF	R20E
Bridle Drift	101,7	30,7	0,00	0	0	30,7	East London TLC	R20F
Sandile	30,9	11,6	0,80	0	5,6	18,0	DWAF	R10B
Binfield Park	36,8	1,0	6,30	0	9,2	16,5	DWAF	R10G
Pleasant View	2,0	0,03	1,49	0	0	1,5	DWAF	R10G
Debe	6,0	0,35	0,00	0	1,8	2,2	DWAF	R10E
Mnyameni	2,05	0,45	0,55	0	1,3	2,3	DWAF	R10B
Cata	12,1	0	4,20	0	2,0	6,2	DWAF	R10B
Waterdown	36,6	12,45	4,05	0	0	16,5	DWAF	S32E
Bongolo	6,95	0,65	0,00	0	0	0,7	Queenstown	S31F
Bushmanskrantz	4,62	0,57	1,50	0	0	2,1	DWAF	S32F
Macubeni	1,85	1,54	0,00	0	0	1,5	DWAF	S10F
Tsojana	9,35	3,16	0,00	0	0	3,2	DWAF	S50F
Oxkraal	17,8	0	0,00	0	6,18	6,2	DWAF	S32G
Shiloh	0,52	0	0,34	0	0	0,3	DWAF	S32G
Thrift	2,6	0	0,58	0	0	0,6	DWAF	S32A
Limietskloof	0,78	0	0,13	0	0	0,1	DWAF	S32A
Tentergate	1,72	0	0,26	0	0	0,3	DWAF	S32B
Mitford	0,89	0	0,05	0	0	0,1	DWAF	S32C
Glenbrock	0,41	0	0,12	0	0	0,1	DWAF	S32C
Lubisi	135,0	Negligible	28,50	0	0	28,5	DWAF	S20C
Xonxa	126,0	0	2,00	0	25	27,6	DWAF	S10E
Ncora	120,0	1,0	12,00	85	0	98,0	DWAF	S50E
Doring River	17,84	0,78	2,60	0	0	3,4	DWAF	S20A
Umtata	228,0	19	0,00	126	0	145,0	DWAF	T20B
Corana	0,71	0,34	0,00	0	0	0,3	DWAF	T70A
Mabeleni	2,0	1,73	0,00	0	0	1,7	DWAF	T20A
Mlanga	1,53	0,78	0,00	0	0	0,8	DWAF	T70A
Lower Bulolwa	0,13	0,53	0,00	0	0	0,5	Port St Johns	T70B
Belfort	0,6	0,47	0,00	0	0	0,5	DWAF	T33A
Ntenetyana	1,7	2,2	0,00	0	0	2,2	DWAF	T33G
Tabankulu	0,5	Not known	0,00	0	0	-	Not known	
Magwa	2,6	Not known	0,00	0	0	-	Not known	
Mountain	1,08	0,5	0,00	0	0	0,5	Matatiele TLC	T33A
Crystal Springs	2,14	2,0	0,00	0	0	2,0	Kokstad TLC	T32C
TOTALS	1 077,69	144,0	71,00	211	63,18	483,6		

* Yields are at reliabilities of approximately 1:50 years. The allocations of water to irrigation are greater than the volumes shown because water is supplied at a lower assurance

** It has been assumed that 5,5 Mm³/a of the yield will be allocated to the ecological Reserve.

*** It has been assumed that 0,9 Mm³/a of the yield will be allocated to the ecological Reserve.

4.2 REGIONAL POTABLE WATER SUPPLY SCHEMES

4.2.1 The Amatole Water Supply System

The Amatole Water Supply System which serves industry and approximately 578 000 people in the East London/King William's Town urban complex, as well as 147 000 people in villages in the surrounding rural areas and the towns of Stutterheim and Kei Road, provides 50% of the potable water supplied by formal schemes in the WMA. The system is a complex one that has developed from a number of separate water supply schemes, some of which have become interlinked as their supply areas have been extended. Most of the raw water supplies are obtained from surface water sources, the groundwater resources of the area being suitable only for localised schemes which account for a very small portion of the total supply.

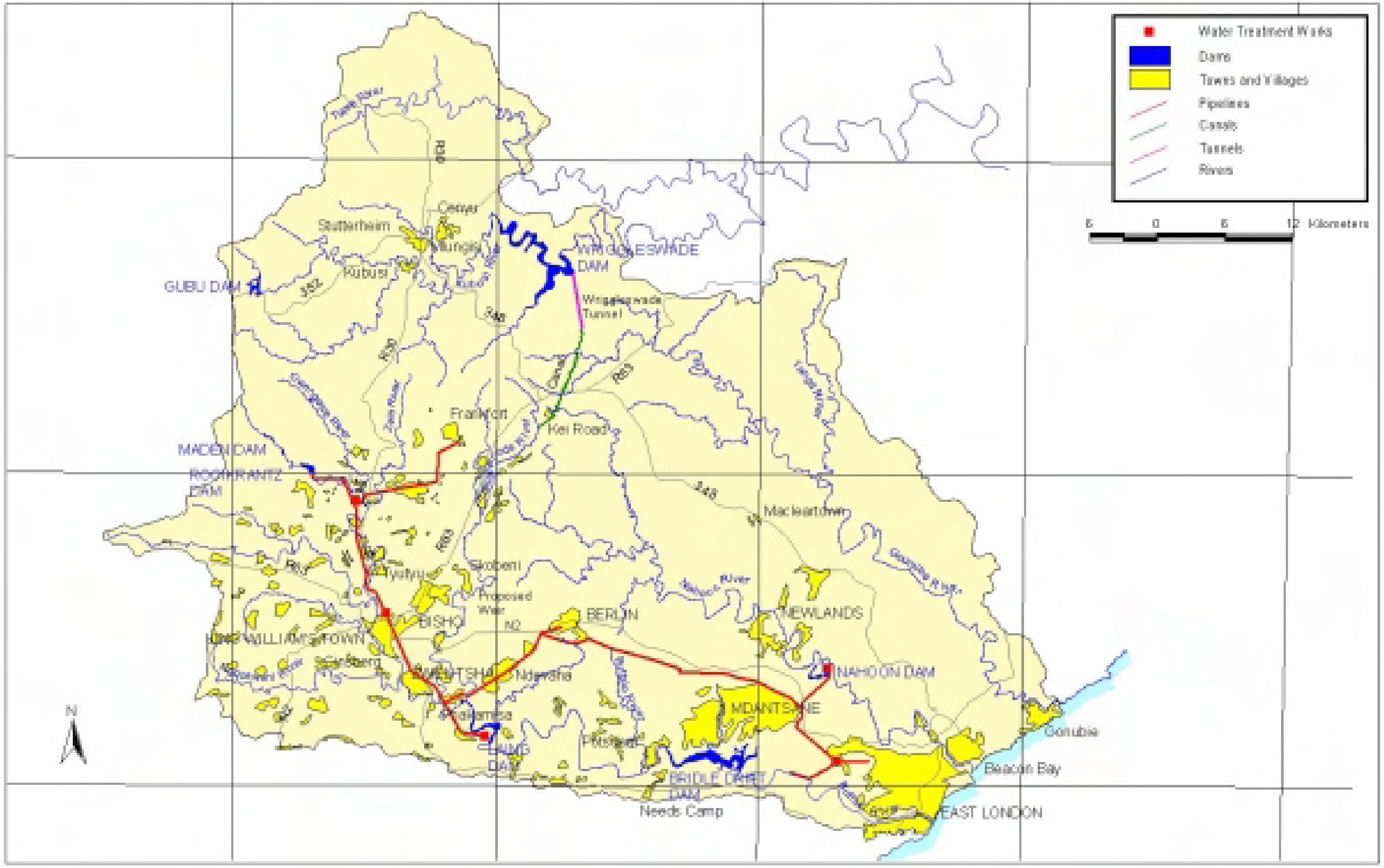
Surface water supplies are obtained from the Buffalo, Nahoon and Kubusi Rivers, which are regulated by seven dams, of which four are on the Buffalo River, two on the Kubusi, and one on the Nahoon (see Diagram 4.2.1.1).

Most of the water demand on the system is in the catchment of the Buffalo River and the adjacent coastal strip and is at present supplied from the dams on the Buffalo and Nahoon Rivers. As a result of the continuing steady growth in this demand it will soon be necessary to supplement supplies with water from the Kubusi River. DWAF has made provision for this by developing a scheme whereby water can be conveyed from Wriggleswade Dam on the Kubusi River to the Buffalo River Basin by means of a canal and tunnel system. The canal can discharge into the headwaters of the Nahoon River or into the Buffalo Basin in the upper reaches of the Yellowwoods River, which is one of the main tributaries of the Buffalo River.

As the Kubusi River water will be discharged into the Buffalo and Nahoon basins at a high level it could be purified at a new high level treatment works and distributed by gravity, or it could be allowed to run down to one or more of the existing dams and be distributed from there, an arrangement that would entail higher pumping costs but that might achieve economies through the utilisation of existing infrastructure. Studies have been carried out to plan the future development of the scheme. The main components of the existing infrastructure are shown on Diagram 4.2.1.1 and details of the existing water treatment works and their sources of raw water are given in Table 4.2.1.1.

The centres of East London, Gonubie, Beacon Bay and the Newlands area can be supplied from Nahoon, Bridle Drift and Wriggleswade Dams.

The towns and some of the rural villages in the upper part of the Buffalo River catchment are supplied from Laing, Rooikrantz and Maden Dams, and also have access to water from Wriggleswade Dam by means of transfers to Laing Dam. Mdantsane can be supplied from Laing, Bridle Drift or Nahoon Dams. Some of the rural villages in the area are not connected to the scheme yet, but it is planned to supply all except a few that are already supplied from Sandile Dam.



THE AMATOLE WATER RESOURCES SYSTEM

DIAGRAM 4.2.1.1

TABLE 4.2.1.1: WATER TREATMENT WORKS OF THE AMATOLE SYSTEM

TREATMENT WORKS			RAW WATER SOURCE *				
NAME	CAPACITY (Mℓ/d)	OWNER/ OPERATOR	NAME	1:50 YEAR YIELD **		ADDITIONAL YIELD ALLOCATED TO OTHER USERS (million m^3/a)	OWNER/OPERATOR
				(million m^3/a)	(Mℓ/d)		
Rooikrantz King William's Town	1,2 7,0	DWAF/Amatola Water King William's Town TLC	Rooikrantz Dam Rooikrantz and Maden Dams	3,10	8,5	None	DWAF/Amatola Water DWAF/Amatola Water King William's Town TLC
Laing Dam	27,3 ****	DWAF/Amatola Water	Laing Dam	14,90	45,0	None	DWAF/Amatola Water
Umzoniana	120,0	East London TLC	Bridle Drift Dam	30,70	79,0	None	East London TLC
Nahoon	33,0	DWAF/Amatola Water	Nahoon Dam	5,60	15,0	1,3 irrigation 0,9 environmental	DWAF/Amatola Water
Stutterheim	2,5	Stutterheim TLC	Gubu Dam Kubusi River Boreholes	2,27	6,3	0,63 irrigation	DWAF/Amatola Water
Kei Road	0,3	Kei Road TLC	Wriggleswade Dam	0,10	0,3	16,8 future urban 3,0 irrigation 5,5 environmental	DWAF/Amatola Water
Needs Camp	0,8	Provincial Govt.	Buffalo River	***	***	None	
TOTALS	192,1			56,67	154,1	28,13	

* Includes effluent return flows for expected level of development in the year 2010

** Yields from individual dams vary depending on how the system is operated.

*** Included in firm yield of Laing Dam.

**** Capacity in 1995 was 17 Mℓ/day, but the works were being refurbished in 2000 to have a capacity of 27,3 Mℓ/day.

The raw water supplies to this part of the system will meet the requirements of consumers to about the year 2008, but the treatment capacity may need to be increased.

Needs Camp is supplied with water abstracted from the Buffalo River between Laing and Bridle Drift Dams. Water is treated at a small works with a capacity of 0,8 Mℓ/d and distributed to 29 000 people in Needs Camp, ten rural villages and the coastal resort of Kayser's Beach. The average availability of water from this scheme is estimated to be 22 ℓ/c/d, assuming a peaking factor of 1,2. This is a temporary arrangement and it is planned eventually to decommission the treatment works and connect the distribution pipework to the Mdantsane supply main.

Water for the supply to Kei Road is abstracted from the Wriggleswade Canal, and treated at the town's own plant before distribution to the 3 000 consumers. The capacity of the plant is 0,3 Mℓ/d, or 0,09 million m^3/a at a peaking factor of 1,2. Average availability of water to the consumers is 82 ℓ/c/d, treatment capacity being the limiting factor.

Water for Stutterheim and five surrounding settlements is obtained from Gubu Dam and the Kubusi River. As these abstractions affect the yield of Wriggleswade Dam, the supply is considered to be part of the Amatole Water Supply System. Water is also obtained from two mountain streams and two boreholes, but the yield of these sources falls to only about 0,07 million m^3/a during droughts. The supply from the Kubusi River is abstracted from a weir near Stutterheim. When there is insufficient water in the river, releases are made from Gubu Dam.

The allocation from the dam is 2,2 million m^3/a, but about 30% of this is lost between the dam and the weir. These sources will meet the requirements of the scheme to about the year 2000. The treatment works have a capacity of 2,5 Mℓ/d, or 0,76 million m^3/a at a peaking factor of 1,2. Treatment capacity is, therefore, the limiting factor in the availability of water, which is an average of 65 ℓ/c/d for the 32 000 people supplied by the scheme.

4.2.2 Other Regional Water Supply Schemes in the Amatole Region (Drainage Region R)

In addition to the Amatole System, there are nine other regional potable water supply schemes in Drainage Region R, as described hereunder :

(i) The Mgwali Heckel Scheme provides standpipe supplies to six villages north-east of Stutterheim from boreholes. The yield of the boreholes is 0,42 million m^3/a, and they supply some 4 500 people. Present availability of water is, therefore, 255 ℓ/c/d. The supply is expected to be adequate to beyond the year 2015.

(ii) The Wartburg Scheme provides standpipe supplies to five villages and an informal settlement with a combined population of 5 000 people. Water is provided from three boreholes with a combined yield of 0,27 million m^3/a. Availability of water is 148 ℓ/c/d of the population served. The supply is expected to be adequate in terms of quantity to beyond the year 2015.

(iii) The Kwelera Scheme provides standpipe supplies to 18 000 people living in seven villages in an area situated 30 km north-east of East London. Water is obtained from eleven boreholes with a combined yield of 0,88 million m^3/a. Average availability of water to consumers is 133 ℓ/c/d. The salinity of the water from some of the boreholes is higher than desirable, but this has been overcome by blending with better quality water from other boreholes. The capacities of some of the borehole pumps will need to be upgraded to meet peak summer demands by about the year 2010, but the quantity of water available should be adequate to beyond 2015.

(iv) The Mooiplaas Scheme provides standpipe supplies to about 30 000 people living in fifteen villages in the Mooiplaas area, which is about 35 km north-east of East London. Water is supplied from fifteen boreholes with a combined yield of 0,60 million m^3/a. Availability of water is 55 ℓ/c/d at present, but water quality is reported to be marginal in terms of salinity and nitrate concentrations. The population in this area is expected to increase steadily at a rate of about 3% per annum, with the result that additional raw water supplies will be required soon after the year 2000 (DWAF, 1994).

(v) The Tyume Valley Water Supply Scheme was planned to provide water to some 43 000 inhabitants of the Tyume River valley from the town of Alice upstream. In 1995, only some 15 000 people in Alice and some areas in its vicinity are supplied. The inhabitants of many of the rural villages still relied on supplies from local boreholes, springs and small dams that were in many cases inadequate. Water for the scheme is obtained from Binfield Park Dam which has a 1:50 year yield of 3,65 million m^3/a allocated to domestic water supplies. It is piped from the dam to the treatment works at Alice which have a capacity of 3,6 Mℓ/d or 1,1 million m^3/a. Present average availability of water to the consumers of the scheme is 195 ℓ/c/d. Binfield Park Dam was also intended to support 793 ha of irrigation and the remaining yield of the dam of 15,39 million m^3/a at 1 in 10 year reliability was allocated to this. A 4,8 Mℓ/d water treatment works was constructed near Binfield Park Dam, but this was not used as the rural water supply scheme for which it was intended was not constructed. There is a third treatment works at Pleasant View Dam. This has a capacity of 0,75 Mℓ/d and supplies the Phandulwazi Agricultural College. Pleasant View Dam is upstream of Binfield Park and was originally constructed to supply water to Alice. It has a 1:10 year yield of 1,95 million m^3/a. At one time it was planned to develop 240 ha of irrigation using water from the dam as it is no longer required to supply Alice.

(vi) Debe Regional Water Supply Scheme provides standpipe supplies to 23 rural villages scattered over a 400 km^2 area. The scheme supplies a total of 29 000 people from Debe Dam which has a 1:50 year yield of 2,15 million m^3/a. The treatment works has a capacity of 1,5 Mℓ/d or 0,45 million m^3/a. The limiting factor on the capacity of the scheme at present is, therefore, the treatment capacity. The treatment works were designed to be trebled in size to keep pace with growth in water requirements. The present average availability of water to consumers is 42 ℓ/c/d.

(vii) The Keiskammahoek Water Supply Scheme supplies water from Mnyameni Dam to the town of Keiskammahoek and seven rural villages. The 1:50 year yield of the dam is 2,3 million m^3/a. A pipeline from the dam conveys water to the Keiskammahoek Water Treatment Works some 12 km south of the dam. It also supplies two other small treatment works along the way, namely at Upper Gxulu (0,11 Mℓ/d) and at Upper Mnyameni (0,56 Mℓ/d). The Keiskammahoek works have a capacity of 2,22 Mℓ/d. Thus, the scheme is able to supply 0,88 million m^3/a of treated water. The average availability of water to the 12 000 consumers that it supplies is 200 ℓ/c/d. This is considerably more than the present water requirement which is estimated to be 0,34 million m^3/a, or 78 ℓ/c/d. The scheme also provides water for the irrigation of about 200 ha of land from the raw water pipeline.

(viii) Wesley Regional Water Supply Scheme provides treated water to Wesley and coastal resorts between the Bira River mouth and the Fish River mouth. Water is pumped from the Keiskamma River into the headwaters of the Bira River and abstracted at a weir on the Bira River 23 km downstream. It is treated at a 43 Mℓ/d capacity works near the weir and distributed from there. This scheme supplies about 700 people at Wesley and a small number of permanent residents at the coastal resorts, but it has been sized to meet peak holiday season requirements when large numbers of tourists visit the coastal resorts.

(ix) The Sandile Regional Water Supply Scheme supplies treated water to the urban centres of Middledrift and Dimbaza, Fort Cox Agricultural College and more than fifty rural villages scattered throughout the middle reaches of the Keiskamma River Basin. Water is obtained from Sandile Dam which can supply 11,60 million m^3/a for domestic use at a 1:50 year risk of failure and, in addition, 8,73 million m^3/a of irrigation water at a 1:10 year risk of failure. The water treatment works has a capacity of 18 Mℓ/d, or 5,4 million m^3/a. The average availability of water to the 104 000 people supplied by the scheme is 142 ℓ/c/d, but some 60 villages are still to be connected to the scheme in terms of the original planning. These latter villages at present rely on untreated borehole supplies, many of which are poor in quality, because of high salinity, and low in yield.

4.2.3 Regional Water Supply Schemes in the Great Kei River Basin (Drainage Region S)

In 1995, there were ten regional potable water supply schemes as described below :

(i) The Klipplaat River Government Water Scheme supplies raw water for domestic supplies to Queenstown and Sada, and irrigation water to farmers along the Klipplaat River, from the Waterdown Dam. The dam is owned and operated by DWAF. Its live storage capacity is 36,6 million m^3 and its 1:50 year yield is about 16,5 million m^3/a. The existing allocations from the dam, comprising 8,25 million m^3/a to Queenstown, 4,2 million m^3/a to Sada, and 14,83 million m^3/a to irrigation cannot be supported at an acceptable level of assurance.

(ii) The Queenstown Water Supply Scheme, serves the urban areas of Queenstown and Ezibeleni. Water is conveyed by pipeline from the Waterdown and Bongolo Dams to the Queenstown Water Treatment Works (40 Mℓ/d) and distributed to consumers from there. Bongolo Dam has a firm yield of 0,65 million m^3/a, which, together with the 8,25 million m^3/a allocation from Waterdown Dam, gives a total raw water supply of 8,9 million m^3/a. The treatment works can produce 12 million m^3/a. Therefore, the capacity of the scheme is limited by the source. The average availability of water to the 50 450 consumers supplied is 483 ℓ/c/d. Present requirements from the scheme are about 7 million m^3/a. It is estimated that additional raw water supplies will be required in the near future.

(iii) The Zweledinga Irrigation Scheme is intended primarily for irrigation, but supplies water to two rural villages as well. The water for each village is treated at a separate small treatment works. These are the Yonda WTW (capacity 0,18 Mℓ/d) and the Mbekweni WTW (capacity 0,16 Mℓ/d). Water is supplied from Bushmanskrantz Dam which has live storage of 4,62 million m^3 and a firm yield of 2,07 million m^3/a.

The irrigation requirement is 1,50 million m^3/a and the domestic water supply requirement is 0,04 million m^3/a. The scheme is owned and operated by DWAF. The consumers supplied by the two schemes are estimated to number about 9 200. Usage in 1995 was 12 ℓ/c/d, while water availability was 30 ℓ/c/d.

(iv) Cacadu Rural Water Supply Scheme provides standpipe supplies to approximately 64 000 people, including the population of the town of Lady Frere. Water is obtained from Macubeni Dam, which has a live storage capacity of 1,85 million m^3 and a firm yield of 1,54 million m^3/a. It is distributed via a treatment works with a capacity of 3,5 Mℓ/d, or 1,06 million m^3/a. The capacity of the scheme is, therefore, determined by the treatment works. Availability of water to consumers is 45 ℓ/c/d. The dam is expected to be subjected to a fairly high rate of siltation and should be closely monitored in this respect.

(v) Zimele Rural Water Supply Programme had developed protected spring supplies for some 80 villages by 1993 and it is anticipated that the programme will eventually provide water for 120 000 people in 100 villages in the Cacadu, Cofimvaba and Xalanga magisterial districts. The average quantity of water available to consumers through the scheme is not known.

(vi) The Hewu Groundwater Scheme supplies water to 48 villages in the Hewu magisterial district from boreholes equipped with windmills or diesel driven pumps. Borehole yields in this area are normally in excess of 5 m^3/hr (DWAF, 1993). Development of the scheme is ongoing. The total population served is about 66 000 people. It was estimated (DWAF, 1993) that by 1991, about 72% of the population had access to an average of 30 ℓ/c/d of potable water. Supplies to the remainder of the population were inadequate but were being improved.

(vii) Ilinge Water Supply Scheme supplies the town of Ilinge and surrounding villages from six boreholes. The scheme has a yield of 1,3 million m^3/a and supplied some 13 000 consumers in 1995. Water availability was, therefore, 279 ℓ/c/d. The scheme is expected to be adequate to beyond the year 2015.

4.2.4 Regional Water Supply Schemes in Drainage Region T

The localities of five regional potable water supply schemes that existed in 1995 are shown on Figure 4.1.1 and the schemes are described briefly below :

(i) The Umtata Municipality Water Supply Scheme supplies the city itself and a number of surrounding settlements. Reliable information on the number of people supplied is not available, but it is estimated to have been 175 000 in 1995. Raw water is obtained from the Umtata Dam, which has a 1:50 year yield of 145 million m^3/a. Water from the dam is used for water supplies for Umtata, and for a hydropower scheme situated downstream. The treatment works have a capacity of 40 Mℓ/d and produced 13,9 million m^3 in 1997 and the potable water supply bulk distribution system has a capacity of 60 Mℓ/d, or 19 million m^3/a. The capacity of the scheme is, therefore, limited by the treatment capacity.

(ii) The Libode Rural Water Supply Scheme supplies treated water to 60 000 people living in 57 rural villages and the town of Libode. Raw water is obtained from Mlanga Dam, which has a 1:50 year yield of 0,78 million m^3/a. The treatment works, with a capacity of 3,5 Mℓ/d, can produce about 1 million m^3/a. Therefore, the capacity of the scheme would be limited by the source of raw water in dry years, and is nominally 0,78 million m^3/a. This equates to an average of 36 ℓ/c/d.

If the scheme is to be upgraded to eventually provide 60 ℓ/c/d, both the raw water supply and the treatment capacity will have to be increased.

(iii) The Corana Rural Water Supply Scheme supplies 20 villages adjacent to the Libode Scheme supply area. Water is obtained from Corana Dam (yield 0,34 million m^3/a), purified at a treatment works near the dam with a capacity of 0,72 Mℓ/d, and distributed to approximately 47 000 people. The scheme provided 13 ℓ/c/d in 1995, the limiting factor being the treatment capacity. There were plans to reduce the supply area of the scheme to 12 villages with a population of 23 000. The other villages will be connected to the Umtata supply.

(iv) The Mhlahlane Rural Water Supply Scheme draws water from Mabeleni Dam and supplies 28 000 people in eight villages and some peri-urban areas of Umtata. The dam has a yield of 1,73 million m^3/a and the treatment works a capacity of 0,85 Mℓ/d, or 0,26 million m^3/a. Thus, the limiting factor on the capacity of the scheme, which at present can provide consumers with an average of 25 ℓ/c/d is the size of the treatment works.

(v) The Mtangana Scheme relies on Mtangana Dam, with a yield of 0,06 million m^3/a, and boreholes and springs with a combined yield of about 0,08 million m^3/a, to provide untreated water to about 16 000 people in 20 villages. By developing additional springs and boreholes, the scheme could be extended to serve another 71 villages which have inadequate supplies at present. The present level of supply is 24 ℓ/c/d, but it is understood that difficulties are being experienced in maintaining and operating the scheme.

4.3 POTABLE WATER SUPPLY SCHEMES FOR INDIVIDUAL TOWNS

In the Amatole Region (Drainage Region R), all the towns, with the exceptions of the small holiday resorts that are spread along the coast, obtain their water from regional water supply schemes. In the Great Kei River Basin (Drainage Region S), four towns have their own individual schemes, and there are towns with individual schemes in the portion of Drainage Region T that lies within the WMA.

The schemes in the Great Kei River Basin are the following :

(i) The Komga town water supply relies for raw water on five boreholes, one spring and a pumping scheme from the Kei River. The water from the groundwater sources, which has higher than desirable concentrations of nitrates, is mixed with treated water from the Kei River before distribution to the 5 100 inhabitants of the town. The groundwater sources have a yield of 0,25 million m^3/a and the treatment works can provide 0,25 million m^3/a, giving a total available supply of 0,5 million m^3/a. Average availability of water is, therefore, 268 ℓ/c/d. The bulk supply capacity of the scheme is expected (DWAF, 1994) to be adequate to 2010, but pumping capacity between the treatment works and the town will need to be increased before then.

(ii) The town of Butterworth obtains raw water from the Xilinxa Dam, which releases water to the Gcuwa Weir, both on the Xilinxa River. The combined firm yield of the two dams is 9,4 million m^3/a. This could be increased to 11,3 million m^3/a if water were to be piped from Xilinxa Dam instead of being released down the river to Gcuwa Weir, as it is at present. Of this, 2 million m^3/a will be required for a proposed rural water supply scheme, leaving 7,4 million m^3/a for

Butterworth. It is expected that this will meet requirements to the year 2006. Thereafter an additional source of supply will be required. The treatment works have a capacity of 18 Mℓ/d, or 5,5 million m^3/a, which is equal to the present water requirement of the town. The present quantity of water available to the industries and the 36 450 people in the town is, therefore, limited by treatment capacity. The industrial requirement is 3,0 million m^3/a. Therefore, average availability of water for domestic use is 188 ℓ/c/d.

(iii) Cathcart relies on the Sam Meyer Dam for its water supply. The 1:50 year yield of the dam, which was raised in the year 2000, is 1,0 million m^3/a. The capacity of the treatment works is 3,2 Mℓ/d. Water use in 1995 by the population of 8 000 was 0,5 million m^3/a, or 171 ℓ/c/d.

(iv) The town of Indwe draws water from the Doring River Dam. The 1:50 year yield of the dam is 3,38 million m^3/a. Of this, 0,78 million m^3/a is allocated to the town water supply and the rest to irrigation. The requirement in 1995 was 0,35 million m^3/a, which was equivalent to an average use of 151 ℓ/c/d by the 6 350 inhabitants of the town. The raw water supply will be adequate to beyond 2015.

The individual town supplies in Drainage Region T are the following :

(i) The supply to the town of Willowvale is from a weir on the Nqadu River and two small dams south of the town. The yield is estimated to be 0,15 million m^3/a. The water treatment works have a capacity of 0,36 Mℓ/d, or 0,11 million m^3/a. Present water use by the 2 000 inhabitants of the town is 0,05 million m^3/a. Availability of water, which is determined by treatment capacity, is 150 ℓ/c/d.

(ii) Centane, with a population of about 1 400 people in 1995, obtains water from a borehole and the local river. The yield is estimated to be 0,05 million m^3/a. There is no treatment works. Water availability in 1995 was 97 ℓ/c/d, but the quality of the supply is unknown.

(iii) Tsomo obtains water from a sump in the Tsomo River. The yield of the supply is not known, but it is apparently sufficient for the 1995 requirements of the population of 2 050 people of 0,12 million m^3/a, or 160 ℓ/c/d.

(iv) The town of Idutywa relies on two boreholes, with a yield of 0,27 million m^3/a and three small dams with a yield of 0,22 million m^3/a. The treatment works has a capacity of 1 Mℓ/d, or 0,30 million m^3/a and is the limiting factor in the water supply. Water availability to the population of 12 000 is 68 ℓ/c/d.

(v) The town of Nqamakwe relies on four boreholes with a yield of 0,05 million m^3/a. Availability of water to the 2 050 residents in 1995 was 66 ℓ/c/d.

(vi) Water for the town of Cala is obtained from a weir on the Tsomo River and weirs on two mountain streams. The yield of the raw water sources is not known. The treatment works has a capacity of 1,8 Mℓ/d, or 0,54 million m^3/a. Thus, assuming the raw water supply to be adequate for the treatement works, the availability of potable water to the population in 1995 of approximately 13 350 people was 111 ℓ/c/d.

(vii) Elliot obtains water from the Thompson Dam which has a 1:50 year yield of 0,44 million m^3/a. The water treatment works has a capacity of 1,8 Mℓ/d or 0,54 million m^3/a. The limiting factor on the capacity of the scheme is, therefore, the raw water source. The availability of water in 1995 to the population of 11 050 people was 98 ℓ/c/d.

(viii) The water supply to Ugie is from a weir on the Wildebeest River. Water is diverted to a treatment works with a capacity of 0,8 Mℓ/d, or 0,24 million m^3/a. Availability of water to the population of approximately 4 000 people in 1995 was, therefore, 165 ℓ/c/d.

(ix) The Qumbu Town Scheme relied on two boreholes with a combined yield of 0,04 million m^3/a to supply water to the 4 650 inhabitants of the town in 1995. The water was not treated and the available supply could provide an average of 25 ℓ/c/d to consumers. It appears that the water source will have to be supplemented if the population grows any further.

(x) The Port St Johns Town Scheme abstracts raw water from the Lower Bulolwa Dam, which has a capacity of 0,13 million m^3 and a 1:50 year yield of 0,53 million m^3/a. The capacity of the scheme is limited by the water treatment works, which, with a maximum output of 1,1 Mℓ/d, can provide an average of 0,33 million m^3 of water per annum. The population of the town in 1995 was 12 050 people. Therefore, the water supply scheme provided for an average of 76 ℓ/c/d to the town population. Both the raw water supply and the treatment capacity are being augmented at present (2002).

(xi) Ngqeleni Town Water Supply Scheme relies for raw water on a small dam with a yield of 0,1 million m^3/a and two boreholes with a combined yield of 0,04 million m^3/a. The water treatment works has a capacity of 0,2 Mℓ/d. The capacity of the scheme in 1995 was 0,07 million m^3/a, the limiting factor being treatment works capacity. The scheme could provide an average of 30 ℓ/c/d to the 6 050 inhabitants of the town. The planned development of a low cost housing extension and the construction of a water-borne sewerage scheme were expected to increase the water requirements to about 0,11 million m^3/a by the year 2000.

(xii) The Mqanduli Town Scheme relies on a weir on a local river for raw water. The treatment works capacity is 0,18 Mℓ/d and limits the scheme capacity to 0,05 million m^3/a. The scheme supplied 4 650 people in 1995. Therefore the water availability was 32 ℓ/c/d.

(xiii) The Elliotdale Town Scheme supplied treated water to the town population in 1995 of 2 000 people from a weir on a local river. The treatment works had a capacity of 0,2 Mℓ/d, or 0,06 million $^3/a$. Water availability was 83 ℓ/c/d of the population.

(xiv) The Tsolo Town Scheme provided treated water to the town population in 1995 of 4 650 people from a weir on the Nqadu River. The yield was estimated to be 0,16 million m^3/a, and was the limiting factor on the capacity of the scheme. The treatment works had a capacity of 1,1 Mℓ/d, or 0,33 million m^3/a. Water availability was 94 ℓ/c/d of the population of the town.

(xv) The town of Engcobo relies for its water on two streams with a combined 1:50 year yield of 0,21 million m^3/a. The water treatment works has a capacity of

0,95 Mℓ/d, or 0,29 million m^3/a. The availability of water to the population of 5 650 people in 1995 was, therefore, determined by the source, and was 101 ℓ/c/d. This was inadequate for the requirements of the town, which is a busy regional centre.

4.4 CONTROLLED IRRIGATION SCHEMES

4.4.1 Schemes in the Amatole Region (Drainage Region R)

The three irrigation schemes in the Amatole Region for which water is provided from dams owned by DWAF are described below :

(i) The Zanyokwe Irrigation Scheme is supplied with water from Sandile Dam which has 8,73 million m^3/a of water at 1:10 year assurance allocated to irrigation. The scheme is supplied from a pipeline from the dam which also carries raw water to the Sandile Water Treatment Works. An area of 471 ha of land is scheduled under the Zanyokwe Scheme, but irrigation has declined in recent years and it is reported (Dept of Agricultural and Land Affairs, 1996) that less than 25% of the scheduled land was irrigated in 1995. Crops grown are mainly mixed vegetables.

The pipeline was designed to supply water to 760 ha of land with a water requirement of 8,36 million m^3/a. Releases from Sandile Dam are also made into the river course to supplement natural flow for the irrigation of 62 ha of land along the Keiskamma River.

The Zanyokwe Scheme is due for physical rehabilitation in 2003 and work on creating the Zanyokwe Water User Association is almost complete.

(ii) The Keiskamma Irrigation Scheme is supplied with water by pipeline from the Myameni and Cata Dams. An area of 854 ha of land was originally developed for co-operative dairy farming, and 744 ha was used in 1995 at present (Water Research Commission, 1996). The Cata Dam, with a 1:10 year yield of 7,9 million m^3/a is used purely for irrigation, but the Mnyameni Dam also provides water for domestic use in Keiskammahoek and surrounding villages. After allowing for the domestic requirements, a quantity of 1,96 million m^3/a of water is available for irrigation at 1:10 year assurance. Thus a total of 9,86 million m^3/a of water is available from the two dams, while the present water requirement for irrigation is approximately 6,0 million m^3/a. Some 200 ha of suitable additional land that could be irrigated from the pipelines have been identified previously. This would require an additional 1,6 million m^3/a of water, still leaving a surplus of 2,26 million m^3/a available from the dams.

(iii) The Tyume Irrigation Scheme draws water from a pipeline from Binfield Park Dam that also supplies the Alice Water Treatment Works. After allowing for domestic requirements there is 17,7 million m^3/a of water available from the dam for irrigation use at 1:10 year assurance. In 1995, 114 ha of citrus orchards, with a water requirement of 0,7 million m^3/a were irrigated under the scheme. There was, therefore, about 17 million m^3/a of surplus water available. During dry years some of this was used to support opportunistic irrigation further down the Tyume and Keiskamma Rivers.

4.4.2 Schemes in the Great Kei River Basin (Drainage Region S)

There are six irrigation schemes in the Great Kei Basin where water is supplied from dams owned by DWAF, as described below :

(i) The Klipplaat Government Water Scheme has the Waterdown Dam as its central component. Water is released from the dam into the river channel to supply a scheduled irrigation area of 1 905 ha along the Klipplaat River to its confluence with the Black Kei, and along the Black Kei to its confluence with the White Kei. Water for the Shiloh Irrigation Scheme near Whittlesea is diverted at a weir on the Klipplaat River and conveyed via an earth canal to the farming units. The remainder of the irrigators extract water directly from the river channel. The scheme extends over an almost 150 km length of river and there are considerable losses between the dam and the lower irrigators. At present about 1 820 ha of the scheduled area of 1 905 ha is irrigated. The field edge requirement is estimated (DWAF, 1993) to be 13,34 million m^3/a, while the allocation from the dam is 14,83 million m^3/a. When the allocation of 12,45 million m^3/a for urban demands is added to this, it is clear that the total allocation from the dam exceeds both its firm yield of 16,5 million m^3/a and its 1:10 year yield of 22,1 million m^3/a. The crops grown are lucerne (60%), maize and pasture.

(ii) The Oxkraal Irrigation Scheme comprises the Oxkraal and Shiloh Dams which were constructed with the intention of irrigating 541 ha of land from Oxkraal Dam and 25 ha from Shiloh Dam for small scale farmers. The lands have not been developed, but as an interim measure, water from Oxkraal Dam is released down the river for use on land scheduled under Waterdown Dam. Shiloh Dam, with a firm yield of 0,34 million m^3/a, was unused in 1995 and remains unused in 2002.

(iii) The Nthabethemba Irrigation Scheme comprises a number of separate schemes along the Black Kei River upstream of its confluence with the Klipplaat River. The schemes draw water from the Tentergate, Mitford and Glenbrock Dams and from natural flow in the river. An area of 1 200 ha of land has been developed for irrigation but about 480 ha of this which was for small scale farmers, has subsequently fallen into disuse. Crops grown are maize (80%) and mixed vegetables.

The combined 1:10 year yield of the dams is 2,19 million m^3/a (DWAF, 1993) and the 1:10 year low flow in the Black Kei River is estimated to be 0,33 million m^3/a, giving a total availability of water of 2,52 million m^3/a. This is substantially less than the 4,9 million m^3/a water requirement of the existing irrigated lands (excluding those that have fallen into disuse). The possibility of constructing a major dam on the Black Kei River to provide additional water to the scheme has been investigated (DWAF, 1997) but found to be a very expensive option.

The Thrift and Limietskloof Dams were purchased recently from their original owners, to augment the scheme. The existing Thibet Park diversion canal, which is unlined, needs to be upgraded to achieve effective augmentation from these dams.

(iv) The Zweledinga Irrigation Scheme obtains water from Bushmanskrantz Dam which is situated on the Oxkraal River upstream of Oxkraal Dam. Water is supplied by pipeline from the dam to several small scale farmer schemes which together comprise the Zweledinga Irrigation Scheme. The total irrigated area is 259 ha, with a water requirement of 1,50 million m^3/a. The 1:10 year yield of Bushmanskrantz Dam is 2,52 million m^3/a. This adequately meets the requirements of the irrigation scheme and the potable water supplies to the villages of Yonda and Mbekweni described earlier in this chapter. The main crop grown is maize.

(v) The Qamata Irrigation Scheme was established in 1966 to promote irrigation by small scale farmers. The scheme uses water from Lubisi Dam. Water is released from the dam into the bed of the Indwe River and abstracted at the Lanti diversion weir 9,5 km downstream. The water is conveyed to the irrigated lands via a 28,5 km long concrete lined canal, two balancing dams and thirty-four leidams. Flood irrigation methods are used and the main crop grown is maize, with smaller quantities of lucerne and vegetables. Original planning was for the development of 3 574 ha of land in 1,25 ha plots, but only 2 600 ha were in fact developed. It is reported (Department of Agriculture and Land Affairs, 1996) that only 25% of the area was cropped in 1995 and that the infrastructure was in a poor state of repair.

The Lubisi Dam has a 1:10 year yield of 30,5 million m^3/a. Allowing for conveyance losses estimated at 4,5 million m^3/a (Kei Basin Consulting Engineers, 1993), the yield of the dam is sufficient for the irrigation of 3 050 ha of land. This is well in excess of the 650 ha that were cropped in 1995.

DWAF and the Department of Agricultural and Land Affairs are presently (2002) rehabilitating the infrastructure, and a water user association is soon to be created.

(vi) The Xonxa Dam was constructed in 1972 with the intention of providing water for some 4 900 ha of land along the White Kei River. To date, only 1 643 ha of land have been developed under the Xonxa Irrigation Scheme. Water is released from the dam into the White Kei River and extracted by means of diversion weirs or by pumping from the river into storage reservoirs. Most of the irrigation is by centre pivot, but sprinklers are used on the smaller plots. The scheme supported 224 farmers and the crops produced were maize, vegetables and lucerne. The scheme has experienced difficulties in maintaining pumps and irrigation equipment and has not been financially viable. As a result, it has declined to the extent that an area of only about 60 ha of land was currently irrigated in 1995.

The field edge irrigation requirement of the irrigated lands is estimated to be 9 000 m^3/ha/a and conveyance losses 1,58 million m^3/a (DWAF, 1993). The 1:10 year yield of Xonxa Dam is 33,0 million m^3/a. Therefore the dam is capable of supporting 3 490 ha of irrigation. It appears unlikely, because of unsuitability of much of the soil, that the irrigated area will ever increase to more than 1 000 ha (DWAF, 1997). Therefore, water from Xonxa Dam could be used for other purposes. One possibility is for domestic supplies to villages in the area and to Queenstown.

4.4.3 Schemes in Drainage Region T

There is only one scheme in Drainage Region, T. It is the Ncora Irrigation Scheme, situated in the Mbashe River catchment, which was developed in 1978 when 2 162 ha were put under irrigation using water from Ncora Dam. Subsequently, an additional 838 ha of irrigable land was developed, bringing the total area under irrigation to 3 000 ha. The scheme comprises a central commercial farm unit of 1 743 ha of irrigated land and over 1 700 smaller irrigated units ranging in size between 0,3 ha and 5 ha. Dairy products, maize and vegetables are produced. Because of disagreements between stakeholders in the scheme, it has not prospered in recent years and it is reported (Department of Agriculture and Land Affairs, 1996) that less than 25% of the irrigable lands were cultivated in 1995.

The existing primary infrastructure for irrigation (main canals, storage dams and main pipelines) has been estimated (Stephenson & Associates, 1988) to be sufficient for the development of a total area of irrigated land of 4 745 ha, including that already developed. The field edge water requirement of this would be 48,4 million m^3/a. An additional 0,8 million m^3/a would be required for other uses on the scheme and conveyance losses, bringing the total requirement for the fully developed scheme to 49,2 million m^3/a.

Water is supplied by an inter-basin transfer from Ncora Dam which has a 1:20 year yield of 115 million m^3/a (Stephenson & Associates, 1988). Of this, 85 million m^3/a is allocated to the Collywobbles Hydropower Station and is not available for irrigation. Therefore 30 million m^3/a is available for irrigation at 1:20 year reliability. The equivalent quantity of water available at 1 in 10 year reliability would be approximately 35 million m^3/a, which is less than that required for full scheme development. It would support about 3 000 ha of irrigation, which is the current level of development.

4.5 HYDRO-POWER AND PUMPED STORAGE

There are four hydro-electric powerstations in the WMA, situated as shown on Figure 4.1.1. They were owned by the Transkei Electricity Supply Corporation (TESCOR), but were taken over by Eskom in 1994. The main source of power in 1995 in the area to the east of the Great Kei River was a 132 kV powerline that runs from Kei Bridge to Umtata. A second 132 kV powerline from Kwazulu-Natal was commissioned in 1997. The four hydro-power stations are connected into the same grid as the 132 kV lines and operate in a fully inter-connected fashion, co-generating with the Eskom thermal power stations. Details of the hydro stations follow.

- Collywobbles Power Station on the Mbashe River operates as a run-of-river station, but also has an allocation of 85 million m^3/a of water from Ncora Dam on the Tsomo River. It has 3 x 14,5 MW generating sets installed and provision has been made in the structure for the installation of a fourth 14,5 MW set in the future. Water is diverted into the power station by a diversion weir. The weir basin has silted up and has negligible storage. Regular removal of silt by dredging is necessary to keep the power station intake clear. Prior to the commissioning of the second 132 kV powerline in 1997, the power station was operated as much as possible throughout the year. In summer, when there is plenty of water in the Mbashe River, it was run to produce as much energy as the available water and system demand allowed. In winter, when there is a deficiency of water in the Mbashe River, it was operated at a low load factor to provide peaking power. Since 1997 it has been operated in parallel with the other hydro-power stations to minimise the total cost of electricity taken from the Eskom transmission network, in accordance with the Eskom Time of Use Tariff (DWAF, 2001a). Water requirements are 2,96 million m^3 per GWh (Power & Stephenson, 1987).

- Ncora Power Station is situated at Ncora Dam on the Tsomo River and has 1 x 1,6 MW and 2 x 0,4 MW generating sets installed. The station is normally operated only when water is released from Ncora Dam to the Collywobbles Power Station. Water requirements are 10,5 million m^3 per GWh.

- The Umtata Falls facility consists of two stations on the Umtata River that operate in tandem, using water released from Umtata Dam. The First Falls station has 2 x 3 MW generators installed, with room for the future installation of an additional 6 MW of generating capacity. Diversion into the power station is by means of a 12m high gated concrete weir with a storage capacity of 0,96 million m^3. The Second Falls Station has 2 x 5,5 MW sets installed with provision for the future installation of another 11 MW of generating capacity. Diversion into the station is by means of a 13m high gated concrete weir with a storage capacity of 1,3 million m^3. Water requirements of the two stations operated together are 5,4 million m^3 per GWh.

  Initially, the Umtata Falls facility was used for peaking power and operated at a load factor of about 0,13, but demand in Umtata increased to the extent that the facility is operated at higher load factors, the average annual load factor between 1979 and 1994 being 0,21 (DWAF, 2001a). Since 1997 the facility has been operated to minimise the total cost of electricity taken from the Eskom transmission network in accordance with the Eskom Time of Use Tariff.

Technical details of the power stations are summarised in Table 4.5.1. There are no pumped storage schemes in the WMA.

TABLE 4.5.1: HYDRO-POWER STATIONS

CHARACTERISTIC		**STATION**			
		COLLYWOBBLES	**NCORA**	**MTATA FALLS (1st Falls)**	**MTATA FALLS (2nd Falls)**
Locality	Latitude Longitude	32° 02' 36" S 28° 37' 36" E	31° 47' 11" S 27° 40' 39" E	31° 36' 00" 28° 49' 09" E	31° 41' 02" 28° 53' 00" E
Rated capacity		14,5 x 3 = 43,5 MW	2,1 MW	3,0 x 2 = 6,0 MW	5,5 x 2 = 11,0 MW
Peak capacity (generator limitation()		17,5 x 3 = 52.5 ,W	2,4 MW	3,4 X 2 = 6,8 MW	6,0 x 2 = 12,0 MW
Rated head		148 m	48 m	28 m	50 m
Load factor		37%	44%	39%	18%

(1) Load factor may vary from year to year. The values given are typical for each station.

CHAPTER 5: WATER REQUIREMENTS

5.1 SUMMARY OF WATER REQUIREMENTS

Water requirements in the Mzimvubu to Keiskamma WMA totalled an estimated 2 656 million m³/a in 1995, distributed amongst user groups as shown in Table 5.1.1. The major requirements were for the riverine ecosystem, which, at 1 488 million m³/a, accounted for 56% of total water requirements, hydro-power which used 570 million m^3/a (21%), and agriculture, which required an estimated 220 million m³/a (8%) to sustain it. Afforestation used a substantial 165 million m^3/a, and alien vegetation used 95 million m^3/a. Urban and domestic water use was relatively small at 115 million m³/a (4%), and the remaining groups of bulk water use, water transfer and neighbouring states used only small quantities of water, or none at all.

The values shown in Table 5.1.1 include conveyance and distribution losses, where applicable, and have not had return flows that are re-used further downstream deducted from them. Therefore, they represent estimates of gross water use.

It should be noted that, because of the limited availability of reliable data, the level of confidence in the estimates is not high. Values are given to two decimal places in Table 5.1.1 for ease of correlation with other more detailed tables appearing later in this chapter, but that does not mean that the values are accurate to two decimal places.

The agricultural water requirements shown in Table 5.1.1 represent irrigation and livestock watering requirements. Livestock accounts for 52 million m³/a.

The distribution of total equivalent water requirements at 1:50 year assurance is shown on Figure 5.1.1, and water requirements per user group are shown on Figure 5.1.2.

TABLE 5.1.1: WATER REQUIREMENTS PER USER GROUP IN 1995

USER GROUP	ESTIMATED WATER REQUIREMENT		REQUIREMENTS AT 1:50 YEAR ASSURANCE	
	(million m^3/a)	%	(million m^3/a)	%
Ecological Reserve (5)	1 488,20	56	232,70	29
Domestic (1)	115,03	4	115,03	14
Bulk water use (4)	1,60	1	1,60	1
Neighbouring States	0,00	0	0,00	0
Agriculture (2)	220,34	8	193,42	24
Afforestation	164,58	6	46,00	6
Alien vegetation	95,35	4	23,20	3
Water transfers (3)	0,00	0	0,00	0
Hydropower	570,00	21	185,00	23
TOTALS	2 656,10	100	796,95	100

(1) Includes urban and rural domestic requirements (excluding stock watering) and commercial, institutional and municipal requirements.
(2) Includes requirements for irrigation, dry land sugar cane, livestock and game.
(3) Only transfers out of the WMA are included.
(4) Includes thermal power stations, major industries and mines.
(5) At outlet of WMA.
(6) The requirement shown at 1:50 year assurance represents the impact on the system yield, as developed in 1995, of the estimated water requirement.

The requirements at 1:50 year assurance for the domestic, bulk water use and agricultural user groups, are equivalent requirements. They are presented in this way to bring quantities of water that are required at different assurances of supply by consumers to a common base for purposes of comparing water requirements with the available yield. For example, a portion of the yield of a dam might be allocated to industrial use at 1:200 year assurance, a portion to irrigation of orchards at 1:20 year assurance, and a portion to annual crops at 1:5 year assurance. The yield/assurance curve for a dam defines the quantity of water that can be supplied at any particular assurance : the lower the assurance, the greater the quantity of water that can be provided. Thus, for the hypothetical dam of the above example, the quantity of water supplied at 1:200 year assurance could be converted to a theoretical equivalent greater quantity of water at 1:50 year assurance by using the yield/assurance curve. Similarly, the quantities of water supplied at 1:20 year assurance and 1:5 year assurance could be converted to equivalent theoretical smaller quantities at 1:50 year assurance. Adding together the three equivalent quantities at 1:50 year assurance would give the total equivalent requirement at 1:50 year assurance. This value could be compared with the yield of the dam at 1:50 year assurance to determine the balance between yield and allocations of water.

Domestic water requirements and the drinking water requirements of livestock have been assumed to be supplied at 1:50 year assurance under normal conditions. The assurances at which water for irrigation is required have been assumed to vary with the commercial value of the crops irrigated. This accounts for the smaller requirement at 1:50 year assurance for agriculture in Table 5.1.1.

The hydro-power requirement varies considerably from year to year and the 570 million ^{3}/a is indicative of the maximum requirement. The 1:50 year requirement of 185 million m^3/a is the quantity of water assumed to be available from dams under 1:50 year drought conditions when it has been assumed that negligible run-of-river flow would be available.

The estimated water requirement for the ecological Reserve shown in Table 5.1.1 is the average volume of water that needs to be allowed to flow into the sea from the WMA. The requirement at 1:50 year assurance is the impact of the requirement for the ecological Reserve on the available 1:50 year yield of the water resources as developed in 1995. It should be noted that, if more major dams were constructed, the impact of the ecological Reserve on the 1:50 year yield would increase.

Similarly, the estimated requirements for afforestation and alien vegetation are the reductions that they cause in mean annual runoff, while the requirements at 1:50 year assurance are their impacts on the available 1:50 year yield in 1995.

5.2 ECOLOGICAL COMPONENT OF THE RESERVE

5.2.1 Introduction

The classification of the main stem rivers in the vicinity of the outlets of the quaternary catchments is described in Section 2.6.3. On the basis of this classification, a so-called desktop method has been developed (Hughes and Münster, 1999) to provide a low-confidence estimate of the quantity of water required for the ecological component of the Reserve, which is suitable for use in this water resources situation assessment.

The method involves the extrapolation of high confidence results of previous instream flow requirement (IFR) workshops, the use of a reference time series of monthly runoff at the outlet of the quaternary catchment and a number of hydrological indices or parameters that have been defined for 21 desktop Reserve parameter regions in South Africa. These desktop Reserve parameter regions are described and shown in Figure 5.2.1.1. The instream flow requirements that were determined previously were mostly based on the use of the Building Block Method (King and Louw, 1998). The monthly time series of natural flow that has been used is described in Section 6.3. The following are the two main hydrological parameters :

- a measure of the longer term variability, which is a combination of the coefficients of variation of winter and summer volumes (CV); and
- an estimate of the proportion of the total flow that occurs as base flow (BFI), which can be considered to be a measure of short-term variability.

The ratio of the above two indices (CV/BFI) has been used as an overall hydrological index of flow variability or reliability. Rivers with low variability and a high base flow response have very low hydrological indices of flow variability and vice versa.

A relationship has been found between the hydrological index of flow variability, the ecological status and the annual requirements for low and high flows for the so-called maintenance and drought periods of the modified flow regime for the river. The essence of the relationship is that for a particular ecological status or class, the water required for the ecological component of the Reserve will increase as the hydrological index of flow variability decreases, and vice versa. Likewise the water requirement will decrease as the ecological status is decreased.

The method that has been used is based on a series of assumptions, many of which have not yet been verified due to either a lack of information or of time since the method was developed. The following is a summary of the main limitations in order to provide an indication of the level of accuracy that can be expected :

- The extrapolations from past IFR workshops are based on a very limited data set, which does not cover the whole of the country. While some development work has been completed to try and extend the extrapolations and has improved the high flow estimations for dry and variable rivers, this has been limited.
- The extrapolations are based on a hydrological index and no allowance (in the desktop method adopted for this water resources situation assessment) has been made for regional, or site specific ecological factors. It is unlikely that an index based purely on hydrological characteristics can be considered satisfactory but it represents a pragmatic solution in the absence of sufficient ecological data.
- The method assumes that the monthly time series of natural flows are representative of real natural flow regimes and many of the algorithms rely upon the flow characteristics being accurately represented. Should the data indicate more extended base flows than actually occur, the hydrological index of flow variability would be under-estimated and the water requirements for the ecological component of the Reserve would be over-estimated.

5.2.2 Quantifying the Water Requirements

A simulation model has been developed to simulate the relationships that were found to exist between the hydrological index of flow variability, the ecological status and the annual requirements for low and high flows and for so-called maintenance and drought flow periods (Hughes and Münster, 1999).

The simulation model provides annual maintenance and drought low flows and maintenance high flows (expressed as a proportion of the mean annual runoff). The model also provides for the seasonal distribution and assurances associated with the monthly flows on the basis of a set of default parameters that has been developed for each of the 21 desktop Reserve parameter regions of South Africa referred to in Section 5.2.1. The quaternary catchments in the Mzimvubu to Keiskamma WMA fall within the so-called Eastern Cape, Amatole, T Drainage Region and T Drainage Region (coast) regions.

The monthly time series of natural flows at the outlets of the quaternary catchments have been used to generate an equivalent time series of water requirements for the ecological component of the Reserve. This has been accomplished by relating the assurances of the natural flows in a particular month to the assurances of the flow required for the ecological component of the Reserve during the same month.

In the water balance model it is necessary to express the water requirements for the ecological component of the Reserve in terms of annual requirements that are directly comparable to those of any other sector. It therefore becomes necessary to reduce these water requirements to a common assurance and more specifically the effect that these requirements will have on the capacity of the river system to supply water at a specific assurance, i.e. the effect on the yield of the river system.

The effects on the yield of the river system of the water required for the ecological component of the Reserve have been based on an analysis of the monthly time series of these water requirements for the same 70-year period as for the natural time series of flows that is described in Section 6.3. This has been estimated by establishing the average annual quantity of water required for the ecological component of the Reserve during the most severe or so-called critical drought that has determined the yield of the river system at a recurrence interval of 50 years. The duration of the critical drought can be approximated by the (inverse of) marginal rate of increase of the yield of the river system per unit increase in storage capacity, i.e. the slope of the storage-yield curve at the storage capacity under consideration. The periods of high and low flows in the monthly time series of water requirements for the ecological component of the Reserve also mimic the periods of high and low flows in the monthly time series of natural flows used to establish the yield of the river system. Therefore, the portion of the yield of the system that is required for the ecological component of the Reserve can be estimated by finding the least average flow for all periods in the monthly time series of water requirements for the ecological component of the Reserve that are as long as the critical drought period.

The monthly time series of water requirements for the ecological component of the Reserve has been determined at the outlet of each quaternary catchment for each of the ecological status Classes A to D. These time series have been analysed for various lengths of the critical drought to establish the system yield required for the ecological component of the Reserve. This has been done for a range of system capacities, from which the appropriate value corresponding to the storage capacity being considered has then been selected for use in the water balance.

The method that has been used to quantify the water requirements is based on a series of assumptions, many of which have not yet been verified due to either a lack of information or of time since the method was developed. The following is a summary of the main limitations in order to provide an indication of the level of accuracy that can be expected :

- The seasonal distributions of the annual estimates of water requirements are based on analyses of the base flow characteristics of some 70 rivers using daily data, the results of which were then regionalised. Some individual quaternary catchments that have been allocated to a specific region may however, have somewhat different characteristics.

- Similarly, the regional parameters for the assurance rule curves have been based on the duration curve characteristics of the natural flow regimes represented by the monthly time series of flow described in Section 6.3 and some experience of setting assurance rules used at past IFR workshops. Regionalising was done by investigating a representative sample of quaternary catchments and it is therefore possible that some have been assigned to the wrong regions.

- The estimates of water required for the ecological component of the Reserve are the best estimates that can be given at this stage, but must be regarded as low confidence estimates. As more detailed estimates are made for a wider range of rivers, the estimates will be improved through modifications made to the delineation of the regions and the regional parameters that have been assigned. It is also anticipated that a better way of accounting for regional or site specific ecological considerations will be added in due course.

5.2.3 Comments on the Results

The determination of the PESC, as described in Section 2.6, is a critical component of quantifying the water requirements of the ecological component of the Reserve. The members of the specialist team that carried out the assessment expressed their opinions on the strengths and weaknesses of the processes. These opinions are summarised below:

- The process could be improved with the use of up to date GIS land usage maps with the EISC on them.

- Inclusion of an amphibian and vegetation expert would aid the process and validity of the Eastern Cape data.

- Findings should be treated with extreme caution and only used as a desktop estimate as some of the confidence levels are very low.

- There is a need for a follow-up survey to validate the data.

- Quaternary catchments are a problem as they are non-ecological (should be an eco-region approach).

- There is a need to note that present status of rivers can vary within groupings due to localised degradation of sections of rivers.

- In order to aid the process, more readily available information in the form of maps (e.g. land-use coverages, vegetation zones, etc) should have been made available.

- Where very little or no direct knowledge of a river was available, it proved necessary to provide an assessment by using regional expertise to extrapolate and using 1 250 000 maps to examine contours (for gradient, gorges, etc), roads (for indicators of access or isolation), towns and villages (as indications of population density) and land uses (e.g. plantations).

- Confidence scores should be extrapolated to ensure that where riverine systems are not well known this can be indicated.

- The Models are based only on flow and water quality, with the result that improvements to the riverine system by means of changing land use practices was not taken into account.

5.2.4 Presentation of Results

The water requirements of the ecological component of the Reserve derived from the assessment are shown in Table 5.2.4.1 in terms of percentage of MAR, long term average annual flow volume and impact on 1:50 year yield, for key points. The key points are all located at the outlets of the key areas described in Section 2.1.

The long term average total ecological flow requirement for the whole WMA is 1 488 million m^3/a, or 20,5% of the total natural MAR. However, it can be seen from Table 5.2.4.1 that the percentage of the MAR required for ecological flows varies considerably from key point to key point within the WMA. The highest requirement in terms of percentage of MAR is in the Pondoland Coastal Catchments where up to 29,15% is required, because of the high conservation value of the rivers, whereas the requirement for the Klaas Smits River, which has been heavily impacted by farming activities is only 8,9%. It should be noted that the requirements are for the preservation of the rivers in their present states, and do not provide for improvement.

TABLE 5.2.4.1: WATER REQUIREMENTS FOR THE ECOLOGICAL COMPONENT OF THE RESERVE

KEY POINT	PRESENT [2] ECOLOGICAL STATUS CLASS (PESC)	RIVERINE ECOLOGICAL WATER REQUIREMENTS FOR PESC			
		% VIRGIN MAR	LONG-TERM AVERAGE REQUIREMENT (million m^3/a)	CUMULATIVE IMPACT ON 1:50 YEAR YIELD (million m^3/a)	INCREMENTAL IMPACT ON 1:50 YEAR YIELD (million m^3/a)
Southern Coastal Catchments (R50A, R50B)	C	12,8	5,4[1]	0,0[1]	0,0
Keiskamma (R10M)	D	9,9	13,6[1]	3,1[1]	3,1
Amatole Coastal Catchments (R40A, R40C)	C	12,8	9,8[1]	0,0[1]	0,0
Buffalo (R20G)	D	9,6	9,4[1]	4,6[1]	4,6
Nahoon, Gqunube (R30A, R30B, R30D, R30F)	D	9,1	18,5[1]	1,3[1]	1,3
White Kei (S10J)	D	9,4	15,2	6,8	3,1
Indwe (S20D)	D	12,6	8,3	5,2	5,2
Klaas Smits (S31G)	D	8,9	4,7	0,2	0,2
Black Kei (S32M)	D	9,6	18,9	2,1	1,9
Thomas (S40F)	C	13,5	61,8	11,9	1,5
Tsomo (S50J)	D	9,3	26,3	6,2	6,2
Kubusi (S60E)	D	18,6	20,6	7,0	7,0
Great Kei and Xilinxa (S70F)	C	14,0	130,4[1]	34,4[1]	9,3
Mbashe (T13E)	C	14,0	112,4[1]	12,0[1]	12,0
Mtata (T20G, T70B, T70D, T70F, T70G, T80A, T80D)	D, B	14,4 and 21,9	145,2[1]	28,7[1]	28,7
Upper Mzimvubu (T33K)	C	15,1	198,2	31,4	4,7
Mzintlava (T32H)	C	16,0	57,2	13,4	13,4
Kinira (T33G)	C	14,9	68,0	13,3	13,3
Tina (T34K)	C	19,7	105,3	22,7	22,7
Tsitsa (T35M)	C	19,7	182,7	60,8	60,8
Lower Mzimvubu (36B)	B	26,2	758,7[1]	115,0[1]	0,1
Pondoland Coastal Catchments (T60 A,D,G,H,J,K)	B	25,6 to 29,5	215,0[1]	25,9[1]	25,9
Southern Wild Coast (T90B,C,D,E,F,G)	B	21,6	69,8[1]	7,7[1]	7,7
TOTAL WMA	-	20,5	1488,2	232,7	232,7

(1) Included in total for WMA
(2) The class allocation in the table denotes that of the river at the key point (i.e. outlet of the catchment). In "combined outlet" key areas, more then one class may be applicable as a common outlet does not physically occur.

5.2.5 Discussion and Conclusions

The determination of the impact of the ecological flow requirements on the 1:50 year yield of the Mzimvubu to Keiskamma WMA is complex because there are several dams of significant size and there is also use of the run-of-river yield in some areas. The estimated impact on the total 1:50 year yield of the WMA is 232,7 million m^3/a, made up as shown in Table 5.2.4.1. These estimates are at a low level of confidence and it is possible that the true impact is higher than estimated. The impacts are a combination on the yields of dams and impacts on utilised run-of-river yield, calculated as described in Section 7.1.3.

The above is a very rough approach to determining the impact of the ecological reserve on yield, but a more accurate approach would require considerably more detailed calculations that do not fall within the scope of this situation assessment.

5.3 URBAN AND RURAL

5.3.1 Introduction

The distribution of urban water requirements and rural domestic water requirements is shown on Figure 5.3.1.1 and in Table 5.3.1.1. As previously stated, the requirements shown include distribution and conveyance losses.

The total combined requirement at 1995 levels of development was estimated to be 115 million m^3/a, of which approximately 84 million m^3/a was required by towns and 31 million m^3/a by consumers in the rural areas. Some 60% of the water requirements of the towns occurred in the East London/King William's Town urban complex (now known as Buffalo City). It was assumed that the full urban and rural requirements were both at 1:50 year assurance.

Table 5.3.1.1 also shows the Human Reserve requirement, calculated on the basis of 25 ℓ/person/day for the total population, and totalling 41,25 million m^3/a for the WMA. This requirement is included in those requirements shown in the other columns of Table 5.3.1.1.

5.3.2 Urban

Introduction

A study by Schlemmer *et al* (2001) in support of the development of the National Water Resource Strategy developed a methodology to provide a framework for estimation of both direct and indirect water requirements for the entire South Africa, as well as for the development of long-term projections. A framework methodology was developed on the basis of available information. Information collected in the field as part of the Water Resources Situation Assessments was used to refine the analysis, identify default values and where available update the default database figures.

TABLE 5.3.1.1: URBAN AND RURAL DOMESTIC WATER REQUIREMENTS IN 1995

CATCHMENT					URBAN REQUIREMENTS (million m^3/a)	RURAL DOMESTIC WATER REQUIREMENTS (million m^3/a)	COMBINED URBAN AND RURAL DOMESTIC REQUIREMENTS (million m^3/a)	REQUIREMENTS AT 1:50 YEAR ASSURANCE (million m^3/a)	HUMAN RESERVE
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY					
No.	Description	No.	Description	No.					
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	0,00	0,28	0,28	0,28	0,28
		R1	Keiskamma (all E Cape)	R10A to R10M	1,35	1,34	2,69	2,69	1,50
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	0,00	0,30	0,30	0,30	0,30
		R2	Buffalo (all E Cape)	R20A to R20G	49,70	1,05	50,75	50,75	6,32
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	0,32	0,39	0,71	0,71	0,48
		TOTAL IN AMATOLE REGION (all E Cape)			**51,37**	**3,36**	**54,73**	**54,73**	**8,89**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	0,00	1,31	1,31	1,31	1,31
		S2	Indwe (all E Cape)	S20A to S20D	0,44	0,59	0,99	0,99	0,71
		S3	Klaas Smits (all E Cape)	S31A to S31G	7,49	0,09	7,58	7,58	0,60
			Black Kei (all E Cape)	S32A to S32M	1,88	0,68	2,56	2,56	1,21
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			9,81	2,68	12,49	12	3,83
		S4	Thomas (all E Cape)	S40A to S40F	0,81	0,25	1,06		0,32
		S5	Tsomo (all E Cape)	S50A to S50J	0,92	1,43	2,35	2,35	1,60
		S6	Kubusi (all E Cape)	S60A to S60E	0,87	0,16	1,03	1,03	0,41
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	0,30	1,37	1,67	1,67	1,42
		TOTAL IN GREAT KEI BASIN (all E Cape)			**12,72**	**5,89**	**18,61**	**18,61**	**7,59**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	0,95	3,01	3,96	3,96	3,16
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	12,56	4,69	17,25	17,25	6,46
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	0,00 0,60	0,26 1,33	0,26 1,93	0,26 1,93	0,33 1,49
			Mzintlava in KwaZulu-Natal Mzintlava in E Cape	T32A to T32H	1,59 0,61	0,09 1,25	1,68 1,86	1,68 1,86	0,27 1,38
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	0,86 0,23	0,01 1,80	0,87 2,03	0,87 2,03	0,12 1,78
			Tina (all E Cape)	T34A to T34K	0,35	1,35	1,70	1,70	1,46
			Tsitsa (all E Cape)	T35A to T35M	0,57	1,74	2,31	2,31	1,86
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,00	0,44	0,44	0,44	0,55
		Total in Mzimvubu Basin in KwaZulu-Natal			2,45	0,36	2,81	2,81	0,72
		Total in Mzimvubu Basin in E Cape			2,37	7,91	10,28	10,28	8,51
		Total Mzimvubu			4,82	8,27	13,09	13,09	9,23
		T6	Pondoland Coastal Catchments	T60A to T60K	1,11	3,35	4,46	4,46	3,48
		T9	Southern Wild Coast	T90A to T90G	0,92	1,99	2,91	2,91	2,44
		Total in Transkei Region in KwaZulu-Natal			2,45	0,36	2,81		0,72
		Total in Transkei Region in E Cape			17,93	20,95	38,88		24,06
		TOTAL IN TRANSKEI REGION			**20,38**	**21,31**	**41,69**	**41,69**	**24,78**
TOTAL IN WMA IN KWAZULU-NATAL					**2,45**	**0,36**	**2,81**	**2,81**	**0,72**
TOTAL IN WMA IN E CAPE					**82,02**	**30,20**	**112,22**	**112,22**	**40,53**
TOTAL IN WMA					**84,47**	**30,56**	**115,03**	**115,03**	**41,25**

Methodology

Urban water requirements were classified into direct use by the population plus indirect use by commerce, industries, institutions and municipalities related to the direct use. These are dealt with below.

Direct Water Use

The following criteria were considered significant in identifying categories of direct water use :

- Economic strata.
- Types of housing.
- Levels of service provided.
- Extent of local authority records.

It was recognised that a critical factor to be considered was the dependence on data that was required from Local and Water Service Authorities. Generally many authorities have records of water supplied to different users; individual households, and at times to flats and multi-household complexes. Further detail is not common.

Categories of direct water use were then identified in order to develop profiles of use per urban centre (see table below). The populations of the urban centres that had been determined were allocated to these categories by Schlemmer *et al* (2001), on the basis of socio-economic category characteristics of each centre.

The study then proceeded to derive per capita water use for each of these categories using information from the South African Local Government Handbook, and the data collected as part of the Water Resources Situation Assessments from local authorities at the time. Where detailed data was not available, an estimation procedure was followed. The categories defined were associated with default unit water uses to generate overall water use estimates where hard data was not available. These categories and default unit water uses are listed in Table 5.3.2.1.

TABLE 5.3.2.1: DIRECT WATER USE: CATEGORIES AND ESTIMATED UNIT WATER USE

CATEGORY		WATER USE ℓ/c/d
1.	Full service : Houses on large erven > 500m^2	320
2.	Full service: Flats, Town Houses, Cluster Houses	320
3.	Full service : Houses on small erven <500m^2	160
4.	Small houses, RDP houses and shanties with water connection but minimal or no sewerage service	90
5.	Informal houses and shanties with service by communal tap only	10
6.	No service from any water distribution system	6
7.	Other/Miscellaneous	90

Indirect Water Use

Indirect water use was considered in terms of four categories, viz. commercial, industrial, institutional and municipal. Again, available information was complemented by data collected as part of the Water Resources Situation Assessments from local authorities at the time. Limited hard data was obtained at the level of detail sought.

In order to develop a comprehensive set of estimates, a standard table relating the components of indirect water use to the total direct water use of an urban centre was developed. The urban centres were first classified according to shared characteristics related to water use. The classification used is shown in Table 5.3.2.2.

TABLE 5.3.2.2: CLASSIFICATION OF URBAN CENTRES RELATED TO INDIRECT WATER USE

CLASSIFICATION	TYPE OF CENTRE	PERCEPTION
1.	Long established Metropolitan centres (M)	Large conurbation of a number of largely independent local authorities generally functioning as an entity.
2.	City (C)	Substantial authority functioning as a single entity isolated or part of a regional conurbation.
3.	Town: Industrial (Ti)	A town serving as a centre for predominantly industrial activity.
4.	Town: Isolated (Tis)	A town functioning generally as a regional centre of essentially minor regional activities.
5.	Town: Special (Ts)	A town having significant regular variations of population consequent on special functions. (Universities, holiday resorts, etc.).
6.	Town: Country (Tc)	A small town serving essentially as a local centre supporting only limited local activities.
New Centres		
7.	Contiguous (Nc)	A separate statutory authority, or number of authorities adjacent to, or close to, a metropolis or city and functioning as a component part of the whole conurbation.
8.	Isolated (Nis)	A substantial authority or group of contiguous authorities not adjacent to an established metropolis or city.
9.	Minor (Nm)	Smaller centres with identifiable new or older established centres not constituting centres of significant commercial or industrial activity.
10.	Rural (Nr)	All other areas not having significant centres.

Default profiles of indirect water use in relation to total water use were developed on the basis of available information for these classes, and are given in the Table 5.3.2.3.

TABLE 5.3.2.3: INDIRECT WATER USE AS A COMPONENT OF TOTAL DIRECT WATER USE

URBAN CENTRE CLASSIFICATION	COMMERCIAL	INDUSTRIAL	INSTITUTIONAL	MUNICIPAL
Metropolitan Cities Towns Industrial Towns Isolated	0.2	0.3	0.15	0.08
Towns Special	0.30	0.15	0.08	0.03
Towns Country	0.10	0.15	0.03	0.10
New Centres	0.15	0.08	0.08	0.08

Where detailed data was not available, Table 5.3.2.3 was used as a basis for estimating the indirect water use.

The distribution of urban water requirements determined on this basis is shown in Table 5.3.2.4, where bulk conveyance losses and distribution losses have been added to the estimated direct and indirect water requirements to derive total water requirements.

Information on water use by different categories of housing and on the ratios of indirect to direct water use is not available for the towns in the Mzimvubu to Keiskamma WMA. Therefore, the appropriate ratios of those shown in the above tables were used to estimate the split between direct and indirect water use.

The full requirements of the seven categories of direct water use shown in Table 5.3.2.1 and the four categories of indirect water use shown in Table 5.3.2.3 are supplied at different assurances, some at more than 1:50 year assurance and some at less than 1:50 year assurance. However, as neither the quantities of water required in the various user categories, nor the assurances at which they are supplied are accurately known for all urban areas, it was assumed that the average assurance of supply is 1:50 year.

Water Losses

Water losses occur in the conveyance of water from the raw water source to the water treatment works and from the treatment works to bulk treated water storage reservoirs. These are referred to in this report as bulk conveyance losses. They occur as a result of spillage, leakage and evaporation from canals, leakage from pipelines and storage reservoirs, and backwashing of filters at water treatment works.

Further losses occur between the bulk treated water storage reservoirs and consumers, mainly as a result of leaking or broken pipes and fittings. These are known as distribution losses.

Little information on losses in the various town supplies could be obtained. Therefore it was necessary to make assumptions based on the type of raw water supply, the distance over which water is conveyed, and the nature of the distribution system to estimate a single value for each town that includes all categories of losses. The assumed values are shown in Table 5.3.2.4.

Return Flows

In the context of the overall water resources of the WMA, some of the water used by urban consumers is returned to the rivers as treated effluent, and can contribute to ecological flow requirements or be abstracted and re-used further downstream. However, most of the urban use is in coastal areas where the treated effluent is discharged to the sea.

Return flows of treated sewage effluent from the WMA are estimated to have totalled 33,65 million m^3 in 1995. Some 20 million m^3 of these were generated in the Amatole Region and, of those 20 million m^3, about 10 million m^3 were discharged into the sea through marine outfall pipes. The remaining return flows in the Amatole Region were discharged to watercourses, re-cycled to industry, or used for irrigation. Effluent that is returned to watercourses downstream of the dams that provide the water supply for the East London/King William's Town area is assumed to have contributed to the ecological flow requirements. Therefore, only the 10 million m^3 discharged to sea was not re-usable.

TABLE 5.3.2.4: URBAN WATER REQUIREMENTS IN 1995 (PAGE 1 OF 2)

CATCHMENT					WATER REQUIREMENTS						RETURN FLOWS			
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	DIRECT	INDIRECT	LOSSES		TOTAL	TOTAL AT 1:50 YEAR ASSURANCE	EFFLUENT	IMPERVIOUS URBAN AREA	TOTAL RETURN FLOW	RETURN FLOW AT 1:50 YEAR ASSURANCE
No.	Description	No.	Description	No.	(million m^3/a)	(million m^3/a)	(million m^3/a)	%	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	0,00	0,00	0,00	-	0,00	0,00	0,00	0,00	0,00	0,00
		R1	Keiskamma (all E Cape)	R10A to R10M	0,72	0,28	0,35	26	1,35	1,35`	0,56	0,00	0,56	0,56
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	0,00	0,00	0,00	-	0,00	0,00	0,00	0,00	0,00	0,00
		R2	Buffalo (all E Cape)	R20A to R20G	19,94	11,80	17,96	36	49,70	49,70	19,63	2,84	22,47	19,63
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	0,17	0,07	0,08	25	0,32[(1)]	0,32 [(1)]	0,10	0,36	0,46	0,10
		TOTAL IN AMATOLE REGION (all E Cape)			**20,83**	**12,15**	**18,39**	**36**	**51,37**	**51,37**	**20,29**	**3,20**	**23,49**	**20,29**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	0,00	0,00	0,00	-	0,00	0,00	0,00	0,00	0,00	0,00
		S2	Indwe (all E Cape)	S20A to S20D	0,24	0,09	0,11	25	0,44	0,44	0,12	0,19	0,31	0,12
		S3	Klaas Smits (all E Cape)	S31A to S31G	3,25	2,31	1,93	25	7,49	7,49	3,37	0,98	4,35	3,37
			Black Kei (all E Cape)	S32A to S32M	1,02	0,39	0,47	25	1,88	1,88	0,70	0,55	1,25	0,70
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			4,51	2,79	2,51	25	9.81	9,81	4,19	1,72	5,91	4,19
		S4	Thomas (all E Cape)	S40A to S40F	0,44	0,17	0,20	25	0,81	0,81	0,33	0,03	0,36	0,33
		S5	Tsomo (all E Cape)	S50A to S50J	0,50	0,18	0,24	26	0,92	0,92	0,28	0,10	0,38	0,28
		S6	Kubusi (all E Cape)	S60A to S60E	0,37	0,27	0,23	26	0,87	0,87	0,34	0,14	0,48	0,34
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	0,16	0,06	0,08	26	0,30	0,30	0,11	0,41	0,52	0,11
		TOTAL IN GREAT KEI BASIN (all E Cape)			**5,99**	**3,47**	**3,26**	**26**	**12,72**	**12,72**	**5,25**	**2,40**	**7,65**	**5,25**

TABLE 5.3.2.4: URBAN WATER REQUIREMENTS IN 1995 (PAGE 2 OF 2)

CATCHMENT					WATER REQUIREMENTS						RETURN FLOWS			
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	DIRECT	INDIRECT	LOSSES		TOTAL	TOTAL AT 1:50 YEAR ASSURANCE	EFFLUENT	IMPERVIOUS URBAN AREA	TOTAL RETURN FLOW	RETURN FLOW AT 1:50 YEAR ASSURANCE
No.	Description	No.	Description	No.	(million m^3/a)	(million m^3/a)	(million m^3/a)	%	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	0,52	0,19	0,24	25	0,95	0,95	0,37	0,00	0,37	0,37
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	5,55	3,82	3,19	25	12,56	12,56	5,18	1,00	6,18	5,18
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	0,00 0,33	0,00 0,12	0,00 0,15	25 25	0,00 0,60	0,00 0,60	0,00 0,21	0,00 0,20	0,00 0,41	0,00 0,21
			Mzintlava in KwaZulu-Natal Mzimtlava in E Cape	T32A to T32H	0,86 0,33	0,33 0,12	0,40 0,16	25 25	1,59 0,61	1,59 0,61	0,58 0,23	0,22 0,08	0,80 0,31	0,58 0,23
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	0,47 0,12	0,17 0,05	0,22 0,06	25	0,86 0,23	0,86 0,23	0,39 0,10	0,00 0,00	0,39 0,10	0,39 0,10
			Tina(all E Cape)	T34A to T34K	0,19	0,07	0,09	25	0,35	0,35	0,11	0,00	0,11	0,11
			Tsitsa (all E Cape)	T35A to T35M	0,31	0,11	0,15	26	0,57	0,57	0,17	0,00	0,17	0,17
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,00	0,00	0,00	-	0,00	0,00	0,00	0,00	0,00	0,00
		Total in Mzimvubu in KwaZulu-Natal			1,33	0,50	0,62	25	2,45	2,45	0,97	0,22	1,19	0,97
		Total Mzimvubu in E Cape			1,29	0,48	0,60	25	2,37	2,37	0,83	0,28	1,11	0,83
		Total Mzimvubu			2,62	0,98	1,22	25	4,82	4,82	1,80	0,50	2,30	1,80
		T6	Pondoland Coastal Catchments	T60A to T60K	0,60	0,23	0,28	25	1,11	1,11	0,41	0,00	0,41	0,41
		T9	Southern Wild Coast	T90A to T90G	0,50	0,19	0,23	25	0,92	0,92	0,33	0,00	0,33	0,33
		Total in Transkei Region in KwaZulu-Natal			1,33	0,50	0,62	25	2,45	2,45	0,97	0,22	1,19	0,97
		Total in Transkei Region in E Cape			8,45	4,91	4,57	25	17,93	17,93	7,13	1,28	8,41	7,13
		TOTAL IN TRANSKEI REGION			**9,78**	**5,41**	**5,19**	**25**	**20,38**	**20,38**	**8,10**	**1,50**	**9,60**	**8,10**
TOTAL IN WMA IN KWAZULU-NATAL					**1,33**	**0,50**	**0,62**	**25**	**2,45**	**2,45**	**0,97**	**0,22**	**1,19**	**0,97**
TOTAL IN WMA IN E CAPE					**35,27**	**20,53**	**26,22**	**32**	**82,02**	**82,02**	**32,68**	**6,88**	**39,56**	**32,68**
TOTAL IN WMA					**36,60**	**21,03**	**26,84**	**31**	**84,47**	**84,47**	**33,65**	**7,10**	**40,75**	**33,65**

(1) This is the requirement of the small coastal resorts. The requirements of Beacon Bay and Gonubie are included in the Buffalo Key Area.

(2) 1:50 year increased runoff from impervious areas assumed to be negligible.

Similarly, it is assumed that all the effluent generated in other parts of the WMA was re-usable. Thus, the total re-usable quantity in 1995 was 23,65 million m^3.

Where there are urban areas, increased runoff from paved areas can significantly increase the runoff to rivers. This runoff can be considered to be a component of urban return flows. It is estimated that, in the Mzimvubu to Keiskamma WMA, urban areas increase the runoff by some 7 million m^3/a but this figure appears high and should be reviewed. It is also of low assurance and it has, therefore, been assumed that the increase in runoff at 1:50 year assurance is negligible.

5.3.3 Rural

Rural water users include the inhabitants of farms, small rural settlements not classified as towns, and coastal resorts that are not classified as towns. The rural population in the Mzimvubu to Keiskamma WMA constitutes 75% of the total and consequently, the rural water requirements are a significant component of the total water requirement in the WMA.

As comprehensive information on water use by the rural population is not available, and as 75% of the rural population in 1995 had only rudimentary water supply facilities, an average water requirement of 25 ℓ/c/d has been assumed for the whole rural population.

Drinking water for livestock is also considered to be part of rural water requirements and was calculated as 45 ℓ/ELSU/day using the Equivalent Large Stock Units shown in Table 3.5.4.1.

Distribution losses for water for both human use and for livestock were considered to be negligible and included in the per capital allowances.

The distribution of water requirements is shown in Table 5.3.3.1 where it can be seen that all rural water requirements were estimated to total approximately 70 million m^3/a in 1995, including distribution losses.

It was assumed that the total rural water requirement is at 1:50 year assurance.

Return flows from rural users are assumed to be negligible.

5.4 BULK WATER USE

Bulk water use for the purposes of this report is defined as water use by an industry that has its own water suply scheme or is supplied individually (i.e. not as part of an urban supply) with water by DWAF, a district council, or a waterboard.

The only bulk users identified in the Mzimvubu to Keiskamma WMA are the Da Gama Textiles factories at Zwelitsha and East London. The Zwelitsha factory receives 1,5 million m^3/a of raw water from Rooikrantz Dam, and the East London factory used to receive 1,8 million m^3/a of treated water from Nahoon Dam, but, in 1995 reduced its requirements to the present level of 0,1 million m^3/a.

Thus, the total bulk water use in 1995 was 1,6 million m^3/a, all of which occurred in the Buffalo key area.

TABLE 5.3.3.1: RURAL DOMESTIC WATER REQUIREMENTS IN 1995 (PAGE 1 OF 2)

CATCHMENT					RURAL WATER REQUIREMENTS						RETURN FLOWS	
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	DOMESTIC	LIVESTOCK AND GAME	LOSSES		TOTAL	TOTAL AT 1:50 YEAR ASSURANCE	NORMAL	AT 1:50 YEAR ASSURANCE
No.	Description	No.	Description	No.	(million m^3/a)	(million m^3/a)	(million m^3/a)	%	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	0,28	0,24	0	0	0,52	0,52	0	0
		R1	Keiskamma (all E Cape)	R10A to R10M	1,34	1,30	0	0	2,64	2,64	0	0
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	0,30	0,23	0	0	0,53	0,53	0	0
		R2	Buffalo (all E Cape)	R20A to R20G	1,05	0,22	0	0	1,27	1,27	0	0
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	0,39	0,68	0	0	1,07	1,07	0	0
		TOTAL IN AMATOLE REGION (all E Cape)			**3,36**	**2,67**	**0**	**0**	**6,03**	**6,03**	**0**	**0**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	1,31	1,08	0	0	2,39	2,39	0	0
		S2	Indwe (all E Cape)	S20A to S20D	0,59	0,60	0	0	1,19	1,19	0	0
		S3	Klaas Smits (all E Cape)	S31A to S31G	0,09	0,71	0	0	0,80	0,80	0	0
			Black Kei (all E Cape)	S32A to S32M	0,68	1,26	0	0	1,94	1,94	0	0
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			2,67	3,65	0	0	6,32	6,32	0	0
		S4	Thomas (all E Cape)	S40A to S40F	0,25	0,73	0	0	0,98	0,98	0	0
		S5	Tsomo (all E Cape)	S50A to S50J	1,43	2,14	0	0	3,57	3,57	0	0
		S6	Kubusi (all E Cape)	S60A to S60E	0,16	0,37	0	0	0,53	0,53	0	0
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	1,37	1,51	0	0	2,88	2,88	0	0
		TOTAL IN GREAT KEI BASIN (all E Cape)			**5,88**	**8,40**	**0**	**0**	**14,28**	**14,28**	**0**	**0**

TABLE 5.3.3.1: RURAL DOMESTIC WATER REQUIREMENTS IN 1995 (PAGE 2 OF 2)

CATCHMENT					RURAL WATER REQUIREMENTS						RETURN FLOWS	
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	DOMESTIC	LIVESTOCK AND GAME	LOSSES		TOTAL	TOTAL AT 1:50 YEAR ASSURANCE	NORMAL	AT 1:50 YEAR ASSURANCE
No.	Description	No.	Description	No.	(million m^3/a)	(million m^3/a)	(million m^3/a)	%	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	3,01	8,31	0	0	11,32	11,32	0	0
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	4,69	8,13	0	0	12,82	12,82	0	0
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	0,26 1,33	1,82 2,41	0 0	0 0	2,08 3,74	2,08 3,74	0 0	0 0
			Mzintlava in KwaZulu-Natal Mzintlava in E Cape	T32A to T32H	0,09 1,25	1,04 1,56	0 0	0	1,13 2,81	1,13 2,81	0 0	0 0
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	1,01 1,80	0,06 3,34	0 0	0 0	0,07 5,14	0,07 5,14	0 0	0 0
			Tina (all E Cape)	T34A to T34K	1,35	3,60	0	0	4,95	4,95	0	0
			Tsitsa (all E Cape)	T35A to T35M	1,74	5,83	0	0	7,57	7,57	0	0
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,44	0,24	0	0	0,68	0,68	0	0
		Total in Mzimvubu in KwaZulu-Natal			0,36	2,92	0	0	3,28	3,28	0	0
		Total in Mzimvubu in E Cape			7,91	16,98	0	0	24,89	24,89	0	0
		Total Mzimvubu			8,27	19,90	0	0	28,17	28,17	0	0
		T6	Pondoland Coastal Catchments	T60A to T60K	3,35	1,16	0	0	4,51	4,51	0	0
		T9	Southern Wild Coast	T90A to T90G	1,99	3,53	0	0	5,52	5,52	0	0
		Total in Transkei Region in KwaZulu-Natal			0,36	2,92	0	0	3,28	3,28	0	0
		Total in Transkei Region in E Cape			20,95	38,11	0	0	59,06	59,06	0	0
		TOTAL IN TRANSKEI REGION			**21,31**	**41,03**	**0**	**0**	**62,34**	**62,34**	**0**	**0**
TOTAL IN WMA IN KWAZULU-NATAL					**0,36**	**2,92**	**0**	**0**	**3,28**	**3,28**	**0**	**0**
TOTAL IN WMA IN E CAPE					**30,20**	**49,18**	**0**	**0**	**79,38**	**79,38**	**0**	**0**
TOTAL IN WMA					**30,56**	**52,10**	**0**	**0**	**82,66**	**82,66**	**0**	**0**

TABLE 5.6.2.1: IRRIGATION WATER REQUIREMENTS (PAGE 1 OF 2)

CATCHMENT					WATER REQUIREMENTS					RETURN FLOWS	
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	FIELD EDGE WATER REQUIREMENT (million m^3/a)	LOSSES		TOTAL WATER REQUIREMENT	TOTAL WATER REQUIREMENT AT 1:50 YEAR ASSURANCE	NORMAL	AT 1:50 YR ASSURANCE
No.	Description	No.	Description	No.		(million m^3/a)	%	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)
R	Amatole Region	R5	Southern Coastal Catchment (all E Cape)	R50A, R50B	1,79	0,32	15	2,11	1,78	0,11	0,09
		R1	Keiskamma (all E Cape)	R10A to R10M	3,82	0,67	15	4,49	3,78	0,22	0,19
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	4,27	0,75	15	5,02	4,25	0,25	0,21
		R2	Buffalo (all E Cape)	R20A to R20G	3,11	0,54	15	3,65	3,08	0,18	0,15
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	12,75	2,25	15	15,00	12,69	0,75	0,63
		TOTAL IN AMATOLE REGION (all E Cape)			**25,74**	**4,53**	15	**30,27**	**25,58**	**1,51**	**1,27**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	5,59	0,81	15	5,40	4,46	0,54	0,45
		S2	Indwe (all E Cape)	S20A to S20D	7,63	1,35	15	8,98	7,57	0,90	0,76
		S3	Klaas Smits (all E Cape)	S31A to S31G	27,50	4,86	15	32,36	26,30	3,23	2,63
			Black Kei (all E Cape)	S32A to S32M	21,70	3,82	15	25,52	21,32	2,55	2,13
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			61,42	10,84	15	72,26	59,65	7,22	5,97
		S4	Thomas (all E Cape)	S40A to S40F	17,19	3,04	15	20,23	17,01	2,02	1,70
		S5	Tsomo (all E Cape)	S50A to S50J	2,13	0,38	15	2,51	2,18	0,25	0,22
		S6	Kubusi (all E Cape)	S60A to S60E	5,90	1,04	15	6,94	5,84	0,69	0,58
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	3,66	0,64	15	4,30	3,64	0,43	0,36
		TOTAL IN GREAT KEI BASIN (all E Cape)			**90,30**	**15,94**	15	**106,24**	**88,32**	**10,61**	**8,83**

TABLE 5.6.2.1: IRRIGATION WATER REQUIREMENTS (PAGE 2 OF 2)

CATCHMENT					WATER REQUIREMENTS					RETURN FLOWS	
PRIMARY		SECONDARY		TERTIARY QUATERNARY	FIELD EDGE WATER REQUIREMENT (million m³/a)	LOSSES		TOTAL WATER REQUIREMENT	TOTAL WATER REQUIREMENT AT 1:50 YEAR ASSURANCE	NORMAL	AT 1:50 YEAR ASSURANCE
No.	**Description**	**No.**	**Description**	**No.**		**(million m³/a)**	**%**	**(million m³/a)**	**(million m³/a)**	**(million m³/a)**	**(million m³/a)**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	3,53	0,62	15	4,15	3,61	0,41	0,36
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	2,12	0,37	15	2,49	2,14	0,25	0,21
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	5,54 0,00	0,98 0,00	15 0	6,52 0,00	5,63 0,00	0,65 0,00	0,56 0,00
			Mzintlava in KwaZulu-Natal Mzintlava in E Cape	T32A to T32H	15,69 0,00	2,77 0,00	15 0	18,46 0,00	15,94 0,00	1,85 0,00	1,59 0,00
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	0,00 0,00	0,00 0,00	0 0	0,00 0,00	0,00 0,00	0,00 0,00	0,00 0,00
			Tina (all E Cape)	T34A to T34K	0,00	0,00	15	0,00	0,00	0,00	0,00
			Tsitsa (all E Cape)	T35A to T35M	0,00	0,00	15	0,00	0,00	0,00	0,00
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,10	0,02	15	0,12	0,10	0,01	0,01
		Total in Transkei Region in KwaZulu-Natal			21,23	3,75	15	24,98	21,57	2,50	2,15
		Total in Transkei Region in E Cape			0,10	0,02	15	0,12	0,10	0,01	0,01
		Total Mzimvubu			21,33	3,76	15	25,09	21,67	2,51	2,16
		T6	Pondoland Coastal Catchments	T60A to T60K	0,00	0,00	15	0,00	0,00	0,00	0,00
		T9	Southern Wild Coast	T90A to T90G	0,00	0,00	15	0,00	0,00	0,00	0,00
		Total in Transkei Region in KwaZulu-Natal			21,23	3,75	15	24,98	21,57	2,50	2,15
		Total in Transkei in E Cape			5,75	1,00	15	6,75	5,85	0,67	0,58
		TOTAL IN TRANSKEI REGION			**26,98**	**4,75**	**15**	**31,73**	**27,42**	**3,17**	**2,73**
TOTAL IN WMA IN KWAZULU-NATAL					**21,23**	**375**	**15**	**24,98**	**21,57**	**2,50**	**2,15**
TOTAL IN WMA IN E CAPE					**121,79**	**21,47**	**15**	**143,26**	**119,75**	**12,79**	**10,68**
TOTAL IN WMA					**143,02**	**25,22**	**15**	**168,24**	**141,32**	**15,29**	**12,83**

5.5 NEIGHBOURING STATES

No water is supplied to neighbouring states, nor are any water resources shared with them.

5.6 IRRIGATION

5.6.1 General

Comprehensive detailed observed data on water use for irrigation in the WMA is not available. Therefore, irrigation water requirements were estimated from available information on irrigated areas, typical unit requirements and assurances of supply.

The information on irrigated areas was that shown in Table 3.5.2.1., which was obtained from the sources described in Section 3.5.2. Water requirements were calculated by applying typical values of water use per hectare, provided by officials of the DWAF Eastern Cape Regional Office, to the average irrigated areas shown in Table 3.5.2.1.

5.6.2 Water Use Patterns

Estimated average water requirements for irrigation in 1995 and equivalent requirements at 1:50 year assurance are shown for key areas in Table 5.6.2.1. The table also shows estimated conveyance losses, and estimated return flows. Insufficient information is available for a distinction to be made between conveyance losses to farms and "on-farm" conveyance losses.

The typical annual irrigation requirements per hectare, on which the calculation of the field edge water requirements shown in Table 5.6.2.1 was based, are shown in Table 5.6.2.2.

TABLE 5.6.2.2: TYPICAL ANNUAL FIELD EDGE IRRIGATION REQUIREMENTS

AREA	TERTIARY/ QUATERNARY CATCHMENTS	PREDOMINANT CROP	ASSUMED FIELD EDGE WATER REQUIREMENT FOR A TYPICAL CROP MIX (m^3/ha/a)
Amatole Region	R1 to R5	Vegetables Pasture	6600
Great Kei River Basin	S1 to S7	Lucerne Maize, Vegetables Pasture	8600
Mbashe River Basin	T1	Maize Vegetables	7500
Mtata	T2, T7, T8	Vegetables	6000
Mzimvubu River Basin	T3	Pasture Vegetables	6000

5.6.3 Water Losses

Irrigation water losses are considered in two categories, namely :

- Canal and river losses incurred in conveying water from the dam in which it is stored to the farms where it is used for irrigation, and

- On-farm conveyance losses, which occur in conveying the water from the point at which it is abstracted from a canal, river or farm dam to field edge

As reliable information on farm conveyance losses is not available, estimates of combined canal, river, and on-farm conveyance losses were provided by officials of the DWAF Eastern Cape Regional Office. These are reported as combined conveyance losses in Table 5.6.2.1 where they are shown as percentages of total water use.

5.6.4 Return Flows

Irrigation return flows are generated from water lost during conveyance to irrigated lands, by surface runoff and seepage of irrigation water applied to lands, and by excess water applied to leach unwanted salts from the soils of irrigated lands.

Leaching of soils is not widely practised in the Mzimvubu to Keiskamma WMA, and most of the irrigation return flows arise from conveyance losses and normal irrigation of lands.

No reliable observed data on the quantity of irrigation return flows were found. Therefore estimates, provided by officials of the DWAF Eastern Cape Regional Office, of the percentages of total irrigation requirements that become return flows were used to obtain an indication of the volume of return flows generated. The return flows were assumed to be 5% of total irrigation requirements in the Amatole Region and 10% in all other parts of the WMA.

5.7 DRYLAND SUGARCANE

Dryland sugarcane, by definition, is totally dependent on natural rainfall, unlike irrigated sugarcane. However, the distinction between dryland and irrigated sugarcane is not always that clear because in many areas sugarcane is only irrigated occasionally, well below theoretical optimum application rate, and it is debatable whether some of this is dryland or irrigatred.

There are numerous factors affecting the streamflow reduction caused by water use of dryland sugarcane relative to the natural vegetation, such as the local climate, soil characteristics and sugarcane harvesting patterns. Previous studies have indicated that the streamflow reduction by sugarcane can vary between 5% and 70% of the water use by the natural vegetation. Sugarcane may reduce the storm flow (overland) component of stream flow relative to that of certain natural landscapes such as coastal forest. However, the base flow in winter months is in many cases higher, albeit marginally, under sugarcane, owing to its shallower root system (Schulze *et al*, 1999).

In recent years it has been accepted that sugarcane reduces stream flow due to its high leaf area index, and should therefore be taken into account in hydrological and water resources modelling. However, the reduction in streamflow due to dryland sugarcane has not been researched or documented as comprehensively as that of afforestation and there is cdonsiderable uncertainty as to the extent of this impact. Probably the most comprehensive researched or documented as comprehensively as that of afforestation and there is considerable uncertainty as to the extent of this impact. Probably the most comprehensive research into this field (Schulze *et al*, 1999) was unable to produce generalised curves indicating stream flow reduction on a quaternary catchment basis, due to the many interacting non-linearities in the biophysical system. The results of this study did, however, indicate that the reduction of runoff due to dryland sugarcane is significantly less than the average reduction due to afforestation. A reduction equal to 75% of that of afforestation has therefore been used for this water resources situation assessment. Hence, 1,0 ha of dryland sugarcane is deemed equivalent to 0,75ha of afforestation. More refined estimates have been used when available.

The impact of the reduction in runoff on catchment yield was determined in the same manner as for afforestation and alien vegetation. In the Mzimvubu to Keiskamma WMA dryland sugarcane is grown only in catchment T60A where 11 km^2 were cultivated in 1995 (CSIR 1999). It is estimated that this causes a reduction in runoff of 1,0 million m^3/a. The impact on the 1:50 year system yield is negligible.

5.8 WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

No comprehensive information on river channel losses was found in this study and they have, therefore, been assumed to be negligible, although it is known that losses do occur in certain irrigation schemes where water is released to the river channel (see Section 4.4.2). These losses have been included in irrigation conveyance losses.

Approximately 63 million m^3/a of water is estimated to evaporate from dams, of which 55 million m^3/a is from major dams. The remainder of some 8 million m^3/a is from farm dams and small municipal dams.

These are rough estimates only, and are probably indicative of the upper limits of evaporation losses, which vary widely from year to year, depending on climatic conditions and the storage volumes in the dams.

The distribution of evaporation losses from dams is shown in Table 5.8.1.

5.9 AFFORESTATION

The water use by commercial afforestation is based on the so-called CSIR curves (CSIR, 1995), which have replaced the so-called Van der Zel curves that were used for the preparation of WR90 (Midgley, *et al,* 1994). The Van der Zel curves were considered to be too simplistic compared to the CSIR curves, which now take the species, age and site conditions into account in estimating the stream flow reductions. A study was undertaken (Ninham Shand, 1999) to provide adjusted naturalised flow sequences for the Water Situation Assessment Model (WSAM) (DWAF, 2000a) based on the WR90 naturalised flow data. This now enables the CSIR curve-based stream flow reduction estimates to be used in the WSAM and these reduction estimates have been used in the WRSA reports. Details of the method of estimating the reduction in runoff by or water use of commercial afforestation are described in CSIR (1995) curve-based stream flow reduction estimates to be used in the WSAM and these reduction estimates have been used in the WRSA reports. Details of the method of estimating the reduction in runoff by or water use of commercial afforestation are described in CSIR (1995).

TABLE 5.8.1: EVAPORATION LOSSES FROM DAMS

PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	EVAPORATION LOSSES FROM DAMS		
No.	Description	No.	Description	No.	MAJOR DAMS (million m^3/a)	MINOR DAMS (million m^3/a)	TOTAL (million m^3/a)
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	0,28	0,12	0,40
		R1	Keiskamma (all E Cape)	R10A to R10M	3,16	0,16	3,32
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	0,00	0,06	0,06
		R2	Buffalo (all E Cape)	R20A to R20G	4,75	0,26	5,01
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	1,12	0,32	1,44
		TOTAL IN AMATOLE REGION (all E Cape)			**9,31**	**0,92**	**10,23**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	8,42	0,50	8,92
		S2	Indwe (all E Cape)	S20A to S20D	8,74	0,20	8,94
		S3	Klaas Smits (all E Cape)	S31A to S31G	0,96	1,05	2,01
			Black Kei (all E Cape)	S32A to S32M	2,97	0,68	3,65
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			21,09	2,43	23,52
		S4	Thomas (all E Cape)	S40A to S40F	0,25	0,00	0,25
		S5	Tsomo (all E Cape)	S50A to S50J	9,50	0,13	9,63
		S6	Kubusi (all E Cape)	S60A to S60E	5,63	0,13	5,76
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	1,29	0,31	1,60
		TOTAL IN GREAT KEI BASIN (all E Cape)			**37,76**	**3,00**	**40,76**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	0,00	0,00	0,00
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	7,78	0,43	8,21
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	0,00 0,00	1,34 0,00	1,34 0,00
			Mzintlava in KwaZulu-Natal Mzintlava in E Cape	T32A to T32H	0,00 0,00	1,25 0,00	1,25 0,00
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	0,00 0,00	0,15 0,26	0,15 0,26
			Tina (all E Cape)	T34A to T34K	0,00	0,00	0,00
			Tsitsa (all E Cape)	T35A to T35M	0,00	0,44	0,44
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,00	0,04	0,04
		Total in Mzimvubu in KwaZulu-Natal			0,00	2,74	2,74
		Total in Mzimvubu in E Cape			0,00	0,74	0,74
		Total Mzimvubu			0,00	3,48	3,48
		T6	Pondoland Coastal Catchments	T60A to T60K	0,00	0,01	0,01
		T9	Southern Wild Coast	T90A to T90G	0,00	0,07	0,07
		Total in Transkei Region in KwaZulu-Natal			0,00	2,74	2,74
		Total in Transkei Region in E Cape			7,78	1,25	9,03
		TOTAL IN TRANSKEI REGION			**7,78**	**3,99**	**11,77**
TOTAL IN WMA IN KWAZULU-NATAL					**0,00**	**2,74**	**2,74**
TOTAL IN WMA IN E CAPE					**54,85**	**5,17**	**60,02**
TOTAL IN WMA					**54,85**	**7,91**	**62,76**

The impact of the reduction in runoff due to afforestation on the yield of a catchment depends on the storage in that catchment. It was accepted that the storage/yield characteristics of a catchment with afforestation were similar to those of the natural catchment and that the latter characteristics could be used to estimate the yield of a catchment with afforestation. The estimates of the impact on the yield of a catchment were made separately for each of the incremental catchments between key points. The total storage within the incremental catchment was transposed to its outlet and formed the basis for determining the incremental yield of the catchment under both natural conditions and the effects of only the afforestation. The yields were estimated from the storage yield characteristics used in the WSAM for any particular recurrence interval of concern. The difference between the incremental yields under natural conditions and with only the effects of afforestation was the impact of the reduction in runoff due to afforestation in the incremental catchment on the yield of the catchment.

An area of 1678 km^2 of commercial timber plantations is found in the Mzimvubu to Keiskamma WMA. The distribution of reduction in runoff by afforestation is shown in Figure 5.9.1 and in Table 5.9.1. The total reduction in runoff due to afforestation is estimated to be 165 million m^3/a. The corresponding reduction in the system 1:50 year yield (estimated by the WSAM development team) is 46 million m^3/a.

The impact on yield is low in relation to the reduction in streamflow because very little of the afforestation is in catchments regulated by major dams. The estimate is at a low level of confidence and requires verification.

TABLE 5.9.1: WATER USE BY AFFORESTATION IN 1995

PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	AVERAGE WATER USE		REDUCTION IN SYSTEM 1;50 YEAR YIELD	
No.	Description	No.	Description	No.	(million m^3/a)	(mm/a) (1)	(million m^3/a)	(mm/a) (1)
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	0,00	0,00	0,00	0
		R1	Keiskamma (all E Cape)	R10A to R10M	3,57	1,32	1,63	0,60
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	0,16	0,19	0,07	0,08
		R2	Buffalo (all E Cape)	R20A to R20G	4,12	3,20	1,90	1,48
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	0,02	0,00	0,00	0,00
		TOTAL IN AMATOLE REGION (all E Cape)			**7,87**	**0,99**	**3,60**	**0,45**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	0,04	0,01	0,00	0,00
		S2	Indwe (all E Cape)	S20A to S20D	0,00	0,00	0,00	0,00
		S3	Klaas Smits (all E Cape)	S31A to S31G	0,00	0,00	0,00	0,00
			Black Kei (all E Cape)	S32A to S32M	1,78	0,42	1,19	0,28
		Total : Black and White Kei (S1, S2, S3) (all E Cape)			1,82	0,16	1,19	0,10
		S4	Thomas (all E Cape)	S40A to S40F	0,31	0,14	0,21	0,10
		S5	Tsomo (all E Cape)	S50A to S50J	1,72	0,50	1,16	0,34
		S6	Kubusi (all E Cape)	S60A to S60E	11,76	9,13	7,87	6,11
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	0,99	0,46	0,67	0,31
		TOTAL IN GREAT KEI BASIN (all E Cape)			**16,61**	**0,81**	**11,10**	**0,54**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	18,08	2,99	0,00	0,00
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	37,44	6,77	28,50	5,16
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	0,97 0,27	0,20 0,06	0,04 0,00	0,01 0,00
			Mzintlava in KwaZulu-Natal Mzintlava in E Cape	T32A to T32H	1,42 1,33	0,14 0,45	0,01 0,03	- 0,01
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	0,01 0,60	- 0,18	- 0,02	- 0,01
			Tina (all E Cape)	T34A to T34K	10,46	3,27	0,37	0,12
			Tsitsa (all E Cape)	T35A to T35M	65,53	13,29	2,33	0,47
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,06	0,08	0,00	0,00
		Total in Mzimvubu in KwaZulu-Natal			1,40	0,07	0,05	-
		Total in Mzimvubu in E Cape			78,27	3,94	2,75	0,14
		Total Mzimvubu			79,67	4,01	2,80	0,14
		T6	Pondoland Coastal Catchments	T60A to T60K	3,52	0,94	0,00	0,00
		T9	Southern Wild Coast	T90A to T90G	1,38	0,55	0,00	0,00
		Total in Transkei Region in KwaZulu-Natal			1,40	0,04	0,05	-
		Total in Transkei Region in E Cape			138,70	3,66	31,25	0,82
		TOTAL IN TRANSKEI REGION			**140,10**	**3,70**	**31,30**	**0,82**
TOTAL IN WMA IN KWAZULU-NATAL					**1,40**	**0,01**	**0,05**	**-**
TOTAL IN WMA IN E CAPE					**163,18**	**2,47**	**45,95**	**0,69**
TOTAL IN WMA					**164,58**	**2,48**	**46,00**	**0,69**

(1) Based on total catchment area, not area of afforestation.

5.10 HYDRO-POWER AND PUMPED STORAGE

These are hydro-power stations at Ncora Dam (S50E), at Collywobbles on the Mbashe River (T13D), and at First Falls (T20C) and Second Falls (T20D) on the Mtata River. The Ncora power station is a secondary user of water released from Ncora Dam for irrigation and power generation at the Collywobbles Power Station.

The Collywobbles Power Station is operated as a base load electricity generator during summer and a peaking station in winter. The quantity of water used for power generation varies considerably from year to year. At a load factor of 0,3, about 300 million m^3/a of water is required. Of this, about 85 million m^3/a is provided from Ncora Dam and the rest is obtained from run-of-river flow. The water from Ncora Dam is normally used during the winter months when natural flow in the river is low. This water is not re-used futher downstream after it has been returned to the river from the power station, and it does not contribute to the ecological flow requirements because it increases the flow in the river during the winter months to above natural levels. Therefore, the 8576 million m^3/a used from Ncora Dam is regarded as a primary water use.

The run-of-river flow that is used is returned to the river in a natural pattern and it contributes to the ecological flow requirements. Therefore, it is regarded as a secondary use.

The two power stations on the Mtata River are situated in series along the river and both use the same water for power generation. In 1995 the power stations were operated in either a peak power generation, or energy generation or voltage control mode, depending on the month of the year, the available water stored in Umtata Dam and run-of-river water supplies, and the conditions in the electricity network. Currently, they are operated together with the Collywobbles and Ncora Power Stations to minimise the total cost of electricity taken from the Eskom transmission network (DWAF, 2001b).

The quantity of water used by the Mtata Power Stations between 1993 and 1998 varied between 52 million m^3/a and 272 million m^3/a. During the summer months, water is obtained from run-of-river flow, spills from Umtata Dam, and some releases from the dam. During the winter months water is obtained mainly from releases from Umtata Dam. For the reasons given above for the Collywobbles Power Station, the winter releases from Umtata Dam for power generation are regarded as a primary use and, for purposes of the situation assessment, have been assumed to amount to the equivalent of 100 million m^3/a at 1:50 year assurance.

Thus, the total consumptive hydro-power requirements in the WMA are assumed to be 185 million m^3/a, comprising 100 million m^3/a in the Mtata key area, and 85 million m^3/a in the Mbashe key area.

5.11 ALIEN VEGETATION

Quaternary catchment information for condensed areas of infestation by alien vegetation and stream flow reductions was obtained from the CSIR (Environmentek) (Versfeld, *et al*, 1997).

It has been assumed that water consumption of alien vegetation outside of the riparian zone cannot exceed the natural runoff and water use inside and outside of the riparian zone has been estimated separately wherever possible. In the absence of any better information, it was assumed that 10% of the condensed area under alien vegetation is riparian. The reduction in runoff due to alien vegetation was taken from WSAM using the above assumptions. The impact of this reduction in runoff on catchment yield was determined in the same manner as for afforestation.

The distribution of alien vegetation in the Mzimvubu to Keiskamma WMA is described in Section 3.5.6. Corresponding estimates of average reduction in runoff and reduction in the system 1:50 year yield are shown in Table 5.11.1 and on Figure 5.11.1.

It can be seen from the table that the reduction in runoff caused by alien vegetation occurs throughout the WMA with the exceptions of the White Kei, Indwe, Klaas Smits and Tsomo key areas. The total reduction in runoff in the Mzimvubu to Keiskamma WMA caused by alien vegetation is estimated to be 95 million m^3/a. The reduction in the 1:50 year yield is estimated to be 23 million m^3/a.

It should be noted that the reliability of these estimates is uncertain, as neither the true extent of infestation by alien vegetation, nor its effect on runoff is accurately known.

TABLE 5.11.1: WATER USE BY ALIEN VEGETATION IN 1995

PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	AVERAGE WATER USE		REDUCTION IN SYSTEM 1:50 YEAR YIELD	
No.	**Description**	**No.**	**Description**	**No.**	**(million m^3/a)**	**(mm/a)(1)**	**(million m^3/a)**	**(mm/a)(1)**
R	Amatole Region	R5	Southern Coastal Catchments (all E Cape)	R50A, R50B	2,50	3,10	0,90	1,11
		R1	Keiskamma (all E Cape)	R10A to R10M	6,23	2,31	2,27	0,84
		R4	Amatola Coastal Catchments (all E Cape)	R40A to R40C	3,98	4,66	1,44	1,69
		R2	Buffalo (all E Cape)	R20A to R20G	1,84	1,43	0,66	0,51
		R3	Nahoon, Gqunube (all E Cape)	R30A to R30F	0,92	0,40	0,33	0,14
		TOTAL IN AMATOLE REGION (all E Cape)			**15,48**	**1,95**	**5,60**	**0,70**
S	Great Kei	S1	White Kei (all E Cape)	S10A to S10J	0,00	0,00	0,00	0,00
		S2	Indwe (all E Cape)	S20A to S20D	0,00	0,00	0,00	0,00
		S3	Klaas Smits (all E Cape)	S31A to S31G	0,00	0,00	0,00	0,00
			Black Kei (all E Cape)	S32A to S32M	0,72	0,17	0,28	0,07
		Total : Black Kei (all E Cape)			0,72	0,06	0,28	0,02
		S4	Thomas (all E Cape)	S40A to S40F	12,33	5,68	4,72	2,18
		S5	Tsomo (all E Cape)	S50A to S50J	0,00	0,00	0,00	0,00
		S6	Kubusi (all E Cape)	S60A to S60E	18,76	14,56	7,19	5,60
		S7	Great Kei and Xilinxa (all E Cape)	S70A to S70F	0,30	0,14	0,11	0,05
		TOTAL IN GREAT KEI BASIN (all E Cape)			**32,12**	**1,57**	**12,30**	**0,60**
T	Transkei Region	T1	Mbashe (all E Cape)	T11, T12, T13	0,84	0,14	0,00	0,00
		T2, T7, T8	Mtata (all E Cape)	T20, T70, T80	7,87	3,11	3,80	1,50
		T3	Upper Mzimvubu in KwaZulu-Natal Upper Mzimvubu in E Cape	T31A to T31J T33H to T33K	4,88 5,53	1,02 1,17	0,20 0,23	0,04 0,05
			Mzintlava in KwaZulu-Natal Mzintlava in E Cape	T32A to T32H	5,73 5,17	0,19 3,50	0,24 0,21	0,08 0,07
			Kinira in KwaZulu-Natal Kinira in E Cape	T33A to T33G	0,38 7,14	0,11 2,16	0,01 0,20	- 0,09
			Tina (all E Cape)	T34A to T34K	5,95	1,86	0,25	0,08
			Tsitsa (all E Cape)	T35A to T35M	1,21	0,24	0,05	0,01
			Lower Mzimvubu (all E Cape)	T36A to T36B	0,24	0,33	0,01	0,01
		Total in Mzimvubu in KwaZulu-Natal			10,97	0,55	0,45	0,02
		Total in Mzimvubu in E Cape			25,25	1,27	1,05	0,06
		Total Mzimvubu			36,22	1,82	1,50	0,08
		T6	Pondoland Coastal Catchments	T60A to T60K	2,00	0,53	0,00	0,00
		T9	Southern Wild Coast	T90A to T90G	0,81	0,31	0,00	0,00
		Total in Transkei Region in KwaZulu-Natal			10,97	0,31	0,45	0,01
		Total in Tran skei Region in E Cape			33,78	0,95	4,85	0,13
		TOTAL IN TRANSKEI REGION			**44,75**	**1,26**	**5,30**	**0,14**
TOTAL IN WMA IN KWAZULU-NATAL					**10,97**	**0,16**	**0,45**	**-**
TOTAL IN WMA IN E CAPE					**82,38**	**1,28**	**22,75**	**0,35**
TOTAL IN WMA					**95,35**	**1,44**	**23,20**	**0,35**

(1) Based on total catchment area, not the area of alien vegetation.

5.12 WATER CONSERVATION AND DEMAND MANAGEMENT

5.12.1 Introduction

The Department of Water Affairs and Forestry is entrenching and insisting on efficient water management and use. This concept has been strongly emphasised, both in legislation and through key demonstration water conservation and water demand management projects. The Department of Water Affairs and Forestry is therefore developing a National Water Conservation and Demand Management Strategy, which is aimed at the water supply industry and South African society at large and aims to cover all water use sectors including agriculture, forestry, industry, recreational, ecological, and water services.

Evidence of inefficient water usage can be found in all water use sectors throughout the country and the value of water seems largely unrecognised by many water users. South Africa is a developing country that is water stressed and requires improved management of its limited water resources.

The implementation of water conservation and demand management principles is essential in meeting the national goals of basic water supply for all South Africans and the sustainable use of water resources.

Water conservation and water demand management are not synonymous. The following meanings are therefore assigned to these terms in this report :

- Water conservation is the minimisation of loss or waste, the preservation, care and protection of water resources and the efficient and effective use of water. Water conservation should be both an objective in water resource and water services management as well as a strategy.

- Water demand management is the adaptation and implementation of a strategy (policies and initiatives) by a water institution to influence the water requirements and use of water in order to meet any of the objectives of economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services and political acceptability. Water supply institutions should set water demand goals and targets by managing the distribution systems and consumer requirements in order to achieve the above objectives.

Water demand management is deemed to include the entire water supply chain - from the point of abstraction at the source to the point of use. This includes all levels of water distribution management and consumer demand management. The conservation measures related to the water resources and return flow are part of water resource management and return flow management respectively.

Various obstacles and constraints have to be overcome before the full potential of water conservation and demand management can be achieved.

This section describes the National Water Conservation and demand management objectives that will lead to the development of action plans to be implemented by the various water institutions. The needs and opportunities for the implementation of water conservation are described, as are some of the important principles on water conservation and demand management. This section also describes the platform on which the National Water Conservation and Demand Management strategy will be based. This National Strategy Framework will also be used to develop the functions of the Directorate : Water

Conservation within the Department of Water Affairs and Forestry and the functions of other departments and other water institutions. It is also intended that those principles will assist the water industry to comprehensively implement water conservation and demand management.

5.12.2 Background

Water resources and supply

The sustainability of the limited water resources is threatened in terms of quantity and quality. Unless the current water use pattern is changed, future water requirements will greatly exceed existing available fresh water resources. Frequently the water supply and quality are unreliable or improperly managed, leading to the wasteful use of water by consumers in anticipation of possible supply failures.

Environment

Environmental degradation and the prevention thereof is a key focus in the current policy and legislation. Measures such as providing for water of suitable quality in sufficient quantity in the Reserve to protect the integrity, health and productivity of the rich and diverse ecosystems have become necessary.

Neighbouring states

South Africa and the neighbouring states of Botswana, Lesotho, Mozambique, Namibia, Swaziland and Zimbabwe have certain common water resources and must collaborate to achieve the optimal use of these resources. Except for Lesotho all of these countries are water scarce and it is imperative that none of them should allow the wastage of water resources to the detriment of the other countries.

Basic water supply needs

By the application of water demand management measures to existing water services, water resources and bulk infrastructure can be reallocated for the provision of new services where adequate services do not yet exist. Water demand management is also essential in ensuring the sustainability of the new water service delivery projects and can help to ensure that water remains affordable.

Existing water services

It is estimated that up to 50% of the total quantity of water that is supplied is not accounted for in many of the urban areas. This unaccounted for water consists of a combination of reticulation system leaks, unauthorised water connections, faulty water meters and domestic plumbing leaks. These factors, combined with the low levels of payment and institutional problems of local authorities, affect the sustainability of water services. Current indications are that levels of unaccounted for water are growing despite the formulation of several water conservation strategies in the past.

Irrigation

Irrigation accounts for an estimated 15% of total water use in the Mzimvubu to Keiskamma Water Management Area. Irrigation losses are often quite significant and it is estimated that often no more than 85% of water abstracted from water resources is correctly applied to the root systems of plants. Some irrigation system losses return to the river systems but this return water can be of reduced quality. Irrigation methods, irrigation scheduling, soil preparation, crop selection, crop yield targets and evaporation all affect the efficient use of water.

Forestry
Forestry accounts for an estimated 14% of total water use in the Mzimvubu to Keiskamma Water Management Area. Issues such as site selection and preparation, species selection, rotation periods and plantation management all affect the efficient use of water.

Industry, mining and power generation
Industry is expected to be the biggest contributor to future economic growth in South Africa. The industrial sector is projected to have the greatest growth in water requirements. Much of this growth will occur in major urban centres that only have limited water resources nearby. It is imperative to have assured water supplies at a reasonable cost to support the industrial development and for the industrial sector to improve its efficiency of water use and to minimise waste.

5.12.3 Legal and Regulatory Framework

General
The Water Services Act (No. 108 of 1997) and the National Water Act (No. 36 of 1998) variously require and provide for the implementation of water conservation and demand management measures. One of the functions of the National Water Conservation and Demand Strategy is to fulfil the requirements made through the legislation and to utilise the opportunities created through the legislation to develop comprehensive policies and to identify and develop regulations.

Complimentary to the regulations promulgated in terms of the above two Acts are codes of practice that present guidelines for the maintenance of uniform standards within the water supply industry.

Water Services Act
The Water Services Act (No. 108 of 1997) sets out a framework to ensure the provision of basic water supply and sanitation and a regulatory framework for water services institutions. All water services institutions are required to develop conditions for the provision of water services that must include for measures to promote water conservation and demand management.

National Water Act
The purpose of the National Water Act (No. 36 of 1998) is to, inter alia, ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways that, amongst others, promote efficient, sustainable and beneficial use of water in the public interest.

Codes of Practice
The SABS Code of Practice 0306 : 1998 titled The Management of Potable Water in Distribution Systems has been drafted to establish the management, administrative and operational functions required by a water services institution to account for potable water within distribution systems and apply corrective actions to reduce and control unaccounted for water.

5.12.4 The Role of Water Conservation and Demand Management

Security of supply
The role of water conservation and demand management in ensuring security of supply can be divided into short-term rationing measures during droughts, which amount to a reduction in assurance of supply in respect of some of the water, and sustainable long-term functions.

With the current growth of water requirements it is estimated that unless water conservation and sustainable development policies are implemented, South African will utilise all its natural fresh water resources within 30 years. Possible alternative water resources such as importation of water from neighbouring states, desalination and harvesting icebergs are considered to be too expensive.

Protection of the aquatic environment
Aquatic ecosystems are under threat from current land use practices and over-utilisation of water resources. Reducing water requirements reduces water abstractions that affect the aquatic environment and results in increased stream flows and/or decreased demand on groundwater sources and also reduces or defers the need for dams, that have their own impacts on the environment.

Protection of existing water resources
The protection of water resources through water conservation measures can be achieved as follows :

- The removal of alien invading plants, which reduce surface runoff and the yield of existing resources.
- Rehabilitation of wetlands.
- Protection of groundwater resources by limiting abstraction to the sustainable yield.
- Minimising pollution of water resources.

Economic efficiency
One of the main objectives of water demand management is economic efficiency through the entire water cycle.

In the potable water services sector, economic efficiency may often be a more important objective than water resource considerations. A certain measure that may be economically efficient from the perspective of society may not be economically efficient from the perspective of a specific water institution or user, which can be a major constraint on water demand management. However, the perspective of society needs to have priority over the economic efficiency perspective of the various water institutions or users.

Reducing the growth in water requirements can postpone large infrastructure development costs.

Social development, equity and accountability
Water demand management can enhance the objectives of social development and equity in a number of ways, some of which are given below :

- To promote maintenance, management and prevention of abuse of water infrastructure.

- To reduce domestic water consumption and waste and the cost of potable water services.
- To provide new services to people by using existing resources and bulk infrastructure.
- To offer more employment opportunities to the community.
- To make water institutions accountable to the public and understand the consumers and their needs.

5.12.5 Planning Considerations

Water conservation and demand management initiatives are not only strategies associated with environmental or communications initiatives but must be integrated into the water resource planning process as potential alternatives to increasingly expensive supply side management options.

All water demand management activities that decrease the water requirement tend to affect supply management because existing system capacity is released for other users.

The opportunities for water demand management exist where there are high levels of loss and inefficient use, particularly where water is used for the service that is derived from it and not for the water itself.

5.12.6 Water Conservation and Demand Management Measures

There are a number of categories of water conservation and demand management measures and initiatives that can be implemented. The following categories are general for all water sectors and are according to the different components of the water supply chain :

- Water conservation measures in resource management.
- Water demand management in distribution of supply management.
- Water demand management measures of customer or end user.
- Water conservation measures for return flow management.

5.12.7 Objectives of the National Water Conservation and Demand Management Strategy

The objectives of the National Water Conservation and Demand management Strategy are as follows :

- Create a culture of water conservation and demand management within all water management and water service institutions in South Africa.
- Support water management and water services institutions to implement water demand management and water conservation.
- Create a culture of water conservation and demand management for all consumers and users in South Africa.
- Promote international co-operation and participate with other Southern African countries, particularly co-watercourse states, to develop joint water conservation and demand management strategies.
- Enable water management and water resources institutions to adopt integrated resource planning.
- Promote social development and equity in South Africa.
- Contribute to the protection of the environment, ecology and water resources.
- Contribute to the parameters of water economics to development planning processes.

5.12.8 Water Conservation in South Africa

History

Since 1982 the droughts have accentuated the awareness of the need to conserve water. In 1985 the Water Research Commission initiated a process to establish the National Water Supply Regulation (NWSR), which was proposed to be promulgated under the then Water Act. Participating local authorities were however, encouraged to promulgate the NWSR as their own Water Regulations (by-laws). Port Elizabeth Municipality was the first to adopt the NWSR in 1987. However, in 1992 the Department of Water Affairs and Forestry indicated it would not be involved with the administration of the (then) proposed NWSR and although the United Municipal Executive resolved in 1993 that the NWSR should be adopted by local authorities, little progress was made.

The proceedings of the National Water Supply and Sanitation Policy Conference of 1994 included an estimate of the extent of the problem of water losses due to leakage at 330 million m^3 /a and proposed a policy of water demand management. The subsequent Water Supply and Sanitation Policy White Paper published in 1994 referred to water conservation and demand management and encouraged a culture of water conservation and the introduction of stringent water demand management strategies to reduce water usage and the stress on resources.

The Working for Water programme

The Working for Water programme is part of the National Water Conservation Campaign and is based on the key assumption that invading alien plants pose a considerable threat to South Africa's extremely rich biological diversity, and to the ecological functioning of its natural systems. Also provided by the campaign is a catalogue of devices that can contribute to the efficient consumption of water.

Water restrictions

Restricting water use during extreme droughts through the imposition of conservation measures on consumers is an intermittent form of water demand management. The effects of past water restrictions give an indication of the extent and direction that future water conservation strategies could have.

Overall savings in water use (median estimates) achieved through water restrictions were found to vary according to region and severity of restriction. In the Rand Water area of supply mild restrictions saved about 15% whereas stringent restrictions saved about 27%. For the rest of Gauteng, Free State and Northern Cape these savings were about 19% (mild) and 34% (stringent). In the Umgeni Water area of supply mild restrictions saved only 1% to 5%, whereas stringent measures saved as much as 50%. For the rest of KwaZulu-Natal these savings were 29% (mild) and 46% (stringent).

It was difficult to determine the financial effects of water restrictions. In the Vaal River Supply Area the reduction in water requirements due to water restrictions for the Rand Water, Goldfields and Vaal River supply areas for the period 1982 to 1984 was almost 240 million m^3 of water or 22,5% of the requirement for the year 1982. The greatest total direct tangible financial impact was on public institutions such as the Department of Water Affairs and Forestry, Water Boards, Local Authorities and Eskom. Private households also bore a large financial impact of water restrictions. Mining had the least financial burden to bear because of water restrictions, yet achieved a net saving in water use of almost 32% in the same period. The greatest reduction in water use was for the agricultural sector, which had the second lowest direct financial impact.

From analyses of return flows in Gauteng it is concluded that the ratio of return flow to water use is not materially altered by the imposition of water restrictions. In other words, if the supply is reduced by (say) 20%, it can be assumed that the return flow will also be reduced by 20%.

Experience from past water restrictions that have proved to be the most effective during times of drought, which are relevant to future water conservation efforts are :

- The overall reduction in water use depends on a number of factors. However, when water use is reduced beyond 30% it can be detrimental to the user from a financial and motivational perspective.

- Voluntary reduction in water use fails to achieve the savings possible with mandatory steps.

- The most effective methods of reducing water use are higher tariffs, restriction of garden watering times, the banning of domestic hose pipe usage and allotting quotas to industry, bulk consumers and irrigators.

- The most effective motivations are pamphlets/newsletters, higher tariffs and punitive measures.

- The major interventions required to reduce both physical and non-physical losses from pipe networks are leak detection/monitoring, replacing old plumbing and the repair/monitoring of meters.

- The most effective methods of saving water used by commerce and industry are technical adjustments, recycle/re-use and promotion campaigns.

- The ratio of return flow to water use is not materially changed by changes in water use.

The measures implemented during the drought in the mid- 1980s reduced water use and the growth rate in water usage after the drought had ended. However, there is little or no incentive for existing or new consumers to continue to retain or to adopt the water saving measures when there is no drought.

5.12.9 Water Conservation in the Mzimvubu to Keiskamma Water Management Area

Based on experience elsewhere in South Africa an overall sustainable reduction in water use of up to 25% can be expected without having a detrimental effect on users. Return flows could be reduced by up to 10% of total water use. The main scope for water conservation in the Mzimvubu to Keiskamma WMA appears to be in the main urban centres in parts of which up to 40% of the quantity supplied is not accounted for. This applies particularly to East London, Queenstown and Sada/Whittlesea, where the successful implementation of water conservation would allow the commissioning of new sources of raw water supplies to be postponed by several years.

5.13 WATER ALLOCATIONS

5.13.1 Introduction

As explained in Section 3.4, numerous allocations of water have been made in the past under the provisions of the Water Act of 1956 and earlier legislation. Under the National Water Act (Act No. 36 of 1998) these allocations will be replaced by general authorisations or by licensing of specific water uses. The previous allocations were, however, still valid in 1995, and are discussed in this section of the report for comparison with estimated water availability in 1995.

Allocations of water were made and permits for use of water issued under the following sections of the Water Act of 1956 :

(a) Section 63 : Irrigation scheduling and quotas from Government Water Schemes.
(b) Section 56(3) : Allocations to other users from Government Water Schemes.
(c) Section 62 : Scheduling and quotas from Government Water Control Areas.
(d) Sections 32A and 32B : Scheduling and quotas from Government Subterranean Water Control Areas.
(e) Industrial, mining and effluent permits (including Articles 12, 12B and 21).
(f) Other allocations (including Section 9B permits, Water Court orders and older legislation).

Under (c) and (d) above, reference is made to Government Water Control Areas and Government Subterranean Water Control Areas. The first mentioned were a feature of the Water Act of 1956 which was applied to areas in which it was necessary in the public interest for the allocation of rights to the use of public water to be based on considerations other than only the extent of irrigable riparian land. The Water Act of 1956 provided for such cases to be dealt with by empowering the State President to declare the relevant area a Government Water Control Area in which the Minister of Water Affairs was entitled to allocate water. In all other areas water could be allocated only by a Water Court, primarily in proportion to the extent of irrigable riparian land.

Government Subterranean Water Control Areas provided for a similar situation in areas where over-exploitation of groundwater aquifers occurred.

With the implementation of the National Water Act of 1998, Government Water Control Areas no longer exist.

In the Mzimvubu to Keiskamma WMA, the area adjacent to the Doring River Dam (S20A), part of the Black Kei River catchment and part of the Buffalo River catchment, were Government Water Control Areas.

The Water Act of 1956 provided for the promotion of the interests of local communities through the establishment of irrigation districts. This could be done upon the request of a local community, or on the recommendation of the Minister of Water Affairs on his own initiative. After an irrigation district had been proclaimed by the State President, irrigation board members were elected by those landowners who had an interest in the irrigation of land within the district. An irrigation board administered its district by means of a schedule of rateable areas which recorded the quantity of public water to which each owner of land in the district was entitled. Where the district incorporated land that lay within a Government Water Control Area and in respect of which the Minister of Water Affairs had determined water rights the irrigation board had to include the Minister's determinations in its schedule of rateable areas.

With the introduction of the National Water Act (Act No.36 of 1998), irrigation boards were required to apply for registration as water user associations and, as explained in Section 3.4, the previous concept of riparian rights and private ownership of water was done away with. The nation's water resources became common property, belonging to the nation as a whole, and all water use for irrigation on a commercial scale is now subject to control by the Minister of Water Affairs.

In 1995 there were three irrigation districts in the Mzimvubu to Keiskamma WMA. They are listed in Table 5.13.1.1 but no information was found on the Mzintlava and Umzimvubu Irrigation Districts, and it appears that they may not have been functional. None of the irrigation districts was within a Government Water Control Area, or received water from a Government Water Scheme.

Allocations of water for irrigation under Government Water Schemes and in Government Water Control Areas were made on the basis of scheduled areas of irrigable land for each property to which water was allocated and a quota of a prescribed quantity of water per annum per hectare of land. The annual quantity of water allocated to each property was calculated as the scheduled area multiplied by the quota. A similar system was generally used by irrigation boards to allocate water within the irrigation districts under their control.

Where sources of water are not regulated by large dams annual fluctuations in the amounts of water available for irrigation tend to be large and there is frequently insufficient water to provide the full allocations. This is the case in many of the irrigation districts that rely on run-of-river diversions from local sources. In these circumstances, the quantity of water that was available each year was generally allocated by irrigation boards in proportion to the scheduled areas of land. This was done on the basis of "turns" where the available flow was supplied to individual landowners in rotation for prescribed periods of time.

TABLE 5.13.1.1: IRRIGATION DISTRICTS IN THE MZIMVUBU TO KEISKAMMA WMA

NAME	CATCHMENT	SCHEDULED AREA (ha)	QUOTA (m^3/ha/a)	ALLOCATION (million m^3/a)	SOURCE OF WATER
Kubusi	S60B, S60D	1112,9	Not known	-	Kubusi River, Wriggleswade Dam
Mzintlava	T32A, T32B, T32C	Not known	Not kown	-	Mzintlava River
Umzimvubu	T31B, T31D, T31F	Not known	Not known	-	Mzimvubu River

5.13.2 Permits and Other Allocations in the Mzimvubu to Keiskamma WMA

In the Mzimvubu to Keiskamma WMA allocations of water were made from the Klipplaat and the Doorn River Government Water Schemes, amounting to 17,96 million m^3/a for 2 573 ha of land scheduled under Article 63 and 13,49 million m^3/a for various uses under Section 56(3). In addition, allocations of 48,81 million m^3/a were made from the Upper and Middle Buffalo Government Water Schemes (Rooikrantz Dam and Laing Dam respectively) and the Amatole Government Water Scheme (Wriggleswade Dam). The combined total quantity of allocations is 80,26 million m^3/a.

The schemes under which Section 63 allocations were made are listed in Table 5.13.2.1 and the quantities of water allocated to various categories of users under other legislation are shown in Table 5.13.2.2. The allocations shown in the two tables were derived from information provided in the reports on the Upper Kei Basin Study (DWAF, 1993) and the Amatole System Analysis (DWAF, 1994). They include allocations to consumers within the former Republics of Ciskei and Transkei.

TABLE 5.13.2.1: SECTION 63 SCHEDULING AND QUOTAS FROM GOVERNMENT WATER SCHEMES IN THE MZIMVUBU TO KEISKAMMA WMA

SCHEME	QUATERNARY CATCHMENTS	SCHEDULING (ha)	QUOTA (m^3/ha/a)	ALLOCATION
Klipplaat Government Water Scheme (Waterdown Dam)	S32G to S32M	2 060,3 (1)	6 100	14,83 (2)
Doorn River Government Water Scheme	S20A, S20B	513 (1)	6 100	3,13
TOTALS		**2 573,3**	**-**	**17,96**

1. Includes areas in the former Republic of Ciskei and/or the former Republic of Transkei
2. Includes an allowance for ditribution losses in addition to the quota.

TABLE 5.13.2.2: ALLOCATIONS OTHER THAN SECTION 63 ALLOCATIONS FROM GOVERNMENT WATER SCHEMES TO CONSUMERS IN THE MZIMVUBU TO KEISKAMMA WMA

SCHEME	QUATERNARY CATCHMENTS	ALLOCATION (million m^3/a)					
		HOUSEHOLD & STOCK WATERING	MUNICIPALITIES	BULK INDUSTRIAL	BULK MINING	IRRIGATION	TOTAL
Upper Buffalo Government Water Scheme (Rooikrantz Dam)	R20A, R20B	0,00	2,54	1,02	0	1,24	4,8
Middle Buffalo Government Water Scheme (Laing Dam)	R20D to R20G	0,00	11,62	1,58	0	1,90	15,1
Kubusi River Government Water Scheme (Gubu Dam)	S60A, S60B	0,07	0,24	0,00	0	-	0,31
Amatole Government Water Scheme (Wriggleswade Dam))	S60B, R20E to R20G	0,00	25,6	0,00	0	3,0	28,6
Klipplaat Government Water Scheme (Waterdown Dam)	S32G to S32M	0,00	12,71	0,00	0	0,0	12,71
Doorn River Government Water Scheme (Doring River Dam)	S20A to S20C	0,00	0,78	0,00	0	0,0	8,78
TOTALS		**0,07**	**53,49**	**2,60**	**0**	**6,14**	**62,3**

5.13.3 Allocations in Relation to Water Requirements and Availability

The allocations from Government Water Schemes listed in Tables 5.13.2.1 and 5.13.2.2 total 80,26 million m^3/a, which is only 25% of the total urban, rural domestic and agricultural requirements within the WMA of 322 million m^3/a. Many of these additional requirements are provided for from State owned dams within the Ciskei and the Transkei for which lists of formal allocations in 1995 are not available. Others are supplied from dams owned by local authorities, such as Bridle Drift Dam which provides a large proportion of the water requirements of East London. Therefore allocations can be meaningfully compared with water requirements in only a few areas of the WMA.

In the East London/King William's Town area (now Buffalo City) the formal allocations from the state owned dams are not adhered to as the urban supply schemes have become integrated. The availability of water in this area is sufficient to meet expected requirements to about the year 2010 (DWAF 1999c).

The allocations of 27,54 million m^3/a of water from Waterdown Dam (Klipplaat River Government Water Scheme) exceeds the 1:10 year yield of the dam of 22,1 million m^3/a by a significant amount, with the result that the assurance of supply is lower than desirable. In addition, it is reported that farmers consider the irrigation quota to be too low for crop requirements (DWAF 1993). Therefore, it appears that both the allocations and the availability of water in these areas are too low.

With regard to the Doorn River Government Water Scheme, the irrigation quotas are also reported to be too low (DWAF 1993), but only 35% of the scheduled areas of land had been developed in 1995. Therefore, the land that had been developed was supplied with more than its allocation. Thus, there was sufficient water to meet the allocations, but the allocations were too low.

5.14 EXISTING WATER TRANSFERS

No water is imported to the Fish to Tsitsikamma WMA from other WMAs, and no water was exported in 1995. The following internal transfers occur :

- The transfer of 8,25 million m^3/a from Waterdown Dam (S32G) to Queenstown (S31F) for urban use.
- The transfer of 90 million m^3/a from Ncora Dam (S50E) to the Mbashe River catchment (T12C) for hydropower generation, irrigation and domestic use.
- The transfer of 1,15 million m^3/a from the catchment of the Keiskamma River (R10M) to the Southern Coastal Catchments (R50A, R50B) for domestic water supplies. (This scheme was expanded after 1995 to export water to the town of Peddie in the Fish to Tsitsikamma WMA).
- The facility to transfer 19 million m^3/a from Wriggleswade Dam (S60B) to Laing Dam (R20E).
- The transfer of 6,0 million m^3/a from Nahoon Dam (R30E) to the Buffalo River Catchment (R20F).

Information on the transfers is summarised in Table 5.14.1

TABLE 5.14.1: AVERAGE TRANSFERS WITHIN THE MZIMVUBU TO KEISKAMMA WMA AT 1995 DEVELOPMENT LEVELS

DESCRIPTION OF TRANSFER	SOURCE QUATERNARY	DESTINATION QUATERNARY	QUANTITY (million m^3/a)
Waterdown Dam to Queenstown	S32E	S31F	8,25
Ncora Dam to Mbashe River Catchment	S50E	T12C	90,0
Keiskamma River to Southern Coastal Catchments	R10M	R50A, R50B	1,15
Wrigglewode Dam to Laing Dam	S60B	R20E	19,0
Nahoon Dam to Buffalo River Catchment	R30E	R20F	6,0

5.15 SUMMARY OF WATER LOSSES AND RETURN FLOWS

A summary of water requirements, losses and return flows is presented in Table 5.15.1. These numbers are also represented as pie charts in Diagrams 5.15.1 and 5.15.2.

TABLE 5.15.1: SUMMARY OF WATER REQUIREMENTS, LOSSES AND RETURN FLOWS

CATEGORY			ON-SITE WATER REQUIREMENTS (million m^3/a)	LOSSES (million m^3/a)	LOSSES (%)	RETURN FLOW (million m^3/a)
Irrigation			143,02[(1)]	25,22[(1)]	15	15,29[(1)]
Urban			57,63	26,84	31	33,65
Rural			69,69	0,00	0	0,00
Bulk	a)	strategic	0,00	0,00	0	0,00
	b)	mining	0,00	0,00	0	0,00
	c)	other	1,51	0,00	0	0,45
Hydro-power [(2)]			185,0	0,00	-	185,0
Rivers, wetlands, dams			-	62,76	-	0,00
TOTAL			**456,85**	**114,82**	**-**	**134,39**

(1) Equivalent 1:50 year irrigation values and an on-site water requirement of 120,13 million m^3/a, losses of 21,8 million m^3/a and return flow of 12,83 million m^3/a.

(2) 185,0 million m^3/a is the assumed consumptive use in that it impacts on the available 1:50 year yield of dams. The total requirement is estimated to be 570 million m^3/a, of which 385 million m^3/a is obtained from run-of-river flow.

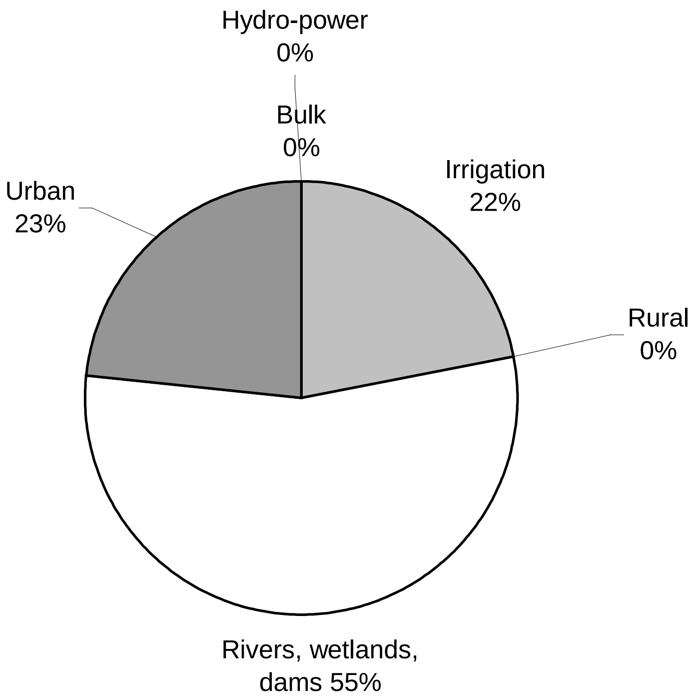


Diagram 5.15.1: Category loss as a proportion of the total losses in the WMA

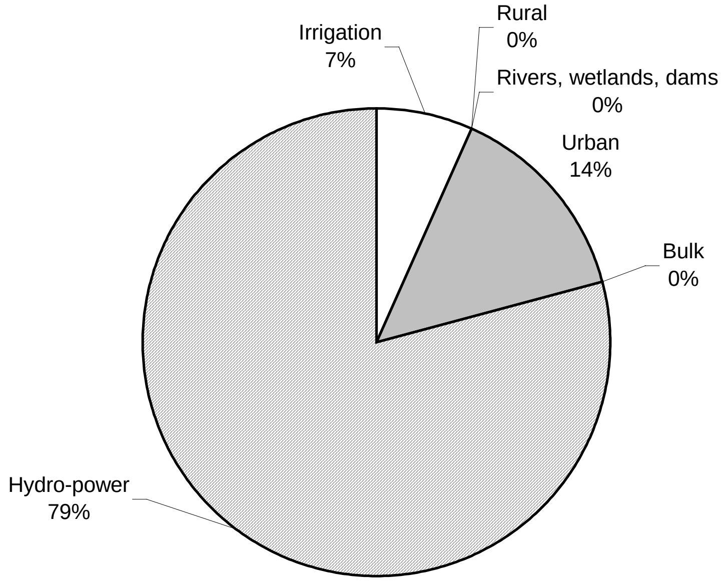


Diagram 5.15.2: Category return flow as a proportion of the total return flow in the WMA

CHAPTER 6: WATER RESOURCES

6.1 EXTENT OF WATER RESOURCES

It has been estimated from the data provided in the Water Research Commission publication, "The Surface Water Resources of South Africa, 1990" (Midgley *et al*, 1994) that, under virgin conditions, the total MAR of the Mzimvubu to Keiskamma WMA was 7 240 million m^3. Approximately 40% of this, or 2 897 million m^3/a, flowed out to sea through the mouth of the Mzimvubu River. The Mzimvubu Basin occupies 30% of the area of the WMA. The basin of the Great Kei River, which also occupies 30% of the area of the WMA provided only 13% of the natural runoff. This illustrates the trend of increasing runoff from south-west to north-east in the WMA. The area to the north-east of the Great Kei River Basin makes up 57% of the area of the WMA and provides 62% of the runoff.

The natural runoff has been reduced by evaporation losses from dams, the pumping of water from rivers and by the effects of timber plantations and alien vegetation. The present day MAR of the WMA as a whole is roughly estimated from the water requirements, evaporation losses and return flows given in this report to be 6 600 million m^3, which is 91% of the natural MAR. Some 40 dams of significant size and about 105 smaller farm dams have been constructed in the WMA, in addition to infrastructure for the abstraction of run-of-river flow. It is estimated that, as a result of this development, a yield of 749 million m^3/a can be obtained from the surface water resources at 1:50 year assurance. The distribution of this yield amongst the catchments making up the WMA is shown in Table 6.1.1 as the "1:50 year utilised yield in 1995".

If more large dams were constructed, the yield available from surface water at 1:50 year assurance could be increased to an estimated maximum of approximately 3 241 million m^3/a. The derivation of the estimate of the maximum potential yield is discussed in Section 6.3. This estimate does not take into account the possible adverse effects on the financial viability of surface water development schemes of the naturally high salinities of the base flows of rivers in some areas of the WMA. Consequently, more detailed investigations of surface water development potential may show the economically utilisable yield to be significantly less than 3 241 million m^3/a.

In the area to the north-east of the Great Kei River Basin a considerable additional quantity of run-of-river flow could be abstracted if the diversion weirs and/or pumps to do this were provided. This, together with the developed yield from dams, is referred to as available yield in Table 6.1.1. It can be seen that the available yield and utlised yield are generally equal in the south-western part of the WMA, whereas the available yield generally exceeds the utilised yield in the north-eastern part. For the WMA as a whole, the available yield of 1 155 million m^3/a exceeds the utilised yield by 406 million m^3/a.

TABLE 6.1.1: WATER RESOURCES

PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	SURFACE WATER RESOURCES				SUSTAINABLE GROUNDWATER EXPLOITATION POTENTIAL NOT LINKED TO SURFACE WATER		TOTAL WATER RESOURCE (million m^3/a)	
No.	Description	No.	Description	No.	CUMULATIVE NATURAL MAR (million m^3)	1:50 YEAR UTILISED YIELD IN 1995 (million m^3/a)	1:50 YEAR AVAILABLE YIELD IN 1995 (million m^3/a)	1:50 YEAR TOTAL POTENTIAL YIELD (million m^3/a)	DEVELOPED IN 1995 (million m^3/a)	TOTAL POTENTIAL (million m^3/a)	1:50 YEAR UTILISED IN 1995 (million m^3/a)	1:50 YEAR TOTAL POTENTIAL (million m^3/a)
R	Amatole Region	R5	Southern Coastal Catchments	R50A, R50B	42,20	3,00	3,00	12,0	0,06	4,18	3,06	12,0
		R1	Keiskamma	R10A to R10M	137,66	56,60	56,60	63,6	0,36	8,27	56,96	64,0
		R4	Amatola Coastal Catchments	R40A to R40C	77,12	6,01	6,01	22,1	0,09	3,54	6,10	22,2
		R2	Buffalo	R20A to R20G	98,0	54,26	54,26	54,3	0,21	1,65	54,47	54,5
		R3	Nahoon, Gqunube	R30A to R30F	204,25	20,13	20,13	62,9	0,49	9,02	20,62	63,4
		TOTAL IN AMATOLE REGION			**559,25**	**140,00**	**140,00**	**214,9**	**1,21**	**26,66**	**141,21**	**216,1**
S	Great Kei	S1	White Kei	S10A to S10J	161,32	31,10	31,10	37,4	0,79	20,22	31,89	38,2
		S2	Indwe	S20A to S20D	65,72	37,40	37,40	37,4	0,05	0,35	8,95	37,4
		S3	Klaas Smits	S31A to S31G	52,45	6,20	6,20	20,2	9,52	20,53	15,42	29,7
			Black Kei	S32A to S32M	196,54	39,27	39,27	54,8	1,46	28,48	56,26	56,3
		Total : Black and White Kei (S1, S2, S3)			357,86	113,97	113,97	149,8	11,82	69,58	80,69	161,6
		S4	Thomas	S40A to S40F	457,50	13,93	13,93	30,3	0,93	13,89	14,86	31,2
		S5	Tsomo	S50A to S50J	283,30	124,86	124,86	124,9	0,02	5,48	121,68	124,9
		S6	Kubusi	S60A to S60E	110,68	50,46	50,46	63,6	0,87	0,00	51,33	64,5
		S7	Great Kei and Xilinxa	S70A to S70F	931,14	16,68	16,68	96,9	0,16	0,00	17,04	97,1
		TOTAL IN GREAT KEI BASIN			**931,14**	**319,90**	**319,90**	**465,5**	**13,80**	**88,95**	**285,40**	**479,3**
T	Transkei Region	T1	Mbashe	T11, T12, T13	802,72	0,65	63,00	491,4	1,02	0,00	1,67	492,4
		T2, T7, T8	Mtata	T20, T70, T80	835,75	223,50	223,50	351,5	1,30	0,00	224,80	352,8
		T3	Upper Mzimvubu	T31A to T31J T33H to T33K	1312,34	11,47	47,80	269,2	1,87	10,64	13,34	271,1
			Mzintlava	T32A to T32H	357,33	20,59	34,30	188,9	0,83	0,00	21,42	189,7
			Kinira	T33A to T33G	456,83	8,53	43,80	245,9	0,00	0,00	8,03	245,9
			Tina	T34A to T34K	534,57	4,62	51,30	265,5	0,00	0,00	4,62	265,5
			Tsitsa	T35A to T35M	927,37	8,58	89,00	460,5	0,00	0,00	8,58	460,5
			Lower Mzimvubu	T36A to T36B	2896,60	0,71	10,30	0,7	0,00	6,97	0,71	2,0
		Total Mzimvubu			2896,60	54,50	276,50	1430,7	2,70	17,61	56,70	1434,7
		T6	Pondoland Coastal Catchments	T60A to T60K	795,93	5,50	105,00	196,6	0,90	0,00	6,40	196,6
		T9	Southern Wild Coast	T90A to T90G	323,54	5,30	27,20	90,7	0,35	0,00	5,65	91,0
		TOTAL IN TRANSKEI REGION			**4462,61**	**289,45**	**695,20**	**2560,9**	**6,27**	**17,61**	**295,22**	**2567,5**
TOTAL IN WMA					**7240,53**	**749,35**	**1155,10**	**3241,3**	**21,28**	**133,22**	**785,78**	**3262,9**

The yields shown in Table 6.1.1 are those available before the ecological Reserve has been provided for. As the National Water Act (No. 36 of 1998) provides for the Reserve to take preference over water users in the allocation of water resources, the yield available for user sectors is less than the totals shown in Table 6.1.1. It has been estimated, as described in Chapter 7, that the effect of implementing the ecological Reserve will be to reduce the 1:50 year yield available for other users by about 233 million m^3/a. About 190 million m^3/a of this impact will be on available, but presently unutilised, yield. Thus, the impact on the yield utilised in 1995 would have been 43 million m^3/a.

Some of the base flow in rivers originates from seepage from groundwater. Therefore, where boreholes extract water from the same groundwater source, the surface water runoff is reduced by the quantity of water abstracted from the boreholes. However, in areas where the nature of the topography on the climate make it impractical to develop surface water resources on a large scale, groundwater may be the more important component of the utilisable water resources.

In an assessment of the extent to which the groundwater resources are additional to the surface water resources of the Mzimvubu to Keiskamma WMA it was concluded for the reasons given in Section 6.2 that, as a rough approximation, groundwater resources and surface water resources should be assumed to be linked. It has, however, also been assumed that the surface water yields determined for development in 1995 made allowance for the effects on surface water runoff of groundwater use as it was in 1995. Therefore, in Table 6.1.1, the total water resource developed in 1995 is the sum of the developed surface water and groundwater yield. The total potential water resource includes, in addition to the surface and groundwater development in 1995, a rough estimate of all potential additional surface water resource developments required to utilise the water resources to their maximum economically viable potential. It has been simplistically assumed that any further development of groundwater yield would result in an equal reduction in surface water yield. The derivation of the estimates of additional surface water yield is described in Section 6.3.

The total available water resource in 1995 was estimated to have a yield, at 1:50 year assurance, of 1 176 million m^3/a (1 155 million m^3/a from surface water and 21 million m^3/a from groundwater), of which 770 million m^3/a was utilised (749 million m^3/a from surface water and 21 million m^3/a from groundwater). The total potential yield at 1:50 year assurance is estimated to be 3 263 million m^3/a. The distribution of the yield in 1995 amongst the key areas is shown diagrammatically on Figure 6.1.1 and Figure 6.1.2 shows the total potential yield in each key area.

6.2 GROUNDWATER

Groundwater is an important part of the total water resources of South Africa and is included in the hydrological cycle. The information provided here gives an overview of the groundwater resources, its interaction with the base flow component of the surface water, the present groundwater use (1995), and its potential for further development.

It must be noted that this information is intended for regional strategic planning and is not suitable for local site evaluations. More detailed information on the approach and methodology can be obtained in Appendix G. All information was collated on a quaternary catchment basis.

The Groundwater 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 (see Figure 6.2.1).

The Harvest Potential was 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 (see Table 6.2.1 and Figure 6.2.2).

The interaction of the groundwater and the surface water was assessed by evaluating the base flow component of the surface water, or more specifically the contribution of the Harvest Potential to the base flow. This 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 reduce the base flow component of the surface water has been qualitatively evaluated (see Figure 6.2.3 and Appendix G). Where the contribution of groundwater to the base flow component of the surface flow is zero, the impact will be negligible, where the contribution is less than 30% of the base flow the impact will be low, where the contribution is between 30% and 80% of the base flow the impact will be moderate, and where the contribution to base flow is more than 80% the impact will be high. This assessment of the interaction of groundwater and the base flow component of the surface water can, however, not be used directly to determine the additional contribution of groundwater abstraction to the total utilisable water resource without also taking account of the effect of surface water storage capacity and the reduction in surface water runoff that is caused by the increase of groundwater recharge (induced recharge) that results from groundwater abstraction. The estimates of utilisable surface water given in Section 6.3 have been derived on the basis of no increased groundwater abstraction. It has been assumed for the purposes of the water resources assessment that any increase in groundwater abstraction would result in a corresponding decrease in surface water development potential.

The existing groundwater use was determined by Baron and Seward (2000). Estimates of groundwater use were also made at a workshop held on the Mzimvubu to Keiskamma WMA by the water resources situation assessment team. This provided local input to the estimates of groundwater use provided by Baron and Seward which were then adjusted accordingly to obtain the estimated groundwater use shown in Table 6.2.1 and Figure 6.2.4.

The groundwater balance compares existing groundwater use to the Harvest and Exploitation Potential to determine the extent to which the groundwater resources are utilised (see Figure 6.2.5 and Appendix G). If the total use was greater than the Harvest Potential the groundwater in the catchment was considered to be over-utilised, if the total use was greater than the Exploitation Potential but less than the Harvest Potential the groundwater in the catchment was considered to be heavily utilised, if the total use was more than 66% of the Exploitation Potential the groundwater in the catchment was considered to be moderately utilised, and if the total use was less than 66% of the Exploitation Potential, the groundwater in the catchment was considered to be under-utilised.

TABLE 6.2.1: GROUNDWATER RESOURCES AT 1:50 YEAR ASSURANCE OF SUPPLY

PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	GROUNDWATER EXPLOITATION POTENTIAL (million m^3/a)	GROUNDWATER USE IN 1995 (million m^3/a)	UNUSED GROUNDWATER EXPLOITATION POTENTIAL IN 1995 (million m^3/a)	GROUNDWATER CONTRIBUTION TO SURFACE BASE FLOW (million m^3/a)	PORTION OF GROUNDWATER EXPLOITATION POTENTIAL NOT CONTRIBUTING TO SURFACE BASE FLOW (million m^3/a)	GROUNDWATER UTILISABLE WITHOUT DESALINATION (million m^3/a)
No.	Description	No.	Description	No.						
R	Amatole Region	R5	Southern Coastal Catchment	R50A, R50B	6,03	0,06	5,97	1,85	4,18	2,45
		R1	Keiskamma	R10A to R10M	24,34	0,36	23,98	16,07	8,27	12,26
		R4	Amatola Coastal Catchments	R40A to R40C	7,56	0,09	7,47	4,02	3,54	3,78
		R2	Buffalo	R20A to R20G	11,44	0,21	11,23	9,79	1,65	6,82
		R3	Nahoon, Gqunube	R30A to R30F	21,24	0,49	20,74	12,22	9,02	13,86
		TOTAL IN AMATOLE REGION			**70,61**	**1,21**	**69,40**	**43,96**	**26,66**	**39,17**
S	Great Kei	S1	White Kei	S10A to S10J	27,63	0,79	26,84	7,41	20,22	21,21
		S2	Indwe	S20A to S20D	12,65	0,05	12,59	12,30	0,35	9,70
		S3	Klaas Smits	S31A to S31G	25,39	9,52	15,87	4,86	20,53	22,15
			Black Kei	S32A to S32M	43,97	1,46	42,51	15,49	28,48	32,27
		Total : Black and White Kei (S1, S2, S3)			109,64	11,82	97,82	40,06	69,58	85,33
		S4	Thomas	S40A to S40F	19,77	0,93	18,85	5,88	13,89	14,29
		S5	Tsomo	S50A to S50J	26,69	0,02	26,67	21,21	5,48	20,02
		S6	Kubusi	S60A to S60E	11,60	0,87	10,73	17,50	0,00	6,18
		S7	Great Kei and Xilinxa	S70A to S70F	18,34	0,16	18,18	21,01	0,00	11,98
		TOTAL IN GREAT KEI BASIN			**186,05**	**13,80**	**172,25**	**105,66**	**88,95**	**137,80**
T	Transkei Region	T1	Mbashe	T11, T12, T13	52,91	1,02	51,89	63,49	0,00	36,14
		T2, T7, T8	Mtata	T20, T70, T80	42,51	1,30	41,21	86,49	0,00	26,01
		T3	Upper Mzimvubu	T31A to T31J T33H to T33K	41,22	1,87	39,35	30,58	10,64	36,81
			Mzintlava	T32A to T32H	2,83	0,83	2,00	38,29	0,00	1,88
			Kinira	T33A to T33G	26,30	0,00	26,30	44,47	0,00	22,36
			Tina	T34A to T34K	27,89	0,00	27,89	49,73	0,00	23,99
			Tsitsa	T35A to T35M	46,37	0,00	46,37	80,06	0,00	39,41
			Lower Mzimvubu	T36A to T36B	16,86	0,00	16,86	9,89	6,97	2,32
		Total Mzimvubu			161,47	2,70	158,77	253,01	17,61	126,77
		T6	Pondoland Coastal Catchments	T60A to T60K	66,77	0,90	65,87	91,69	0,00	57,93
		T9	Southern Wild Coast	T90A to T90G	20,84	0,35	20,49	43,27	0,00	9,10
		TOTAL IN TRANSKEI REGION			**344,50**	**6,27**	**338,23**	**537,95**	**17,61**	**256,62**
TOTAL IN WMA					**601,16**	**21,28**	**579,88**	**687,57**	**133,22**	**433,59**

In the Mzimvubu to Keiskamma WMA, groundwater was considered to be under-utilised throughout the WMA, except in catchment S31E of the Klaas Smits area, where it is moderately utilised.

Some of the groundwater is too saline to be fit for human consumption without desalination. The quantity of the groundwater exploitation potential that is potable without desalination is shown in the column on the right hand edge of Table 8.1. It amounts to 72% of the total groundwater exploitation potential.

6.3 SURFACE WATER RESOURCES

The basis for the analysis of surface water resources was the synthesised streamflow data at quaternary catchment level developed for the Water Research Commission funded study of the water resources of South Africa (Midgley *et al*, 1994) which is commonly referred to as WR90. Certain adjustments, as described below were made to these flow sequences.

The WR90 natural flows have taken account of afforestation-related streamflow reductions according to the "Van der Zel curves". Recently these curves have been seen as too simplistic, and have been superseded by the "CSIR curves". These curves allow the species, age and site conditions of the afforested area to be taken into account in estimating the streamflow reduction, and are currently the preferred estimation method.

For the purpose of the Water Situation Assessment Model it was decided to adjust the WR90 quaternary naturalised flows to reflect the CSIR afforestation-related streamflow reduction effects. An investigation to determine a method of making the adjustments without serious time or cost implications was conducted (Ninham Shand, 1999). The selected method consisted of the following steps :

(1) The afforestation water use time series based on the Van der Zel 15-year rotation curve was generated
(2) This time series (the result of (1)) was then subtracted from the Van der Zel-based naturalised flow time series generated for the whole calibration catchment.
(3) The naturalised flow from the afforested portion of the catchment (Van der Zel-based) was used to obtain an afforestation water use time series based on the CSIR curves. This result was added to the result of (2), yielding a time series of adjusted (CSIR-based) naturalised flows.

These adjusted flows have been used for the catchments that contain afforestation.

A validation of this adjustment method was carried out for five gauged catchments from three geographically different regions, which had full hydrological studies available from recent basin studies. Calibration configurations were obtained from these studies. An identical configuration was set up to include the CSIR afforestation-related flow reduction function, and the Pitman model was recalibrated. This resulted in two calibrated" sets of Pitman model parameters for each catchment, the one using the Van der Zel, and the other using the CSIR afforestation-related streamflow reduction functions.

Monthly naturalised flows were simulated using the two calibrated parameter sets. The CSIR series was used as the "true" series for validation and compared with the Van der Zel time series after it was adjusted as described above.

Differences between the MARs of the adjusted (CSIR-based) naturalised flows and the re-calibrated "true" naturalised flows were within 5%, which was considered to be acceptable.

Based on the three steps described above, the WR90 naturalised flow series were then adjusted for all the afforested quaternary catchments in the country. If the runoff reduction due to afforestation estimated by means of the CSIR curves was lower than the runoff reduction estimated by means of the Van der Zel curves, the virgin runoff of WR90 would have been reduced and vice versa. The difference between the adjusted MARs and the original WR90 values ranges between a reduction of 18% and an increase of 28%. For most of the catchments the difference varies between zero and an increase of 7%. In the Mzimvubu to Keiskamma WMA the decrease was between 3% and 7%.

The proposed methodology ensures that the calculated runoff from an afforested catchment (which would be observed at a streamflow gauge) is the same, irrespective of the afforestation water use model that has been used.

The most important limitations of the method described above are :

- The updated afforestation water use was estimated by means of the CSIR curves (as described in (3)), but the uncorrected naturalised flows based on the original Van der Zel curves were used as an input into this calculation. As a refinement, one could consider the possibility of repeating the process, but this time estimating afforestation water use, not using the original WR90 naturalised flows, but rather the newly adjusted ones. This could then be used to make a second estimate of the CSIR-based natural flows. Further re-iterations of this process might improve the accuracy.
- Catchments upstream of some calibration gauges contained quaternaries with and without afforestation. Changing the MARs of only afforested quaternary catchments therefore made the naturalised MAR of the total catchment less accurate, as the MARs of unafforested catchments were not adjusted.

The perfect solution is to re-calibrate all affected catchments. However, as was explained above, at this stage it was considered inappropriate.

Four detailed studies of the hydrology of portions of the Mzimvubu to Keiskamma WMA have been carried out in the past. Brief descriptions of them follow.

- The Amatole Water Resources System Analysis (DWAF, 1995) carried out by Ninham Shand and HKS included hydrological modelling of the Buffalo (R20), Nahoon (R30E, R30F), Gqunube (R30C, R30D), Kubusi (S60A to S60D) Rivers.

- The Upper Kei Basin Study (DWAF, 1993) carried out by HKS and Ninham Shand included hydrological modelling of the Kei River catchment upstream of the confluence of the Black Kei and the White Kei Rivers (S1, S2, S3).

- The Mzimvubu Transfer Options component of the Vaal Augmentation Planning Study (DWAF, 1995), which included hydrological modelling of the Mzimvubu Basin.

- The Mbashe Basin Study (Stephenson & Associates, 1988), which included hydrological modelling of the Mbashe River Basin (T1).

Where appropriate, the results of the above studies were used to derive the 1995 yields shown in Table 6.3.1. In those areas not covered by the above studies, and those areas where the study data were not sufficiently detailed from localised studies, the appropriate storage-draft-frequency curves from WR90 were used to estimate the yields of the main dams.

The combined yields of farm dams and run-of-river flow in the Great Kei River Basin and the areas to the west of it, where the water resources are heavily utilised were estimated on the following basis. It was assumed that, because of the high investment cost, the development of irrigated land has been balanced against the availability of water. The availability of water from government water schemes is well documented, but the yield from "private" sources is not. Therefore, it was assumed that the portion of estimated livestock and irrigation requirements that is not provided for from government water schemes is provided from farm dams and run-of-river yield. Thus, this yield was calculated by subtracting the portions of the yields of major dams used for irrigation, from the equivalent 1:50 year irrigation requirement after adjusting it for re-used return flows, and adding the requirements of livestock and rural communities not served by regional schemes to the result. The estimates obtained in this way are probably slightly high because it is unlikely that all the land irrigated from run-of-river flow on average could be irrigated during a 1:50 year drought.

In the area to the north-east of the Great Kei River Basin a similar approach was adopted with the utilised 1:50 year run-of-river yield being assumed to equal those water requirements that are not provided from major dams, except that the 1:50 year run-of-river contribution to hydro-power generation was assumed to be negligible.

In the north-eastern portion of the WMA the utilised run-of-river yield is less than the yield that could be utilised by providing additional diversion weirs and/or pumping equipment (defined in this document as the available run-of-river yield). In this area the requirements of the ecological Reserve are generally greater than the utilised run-of-river yield, but less than the available run-of-river yield. Therefore, in order to determine whether or not the requirements of the ecological Reserve impact upon the utilised 1:50 year run-of-river yield, it was necessary to estimate the available 1:50 year run-of-river yield and to determine the utilisable portion of this after allowing for the impact of the ecological Reserve.

The available 1:50 year run-of-river yield was assumed to be 60% of the 12 month duration 1:50 year low flow determined from the appropriate WR90 deficient flow-frequency-duration curve. The 40% of the flow not included was assumed to be the flood component of the flow that cannot be utilised without providing major storage.

Run-of-river yields determined for the western portion of the WMA were compared with those determined from water requirements and showed reasonable agreement for those key areas where there is not significant storage.

TABLE 6.3.1: SURFACE WATER RESOURCES

PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	INCREMENTAL CATCHMENT AREA (km^2)	MEAN ANNUAL PRECIPITATION (mm/a)	MEAN ANNUAL EVAPORATION (mm/a)	NATURAL MAR		INCREMENTAL YIELD (1:50 YEAR)		
No.	**Description**	**No.**	**Description**	**No.**				**INCREMENTAL (million/m^3)**	**CUMULATIVE (million/m^3)**	**AVAILABLE IN 1995 (million m^3/a)**	**UTILISED IN 1995 (million m^3/a)**	**TOTAL POTENTIAL (million m^3/a)**
R	Amatole Region	R5	Southern Coastal Catchments	R50A, R50B	807	580	1400	42,20	42,20	3,00	3,00	12,0
		R1	Keiskamma	R10A to R10M	2697	668	1500	137,66	137,66	56,60	56,60	63,6
		R4	Amatola Coastal Catchments	R40A to R40C	854	680	1375	77,12	77,12	6,01	6,01	22,1
		R2	Buffalo	R20A to R20G	1286	746	1425	98,02	98,02	54,26	54,26	54,3
		R3	Nahoon, Gqunube	R30A to R30F	2292	766	1350	204,25	204,25	20,13	20,13	62,9
		TOTAL IN AMATOLE REGION			**7936**	**701**	**1430**	**559,25**	**559,25**	140,00	140,00	**214,9**
S	Great Kei	S1	White Kei	S10A to S10J	2925	575	1625	95,60	161,32	31,10	31,10	37,4
		S2	Indwe	S20A to S20D	16047	642	1600	65,72	65,72	37,40	37,40	37,40
		S3	Klaas Smits	S31A to S31G	2652	517	1675	52,45	52,45	6,20	6,20	20,2
			Black Kei	S32A to S32M	4253	548	1600	144,09	196,54	39,27	39,27	54,8
		Total : Black and White Kei (S1, S2, S3)			11437	560	1625	357,86	357,86	113,97	113,97	149,8
		S4	Thomas	S40A to S40F	2169	590	1500	99,64	457,50	13,93	13,93	30,3
		S5	Tsomo	S50A to S50J	3433	710	1500	283,30	283,30	124,86	124,86	121,7
		S6	Kubusi	S60A to S60E	1288	673	1450	110,68	110,68	50,46	50,46	63,6
		S7	Great Kei and Xilinxa	S70A to S70F	2158	720	1350	175,26	931,14	16,68	16,68	96,9
		TOTAL IN GREAT KEI BASIN			**20485**	**613**	**1550**	**931,14**	**931,14**	319,90	319,90	**462,3**
T	Transkei Region	T1	Mbashe	T11, T12, T13	6053	785	1380	802,72	802,72	63,00	0,65	491,4
		T2, T7, T8	Mtata	T20, T70, T80	5526	885	1200	835,75	835,75	223,50	223,50	351,5
		T3	Upper Mzimvubu	T31A to T31J T33H to T33K	4740	796	1300	498,18	1312,34	47,80	11,47	269,2
			Mzintlava	T32A to T32H	2950	839	1225	357,33	357,33	34,30	20,59	188,9
			Kinira	T33A to T33G	3309	782	1350	456,83	456,83	43,80	8,53	245,9
			Tina	T34A to T34K	4929	844	1350	534,57	534,57	51,30	4,62	265,5
			Tsitsa	T35A to T35M	3197	864	1340	927,37	927,37	89,00	8,58	460,5
			Lower Mzimvubu	T36A to T36B	727	980	1175	122,32	2896,6	10,30	0,71	0,7
		Total Mzimvubu			19852	833	1315	2896,6	2896,6	276,50	54,50	1301,0
		T6	Pondoland Coastal Catchments	T60A to T60K	3733	1019	1150	795,93	795,93	105,00	5,50	196,6
		T9	Southern Wild Coast	T90A to T90G	2626	873	1260	323,54	323,54	27,20	5,30	90,7
		TOTAL IN TRANSKEI REGION			**37790**	**853**	**1300**	**4462,61**	**4462,61**	695,25	289,45	**2431,2**
TOTAL IN WMA					**66211**	**758**	**1390**	**7240,53**	**7240,53**	1155,10	749,35	**3238,1**

The estimated utilised 1:50 year surface water yields in 1995 and the estimated available 1:50 year yields are shown for each key area in Table 6.3.1. The utilised yields were calculated as the sums of

- the 1:50 year yields of major dams;
- the 1:50 year yield of farm dams and run-of-river flow;
- the impact of afforestation on the 1:50 year system yield;
- the impact of alien vegetation on the 1:50 year system yield.

The total utilised 1:50 year yield in 1995 for the WMA was estimated to be 749 million m^3/a. The components of the yield making up the total are shown for each key area in Table 6.3.2.

The available 1:50 year yield was assumed to equal the utilised yield in the Great Kei River Basin and the areas to the west of it. In the eastern portion of the WMA, it was assumed to be the available 1:50 year run-of-river yield, determined from WR90 as described above, except that for the Mtata area, the run-of-river yields of the catchments downstream of Umtata Dam and the adjacent coastal catchments (T7 and T8) were added to the yield of Umtata Dam and the impact on yield of the afforestation upstream of the dam.

The total available 1:50 year yield, also shown in Table 6.3.1, was estimated to be 1 155 million m^3/a, which is 406 million m^3/a more than the 1:50 year utilised yield in 1995.

The estimates are at a low level of confidence because of the uncertainty surrounding the true run-of-river yields and the true impacts on yield of alien vegetation and afforestation (see Section 7.1.4).

There is some available information regarding the potential future development of surface and groundwater resources in the Mzimvubu to Keiskamma WMA. The yield of the Mzimvubu Basin has been investigated for its potential as a source of water for the Witwatersrand (DWAF, 1995) and schemes for augmenting supplies to the East London/King William's Town area have been investigated (DWAF, 1999c), both at pre-reconnaissance level.

As the above studies did not cover the whole WMA, they were not used for the purposes of determining maximum potential yield. Instead, as an aid to estimating the total potential yield available from the catchments within the WMA, future storage dams of a particular maximum net storage capacity have been postulated. The method used is extremely rough and the results are very approximate, merely giving an indication of the potential yield in each key area. These results should not be used for any study where accurate results are necessary. More detailed investigation in the specific area should be undertaken when more reliable results are required.

The capacities and yields of the hypothetical dams were derived as follows:

Estimates of the maximum feasible storage (expressed as a percentage of MAR) for dams in each WR90 hydro zone were derived for this project (DWAF, 1999d). Dams that will capture and regulate all the runoff from a catchment are not economical to build. In the drier areas where the runoff is more variable the sizes of such dams also become prohibitive. A simple technique, based on past experience, has therefore been developed whereby plausible estimates of maximum feasible dam sizes have been derived for the entire South Africa and which will provide consistent results throughout the country.

The water balance model (WSAM) will, however, be enhanced in future to contain additional functionality to allow users to optimise the likely maximum storage capacity.

The technique that was adopted introduces a limit line to the net storage-gross yield relationship for a 50 year recurrence interval, as shown in Diagram 6.3.1. The net total incremental quaternary catchment storage capacity used to estimate the potential contribution to the yield by a quaternary catchment has been determined from the intersection of the net storage-gross yield relationship for a 50 year recurrence interval for a particular hydrologic zone, and the limit line shown in Diagram 6.3.1. This is illustrated by means of the typical net storage-gross yield relationships shown in Diagram 6.3.1 for rivers of low, moderate and high flow variability, which generally correspond to rivers draining high, moderate and low rainfall catchment areas respectively. The net total incremental storage capacities derived by means of this method have been rounded off to range from 150% of the MAR in the higher rainfall quaternary catchments to 200% of the MAR in the drier quaternary catchments within the WMA, as summarised in Table 6.3.2.

The instream flow requirement for the most downstream quaternary catchment in each key area was subtracted from the incremental MAR at that point. The remaining MAR was used to determine the 1:50 year gross yield from WR90 corresponding to the maximum feasible storage capacity determined from the MAR. The value was estimated to be 4 405 million m^3/a for the WMA as a whole for a storage capacity of 12 319 million m^3. These values are the sums of separate values calculated for each key area. The calculations are shown in Table 6.3.2.

The gross yields given by the WR90 curves have not had evaporation losses subtracted from them. The effects of evaporation losses were estimated by comparing the yields of representative existing dams (Nahoon, Waterdown, Wriggleswade, and a previously investigated 1,5 MAR dam in the Mzimvubu catchment) as calculated in previous more detailed studies, with gross yields calculated using the WR90 curves. The ratios of yields allowing for evaporation losses, to gross yields ranged from 0,57 for Waterdown Dam, through 0,73 for Nahoon Dam, to 0,83 for Wriggleswade Dam and 0,89 for the Mzimvubu Dam.

The appropriate one of these four ratios was applied to each of the gross yields calculated to obtain a yield adjusted for evaporation losses. This gave a potential maximum yield for the whole WMA of 3 690 million m^3/a.

In order to determine the quantity of additional yield that would have to be developed to reach the full potential yield of the water resources, the 1:50 year yields in 1995 of existing major dams (totalling 501 million m^3/a for the WMA), farm dams and developed run-of-river yield (totalling 244 million m^3/a) and the impacts on yield of afforestation and alien vegetation (totalling 69 million m^3/a) were subtracted from the estimated potential maximum yield of 3 690 million m^3/a.

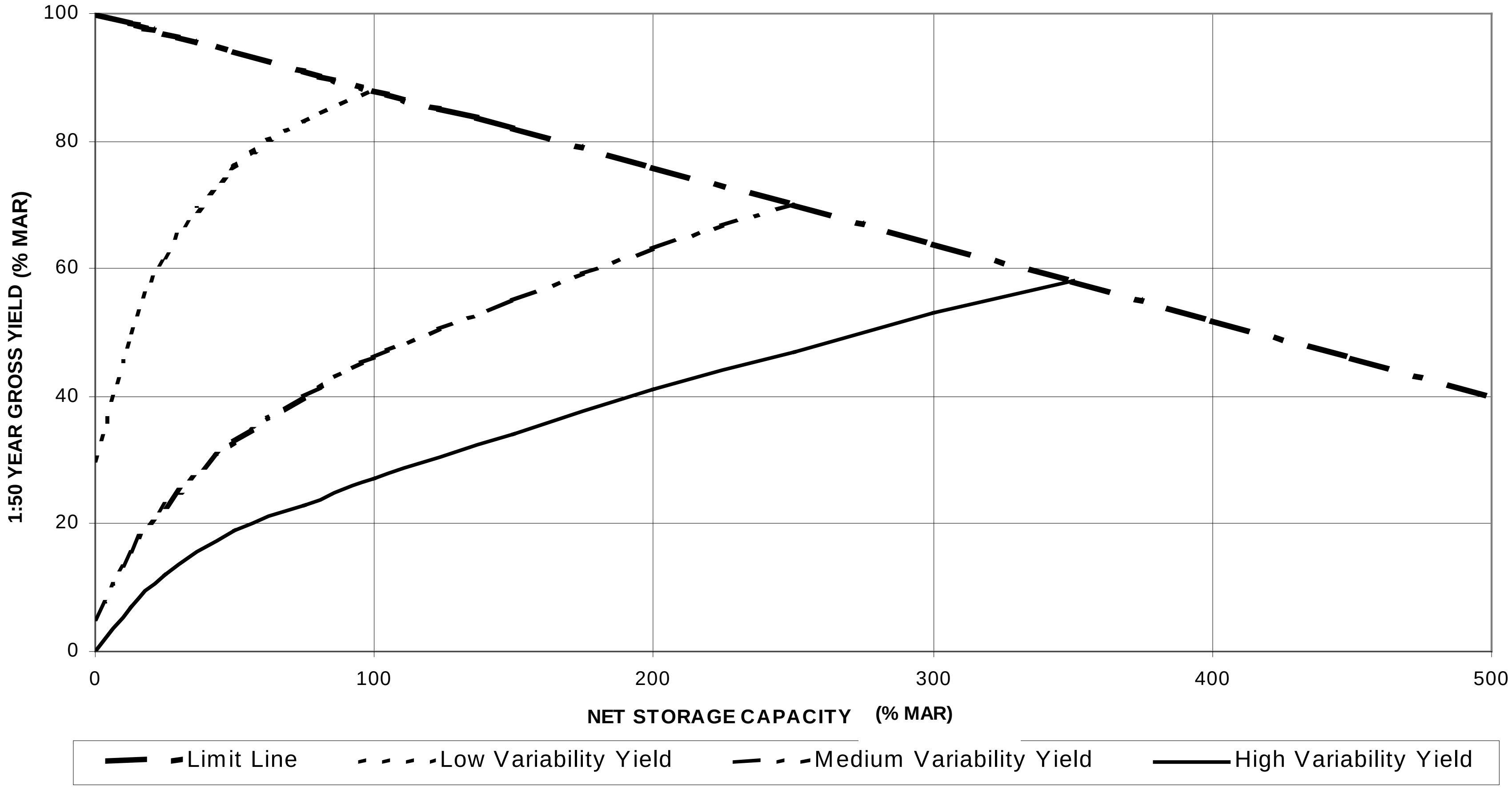


DIAGRAM 6.3.1: DAM STORAGE LIMITS

TABLE 6.3.2: CALCULATION OF POTENTIAL SURFACE MAXIMUM YIELD IN THE MZIMVUBU TO KEISKAMMA WMA

Key Area		WR90 Hydro Zone	Maximum Feasible Storage Capacity	Incremental MAR	Incremental IFR	Incremental MAR less IFR	Maximum Feasible Storage Capacity	1:50 year RI Gross Draft as % MAR (from WR90 Storage-Draft-Frequency)	Gross Potential Maximum Yield (WR90 1:50 Yield)	Ratio used for allowance for evaporative losses (see Note 1 below)	Net Potential Maximum Yield (WR90 1:50 Yield)	Yield of Major Dams in 1995	Run of River & Minor Dam Yield in 1995	Impact of Afforestation on Yield	Impact of Alien Vegetation on Yield in 1995	Total Utilised Yield in 1995	Interim potential develop-able yield	Adjusted Potential Develop-able Yield (See Note 2 below)	Accepted Potential Develop-able Yield (-ve values zeroed)	Final Nett Potential Maximum Yield (WR90 1:50 Yield)
Description	**Catchments**		**% MAR**	**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**	**% MAR**	**$10^6m^3/a$**		**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**	**$10^6m^3/a$**
Southern Coast	R50A, R50B	S	200	42,2	5,40	36,8	84,4	0,78	28,7	0,73	20,9	0,0	2,10	0,0	0,90	3,00	17,9	9,0	9,0	12,0
Keiskamma	R10A-R10M	K, S	200	137,7	13,6	124,1	275,4	0,78	96,8	0,73	70,17	46,7	6,0	1,63	2,27	56,60	14,1	7,0	7,0	63,6
Amatole Coastal	R40A-R40C	S	200	77,1	9,8	67,3	154,2	0,78	52,5	0,73	38,3	0,0	4,5	0,07	1,44	6,01	32,3	16,1	16,1	22,1
Buffalo	R20A-R20G	K, S	175	98,0	9,4	88,6	171,5	0,78	69,1	0,73	50,4	48,7	3,0	1,90	0,66	54,26	-3,86	-	0,0	54,3
Nahoon Gqunube	R30A-R30F	S	200	204,2	18,5	185,7	408,4	0,78	144,8	0,73	105,7	7,8	12,0	0,00	0,33	20,13	85,6	42,8	42,8	62,9
White Kei	S10A-S10J	L, N	200	95,6	6,9	88,7	191,2	0,74	65,6	0,57	37,4	29,1	2,0	0,00	0,00	31,10	6,3	-	6,3	37,4
Indwe	S20A-S20D	J	150	65,7	8,3	57,4	98,6	0,80	45,9	0,57	27,5	31,9	5,5	0,00	0,00	37,4	-11,3	-	0,0	37,4
Klaas Smits	S31A-S31G	L	200	52,5	4,7	47,8	105,0	0,74	35,4	0,57	20,2	1,0	5,2	0,00	0,00	6,20	14,0	-	14,0	20,2
Black Kei	S32A-S32M	E, N	200	144,1	14,2	129,9	288,2	0,74	96,1	0,57	54,8	26,3	11,5	1,19	0,28	39,27	15,5	-	15,5	54,8
Thomas	S40A-S40F	N	200	99,6	27,7	71,9	199,2	0,74	53,2	0,57	30,3	1,0	8,0	0,21	4,72	13,93	16,4	-	16,4	30,3
Tsomo	S50A-S50J	H, N	200	283,3	,26,3	257,0	566,6	0,74	190,2	0,57	108,4	117,2	6,5	1,16	0,00	124,86	-13,12	-	0,0	124,9
Kubusi	S60A-S60E	D, E	150	110,7	20,6	90,1	166,0	0,85	76,6	0,83	63,6	28,4	7,0	7,87	7,19	50,46	13,1	-	13,1	63,6
Great Kei and Xilinxa	S70A-S070F	N, M	200	175,3	21,7	153, 6	350,6	0,76	116,7	0,83	96,9	9,4	6,5	0,67	0,11	16,68	80,2	-	80,2	96,9
Mbashe	T11, T12, T13	H, M	200	802,7	112,4	690,3	1 605,4	0,80	552,2	0,89	491,4	0,0	65,0	0,00	0,00	0,65	490,7	-	490,7	491,4
Mtata	T20, T70, T80	M	200	835,8	145,2	690,6	1 671,6	0,78	538,7	0,89	479,4	148,2	43,0	28,50	3,80	223,50	255,9	128,0	128,0	351,5
Upper Mzimvubu	T31A-T31J T33H-T33K	G	150	498,2	73,0	403,3[3]	747,3	0,75	302,5	0,89	269,2	0,0	11,(	0,04	0,43	11,47	257,7	-	257,7	269,2
Mzintlava	T32A-T32H	G	150	357,3	57,2	282,8[3]	536,0	0,75	212,2	0,89	188,9	2,0	18,1	0,04	0,45	20,59	168,3	--	168,3	188,9
Kinira	T33A-T33G	G	150	456,8	68,0	368,4[3]	685,2	0,75	276,3	0,89	245,9	3,2	5,0	0,02	0,31	8,53	237,4	-	237,4	245,9
Tina	T34A-T34K	C, G	150	534,6	105,3	397,7[3]	801,9	0,75	298,3	0,89	265,5	0,0	4,0	0,37	0,25	4,62	260,9	-	260,9	265,5
Tsitsa	T35A-T35M	C, G	150	927,4	182,7	689,9[3]	1 391,1	0,75	517,4	0,89	460,5	0,0	6,2	2,33	0,05	8,58	451,9	-	451,9	460,5
Lower Mzimvubu	T36A-T36B	M	200	122,3	272,5	(-150,2)	0	0,75	0,0	0,89	0,0	0,0	0,7	0,00	0,01	0,71	-0,71	-	0,0	0,7
Pondoland Coast	T50A-T60K	F	150	795,9	215,0	580,9	1 193,9	0,75	435,7	0,89	387,8	0,0	5,5	0,00	0,00	5,50	382,3	191,1	191,1	196,6
Southern Wild Coast	T90A-T90G	M	200	323,5	69,8	253,7	627,0	0,78	197,9	0,89	761,1	0,0	5,3	0,00	0,00	5,30	170,8	85,4	85,4	90,7
TOTALS	-	-	-	**7240,5**	**1488,2**	-	**12 318,7**	-	**4405,1**	**0,84**	**3 689,8**	**500,9**	**243,6**	**46,00**	**23,20**	**749,35**	-	-	**2491,8**	**3241,3**

Note 1 : Allowance for evaporation losses from Dams: one of four ratios was taken, based on a comparison of the WR90 1:50 year gross yields with net yields obtained in other studies for the following dams: Nahoon Dam = 0,73; Waterdown Dam = 0,57, Wriggleswade Dam 0,83; a proposed 1,5 MAR dam in the Mzimvubu catchment = 0,89

Note 2: For coastal catchments only, only half the potential yield was taken (but the full storage was kept). This is because, based on the numbers for the Groot Brak River in the Gouritz WMA, where the Wolwedans Dam was built in 1993, only half of the potential yield will be available to consumers, because the rest will be required for estuarine flow requirements.

Note 3 : (Incremental MAR - Incremental IFR) x 0,95 to allow for additional runoff required to provide the IFR for the Lower Mzimvubu.

The calculation was performed for each key area. In the Southern Coast, Keiskamma, Amatola Coastal, Nahoon/Gqunube, Mtata, Pondoland Coast, and Southern Wild Coast key areas, the utilisable portion of the underdeveloped yield was assumed to be half of the full amount, it being assumed that the other half would be required to provide the freshwater ecological flow requirements of the estuaries. This adjustment was based on the figures for the existing Wolwedans Dam on the Great Brak River in the Gouritz WMA. The potential maximum yield for each key area was calculated by adding the utilisable undeveloped potential yield to the developed yield in 1995. The calculations are summarised in Table 6.3.2, where it can be seen that the potential undeveloped yield of the WMA is estimated to be 2 492 million m^3/a, and that, if developed, this would bring the total utilisable yield obtainable from the surface water resources of the WMA to 3 241 million m^3/a after allowing for the requirements of the ecological Reserve.

The natural MAR generated by each quaternary catchment is shown on Figure 6.3.1 and the remaining undeveloped potential yield is shown diagrammatically on Figure 6.3.2.

6.4 WATER QUALITY

6.4.1 Mineralogical Surface Water Quality

The purpose of this assessment is to provide an indication of where water quality problems can be expected rather than provide a comprehensive overview of water quality in the Water Management Area.

The mineralogical water quality of the surface water bodies is described in terms of total dissolved salts (TDS). Data for the assessment were obtained from the water quality database of the Department of Water Affairs and Forestry.

The surface water quality monitoring stations that were used to provide the data are shown in Figure 6.4.1.1. There is a good distribution of monitoring points in the Amatole catchments (R10, 20, 30) and the Kubusi catchment (S60). The Buffalo River (R20) is especially well monitored due to its economic importance to the region. Most of the Kei Basin (S catchment), Mbashe Basin (T10, T90), Mtata Basin (T20, T80), Mzimvubu Basin (T30) and Pondoland coast (T60) was part of the former Republic of Transkei and, although there is a fair distribution of monitoring points over these catchments, the historical water quality record is quite poor. At most of these monitoring points, good monthly data records only started in late 1996, early 1997.

Only data sets that had data for the period 1994 to 1998 were used. The data sets were filtered to monthly data, and various techniques were used to fill in missing values where possible. The assessment method calls for the consultants to use only those data sets that spanned at least two years and contained at least 24 data points for analysis. These were used to derive the mean and maximum TDS concentrations. Owing to the poor status of water quality monitoring in part of the WMA, mostly the monitoring points in the Transkei, more recent data (1997 to 1999) were used to characterise the water quality. In some cases, too little data was available to meet the specifications for classifying the mineralogical status. However, the mean and maximum statistics were still calculated to provide an indication of the TDS class. These results were not used in Table 6.4.1.3 but were commented on in the discussion section that follows after the Table.
Details of the TDS classification for the various catchments are given in Appendix G.

The water quality is described in terms of a classification system developed for this water resources situation assessment. The uses that were taken into account were domestic use and irrigation. It was assumed that if the water quality met the requirements for domestic and irrigation use it would in most cases satisfy the requirements of other uses. The South African Water Quality Guidelines of the Department of Water affairs and Forestry (DWAF, 1996) for these two uses were combined into a single classification system as shown in Table 6.4.1.1.

TABLE 6.4.1.1: CLASSIFICATION SYSTEM FOR MINERALOGICAL WATER QUALITY

CLASS	COLOUR CODE	DESCRIPTION	TDS RANGE (Mg/ℓ)
0	Blue	Ideal water quality	<260
1	Green	Good water quality	260 - 600
2	Yellow	Marginal water quality	601 - 1800
3	Red	Poor water quality	1801 - 3400
4	Purple	Completely unacceptable water quality	>3400

Where water quality data were available, water quality was assessed at a quaternary catchment level of resolution. The final classification of the mineralogical surface water quality of a quaternary catchment was based on both average conditions and extreme conditions. For this purpose the data set was inspected for the worst two-year period observed. The average concentration and the maximum were used to determine the class of the water as shown in Table 6.4.1.2.

TABLE 6.4.1.2: OVERALL CLASSIFICATION

AVERAGE CONCENTRATION CLASS	MAXIMUM CONCENTRATION CLASS	OVERALL CLASSIFICATION
Blue	Blue Green Yellow Red Purple	Blue Green Green Yellow Purple
Green	Green Yellow Red Purple	Green Yellow Yellow Purple
Yellow	Yellow Red Purple	Yellow Red Purple
Red	Red Purple	Red Purple
Purple	Purple	Purple

The water quality of the Mzimvubu to Keiskamma Water Management Area is summarised in Table 6.4.1.3 and is shown on Figure 6.4.1.1.

TABLE 6.4.1.3: SUMMARY OF MINERALOGICAL SURFACE WATER QUALITY OF THE MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

SECONDARY CATCHMENT	NO OF QUATERNARY CATCHMENTS	NO OF QUATERNARY CATCHMENTS IN CLASS					
		BLUE	GREEN	YELLOW	RED	PURPLE	NO DATA
R10	12	1	9	2	0	0	0
R20	7	0	3	3	0	0	1
R30	6	0	4	0	0	0	2
R40	3	0	0	0	0	0	3
R50	2	0	0	0	0	0	2
S10	9	0	0	0	0	0	9
S20	4	0	4	0	0	0	0
S30	19	0	7	7	0	0	5
S40	6	0	0	0	0	0	6
S50	9	0	9	0	0	0	0
S60	5	2	3	0	0	0	0
S70	6	0	6	0	0	0	0
T10	20	0	0	0	0	0	20
T20	7	0	0	0	0	0	7
T30	51	42	7	0	0	0	2
T60	10	0	0	0	0	0	10
T70	7	0	2	0	0	0	5
T80	4	0	0	0	0	0	4
T90	7	0	0	0	0	0	7

The mineralogical surface water quality of the Mzimvubu to Keiskamma Water Management Area is showing signs of urban and industrial impacts.

Amatole catchments (R catchments)

The Keiskamma catchment has ideal water quality in its headwaters that changes to good in a downstream direction. Water quality in the Buffalo River catchment varies from good to marginal. The elevated salts in the marginal TDS catchments are the result of natural mudstones and industrial discharges in the King William's Town area. Water quality in the Nahoon and Gqunube catchments were classified as good.

Kei Basin (S catchment)

Water quality in the Kei Basin varies from ideal in the Kubusi River catchment (S60), to good for the largest part of the catchment to marginal in the western part (S32) of the Basin. The elevated TDS in the western part of the catchment is largely the result of the catchment geology.

Mbashe Basin (T10 and T90)

There was insufficient data in the Mbashe Basin to classify the mineralogical water quality. However, the limited data that is available in the catchment indicates that the quality is probably ideal to good, which is similar to the adjacent catchments where the mineralogical quality was classified as good.

Mtata Basin (T20, T70 and T80)
With the exception of T70A and B, there was insufficient data in the Mtata Basin to classify the mineralogical water quality. However, the limited data available at sampling points in the Mtata River seem to indicate that the mineralogical status is ideal. In the Mngazi River, water quality was classified as good. The mineralogical quality is probably ideal to good over the remainder of the Basin.

Mzimvubu Basin (T30)
Water quality in the Mzimvubu Basin varied from ideal to good for most of the catchments.

Pondoland coast (T60)
There was insufficient data to classify the mineralogical quality in the Pondoland coastal rivers. However, the limited data that is available in the T60 catchment indicates that water quality is probably ideal.

These findings agree with those of Du Preez (1985) who found that there was an east to west salinity gradient, with lower salinity being recorded in the eastern parts of the WMA and higher salinities being recorded in the western parts of the WMA. It was concluded that the gradient was a characteristic of the geology and soil conditions of the WMA.

6.4.2 Mineralogical Groundwater Quality

The groundwater quality is one of the main factors affecting the development of available groundwater resources. Although there are numerous problems associated with water quality, some of which are easily corrected, total dissolved solids (TDS), nitrates (NO_3 as N) and fluorides (F) are thought to represent the majority of serious water quality problems that occur.

The water quality has been evaluated in terms of TDS and potability. The information was obtained from WRC Project K5/841 (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 Vegter's maps (Vegter, 1995). The potability evaluation done by Simonic (2000) was based on the evaluation of chloride, fluoride, magnesium, nitrate, potassium, sodium, sulfate and calcium using the Quality of Domestic Water Supplies, Volume I (DWAF, 1998).

The portion of the groundwater resources considered to be potable has been calculated as that portion classified as ideal, good and marginal (Class 0, 1 and 2) according to the classification system given in Section 6.4.1. Water classified as poor and unacceptable (Class 3 and 4) has been considered to be **not** potable.

In catchments where no information was available, estimates of the portion of potable groundwater were made using Vegter's maps (Vegter, 1995).

Figure 6.4.2.1 gives an evaluation of the mean TDS per quaternary catchment and Figure 6.4.2.2 gives an estimate of the percentage of potable groundwater per quaternary catchment.

6.4.3 Microbiological Water Quality

Background

A method was developed and applied to assess the risk of microbial contamination of surface water and groundwater resources in South Africa. (Refer to Appendix G2 for details of the study). Maps depicting the potential vulnerability of surface water and groundwater to microbial contamination were produced at a quaternary catchment resolution. The maps provide a comparative rating of the risk of faecal contamination of the surface water and groundwater resources. The microbial information that has been provided is, however, intended for planning purposes only and is not suitable for detailed water quality assessments.

Mapping microbial contamination of surface water resources

As part of the National Microbiological Monitoring Programme a screening method was developed to identify the risk of faecal contamination in various catchments. This screening method uses a simple rule based weighting system to indicate the relative faecal contamination from different land use areas. It has been confirmed that the highest faecal contamination rate is derived from high population densities with poor sanitation services. The Programme produced a map, at quaternary catchment resolution, showing the potential faecal contamination in the selected catchments. Unfortunately, the map did not cover the entire country.

As part of this study, the same screening method was applied to produce a potential surface faecal contamination map for the whole of South Africa using national databases for population density and degree of sanitation. The portion applicable to the Mzimvubu to Keiskamma WMA is given in Figure 6.4.3.1. The potential varies from low to high with the majority of the quaternaries classified as a medium risk. However, there are large areas where a high risk has been identified. The high-risk areas are a reflection of the high rural population with limited sanitation infrastructure and high rainfall in the WMA that can wash contaminants into surface water bodies.

Mapping aquifer vulnerability of groundwater resources

Certain aquifers are more vulnerable to contamination than others. The DRASTIC method used in this study is an acknowledged method for assessing aquifer vulnerability to contamination. The method is a weighting and rating technique that considers up to seven geologically and geohydrologically based factors to estimate groundwater vulnerability. The magnitudes or severities of pollution sources are, however, not considered. Three of the above factors were used in this study to estimate the vulnerability of groundwater to microbial contamination.

Because of attenuation mechanisms that control microbial contamination entering the subsurface, it was considered conceptually correct to only consider groundwater depth, soil media and impact of the vadose zone media. Comparison of the different maps showed remarkable similarity and confirmed that the vulnerability is largely controlled by the selected three parameters. This similarity promotes confidence in the resultant microbial contamination vulnerability map.

A GIS model, which considered the three factors, was developed and a vulnerability rating of low, medium and high was calculated for each grid element in the GIS coverage. A numerical control was included to account for deep groundwater below 35 metres. At this depth it was assumed that the surface contamination rate would be low, irrespective of the other two factors.

Mapping microbial contamination of groundwater sources

The potential surface faecal contamination and aquifer vulnerability maps were then intersected to derive a potential groundwater faecal contamination map for South Africa at a quaternary scale. The portion applicable to the Mzimvubu to Keiskamma WMA is given in Figure 6.4.3.2. This map shows the degree of potential faecal contamination in groundwater using a rating scale which ranges from low to medium to high. The majority of the quaternaries in the WMA have been identified as medium risk to groundwater with a high risk associated only with four quaternaries in the WMA. With a large rural population that is probably dependent on groundwater as a primary source of domestic water, a medium risk is sufficiently high to raise a concern about groundwater contamination and the safety of rural water supply projects.

Conclusions and recommendations

A limitation of the study was the inability to validate results due to the limited information on groundwater contamination resulting from human wastes.

Once sufficient microbial data becomes available, the numerical methods and associated assumptions should be validated and the maps replotted. Monitoring data from selected areas should also be collected to assess the validity of the vulnerability assessment presented in this report.

6.4.4 Water Quality Issues

A number of key water quality issues have been identified :

- The quality of runoff in the former Transkei and Ciskei is dominated by runoff from extensive rural settlements. In the mid 1990s, 50% of the total population of the Eastern Province lived in these rural areas. Sanitation infrastructure was poor and concerns were expressed about microbial contamination of surface water that affected domestic water supply (in used untreated) and contact recreation. Cattle have direct access to the water and they contributed to the microbial contamination (DWAF, 1998b).

- Concerns were expressed about urban contamination from the Butterworth area (Du Preez, 1985) but not the Umtata area where it was concluded that releases for hydropower were sufficient to dilute urban contamination. However, the situation has deteriorated since then as a result of the growth of Umtata and the increased discharge of raw sewage into the Mtata River (DWAF, 2002), which is a severe health threat to rural communities downstream who use the water for household purposes.

- Elevated levels of iron and manganese were found by Du Preez (1985) which was ascribed to the natural abundance of red ochre soils in the region. Elevated iron and manganese can cause problems in the treatment of drinking water.

- Du Preez (1985) also found elevated levels of arsenic in rivers of the coastal plain. This was ascribed to cattle dipping in communal dips which were situated close to rivers (which served as the source of water for the dip). Old and unusable dip was discarded into soak pits which probably leached into surface water bodies.

- Water bodies in the Buffalo River suffer from eutrophication related water quality problems which are the result of nutrient enrichment (DWAF, 1999c). Van Ginkel *et al*, (2000) found Laing and Bridle Drift Dams to be hyper-eutrophic (highly enriched) and that toxic cyanobacterial blooms are likely to develop. The origin of the nutrients is urban runoff and sewage effluent discharge. Water hyacinth has also been observed in the Buffalo River system.

6.5 SEDIMENTATION

The relationship between the flow in a river and the quantity of sediment that it carries is not constant but varies with the availability of sediment in the catchment of the river. This, in turn, varies with factors such as the condition of natural vegetation, the area of land cultivated and type of crops grown, and the extent of human settlements. Nevertheless, the analysis of measurements taken by DWAF, over many years, of silt accumulation in existing reservoirs countrywide, has made it possible to calculate average sediment yields for the catchments of these reservoirs. The results of analysis of data for reservoirs in the Mzimvubu to Keiskamma WMA is shown in Table 6.5.1.

TABLE 6.5.1: RECORDED RESERVOIR SEDIMENTATION RATES FOR RESERVOIRS IN THE MZIMVUBU TO KEISKAMMA WMA

QUATERNARY CATCHMENT NO.	RIVER	DAM NAME	ECA (km^2)	PERIOD	V_T (million m^3)	V_{50} (million m^3)	SEDIMENT YIELD ($t/km^2.a$)
R20E	Buffalo	Laing	862	1950 - 1981	1,708	2,400	75
R20F	Buffalo	Bridle Drift	263	1968 - 1981	5,146	10,430	1 071
R20A	Buffalo	Maden	30	1909 - 1981	0,053	0,047	42
R30E	Nahoon	Nahoon	473	1964 - 1992	2,067	2,651	151
S10E	White Kei	Xonxa	1 487	1974 - 1986	22,486	48,536	881
S20A	Doring	Indwe	295	1969 - 1984	3,864	7,061	646
S32E	Klipplaat	Waterdown	603	1958 - 1988	0,213	0,264	12
S50E	Tsomo	Ncora	1 772	1976 - 1988	8,193	17,686	269
S60A	Gubu	Gubu	23	1970 - 1981	0,059	0,137	161
T20B	Mtata	Umtata	868	1977 - 1987	1,129	2,859	89

ECA = Total catchment area - catchment area of next major dam upstream
V_T = Sediment volume at end of period
V_{50} = Estimated sediment volume after fifty years at the same average yield.

Using the available data of this type on sediment accumulation in reservoirs and additional data on sediment loads in rivers, Rooseboom, *et al* in 1992 prepared a mean sediment yield map of South Africa. From this map and associated soil erodibility maps, an estimate of the average sediment yield from any desired area can be made. The Water Research Commission publication, *Surface Water Resources of South Africa, 1990 (WR90)*, presents estimates of the mean sediment yield for quaternary sub-catchments calculated from the sediment yield and soil erodibility maps. Mean values of sediment yield in the Mzimvubu to Keiskamma WMA, calculated from the WR90 estimates are 185 $t/km^2.a$ throughout, except for the catchment of the Doring River Dam (S20A) where the value is 335 $t/km^2.a$. Rooseboom also carried out statistical analyses of the recorded sediment yield data to obtain an indication of the confidence with which the sediment yield could be estimated for the various regions of South Africa. From these analyses he derived sets of curves which give multiples by which the estimated mean sediment yields should be multiplied to change the confidence level from the 50% confidence level of the mean yields. However, the data presented in this report is at the 50% confidence level.

Values of sediment yield in tonnes per year, and the 25 year sediment volume, expressed in million m^3 and adjusted to allow for consolidation of the sediment, are presented for each quaternary catchment in Appendix G. On Figure 6.5.1, the 25 year sediment volume is shown as a percentage of the naturalised incremental MAR for each quaternary catchment.

The information has been produced in this form for use in predicting the probable effects of sediment on the yields of dams in the WMA.

Research has shown that reservoirs with storage capacities in excess of 10% of the mean annual runoff will retain at least 70% of incoming sediments. It is only where reservoirs have storage capacities of very much less than 10% of mean annual runoff that it becomes possible to pass most of the incoming sediments through by designing the reservoirs so that high flow velocities are maintained through them during floods. Even so, a great deal of doubt exists regarding the accuracy with which the effective losses in the storage capacities of small reservoirs can be predicted. Only where adequate discharge facilities are provided and proper operational procedures are followed is it possible to ensure that a small reservoir will not lose virtually all its storage capacity, permanently or intermittently. Therefore, unless conditions for scouring are particularly favourable, it is not advisable to construct small storage dams on big rivers that carry high sediment loads. Where large dams are constructed, it is necessary to provide sufficient additional storage to accommodate the volume of sediment expected to accumulate during the economic life of the dam. Depending upon the characteristics of the dam site, it may be necessary either to construct the dam initially to provide the full volume of additional storage required to accommodate sediment, or to design the dam to be raised at a later stage if the accumulation of sediment begins to reduce the yield of the dam significantly.

CHAPTER 7: WATER BALANCE

7.1 METHODOLOGY

7.1.1 Water Situation Assessment Model

The Water Situation Assessment Model (WSAM) was developed with the purpose of providing a reconnaissance level decision support tool. The model is intended to provide a broad overview of the water situation in South Africa taking into account all significant water uses and resources. The model can produce output at a variable resolution, down to quaternary catchment scale.

The data input to the model was gathered by various organisations and individuals, but the Water Resources Situation Assessments (WRSA) were the main vehicle for providing data for the model. Appendix H lists the organisations responsible for the various components of the data. This list also gives the reader a good indication of the type of data in the database.

The intention was to use the WSAM to determine the water balance for the WRSA reports and also to use the WSAM reporting tools to produce as many of the tables in the WRSA reports as was practical. However, due to various unresolved developmental problems with the WSAM, another approach was adopted, as described in this section. For this reason, the WSAM is not described in any detail in this report. The reader is referred to the WSAM user manual for more information on this model.

7.1.2 Estimating the Water Balance

The water balance is simply the difference between the water resource and the sum of all the water requirements and losses. While the water requirements and losses are easily abstracted from the database, to estimate the water resource directly from the known yields of dams would be difficult and impractical. The main reason for this is that the run-of-river component of the resource is difficult to determine without some form of modelling, especially where there are multiple dams and abstractions and the different modes of operation of the dams influence the yields.

The water balance produced by the WSAM is not yet correct in all cases due to the following unresolved problems :

- The ecological Reserve has spurious impacts on the water balance, which do not appear to be correct;
- The impacts of afforestation and alien vegetation, as reported on the balance do not appear to be correct;
- It is not possible to model actual known river losses; and
- Return flows from irrigation are not modelled correctly.

The approach taken to determine the water balance was therefore to remove the above questionable components out of the WSAM modelling procedure. This is done relatively easily. The above impacts (ecological Reserve, etc.) were then determined external to the model and added or subtracted from the WSAM water balance as appropriate. This procedure achieved a resultant water balance that seemed to be in reasonable agreement with other estimates in most cases. However, in the case of the Mzimvubu to Keiskamma WMA, WSAM did not appear to determine the run-of-river yield, and hence the water balance, reliably. Therefore, these were determined external to the model, but making use of the database in the model.

7.1.3 Estimating the Water Requirements

The water requirements determined by the WSAM are mostly accepted to be correct. In order to facilitate the production of the WRSA reports, this data was abstracted from the WSAM into a spreadsheet and various worksheets set up, which reference this abstracted data. These worksheets were structured so a to present most of the information contained in the tables of this report. This is not only limited to water requirements but also lists land uses such as irrigated areas, afforested areas, etc.

The data were abstracted in two different formats: at key area resolution (incremental between key points) and at quaternary catchment resolution. The key area data has been aggregated by the WSAM except for a few parameters relating mainly to irrigation, which the WSAM did not aggregate correctly. In these cases, default values were used. A list of these parameters and the default values is attached as Appendix H. The data at quaternary catchment resolution was abstracted for information purposes only. It is attached in the Appendixes to this report.

Water requirements or gains that the WSAM could not calculate were determined as follows :

Ecological Reserve

The impact of the ecological Reserve on the yield of a catchment depends on the storage in that catchment. It was accepted that the water required for the ecological Reserve follows the same general pattern of (i.e. mimics) the natural flow and that the storage/yield characteristics of the natural catchment could therefore also be used to estimate the yield of the catchment after allowing for the water requirements of the ecological Reserve. The estimates of the impact on the yield of a catchment were made separately for each of the incremental catchments between key points. The total storage within the incremental catchment was transposed to its outlet and formed the basis for determining the incremental yield of the catchment under natural conditions, both with and without provision for the ecological Reserve. The yields were estimated from the storage yield characteristics used in the WSAM for any particular recurrence interval of concern. The incremental impact of the ecological Reserve on the water resources of a particular key area was taken to be the difference between the impact at the downstream key point less the impact at the upstream key point.

The impact of the ecological Reserve on the run-of-river yield was accepted to be the annual equivalent of the lowest 4-month water requirement for the ecological Reserve. This value was used to establish the incremental impact of the ecological Reserve on the yield at a key point at which there was no significant storage in the incremental catchment.

Using the above method, negative impacts are sometimes possible. The reason for this is that the water required for the ecological Reserve at an upstream point may become available for use further downstream, if the ecological Reserve is less at the downstream point.

Water losses

The WSAM models losses as a function of the flow in the river. The water loss under natural flow conditions is used in the WSAM to calculate the water loss under the altered flow conditions. While this is conceptually correct, it is found to be very difficult to model the known loss under current conditions. For this reason, the WSAM was run with zero losses and the known losses taken into account external to the model when determining the water balance.

Irrigation return flows

The average return flow from irrigation in South Africa according to the WSAM is in the order of 3%. This is clearly erroneous and not in accordance with the 10% to 15% default agreed upon at various workshops. Irrigation return flows were therefore calculated external to the model and were usually assumed to be 10%. Where the consultant and/or other persons had more detailed information of the return flows that could be expected these were adopted instead.

7.1.4 Estimating the Water Resources

The water resources were estimated using data from other more detailed studies as described in Section 6.2 for groundwater and Section 6.3 for surface water. For areas where no suitable studies have been carried out, or the studies did not provide all of the data required, rough estimates of surface water resources were made as described in Section 6.3, using the regional data provided in the publication, the Surface Water Resources of South Africa, 1990 (Midgley *et al*, 1994). The impacts of afforestation and alien vegetation were estimated external to the model by the WSAM development team. These estimates are at a low level of confidence and require verification.

7.2 OVERVIEW

For purposes of considering the water balance situation within the WMA, the outlets of the key areas defined in Table 2.1.1 in Section 2.1, and used in most of the tables in this report, were used, and referred to as key points. For key areas comprising two or more separate rivers flowing into the sea, the water balances at the river mouths were combined to obtain a composite value for a hypothetical key point for the key area. The key points are shown on Table 7.2.1.

TABLE 7.2.1: KEY POINTS FOR YIELD DETERMINATION

LOCATION OF KEY POINT			DESCRIPTION
PRIMARY CATCHMENT	KEY AREA	KEY POINT QUATERNARY CATCHMENT	
R	Southern Coastal Catchments	R50A, R50B	Hypothetical point for mouths of small coastal rivers
	Keiskamma	R10M	Mouth of Keiskamma River
	Amatola Coastal Catchments	R40A, R40C	Hypothetical point for mouths of coastal rivers between the Keiskamma and Buffalo River estuaries
	Buffalo	R20G	Mouth of Buffalo River
	Nahoon, Gqunube	R30A, R30B, R30D, R30F	Hypothetical point for mouths of rivers between the Buffalo and Great Kei River estuaries
S	White Kei	S10J	White Kei River at its confluence with the Black Kei River
	Indwe	S20D	Indwe River at its confluence with the White Kei River
	Klaas Smits	S31G	Klaas Smits River at its confluence with the Black Kei River
	Black Kei	S32M	Black Kei River at its confluence with the White Kei River
	Thomas	S40F	Great Kei River at its confluence with the Tsomo River
	Tsomo	S50J	Tsomo River at its confluence with the Great Kei River
	Kubusi	S60E	Kubusi River at its confluence with the Great Kei River
	Great Kei and Xilinxa	S70F	Mouth of the Great Kei River
T	Mbashe	T13E	Mouth of the Mbashe River
	Mtata	T20G, T70B, T70D, T70F, T70G, T80A, T80B	Hypothetical point for mouths of rivers between the Mbashe and Mzimvubu River estuaries
	Upper Mzimvubu	T33K	Mzimvubu River at its confluence with the Tsitsa and Tina rivers
	Mzintlava	T32H	Mzintlava River at its confluence with the Mzimvubu River
	Kinira	T33G	Kinira River at its confluence with the Mzimvubu River
	Tina	T34K	Tina River at its confluence with the Tsitsa River
	Tsitsa	T35M	Tsitsa River at its confluence with the Tina and Mzimvubu Rivers
	Lower Mzimvubu	T36B	Mouth of the Mzimvubu River
	Pondoland Coastal Catchments	T60A, T60D, T60G, T60H, T60J, T60K	Hypothetical point for mouths of rivers north of the Mzimvubu River estuary
	Southern Wild Coast	T90B, T90C, T90E, T90F, T90G	Hypothetical point for mouths of rivers between the Mbashe and the Great Kei River estuaries

In Table 7.2.2 the average water requirements at the key points are shown.

It can be seen from Table 7.2.2 that the total water requirement in the WMA in 1995 is estimated to have been 2 656 million m^3. This value includes the provision of 1 488 million m^3/a for the ecological Reserve. A quantity of 169 million m^3/a, or 6% of the total requirements occurs in the coastal catchments surrounding East London (the Amatole Region). The requirement for the Great Kei River catchment is approximately 12% or 312 million m^3/a, and the Transkei Region requires 82%, or 2 174 million m^3/a.

The requirements are dominated by the ecological Reserve and hydro-power in the Transkei Region. If these two categories are excluded, the Transkei accounts for only 46% of the remaining requirements, the Great Kei River catchment 29% and the Amatole Region 25%.

As the water balance has been calculated on the basis of the 1:50 year yield of the water resources, it is necessary to consider the water requirements at 1:50 year assurance. These are shown in Table 7.2.3, where it can be seen that the total water requirements have reduced by 70% from 2 656 million m^3/a to 797 million m^3/a.

In the Mzimvubu to Keiskamma WMA, where 67% of the total utilised yield in 1995 was estimated to be obtained from major dams, the impact of afforestation and alien vegetation on the 1:50 year yield may be underestimated, as the method used for the estimates (See Section 7.1.4) may be more reliable for the impacts on the yields of major dams than for impacts on run of river yield. This aspect requires further investigation.

The yield balance shown in Table 7.2.4 is at a low level of confidence because of the uncertainty associated with the large run-of-river component of the available yield and the uncertainty, referred to above, as to the reliability of the estimates of the impacts on run-of-river yield of alien vegetation and afforestation.

The table shows an overall surplus in available 1:50 year yield of approximately 634 million m^3/a.

Some 65 million m^3/a of the surplus is in the Amatole Region, where the 19 million m^3/a of water that can be imported from Wriggleswade Dam has been included in the balance. The water, which is for urban supplies, was available in 1995 in the Buffalo River catchment, but not used as water was also imported from the Nahoon catchment and provided a surplus over requirements of about 3 million m^3. This, together with the 19 million m^3/a available from Wriggleswade Dam accounted for the surplus of 22 million m^3/a shown for the Buffalo key area. Most of the rest of the surplus in the Amatole Region occurs in the Keiskamma key area where the yields of a number of dams built to supply water mainly for irrigation schemes are not fully utilised.

The surplus of 68 million m^3/a in the Great Kei River Basin arises mainly from unutilised portions of the yields of Ncora, Xonxa Dams, Lubisi and other dams which were originally allocated to irrigation. In other parts of the basin there are small deficits caused by the inability of the 1:50 year yields of the water resources to meet the full irrigation requirements. This is a normal situation for irrigation which can generally accommodate a water supply at an assurance of less than 1:50 years.

TABLE 7.2.2: AVERAGE WATER REQUIREMENTS BY KEY AREA IN 1995 (in million m^3/a)

CATCHMENT					STREAMFLOW REDUCTION ACTIVITIES		WATER USE		WATER REQUIREMENT						ECOLOGICAL RESERVE	TOTAL WATER REQUIRE-MENT
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	AFFORE-STATION	DRYLAND SUGAR CANE	ALIEN VEGE-TATION	RIVER LOSSES	BULK	IRRIGA-TION	RURAL	URBAN	HYDRO-POWER	WATER TRANSFERS OUT OF WMA		
No.	Description	No.	Description	No.												
R	Amatole Region	R5	Southern Coastal Catchments	R50A, R50B	0,00	0,00	2,50	0,00	0,00	2,11	0,52	0,00	0,00	0,00	5,4	10,53
		R1	Keiskamma	R10A to R10M	3,57	0,00	6,23	0,00	0,00	4,49	2,64	1,35	0,00	0,00	13,6	31,88
		R4	Amatola Coastal Catchments	R40A to R40C	0,16	0,00	3,98	0,00	0,00	5,02	0,53	0,00	0,00	0,00	9,8	19,49
		R2	Buffalo	R20A to R20G	4,12	0,00	1,84	0,00	1,60	3,65	1,27	49,70	0,00	0,00	9,4	71,58
		R3	Nahoon, Gqunube	R30A to R30F	0,02	0,00	0,92	0,00	0,00	15,00	1,07	0,32	0,00	0,00	18,5	35,83
		TOTAL IN AMATOLE REGION			**7,87**	**0,00**	**15,48**	**0,00**	**1,60**	**30,27**	**6,03**	**51,37**	**0,00**	**0,00**	**56,7**	**169,32**
S	Great Kei	S1	White Kei	S10A to S10J	0,04	0,00	0,00	0,00	0,00	5,40	2,39	0,00	0,00	0,00	15,2	23,03
		S2	Indwe	S20A to S20D	0,00	0,00	0,00	0,00	0,00	8,98	1,19	0,44	0,00	0,00	8,3	18,91
		S3	Klaas Smits	S31A to S31G	0,00	0,00	0,00	0,00	0,00	32,36	0,80	7,49	0,00	0,00	4,7	45,35
			Black Kei	S32A to S32M	1,78	0,00	0,72	0,00	0,00	25,52	1,94	1,88	0,00	0,00	18,9	50,74
		Total : Black and White Kei (S1, S2, S3)			1,82	0,00	0,72	0,00	0,00	72,26	6,32	9,81	0,00	0,00	18,9	109,83
		S4	Thomas	S40A to S40F	0,31	0,00	12,33	0,00	0,00	20,23	0,98	0,81	0,00	0,00	61,8	96,46
		S5	Tsomo	S50A to S50J	1,72	0,00	0,00	0,00	0,00	2,51	3,57	0,92	0,00	0,00	26,3	35,02
		S6	Kubusi	S60A to S60E	11,76	0,00	18,76	0,00	0,00	6,94	0,53	0,87	0,00	0,00	20,6	59,46
		S7	Great Kei and Xilinxa	S70A to S70F	0,99	0,00	0,30	0,00	0,00	4,30	2,88	0,30	0,00	0,00	130,4	139,17
		TOTAL IN GREAT KEI BASIN			**16,61**	**0,00**	**32,12**	**0,00**	**0,00**	**106,24**	**14,28**	**12,72**	**0,00**	**0,00**	**130,4**	**312,37**
T	Transkei Region	T1	Mbashe	T11, T12, T13	18,08	0,00	0,84	0,00	0,00	4,15	11,32	0,95	300,00	0,00	112,4	447,74
		T2, T7, T8	Mtata	T20, T70, T80	37,44	0,00	7,87	0,00	0,00	4,49	12,82	12,56	270,00	0,00	145,2	490,38
		T3	Upper Mzimvubu	T31A to T31J T33H to T33K	1,24	0,00	10,39	0,00	0,00	6,52	5,82	0,60	0,00	0,00	198,2	222,77
			Mzintlava	T32A to T32H	1,75	0,00	10,90	0,00	0,00	18,46	3,94	2,20	0,00	0,00	57,2	94,45
			Kinira	T33A to T33G	0,61	0,00	7,52	0,00	0,00	0,00	5,21	1,09	0,00	0,00	68,0	82,43
			Tina	T34A to T34K	10,46	0,00	5,95	0,00	0,00	0,00	4,95	0,35	0,00	0,00	105,3	127,01
			Tsitsa	T35A to T35M	65,53	0,00	1,21	0,00	0,00	0,00	7,57	0,57	0,00	0,00	182,7	257,58
			Lower Mzimvubu	T36A to T36B	0,06	0,00	0,24	0,00	0,00	0,12	0,68	0,00	0,00	0,00	758,7	759,80
		Total Mzimvubu			79,67	0,00	36,22	0,00	0,00	25,09	28,17	4,82	0,00	0,00	758,7	932,67
		T6	Pondoland Coastal Catchments	T60A to T60K	3,52	1,00	2,00	0,00	0,00	0,00	4,51	1,11	0,00	0,00	215,0	226,78
		T9	Southern Wild Coast	T90A to T90G	1,38	0,00	0,81	0,00	0,00	0,00	5,52	0,92	0,00	0,00	69,8	78,43
		TOTAL IN TRANSKEI REGION			**140,10**	**1,00**	**47,75**	**0,00**	**0,00**	**31,73**	**62,34**	**20,38**	**570,00**	**0,00**	**1301,1**	**2174,38**
TOTAL IN WMA					**164,58**	**1,00**	**95,35**	**0,00**	**1,60**	**168,24**	**82,66**	**84,47**	**570,00**	**0,00**	**1488,2**	**2656,10**

TABLE 7.2.3: EQUIVALENT WATER REQUIREMENTS IN 1995 AT 1:50 YEAR ASSURANCE (in million m^3/a)

CATCHMENT					STREAMFLOW REDUCTION ACTIVITIES		WATER USE		WATER REQUIREMENT						ECOLOGICAL RESERVE	TOTAL WATER REQUIRE-MENT
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	AFFORE-STATION	DRYLAND SUGAR CANE	ALIEN VEGE-TATION	RIVER LOSSES	BULK	IRRIGA-TION	RURAL	URBAN	HYDRO-POWER	WATER TRANSFERS OUT OF WMA		
No.	Description	No.	Description	No.												
R	Amatole Region	R5	Southern Coastal Catchments	R50A, R50B	0,00	0,00	0,90	0,00	0,00	1,78	0,52	0,00	0,00	0,00	0,00	3,20
		R1	Keiskamma	R10A to R10M	1,63	0,00	2,27	0,00	0,00	3,78	2,64	1,35	0,00	0,00	3,10	14,77
		R4	Amatola Coastal Catchments	R40A to R40C	0,07	0,00	1,44	0,00	0,00	4,25	0,53	0,00	0,00	0,00	0,00	6,29
		R2	Buffalo	R20A to R20G	1,90	0,00	0,66	0,00	1,60	3,08	1,27	49,70	0,00	0,00	4,60	62,81
		R3	Nahoon, Gqunube	R30A to R30F	0,00	0,00	0,33	0,00	0,00	12,69	1,07	0,32	0,00	0,00	1,30	15,71
		TOTAL IN AMATOLE REGION			**3,60**	**0,00**	**5,60**	**0,00**	**1,60**	**25,58**	**6,03**	**51,37**	**0,00**	**0,00**	**9,00**	**102,78**
S	Great Kei	S1	White Kei	S10A to S10J	0,00	0,00	0,00	0,00	0,00	4,46	2,39	0,00	0,00	0,00	6,80	13,65
		S2	Indwe	S20A to S20D	0,00	0,00	0,00	0,00	0,00	7,57	1,19	0,44	0,00	0,00	5,20	14,40
		S3	Klaas Smits	S31A to S31G	0,00	0,00	0,00	0,00	0,00	26,30	0,80	7,49	0,00	0,00	0,20	34,79
			Black Kei (all E Cape)	S32A to S32M	1,19	0,00	0,28	0,00	0,00	21,32	1,94	1,88	0,00	0,00	2,10	28,71
		Total : Black and White Kei (S1, S2, S3)			1,19	0,00	0,28	0,00	0,00	59,65	6,32	9,81	0,00	0,00	8,90	86,15
		S4	Thomas	S40A to S40F	0,21	0,00	4,72	0,00	0,00	17,01	0,98	0,81	0,00	0,00	1,50	25,23
		S5	Tsomo	S50A to S50J	1,16	0,00	0,00	0,00	0,00	2,18	3,57	0,92	0,00	0,00	6,20	14,03
		S6	Kubusi	S60A to S60E	7,87	0,00	7,19	0,00	0,00	5,84	0,53	0,87	0,00	0,00	7,00	29,30
		S7	Great Kei and Xilinxa	S70A to S70F	0,67	0,00	0,11	0,00	0,00	3,64	2,88	0,30	0,00	0,00	9,30	16,90
		TOTAL IN GREAT KEI BASIN			**11,10**	**0,00**	**12,30**	**0,00**	**0,00**	**88,32**	**14,28**	**12,71**	**0,00**	**0,00**	**34,40**	**173,11**
T	Transkei Region	T1	Mbashe	T11, T12, T13	0,00	0,00	0,00	0,00	0,00	3,61	11,32	0,95	85,00	0,00	12,00	112,88
		T2, T7, T8	Mtata	T20, T70, T80	28,50	0,00	3,80	0,00	0,00	2,14	12,82	12,56	100,00	0,00	28,70	188,52
		T3	Upper Mzimvubu	T31A to T31J T33H to T33K	0,04	0,00	0,43	0,00	0,00	5,65	5,82	0,60	0,00	0,00	4,70	17,22
			Mzintlava	T32A to T32H	0,04	0,00	0,45	0,00	0,00	15,94	3,94	2,20	0,00	0,00	13,40	35,97
			Kinira	T33A to T33G	0,02	0,00	0,31	0,00	0,00	0,00	5,21	1,09	0,00	0,00	13,30	19,93
			Tina	T34A to T34K	0,37	0,00	0,25	0,00	0,00	0,00	4,95	0,35	0,00	0,00	22,70	28,62
			Tsitsa	T35A to T35M	2,33	0,00	0,05	0,00	0,00	0,00	7,57	0,57	0,00	0,00	60,80	71,32
			Lower Mzimvubu	T36A to T36B	0,00	0,00	0,01	0,00	0,00	0,10	0,68	0,00	0,00	0,00	0,10	0,89
		Total Mzimvubu			2,80	0,00	1,50	0,00	0,00	21,67	28,17	4,82	0,00	0,00	115,0	173,96
		T6	Pondoland Coastal Catchments	T60A to T60K	0,00	1,00	0,00	0,00	0,00	0,00	4,51	1,11	0,00	0,00	25,90	31,16
		T9	Southern Wild Coast	T90A to T90G	0,00	0,00	0,00	0,00	0,00	0,00	5,52	0,92	0,00	0,00	7,70	14,14
		TOTAL IN TRANSKEI REGION			31,30	**0,00**	5,30	**0,00**	**0,00**	27,42	62,34	20,36	185,00	**0,00**	189,30	521,02
TOTAL IN WMA					**46,00**	**0,00**	**23,20**	**0,00**	**1,60**	**141,32**	**82,66**	**84,44**	**185,00**	**0,00**	**232,70**	**796,92**

The large surplus of 634 million m^3/a in the Transkei Region is available run-of-river yield and return flow from hydro-power stations that cannot be utilised at present because the infrastructure required to abstract it is not in place. This yield is surplus to the water requirements of rural villages, which have been included in the yield balance. Therefore, there is no immediate demand for the water and the infrastructure to use the excess yield is only likely to be developed as demands for additional water occur.

It should be noted that the ecological Reserve requirements are based on maintaining the present ecological status of the rivers. In most of the WMA, the PESC is C or D. Decisions to manage the rivers to achieve higher classes would be likely to reduce the surplus yields shown in Table 7.2.4.

The water balance for each key area is shown diagrammatically on Figure 7.2.1.

TABLE 7.2.4: WATER REQUIREMENTS AND AVAILABILITY IN 1995

CATCHMENT					AVAILABLE YIELD AT 1:50 YEAR ASSURANCE			WATER TRANSFERS AT 1:50 YEAR ASSURANCE		RETURN FLOWS AT 1:50 YEAR ASSURANCE		WATER (1) REQIREMENTS AT 1:50 YEAR ASSURANCE (million m³/a)	YIELD BALANCE (1) AT 1:50 YEAR ASSURANCE (million m³/a)
PRIMARY		SECONDARY		TERTIARY/ QUATERNARY	SURFACE WATER (million m³/a)	GROUND-WATER (million m³/a)	TOTAL (million m³/a)	IMPORTS (million m³/a)	EXPORTS (million m³/a)	RE-USABLE (million m³/a)	TO SEA (million m³/a)		
No.	Description	No.	Description	No.									
R	Amatole Region	R5	Southern Costal Catchments	R50A, R50B	3,00	0,06	3,06	1,15		0,09	0,00	3,20	+ 1,10
		R1	Keiskamma	R10A to R10M	56,60	0,36	56,96	0,00	1,15	0,75	0,00	14,77	+ 41,79
		R4	Amatole Coastal Catchments	R40A to R40C	6,01	0,09	6,10	0,00		0,21	0,00	6,29	+ 0,02
		R2	Buffalo	R20A to R20G	54,26	0,21	54,47	25,00	0,00	5,62	17,00	62,81	+ 22,28
		R3	Nahoon, Gqunube	R30A to R30F	20,13	0,49	20,62	0,00	6,00	1,09	0,00	15,71	0,00
		TOTAL IN AMATOLE REGION			**140,00**	**1,21**	**141,21**	**19,00**	**0,00**	**7,76**	**17,00**	**102,78**	**+ 65,19**
S	Great kei	S1	White Kei	S10A to S10J	31,10	0,79	31,89	0,00	0,00	0,45	0,00	13,65	+ 18,69
		S2	Indwe	S20A to S20D	37,40	0,05	37,45	0,00	0,00	1,07	0,00	14,40	+ 24,12
		S3	Klaas Smits	S31A to S31G	6,20	9,52	15,72	8,25	0,00	6,98	0,00	34,79	- 3,84
			Black Kei	S32A to S32M	39,27	1,46	40,73	0,00	8,25	3,38	0,00	28,71	- 9,15
		Total : Black and white Kei (S1, S2, S3)			113,97	11,82	125,70	0,00	0,00	11,88	0,00	86,15	+ 51,52
		S4	Thomas	S40A to S40F	13,93	0,93	14,86	0,00	0,00	2,06	0,00	25,23	- 8,31
		S5	Tsomo	S50A to S50J	124,86	0,02	124,88	0,00	90,00	0,60	0,00	14,03	+ 21,45
		S6	Kubusi	S60A to S60E	50,46	0,87	51,33	0,00	19,00	1,06	0,00	29,30	+ 4,09
		S7	Great Kei and Xilinxa	S70A to S70F	16,68	0,16	17,04	0,00	0,00	0,88	0,00	16,90	+ 1,02
		TOTAL IN GREAT KEI BASIN			**319,90**	**13,80**	**333,70**	**0,00**	**109,00**	**16,48**	**0,00**	**173,11**	**+ 68,27**
T	Transkei Region	T1	Mbashe	T11, T12, T13	63,00	1,02	64,02	90,00	0,00	97,00	0,00	112,88	+ 138,14
		T2, T7, T8	Mtata	T20, T70, T80	223,50	1,30	224,80	0,00	0,00	128,30	0,00	188,52	+ 164,58
		T3	Upper Mzimvubu	T31A to T31J T33H to T33K	47,80	1,87	49,67	0,00	0,00	0,97	0,00	17,22	+ 33,42
			Mzintlava	T32A to T32H	34,30	0,83	35,13	0,00	0,00	2,70	0,00	35,97	+ 1,86
			Kinira	T33A to T33G	43,80	0,00	43,80	0,00	0,00	0,49	0,00	19,93	+ 24,36
			Tina	T34A to T34K	51,30	0,00	51,30	0,00	0,00	0,11	0,00	28,62	+ 22,79
			Tsitsa	T35A to T35M	89,00	0,00	89,00	0,00	0,00	0,17	0,00	71,32	+ 17,85
			Lower Mzimvubu	T36A to T36B	10,30	0,00	10,30	0,00	0,00	0,01	0,00	0,89	+ 9,42
		Total Mzimvubu			276,50	2,70	279,20	0,00	0,00	4,45	0,00	173,96	+ 109,79
		T6	Pondoland Coastal Catchments	T60A tp T60K	105,00	0,90	105,90	0,00	0,00	0,41	0,00	31,16	+ 75,23
		T9	Southern Wild Coast	T90A to T90G	27,20	0,35	27,55	0,00	0,00	0,33	0,00	14,14	+ 13,74
		TOTAL IN TRANSKEI REGION			**695,20**	**6,27**	**701,47**	**90,00**	**0,00**	**45,49**	**0,00**	**521,02**	**+ 501,35**
TOTAL IN WMA					**1155,10**	**21,28**	**1176,38**	**0,00**	**0,00**	**69,73**	**17,00**	**796,92**	**634,19**

(1) Not all of the values in these columns can be summed vertically because they include the cumulative impact of the ecological component of the Reserve.

CHAPTER 8: COSTS OF WATER RESOURCE DEVELOPMENT

The yields of water resource schemes to develop the full potential of water resources within the WMA are given in Section 6.3, along with a description of how they were derived.

The corresponding capacities which were used as a basis for calculating costs were derived as follows. The calculations are given in Table 8.1.

The determination of the maximum feasible storage capacity of 12 319 million m^3 was described in Section 6.3. The capacities of the existing major dams per key area were subtracted from this capacity. The capacity was reduced to 11 245 million m^3.

An allowance for 1 in 25 year sediment accumulation in the dams was made, increasing the required capacity to 11 527 million m^3.

The cost curve derived for the purposes of this project is given in Diagram 8.1, and is based on the following equation : Total cost = 39.3 x capacity $^{(0,467)}$. As is evident from the large scattering of points through which the curve in Diagram 8.1 is drawn, this is a very rough estimate and the resulting cost estimates should be used appropriately.

The cost of providing the required dams was derived for each key area from the curve and is shown in Table 8.1 as the "Total Cost of Hypothetical Dams". It totals R20 232 million for the whole WMA.

An estimated 1 376 million m^3/a would be provided from the Mzimvubu River Basin at a cost of R4 513 million. This is 55% of the total potential additional surface water yield of the WMA at 22% of the cost. This indicates that it is likely to be more economical to develop the larger rivers (provided that there is a requirement for big volumes of water) than the smaller rivers of the coastal catchments which would require more numerous, but smaller, dams, and where the assumptions made regarding the water requirements of the estuaries significantly increases costs.

It is of interest to note that in the Vaal Augmentation Planning Study (DWAF, 1995) it was estimated that, after allowing for local requirements, a maximum yield of 1 240 million m^3/a could be obtained from the Mzimvubu River Basin for export to other areas. This is in approximate agreement with the maximum potential additional 1:50 year yield of 1 376 million m^3/a referred to above.

TABLE 8.1: CAPITAL COST OF DAMS

KEY POINT DESCRIPTION	MOST D/S QUAT	MAXIMUM FEASIBLE STORAGE CAPACITY (million m^3)	CAPACITIES OF EXISTING MAJOR DAMS (million m^3)	HYPOTHETICAL DAM CAPACITY (LIVE) (million m^3)	1 IN 25 YR SEDIMENT YIELD (million m^3)	HYPOTHETICAL DAM CAPACITY (GROSS)		TOTAL COST OF HYPOTHETICAL DAMS (R million)
						NO. OF DAMS	TOTAL CAPACITY (million m^3)	
Southern Coastal	-	84	0	84	4	2	88	460
Keiskamma	R10M	275	90	185	9	1	194	460
Amatole Coastal	-	154	0	154	4	3	158	750
Buffalo	R20G	172	128	44	1	1	45	232
Nahoon Gqunube	-	408	21	387	11	4	398	1 347
Wnite Kei	S10J	191	128	63	4	1	67	280
Indwe	S20D	99	153	0	-	0	0	0
Klaas Smits	S31G	105	7	98	12	1	110	353
Black Kei	S32M	288	70	218	15	1	233	500
Thomas	S40F	199	0	199	11	1	210	477
Tsomo	S50J	567	122	445	13	1	458	687
Kubusi	S60E	166	100	66	2	1	68	282
Great Kei/Xilinxa	S70F	351	15	336	10	1	346	603
Mbashe	T13E	1 605	0	1 605	30	1	1 635	1 244
Mtata	-	1 672	232	1 440	28	7	1 468	3 340
Upper Mzimvubu	T33K	747	0	747	24	1	771	876
Mzintlava	T32H	536	2	534	15	1	549	748
Kinira	T33G	685	3	682	16	1	678	825
Tina	T34K	802	0	802	16	1	818	900
Tsitsa	T35M	1 391	0	1 391	25	1	1 416	1 164
Lower Mzimvubu	T36B	0	0	0	-	0	0	0
Pondoland Coast	-	1 194	3	1 191	19	6	1 210	2 810
Southern Wild Coast	T90G	627	0	627	13	5	640	1 894
TOTALS		**12 319**	**1 074**	**11 245**	**282**	**42**	**11 527**	**20 232**

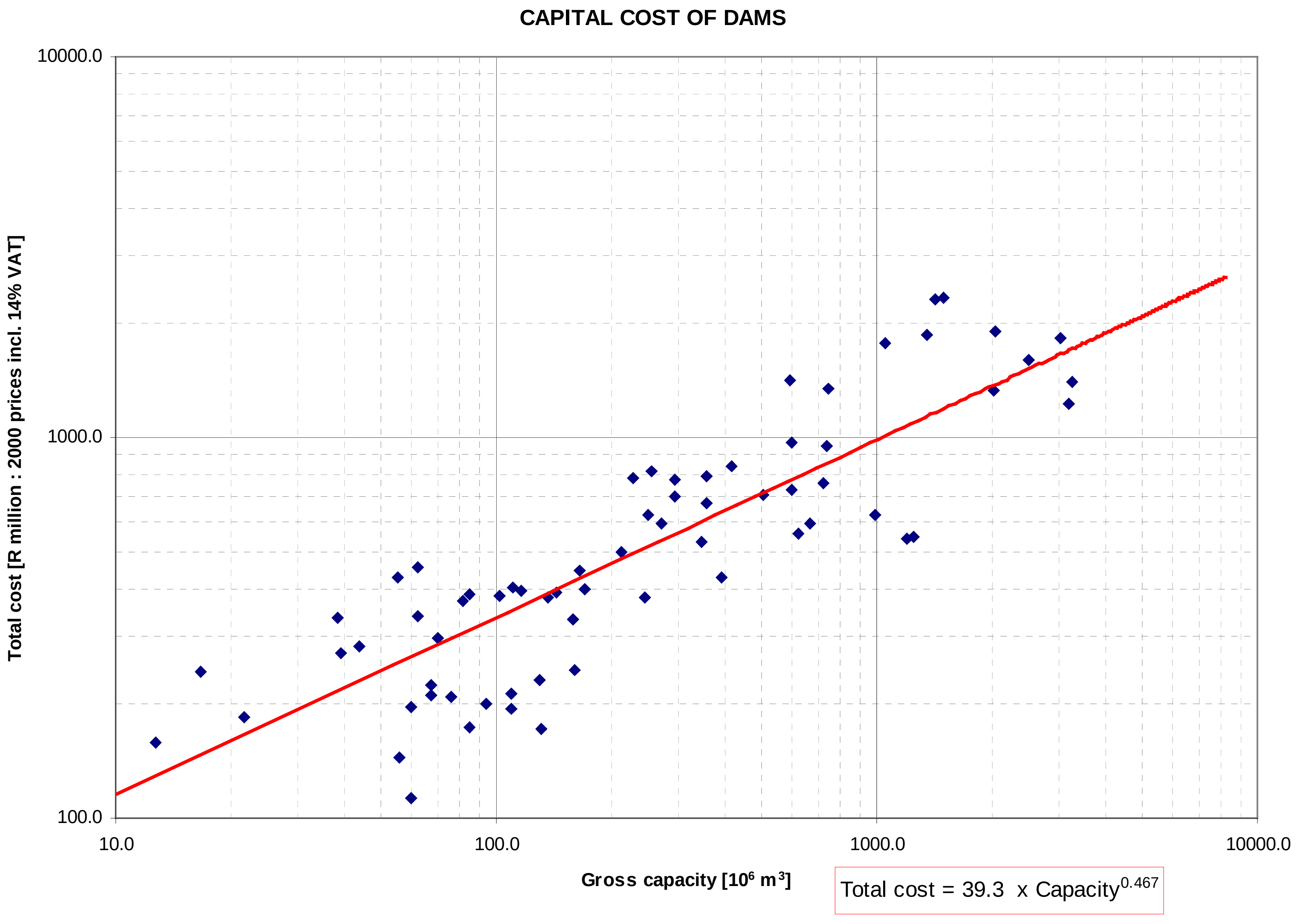


Diagram 8.1: Capital cost of dams

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

The main characteristics of the Mzimvubu to Keiskamma WMA, as determined from the information gathered in this situation assessment are listed below :

(i) The Mzimvubu to Keiskamma WMA covers an area of 66 211 km^2 in which the mean annual precipitation ranges from 450 mm in the north-western interior to more than 1 200 mm along the coast in the north-east. Rainfall occurs throughout the year in the WMA, but is highest during the summer months.

(ii) The north-western portion of the WMA, making up 6% of its total surface area, lies within the KwaZulu-Natal Province. The rest of the WMA is in the Eastern Cape Province.

(iii) The geology of the WMA consists mainly of Karoo sediments with a narrow band of sandstones, quartzites and conglomerates of the Cape Supergroup along the northern coast.

(iv) The rivers of the northern coastal catchments are of high to very high ecological importance and sensitivity, and have largely natural present ecological status classes. Consequently they have high ecological flow requirements. Most of the other rivers are of moderate ecological importance and sensitivity, have moderately modified to largely modified present ecological status classes, and have correspondingly lower ecological flow requirements.

(v) The population of the WMA in 1995 was approximately 4 521 000 people. Some 60 % of the population lived in the portion to the north-east of the Great Kei River Basin, and 26 % of the total population lived in the towns of the WMA. About 1,5% of the population lived in KwaZulu-Natal Province.

(vi) Much of the economic activity is concentrated in the south-western portion of the WMA, with the East London/King William's Town area (now Buffalo City) contributing 56 % of the GGP in 1997. The GGP of the whole WMA was R62 billion in 1997, with the most important economic sectors, in terms of their contributions to GGP, being Government (30,8 %), Manufacturing (20,4 %), and Trade (14,7 %). Agriculture contributed only 6% to the GGP. The economy is depressed with 48% of the labour force being unemployed in 1994, and all economic sectors except electricity showing negative growth between 1967 and 1997.

(vii) Land-use is predominantly for rough grazing for livestock. Some 268 km^2, or 0,4 % of the surface area of the WMA is used for irrigated crops, but only about 187 km^2 of land is irrigated in average years, with larger areas irrigated occasionally when rainfall is favourable in the drier areas. Afforestation, mainly in the north-eastern interior, covers some 1 678 km^2, and 159 km^2 of land consists of nature reserves. Alien vegetation other than the afforestation covered an equivalent condensed area of 730 km^2.

(viii) There were about 7 900 000 head of livestock in the WMA in 1995. Sheep and goats made up 74 % of the livestock numbers, with sheep predominating.

(ix) Water related infrastructure is well developed, particularly in the south-western half of the WMA, while developments in the north-eastern portion, although generally less extensive, include four hydro-power stations.

(x) Town bulk water supply schemes were generally adequate in 1995, but the requirements from many of the smaller towns were approaching their capacities and supplies are likely to require augmentation soon. Additional raw water supplies are generally available from local sources, but the necessary infrastructure needs to be developed. The water supply to the bigger urban area of Queenstown will need to be augmented in the near future and water may need to be imported from some distance away. The water requirements of the East London/King William's Town area (Buffalo City) exceed the yield of the local resources, but the infrastructure to import water from adjacent catchments has been provided and the supply should suffice until about the year 2010.

(xi) About 20% of the rural population received water from regional potable water supply schemes. The majority of the rest of the rural population had inadequate water supplies.

(xii) The existing allocations of water from Waterdown Dam under the Klipplaat River Government Water Scheme for urban use and irrigation cannot be supported at an acceptable level of assurance. In contrast, the yields of eight dams constructed in the former Republics of Transkei and Ciskei for the supply mainly of irrigation water, are under-utilised, with the result that a total of 64 million m^3/a of yield from these dams was not used in 1995.

(xiii) Water requirements in 1995 were estimated to total 1 168 million m^3/a, excluding the requirements of the ecological Reserve, but including water use by afforestation and alien vegetation. The major water user sector was hydro-power generation, which required 570 million m^3/a, or 49 % of the total consumptive requirement (i.e. excluding the ecological Reserve). The next biggest water user was agriculture, at 18 % of the total consumptive requirement, followed by afforestation (14%), urban and rural domestic requirements (10 %), alien vegetation (8%), and bulk supplies to industry (1%). The estimate of water use by alien vegetation is at a low level of confidence. With the requirements of the ecological Reserve added, the total water requirement becomes 2 656 million m^3/a.

(xiv) The equivalent water requirement at 1:50 year assurance, with the requirements of the ecological Reserve and water use by alien vegetation and afforestation all included as impacts on yield, was 797 million m^3/a. The estimates of the impacts on yield are at a low level of confidence.

(xv) The natural MAR of the Mzimvubu to Keiskamma WMA was 7 240 million m^3/a and the yield utilised from surface water resources in 1995 was 749 million m^3/a at 1:50 year assurance. Some 33 % of the utilised yield was from farm dams and run-of-river abstractions, and 67 % from major dams. In addition, boreholes with an estimated yield of 21 million m^3/a had been developed, bringing the total utilised yield in 1995 to 770 million m^3/a at 1:50 year assurance.

(xvi) In the north-eastern part of the WMA, the full available run-of-river yields is not utilised because there is insufficient demand for the water. As the requirements of the ecological Reserve impact on the full available run-of-river yield, it was necessary to take it into account in the yield balance. The unutilised portion of the available run-of-river yield in 1995 was estimated (at a low level of confidence) to be 406 million m^3/a, which, when added to the utlised yield in 1995 of 770 million m^3/a, brings the total available yield to 1 176 million m^3/a.

(xvii) Comparison of the equivalent 1:50 year assurance water requirements of 797 million m^3/a with the available yield 1 176 million m^3/a, shows a surplus of

379 million m^3/a. Re-usable return flows of 255 million m^3/a increase the surplus to 634 million m^3/a.

(xviii) The greater part of the surplus, amounting to 634 million m^3/a, occurs in the area to the north-east of the Great Kei River Basin. There are also overall surpluses in the remaining areas of the Amatole Region and the Great Kei River Basin. Localised deficits occur in the latter area in the Klaas Smits and Thomas River catchments. These are attributable to equivalent irrigation requirements at 1:50 year assurance exceeding the 1:50 year yield.

(xix) The maximum potential utilisable yield of the water resources of the WMA is estimated to be 3 263 million m^3/a, which is 2 087 million m^3/a more than the available yield in 1995 of 1 176 million m^3/a. The reliability of this estimate is uncertain because of a lack of reliable information on the ecological flow requirements of the estuaries, and on the availability of suitable dam sites in some areas.

(xx) The natural quality of groundwater and of surface water base flows in the WMA is variable, with elevated salinities in some areas. Therefore, the viability of developing the full potential yield may be adversely affected by water quality.

(xxi) In the catchments of the Buffalo and Nahoon Rivers water quality has been adversely affected by urban development and gives cause for concern.

(xxii) The Mtata River is heavily polluted by flows of untreated sewage from the Umtata urban area and the pollution is a health threat to rural communities downstream who use the river water.

(xxiii) There is a high risk of microbial contamination of both suface water and groundwater in most parts of the densely populated tribal areas of the WMA, and this poses a health threat to rural communities who rely on untreated supplies of potable water.

(xxiv) The capital cost of developing the full potential yield of the water resources of the WMA is estimated to be approximately R20 300 million at year 2000 prices. However, the viability of developing the full potential yield may be affected by water quality as well as the high cost of constructing dams and the demand for water, and it is likely that only a portion of this yield could be fully developed.

(xxv) The estimate of the cost of developing the potential water resources was based solely on surface water development, but the limited development of groundwater may be more economical in some areas.

It is concluded from the above that :

- The Mzimvubu to Keiskamma WMA is a water rich area in which the water resources have not been fully developed. The water requirements within the WMA are much less than the potential yield and are likely to continue to be so for the foreseeable future.

- It is only in a few areas such as the urban areas of Buffalo City and Queenstown, and parts of the Great Kei Basin where irrigated agriculture is well developed, that water requirements exceed the yields of the local resources and water needs to be imported from adjacent catchments. (Studies to investigate ways of providing for the future needs of the affected urban areas have been carried out since 1995 or planned in the future.)

- The issues relating to deteriorating wate quality are cause for concern :
  - The water quality problems in the Buffalo City area have been investigated in detail and the actions required to address them have been identified.
  - The pollution by raw sewage in the Mtata River can only be addressed by improving the sewerage reticulation in the Umtata urban area, improving sewage treatment facilities, and implementing effective water conservation and demand management to reduce the volume of flow in the sewerage system.
  - The threat of microbial pollution of water resources in the rural areas needs to be countered by the provision of effective sanitation systems in conjunction with safe potable water supplies. Major initiatives in this regard have been underway for some years and are continuing.

It became apparent in the course of carrying out this assessment that the available data on the following aspects is inadequate :

- Ecological flow requirements of both rivers and estuaries and their impact on the available yield of the water resources.
- The impacts of alien vegetation and afforestation on the yield of the water resources.
- The distribution, types and areas of crops irrigated from "private" sources and their water requirements.
- The capacities of the raw water supplies to some of the towns. (This data should be obtained for information on urban water supply infrastructure to be comprehensive, but is not of high priority and should be available from the water services development plans prepared by the towns).
- The numbers and types of game in the WMA and verification of livestock numbers in areas that fall within the former Republics of Transkei or Ciskei. (This is not of high priority because the changes in the estimates of the overall water requirements in the WMA are likely to be small. Nevertheless, the information should be obtained for completeness of the data on the water requirements of livestock and game).

Ideally, all the information referred to above should be available to facilitate the efficient management of the water resources of the Mzimvubu to Keiskamma WMA and the planning of their further development. However, a considerable amount of work will be required to obtain all the information, and it is unlikely that the task could be completed in a short time. Therefore, a phased approach is suggested, in which the required information is collected for particular areas as it becomes necessary to address water resources problems, or as the ecological Reserve is implemented.

REFERENCES

Acocks, J P H. 1988. *Veld types of South Africa*. Botanical Survey of South Africa, Memoirs, 57. Pretoria, RSA : Botanical Research Institute. p 146.

Baron and Seward. 2000. *Evaluation of groundwater use in South Africa*. Unpublished DWAF information.

CSIR. 1995. *Handy Reference Manual on the Impacts of Timber Plantations on Runoff in South Africa*. Forestek, Stellenbosch.

CSIR. 1999. South African National Land-cover Database project produced for the Agricultural Research Council of South Africa.

Department of Agriculture, Pretoria. 1994. National Livestock Census.

Department of Agriculture and Land Affairs, Province of the Eastern Cape, South Africa. 1996. *Final Report on Proposed Transformation of Agriculture Parastatals and Some Major Agricultural Projects in the Eastern Cape.*

Department of Water Affairs and Forestry, South Africa. 1993. *Upper Kei Basin Study, Volume 4 : Existing Water Development.* Prepared on behalf of the Department of Water Affairs and Forestry. Report No. P S000/00/0493.

Department of Water Affairs and Forestry, South Africa. 1995a. *Amatole Water Resources System Analysis : Main Report.* DWAF Report No. PD 000/00/0295. Prepared by Ninham Shand and HKS.

Department of Water Affairs and Forestry, South Africa. 1995b. *Reconnaissance Hydrology*. Prepared on behalf of the Department of Water Affairs and Forestry by Consult 4 as part of the Vaal Augmentation Planning Study, Mzimvubu Transfer Options : Reconnaissance Phase.

Department of Water Affairs and Forestry, South Africa. 1996. *South African Water Quality Guidelines* (second edition), Volumes 1 to 8.

Department of Water Affairs and Forestry, South Africa. 1997. *Queenstown Water Supply Feasibility Study : Draft Main Report*. Prepared on behalf of the Department of Water Affairs and Forestry by HKS and Ninham Shand.

Department of Water Affairs and Forestry, South Africa. 1998a. *Quality of domestic water supplies, Volume 1 : Assessment Guide*.

Department of Water Affairs and Forestry, South Africa. 1998b. *Eastern Cape Water Resources Situation Assessment. Appendix I: Water Quality*. Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry, South Africa. 1999a. *Eco Info Database*. Prepared and held by DWAF Institute for Water Quality Studies.

Department of Water Affairs and Forestry, South Africa. 1999b. *Eastern Cape Water Resources Situation Assessment. Main Report*. Prepared by Ninham Shand.

Department of Water Affairs and Forestry, South Africa. 1999c. *Amatole Water Resources System Analysis Phase II. Volume 2 - Main Report*. Report No. PG 000/00/1698.

Department of Water Affairs and Forestry, South Africa. 1999d. *Maximum dam sizes to be used in potential yield analyses for Provincial Water Resource Situation Assessments*. Prepared by Stewart Scott Consulting Engineers for the Department of Water Affairs and Forestry, Directorate of Project Planning.

Department of Water Affairs and Forestry, South Africa. 2000a. *Water Balance Model : A decision support system for reconnaissance level planning*.

Department of Water Affairs and Forestry, South Africa. 2000b. National Demographic Study.

Department of Water Affairs and Forestry, South Africa. 2001a. Matutu River Basin Study : Volume 10 : Hydro Power Schemes (First Draft). Prepared by FST in association with WRP.

Department of Water Affairs and Forestry, South Africa. 2002. Mtata Basin Study : Summary Report. Prepared by FST in association with WRP.

Development Bank of Southern Africa. 1987. *Transkei Development Information*.

Development Bank of Southern Africa. 1991. *A Regional Profile of the Southern Africa Population and its Urban and Non-urban Distribution*. 1070 - 1990.

Du Preez, A.L. 1985. *The chemical composition of Transkei River water*. Water SA, 11(1): 41-47.

Gaffney Group. 1998. Official South African Local Government Yearbook 1997 – 1998.

Görgens, A. 1998. *Methodology for incorporation of alien vegetation impacts in the national water balance model*. Memorandum to Department of Water Affairs and Forestry.

HKS. 1991. *Ciskei National Water Development Plan*. Prepared for the Department of Public Works, Ciskei.

Hughes, DA and Münster, F. 1999. *A decision support system for an initial "low-confidence" estimate of the quantity component of the Reserve for rivers*. Unpublished discussion document available at http://www.ru.ac.za.departments/iwr.

Kassier, *et al*. 1988. *Marketing Potential for Irrigation Crops in Region D : Final Report*. Prepared on behalf of the Regional Liaison Committee for Region D.

King, J and Louw, D. 1998. Instream flow assessments for regulated rivers in South Africa using the Building Block Methodology. *Aquatic Ecosystem Health and Management*, 1, 109-124.

Le Maitre, D C, Versfeld, D B, and Chapman, R A. 1999. *The impact of Invading Alien Plants on Surface Water Resources in South Africa: A Preliminary Assessment*.

Midgley, D C, Pitman, W V and Middleton, B J. 1994. *The Surface Water Resources of South Africa, 1990*. Volumes 1 to 6. Report to the Water Research Commission, Pretoria.

Nel, Van Wilgen and Gelderblom. 1999. *The Contribution of Plantation Forestry to the Problem of Invading Alien Trees in South Africa: A Preliminary Assessment*.

Ninham Shand (Pty) Ltd. 1999. Interim Adjustment of WR90 Quaternary Naturalised Flows to Reflect CSIR Afforestation-Related Streamflow Reduction Activities

Rooseboom *et al* 1992. The Development of the New Sediment Yield Map of Southern Africa. Water Research Commission Publication No. 297/2/92.

Schlemmer, L, MarkData (Pty) (Ltd), and Eric Hall & Associates. 2001. *The Distribution of South Africa's Population, Economy and Water Usage into the Long-term Future: Report on Phase 2*. Report No. PRSA/00/2200, to the Department of Water Affairs and Forestry, Directorate: Water Resources Planning, Pretoria.

Schulze, R E, Jaharaj, M, Lynch, S D, Howe, B J, Melvil-Thomson, B. 1997. *South African Atlas of Agrohydrology and Climatology*. Report to the Water Research Commission, Pretoria. Report No. TT82/96.

Schulze, R E. 1999.

Seward, P and Seymour, A. 1996. *Groundwater harvest potential of the Republic of South Africa.*

Simonic, M. 2000. *Assessment of the ambient groundwater quality on a national scale in the Republic of South Africa*. WRC Project K5/841.

Sinclair, S.A., Lane, S.B and Grindley, J.R. 1986. *Estuaries of the Cape: Part II: Synopsis of available information on individual systems*. Report No. 32 – Verlorenvlei (CW13). Heydorn, A.E.F. and Morant, P.D. (Eds). Stellenbosch, CSIR Research Report. 431

Stephenson & Associates. 1988. *Mbashe Basin Study*. Prepared for Government of Transkei, Deparment of Works and Energy.

Van Ginkel, C.E., Hohls, B.C., Belcher, A., Vermaak, E. and Gerber, A. 2000. *Assessment of the Trophic Status Project*. Internal Report No. N/0000/00/DEQ/1799. Institute for Water Quality Studies. Department of Water Affairs and Forestry, Pretoria.

Vegter, J R. 1995. *Groundwater resources of the Republic of South Africa*. WRC Project 483.

Versfeld, D B, Le Maitre, D C and Chapman, R A. 1997. *Alien Invading Plants and Water Resources in South Africa*. Report to the Water Research Commission, Pretoria.

Water Research Commission. 1998. *Alien Invading Plants and Water Resources in South Africa: A Preliminary Assessment*. Undertaken by D B Versveld, D C le Maitre and R A Chapman for the Water Research Commission. WRC Report No. TT99/98.

APPENDICES

LIST OF CONTENTS

NOTE: BLANKS INDICATE THAT DATA WAS NOT READILY AVAILABLE

ABBREVIATIONS AND ACRONYMS

AEMC	Attainable Ecological Management Class
CMA	Catchment Management Agency
DBSA	Development Bank of Southern Africa
DEMC	Default Ecological Management Class
DESC	Default Ecological Sensitivity Class
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
EISC	Ecological Importance and Sensitivity Class
GIS	Geographical Information System
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NWA	National Water Act (Act No. 36 of 1998)
PESC	Present Ecological Status Class
TDS	Total Dissolved Salts
TLC	Transitional Local Council
TRC	Transitional Rural Council
WMA	Water Management Area
WRSA	Water Resources Situation Assessment
WSAM	Water Situation Assessment Model
ha	hectare
km^2	square kilometres
m^3	cubic metre
10^6m^3	million cubic metres
$10^6m^3/a$	million cubic metres per year
%	percent

APPENDIX A

DEMOGRAPHIC DATA

Listing of urban, rural and total populations per quaternary catchment as contained in the database of the Water Situation Assessment Model.

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX A

DEMOGRAPHIC DATA PER QUATERNARY CATCHMENT

QUATERNARY CATCHMENT	oPOPi URBAN POPULATION	oPORi RURAL POPULATION	TOTAL POPULATION
	Number	Number	Number
R10A	0	9377	9377
R10B	1150	12750	13900
R10C	0	6900	6900
R10D	0	11850	11850
R10E	2800	15840	18640
R10F	1250	2558	3808
R10G	0	16580	16580
R10H	12450	23450	35900
R10J	0	2720	2720
R10K	0	30550	30550
R10L	0	7487	7487
R10M	0	7016	7016
R20A	0	3664	3664
R20B	0	21300	21300
R20C	0	11020	11020
R20D	127500	23600	151100
R20E	0	33380	33380
R20F	0	21150	21150
R20G	450700	633	451333
R30A	1900	9966	11866
R30B	0	12580	12580
R30C	0	2328	2328
R30D	0	2053	2053
R30E	8250	13370	21620
R30F	0	2082	2082
R40A	0	5845	5845
R40B	0	16680	16680
R40C	0	10270	10270
R50A	0	10910	10910
R50B	0	20190	20190
S10A	0	478	478

QUATERNARY CATCHMENT	oPOPi URBAN POPULATION	oPORi RURAL POPULATION	TOTAL POPULATION
	Number	Number	Number
S10B	0	13830	13830
S10C	0	11970	11970
S10D	0	19670	19670
S10E	0	14840	14840
S10F	0	18010	18010
S10G	0	31350	31350
S10H	0	19980	19980
S10J	0	13760	13760
S20A	6350	5823	12173
S20B	5850	5810	11660
S20C	0	33420	33420
S20D	0	20020	20020
S31A	5600	631	6231
S31B	0	519	519
S31C	0	718	718
S31D	0	4266	4266
S31E	0	1937	1937
S31F	50450	826	51276
S31G	0	1264	1264
S32A	0	313	313
S32B	0	13050	13050
S32C	0	17660	17660
S32D	0	765	765
S32E	0	2368	2368
S32F	0	13790	13790
S32G	50400	6645	57045
S32H	0	5881	5881
S32J	7700	11510	19210
S32K	0	838	838
S32L	0	1226	1226
S32M	0	635	635
S40A	8000	751	8751
S40B	0	938	938
S40C	0	831	831
S40D	0	4285	4285
S40E	0	14990	14990

QUATERNARY CATCHMENT	oPOPi URBAN POPULATION	oPORi RURAL POPULATION	TOTAL POPULATION
	Number	Number	Number
S40F	0	5417	5417
S50A	0	491	491
S50B	0	908	908
S50C	0	6205	6205
S50D	13350	18840	32190
S50E	0	18990	18990
S50F	0	7479	7479
S50G	0	33930	33930
S50H	3350	25090	28440
S50J	2050	44880	46930
S60A	26700	5737	32437
S60B	0	5889	5889
S60C	0	2847	2847
S60D	0	3008	3008
S60E	0	579	579
S70A	5100	15430	20530
S70B	0	16750	16750
S70C	0	14390	14390
S70D	1200	46220	47420
S70E	0	48490	48490
S70F	0	8326	8326
T11A	11050	1831	12881
T11B	0	1805	1805
T11C	0	30670	30670
T11D	0	7927	7927
T11E	0	6948	6948
T11F	0	18500	18500
T11G	0	15270	15270
T11H	0	10650	10650
T12A	0	8600	8600
T12B	5650	19940	25590
T12C	0	20680	20680
T12D	0	21780	21780
T12E	0	30500	30500
T12F	0	25620	25620
T12G	0	19110	19110

QUATERNARY CATCHMENT	oPOPi URBAN POPULATION	oPORi RURAL POPULATION	TOTAL POPULATION
	Number	Number	Number
T13A	0	15910	15910
T13B	0	17290	17290
T13C	0	20980	20980
T13D	0	26330	26330
T13E	0	9353	9353
T20A	0	12820	12820
T20B	0	28940	28940
T20C	0	24010	24010
T20D	175200	61730	236930
T20E	0	36220	36220
T20F	4650	45010	49660
T20G	0	16650	16650
T31A	0	655	655
T31B	0	787	787
T31C	0	15780	15780
T31D	0	2537	2537
T31E	0	23930	23930
T31F	1550	1811	3361
T31G	0	693	693
T31H	0	22390	22390
T31J	0	16770	16770
T32A	0	2391	2391
T32B	0	2162	2162
T32C	19550	2951	22501
T32D	0	2092	2092
T32E	0	40890	40890
T32F	6600	22320	28920
T32G	0	38900	38900
T32H	7650	35150	42800
T33A	4500	74540	79040
T33B	450	40550	41000
T33C	0	18620	18620
T33D	4300	18940	23240
T33E	0	11400	11400
T33F	0	11960	11960
T33G	0	22440	22440

QUATERNARY CATCHMENT	oPOPi URBAN POPULATION	oPORi RURAL POPULATION	TOTAL POPULATION
	Number	Number	Number
T33H	23250	46490	69740
T33J	0	30760	30760
T33K	0	12180	12180
T34A	0	6339	6339
T34B	0	7868	7868
T34C	0	7324	7324
T34D	0	18930	18930
T34E	0	675	675
T34F	0	7322	7322
T34G	0	14460	14460
T34H	0	43600	43600
T34J	0	21150	21150
T34K	12050	20410	32460
T35A	0	10220	10220
T35B	0	1236	1236
T35C	0	167	167
T35D	4700	8277	12977
T35E	0	22440	22440
T35F	4000	715	4715
T35G	0	7742	7742
T35H	0	24280	24280
T35J	0	15600	15600
T35K	4650	56170	60820
T35L	0	23650	23650
T35M	0	20100	20100
T36A	0	29180	29180
T36B	0	18760	18760
T60A	2950	66030	68980
T60B	0	56910	56910
T60C	0	34790	34790
T60D	0	14200	14200
T60E	0	22800	22800
T60F	11350	51220	62570
T60G	0	27160	27160
T60H	0	12330	12330
T60J	0	50470	50470

QUATERNARY CATCHMENT	oPOPi URBAN POPULATION	oPORi RURAL POPULATION	TOTAL POPULATION
	Number	Number	Number
T60K	0	31020	31020
T70A	0	32250	32250
T70B	12050	29780	41830
T70C	0	16150	16150
T70D	0	30490	30490
T70E	5800	23740	29540
T70F	6050	23480	29530
T70G	0	23740	23740
T80A	0	25830	25830
T80B	0	24320	24320
T80C	2000	28340	30340
T80D	0	30520	30520
T90A	12200	34250	46450
T90B	0	26950	26950
T90C	0	29150	29150
T90D	36450	31100	67550
T90E	0	32240	32240
T90F	0	20860	20860
T90G	1400	43210	44610
TOTALS	1172150	3348702	4520852

APPENDIX B

SUPPLEMENTARY ECONOMIC DATA

APPENDIX B.1	**Graphs of gross geographic product, labour and shift-share**
APPENDIX B.2	**Water Management Areas in national context**
APPENDIX B.3	**Economic sector description**
APPENDIX B.4	**Economic information system**

APPENDIX B.1

GRAPHS: GROSS GEOGRAPHIC PRODUCT, LABOUR AND SHIFT-SHARE

APPENDIX B.1
DESCRIPTION OF GRAPHS

Diagram No	Graphic Illustration	Description
B.1	• **Gross Geographic Product**: ⇨ Contribution by Magisterial District to Mzimvubu to Keiskamma Economy, 1997 (%)	Each WMA comprises a number of Magisterial Districts. This graph illustrates the percentage contribution of each MD to the WMA economy as a whole. It shows which are the most important sub-economies in the region.
B.2	⇨ Contribution by sector to National Economy, 1988 and 1997 (%)	This graph illustrates the percentage contribution of each sector in the WMA economy, e.g. agriculture, to the corresponding sector in the national economy.
B.3	• **Labour Force Characteristics**: ⇨ Composition of Mzimvubu to Keiskamma Labour Force 1994 (%)	The total labour force may be divided into three main categories, namely formal employment, informal employment and unemployment, as outlined in this graph.
B.4	⇨ Contribution by Sector to Mzimvubu to Keiskamma Employment, 1980 and 1994 (%)	Shows the sectoral composition of the formal WMA labour force.
B.5	⇨ Contribution by Sectors of Mzimvubu to Keiskamma Employment to National Sectoral Employment, 1980 and 1994 (%)	Similar to the production function (i.e. GGP), this graph illustrates the percentage contribution of each sector in the WMA economy, e.g. mining, to the corresponding sector in the national economy.
B.6	⇨ Compound Annual Employment Growth by Sector of Mzimvubu to Keiskamma versus South Africa, 1988 to 1994 (%)	Annual compound growth by sector is shown for the period 1980 to 1994.
B.7	• **Shift-Share**: ⇨ Shift-Share Analysis, 1997	Compares the contribution of each sector in the WMA economy to its recent growth performance. This serves as an instrument to identify sectors of future importance (towards top right hand side of the graph) and sectors in distress (towards the bottom left hand side of the graph).

Figure B.1: Contribution by Magisterial District to Mzimvubu to Keiskamma Economy, 1997 (%)

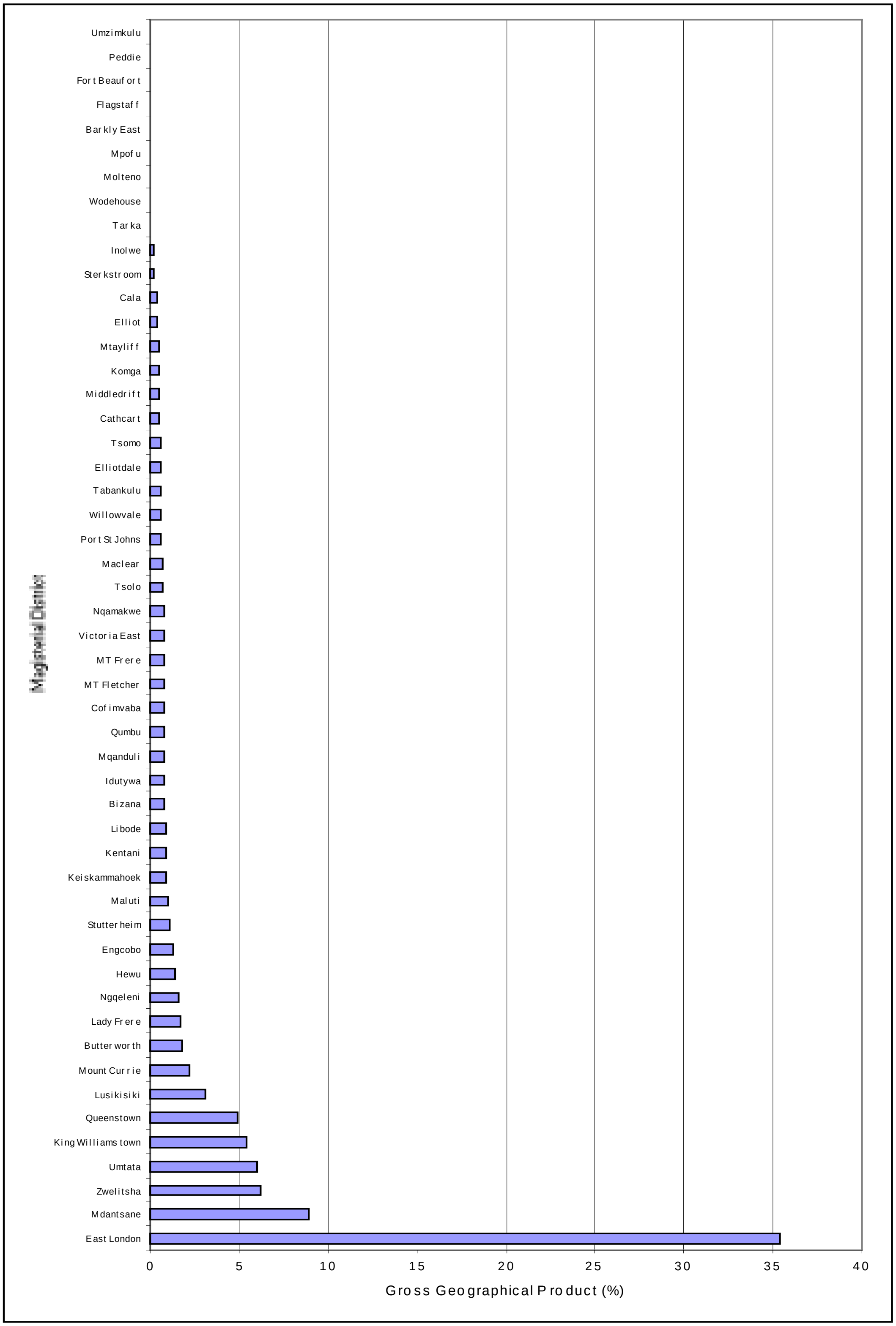


Figure B.2: Contribution by Sector to National Economy, 1988 and 1997 (%)

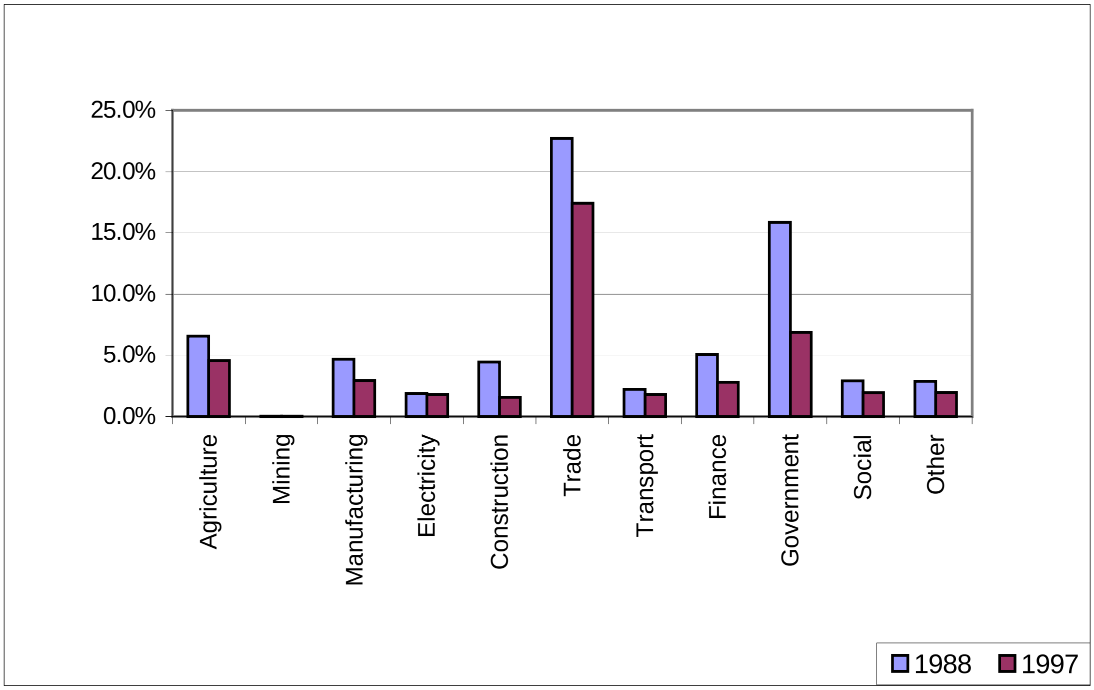


Figure B.3: Composition of Mzimvubu to Keiskamma Labour Force, 1994 (%)

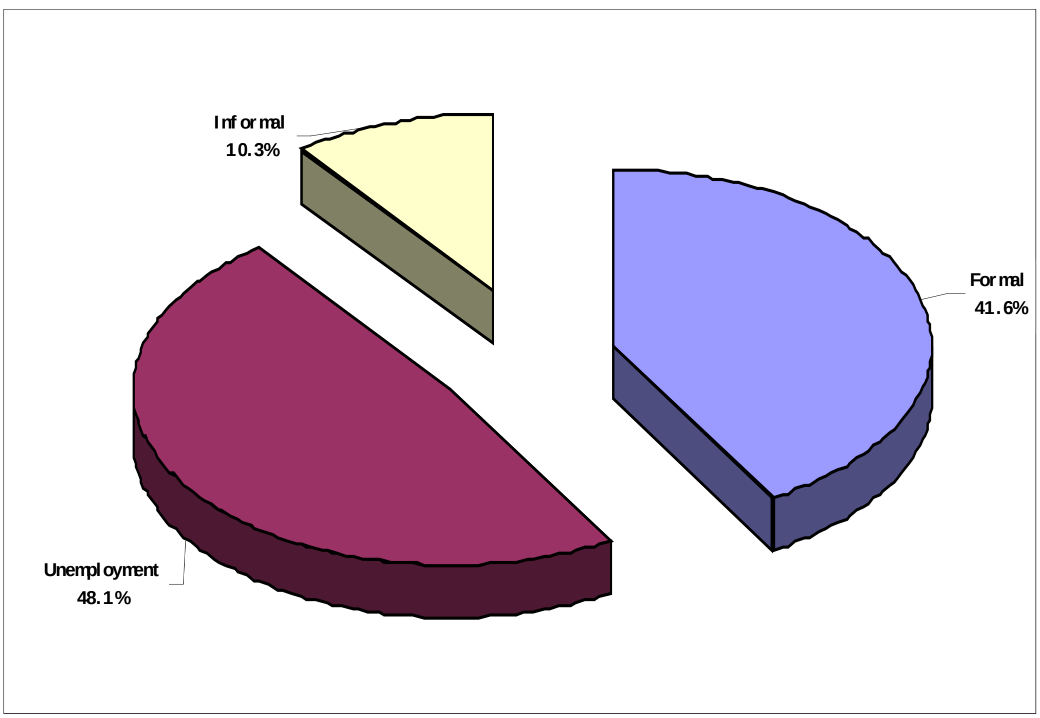


Figure B.4: Contribution by Sector to Mzimvubu to Keiskamma Employment, 1980 and 1994 (%)

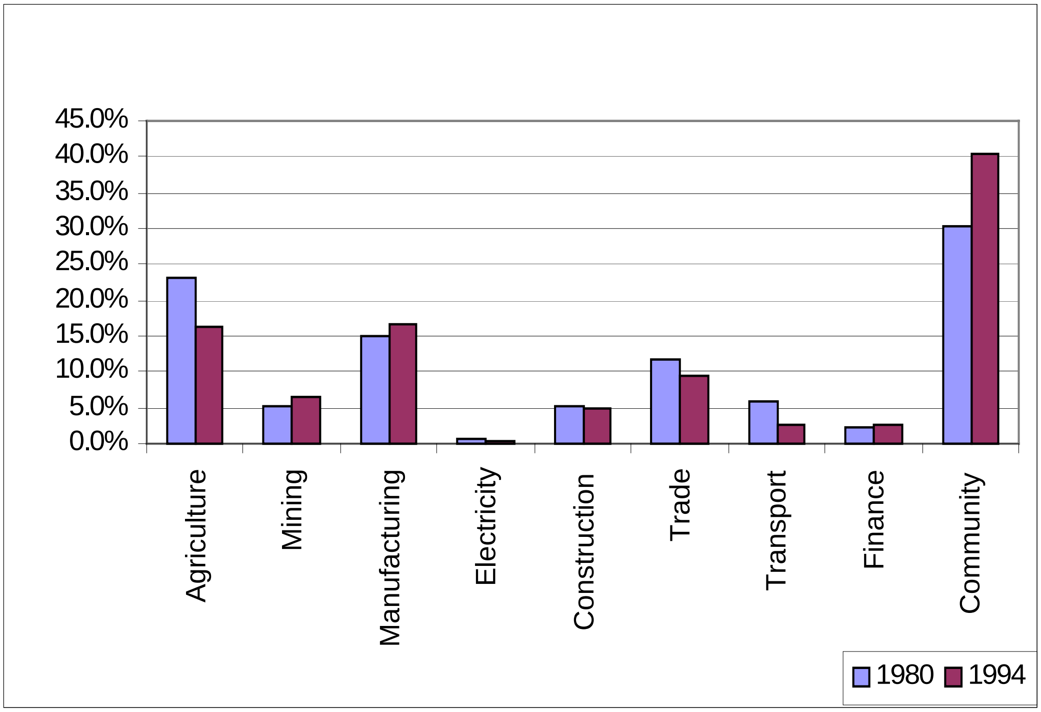


Figure B.5 Contribution by Sectors of Mzimvubu to Keiskamma Employment to National Sectoral Employment, 1980 and 1994 (%)

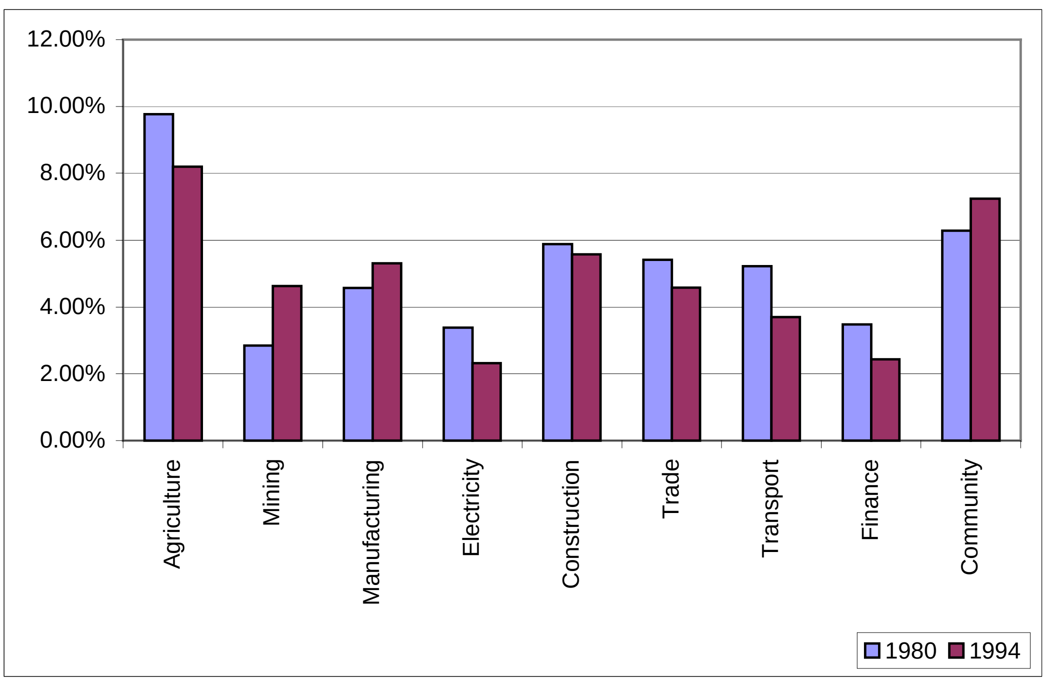


Figure B.6: Average Annual Employment Growth by Sector of Mzimvubu to Keiskamma versus South Africa, 1980 to 1994 (%)

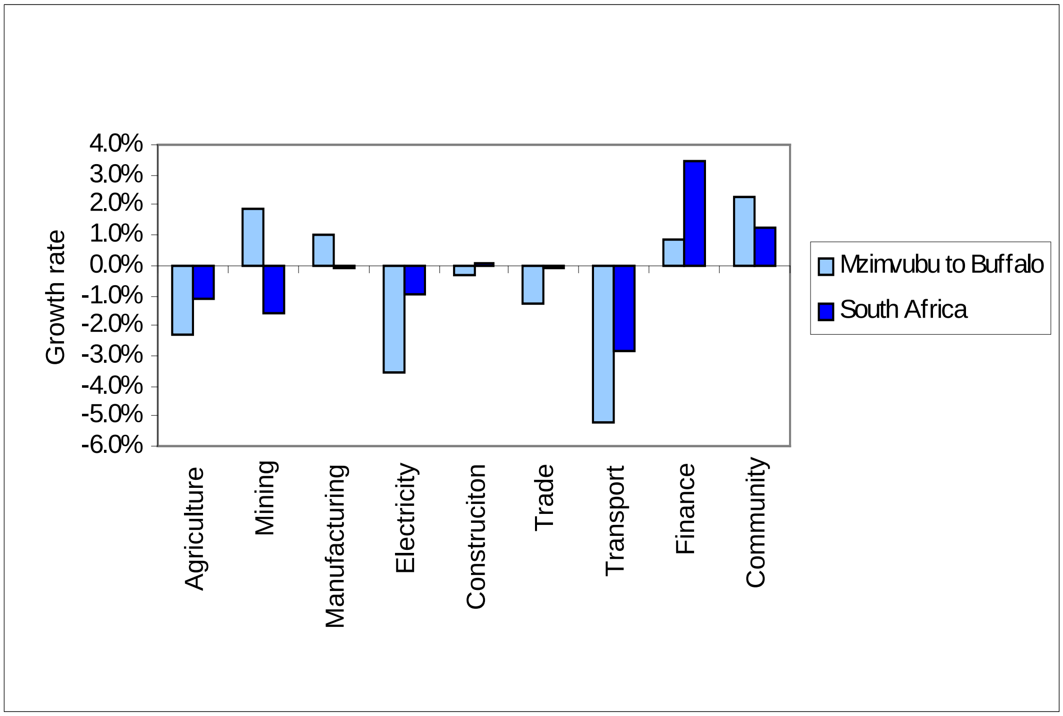
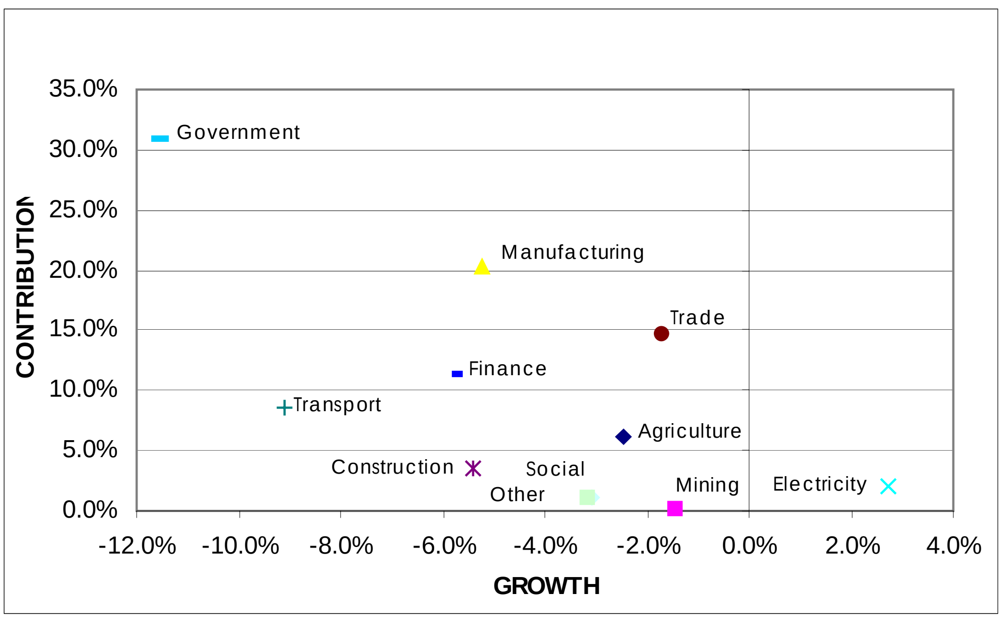


Figure B.7: Shift-Share Analysis, 1997



APPENDIX B.2

WATER MANAGEMENT AREAS IN NATIONAL CONTEXT

WATER MANAGEMENT AREAS IN NATIONAL CONTEXT

B.1 INTRODUCTION

The purpose of this section is to illustrate the relative importance of the nineteen different water management areas (WMAs) in South Africa. The following aspects are outlined:

- Contribution by WMA to national economy
- Contribution by WMA to formal employment
- Economic growth by WMA.

B.2 CONTRIBUTION BY WATER MANAGEMENT AREA TO NATIONAL ECONOMY

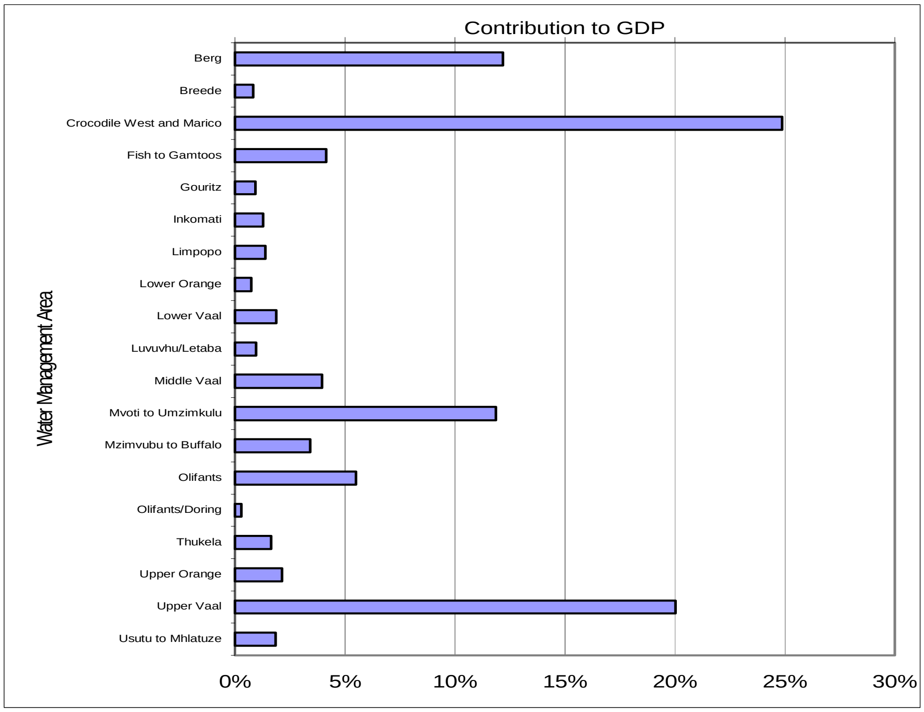
- The largest contribution to the national economy is made by the Crocodile West and Marico WMA which contributes (19.1%) to GDP. This WMA comprises, inter alia, magistrates districts of Pretoria, Johannesburg, Germiston, Kempton Park, Benoni, Thabazimbi and Lichtenburg.

- The second largest WMA to the national economy, is the Upper Vaal, which contributes 16.6% to GDP. This WMA comprises mainly portions of Johannesburg, Vereeniging and Vanderbijlpark.

- The Berg WMA contributes 11.25% to the GDP of the national economy and comprises mainly the Cape Metropolitan Area (CMA).

- Mvoti to Umzimkulu WMA makes the fourth largest contribution of 10.72% to the GDP of the national economy. This WMA includes the Durban-Pinetown Metropolitan Area.

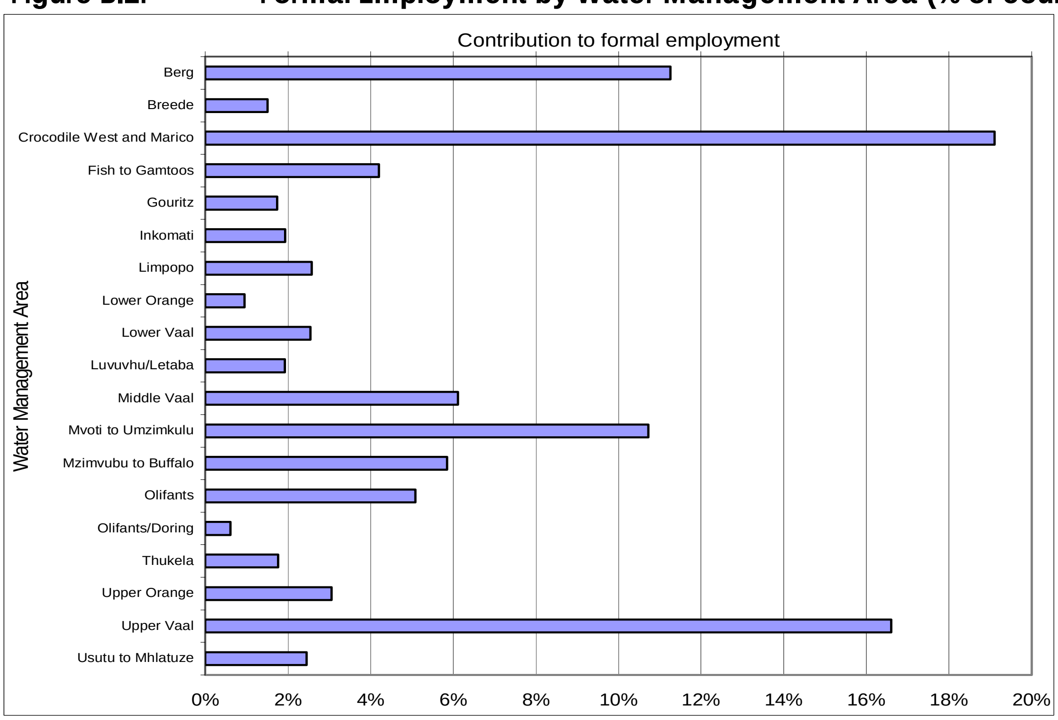
Figure B.1: Total GGP by Water Management Area (% of Country)



B.3 CONTRIBUTION BY WATER MANAGEMENT AREA TO NATIONAL EMPLOYMENT

- Contribution to formal employment corresponds to economic production and is mainly concentrated in the four dominant WMAs.

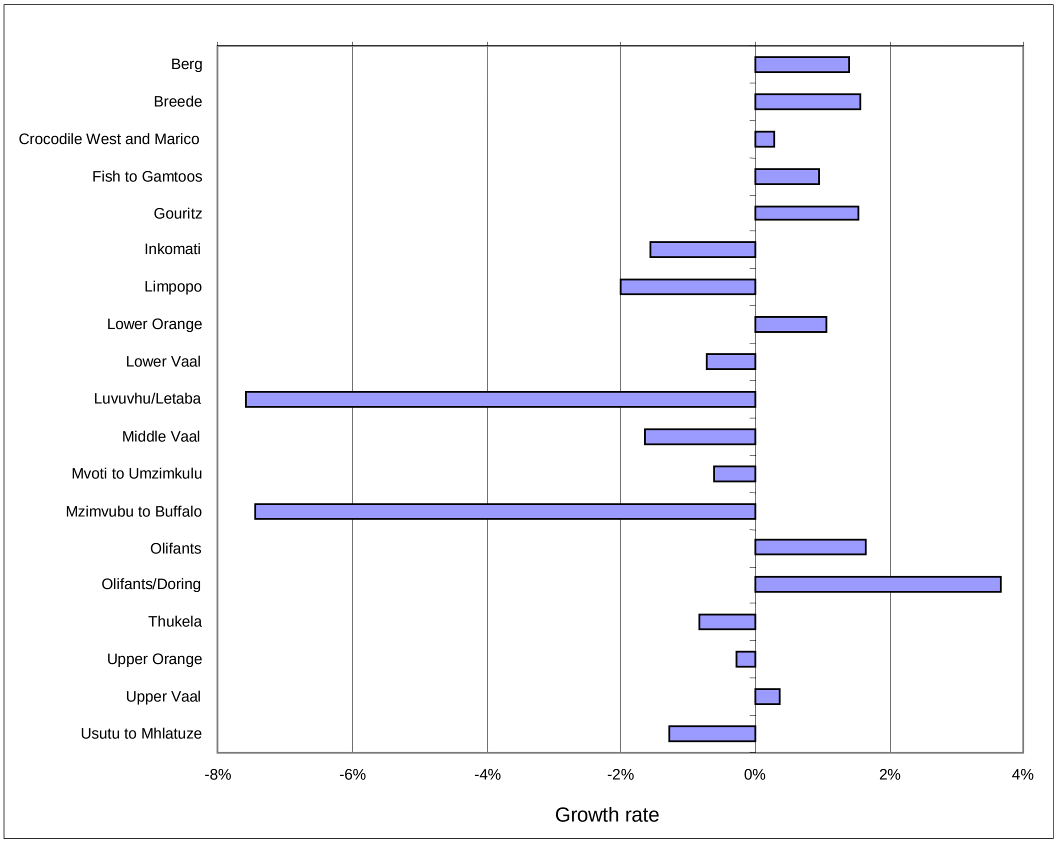
Figure B.2: Formal Employment by Water Management Area (% of country)



B.4 ECONOMIC GROWTH BY WATER MANAGEMENT AREA

- In terms of economic growth, three of the dominant four WMAs recorded positive economic growth between 1988 and 1997: the Berg grew at 1.4% per annum, Crocodile West and Marico at 0.28% per annum and Upper Vaal at 0.36% per annum. Marginal negative growth was recorded over the nine year period in the Mvoti to Umzimkulu WMA: -0.62% per annum.

Figure B.3: Average Annual Economic Growth by Water Management Area, 1988 - 1997 (%)



APPENDIX B.3
ECONOMIC SECTOR DESCRIPTION

ECONOMIC SECTOR DESCRIPTION

- **Agriculture:** This sector includes agriculture, hunting and related services. It comprises activities such as growing of crops, market gardening, horticulture, mixed farming, production of organic fertiliser, forestry, logging and related services and fishing, operation of fish hatcheries and fish farms.

- **Mining:** This section entails the mining and quarrying of metallic minerals (coal, lignite, gold, cranium ore, iron ore, etc); extraction of crude petroleum and natural gas, service activities incidental to oil and gas extraction; stone quarrying; clay and sand pits; and the mining of diamonds and other minerals.

- **Manufacturing:** Manufacturing includes, inter alia, the manufacturing of food products, beverages and tobacco products; production, processing and preserving of meat, fish, fruit, vegetables, oils and fats, dairy products and grain mill products; textile and clothing; spinning and weaving; tanning and dressing of leather; footwear; wood and wood products; paper and paper products; printing and publishing; petroleum products; nuclear fuel; and other chemical substances.

- **Electricity, Water and Gas:** Utilities comprise mainly three elements, namely electricity, water and gas. The services rendered to the economy include the supply of electricity, gas and hot water, the production, collection and distribution of electricity, the manufacture of gas and distribution of gaseous fuels through mains, supply of steam and hot water, and the collection, purification and distribution of water.

- **Construction:** This sector includes construction; site preparation building of complete constructions or parts thereof; civil engineering; building installation; building completion; and the renting of construction or demolition equipment with operators all form part of the construction sector.

- **Trade:** Trade entails wholesale and commission trade; retail trade; repair of personal household goods; sale, maintenance and repair of motor vehicles and motor cycles; hotels, restaurants, bars canteens, camping sites and other provision of short-stay accommodation.

- **Transport:** The transportation sector comprises land transport; railway transport; water transport; transport via pipelines; air transport; activities of travel agencies; post and telecommunications; courier activities; and storage.

- **Business and Financial Services:** The economic activities under this category include, inter alia, financial intermediation; insurance and pension funding; real estate activities; renting of transport equipment; computer and related activities; research and development; legal; accounting, book-keeping and auditing activities; architectural, engineering and other technical activities; and business activities not classified elsewhere.

- **Government and Social services (Community Services)**: This sector includes public administration and defence, social and related community services (education, medical, welfare and religious organisations), recreational and cultural services and personal and household services.

- **Other:** Private households, extraterritorial organisations, representatives of foreign governments and other activities not adequately defined.

APPENDIX B.4
ECONOMIC INFORMATION SYSTEM

ECONOMIC INFORMATION SYSTEM
for Department of Water Affairs and Forestry

1. Background

The Economic Information System was developed for the Department of Water Affairs and Forestry due to a need for a comprehensive source of readily available economic data that can be utilised as a management tool for decision making.

Relevant information required for planning the allocation and utilisation of scarce resources such as water has always been a difficult process due to:

- **Inaccessibility of information**
- **Incompatibility of information**
- **No framework of reference for analysis**

The purpose of the Economic Information System was thus to combine all readily available economic information into a single computer package that would be readily accessible, easy to use and could be distributed without restrictions.

2. The System

The characteristics of the Economic Information System can be summarised as follows:

- Provides immediate access to a comprehensive economic database.
- Stand alone software programme that can be loaded onto a personal computer.
- System provides not only the existing data but also allows first degree transformation of data both geographically and functionally.
- Allows multidimensional access and presentation of information, that is, on a sectoral, geographical and functional basis.
- Provides time series information to enable users to determine trends and make projections.

Urban-Econ collected existing data from a range of secondary sources. The following data were combined in a single database which can be queried spatially, thematically and temporally *via* a user-friendly computer interface.

Diagram 1 depicts the economic information system in a flow chart format. It is possible to display the data in:

- Tables
- Graphs
- Thematic maps (this provides a better perspective of the spatial context and significance of other spatial features relevant to the data.

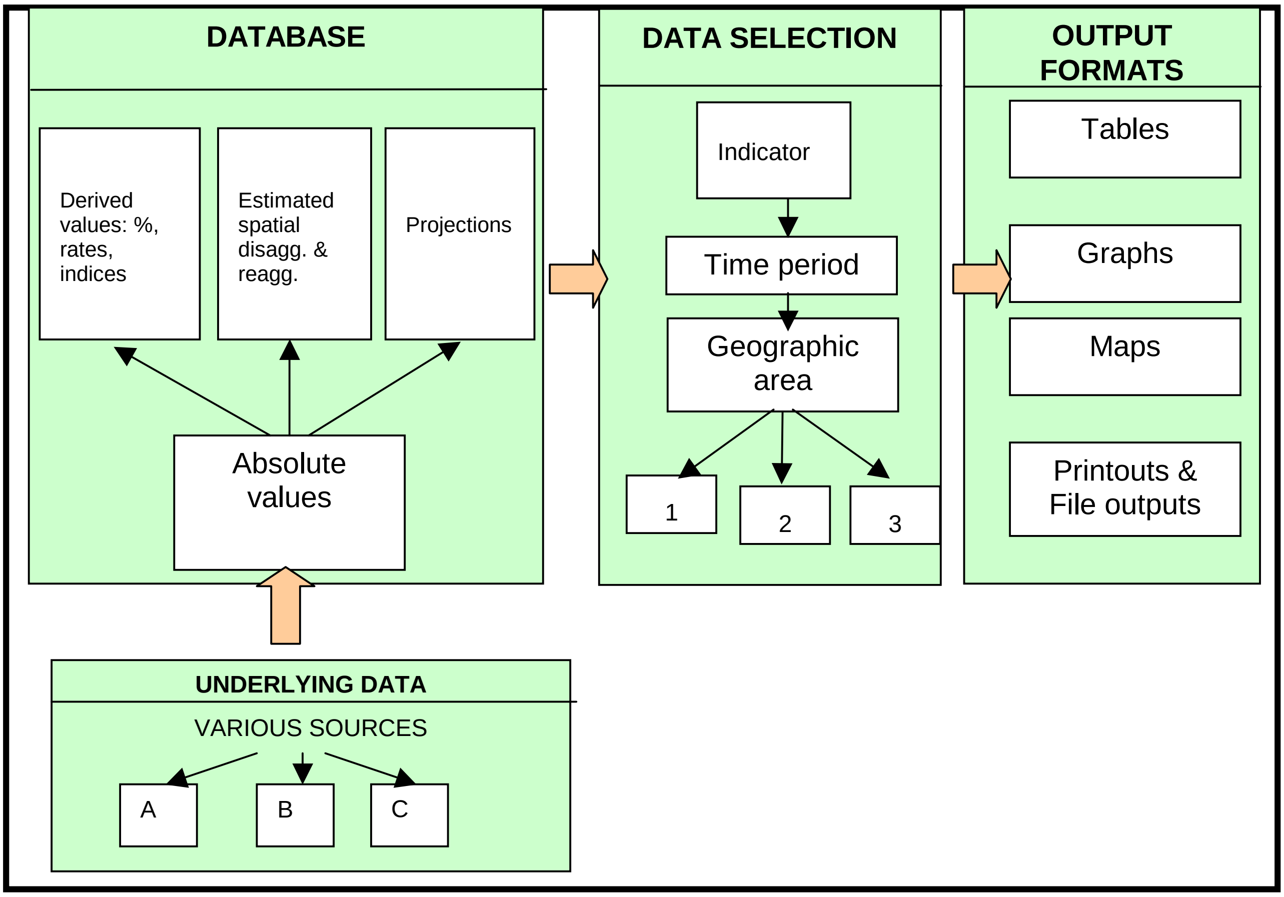
Indicator	Categories	Timespan	Geographic detail
Gross geographic product	Major sectors	1972-1997	Magisterial districts
Labour distribution	Employment/un-employment Major sectors	1980, 1991, 1994	Magisterial districts
Electricity consumption	Economic sectors, domestic	1988-1997	Local authority area, service council area
Electricity connections	Economic sectors, domestic	1988-1997	Local authority area, service council area
Remuneration*	Economic sectors	1993-1998	Magisterial districts
Turnover*	Economic sectors	1993-1998	Magisterial districts
Number of firms*	Economic sectors	1992-1998	Magisterial districts
Tax revenue	Company, Personal, VAT	1992-1997	Tax office area
Buildings completed	Residential, office, shops, industrial	1991-1996	Local authority area, service council area
Telephone connections	Business, residence	1998 1976-1997	Magisterial district Province
Vehicle sales	Commercial, passenger	1980-1997	Towns

* Figures complete for totals, but incomplete for economic sectors

On-line documentation is provided which gives information on:

- The definition of an indicator
- How the figures were obtained
- How reliable the figures are
- How complete the figures are
- To what detail the figures are available
- What the relevance or limitations of the figures are for analytical purposes.

Diagram 1: Overview of Economic Information System



3. Examples of utilisation

- A user can select a main area for analysing the spatial variations of an indicator. Within that area, any level of geographic detail, i.e. magisterial district level or town level in the case of data relating to a local authority area can be assessed.
- It is possible to compare changes over time between different areas. This may indicate whether patterns of economic activity are changing, for example that it is growing in one area and declining in another area, which will have an impact on, for example, human settlement and the demand for water.
- A user can select more than one indicator to ascertain how the trends of the different indicators are correlated in different areas or over time. If indicators are correlated, there may be a causal relationship between the two, or it may reveal that changes in both indicators are a consequence of some other factor. If these causal relationships can be determined, it may also become known whether the causal factors are changing permanently or temporarily, which will inform the user whether there should be a long-term planning response or not.

APPENDIX C

LEGAL ASPECTS

Not used

APPENDIX D

LAND USE DATA

APPENDIX D.1	**Listing per quaternary catchment of land use data contained in the database of the Water Situation Assessment Model.**
APPENDIX D.2	**Conversion of mature livestock and game populations to Equivalent Large Stock Units.**
APPENDIX D.3	**Tree species in commercial forests.**

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX D.1

LISTING PER QUATERNARY CATCHMENT OF LAND USE DATA CONTAINED IN THE DATABASE OF THE WATER SITUATION ASSESSMENT MODEL

QUATERNARY CATCHMENT	aAAAi	aFCAi	aFINi	aISAi	aNAEi	oRSUi
	AREA UNDER ALIEN VEGETATION	AREA UNDER AFFORESTATION	INDIGENOUS FOREST AREA	AVERAGE FIELD AREA IRRIGATED	URBAN AREAS AND RURAL VILLAGES	NUMBER OF LARGE STOCK UNITS
	km²	km²	km²	km²	km²	Number
R10A	13.38	9.54	0.00	0.48	1.60	5175
R10B	12.84	10.78	13.26	4.79	3.58	8402
R10C	4.44	9.61	0.00	0.51	1.27	4688
R10D	2.20	6.46	5.38	0.00	0.16	5906
R10E	0.00	0.21	0.00	0.00	4.97	6575
R10F	5.39	28.14	4.73	0.00	0.00	1826
R10G	2.69	1.37	5.67	0.00	5.43	4323
R10H	0.00	0.00	0.00	0.00	8.02	6149
R10J	0.00	0.00	0.00	0.00	1.86	5906
R10K	0.00	1.91	0.00	0.00	13.51	19970
R10L	0.00	0.03	0.00	0.00	0.00	7245
R10M	5.17	0.41	0.00	0.00	0.85	3227
R20A	3.22	47.88	0.00	0.00	1.81	487
R20B	2.13	9.88	0.00	3.93	5.31	548
R20C	2.42	5.11	0.00	0.00	2.48	426
R20D	0.02	0.00	0.00	0.00	21.22	913
R20E	3.75	7.83	0.00	0.78	11.56	852
R20F	2.95	4.17	0.00	0.00	33.47	7245
R20G	0.15	0.00	0.00	0.00	24.19	2861
R30A	0.03	0.00	0.00	4.62	2.87	13272
R30B	2.04	0.00	0.00	4.25	0.00	14551
R30C	4.86	0.04	0.00	4.07	0.00	1766
R30D	0.10	0.00	0.00	2.21	3.36	4201
R30E	0.51	0.75	0.00	2.43	2.36	1644
R30F	0.83	0.00	0.00	1.75	19.63	5784
R40A	17.35	0.00	0.00	2.91	3.99	9193
R40B	0.09	4.10	0.00	2.26	0.55	1157
R40C	10.96	0.72	0.00	1.30	0.19	3592
R50A	18.01	0.00	0.00	1.31	0.09	7245

QUATERNARY CATCHMENT	aAAAi	aFCAi	aFINi	aISAi	aNAEi	oRSUi
	AREA UNDER ALIEN VEGETATION	AREA UNDER AFFORESTATION	INDIGENOUS FOREST AREA	AVERAGE FIELD AREA IRRIGATED	URBAN AREAS AND RURAL VILLAGES	NUMBER OF LARGE STOCK UNITS
	km²	km²	km²	km²	km²	Number
R50B	9.40	0.00	0.00	1.41	0.00	7549
S10A	0.00	0.00	0.00	0.73	0.00	4201
S10B	0.00	0.00	0.00	1.09	1.48	8158
S10C	0.00	0.00	0.00	0.65	0.00	4810
S10D	0.00	0.33	0.00	0.88	2.00	7793
S10E	0.00	0.00	0.00	0.26	4.50	5906
S10F	0.00	0.00	0.00	0.59	5.91	6149
S10G	0.00	1.52	0.00	0.80	15.03	9254
S10H	0.00	0.00	0.00	0.14	6.24	11629
S10J	0.00	0.05	0.00	0.18	5.52	7976
S20A	0.00	0.00	0.00	3.32	1.68	6088
S20B	0.00	0.00	0.00	2.14	1.45	9132
S20C	0.00	0.00	0.00	0.87	20.29	13577
S20D	0.00	0.01	0.00	2.54	7.44	7610
S31A	0.00	0.00	0.00	2.83	0.59	6636
S31B	0.00	0.00	0.00	1.70	0.00	6514
S31C	0.00	0.00	0.00	3.11	0.00	9863
S31D	0.00	0.00	0.00	1.88	0.36	5358
S31E	0.00	0.00	0.00	9.15	0.00	7123
S31F	0.00	0.00	0.00	2.87	16.96	3653
S31G	0.00	0.00	0.00	10.44	0.54	3896
S32A	0.00	0.00	0.00	0.27	0.00	5297
S32B	0.00	0.00	0.00	0.70	5.58	9254
S32C	0.00	0.00	0.00	1.12	11.44	8767
S32D	5.48	13.97	0.00	2.61	0.00	4992
S32E	0.00	5.50	0.00	2.35	0.00	4871
S32F	0.00	1.52	0.00	0.00	2.58	5540
S32G	0.00	0.00	0.00	6.34	3.96	4018
S32H	0.00	0.00	0.00	6.13	0.00	5662
S32J	0.00	0.00	0.00	1.27	6.54	9011
S32K	0.00	0.00	0.00	1.61	0.00	6514
S32L	0.00	0.00	0.00	1.17	0.00	4688
S32M	0.00	0.00	0.00	1.65	0.00	7976
S40A	13.73	0.00	0.00	5.00	0.62	10715

QUATERNARY CATCHMENT	aAAAi AREA UNDER ALIEN VEGETATION km²	aFCAi AREA UNDER AFFORESTATION km²	aFINi INDIGENOUS FOREST AREA km²	aISAi AVERAGE FIELD AREA IRRIGATED km²	aNAEi URBAN AREAS AND RURAL VILLAGES km²	oRSUi NUMBER OF LARGE STOCK UNITS Number
S40B	81.98	1.01	0.00	4.91	0.00	10533
S40C	16.08	0.00	0.00	3.68	0.00	7854
S40D	0.00	0.67	0.00	0.74	0.16	2922
S40E	30.12	7.89	0.00	2.45	0.77	7489
S40F	8.81	0.00	0.00	3.21	0.00	4992
S50A	0.00	0.00	0.00	0.29	0.00	6819
S50B	0.00	0.00	0.00	0.42	0.00	10167
S50C	0.00	1.96	0.00	0.48	0.00	11689
S50D	0.00	3.30	0.00	0.43	9.17	15099
S50E	0.00	18.45	0.00	0.17	9.12	17047
S50F	0.00	1.76	0.00	0.04	5.66	2131
S50G	0.00	1.73	0.00	0.50	13.55	23988
S50H	0.00	1.77	0.00	0.15	7.77	9132
S50J	0.00	4.01	0.00	0.00	10.32	34460
S60A	44.73	97.21	34.66	0.35	2.03	4871
S60B	35.86	10.11	0.00	1.01	0.00	3957
S60C	56.77	31.76	5.61	0.57	0.00	3227
S60D	8.96	8.14	0.08	2.88	0.00	3957
S60E	2.20	0.00	0.00	2.03	0.00	6697
S70A	0.55	1.20	0.00	1.51	1.47	10533
S70B	0.17	0.00	0.00	0.28	0.00	12359
S70C	0.00	0.00	0.00	0.19	7.36	9985
S70D	0.93	12.36	0.00	0.57	16.32	25875
S70E	0.24	6.23	0.00	0.47	5.39	22222
S70F	0.76	1.38	0.00	1.23	0.00	11142
T11A	0.00	51.59	0.00	0.00	2.90	15269
T11B	0.00	21.14	0.00	0.00	0.00	19248
T11C	0.90	8.05	0.00	1.26	0.00	36090
T11D	0.00	18.74	0.00	0.00	0.00	32111
T11E	0.96	27.56	0.00	0.00	0.00	21839
T11F	0.00	1.30	0.00	0.00	0.00	25726
T11G	3.11	11.62	3.60	0.00	0.00	28039
T11H	0.00	5.41	0.00	0.00	0.00	20821
T12A	0.00	35.26	2.74	0.00	4.87	26096

QUATERNARY CATCHMENT	aAAAi	aFCAi	aFINi	aISAi	aNAEi	oRSUi
	AREA UNDER ALIEN VEGETATION	AREA UNDER AFFORESTATION	INDIGENOUS FOREST AREA	AVERAGE FIELD AREA IRRIGATED	URBAN AREAS AND RURAL VILLAGES	NUMBER OF LARGE STOCK UNITS
	km²	km²	km²	km²	km²	Number
T12B	0.00	1.03	0.30	0.00	4.30	21562
T12C	0.00	12.82	0.00	1.06	16.85	10549
T12D	0.00	6.76	0.00	2.38	19.00	11845
T12E	0.00	4.62	0.00	0.00	1.37	38589
T12F	0.00	9.23	0.00	0.00	0.00	32389
T12G	0.00	0.08	0.00	0.00	1.59	22117
T13A	0.00	2.84	0.00	0.00	0.05	27669
T13B	0.00	0.01	0.00	0.00	1.18	27391
T13C	0.00	1.29	0.00	0.00	0.86	25448
T13D	0.00	0.00	0.00	0.00	0.23	43216
T13E	0.67	0.00	0.00	0.00	0.00	20266
T20A	20.77	204.60	17.55	0.00	0.00	46269
T20B	3.87	26.28	15.04	0.00	2.49	22857
T20C	2.11	3.29	0.00	0.00	7.47	30815
T20D	0.55	3.76	0.00	0.00	15.10	37293
T20E	0.00	0.00	0.00	0.98	0.00	36368
T20F	2.42	6.68	0.56	0.00	0.87	52192
T20G	2.09	0.67	0.28	0.00	0.00	22117
T31A	1.65	9.01	0.00	0.08	0.00	10075
T31B	1.97	1.13	0.00	3.15	0.00	13166
T31C	5.82	0.00	0.00	0.00	0.00	8950
T31D	1.08	0.00	0.00	4.31	0.00	16070
T31E	13.77	0.48	0.00	0.00	0.00	31416
T31F	4.97	0.00	0.00	1.69	1.38	27971
T31G	4.48	0.00	0.00	0.00	0.00	9638
T31H	28.93	0.05	0.00	0.00	0.00	41918
T31J	2.85	0.00	0.00	0.00	0.00	34429
T32A	7.00	0.85	0.00	3.19	0.49	15908
T32B	12.59	0.16	0.00	8.27	0.00	14316
T32C	12.05	5.44	0.00	4.27	3.15	17191
T32D	10.00	0.00	0.00	10.42	1.54	15927
T32E	13.91	0.35	2.72	0.00	1.12	29427
T32F	2.06	4.76	1.29	0.00	0.69	23412
T32G	8.43	8.03	9.38	0.00	0.00	20544

QUATERNARY CATCHMENT	aAAAi	aFCAi	aFINi	aISAi	aNAEi	oRSUi
	AREA UNDER ALIEN VEGETATION	AREA UNDER AFFORESTATION	INDIGENOUS FOREST AREA	AVERAGE FIELD AREA IRRIGATED	URBAN AREAS AND RURAL VILLAGES	NUMBER OF LARGE STOCK UNITS
	km²	km²	km²	km²	km²	Number
T32H	8.27	5.91	4.84	0.00	0.28	21284
T33A	17.30	0.27	0.00	0.00	7.58	40202
T33B	0.99	0.27	0.00	0.00	0.00	37663
T33C	0.64	0.00	0.00	0.00	0.00	21654
T33D	22.70	0.00	0.00	0.00	0.00	27206
T33E	0.00	0.00	0.00	0.00	0.00	15732
T33F	2.35	4.89	0.00	0.00	0.00	30075
T33G	0.53	1.54	0.00	0.00	0.00	34610
T33H	2.86	2.54	0.00	0.00	5.27	26849
T33J	3.64	1.51	0.00	0.00	0.00	33973
T33K	0.00	0.00	0.00	0.00	0.00	3379
T34A	0.00	0.00	0.00	0.00	0.00	14251
T34B	1.00	0.85	0.00	0.00	0.00	14529
T34C	0.00	0.00	0.00	0.00	0.00	16657
T34D	1.33	1.14	0.00	0.00	0.62	20173
T34E	6.72	5.56	0.00	0.00	0.00	19433
T34F	9.41	0.00	0.00	0.00	0.00	14066
T34G	0.64	7.33	1.05	0.00	0.00	32574
T34H	8.26	58.89	5.39	0.00	0.00	40717
T34J	0.00	2.28	0.00	0.00	0.00	20451
T34K	0.00	0.00	0.00	0.00	0.00	26281
T35A	1.82	72.78	0.00	0.00	0.00	28039
T35B	0.20	33.11	0.00	0.00	0.00	28687
T35C	0.00	93.65	0.00	0.00	0.07	22117
T35D	0.00	30.30	0.00	0.00	2.00	25171
T35E	0.04	46.79	0.17	0.00	0.00	44789
T35F	0.00	157.80	0.00	0.00	1.53	26003
T35G	0.00	88.99	0.00	0.00	0.00	41642
T35H	0.00	29.23	0.26	0.00	0.00	29335
T35J	0.76	19.02	0.18	0.00	0.00	10642
T35K	3.42	32.25	1.07	0.00	2.61	56911
T35L	0.00	2.09	0.00	0.00	0.00	31001
T35M	0.00	0.04	0.00	0.00	0.00	10642
T36A	0.00	0.85	0.00	0.00	0.00	9439

QUATERNARY CATCHMENT	aAAAi	aFCAi	aFINi	aISAi	aNAEi	oRSUi
	AREA UNDER ALIEN VEGETATION	AREA UNDER AFFORESTATION	INDIGENOUS FOREST AREA	AVERAGE FIELD AREA IRRIGATED	URBAN AREAS AND RURAL VILLAGES	NUMBER OF LARGE STOCK UNITS
	km²	km²	km²	km²	km²	Number
T36B	1.54	0.09	0.00	0.12	0.22	5367
T60A	0.00	0.06	0.09	0.00	0.01	833
T60B	3.45	5.75	1.14	0.00	0.00	24800
T60C	0.00	0.00	0.00	0.00	0.00	555
T60D	0.00	0.00	0.00	0.00	0.00	648
T60E	1.58	2.87	0.00	0.00	0.10	9254
T60F	3.77	0.00	0.00	0.00	0.49	9531
T60G	0.00	0.00	0.00	0.00	0.00	7403
T60H	0.70	19.58	0.00	0.00	0.00	6570
T60J	0.17	1.19	0.00	0.00	0.00	6015
T60K	0.95	0.00	0.00	0.00	0.00	4997
T70A	0.02	12.19	0.00	0.60	1.99	10920
T70B	7.81	2.00	0.00	0.61	0.26	5552
T70C	0.60	1.26	0.00	0.25	0.00	20544
T70D	0.00	0.00	0.00	0.00	0.00	6663
T70E	2.91	12.69	0.00	0.00	0.44	23690
T70F	2.46	0.00	0.00	0.15	0.53	27577
T70G	0.00	4.13	0.00	0.06	0.00	27947
T80A	1.08	3.11	0.00	0.00	0.00	25078
T80B	0.52	1.22	0.00	0.20	0.00	28224
T80C	0.00	4.79	0.37	0.00	0.66	37108
T80D	0.67	3.05	0.00	0.08	0.00	33777
T90A	6.51	5.69	0.00	0.00	4.35	25941
T90B	0.18	0.80	0.00	0.00	2.07	30885
T90C	0.84	5.06	0.00	0.00	1.74	29126
T90D	0.07	3.63	0.15	0.00	0.71	29672
T90E	0.03	2.66	0.06	0.00	0.00	32676
T90F	0.00	4.14	8.71	0.00	0.00	25395
T90G	0.33	4.39	0.00	0.00	0.00	41414
TOTALS	730.38	1677.86	146.33	187.13	505.09	**3173348**

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX D.2

CONVERSION OF MATURE LIVESTOCK AND GAME POPULATIONS TO EQUIVALENT LARGE STOCK UNITS (ELSU)

SPECIES	GROUP *	NUMBER PER ELSU
Livestock :		
Cattle	L	0,85
Sheep	S	6,5
Goats	S	5,8
Horses	L	1
Donkeys / mules	S	1,1
Pigs	S	4
Game :		
Black Wildebeest	LA	3,3
Blesbuck	SA	5,1
Blou Wildebeest	LA	2,4
Buffalo	BG	1
Eland	BG	1
Elephant	BG	0,3
Gemsbok	LA	2,2
Giraffe	BG	0,7
Hippopotamus	BG	0,4
Impala	SA	7
Kudu	LA	2,2
Nyala	SA	3,3
Ostrich	--	2,7
Red Hartebeest	LA	2,8
Roan Antelope	LA	2
Sable Antelope	LA	2
Southern Reedbuck	SA	7,7
Springbok	SA	10,3
Tsessebe	LA	2,8
Warthog	O	5
Waerbuck	SA	2,4
Rhinoceros	BG	0,4
Zebra	O	1,6

* Groups (in terms of water consumption :
L = cattle and horses; S = small livestock; LA = large antelope; SA = small antelope; BG = big game;
O = other game.

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX D.3

TREE SPECIES IN COMMERCIAL FORESTS PER QUATERNARY CATCHMENT

QUATERNARY CATCHMENT	aFCAi AREA UNDER AFFORESTATION km²	SPECIES
R10A	9.54	PINE
R10B	10.78	PINE
R10C	9.61	PINE
R10D	6.46	PINE
R10E	0.21	PINE
R10F	28.14	PINE (95%) & WATTLE (5%)
R10G	1.37	PINE
R10H	0.00	
R10J	0.00	
R10K	1.91	EUCALYPTUS
R10L	0.03	EUCALYPTUS
R10M	0.41	EUCALYPTUS (64%) & PINE (36%)
R20A	47.88	EUCALYPTUS (3%) & PINE (97%)
R20B	9.88	EUCALYPTUS (18%) & PINE (82%)
R20C	5.11	PINE
R20D	0.00	
R20E	7.83	EUCALYPTUS (22%), PINE (76%) & WATTLE (2%)
R20F	4.17	EUCALYPTUS (2%), PINE (92%) & WATTLE (6%)
R20G	0.00	
R30A	0.00	
R30B	0.00	
R30C	0.04	WATTLE
R30D	0.00	
R30E	0.75	WATTLE
R30F	0.00	
R40A	0.00	
R40B	4.10	EUCALYPTUS (91%) & PINE (9%)
R40C	0.72	PINE
R50A	0.00	
R50B	0.00	

QUATERNARY CATCHMENT	aFCAi AREA UNDER AFFORESTATION km²	SPECIES
S10A	0.00	
S10B	0.00	
S10C	0.00	
S10D	0.33	EUCALYPTUS
S10E	0.00	
S10F	0.00	
S10G	1.52	
S10H	0.00	
S10J	0.05	PINE
S20A	0.00	
S20B	0.00	
S20C	0.00	
S20D	0.01	EUCALYPTUS
S31A	0.00	
S31B	0.00	
S31C	0.00	
S31D	0.00	
S31E	0.00	
S31F	0.00	
S31G	0.00	
S32A	0.00	
S32B	0.00	
S32C	0.00	
S32D	13.97	PINE (87%) & WATTLE (13%)
S32E	5.50	PINE
S32F	1.52	PINE
S32G	0.00	
S32H	0.00	
S32J	0.00	
S32K	0.00	
S32L	0.00	
S32M	0.00	
S40A	0.00	
S40B	1.01	PINE
S40C	0.00	
S40D	0.67	EUCALYPTUS (97%) & PINE (3%)

QUATERNARY CATCHMENT	aFCAi AREA UNDER AFFORESTATION km²	SPECIES
S40E	7.89	EUCALYPTUS (9%) & PINE (91%)
S40F	0.00	
S50A	0.00	
S50B	0.00	
S50C	1.96	PINE
S50D	3.30	EUCALYPTUS (22%) & PINE (78%)
S50E	18.45	EUCALYPTUS (15%) & PINE (85%)
S50F	1.76	EUCALYPTUS
S50G	1.73	EUCALYPTUS
S50H	1.77	EUCALYPTUS (91%) & PINE (9%)
S50J	4.01	EUCALYPTUS (79%) & PINE (21%)
S60A	97.21	EUCALYPTUS (8%), PINE (91%) & WATTLE (1%)
S60B	10.11	PINE (6%) & WATTLE (94%)
S60C	31.76	PINE
S60D	8.14	PINE
S60E	0.00	
S70A	1.20	EUCALYPTUS (47%) & PINE (53%)
S70B	0.00	
S70C	0.00	
S70D	12.36	EUCALYPTUS (78%) & PINE (22%)
S70E	6.23	EUCALYPTUS (94%) & PINE (6%)
S70F	1.38	EUCALYPTUS
T11A	51.59	PINE
T11B	21.14	PINE
T11C	8.05	EUCALYPTUS (9%) & PINE (91%)
T11D	18.74	PINE
T11E	27.56	PINE
T11F	1.30	EUCALYPTUS (31%) & PINE (69%)
T11G	11.62	PINE
T11H	5.41	EUCALYPTUS (20%) & WATTLE (80%)
T12A	35.26	PINE
T12B	1.03	EUCALYPTUS (66%) & PINE (34%)
T12C	12.82	PINE
T12D	6.76	EUCALYPTUS (27%) , PINE (63%) & WATTLE (10%)
T12E	4.62	EUCALYPTUS (16%) , PINE (22%) & WATTLE (62%)

QUATERNARY CATCHMENT	aFCAi AREA UNDER AFFORESTATION km²	SPECIES
T12F	9.23	EUCALYPTUS (73%) , PINE (14%) & WATTLE (13%)
T12G	0.08	WATTLE
T13A	2.84	EUCALYPTUS (52%) & WATTLE (48%)
T13B	0.01	EUCALYPTUS
T13C	1.29	WATTLE
T13D	0.00	
T13E	0.00	
T20A	204.60	EUCALYPTUS (5%) & PINE (95%)
T20B	26.28	EUCALYPTUS (10%) & PINE (90%)
T20C	3.29	EUCALYPTUS
T20D	3.76	EUCALYPTUS (29%) & WATTLE (71%)
T20E	0.00	
T20F	6.68	EUCALYPTUS
T20G	0.67	EUCALYPTUS
T31A	9.01	PINE
T31B	1.13	PINE
T31C	0.00	
T31D	0.00	
T31E	0.48	EUCALYPTUS
T31F	0.00	
T31G	0.00	
T31H	0.05	EUCALYPTUS (94%) & PINE (6%)
T31J	0.00	
T32A	0.85	EUCALYPTUS (97%) & PINE (3%)
T32B	0.16	PINE
T32C	5.44	PINE
T32D	0.00	
T32E	0.35	EUCALYPTUS (89%) & PINE (11%)
T32F	4.76	EUCALYPTUS (47%) & PINE (53%)
T32G	8.03	PINE
T32H	5.91	EUCALYPTUS (26%) & PINE (74%)
T33A	0.27	EUCALYPTUS
T33B	0.27	EUCALYPTUS
T33C	0.00	
T33D	0.00	
T33E	0.00	

QUATERNARY CATCHMENT	aFCAi AREA UNDER AFFORESTATION km²	SPECIES
T33F	4.89	PINE
T33G	1.54	EUCALYPTUS (73%) & PINE (27%)
T33H	2.54	EUCALYPTUS (45%) & PINE (55%)
T33J	1.51	EUCALYPTUS
T33K	0.00	
T34A	0.00	
T34B	0.85	EUCALYPTUS (84%) & PINE (16%)
T34C	0.00	
T34D	1.14	EUCALYPTUS (98%) & PINE (2%)
T34E	5.56	PINE
T34F	0.00	EUCALYPTUS
T34G	7.33	PINE
T34H	58.89	EUCALYPTUS (1%) & PINE (99%)
T34J	2.28	EUCALYPTUS
T34K	0.00	
T35A	72.78	PINE
T35B	33.11	PINE
T35C	93.65	PINE
T35D	30.30	PINE
T35E	46.79	PINE (98%) & WATTLE (2%)
T35F	157.80	PINE
T35G	88.99	PINE
T35H	29.23	PINE
T35J	19.02	PINE
T35K	32.25	EUCALYPTUS (34%), PINE (62%) & WATTLE (4%)
T35L	2.09	EUCALYPTUS (41%) & PINE (59%)
T35M	0.04	EUCALYPTUS
T36A	0.85	EUCALYPTUS
T36B	0.09	PINE
T60A	0.06	EUCALYPTUS
T60B	5.75	EUCALYPTUS (6%) & PINE (94%)
T60C	0.00	
T60D	0.00	
T60E	2.87	PINE
T60F	0.00	
T60G	0.00	

QUATERNARY CATCHMENT	aFCAi AREA UNDER AFFORESTATION km²	SPECIES
T60H	19.58	PINE
T60J	1.19	PINE
T60K	0.00	
T70A	12.19	EUCALYPTUS
T70B	2.00	EUCALYPTUS (25%) & PINE (75%)
T70C	1.26	EUCALYPTUS
T70D	0.00	
T70E	12.69	EUCALYPTUS
T70F	0.00	
T70G	4.13	EUCALYPTUS
T80A	3.11	EUCALYPTUS
T80B	1.22	EUCALYPTUS
T80C	4.79	EUCALYPTUS
T80D	3.05	EUCALYPTUS (60%) & PINE (40%)
T90A	5.69	EUCALYPTUS (39%) & PINE (61%)
T90B	0.80	EUCALYPTUS (64%) & PINE (36%)
T90C	5.06	EUCALYPTUS (86%) & PINE (14%)
T90D	3.63	EUCALYPTUS (71%) & PINE (29%)
T90E	2.66	EUCALYPTUS (64%) & PINE (36%)
T90F	4.14	EUCALYPTUS (52%) & PINE (48%)
T90G	4.39	EUCALYPTUS (84%) & PINE (16%)
TOTALS	**1677.86**	---

APPENDIX E

WATER RELATED INFRASTRUCTURE

APPENDIX E.1	**Existing water supply schemes - not used - table in main report**
APPENDIX E.2	**Main dams - not used - table in main report**
APPENDIX E.3	**Farm dam data per quaternary catchment**

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
APPENDIX E.1 : EXISTING WATER SUPPLY SCHEMES
E.1.1 : POTABLE WATER SUPPLY SCHEMES IN 1995

SCHEME NAME	RAW WATER SOURCE	POPULATION SUPPLIED	SCHEME CAPACITY			CATCHMENT NO.
			10^6 m^3/a	ℓ/c/d	Limiting Factor	
Amatole System	Wriggleswade, Nahoon, Bridle Drift, Laing, Rooikrantz, Maden, Gubu Dams	725 000	57,0	215	Treatment capacity	R20A, B, C, D, E, F, G R30E, F, R30D
Komga	Boreholes, Kei River	5 100	0,50	268	Treatment capacity	S70A
Butterworth	Xilinxa Dam	36 450	5,45	188	Treatment capacity	S70E
Willowvale	Weir on river	2 000	0,11	150	Treatment capacity	T90C
Centane	Borehole and river	1 400	0,05	97	Source	T90G
Tsomo	River sump	2 050	0,12	160	Treatment capacity	S50J
Idutywa	Local dams	12 000	0,30	68	Treatment capacity	T90A
Nqamakwe	Boreholes	2 050	0,05	66	Source	S50J
Cathcart	Sam Meyer Dam	8 000	0,50	172	Source	S40A
Mgwali Heckel Scheme	Boreholes	4 500	0,42	255	Source	S60D
Wartburg Scheme	Boreholes	5 000	0,27	148	Source	S60C
Kwelera Scheme	Boreholes	18 000	0,88	133	Source	R30B, D
Mooiplaas Scheme	Boreholes	30 000	0,60	55	Source	R30A, B
Alice (Tyume Valley Scheme)	Binfield Park Dam	15 300	1,1	195	Treatment capacity	R10H
Debe Regional Water Supply Scheme	Debe Dam	29 000	0,45	43	Treatment capacity	R10E, J, K
Keiskammahoek Water Supply Scheme	Mnyameni Dam	12 000	0,88	200	Treatment capacity	R10B
Wesley Regonal Water Supply Scheme	Keiskamma River	700	1,15	N/A	Treatment capacity	R10M, R50A, B
Sandile Regional Water Supply Scheme	Sandile Dam	104 000	5,4	142	Treatment capacity	R10D, E, K, R20C, D
Hamburg	Boreholes	1 700	Not known			R10M
Indwe	Doring River Dam	6 350	0,35	151	Treatment capacity	S20A
Cala	Tsomo River and boreholes	13 350	0,55	111	Treatment capacity	S50A
Elliot	Thompson Dam	11 050	0,44	98	Source	T11A
Ugie	Weir on river	4 000	0,24	165	Treatment capacity	T35F
Maclear	Maclear Dam	4 700	0,22	128	Source	T35D
Queenstown	Waterdown Dam; Bongolo Dam	50 450	8,9	483	Source	S31F
Sada/Whittlesea	Waterdown Dam	50 400	3,4	185	Treatment capacity	S32G/H
Yonda/Mbekweni	Bushmanskrantz Dam	9 200	0,10	30	Treatment capacity	S32F, G
Cacadu Rural Water Supply Scheme	Macubeni Dam	64 000	1,06	45	Treatment capacity	S20A, S10F, G
Hewu Groundwater Scheme	Boreholes and springs	48 000	0,53	30	Source	S32C, F
Ilinge Scheme	Boreholes	13 000	1,3	274	Source	S32J
Tsojana Scheme	Tsojana Dam	5 000	0,14	79	Treatment capacity	S50H
Libode Regional	Mlanga Dam	60 000	0,78	36	Source	T20D, E; T70A, B, C , E
Corana	Corana Dam	47 000	0,22	13	Treatment capacity	T20B, D, E
Mhlahlane	Mabeleni Dam	28 000	0,26	25	Treatment capacity	T20A, B
Umtata Town	Umtata Dam	175 000	13,9	218	Treatment capacity	T20B, C, D
Mtangana	Mtangana Dam, springs, boreholes	16 000	0,14	24	Source	T12E, F, G
Qumbu Town	Boreholes	4 650	0,04	20	Source	T35K
Port St Johns	Lower Bulolwa Dam	12 050	0,33	76	Source/ Treatment capacity	T36B T70B
Ngqeleni	Dam and boreholes	6 050	0,07	30	Treatment capacity	T70F
Mqanduli	Weir on river	4 650	0,05	32	Treatment capacity	T20F
Elliotdale	Weir on river	2 000	0,06	83	Treatment capacity	T80C
Tsolo	Weir on river	4 650	0,16	94	Source	T35K
Engcobo	Two streams and borehole	5 650	0,21	101	Source	T12B
Belfort Scheme	Belfort Dam	5 000	0,30	166	Treatment capacity	T33A
Kwa Bhaca	Ntenetyana Dam	59 000	0,33	15	Treatment capacity	T33G, H, T34H, J
Lusikisiki	Xura River Weir	50 000	0,57	32	Treatment capacity	T60F, G, H, J
Mnceba	Weir on river	29 000	0,63	60	Treatment capacity	T31J, T32F, T33H
Flagstaff Town	Boreholes and dam	7 650	0,18	65	Treatment capacity	T32H
Mt Ayliff Town	Weir on stream	6 600	0,04	18	Source	T32F
Mt Fletcher Town	Boreholes	12 050	0,05	12	Source	T34D
Tabankulu Town	Dam	23 250	0,25	30	Treatment capacity	T33H
Kokstad	Crystal Springs Dam	19 550	2,00	280	Source	T32C
Matatiele	Mountain Dam, Borehole	4 500	1,23	749	Source	T33A
	TOTALS	1 876 050	114,01	170		

APPENDIX E.1 : EXISTING WATER SUPPLY SCHEMES
E.1.2 : CONTROLLED IRRIGATION SCHEMES IN THE MZIMVUBU TO KEISKAMMA WMA IN 1995

SCHEME NAME	SCHEDULED AREA (ha)	IRRIGATED AREA IN 1995 (ha)	PRODUCE	SUPPLY SOURCE	AVAILABLE WATER (1) (million m^3/a)	PRESENT AVERAGE ANNUAL USE (million m^3/a)	CATCHMENT NO.
Zanyokwe Irrigation Scheme	47 (1)	90	Vegetables	Sandile Dam	5,18	1,0	R10C, D
Keiskamma Irrigation Scheme	854	744	Dairy products	Mnyameni and Cata Dams	9,86	6,02	R10B
Tyume Irrigation Scheme	231	114	Citrus	Binfield Park Dam	17,36	0,7	R10G, H
Klipplaat Govt Water Scheme	1 905	1 820	Lucerne, maize, pasture	Waterdown Dam	7,2	18	S32G, H S31G S32K, M
Oxkraal Irrigation Scheme	0 (2)	0	None	Oxkraal Dam Shiloh Dam	7,9 0,4	1,7 (2)	S32G
Nthabethemba Irrigation Scheme	1 200	720	Maize, vegetables	Thrift, Limietskloof, Tentergate, Mitford, Glenbrock Dams and White Kei River	2,52	Not known	S32A, B, C
Zweledinga Irrigation Scheme	239	239	Maize	Bushmanskrantz Dam	2,26	Not known	S32F
Qamata Irrigation Scheme	2 600	650	Maize, lucerne, vegetables	Lubisi Dam	30,5	Not known	S20D
Ncora Irrigation Scheme	3 000	750	Dairy, vegetables, maize	Ncora Dam	35	Not known	T12C, T12D
Xonxa Irrigation Scheme	1 643	60	Maize, vegetables, lucerne	Xonxa Dam	33	Not known	S10H
Doring River	180	180	Lucerne, maize, pasture	Doring River Dam	1,8	1,8	S20B
TOTALS	12 323	5 367			152,98		

(1) Available water at 1:10 year risk of failure.

(2) 566 ha was planned under the Oxkraal Scheme but has not been developed. The dam releases water for irrigators under the Klipplaat Government Water Scheme.

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX E.2

MAIN DAMS

NAME	LIVE CAPACITY (million m^3/a)	YIELD * DOMESTIC SUPPLIES (million m^3/a)	IRRIGATION (million m^3/a)	HYDRO-POWER (million m^3/a)	SURPLUS/ OTHER (million m^3/a)	TOTAL (million m^3/a)	OWNER	CATCHMENT NO.
Xilinxa	14,5	9,4	0,00	0	0	9,4	DWAF	S70C
Gcuwa	0,9						DWAF	S70D
Gubu	8,8	2,27	0,63	0	0,1	2,9	DWAF	S60A
Wriggleswade	91,2	16,9	3,00	0	5,5 **	25,4	DWAF	S60B
Nahoon	20,7	5,6	1,30	0	0,9 ***	7,8	DWAF	R30E
Maden	0,22	3,1	0,00	0	0	3,1	King William's Town TLC	R20A
Rooikrantz	4,90						DWAF	R20A
Laing	21,0	14,9	0,00	0	0	14,9	DWAF	R20E
Bridle Drift	101,7	30,7	0,00	0	0	30,7	East London TLC	R20F
Sandile	30,9	11,6	0,80	0	5,6	18,0	DWAF	R10B
Binfield Park	36,8	1,0	6,30	0	9,2	16,5	DWAF	R10G
Pleasant View	2,0	0,03	1,49	0	0	1,5	DWAF	R10G
Debe	6,0	0,35	0,00	0	1,8	2,2	DWAF	R10E
Mnyameni	2,05	0,45	0,55	0	1,3	2,3	DWAF	R10B
Cata	12,1	0	4,20	0	2,0	6,2	DWAF	R10B
Waterdown	36,6	12,45	4,05	0	0	16,5	DWAF	S32E
Bongolo	6,95	0,65	0,00	0	0	0,7	Queenstown	S31F
Bushmanskrantz	4,62	0,57	1,50	0	0	2,1	DWAF	S32F
Macubeni	1,85	1,54	0,00	0	0	1,5	DWAF	S10F
Tsojana	9,35	3,16	0,00	0	0	3,2	DWAF	S50F
Oxkraal	17,8	0	0,00	0	6,18	6,2	DWAF	S32G
Shiloh	0,52	0	0,34	0	0	0,3	DWAF	S32G
Thrift	2,6	0	0,58	0	0	0,6	DWAF	S32A
Limietskloof	0,78	0	0,13	0	0	0,1	DWAF	S32A
Tentergate	1,72	0	0,26	0	0	0,3	DWAF	S32B
Mitford	0,89	0	0,05	0	0	0,1	DWAF	S32C
Glenbrock	0,41	0	0,12	0	0	0,1	DWAF	S32C
Lubisi	135,0	Negligible	28,50	0	0	28,5	DWAF	S20C
Xonxa	126,0	0	2,00	0	25	27,6	DWAF	S10E
Ncora	120,0	1,0	12,00	85	0	98,0	DWAF	S50E
Doring River	17,84	0,78	2,60	0	0	3,4	DWAF	S20A
Umtata	228,0	19	0,00	126	0	145,0	DWAF	T20B
Corana	0,71	0,34	0,00	0	0	0,3	DWAF	T70A
Mabeleni	2,0	1,73	0,00	0	0	1,7	DWAF	T20A
Mlanga	1,53	0,78	0,00	0	0	0,8	DWAF	T70A
Lower Bulolwa	0,13	0,53	0,00	0	0	0,5	Port St Johns	T70B
Belfort	0,6	0,47	0,00	0	0	0,5	DWAF	T33A
Ntenetyana	1,7	2,2	0,00	0	0	2,2	DWAF	T33G
Tabankulu	0,5	Not known	0,00	0	0	-	Not known	
Magwa	2,6	Not known	0,00	0	0	-	Not known	
Mountain	1,08	0,5	0,00	0	0	0,5	Matatiele TLC	T33A
Crystal Springs	2,14	2,0	0,00	0	0	2,0	Kokstad TLC	T32C
TOTALS	1 077,69	144,0	71,00	211	63,18	483,6		

* Yields are at reliabilities of approximately 1:50 years. The allocations of water to irrigation are greater than the volumes shown because water is supplied at a lower assurance

** It has been assumed that 5,5 Mm^3/a of the yield will be allocated to the ecological Reserve.

*** It has been assumed that 0,9 Mm^3/a of the yield will be allocated to the ecological Reserve.

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX E.3

FARM DAM DATA
PER QUATERNARY CATCHMENT

QUATERNARY CATCHMENT	oDISi FULL SUPPLY CAPACITY (million m^3)	aDMIi FULL SUPPLY AREA km^2	oDIEo EVAPORATION LOSSES (million m^3)
R10A	0.00	0.00	0.00
R10B	0.00	0.00	0.00
R10C	0.00	0.00	0.00
R10D	0.00	0.00	0.00
R10E	0.00	0.00	0.00
R10F	0.00	0.00	0.00
R10G	0.41	0.13	0.12
R10H	0.00	0.00	0.00
R10J	0.00	0.00	0.00
R10K	0.13	0.05	0.04
R10L	0.00	0.00	0.00
R10M	0.00	0.00	0.00
R20A	0.32	0.08	0.04
R20B	0.00	0.00	0.00
R20C	0.00	0.00	0.00
R20D	0.14	0.09	0.07
R20E	0.00	0.00	0.00
R20F	0.00	0.00	0.00
R20G	1.69	0.26	0.15
R30A	0.00	0.00	0.00
R30B	0.48	0.12	0.07
R30C	0.82	0.18	0.12
R30D	0.00	0.00	0.00
R30E	0.53	0.19	0.13
R30F	0.00	0.00	0.00
R40A	0.23	0.05	0.03
R40B	0.06	0.02	0.01
R40C	0.09	0.02	0.01
R50A	0.67	0.15	0.12
R50B	0.00	0.00	0.00
S10A	0.68	0.30	0.31

QUATERNARY CATCHMENT	oDISi FULL SUPPLY CAPACITY (million m³)	aDMIi FULL SUPPLY AREA km²	oDIEo EVAPORATION LOSSES (million m³)
S10B	0.27	0.12	0.12
S10C	0.00	0.00	0.00
S10D	0.00	0.00	0.00
S10E	0.00	0.00	0.00
S10F	0.13	0.08	0.08
S10G	0.00	0.00	0.00
S10H	0.00	0.00	0.00
S10J	0.00	0.00	0.00
S20A	0.75	0.16	0.14
S20B	0.21	0.07	0.06
S20C	0.00	0.00	0.00
S20D	0.00	0.00	0.00
S31A	0.05	0.02	0.02
S31B	0.00	0.00	0.00
S31C	1.84	0.67	0.73
S31D	0.18	0.06	0.06
S31E	0.06	0.03	0.03
S31F	0.10	0.07	0.07
S31G	0.45	0.13	0.13
S32A	0.00	0.00	0.00
S32B	0.02	0.01	0.01
S32C	1.34	0.43	0.45
S32D	0.10	0.03	0.02
S32E	0.12	0.02	0.02
S32F	0.00	0.00	0.00
S32G	0.85	0.17	0.17
S32H	0.00	0.00	0.00
S32J	0.00	0.00	0.00
S32K	0.00	0.00	0.00
S32L	0.00	0.00	0.00
S32M	0.00	0.00	0.00
S40A	0.97	0.21	0.19
S40B	0.27	0.07	0.06
S40C	0.00	0.00	0.00
S40D	0.00	0.00	0.00
S40E	0.00	0.00	0.00

QUATERNARY CATCHMENT	oDISi FULL SUPPLY CAPACITY (million m³)	aDMIi FULL SUPPLY AREA km²	oDIEo EVAPORATION LOSSES (million m³)
S40F	0.00	0.00	0.00
S50A	0.25	0.08	0.06
S50B	0.00	0.00	0.00
S50C	0.23	0.08	0.07
S50D	0.00	0.00	0.00
S50E	0.00	0.00	0.00
S50F	0.00	0.00	0.00
S50G	0.00	0.00	0.00
S50H	0.00	0.00	0.00
S50J	0.00	0.00	0.00
S60A	0.01	0.01	0.01
S60B	0.40	0.14	0.11
S60C	0.00	0.00	0.00
S60D	0.14	0.02	0.02
S60E	0.00	0.00	0.00
S70A	0.00	0.00	0.00
S70B	0.21	0.07	0.04
S70C	0.00	0.00	0.00
S70D	0.89	0.40	0.26
S70E	0.00	0.00	0.00
S70F	0.00	0.00	0.00
T11A	0.00	0.00	0.00
T11B	0.00	0.00	0.00
T11C	0.00	0.00	0.00
T11D	0.00	0.00	0.00
T11E	0.00	0.00	0.00
T11F	0.00	0.00	0.00
T11G	0.00	0.00	0.00
T11H	0.00	0.00	0.00
T12A	0.00	0.00	0.00
T12B	0.00	0.00	0.00
T12C	0.00	0.00	0.00
T12D	0.00	0.00	0.00
T12E	0.00	0.00	0.00
T12F	0.00	0.00	0.00
T12G	0.00	0.00	0.00

QUATERNARY CATCHMENT	oDISi	aDMIi	oDIEo
	FULL SUPPLY CAPACITY (million m³)	**FULL SUPPLY AREA km²**	**EVAPORATION LOSSES (million m³)**
T13A	0.00	0.00	0.00
T13B	0.00	0.00	0.00
T13C	0.00	0.00	0.00
T13D	0.00	0.00	0.00
T13E	0.00	0.00	0.00
T20A	2.10	0.53	0.23
T20B	0.95	0.14	0.07
T20C	0.00	0.00	0.00
T20D	0.00	0.00	0.00
T20E	1.20	0.32	0.13
T20F	0.00	0.00	0.00
T20G	0.00	0.00	0.00
T31A	0.10	0.02	0.01
T31B	2.19	1.08	0.59
T31C	0.34	0.17	0.10
T31D	0.24	0.14	0.09
T31E	0.82	0.21	0.13
T31F	0.75	0.50	0.32
T31G	0.28	0.08	0.04
T31H	0.00	0.00	0.00
T31J	0.35	0.14	0.07
T32A	1.93	1.00	0.53
T32B	2.42	0.88	0.43
T32C	2.14	0.57	0.27
T32D	0.30	0.07	0.03
T32E	0.00	0.00	0.00
T32F	0.00	0.00	0.00
T32G	0.00	0.00	0.00
T32H	0.00	0.00	0.00
T33A	1.62	0.26	0.15
T33B	0.00	0.00	0.00
T33C	0.00	0.00	0.00
T33D	0.00	0.00	0.00
T33E	0.00	0.00	0.00
T33F	0.00	0.00	0.00
T33G	1.50	0.50	0.25

QUATERNARY CATCHMENT	oDISi	aDMIi	oDIEo
	FULL SUPPLY CAPACITY (million m^3)	FULL SUPPLY AREA km^2	EVAPORATION LOSSES (million m^3)
T33H	0.00	0.00	0.00
T33J	0.00	0.00	0.00
T33K	0.00	0.00	0.00
T34A	0.00	0.00	0.00
T34B	0.00	0.00	0.00
T34C	0.00	0.00	0.00
T34D	0.00	0.00	0.00
T34E	0.00	0.00	0.00
T34F	0.00	0.00	0.00
T34G	0.00	0.00	0.00
T34H	0.00	0.00	0.00
T34J	0.00	0.00	0.00
T34K	0.00	0.00	0.00
T35A	0.00	0.00	0.00
T35B	0.00	0.00	0.00
T35C	0.00	0.00	0.00
T35D	0.00	0.00	0.00
T35E	0.24	0.08	0.04
T35F	0.41	0.19	0.11
T35G	0.68	0.25	0.16
T35H	0.00	0.00	0.00
T35J	0.00	0.00	0.00
T35K	1.42	0.24	0.13
T35L	0.00	0.00	0.00
T35M	0.00	0.00	0.00
T36A	0.20	0.05	0.02
T36B	0.37	0.09	0.02
T60A	0.00	0.00	0.00
T60B	0.00	0.00	0.00
T60C	0.00	0.00	0.00
T60D	0.00	0.00	0.00
T60E	0.00	0.00	0.00
T60F	0.00	0.00	0.00
T60G	0.00	0.00	0.00
T60H	0.50	0.19	0.01
T60J	0.00	0.00	0.00

QUATERNARY CATCHMENT	oDISi	aDMIi	oDIEo
	FULL SUPPLY CAPACITY (million m^3)	**FULL SUPPLY AREA km^2**	**EVAPORATION LOSSES (million m^3)**
T60K	0.00	0.00	0.00
T70A	0.00	0.00	0.00
T70B	0.00	0.00	0.00
T70C	0.00	0.00	0.00
T70D	0.00	0.00	0.00
T70E	0.00	0.00	0.00
T70F	0.00	0.00	0.00
T70G	0.00	0.00	0.00
T80A	0.00	0.00	0.00
T80B	0.00	0.00	0.00
T80C	0.00	0.00	0.00
T80D	0.00	0.00	0.00
T90A	0.00	0.00	0.00
T90B	0.00	0.00	0.00
T90C	0.00	0.00	0.00
T90D	0.00	0.00	0.00
T90E	0.00	0.00	0.00
T90F	0.00	0.00	0.00
T90G	0.00	0.00	0.00
TOTALS	**39.14**	**12.49**	**8.10**

APPENDIX F

WATER REQUIREMENTS

APPENDIX F.1	**Urban water requirements per quaternary catchment.**
APPENDIX F.2	**Rural water requirements per quaternary catchment.**
APPENDIX F.3	**Bulk water requirements per quaternary catchment - not used. Data in main report.**
APPENDIX F.4	**Irrigation water requirements per quaternary catchment.**
APPENDIX F.5	**Streamflow reduction activity water requirements per quaternary catchment.**
APPENDIX F.6	**Notes on proceedings of the workshops on ecological flow requirements.**

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX F.1
URBAN WATER REQUIREMENTS PER QUATERNARY CATCHMENT

Areas	fUBLi	gUTRo	oNUQo	oPOPi	oUDRo	oUIRi	oURFo	oUTLo
	Bulk loss factor	Total urban water use	Increased runoff due to urban areas and rural villages	Urban population	Direct urban use	Indirect urban use	Total return flows	Total losses
	Factor	million m^3/a	million m^3/a	Number	million m^3/a	million m^3/a	million m^3/a	million m^3/a
R10A	0.05	0.00	0.12	0	0.00	0.00	0.00	0.00
R10B	0.05	0.11	0.27	1150	0.06	0.02	0.05	0.03
R10C	0.05	0.00	0.09	0	0.00	0.00	0.00	0.00
R10D	0.05	0.00	0.01	0	0.00	0.00	0.00	0.00
R10E	0.05	0.12	0.27	2800	0.06	0.02	0.04	0.03
R10F	0.05	0.09	0.00	1250	0.04	0.02	0.03	0.02
R10G	0.05	0.00	0.32	0	0.00	0.00	0.00	0.00
R10H	0.05	1.03	0.41	12450	0.56	0.21	0.44	0.26
R10J	0.05	0.00	0.08	0	0.00	0.00	0.00	0.00
R10K	0.05	0.00	0.69	0	0.00	0.00	0.00	0.00
R10L	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
R10M	0.05	0.00	0.05	0	0.00	0.00	0.00	0.00
R20A	0.05	0.00	0.16	0	0.00	0.00	0.00	0.00
R20B	0.05	0.00	0.35	0	0.00	0.00	0.00	0.00
R20C	0.05	0.00	0.18	0	0.00	0.00	0.00	0.00
R20D	0.05	6.32	1.21	127500	1.84	3.20	3.08	1.28
R20E	0.05	0.00	0.71	0	0.00	0.00	0.00	0.00
R20F	0.05	0.00	2.08	0	0.00	0.00	0.00	0.00
R20G	0.08	43.17	1.63	450700	18.10	8.60	16.55	16.47
R30A	0.05	0.16	0.21	1900	0.08	0.04	0.06	0.04
R30B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
R30C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
R30D	0.05	0.00	0.24	0	0.00	0.00	0.00	0.00
R30E	0.05	0.17	0.15	8250	0.09	0.03	0.05	0.04
R30F	0.05	0.00	1.34	0	0.00	0.00	0.00	0.00
R40A	0.05	0.00	0.26	0	0.00	0.00	0.00	0.00
R40B	0.05	0.00	0.03	0	0.00	0.00	0.00	0.00
R40C	0.05	0.00	0.01	0	0.00	0.00	0.00	0.00
R50A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
R50B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S10A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S10B	0.05	0.00	0.08	0	0.00	0.00	0.00	0.00
S10C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S10D	0.05	0.00	0.12	0	0.00	0.00	0.00	0.00
S10E	0.05	0.00	0.26	0	0.00	0.00	0.00	0.00
S10F	0.05	0.00	0.34	0	0.00	0.00	0.00	0.00
S10G	0.05	0.00	0.91	0	0.00	0.00	0.00	0.00
S10H	0.05	0.00	0.34	0	0.00	0.00	0.00	0.00
S10J	0.05	0.00	0.30	0	0.00	0.00	0.00	0.00
S20A	0.05	0.23	0.10	6350	0.12	0.05	0.10	0.06
S20B	0.05	0.21	0.09	5850	0.12	0.04	0.03	0.05
S20C	0.05	0.00	1.25	0	0.00	0.00	0.00	0.00
S20D	0.05	0.00	0.49	0	0.00	0.00	0.00	0.00
S31A	0.05	0.37	0.03	5600	0.20	0.07	0.11	0.09
S31B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S31C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00

Areas	fUBLi	gUTRo	oNUQo	oPOPi	oUDRo	oUIRi	oURFo	oUTLo
	Bulk loss factor	Total urban water use	Increased runoff due to urban areas and rural villages	Urban population	Direct urban use	Indirect urban use	Total return flows	Total losses
	Factor	million m^3/a	million m^3/a	Number	million m^3/a	million m^3/a	million m^3/a	million m^3/a
S31D	0.05	0.00	0.02	0	0.00	0.00	0.00	0.00
S31E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S31F	0.05	7.07	0.94	50450	3.05	2.24	3.26	1.78
S31G	0.05	0.00	0.03	0	0.00	0.00	0.00	0.00
S32A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S32B	0.05	0.00	0.26	0	0.00	0.00	0.00	0.00
S32C	0.05	0.00	0.57	0	0.00	0.00	0.00	0.00
S32D	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S32E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S32F	0.05	0.00	0.14	0	0.00	0.00	0.00	0.00
S32G	0.05	1.64	0.20	50400	0.89	0.34	0.62	0.41
S32H	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S32J	0.05	0.23	0.35	7700	0.13	0.05	0.08	0.06
S32K	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S32L	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S32M	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S40A	0.05	0.81	0.03	8000	0.44	0.17	0.33	0.20
S40B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S40C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S40D	0.05	0.00	0.01	0	0.00	0.00	0.00	0.00
S40E	0.05	0.00	0.04	0	0.00	0.00	0.00	0.00
S40F	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S50A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S50B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S50C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S50D	0.05	0.59	0.59	13350	0.33	0.12	0.18	0.15
S50E	0.05	0.00	0.60	0	0.00	0.00	0.00	0.00
S50F	0.05	0.00	0.36	0	0.00	0.00	0.00	0.00
S50G	0.05	0.00	0.85	0	0.00	0.00	0.00	0.00
S50H	0.05	0.20	0.47	3350	0.11	0.04	0.07	0.05
S50J	0.05	0.12	0.64	2050	0.07	0.02	0.03	0.03
S60A	0.05	0.86	0.14	26700	0.38	0.27	0.34	0.22
S60B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S60C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S60D	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S60E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S70A	0.05	0.26	0.09	5100	0.14	0.05	0.10	0.06
S70B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
S70C	0.05	0.00	0.44	0	0.00	0.00	0.00	0.00
S70D	0.05	0.04	0.98	1200	0.02	0.01	0.01	0.01
S70E	0.05	0.00	0.38	36450	0.00	0.00	0.00	0.00
S70F	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T11A	0.05	0.69	0.19	11050	0.38	0.14	0.26	0.17
T11B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T11C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T11D	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T11E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T11F	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T11G	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T11H	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T12A	0.05	0.00	0.34	0	0.00	0.00	0.00	0.00

Areas	fUBLi	gUTRo	oNUQo	oPOPi	oUDRo	oUIRi	oURFo	oUTLo
	Bulk loss factor	Total urban water use	Increased runoff due to urban areas and rural villages	Urban population	Direct urban use	Indirect urban use	Total return flows	Total losses
	Factor	million m^3/a	million m^3/a	Number	million m^3/a	million m^3/a	million m^3/a	million m^3/a
T12B	0.05	0.26	0.28	5650	0.14	0.05	0.11	0.07
T12C	0.05	0.00	1.10	0	0.00	0.00	0.00	0.00
T12D	0.05	0.00	1.21	0	0.00	0.00	0.00	0.00
T12E	0.05	0.00	0.09	0	0.00	0.00	0.00	0.00
T12F	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T12G	0.05	0.00	0.09	0	0.00	0.00	0.00	0.00
T13A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T13B	0.05	0.00	0.07	0	0.00	0.00	0.00	0.00
T13C	0.05	0.00	0.05	0	0.00	0.00	0.00	0.00
T13D	0.05	0.00	0.02	0	0.00	0.00	0.00	0.00
T13E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T20A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T20B	0.05	0.00	0.15	0	0.00	0.00	0.00	0.00
T20C	0.05	0.00	0.41	0	0.00	0.00	0.00	0.00
T20D	0.05	10.15	1.07	175200	4.65	3.40	4.55	2.10
T20E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T20F	0.05	0.25	0.06	4650	0.14	0.05	0.07	0.06
T20G	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T31A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T31B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T31C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T31D	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T31E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T31F	0.05	0.09	0.09	1550	0.05	0.02	0.03	0.02
T31G	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T31H	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T31J	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T32A	0.05	0.00	0.03	0	0.00	0.00	0.00	0.00
T32B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T32C	0.05	1.54	0.21	19550	0.83	0.32	0.62	0.39
T32D	0.05	0.00	0.11	0	0.00	0.00	0.00	0.00
T32E	0.05	0.00	0.08	0	0.00	0.00	0.00	0.00
T32F	0.05	0.25	0.05	6600	0.14	0.05	0.08	0.06
T32G	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T32H	0.05	0.40	0.02	7650	0.22	0.08	0.11	0.10
T33A	0.05	0.98	0.46	4500	0.55	0.21	0.47	0.22
T33B	0.05	0.01	0.00	450	0.01	0.00	0.00	0.00
T33C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T33D	0.05	0.06	0.00	4300	0.03	0.01	0.02	0.01
T33E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T33F	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T33G	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T33H	0.05	0.51	0.38	23250	0.28	0.10	0.18	0.13
T33J	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T33K	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T34A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T34B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T34C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T34D	0.05	0.00	0.04	12050	0.00	0.00	0.00	0.00
T34E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T34F	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00

Areas	fUBLi	gUTRo	oNUQo	oPOPi	oUDRo	oUIRi	oURFo	oUTLo
	Bulk loss factor	Total urban water use	Increased runoff due to urban areas and rural villages	Urban population	Direct urban use	Indirect urban use	Total return flows	Total losses
	Factor	million m^3/a	million m^3/a	Number	million m^3/a	million m^3/a	million m^3/a	million m^3/a
T34G	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T34H	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T34J	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T34K	0.05	0.35	0.00		0.19	0.07	0.11	0.09
T35A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T35B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T35C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T35D	0.05	0.17	0.13	4700	0.09	0.03	0.06	0.04
T35E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T35F	0.05	0.18	0.10	4000	0.10	0.04	0.06	0.05
T35G	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T35H	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T35J	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T35K	0.05	0.23	0.16	4650	0.12	0.05	0.06	0.06
T35L	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T35M	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T36A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T36B	0.05	0.00	0.02	12050	0.00	0.00	0.00	0.00
T60A	0.05	0.21	0.00	2950	0.12	0.04	0.09	0.05
T60B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T60C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T60D	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T60E	0.05	0.00	0.01	0	0.00	0.00	0.00	0.00
T60F	0.05	0.90	0.04	11350	0.49	0.18	0.33	0.22
T60G	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T60H	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T60J	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T60K	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T70A	0.05	0.00	0.15	0	0.00	0.00	0.00	0.00
T70B	0.05	0.99	0.02	0	0.48	0.27	0.39	0.25
T70C	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T70D	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T70E	0.05	0.28	0.03	5800	0.15	0.06	0.10	0.07
T70F	0.05	0.11	0.04	6050	0.06	0.02	0.03	0.03
T70G	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T80A	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T80B	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T80C	0.05	0.13	0.05	2000	0.07	0.03	0.04	0.03
T80D	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T90A	0.05	0.84	0.29	12200	0.44	0.18	0.31	0.22
T90B	0.05	0.00	0.16	0	0.00	0.00	0.00	0.00
T90C	0.05	0.00	0.14	0	0.00	0.00	0.00	0.00
T90D	0.05	1.05	0.05					1.05
T90E	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T90F	0.05	0.00	0.00	0	0.00	0.00	0.00	0.00
T90G	0.05	0.06	0.00	1400	0.03	0.01	0.01	0.01
TOTALS	-	84.47	31,34	1 172 150	36.58	21.05	33.65	26.84

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX F.2

RURAL WATER REQUIREMENTS PER QUATERNARY CATCHMENT

Areas	gRSRo	gRURo	oPORi	oRRFo	oRSUi	oRTLi
	Large stock units consumption rate	Total rural water use	Rural population	Rural return flow	Number of large stock units	Rural loss factor
	l/u/d	million m^3/a	Number	million m^3/a	Number	Factor
R10A	45,0	0.17	9377	0	5175	0.0
R10B	45,0	0.25	12750	0	8402	0.0
R10C	45,0	0.14	6900	0	4688	0.0
R10D	45,0	0.21	11850	0	5906	0.0
R10E	45,0	0.25	15840	0	6575	0.0
R10F	45,0	0.05	2558	0	1826	0.0
R10G	45,0	0.22	16580	0	4323	0.0
R10H	45,0	0.31	23450	0	6149	0.0
R10J	45,0	0.12	2720	0	5906	0.0
R10K	45,0	0.61	30550	0	19970	0.0
R10L	45,0	0.19	7487	0	7245	0.0
R10M	45,0	0.12	7016	0	3227	0.0
R20A	45,0	0.04	3664	0	487	0.0
R20B	45,0	0.20	21300	0	548	0.0
R20C	45,0	0.11	11020	0	426	0.0
R20D	45,0	0.23	23600	0	913	0.0
R20E	45,0	0.32	33380	0	852	0.0
R20F	45,0	0.31	21150	0	7245	0.0
R20G	45,0	0.05	633	0	2861	0.0
R30A	45,0	0.31	9966	0	13272	0.0
R30B	45,0	0.35	12580	0	14551	0.0
R30C	45,0	0.05	2328	0	1766	0.0
R30D	45,0	0.09	2053	0	4201	0.0
R30E	45,0	0.15	13370	0	1644	0.0
R30F	45,0	0.11	2082	0	5784	0.0
R40A	45,0	0.20	5845	0	9193	0.0
R40B	45,0	0.17	16680	0	1157	0.0
R40C	45,0	0.15	10270	0	3592	0.0
R50A	45,0	0.22	10910	0	7245	0.0
R50B	45,0	0.31	20190	0	7549	0.0
S10A	45,0	0.07	478	0	4201	0.0
S10B	45,0	0.26	13830	0	8158	0.0
S10C	45,0	0.19	11970	0	4810	0.0
S10D	45,0	0.31	19670	0	7793	0.0
S10E	45,0	0.23	14840	0	5906	0.0
S10F	45,0	0.27	18010	0	6149	0.0
S10G	45,0	0.44	31350	0	9254	0.0
S10H	45,0	0.37	19980	0	11629	0.0
S10J	45,0	0.26	13760	0	7976	0.0
S20A	45,0	0.15	5823	0	6088	0.0
S20B	45,0	0.20	5810	0	9132	0.0
S20C	45,0	0.53	33420	0	13577	0.0
S20D	45,0	0.31	20020	0	7610	0.0
S31A	45,0	0.11	631	0	6636	0.0
S31B	45,0	0.11	519	0	6514	0.0
S31C	45,0	0.17	718	0	9863	0.0
S31D	45,0	0.13	4266	0	5358	0.0
S31E	45,0	0.13	1937	0	7123	0.0

Areas	gRSRo	gRURo	oPORi	oRRFo	oRSUi	oRTLi
	Large stock units consumption rate	Total rural water use	Rural population	Rural return flow	Number of large stock units	Rural loss factor
	l/u/d	million m^3/a	Number	million m^3/a	Number	Factor
S31F	45,0	0.07	826	0	3653	0.0
S31G	45,0	0.08	1264	0	3896	0.0
S32A	45,0	0.09	313	0	5297	0.0
S32B	45,0	0.27	13050	0	9254	0.0
S32C	45,0	0.31	17660	0	8767	0.0
S32D	45,0	0.09	765	0	4992	0.0
S32E	45,0	0.10	2368	0	4871	0.0
S32F	45,0	0.22	13790	0	5540	0.0
S32G	45,0	0.13	6645	0	4018	0.0
S32H	45,0	0.15	5881	0	5662	0.0
S32J	45,0	0.25	11510	0	9011	0.0
S32K	45,0	0.11	838	0	6514	0.0
S32L	45,0	0.09	1226	0	4688	0.0
S32M	45,0	0.14	635	0	7976	0.0
S40A	45,0	0.18	751	0	10715	0.0
S40B	45,0	0.18	938	0	10533	0.0
S40C	45,0	0.14	831	0	7854	0.0
S40D	45,0	0.09	4285	0	2922	0.0
S40E	45,0	0.26	14990	0	7489	0.0
S40F	45,0	0.13	5417	0	4992	0.0
S50A	45,0	0.12	491	0	6819	0.0
S50B	45,0	0.18	908	0	10167	0.0
S50C	45,0	0.25	6205	0	11689	0.0
S50D	45,0	0.42	18840	0	15099	0.0
S50E	45,0	0.45	18990	0	17047	0.0
S50F	45,0	0.10	7479	0	2131	0.0
S50G	45,0	0.70	33930	0	23988	0.0
S50H	45,0	0.38	25090	0	9132	0.0
S50J	45,0	0.98	44880	0	34460	0.0
S60A	45,0	0.13	5737	0	4871	0.0
S60B	45,0	0.12	5889	0	3957	0.0
S60C	45,0	0.08	2847	0	3227	0.0
S60D	45,0	0.09	3008	0	3957	0.0
S60E	45,0	0.12	579	0	6697	0.0
S70A	45,0	0.31	15430	0	10533	0.0
S70B	45,0	0.36	16750	0	12359	0.0
S70C	45,0	0.30	14390	0	9985	0.0
S70D	45,0	0.85	46220	0	25875	0.0
S70E	45,0	0.81	48490	0	22222	0.0
S70F	45,0	0.26	8326	0	11142	0.0
T11A	45,0	0.27	1831	0	15269	0.0
T11B	45,0	0.33	1805	0	19248	0.0
T11C	45,0	0.87	30670	0	36090	0.0
T11D	45,0	0.60	7927	0	32111	0.0
T11E	45,0	0.42	6948	0	21839	0.0
T11F	45,0	0.59	18500	0	25726	0.0
T11G	45,0	0.60	15270	0	28039	0.0
T11H	45,0	0.44	10650	0	20821	0.0
T12A	45,0	0.51	8600	0	26096	0.0
T12B	45,0	0.54	19940	0	21562	0.0
T12C	45,0	0.36	20680	0	10549	0.0
T12D	45,0	0.39	21780	0	11845	0.0
T12E	45,0	0.91	30500	0	38589	0.0
T12F	45,0	0.77	25620	0	32389	0.0
T12G	45,0	0.54	19110	0	22117	0.0

Areas	gRSRo	gRURo	oPORi	oRRFo	oRSUi	oRTLi
	Large stock units consumption rate	Total rural water use	Rural population	Rural return flow	Number of large stock units	Rural loss factor
	l/u/d	million m^3/a	Number	million m^3/a	Number	Factor
T13A	45,0	0.60	15910	0	27669	0.0
T13B	45,0	0.61	17290	0	27391	0.0
T13C	45,0	0.61	20980	0	25448	0.0
T13D	45,0	0.95	26330	0	43216	0.0
T13E	45,0	0.42	9353	0	20266	0.0
T20A	45,0	0.88	12820	0	46269	0.0
T20B	45,0	0.64	28940	0	22857	0.0
T20C	45,0	0.73	24010	0	30815	0.0
T20D	45,0	1.18	61730	0	37293	0.0
T20E	45,0	0.93	36220	0	36368	0.0
T20F	45,0	1.27	45010	0	52192	0.0
T20G	45,0	0.52	16650	0	22117	0.0
T31A	45,0	0.17	655	0	10075	0.0
T31B	45,0	0.22	787	0	13166	0.0
T31C	45,0	0.29	15780	0	8950	0.0
T31D	45,0	0.29	2537	0	16070	0.0
T31E	45,0	0.73	23930	0	31416	0.0
T31F	45,0	0.48	1811	0	27971	0.0
T31G	45,0	0.16	693	0	9638	0.0
T31H	45,0	0.89	22390	0	41918	0.0
T31J	45,0	0.72	16770	0	34429	0.0
T32A	45,0	0.28	2391	0	15908	0.0
T32B	45,0	0.25	2162	0	14316	0.0
T32C	45,0	0.31	2951	0	17191	0.0
T32D	45,0	0.28	2092	0	15927	0.0
T32E	45,0	0.86	40890	0	29427	0.0
T32F	45,0	0.59	22320	0	23412	0.0
T32G	45,0	0.69	38900	0	20544	0.0
T32H	45,0	0.67	35150	0	21284	0.0
T33A	45,0	1.34	74540	0	40202	0.0
T33B	45,0	0.99	40550	0	37663	0.0
T33C	45,0	0.53	18620	0	21654	0.0
T33D	45,0	0.62	18940	0	27206	0.0
T33E	45,0	0.36	11400	0	15732	0.0
T33F	45,0	0.60	11960	0	30075	0.0
T33G	45,0	0.77	22440	0	34610	0.0
T33H	45,0	0.87	46490	0	26849	0.0
T33J	45,0	0.84	30760	0	33973	0.0
T33K	45,0	0.17	12180	0	3379	0.0
T34A	45,0	0.29	6339	0	14251	0.0
T34B	45,0	0.31	7868	0	14529	0.0
T34C	45,0	0.34	7324	0	16657	0.0
T34D	45,0	0.50	18930	0	20173	0.0
T34E	45,0	0.33	675	0	19433	0.0
T34F	45,0	0.30	7322	0	14066	0.0
T34G	45,0	0.67	14460	0	32574	0.0
T34H	45,0	1.07	43600	0	40717	0.0
T34J	45,0	0.53	21150	0	20451	0.0
T34K	45,0	0.62	20410	0	26281	0.0
T35A	45,0	0.55	10220	0	28039	0.0
T35B	45,0	0.48	1236	0	28687	0.0
T35C	45,0	0.36	167	0	22117	0.0
T35D	45,0	0.49	8277	0	25171	0.0
T35E	45,0	0.94	22440	0	44789	0.0
T35F	45,0	0.43	715	0	26003	0.0

Areas	gRSRo	gRURo	oPORi	oRRFo	oRSUi	oRTLi
	Large stock units consumption rate	Total rural water use	Rural population	Rural return flow	Number of large stock units	Rural loss factor
	l/u/d	million m^3/a	Number	million m^3/a	Number	Factor
T35G	45,0	0.75	7742	0	41642	0.0
T35H	45,0	0.70	24280	0	29335	0.0
T35J	45,0	0.32	15600	0	10642	0.0
T35K	45,0	1.45	56170	0	56911	0.0
T35L	45,0	0.72	23650	0	31001	0.0
T35M	45,0	0.36	20100	0	10642	0.0
T36A	45,0	0.42	29180	0	9439	0.0
T36B	45,0	0.26	18760	0	5367	0.0
T60A	45,0	0.62	66030	0	833	0.0
T60B	45,0	0.93	56910	0	24800	0.0
T60C	45,0	0.33	34790	0	555	0.0
T60D	45,0	0.14	14200	0	648	0.0
T60E	45,0	0.36	22800	0	9254	0.0
T60F	45,0	0.62	51220	0	9531	0.0
T60G	45,0	0.37	27160	0	7403	0.0
T60H	45,0	0.22	12330	0	6570	0.0
T60J	45,0	0.56	50470	0	6015	0.0
T60K	45,0	0.37	31020	0	4997	0.0
T70A	45,0	0.47	32250	0	10920	0.0
T70B	45,0	0.36	29780	0	5552	0.0
T70C	45,0	0.48	16150	0	20544	0.0
T70D	45,0	0.39	30490	0	6663	0.0
T70E	45,0	0.61	23740	0	23690	0.0
T70F	45,0	0.67	23480	0	27577	0.0
T70G	45,0	0.68	23740	0	27947	0.0
T80A	45,0	0.65	25830	0	25078	0.0
T80B	45,0	0.69	24320	0	28224	0.0
T80C	45,0	0.87	28340	0	37108	0.0
T80D	45,0	0.83	30520	0	33777	0.0
T90A	45,0	0.74	34250	0	25941	0.0
T90B	45,0	0.75	26950	0	30885	0.0
T90C	45,0	0.74	29150	0	29126	0.0
T90D	45,0	0.77	31100	0	29672	0.0
T90E	45,0	0.83	32240	0	32676	0.0
T90F	45,0	0.61	20860	0	25395	0.0
T90G	45,0	1.07	43210	0	41414	0.0
TOTALS	**-**	**82.68**	**3 348 702**	**-**	**3173348**	**-**

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX F.3

BULK WATER REQUIREMENTS PER QUATERNARY CATCHMENT

Bulk water use for the purposes of this report is defined as water use by an industry that has its own water supply scheme or is supplied individually (i.e. not as part of an urban supply) with water by DWAF, a district council, or a water board.

The only bulk users identified in the Mzimvubu to Keiskamma WMA are the Da Gama Textiles factories at Zwelitsha in catchment R20D and East London in catchment R20G. The Zwelitsha factory receives 1,5 million m^3/a of raw water from Rooikrantz Dam, and the East London factory used to receive 1,8 million m^3/a of treated water from Nahoon Dam, but, in 1995 reduced its requirements to the present level of 0,1 million m^3/a.

Thus, the total bulk water use in 1995 was 1,6 million m^3, all of which occurred in catchments R20D and R20G.

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
APPENDIX F.4
IRRIGATION WATER REQUIREMENTS PER QUATERNARY CATCHMENT

Quaternary Catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	fIPHi	fIPLi	fIPMi	gIARo
	Maximum area under high category crops	Maximum area under low category crops	Maximum area under medium category crops	Average area irrigated	Conveyance losses for high category crops	Conveyance losses for low category crops	Conveyance losses for medium category crops	Application efficiency for high category crops	Application efficiency for low category crops	Application efficiency for medium category crops	Total water use by irrigationrs
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
R10A	0	0	0.75	0.48	0	0	0.15	0	0	0.75	0.37
R10B	0	0	7.44	4.79	0	0	0.15	0	0	0.75	3.72
R10C	0	0	0.8	0.51	0	0	0.15	0	0	0.75	0.40
R10D	0	0	0	0.00	0	0	0	0	0	0	0.00
R10E	0	0	0	0.00	0	0	0	0	0	0	0.00
R10F	0	0	0	0.00	0	0	0	0	0	0	0.00
R10G	0.57	0	0	0.00	0.15	0	0	0.8	0	0	0.00
R10H	0.57	0	0	0.00	0.15	0	0	0.8	0	0	0.00
R10J	0	0	0	0.00	0	0	0	0	0	0	0.00
R10K	0	0	0	0.00	0	0	0	0	0	0	0.00
R10L	0	0	0	0.00	0	0	0	0	0	0	0.00
R10M	0	0	0	0.00	0	0	0	0	0	0	0.00
R20A	0	0	0	0.00	0	0	0	0	0	0	0.00
R20B	0	0	5.56	3.93	0	0	0.15	0	0	0.75	3.05
R20C	0	0	0.00	0.00	0	0	0	0	0	0	0.00
R20D	0	0	0.00	0.00	0	0	0	0	0	0	0.00
R20E	0	0	1.21	0.78	0	0	0.15	0	0	0.75	0.60
R20F	0	0	0.00	0.00	0	0	0	0	0	0	0.00
R20G	0	0	0.00	0.00	0	0	0	0	0	0	0.00
R30A	0	0	7.18	4.62	0	0	0.15	0	0	0.75	3.58
R30B	0	0	6.61	4.25	0	0	0.15	0	0	0.75	3.30
R30C	0	0	5.87	4.07	0	0	0.15	0	0	0.75	3.16
R30D	0	0	3.44	2.21	0	0	0.15	0	0	0.75	1.72
R30E	0	0	3.77	2.43	0	0	0.15	0	0	0.75	1.88
R30F	0	0	1.95	1.75	0	0	0.15	0	0	0.75	1.36
R40A	0	0	4.52	2.91	0	0	0.15	0	0	0.75	2.26
R40B	0	0	3.51	2.26	0	0	0.15	0	0	0.75	1.75
R40C	0	0	2.03	1.30	0	0	0.15	0	0	0.75	1.01
R50A	0	0	2.03	1.31	0	0	0.15	0	0	0.75	1.01
R50B	0	0	2.19	1.41	0	0	0.15	0	0	0.75	1.09
S10A	0	0	0.75	0.73	0	0	0.15	0	0	0.75	0.74

Quaternary Catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	fIPHi	fIPLi	fIPMi	gIARo
	Maximum area under high category crops	Maximum area under low category crops	Maximum area under medium category crops	Average area irrigated	Conveyance losses for high category crops	Conveyance losses for low category crops	Conveyance losses for medium category crops	Application efficiency for high category crops	Application efficiency for low category crops	Application efficiency for medium category crops	Total water use by irrigationrs
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
S10B	0	0	1.12	1.09	0	0	0.15	0	0	0.75	1.11
S10C	0	0	0.67	0.65	0	0	0.15	0	0	0.75	0.66
S10D	0	0	0.9	0.88	0	0	0.15	0	0	0.75	0.89
S10E	0	0.402	0.268	0.26	0	0.15	0.15	0	0.8	0.8	0.27
S10F	0	0	0.6	0.59	0	0	0.15	0	0	0.75	0.59
S10G	0	0	0.82	0.80	0	0	0.15	0	0	0.75	0.81
S10H	0	0.222	0.148	0.14	0	0.15	0.15	0	0.8	0.8	0.15
S10J	0	0.046	0.184	0.18	0	0.27	0.27	0	0.5	0.5	0.18
S20A	0	0	3.4	3.32	0	0	0.15	0	0	0.75	3.36
S20B	0	0	2.19	2.14	0	0	0.15	0	0	0.75	2.17
S20C	0	0	0.89	0.87	0	0	0.15	0	0	0.75	0.88
S20D	0	3.9	2.6	2.54	0	0.27	0.27	0	0.5	0.5	2.57
S31A	0	0	2.9	2.83	0	0	0.15	0	0	0.75	2.87
S31B	0	1.16	1.74	1.70	0	0.15	0.15	0	0.8	0.8	1.72
S31C	0	2.12	3.18	3.11	0	0.15	0.15	0	0.8	0.8	3.14
S31D	0	1.28	1.92	1.88	0	0.15	0.15	0	0.8	0.8	1.90
S31E	0	6.24	9.36	9.15	0	0.15	0.15	0	0.8	0.8	9.26
S31F	0	1.96	2.94	2.87	0	0.15	0.15	0	0.8	0.8	2.91
S31G	0	7.12	10.68	10.44	0	0.15	0.15	0	0.8	0.8	10.56
S32A	0	1.096	0.274	0.27	0	0.15	0.15	0	0.8	0.8	0.27
S32B	0	2.848	0.712	0.70	0	0.15	0.15	0	0.8	0.8	0.70
S32C	0	4.6	1.15	1.12	0	0.15	0.15	0	0.8	0.8	1.14
S32D	0	0	2.67	2.61	0	0	0.15	0	0	0.75	2.64
S32E	0	1.604	2.406	2.35	0	0.15	0.15	0	0.8	0.8	2.38
S32F	0	3	0	0.00	0	0.15	0	0	0.8	0	0.00
S32G	0	4.324	6.486	6.34	0	0.15	0.15	0	0.8	0.8	6.41
S32H	0	4.18	6.27	6.13	0	0.15	0.15	0	0.8	0.8	6.20
S32J	0	0.326	1.304	1.27	0	0.15	0.15	0	0.8	0.8	1.29
S32K	0	1.096	1.644	1.61	0	0.15	0.15	0	0.8	0.8	1.63
S32L	0	0.8	1.2	1.17	0	0.15	0.15	0	0.8	0.8	1.19
S32M	0	1.128	1.692	1.65	0	0.15	0.15	0	0.8	0.8	1.67
S40A	0	0	5.12	5.00	0	0	0.15	0	0	0.75	5.06
S40B	0	0	5.02	4.91	0	0	0.15	0	0	0.75	4.96
S40C	0	0	3.77	3.68	0	0	0.15	0	0	0.75	3.73

Quaternary Catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	fIPHi	fIPLi	fIPMi	gIARo
	Maximum area under high category crops	Maximum area under low category crops	Maximum area under medium category crops	Average area irrigated	Conveyance losses for high category crops	Conveyance losses for low category crops	Conveyance losses for medium category crops	Application efficiency for high category crops	Application efficiency for low category crops	Application efficiency for medium category crops	Total water use by irrigationrs
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
S40D	0	0.504	0.756	0.74	0	0.15	0.15	0	0.8	0.8	0.75
S40E	0	0	2.51	2.45	0	0	0.15	0	0	0.75	2.48
S40F	0	0	3.28	3.21	0	0	0.15	0	0	0.75	3.24
S50A	0	0	0.3	0.29	0	0	0.15	0	0	0.75	0.30
S50B	0	0	0.43	0.42	0	0	0.15	0	0	0.75	0.43
S50C	0	0	0.49	0.48	0	0	0.15	0	0	0.75	0.48
S50D	0	0	0.44	0.43	0	0	0.15	0	0	0.75	0.44
S50E	0	0.264	0.176	0.17	0	0.15	0.15	0	0.8	0.8	0.17
S50F	0	0.06	0.04	0.04	0	0.15	0.15	0	0.8	0.8	0.04
S50G	0	0	0.51	0.50	0	0	0.15	0	0	0.75	0.50
S50H	0	0.228	0.152	0.15	0	0.15	0.15	0	0.8	0.8	0.15
S50J	0	0	0	0.00	0	0	0	0	0	0	0.00
S60A	0	1.088	0.363	0.35	0	0.15	0.15	0	0.8	0.8	0.36
S60B	0	3.528	1.038	1.01	0	0.15	0.15	0	0.8	0.8	1.03
S60C	0	1.989	0.585	0.57	0	0.15	0.15	0	0.8	0.8	0.58
S60D	0	0	2.95	2.88	0	0	0.15	0	0	0.75	2.92
S60E	0	0	2.08	2.03	0	0	0.15	0	0	0.75	2.06
S70A	0	0	1.55	1.51	0	0	0.15	0	0	0.75	1.53
S70B	0	0	0.29	0.28	0	0	0.15	0	0	0.75	0.29
S70C	0	0	0.19	0.19	0	0	0.15	0	0	0.75	0.19
S70D	0	0	0.58	0.57	0	0	0.15	0	0	0.75	0.57
S70E	0	0	0.48	0.47	0	0	0.15	0	0	0.75	0.47
S70F	0	0	1.26	1.23	0	0	0.15	0	0	0.75	1.25
T11A	0	0	0	0.00	0	0	0	0	0	0	0.00
T11B	0	0	0	0.00	0	0	0	0	0	0	0.00
T11C	0	0	1.26	1.26	0	0	0.15	0	0	0.75	1.11
T11D	0	0	0	0.00	0	0	0	0	0	0	0.00
T11E	0	0	0	0.00	0	0	0	0	0	0	0.00
T11F	0	0	0	0.00	0	0	0	0	0	0	0.00
T11G	0	0	0	0.00	0	0	0	0	0	0	0.00
T11H	0	0	0	0.00	0	0	0	0	0	0	0.00
T12A	0	0	0	0.00	0	0	0	0	0	0	0.00
T12B	0	0	0	0.00	0	0	0	0	0	0	0.00
T12C	0	0.53	0.53	1.06	0	0.15	0.15	0	0.8	0.8	0.94

Quaternary Catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	fIPHi	fIPLi	fIPMi	gIARo
	Maximum area under high category crops	Maximum area under low category crops	Maximum area under medium category crops	Average area irrigated	Conveyance losses for high category crops	Conveyance losses for low category crops	Conveyance losses for medium category crops	Application efficiency for high category crops	Application efficiency for low category crops	Application efficiency for medium category crops	Total water use by irrigationrs
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
T12D	0	0	2.38	2.38	0	0	0.15	0	0	0.75	2.10
T12E	0	0	0	0.00	0	0	0	0	0	0	0.00
T12F	0	0	0	0.00	0	0	0	0	0	0	0.00
T12G	0	0	0	0.00	0	0	0	0	0	0	0.00
T13A	0	0	0	0.00	0	0	0	0	0	0	0.00
T13B	0	0	0	0.00	0	0	0	0	0	0	0.00
T13C	0	0	0	0.00	0	0	0	0	0	0	0.00
T13D	0	0	0	0.00	0	0	0	0	0	0	0.00
T13E	0	0	0	0.00	0	0	0	0	0	0	0.00
T20A	0	0	0	0.00	0	0	0	0	0	0	0.00
T20B	0	0	0	0.00	0	0	0	0	0	0	0.00
T20C	0	0	0	0.00	0	0	0	0	0	0	0.00
T20D	0	0	0	0.00	0	0	0	0	0	0	0.00
T20E	0	0	0.98	0.98	0	0	0	0	0	0	0.69
T20F	0	0	0	0.00	0	0	0	0	0	0	0.00
T20G	0	0	0	0.00	0	0	0	0	0	0	0.00
T31A	0	0	0.1	0.08	0	0	0.15	0	0	0.75	0.05
T31B	0	0	3.2	3.15	0	0	0.15	0	0	0.75	2.23
T31C	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T31D	0	0	4.3	4.31	0	0	0.15	0	0	0.75	3.04
T31E	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T31F	0	0	1.7	1.69	0	0	0.15	0	0	0.75	1.19
T31G	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T31H	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T31J	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T32A	0	0	3.2	3.19	0	0	0.15	0	0	0.75	2.25
T32B	0	0	8.3	8.27	0	0	0.15	0	0	0.75	5.84
T32C	0	0	4.3	4.27	0	0	0.15	0	0	0.75	3.01
T32D	0	0	10.4	10.42	0	0	0.15	0	0	0.75	7.36
T32E	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T32F	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T32G	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T32H	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T33A	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00

Quaternary Catchment	aIHAi Maximum area under high category crops	aILAi Maximum area under low category crops	aIMAi Maximum area under medium category crops	aISAi Average area irrigated	fIHCi Conveyance losses for high category crops	fILCi Conveyance losses for low category crops	fIMCi Conveyance losses for medium category crops	fIPHi Application efficiency for high category crops	fIPLi Application efficiency for low category crops	fIPMi Application efficiency for medium category crops	gIARo Total water use by irrigationrs
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
T33B	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T33C	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T33D	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T33E	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T33F	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T33G	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T33H	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T33J	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T33K	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34A	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34B	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34C	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34D	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34E	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34F	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34G	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34H	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34J	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T34K	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35A	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35B	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35C	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35D	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35E	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35F	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35G	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35H	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35J	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35K	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35L	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T35M	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T36A	0	0	0.0	0.00	0	0	0.15	0	0	0.75	0.00
T36B	0	0	0.1	0.12	0	0	0.15	0	0	0.75	0.12
T60A	0	0	0	0.00	0	0	0	0	0	0	0.00

Quaternary Catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	fIPHi	fIPLi	fIPMi	gIARo
	Maximum area under high category crops	Maximum area under low category crops	Maximum area under medium category crops	Average area irrigated	Conveyance losses for high category crops	Conveyance losses for low category crops	Conveyance losses for medium category crops	Application efficiency for high category crops	Application efficiency for low category crops	Application efficiency for medium category crops	Total water use by irrigationrs
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
T60B	0	0	0	0.00	0	0	0	0	0	0	0.00
T60C	0	0	0	0.00	0	0	0	0	0	0	0.00
T60D	0	0	0	0.00	0	0	0	0	0	0	0.00
T60E	0	0	0	0.00	0	0	0	0	0	0	0.00
T60F	0	0	0	0.00	0	0	0	0	0	0	0.00
T60G	0	0	0	0.00	0	0	0	0	0	0	0.00
T60H	0	0	0	0.00	0	0	0	0	0	0	0.00
T60J	0	0	0	0.00	0	0	0	0	0	0	0.00
T60K	0	0	0	0.00	0	0	0	0	0	0	0.00
T70A	0	0	0.6	0.60	0	0	0.15	0	0	0.75	0.56
T70B	0	0	0.61	0.61	0	0	0.15	0	0	0.75	0.57
T70C	0	0	0.25	0.25	0	0	0	0	0	0	0.24
T70D	0	0	0	0.00	0	0	0.15	0	0	0.75	0.00
T70E	0	0	0	0.00	0	0	0.15	0	0	0.75	0.00
T70F	0	0	0.15	0.15	0	0	0.15	0	0	0.75	0.14
T70G	0	0	0.06	0.06	0	0	0.15	0	0	0.75	0.06
T80A	0	0	0	0.00	0	0	0	0	0	0	0.00
T80B	0	0	0.2	0.20	0	0	0	0	0	0	0.16
T80C	0	0	0	0.00	0	0	0	0	0	0	0.00
T80D	0	0	0.08	0.08	0	0	0	0	0	0	0.07
T90A	0	0	0	0.00	0	0	0	0	0	0	0.00
T90B	0	0	0	0.00	0	0	0	0	0	0	0.00
T90C	0	0	0	0.00	0	0	0	0	0	0	0.00
T90D	0	0	0	0.00	0	0	0	0	0	0	0.00
T90E	0	0	0	0.00	0	0	0	0	0	0	0.00
T90F	0	0	0	0.00	0	0	0	0	0	0	0.00
T90G	0	0	0	0.00	0	0	0	0	0	0	0.00
TOTALS	1.14	57.64	208.885	187.13							168.26

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX F.5

STREAMFLOW REDUCTION ACTIVITY WATER REQUIREMENTS PER QUATERNARY CATCHMENT

QUATERNARY CATCHMENT	aAAAi	aCAUi	aFCAi	aFINi	oARDo	oCDo	oFRDo	vLRLi
	AREA UNDER ALIEN VEGETATION	AREA UNDER DRYLAND SUGAR CANE	AREA UNDER AFFORESTATION	AREA OF INDIGENOUS FORESTS	REDUCTION IN RUNOFF DUE TO ALIEN VEGETATION	REDUCTION IN RUNOFF DUE TO DRYLAND SUGAR CANE	REDUCTION IN RUNOFF DUE TO AFFORESTATION	RIVER LOSSES
	km²	km²	km²	km²	million m³/a	million m³/a	million m³/a	million m³/a
R10A	13.38	0.00	9.54	0.00	1.84	0.00	0.44	0.00
R10B	12.84	0.00	10.78	13.26	1.85	0.00	0.66	0.00
R10C	4.44	0.00	9.61	0.00	0.55	0.00	0.31	0.00
R10D	2.20	0.00	6.46	5.38	0.23	0.00	0.37	0.00
R10E	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.00
R10F	5.39	0.00	28.14	4.73	1.02	0.00	1.70	0.00
R10G	2.69	0.00	1.37	5.67	0.22	0.00	0.03	0.00
R10H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R10J	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R10K	0.00	0.00	1.91	0.00	0.00	0.00	0.03	0.00
R10L	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
R10M	5.17	0.00	0.41	0.00	0.53	0.00	0.01	0.00
R20A	3.22	0.00	47.88	0.00	0.59	0.00	2.85	0.00
R20B	2.13	0.00	9.88	0.00	0.22	0.00	0.39	0.00
R20C	2.42	0.00	5.11	0.00	0.31	0.00	0.33	0.00
R20D	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R20E	3.75	0.00	7.83	0.00	0.37	0.00	0.41	0.00
R20F	2.95	0.00	4.17	0.00	0.32	0.00	0.13	0.00
R20G	0.15	0.00	0.00	0.00	0.03	0.00	0.00	0.00
R30A	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R30B	2.04	0.00	0.00	0.00	0.25	0.00	0.00	0.00

QUATERNARY CATCHMENT	aAAi AREA UNDER ALIEN VEGETATION km²	aCAUi AREA UNDER DRYLAND SUGAR CANE km²	aFCAi AREA UNDER AFFORESTATION km²	aFINi AREA OF INDIGENOUS FORESTS km²	oARDo REDUCTION IN RUNOFF DUE TO ALIEN VEGETATION million m³/a	oCDo REDUCTION IN RUNOFF DUE TO DRYLAND SUGAR CANE million m³/a	oFRDo REDUCTION IN RUNOFF DUE TO AFFORESTATION million m³/a	vLRLi RIVER LOSSES million m³/a
R30C	4.86	0.00	0.04	0.00	0.49	0.00	0.00	0.00
R30D	0.10	0.00	0.00	0.00	0.01	0.00	0.00	0.00
R30E	0.51	0.00	0.75	0.00	0.05	0.00	0.02	0.00
R30F	0.83	0.00	0.00	0.00	0.11	0.00	0.00	0.00
R40A	17.35	0.00	0.00	0.00	2.67	0.00	0.00	0.00
R40B	0.09	0.00	4.10	0.00	0.01	0.00	0.14	0.00
R40C	10.96	0.00	0.72	0.00	1.30	0.00	0.02	0.00
R50A	18.01	0.00	0.00	0.00	1.65	0.00	0.00	0.00
R50B	9.40	0.00	0.00	0.00	0.86	0.00	0.00	0.00
S10A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10D	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.00
S10E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10G	0.00	0.00	1.52	0.00	0.00	0.00	0.03	0.00
S10H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10J	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
S20A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S20B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S20C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S20D	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
S31A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S31B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S31C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S31D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

QUATERNARY CATCHMENT	aAAAi AREA UNDER ALIEN VEGETATION km²	aCAUi AREA UNDER DRYLAND SUGAR CANE km²	aFCAi AREA UNDER AFFORESTATION km²	aFINi AREA OF INDIGENOUS FORESTS km²	oARDo REDUCTION IN RUNOFF DUE TO ALIEN VEGETATION million m³/a	oCDo REDUCTION IN RUNOFF DUE TO DRYLAND SUGAR CANE million m³/a	oFRDo REDUCTION IN RUNOFF DUE TO AFFORESTATION million m³/a	vLRLi RIVER LOSSES million m³/a
S31E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S31F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S31G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S32A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S32B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S32C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S32D	5.48	0.00	13.97	0.00	0.72	0.00	1.35	0.00
S32E	0.00	0.00	5.50	0.00	0.00	0.00	0.40	0.00
S32F	0.00	0.00	1.52	0.00	0.00	0.00	0.04	0.00
S32G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S32H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S32J	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S32K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S32L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S32M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S40A	13.73	0.00	0.00	0.00	1.03	0.00	0.00	0.00
S40B	81.98	0.00	1.01	0.00	6.22	0.00	0.03	0.00
S40C	16.08	0.00	0.00	0.00	1.35	0.00	0.00	0.00
S40D	0.00	0.00	0.67	0.00	0.00	0.00	0.02	0.00
S40E	30.12	0.00	7.89	0.00	2.86	0.00	0.26	0.00
S40F	8.81	0.00	0.00	0.00	0.88	0.00	0.00	0.00
S50A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S50B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S50C	0.00	0.00	1.96	0.00	0.00	0.00	0.07	0.00
S50D	0.00	0.00	3.30	0.00	0.00	0.00	0.18	0.00
S50E	0.00	0.00	18.45	0.00	0.00	0.00	1.06	0.00

QUATERNARY CATCHMENT	aAAAi AREA UNDER ALIEN VEGETATION	aCAUi AREA UNDER DRYLAND SUGAR CANE	aFCAi AREA UNDER AFFORESTATION	aFINi AREA OF INDIGENOUS FORESTS	oARDo REDUCTION IN RUNOFF DUE TO ALIEN VEGETATION	oCDo REDUCTION IN RUNOFF DUE TO DRYLAND SUGAR CANE	oFRDo REDUCTION IN RUNOFF DUE TO AFFORESTATION	vLRLi RIVER LOSSES
	km²	km²	km²	km²	million m³/a	million m³/a	million m³/a	million m³/a
S50F	0.00	0.00	1.76	0.00	0.00	0.00	0.10	0.00
S50G	0.00	0.00	1.73	0.00	0.00	0.00	0.06	0.00
S50H	0.00	0.00	1.77	0.00	0.00	0.00	0.06	0.00
S50J	0.00	0.00	4.01	0.00	0.00	0.00	0.21	0.00
S60A	44.73	0.00	97.21	34.66	6.84	0.00	8.81	0.00
S60B	35.86	0.00	10.11	0.00	4.37	0.00	0.44	0.00
S60C	56.77	0.00	31.76	5.61	6.40	0.00	2.13	0.00
S60D	8.96	0.00	8.14	0.08	0.92	0.00	0.38	0.00
S60E	2.20	0.00	0.00	0.00	0.25	0.00	0.00	0.00
S70A	0.55	0.00	1.20	0.00	0.07	0.00	0.06	0.00
S70B	0.17	0.00	0.00	0.00	0.01	0.00	0.00	0.00
S70C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S70D	0.93	0.00	12.36	0.00	0.12	0.00	0.58	0.00
S70E	0.24	0.00	6.23	0.00	0.02	0.00	0.26	0.00
S70F	0.76	0.00	1.38	0.00	0.08	0.00	0.09	0.00
T11A	0.00	0.00	51.59	0.00	0.00	0.00	2.83	0.00
T11B	0.00	0.00	21.14	0.00	0.00	0.00	1.39	0.00
T11C	0.90	0.00	8.05	0.00	0.14	0.00	0.94	0.00
T11D	0.00	0.00	18.74	0.00	0.00	0.00	1.62	0.00
T11E	0.96	0.00	27.56	0.00	0.15	0.00	3.02	0.00
T11F	0.00	0.00	1.30	0.00	0.00	0.00	0.18	0.00
T11G	3.11	0.00	11.62	3.60	0.44	0.00	1.45	0.00
T11H	0.00	0.00	5.41	0.00	0.00	0.00	0.39	0.00
T12A	0.00	0.00	35.26	2.74	0.00	0.00	2.75	0.00
T12B	0.00	0.00	1.03	0.30	0.00	0.00	0.08	0.00
T12C	0.00	0.00	12.82	0.00	0.00	0.00	1.19	0.00

QUATERNARY CATCHMENT	aAAAi	aCAUi	aFCAi	aFINi	oARDo	oCDo	oFRDo	vLRLi
	AREA UNDER ALIEN VEGETATION	AREA UNDER DRYLAND SUGAR CANE	AREA UNDER AFFORESTATION	AREA OF INDIGENOUS FORESTS	REDUCTION IN RUNOFF DUE TO ALIEN VEGETATION	REDUCTION IN RUNOFF DUE TO DRYLAND SUGAR CANE	REDUCTION IN RUNOFF DUE TO AFFORESTATION	RIVER LOSSES
	km²	km²	km²	km²	million m³/a	million m³/a	million m³/a	million m³/a
T12D	0.00	0.00	6.76	0.00	0.00	0.00	0.48	0.00
T12E	0.00	0.00	4.62	0.00	0.00	0.00	0.41	0.00
T12F	0.00	0.00	9.23	0.00	0.00	0.00	1.02	0.00
T12G	0.00	0.00	0.08	0.00	0.00	0.00	0.01	0.00
T13A	0.00	0.00	2.84	0.00	0.00	0.00	0.22	0.00
T13B	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
T13C	0.00	0.00	1.29	0.00	0.00	0.00	0.09	0.00
T13D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T13E	0.67	0.00	0.00	0.00	0.11	0.00	0.00	0.00
T20A	20.77	0.00	204.60	17.55	3.62	0.00	29.78	0.00
T20B	3.87	0.00	26.28	15.04	0.64	0.00	4.00	0.00
T20C	2.11	0.00	3.29	0.00	0.35	0.00	0.29	0.00
T20D	0.55	0.00	3.76	0.00	0.05	0.00	0.24	0.00
T20E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T20F	2.42	0.00	6.68	0.56	0.20	0.00	0.41	0.00
T20G	2.09	0.00	0.67	0.28	0.33	0.00	0.05	0.00
T31A	1.65	0.00	9.01	0.00	0.32	0.00	0.86	0.00
T31B	1.97	0.00	1.13	0.00	0.31	0.00	0.11	0.00
T31C	5.82	0.00	0.00	0.00	0.98	0.00	0.00	0.00
T31D	1.08	0.00	0.00	0.00	0.13	0.00	0.00	0.00
T31E	13.77	0.00	0.48	0.00	1.84	0.00	0.02	0.00
T31F	4.97	0.00	0.00	0.00	0.57	0.00	0.00	0.00
T31G	4.48	0.00	0.00	0.00	0.71	0.00	0.00	0.00
T31H	28.93	0.00	0.05	0.00	4.41	0.00	0.00	0.00
T31J	2.85	0.00	0.00	0.00	0.36	0.00	0.00	0.00
T32A	7.00	0.00	0.85	0.00	0.93	0.00	0.05	0.00

QUATERNARY CATCHMENT	aAAAi	aCAUi	aFCAi	aFINi	oARDo	oCDo	oFRDo	vLRLi
	AREA UNDER ALIEN VEGETATION	AREA UNDER DRYLAND SUGAR CANE	AREA UNDER AFFORESTATION	AREA OF INDIGENOUS FORESTS	REDUCTION IN RUNOFF DUE TO ALIEN VEGETATION	REDUCTION IN RUNOFF DUE TO DRYLAND SUGAR CANE	REDUCTION IN RUNOFF DUE TO AFFORESTATION	RIVER LOSSES
	km^2	km^2	km^2	km^2	million m^3/a	million m^3/a	million m^3/a	million m^3/a
T32B	12.59	0.00	0.16	0.00	1.84	0.00	0.01	0.00
T32C	12.05	0.00	5.44	0.00	1.72	0.00	0.37	0.00
T32D	10.00	0.00	0.00	0.00	1.25	0.00	0.00	0.00
T32E	13.91	0.00	0.35	2.72	2.08	0.00	0.02	0.00
T32F	2.06	0.00	4.76	1.29	0.38	0.00	0.31	0.00
T32G	8.43	0.00	8.03	9.38	1.31	0.00	0.59	0.00
T32H	8.27	0.00	5.91	4.84	1.41	0.00	0.41	0.00
T33A	17.30	0.00	0.27	0.00	3.04	0.00	0.01	0.00
T33B	0.99	0.00	0.27	0.00	0.19	0.00	0.01	0.00
T33C	0.64	0.00	0.00	0.00	0.11	0.00	0.00	0.00
T33D	22.70	0.00	0.00	0.00	3.72	0.00	0.00	0.00
T33E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T33F	2.35	0.00	4.89	0.00	0.37	0.00	0.47	0.00
T33G	0.53	0.00	1.54	0.00	0.09	0.00	0.12	0.00
T33H	2.86	0.00	2.54	0.00	0.35	0.00	0.17	0.00
T33J	3.64	0.00	1.51	0.00	0.41	0.00	0.08	0.00
T33K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T34A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T34B	1.00	0.00	0.85	0.00	0.21	0.00	0.10	0.00
T34C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T34D	1.33	0.00	1.14	0.00	0.29	0.00	0.12	0.00
T34E	6.72	0.00	5.56	0.00	1.55	0.00	0.66	0.00
T34F	9.41	0.00	0.00	0.00	2.14	0.00	0.00	0.00
T34G	0.64	0.00	7.33	1.05	0.13	0.00	1.05	0.00
T34H	8.26	0.00	58.89	5.39	1.64	0.00	8.39	0.00
T34J	0.00	0.00	2.28	0.00	0.00	0.00	0.15	0.00

QUATERNARY CATCHMENT	aAAAi	aCAUi	aFCAi	aFINi	oARDo	oCDo	oFRDo	vLRLi
	AREA UNDER ALIEN VEGETATION	AREA UNDER DRYLAND SUGAR CANE	AREA UNDER AFFORESTATION	AREA OF INDIGENOUS FORESTS	REDUCTION IN RUNOFF DUE TO ALIEN VEGETATION	REDUCTION IN RUNOFF DUE TO DRYLAND SUGAR CANE	REDUCTION IN RUNOFF DUE TO AFFORESTATION	RIVER LOSSES
	km²	km²	km²	km²	million m³/a	million m³/a	million m³/a	million m³/a
T34K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T35A	1.82	0.00	72.78	0.00	0.45	0.00	8.45	0.00
T35B	0.20	0.00	33.11	0.00	0.05	0.00	3.91	0.00
T35C	0.00	0.00	93.65	0.00	0.00	0.00	9.78	0.00
T35D	0.00	0.00	30.30	0.00	0.00	0.00	2.90	0.00
T35E	0.04	0.00	46.79	0.17	0.01	0.00	5.72	0.00
T35F	0.00	0.00	157.80	0.00	0.00	0.00	17.59	0.00
T35G	0.00	0.00	88.99	0.00	0.00	0.00	8.16	0.00
T35H	0.00	0.00	29.23	0.26	0.00	0.00	2.90	0.00
T35J	0.76	0.00	19.02	0.18	0.17	0.00	2.25	0.00
T35K	3.42	0.00	32.25	1.07	0.54	0.00	3.72	0.00
T35L	0.00	0.00	2.09	0.00	0.00	0.00	0.17	0.00
T35M	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
T36A	0.00	0.00	0.85	0.00	0.00	0.00	0.05	0.00
T36B	1.54	0.00	0.09	0.00	0.24	0.00	0.01	0.00
T60A	0.00	11.00	0.06	0.09	0.00	0.00	0.00	0.00
T60B	3.45	0.00	5.75	1.14	0.60	0.00	0.42	0.00
T60C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T60D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T60E	1.58	0.00	2.87	0.00	0.28	0.00	0.21	0.00
T60F	3.77	0.00	0.00	0.00	0.75	0.00	0.00	0.00
T60G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T60H	0.70	0.00	19.58	0.00	0.20	0.00	2.72	0.00
T60J	0.17	0.00	1.19	0.00	0.05	0.00	0.17	0.00
T60K	0.95	0.00	0.00	0.00	0.13	0.00	0.00	0.00
T70A	0.02	0.00	12.19	0.00	0.00	0.00	0.76	0.00

QUATERNARY CATCHMENT	aAAAi AREA UNDER ALIEN VEGETATION	aCAUi AREA UNDER DRYLAND SUGAR CANE	aFCAi AREA UNDER AFFORESTATION	aFINi AREA OF INDIGENOUS FORESTS	oARDo REDUCTION IN RUNOFF DUE TO ALIEN VEGETATION	oCDo REDUCTION IN RUNOFF DUE TO DRYLAND SUGAR CANE	oFRDo REDUCTION IN RUNOFF DUE TO AFFORESTATION	vLRLi RIVER LOSSES
	km²	km²	km²	km²	million m³/a	million m³/a	million m³/a	million m³/a
T70B	7.81	0.00	2.00	0.00	1.44	0.00	0.20	0.00
T70C	0.60	0.00	1.26	0.00	0.10	0.00	0.08	0.00
T70D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T70E	2.91	0.00	12.69	0.00	0.39	0.00	0.79	0.00
T70F	2.46	0.00	0.00	0.00	0.43	0.00	0.00	0.00
T70G	0.00	0.00	4.13	0.00	0.00	0.00	0.26	0.00
T80A	1.08	0.00	3.11	0.00	0.16	0.00	0.16	0.00
T80B	0.52	0.00	1.22	0.00	0.08	0.00	0.05	0.00
T80C	0.00	0.00	4.79	0.37	0.00	0.00	0.19	0.00
T80D	0.67	0.00	3.05	0.00	0.07	0.00	0.19	0.00
T90A	6.51	0.00	5.69	0.00	0.61	0.00	0.14	0.00
T90B	0.18	0.00	0.80	0.00	0.03	0.00	0.04	0.00
T90C	0.84	0.00	5.06	0.00	0.11	0.00	0.30	0.00
T90D	0.07	0.00	3.63	0.15	0.01	0.00	0.17	0.00
T90E	0.03	0.00	2.66	0.06	0.00	0.00	0.16	0.00
T90F	0.00	0.00	4.14	8.71	0.00	0.00	0.31	0.00
T90G	0.33	0.00	4.39	0.00	0.04	0.00	0.26	0.00
TOTALS	**730.38**	**11.00**	**1677.86**	**146.33**	**95.35**	**0.00**	**164.58**	**0.00**

APPENDIX F.6
FISH TO TSITSIKAMMA WATER MANAGEMENT AREA

EASTERN CAPE WATER RESOURCES SITUATION ASSESSMENT

WORKSHOP ON ECOLOGICAL FLOW REQUIREMENTS PHASE 2: NOTES ON PROCEEDINGS

Prepared for

THE DEPARTMENT OF WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning

By

NINHAM SHAND
Environmental & Engineering Consultants

81 Church Street, Cape Town, 8001
P O Box 1347, Cape Town, 8000
Tel: (021) 424 5544
Fax: (021) 424 5588

Report No. 2948b/ 8331 April 2000

EASTERN CAPE WATER RESOURCES SITUATION ASSESSMENT

WORKSHOP ON ECOLOGICAL FLOW REQUIREMENTS PHASE 2: NOTES ON PROCEEDINGS

CONTENTS

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

The Eastern Cape Water Resources Situation Assessment has been commissioned by the Directorate: Water Resources Planning, of the Department of Water Affairs and Forestry (DWAF) as one of several studies required to provide data for the development of a national water resource strategy in compliance with the provisions of the National Water Act No. 36 of 1998. A requirement of the study was that rough, desktop (i.e. based on available information) estimates of the ecological flow requirements of rivers should be made for each quaternary catchment in the study area (Ninham Shand, 1999) by a procedure prescribed by the Department (Kleynhans *et al.*, 1998). During these workshops, the Ecological Importance and Sensitivity Class (EI&SC) was determined in order to derive the Default Ecological Management Class (DEMC).

Subsequently, a second phase of workshops was commissioned to build on work done in Phase 1. In the Phase 2 workshops, the EI&SC and DEMC were reviewed and then the Present Ecological Status Class (PESC) and Attainable Ecological Status Class (AESC) of rivers within quaternary catchments were determined. This second round of workshops was therefore primarily concerned with assessing the present ecological status of rivers, as well as their potential for rehabilitation with respect to flow, and obtaining an Attainable Ecological Status Class for the rivers. Phase 2 also comprises a rough, desktop estimate, and is based on the methodology prescribed by the Department (Kleynhans, 1999 - see Annexure A). These notes are in respect of the second phase of workshops held for this purpose.

1.2 PARTICIPANTS

It was decided that a two day workshop would be held and a number of experts representing various disciplines relating to rivers were invited to attend. This group of experts was selected by a group referral method. In order to contain costs and facilitate progress, the group was limited to six people. The workshop was held at the Institute for Water Research at Rhodes University in Grahamstown and was facilitated by Neels Kleynhans of the Department of Water Affairs and Forestry's Institute for Water Quality Studies, and Susie Tyson of Ninham Shand's Environmental Section. The delegates who took part in the workshop are as follows:

- Dr N Kleynhans of DWAF (IWQS)
- Dr A Bok of Anton Bok & Associates
- Prof J O'Keefe of the Institute for Water Research
- Mrs H James of the Albany Museum
- Dr J Cambray of the Albany Museum
- S Tyson of Ninham Shand

1.3 PURPOSE AND STRUCTURE OF THIS REPORT

The purpose of this report is to summarise the findings of the workshop. It contains information on the EI&SC, DEMC, PESC, and AESC of the main stem river in each quaternary catchment. In addition, during the workshop, issues and concerns were raised and these are summarised in order to convey these concerns to DWAF. Lastly, it was suggested at the workshop that participants should be given the opportunity to review the findings. Therefore, this draft report affords the participants the opportunity to review the findings by assessing the EI&SC, DEMC, PESC and AESC information contained in the figures and spreadsheet.

CHAPTER 2: METHODOLOGY

2.1 INTRODUCTION

The methodology utilised in the workshop is described in Kleynhans (1999 - see Annexure A). This methodology is summarised in Figure 2.1, which indicates the steps required in the determination of the AEMC.

The first step in the process is to determine the EI&SC. The EI&SC refers to the ecological importance and sensitivity of rivers, i.e., an expression of its importance to the maintenance of ecological diversity and functioning on a local and wider scale, as well as the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. Once the EI&SC has been determined, this index is used as an indicator of the DEMC. For the purposes of the National Water Act, a high EI&SC should justify the assignment of a very high DEMC, as the DEMC is defined in terms of the sensitivity of a system to disturbance and the risk of damaging the system and its capacity for self-recovery. These first two steps in assessing the AEMC were undertaken during the first phase workshop and were merely reviewed during this second phase workshop.

After the EI&SC and DEMC have been determined, the PESC needs to be assessed. This PESC is based on the present habitat integrity (i.e. ecological integrity, condition and naturalness) of the system. Using the EI&SC, DEMC and PESC, the AEMC is then determined. The AEMC is then used as an input into the hydrological model of Hughes and Munster, and is indicative of the most attainable ecological management class that can be achieved for each quaternary as a result of restoring the system from the PESC. In the context of the workshop, restoration is defined as the reestablishment of the structure and function of an ecosystem, including its natural diversity within a 5 year period as a result of changing flows only (Kleynhans, 1999).

Utilisation of this methodology was essential in order to ensure a consistent approach for each of the provinces. An updated version of the previous EcoInfo programme was used to process all the data obtained about the quaternary catchments during the workshop. The programme allowed the classes to be derived immediately as the data was entered.

2.2 GROUPING OF QUATERNARY CATCHMENTS

Due to the vast number of quaternary catchments in the Eastern Cape, it was decided that "like" quaternary catchments would be grouped together. Those catchments which displayed similar characteristics were therefore dealt with as one catchment, and thus only one quaternary catchment for each group was entered into the EcoInfo database. Where knowledge about riverine systems was low, the systems were compared to more well known rivers and low confidence scorings were given.

The quaternary catchment groupings are listed below. Those catchments in bold and underlined contain information in the database that is relevant for all quaternary catchments within that grouping. It was decided during the second round of workshops to subdivide certain groups so as to facilitate assessment thereof. These groups are indicated in the following list.

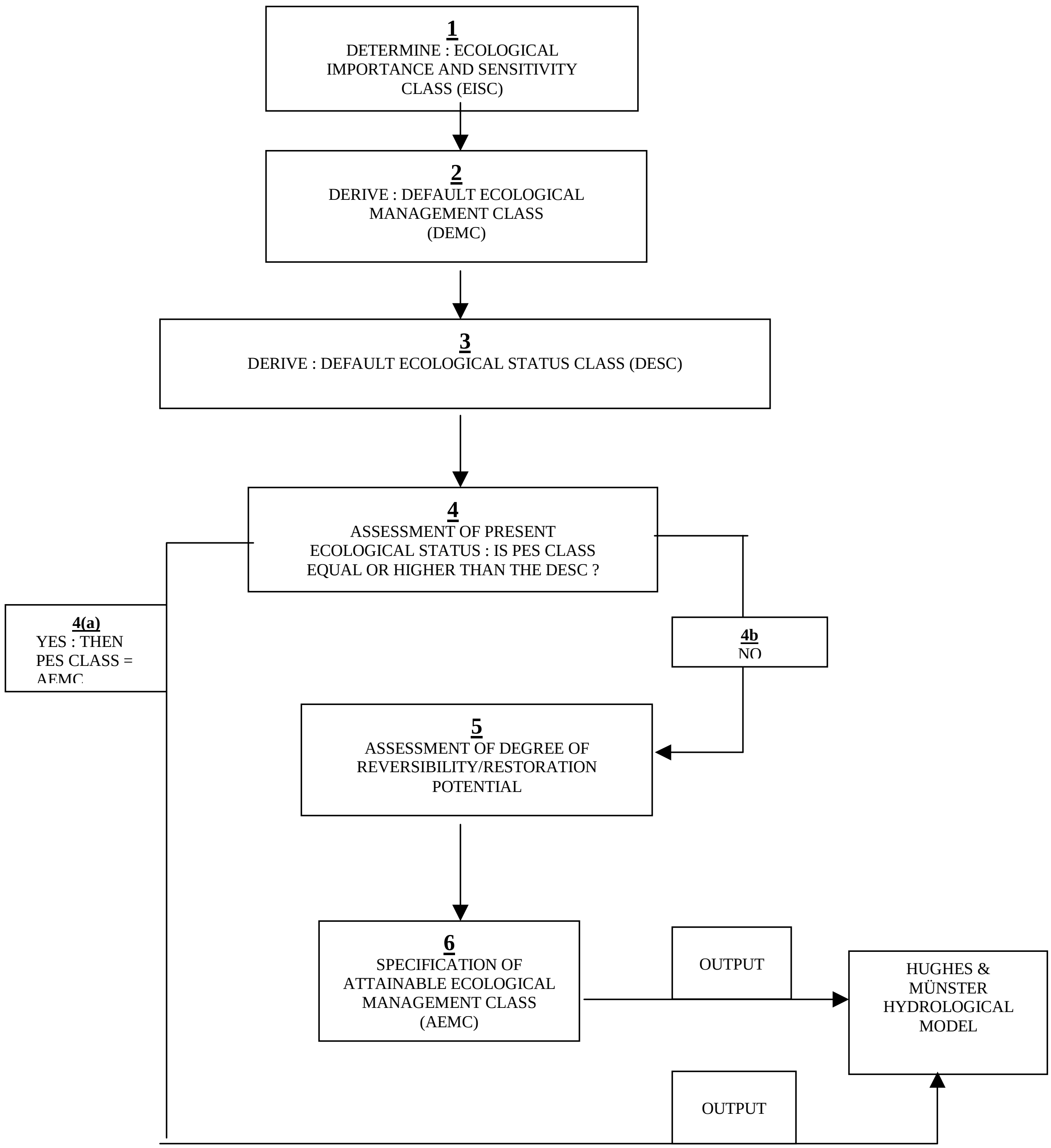


Figure 2.1 : Flow diagram indicating the sequence of steps proposed for the determination of the Attainable Ecological Management Class (from Kleynhans, 1999)

- **K70B**, K80A, K80B, K80C, K80D
- **K80E**, K80F
- **K90A**
- **K90B**, K90C, K90D, K90E
- **K90F**
- **K90G**

- **L11A**, L11B, L11C, L11D, L11E, L11F
- **L12A**, L12B, L12C, L12D
- **L21A**, L21B, L21C, L21D, L21E, L21F, L22A, L22B, L22C, L22D, L23A, L23B, L23C, L23D
- **L40A**, L40B, L60A, L60B, L30A, L30B, L30C, L30D, L50B
- **L70A**, L70B, L70C, L70D, L70E, L70F, L70G
- **L81A**, L81B
- **L81C**, L81D
- **L82A**, L82B, L82C, L82D, L82E, L82F, L82G
- **L82H**, L82J
- **L90A**, L90B, L90C

- **M10A**
- **M10B**
- **M10C**, M10D
- **M20A**
- **M20B**
- **M30A**
- **M30B**

- **N11A**, N11B, N12A, N12B, N12C
- **N13A**, N13B
- **N13C**, 14D, N21A, N21D
- **N14A**, N14B, N14C, N24A
- **N21B,** N21C, N30A
- **N22A**, N22D
- **N23A**
- **N23B**
- **N24B**, N24C, N24D, N22B, N22C, N22E
- **N30B**, N30C
- **N40D**
- **N 40A**

- **N40B**, N40C N40E
- **N40F**
-
- **P10A**, P10B, P10C, P10D, P30A, P40A
- **P10E**, P10F, P10G, P20A, P20B
- **P30B**, P40B, P40C, P40D
-
- **Q12C,** Q13A, Q13B, Q13C, Q22B, Q30B, Q30C, Q30D, Q30E
- **Q14A**, Q14D, Q14E, Q21A, Q21B, Q22A, Q30A
- **Q14B**, Q14C, Q11A, Q11B, Q11C, Q11D, Q12A, Q12B
- **Q43B**, Q42B, Q41A, Q41B, Q41C, Q41D Q44A, Q44B, Q44C
- **Q50A**, Q50B, Q50C, Q70A, Q70B, Q70C, Q91A, Q91B, Q91C
- **Q60A**, Q60B, Q60C, Q92B, Q92C, Q92D, Q92E, Q92F, Q92G
- **Q80A**
- **Q80B**, Q80C, Q80D, Q80E
- **Q80F**
- **Q80G**
- **Q92A**, Q94A, Q94B, Q94C, Q94D, Q94E, Q94F
- **Q93A**, Q93B, Q93C, Q93D
-
- **R10C**, R10D, R10E, R10G, R10H
- **R10J**, R10K, R10L, R10M
- **R20A**, R10A, R10B, R10F
- **R20B**, R20C, R20D, R20E, R20F, R20G
- **R30A**, R30B, R30C, R30D, R30E, R30F
- **R50A**, R50B, R40A, R40B, R40C
-
- **S10E**, S10G, S10H, S10J, S20C, S20D
- **S31A**, S31B, S10A, S10B, S10C, S10D, S10F, S20A, S20B
- **S31D**, S31F, S32J, S32K, S32L, S32M, S40A, S40B, S40C
- **S32D**, S32A, S32B, S32C, S32E, S32F, S32G, S32H, S31C, S31E, S31G
- **S40D**, S40E, S40F, S70A, S70B, S70F
- **S50A**, S50B, S50C, S50D, S50E
- **S50F**, S50G, S50H, S50J
- S60A, **S60B**, S60C, S60D, S60E
- **S70C**, S70D, S70E
-
- **T11A**, T11B, T11C, T11D, T11E, T11F, T12A
- **T12B**, T12C, T12D, T12E, T12F, T12G, T13A, T13B, T13C, T11G, T11H
- **T13D**, T13E

- **<u>T20A</u>**, T20B
- **<u>T20C, T20D, T20E, T20G</u>**
- **<u>T20F</u>**
- **<u>T32A, T32B, T32C, T32D, T32E</u>**
- **<u>T32G</u>**
- **<u>T33G</u>**, T33H, T33J, T32F, T32H, T34H, T34J, T34K, T35K, T35L, T35M
- **<u>T35A</u>**, T35B, T35C, T35D, T35E, T35F, T35G, T35H, T34A, T34B, T34C, T34D, T34E, T34F, T34G, T33A, T33B, T33C, T33D, T33E, T33F, T31A, T31B, T31C, T31D, T31E, T31F, T31G, T31H, T31J
- **<u>T36A</u>**, T36B
- **<u>T40A</u>**, T40B, T40C, T40D, T40E
- **<u>T60A</u>**, T60B, T60C, T60D, T60E, T60F, T60G, T60H, T60J, T60K
- **<u>T90A</u>**, T90B, T90C, T90D, T90E, T90F, T90G, T80 (all), T70 (all), T40F, T40G

CHAPTER 3: RESULTS OF THE WORKSHOP

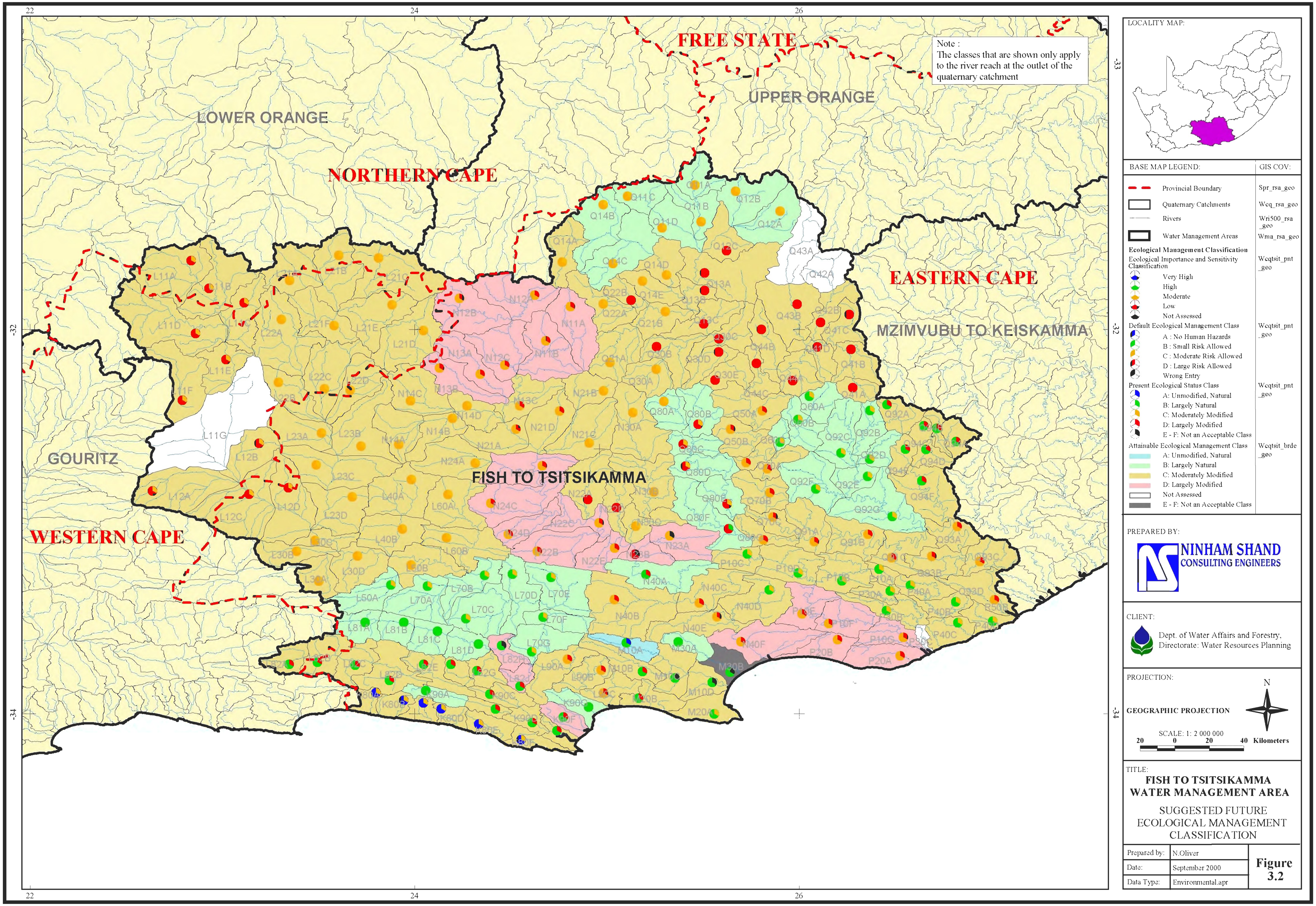
3.1 INTRODUCTION

During the previous workshop, a number of participants requested that the results of the workshop be reviewed once they have been captured and made available by DWAF in a GIS format. The primary reason for this request can be attributed to the conservative EI&SC which the Ecoinfo programme derived from information put into the different categories. Participants felt that the DEMC were sometimes not reflective of the river, and also wanted to get an overall picture of the quaternary catchments for the Eastern Cape.

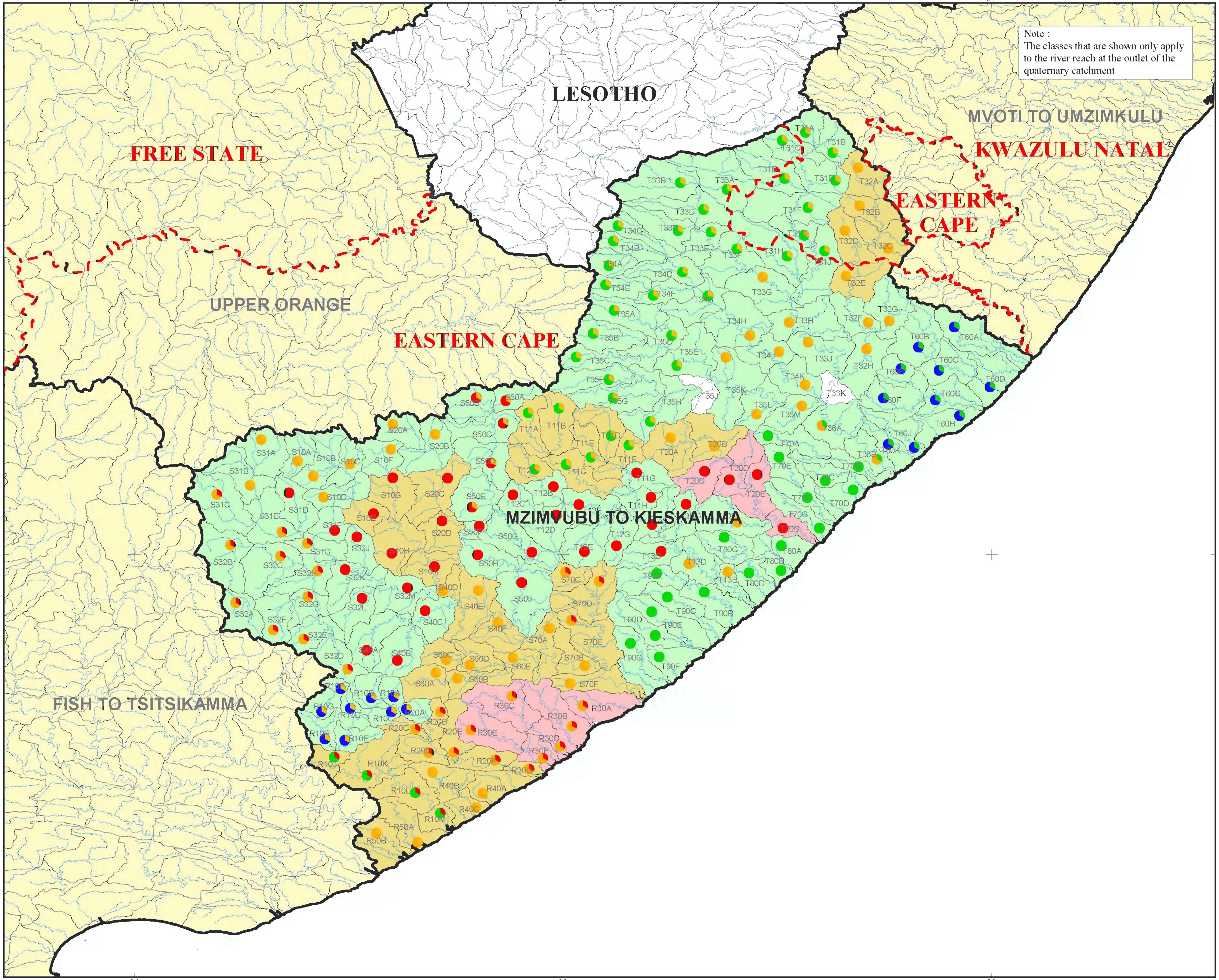
3.2 MANAGEMENT CLASSES

Since the abovementioned information was not available in GIS format prior to the Phase 2 workshops, this report contains a summary of the EI&SC and DEMC, as well as the PESC and AESC in both GIS format (see Figures 3.1 to 3.3) and the data entered in the Ecoinfo programme on CD Rom (see Annexure B).

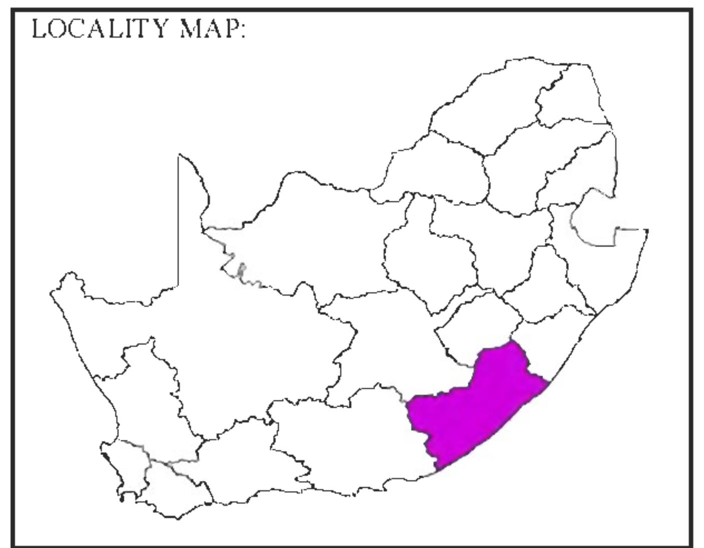
Note :
The classes that are shown only apply to the river reach at the outlet of the quaternary catchment
LOWER ORANGE
NORTHERN CAPE
OLIFANTS / DORING
FISH TO TSITSIKAMMA
EASTERN CAPE
GOURITZ
BERG
WESTERN CAPE
BREEDE
LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
Provincial Boundary — Spr_rsa_geo
Quaternary Catchments — Wcq_rsa_geo
Rivers — Wri500_rsa_geo
Water Management Areas — Wma_rsa_geo
Ecological Management Classification
Ecological Importance and Sensitivity Classification — Weqpnt_gour_geo
Very High
High
Moderate
Low
Not Assessed
Default Ecological Management Class — Weqpnt_gour_geo
A : No Human Hazards
B : Small Risk Allowed
C : Moderate Risk Allowed
D : Large Risk Allowed
Wrong Entry
Present Ecological Management Class — Weqpnt_gour_geo
A: Unmodified, Natural
B: Largely Natural
C: Moderately Modified
D: Largely Modified
E - F: Not an Acceptable Class
Attainable Ecological Management Class — Weqpoly_gour_geo
A: Unmodified, Natural
B: Largely Natural
C: Moderately Modified
D: Largely Modified
Not Assessed
E - F: Not an Acceptable Class
PREPARED BY:
NINHAM SHAND CONSULTING ENGINEERS
CLIENT:
Dept. of Water Affairs and Forestry, Directorate: Water Resources Planning
PROJECTION:
GEOGRAPHIC PROJECTION
N
SCALE: 1: 2 000 000
20 0 20 40 Kilometers
TITLE:
GOURITZ WATER MANAGEMENT AREA
SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASSIFICATION
Prepared by: N.Oliver
Date: July 2000
Data Type: Eme_wma2.apr
Figure 3.1



FREE STATE
UPPER ORANGE
LOWER ORANGE
NORTHERN CAPE
EASTERN CAPE
MZIMVUBU TO KEISKAMMA
GOURITZ
FISH TO TSITSIKAMMA
WESTERN CAPE
Note :
The classes that are shown only apply to the river reach at the outlet of the quaternary catchment
LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
Provincial Boundary
Spr_rsa_geo
Quaternary Catchments
Weq_rsa_geo
Rivers
Wri500_rsa_geo
Water Management Areas
Wma_rsa_geo
Ecological Management Classification
Ecological Importance and Sensitivity Classification
Weqtsit_pnt_geo
Very High
High
Moderate
Low
Not Assessed
Default Ecological Management Class
Weqtsit_pnt_geo
A : No Human Hazards
B : Small Risk Allowed
C : Moderate Risk Allowed
D : Large Risk Allowed
Wrong Entry
Present Ecological Status Class
Weqtsit_pnt_geo
A: Unmodified, Natural
B: Largely Natural
C: Moderately Modified
D: Largely Modified
E - F: Not an Acceptable Class
Attainable Ecological Management Class
Weqtsit_brde_geo
A: Unmodified, Natural
B: Largely Natural
C: Moderately Modified
D: Largely Modified
Not Assessed
E - F: Not an Acceptable Class
PREPARED BY:
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT:
Dept. of Water Affairs and Forestry,
Directorate: Water Resources Planning
PROJECTION:
GEOGRAPHIC PROJECTION
N
SCALE: 1: 2 000 000
20 0 20 40 Kilometers
TITLE:
FISH TO TSITSIKAMMA
WATER MANAGEMENT AREA
SUGGESTED FUTURE
ECOLOGICAL MANAGEMENT
CLASSIFICATION
Prepared by: N.Oliver
Date: September 2000
Data Type: Environmental.apr
Figure 3.2



LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
Provincial Boundary	Spr_rsa_geo
Quaternary Catchments	Weq_rsa_geo
Rivers	Wri500_rsa_geo
Water Management Areas	Wma_rsa_geo
Ecological Management Classification	
Ecological Importance and Sensitivity Classification	Weqkies_pnt_geo
Very High	
High	
Moderate	
Low	
Not Assessed	
Default Ecological Management Class	Weqkies_pnt_geo
A : No Human Hazards	
B : Small Risk Allowed	
C : Moderate Risk Allowed	
D : Large Risk Allowed	
Wrong Entry	
Present Ecological Status Class	Weqkies_pnt_geo
A: Unmodified, Natural	
B: Largely Natural	
C: Moderately Modified	
D: Largely Modified	
E - F: Not an Acceptable Class	
Attainable Ecological Management Class	Weqkies_poly_geo
A: Unmodified, Natural	
B: Largely Natural	
C: Moderately Modified	
D: Largely Modified	
Not Assessed	
E - F: Not an Acceptable Class	

PREPARED BY:

NINHAM SHAND CONSULTING ENGINEERS

CLIENT:

Dept. of Water Affairs and Forestry, Directorate: Water Resources Planning

PROJECTION:

GEOGRAPHIC PROJECTION

SCALE: 1: 2 000 000

20 0 20 40 Kilometers

N

TITLE:

MZIMVUBU TO KIESKAMMA WATER MANAGEMENT AREA

SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASSIFICATION

Prepared by:	N.Oliver	**Figure 3.3**
Date:	September 2000	
Data Type:	Environmental.apr	

CHAPTER 4: DISCUSSION

4.1 COMMENTS AND OBSERVATIONS BY PARTICIPANTS

The participants made the following comments with regard to the methodology and the updated EcoInfo computer programme in particular. At the end of the workshop the participants were encouraged to provide feedback on the strengths and weaknesses of the process. These are:

- The computer programme tended to crash and over-writing of previous data caused problems. As a result, there was a lack of confidence in the computer programme.

- There were problems with the data from the previous workshop, as data had not been converted to the requested GIS format. Furthermore, data seemed to be missing from the DWAF report on the Eastern Cape rivers.

- The workshop highlights rivers which need more baseline studies (use surveys as well as SASS in the more detailed studies).

- All the participants felt more confident with Phase 2 than with Phase 1, however, the process could still be improved with the use of up to date GIS land usage maps with the EI&SC on them.

- Having Neels Kleynhans present at the workshop to interpret the method and to ensure consistency improved the process greatly.

- Inclusion of an amphibian and vegetation expert would aid the process and validity of the Eastern Cape data.

- Findings should be treated with extreme caution and only used as a desktop estimate as some of the confidence levels are very low.

- There is a need for a follow-up survey to validify the data.

- WR90 quaternary areas are still a problem as they are non-ecological (should be an eco-region approach)

- There is a need to note that present status of rivers can vary within groupings due to localised degradation of sections of rivers.

- In order to aid the process, more readily available information in the form of maps (e.g. land-use coverages, vegetation zones, etc) should have been made available.

- Even where very little or no direct knowledge of a river was available, it proved possible to provide quite a good assessment by using regional expertise to extrapolate and using 1:250 000 maps to examine contours (for gradient, gorges, etc), roads (for indicators of access or isolation), towns and villages (as indications of population density) and landuses (e.g. plantations).

- Confidence scores should be extrapolated to ensure that where riverine systems are not well known this can be indicated.

- Need for GIS database overlay to review data.

- Models based only on flow and water quality therefore improvements to the riverine system by means of changing landuse practices was not taken into account.

- The overall workshop is still a lengthy process.

CHAPTER 5: CONCLUSIONS

5.1 CONCLUSIONS

This report has described the methodology used during the workshop and also presented the observations made by participants regarding the process and the methodology. Comments on the process, as well as recommendations, can be viewed in Chapter 4. This draft report will be finalised once the results of the study have been reviewed by the workshop participants.

It should be reiterated (from Kleynhans, 1999) that the estimates originating from the application of this procedure only be used for broad, very general planning purposes. In addition, the confidence levels assigned to the various classes are highly variable, depending on the level of knowledge of participants, and this, as well as the comments given regarding each quaternary, should be borne in mind when utilising the data. In all cases where information requirements go beyond the general planning level, the procedures being developed for the determination of the preliminary, intermediate, or full reserve should be applied.

REFERENCES

Kleynhans, C.J. 1999. *A procedure for the determination of the ecological reserve for the purpose of the National Water Balance Model for South African rivers.* Department of Water Affairs and Forestry.

Ninham Shand, 1999. *Eastern Cape water resources situation assessment: Workshop on ecological flow requirements: notes on proceedings.* Prepared for the Department of Water Affairs and Forestry. Report No. 2949/ 7970

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX F.7

ASSUMED RURAL DOMESTIC PER CAPITA WATER REQUIREMENTS PER QUATERNARY

Average domestic consumption of 25 ℓ/c/d used throughout.

APPENDIX G

WATER RESOURCES

APPENDIX G.1	**Hydrological data per quaternary catchment.**
APPENDIX G.2	**Potential vulnerability of surface water and groundwater to microbial contamination.**
APPENDIX G.3	**Sedimentation data.**
APPENDIX G.4	**Groundwater.**
APPENDIX G.5	**Water quality information.**

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX G.1

HYDROLOGICAL DATA PER QUATERNARY CATCHMENT

1	2	6	4	3	5
Areas	aMTCi	eMRTo	oMAEi	oMAPi	oMARi
	Catchment area	Natural mean annual runoff (accumulative)	Mean annual evaporation	Mean annual precipitation	Natural mean annual runoff (incremental)
	km²	million m³/a	mm/a	mm/a	million m³/a
R10A	138	14.14	1500	835	14.14
R10B	222	38.50	1500	861	24.36
R10C	125	49.49	1500	788	10.99
R10D	178	61.16	1500	710	11.67
R10E	198	67.27	1500	546	6.11
R10F	71	11.36	1550	1036	11.36
R10G	169	18.59	1550	619	7.23
R10H	243	24.77	1550	518	6.18
R10J	179	95.07	1500	452	3.03
R10K	603	111.40	1450	519	16.33
R10L	395	126.40	1400	521	15.05
R10M	176	137.70	1400	619	11.21
R20A	139	21.47	1450	1011	21.47
R20B	155	42.87	1450	696	10.00
R20C	121	11.40	1450	800	11.40
R20D	258	50.00	1450	574	7.13
R20E	249	65.00	1400	657	15.00
R20F	261	83.40	1400	675	18.40
R20G	103	98.02	1350	812	14.62
R30A	426	55.74	1300	866	55.74
R30B	527	51.37	1350	793	51.37
R30C	507	31.13	1400	688	31.13
R30D	151	45.41	1350	785	14.28
R30E	472	26.80	1400	671	26.80
R30F	209	51.73	1350	793	24.93
R40A	333	40.38	1350	765	40.38
R40B	326	20.62	1400	609	20.62
R40C	195	36.74	1350	665	16.12
R50A	394	20.49	1400	579	20.49
R50B	413	21.71	1400	581	21.71
S10A	258	5.99	1650	528	5.99
S10B	399	18.44	1650	579	12.45
S10C	236	24.54	1650	546	6.10

1	2	6	4	3	5
Areas	aMTCi	eMRTo	oMAEi	oMAPi	oMARi
	Catchment area	Natural mean annual runoff (accumulative)	Mean annual evaporation	Mean annual precipitation	Natural mean annual runoff (incremental)
	km²	million m³/a	mm/a	mm/a	million m³/a
S10D	317	34.40	1650	594	9.86
S10E	240	41.74	1600	589	7.34
S10F	301	9.65	1650	584	9.65
S10G	377	23.32	1600	621	13.67
S10H	473	83.12	1600	571	18.06
S10J	324	161.30	1550	566	12.48
S20A	298	11.40	1600	627	11.40
S20B	447	28.18	1600	623	16.78
S20C	552	50.01	1600	634	21.83
S20D	310	65.72	1550	682	15.71
S31A	409	8.35	1700	517	8.35
S31B	400	16.31	1700	513	7.96
S31C	606	10.10	1700	486	10.10
S31D	331	8.46	1650	556	8.46
S31E	440	41.93	1650	482	7.06
S31F	226	5.99	1650	562	5.99
S31G	240	52.45	1650	507	4.53
S32A	324	8.25	1650	547	8.25
S32B	559	15.22	1700	453	6.97
S32C	526	24.05	1650	494	8.83
S32D	307	29.57	1550	704	29.57
S32E	295	51.28	1600	641	21.71
S32F	327	8.97	1600	551	8.97
S32G	238	65.34	1600	516	5.09
S32H	345	94.76	1650	483	5.37
S32J	239	8.93	1600	554	8.93
S32K	399	168.70	1600	529	12.53
S32L	287	9.40	1600	535	9.40
S32M	407	196.50	1550	577	18.47
S40A	446	14.66	1550	553	14.66
S40B	438	15.01	1500	552	15.01
S40C	327	43.72	1500	581	14.05
S40D	121	365.50	1500	648	7.60
S40E	502	437.10	1500	603	27.91
S40F	335	457.50	1450	610	20.41
S50A	224	20.76	1500	730	20.76
S50B	334	41.45	1550	818	41.45

1	2	6	4	3	5
Areas	aMTCi	eMRTo	oMAEi	oMAPi	oMARi
	Catchment area	Natural mean annual runoff (accumulative)	Mean annual evaporation	Mean annual precipitation	Natural mean annual runoff (incremental)
	km²	million m³/a	mm/a	mm/a	million m³/a
S50C	383	87.39	1550	669	25.18
S50D	396	118.60	1550	707	31.17
S50E	448	176.80	1500	783	58.20
S50F	87	6.35	1500	700	6.35
S50G	501	218.00	1450	677	34.92
S50H	375	19.65	1500	635	19.65
S50J	685	283.30	1450	668	45.62
S60A	328	39.27	1500	818	39.27
S60B	264	61.78	1450	622	22.51
S60C	216	16.23	1500	668	16.23
S60D	265	33.03	1450	609	16.80
S60E	215	110.70	1400	649	15.87
S70A	339	882.20	1400	687	30.69
S70B	267	899.20	1350	741	17.05
S70C	198	16.26	1400	663	16.26
S70D	514	64.13	1350	682	47.87
S70E	481	94.97	1350	742	30.84
S70F	359	1027.00	1300	804	32.55
T11A	330	34.17	1500	745	34.17
T11B	415	45.88	1450	747	45.88
T11C	386	146.50	1400	856	66.40
T11D	343	58.56	1400	849	58.56
T11E	233	51.24	1400	939	51.24
T11F	275	166.70	1350	897	56.90
T11G	291	203.00	1350	747	36.30
T11H	216	373.90	1350	721	24.40
T12A	279	40.37	1500	845	40.37
T12B	230	64.56	1450	740	24.19
T12C	284	28.27	1500	742	28.27
T12D	320	59.50	1450	724	31.23
T12E	412	44.41	1400	725	44.41
T12F	346	209.00	1400	746	40.50
T12G	276	235.60	1350	683	26.58
T13A	288	651.10	1300	747	41.70
T13B	285	686.50	1300	704	35.44
T13C	318	729.30	1300	725	42.72
T13D	358	774.80	1250	889	45.58

1	2	6	4	3	5
Areas	aMTCi	eMRTo	oMAEi	oMAPi	oMARi
	Catchment area	Natural mean annual runoff (accumulative)	Mean annual evaporation	Mean annual precipitation	Natural mean annual runoff (incremental)
	km²	million m³/a	mm/a	mm/a	million m³/a
T13E	168	802.70	1200	942	27.88
T20A	481	126.50	1300	940	126.50
T20B	405	215.30	1250	844	88.84
T20C	320	259.10	1250	685	43.78
T20D	388	288.00	1200	764	28.92
T20E	350	322.50	1200	829	34.47
T20F	443	32.81	1200	764	32.81
T20G	213	389.20	1200	958	33.89
T31A	222	39.57	1350	907	39.57
T31B	284	39.16	1350	833	39.17
T31C	291	118.40	1350	830	39.66
T31D	353	150.50	1350	736	32.16
T31E	509	50.77	1350	756	50.77
T31F	605	249.50	1350	713	48.20
T31G	209	276.00	1300	801	26.45
T31H	617	74.05	1300	808	74.06
T31J	507	398.40	1300	807	48.44
T32A	348	37.16	1300	804	37.16
T32B	307	74.57	1250	814	37.41
T32C	373	117.50	1200	781	42.93
T32D	351	148.90	1250	789	31.40
T32E	383	193.30	1200	844	44.37
T32F	297	239.60	1200	924	46.32
T32G	438	54.90	1200	862	54.90
T32H	453	357.30	1200	892	62.84
T33A	672	97.77	1350	757	97.78
T33B	602	98.79	1400	801	98.79
T33C	367	52.28	1400	768	52.29
T33D	461	309.80	1350	736	60.99
T33E	267	333.70	1350	748	23.90
T33F	437	388.20	1350	829	54.47
T33G	503	855.20	1300	835	68.61
T33H	517	899.40	1250	780	44.22
T33J	457	933.30	1200	730	33.86
T33K	169	1312.00	1200	856	21.62
T34A	242	50.56	1400	905	50.56
T34B	246	95.82	1400	860	45.26

1	2	6	4	3	5
Areas	**aMTCi**	**eMRTo**	**oMAEi**	**oMAPi**	**oMARi**
	Catchment area	**Natural mean annual runoff (accumulative)**	**Mean annual evaporation**	**Mean annual precipitation**	**Natural mean annual runoff (incremental)**
	km²	**million m³/a**	**mm/a**	**mm/a**	**million m³/a**
T34C	282	140.00	1400	807	44.18
T34D	342	204.30	1350	850	64.28
T34E	268	55.40	1400	901	55.40
T34F	238	103.50	1350	875	48.09
T34G	358	376.40	1350	894	68.58
T34H	591	485.10	1300	863	108.70
T34J	297	510.60	1250	771	25.54
T34K	333	534.60	1200	715	23.98
T35A	475	105.30	1400	912	105.30
T35B	396	88.50	1400	915	88.51
T35C	306	84.94	1400	1008	84.95
T35D	348	341.10	1350	818	62.41
T35E	492	456.20	1350	918	115.10
T35F	359	69.00	1400	860	69.01
T35G	575	151.10	1400	759	82.12
T35H	520	251.40	1350	845	100.30
T35J	188	297.40	1300	924	45.95
T35K	625	858.70	1300	783	105.10
T35L	340	886.60	1250	764	27.91
T35M	305	1462.00	1200	861	40.71
T36A	462	2840.00	1200	930	66.29
T36B	265	2896.00	1150	1029	56.03
T60A	547	73.30	1150	873	73.30
T60B	528	76.84	1150	896	76.84
T60C	363	140.90	1150	952	64.08
T60D	415	245.50	1150	1072	104.60
T60E	198	28.69	1150	885	28.69
T60F	464	109.30	1150	940	80.61
T60G	360	210.90	1150	1116	101.60
T60H	322	127.50	1150	1277	127.50
T60J	294	78.31	1150	1101	78.31
T60K	242	60.40	1150	1075	60.40
T70A	314	35.67	1200	861	35.67
T70B	277	86.31	1150	974	50.64
T70C	198	28.97	1200	931	28.97
T70D	333	95.35	1150	1002	66.38
T70E	228	22.60	1200	828	22.60

1	2	6	4	3	5
Areas	**aMTCi**	**eMRTo**	**oMAEi**	**oMAPi**	**oMARi**
	Catchment area	**Natural mean annual runoff (accumulative)**	**Mean annual evaporation**	**Mean annual precipitation**	**Natural mean annual runoff (incremental)**
	km²	**million m³/a**	**mm/a**	**mm/a**	**million m³/a**
T70F	265	61.04	1200	928	38.44
T70G	269	40.76	1200	942	40.76
T80A	213	43.06	1200	1002	43.06
T80B	234	37.84	1200	927	37.84
T80C	315	31.28	1200	794	31.28
T80D	280	82.18	1200	965	50.90
T90A	329	18.05	1300	701	18.05
T90B	402	89.46	1200	966	71.41
T90C	367	48.19	1250	896	48.19
T90D	374	32.84	1300	808	32.84
T90E	412	87.50	1250	899	54.66
T90F	282	47.97	1250	976	47.97
T90G	460	50.42	1300	866	50.42
TOTALS	**66211**	**0.00**	**---**	**---**	**7240.53**

APPENDIX G.2

WATER RESOURCES SITUATION ASSESSMENTS

DEPARTMENT: WATER AFFAIRS & FORESTRY
DIRECTORATE: WATER RESOURCE PLANNING

POTENTIAL VULNERABILITY OF SURFACE WATER & GROUNDWATER TO MICROBIAL CONTAMINATION

AUGUST 2001

Parsons & Associates

P O Box 2606
SOMERSET WEST
7129

IWQS

Private Bag X313
PRETORIA
0001

Ninham Shand

P O Box 1348
CAPE TOWN
8000

SUMMARY

This report forms part of the Water Resources Situation Assessments undertaken for the Department of Water Affairs and Forestry. Information is provided on the potential microbial contamination of surface water and groundwater resources in South Africa.

For surface water, initial mapping information was taken from the National Microbiological Monitoring Program where priority contaminated areas were identified and mapped. As part of this project, it was necessary to produce a surface contamination map for the whole country. A national surface faecal contamination map was produced using population density and sanitation type available from DWAF databases. A three category rating system was used (low, medium and high) to describe the surface faecal contamination. This information was delineated on a quaternary catchment basis for the whole country.

For groundwater, the first step involved the development of a groundwater vulnerability map using the depth to groundwater, soil media and impact of the vadose zone media. A three category rating system was used (least, moderate, most) to describe the ease with which groundwater could be contaminated from a source on the surface. The second step involved using the surface contamination and aquifer vulnerability maps to derive a groundwater contamination map. The derived map shows the degree of faecal contamination that could be expected of the groundwater for all areas in South Africa.

Conclusions and recommendations

- Maps were produced that provide an overall assessment of potential microbial contamination of the surface water and groundwater resources of South Africa.

- Spatial resolution of the maps is based on a quaternary catchment scale. It is recommended that these maps are not used to derive more detailed spatial information.

- Once sufficient microbial data are available, it is recommended that the numerical methods, and their associated assumptions, be checked, and the maps replotted where necessary.

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ACKNOWLEDGEMENT

The support of Mr Julian Conrad of Environmentek, CSIR for providing the GIS DRASTIC coverages. His help is fully acknowledged and appreciated.

GLOSSARY

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 boreholes
Contamination	Introduction into the environment of an anthropogenic substance
DRASTIC	Numerical method that describes groundwater characteristics, using: water depth, recharge, aquifer media, soil media, topography, impact on vadose zone, and conductivity
Faecal	Material that contains bodily waste matter derived from ingested food and secretions from the intestines, of all warm-blooded animals including humans
Fitness for use	Assessment of the quality of water based on the chemical, physical and biological requirements of users
Groundwater	Subsurface water occupying voids within a geological stratum
Microbial	Microscopic organism that is disease causing
Ratio	Mathematical relationship defined by dividing one number by another number
Rating	Classification according to order, or grade
Vadose zone	Part of the geological stratum above the saturated zone where voids contain both air and water
Vulnerability	In the context of this report, it is the capability of surface water or groundwater resources to become contaminated

1. INTRODUCTION

The purpose of the Water Resources Situation Assessments is to prepare an overview of the water resources in South Africa. This will take account of the availability and requirements for water, as well as deal with issues such as water quality. The country has been divided into nineteen water management areas. Eight separate studies are being carried out within catchment boundaries that roughly approximate provincial borders. Once these studies have been completed, all information will also be synthesized into a single report for the whole country.

This report describes the method used to prepare a series of maps that show the microbial rating of surface water and groundwater resources in South Africa. Maps are produced at a quaternary catchment scale. It is intended that the appropriate portions of the maps be incorporated into each of the Water Management Area reports.

The microbial information provided in this report is intended for planning purposes, and is not suitable for detailed water quality assessment. The maps provide a comparative rating of the faecal contamination status of the surface water and groundwater resources in South Africa.

This report contains five sections:

- Section One: Introduction
- Section Two: Mapping of surface contamination
- Section Three: Mapping of Groundwater Resources
- Section Four: Conclusions and Recommendations
- Section Five: References

2. MAPPING SURFACE WATER RESOURCES

2.1 Background

The water resources of South Africa have come under increasing influence from faecal contamination as a result of increased urban development and lack of appropriate sanitation. Due to increased use of contaminated water for domestic consumption, people are at serious risk of contracting water-borne disease (e.g. gastroenteritis, salmonellosis, dysentery, cholera, typhoid fever and hepatitis). The Department of Water Affairs and Forestry (DWAF) is the custodian of the national water resources and should ensure *fitness for use* of the water resources. Thus, the Department has developed a monitoring system to provide the necessary management information to assess and control the health hazard in selected areas. This project is called the National Microbiological Monitoring Programme (NMMP).

As part of the NMMP, a screening exercise was carried out to determine the number of catchments that experience faecal contamination. A short-list of tertiary catchment areas was compiled. Data from the database of the Directorate: Water Services Planning of DWAF was used to prioritize catchments to assess the overall health hazard (see Figure 1).

Ratings for land use activity were assigned using the method developed by Goodmin & Wright (1991), IWQS (1996), and Murray (1999). Ratings for land and water use were combined to establish an overall rating. Water use was considered to have a higher effect than the land use so that a 60:40 weighting was used (see Equation 1).

$$OR = 0.4\ TLU + 0.6\ TWU \qquad \text{........ (1)}$$

Where OR = Area Rating (no units)
TLU = Total land use rating for area (no units)
TWU = Total water use rating for area (no units)

Each area was assigned a rating to indicate low (1), medium (2) or high (3) potential risk to users in the catchment area. The following values were used to designate each class:

Low	OR = 0 to 1000
Medium	OR = 1001 to100 000
High	OR > 100 000 ....(2)

Figure 1 shows the surface faecal contamination map for priority rated catchments in South Africa.

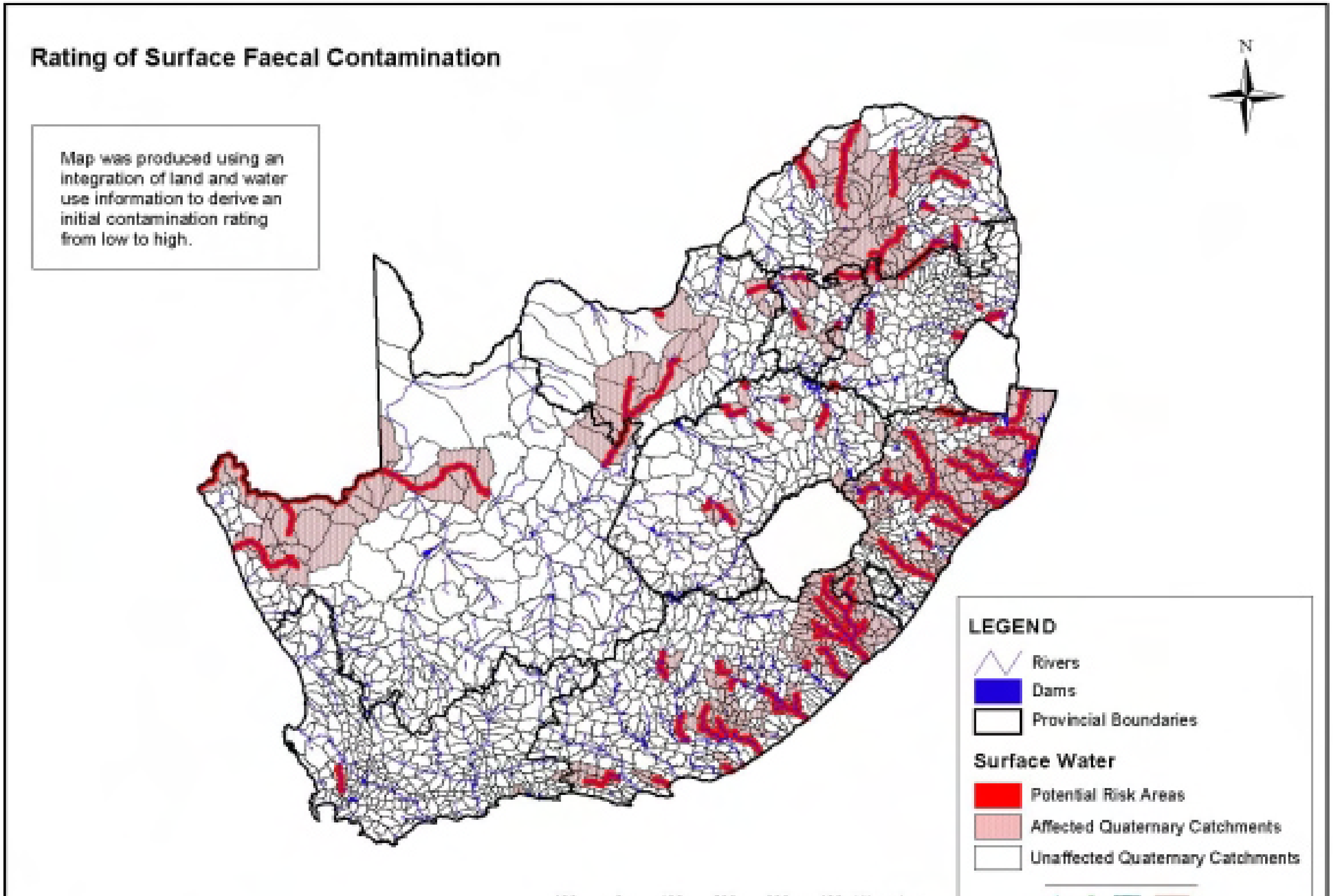

Rating of Surface Faecal Contamination
Map was produced using an integration of land and water use information to derive an initial contamination rating from low to high.
N
LEGEND
Rivers
Dams
Provincial Boundaries
Surface Water
Potential Risk Areas
Affected Quaternary Catchments
Unaffected Quaternary Catchments
100 0 100 200 300 400 Kilometers

FIGURE 1

2.2 Surface faecal contamination

Figure 2 shows the potential surface faecal contamination map, developed using average population density (for a quaternary) and degree of sanitation (Venter, 1998). The land use rating is given by:

$$LU = SA + PD \qquad \text{........ (3)}$$

Where LU = Land use rating per settlement (no units)
SA = No/poor sanitation rating (no units)
PD = Population Density rating (no units)

Land use rankings for quaternary catchments were determined by calculating the total ratings of all settlements within a particular quaternary catchment, given by:

$$TLU = (LU_n) \qquad \text{........ (4)}$$

Where TLU = Total land use rating per quaternary catchment
LU_n = Land use rating for n settlements, per quaternary

Each quaternary catchment was allocated a low (1), medium (2) and high (3) priority rating used to map the information using GIS. Classes were designated by the following values:

Low	=	$TLU < 1000$
Medium	=	$1000 < TLU < 3000$
High	=	$TLU > 3000$ .... (5)

2.3 Results: GIS Surface Water Mapping

Figure 1 was plotted on GIS by firstly assembling the national coverages for the quaternary catchments, rivers and dams. The data described above were processed using the following method:

The quaternary catchments were shaded according to whether they were considered potential risk areas or not (refer to Equations 1 & 2).

Within the quaternaries at risk, the rivers were buffered and shaded red to indicate the risk to potential surface water users.

Figure 2, the potential surface faecal contamination map, was produced as follows:

The ratings (TLU) were distributed into intervals (refer to Equations 5 and 6).

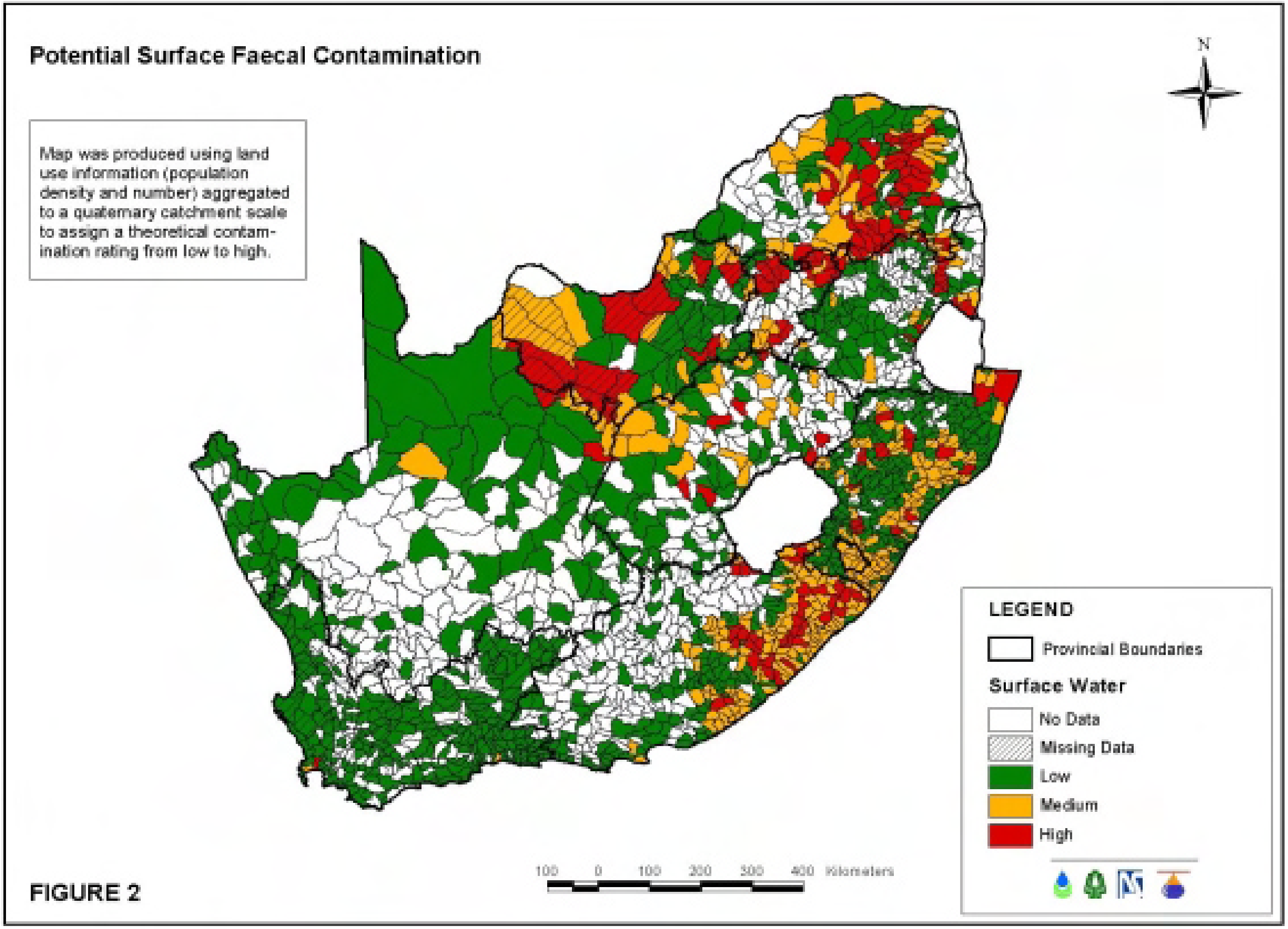

Potential Surface Faecal Contamination
Map was produced using land use information (population density and number) aggregated to a quaternary catchment scale to assign a theoretical contamination rating from low to high.
N
LEGEND
Provincial Boundaries
Surface Water
No Data
Missing Data
Low
Medium
High
100 0 100 200 300 400 Kilometers

FIGURE 2

The quaternary catchments were then shaded according to these rating intervals indicating areas of Low, Medium or High Risk, see below.

Low	Green	TLU < 1000	
Medium	Yellow	1000 < TLU < 3000	
High	Red	TLU > 3000	.... (6)

Quaternary catchments with no data were unshaded.

Quaternary catchments containing missing data were hatched.

3. MAPPING GROUNDWATER RESOURCES

3.1 Background

Groundwater is an important national water resource that plays an important role in meeting water requirements in remote areas. This is particularly true in areas where rainfall is low and surface water resources are scarce.

Microbial contamination of groundwater increases in high population density areas and areas with inadequate sanitation. Approximately three quarters of the population of South Africa do not have access to adequate sanitation.

Considerable work has already been carried out to map the groundwater resources in South Africa. Examples include: the national Groundwater Resources of the Republic of South Africa map produced by Vegter (1995) for the Water Research Commission (WRC), regional 1: 500 000 scale hydrogeological maps produced by DWAF, the national groundwater vulnerability map prepared by Reynders & Lynch (1993) and the aquifer classification map of Parsons & Conrad (1998). Figure 3 shows the vulnerability map used by Parsons & Conrad (1998). The existing work, particularly the vulnerability map (Figure 3), has therefore been used as a basis for assessing the potential of microbial contamination of groundwater systems.

3.2 Method

It is recognised that certain aquifers are more vulnerable to contamination than others. The DRASTIC method (Aller *et al.*, 1985) is a well-known and studied method of assessing aquifer vulnerability to contamination. Reynders & Lynch (1993) and Lynch *et al*. (1994, 1997) prepared a national scale aquifer vulnerability map using DRASTIC that was revised by Parsons & Conrad (1998) using additional data (see Figure 3).

DRASTIC is a weighting, and rating, technique that considers seven factors when estimating the groundwater vulnerability. Factors are geologically and geohydrologically based. Controls relating to the magnitude or severity of the pollution source are not considered. DRASTIC factors are shown in Table 1.

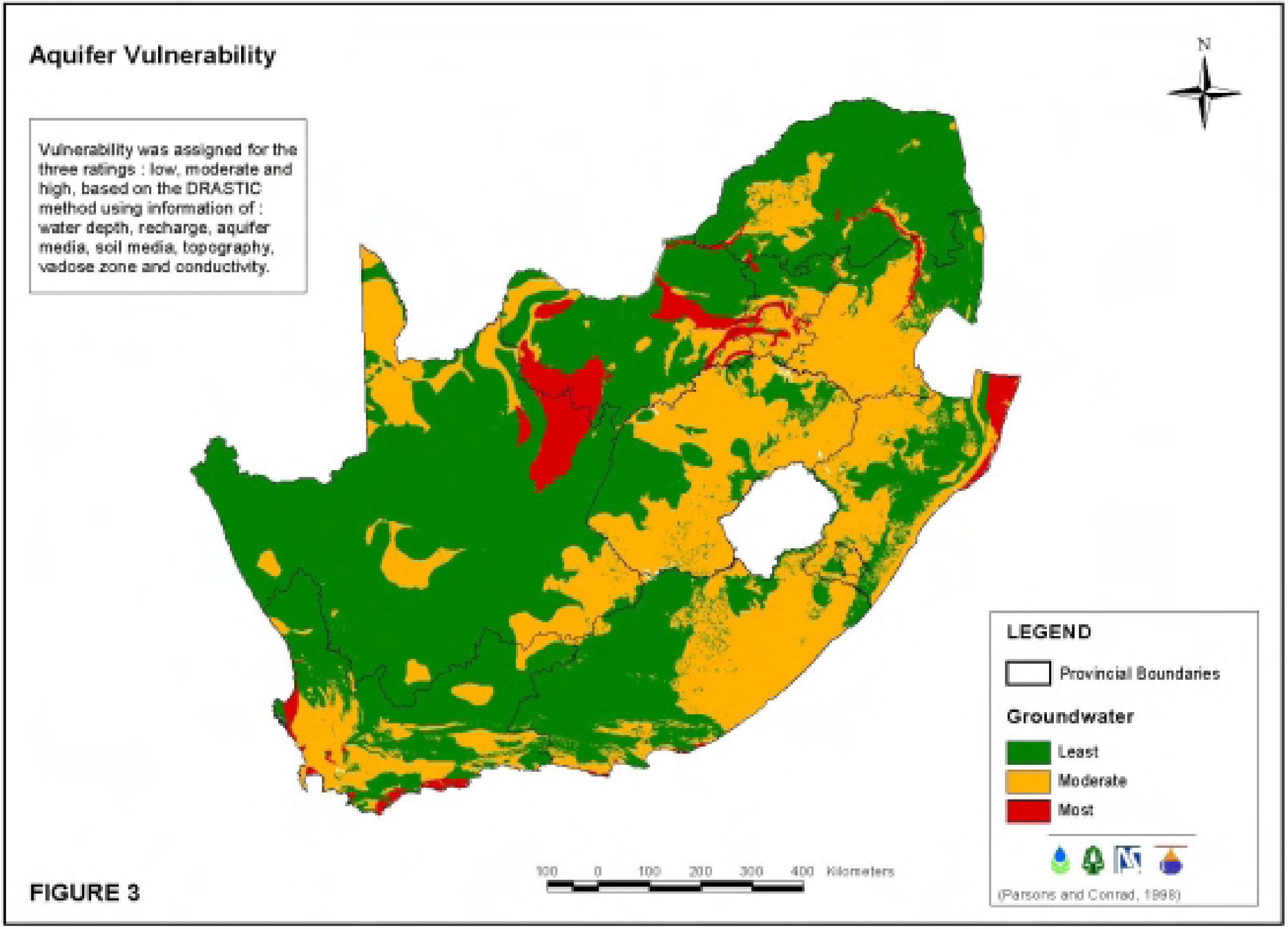

Aquifer Vulnerability
Vulnerability was assigned for the three ratings : low, moderate and high, based on the DRASTIC method using information of : water depth, recharge, aquifer media, soil media, topography, vadose zone and conductivity.
N
LEGEND
Provincial Boundaries
Groundwater
Least
Moderate
Most
100 0 100 200 300 400 Kilometers
(Parsons and Conrad, 1998)

FIGURE 3

TABLE 1: FACTORS USED BY DRASTIC

D	Depth to water
R	(net) Recharge
A	Aquifer media
S	Soil media
T	Topography (slope)
I	Impact of the vadose zone media
C	Conductivity (hydraulic) of the aquifer

Each factor was weighted according to its relative importance (Aller *et al.*, 1985). Using a set of tables, a rating is assigned based on prevailing conditions. A relative DRASTIC index (I) is derived using the following formula, with higher index values showing greater groundwater vulnerability:

$$I = D_R D_W + R_R R_W + A_R A_W + S_R S_W + T_R T_W + I_R I_W + C_R C_W \quad .....(7)$$

where: I = index rating
$_R$ is the rating for each factor, and
$_W$ is the weighting for each factor.

DRASTIC was also developed to assess the vulnerability to pesticide contamination (Aller *et al.*, 1985). In this case, those factors that play an important role in defining vulnerability to pesticide contamination are assigned higher weights.

In the case of microbial contamination, other factors are more important in terms of aquifer vulnerability to microbial contamination. Travel time in the vadose zone is recognised as an important control in this regard (Xu & Braune, 1995; Wright, 1995; DWAF, 1997). It was hence decided to assess aquifer vulnerability to microbial contamination in terms of D, S and I (i.e. all factors that relate to the vadose zone). [1]

The weighting and rating technique used by DRASTIC was followed in the current study, adopting the weights used by the pesticide DRASTIC. Using the following formula, the highest possible index value is 140 and the lowest value is 14,

$$\text{Index} = 5\ D_R + 5\ S_R + 4\ I_R \quad .... (8)$$

It must be noted that (1) the value of the index is relative, (2) the factors used in the index were considered by the team to have the greatest influence in assessing the potential for microbial contamination at the surface entering underlying aquifers.

[1] A similar approach was used by Xu & Braune (1995) where they used the factors D, A and S, and used the weightings assigned by DRASTIC and not Pesticide DRASTIC.

3.3 Aquifer vulnerability map

Three DRASTIC groundwater coverages were used to produce an indication of vulnerability of groundwater contamination, namely, depth to groundwater, soil media and vadose.

Each grid element on the DRASTIC coverages was allocated a rating, that was multiplied by a weighting factor (Depth = 5, Soil = 5, Vadose = 4) to produce a score. These three coverages were intersected and their scores added to produce a relative index for each point on the resulting coverage. An additional assumption was applied that assigned a low vulnerability to all areas with a Depth score of less than or equal to 2. This was used to account for deep infiltration of groundwater (over 35 metres) where long residence time and filtration will reduce the degree of contamination.

The relative index (RI) obtained for each grid allowed for grouping into high, medium and low categories. However, setting the intervals for the three categories proved difficult because of sensitivity to the interval chosen. A large percentage of indices fell in the interval of 60 to 80. It was thus decided to use the interval of 70 to 85 to allow for equal distribution between high, medium and low vulnerability areas (see Figure 4), namely:

Low	Green	$RI < 70$	
Medium	Yellow	$70 < RI < 85$	
High	Red	$RI > 85$	.... (9)

To illustrate the sensitivity to the interval chosen the map was replotted using two further intervals of 60-90 and 65-90 (see Figure 5).

Because of attenuation mechanisms that control microbial contamination entering the subsurface, it was considered conceptually correct to only consider D, S and I. Comparison of Figures 3 and 4 shows remarkable similarity and confirms that the vulnerability *per se* is largely controlled by the three factors (D, S and I), which promotes confidence in the resultant microbial contamination vulnerability map.

A limitation of the study is the inability to validate results obtained. Little information is available regarding groundwater microbial contamination. Monitoring data, from selected areas, should be collected to assess the validity of the vulnerability assessment presented in this report.

3.4 Groundwater faecal contamination

Figure 2 (*Potential Surface Faecal Contamination)* and Figure 4 (*Aquifer vulnerability to Faecal Contamination)* maps were intersected to produce a combined *Risk of Faecal Contamination of Aquifers* map on a quaternary basis, see Figure 6.

A total rating score was calculated for each quaternary (e.g. two medium risk areas and one high risk area gives 2 + 2 + 3). This total was then divided by the total number of different risk areas present in each quaternary to produce an average risk value. Each quaternary catchment was shaded according to this average risk value.

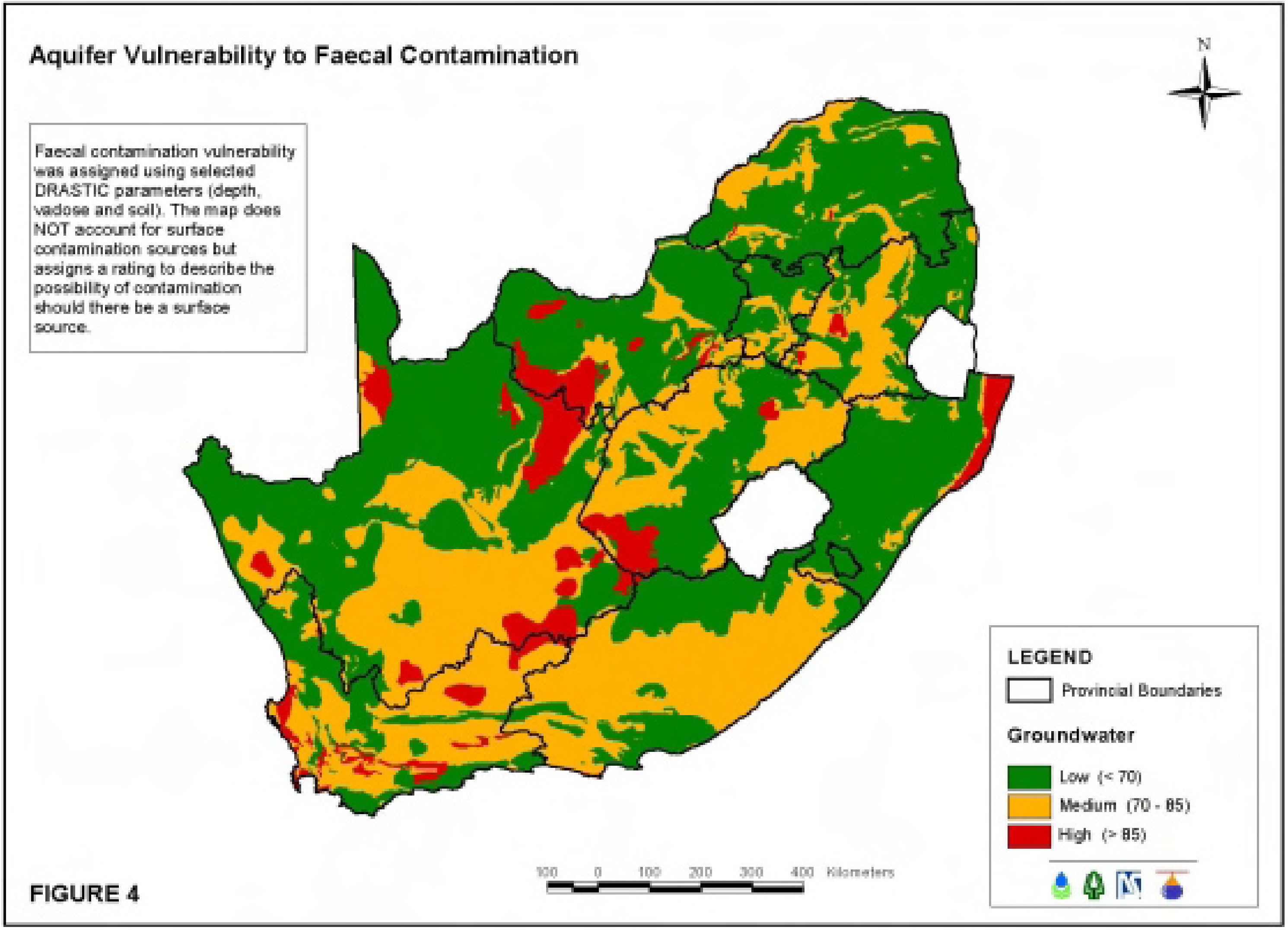
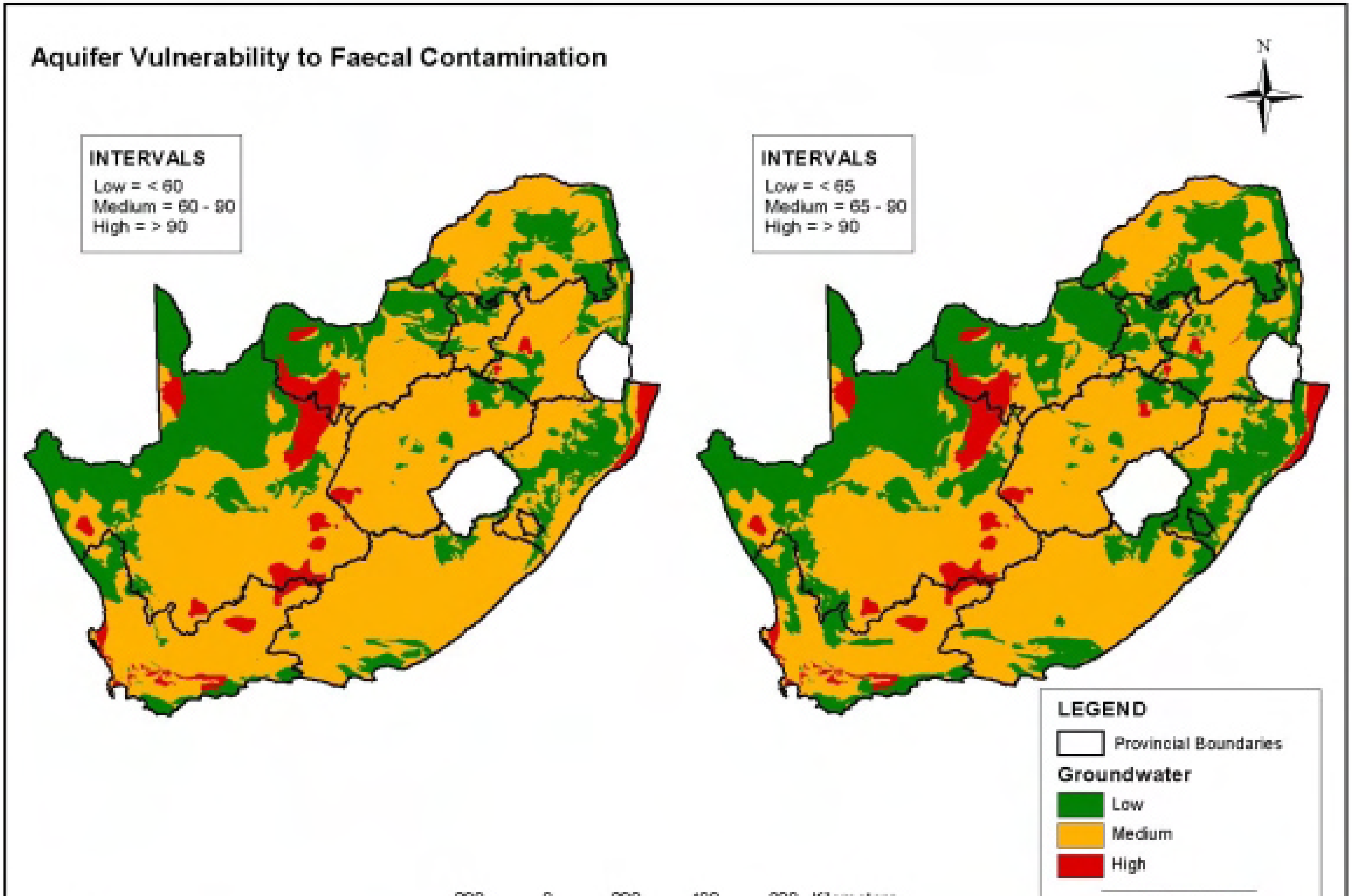

Aquifer Vulnerability to Faecal Contamination
Faecal contamination vulnerability was assigned using selected DRASTIC parameters (depth, vadose and soil). The map does NOT account for surface contamination sources but assigns a rating to describe the possibility of contamination should there be a surface source.
N
LEGEND
Provincial Boundaries
Groundwater
Low (< 70)
Medium (70 - 85)
High (> 85)
100 0 100 200 300 400 Kilometers

FIGURE 4



Aquifer Vulnerability to Faecal Contamination
N
INTERVALS
Low = < 60
Medium = 60 - 90
High = > 90
INTERVALS
Low = < 65
Medium = 65 - 90
High = > 90
LEGEND
Provincial Boundaries
Groundwater
Low
Medium
High
200 0 200 400 600 Kilometers

FIGURE 5

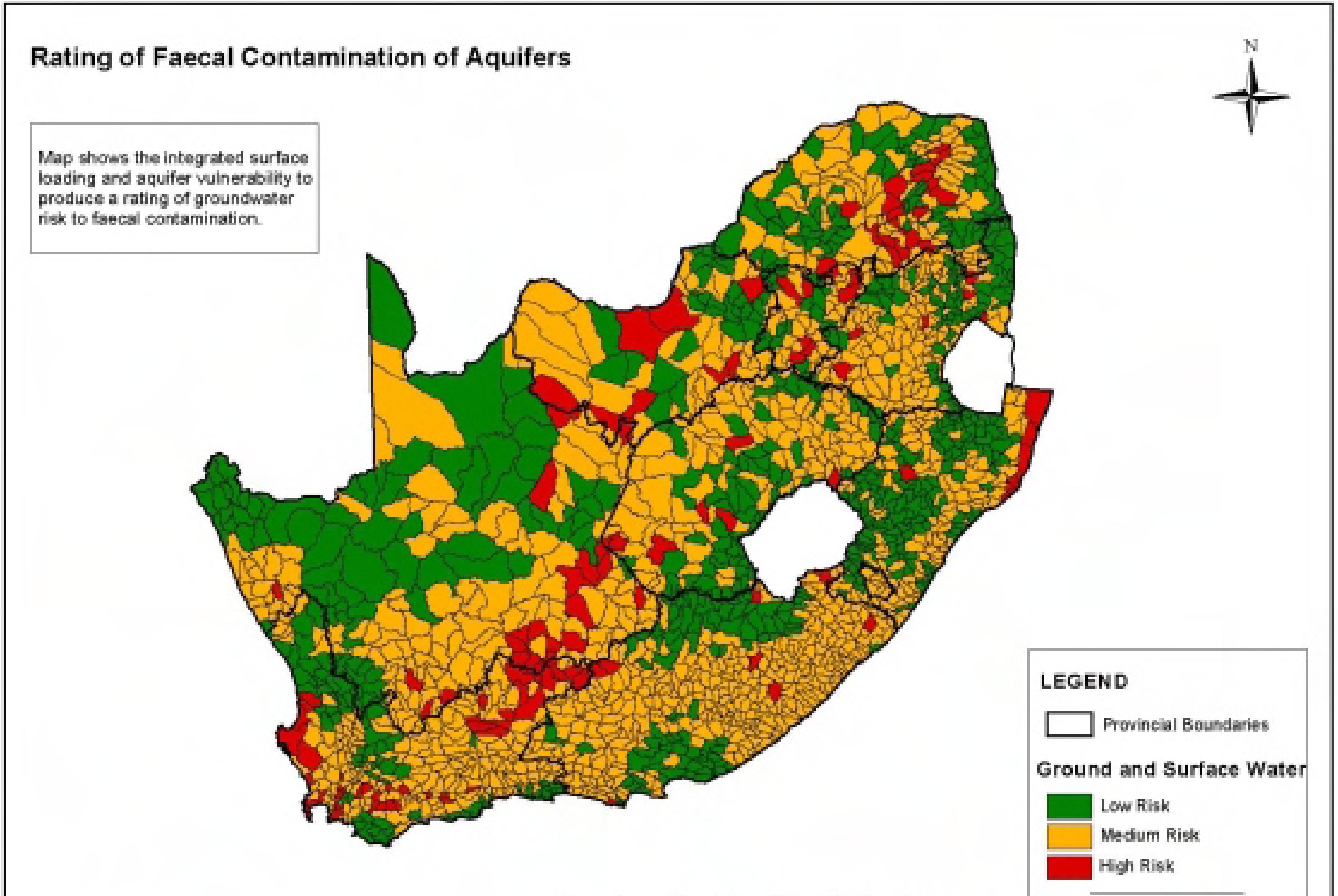

Rating of Faecal Contamination of Aquifers
Map shows the integrated surface loading and aquifer vulnerability to produce a rating of groundwater risk to faecal contamination.
N
LEGEND
Provincial Boundaries
Ground and Surface Water
Low Risk
Medium Risk
High Risk
100 0 100 200 300 400 Kilometers

FIGURE 6

4. CONCLUSIONS & RECOMMENDATIONS

- A series of maps (and their associated GIS coverages) have been produced to show the potential microbial contamination of surface water and groundwater resources in South Africa.

- Maps are produced on a quaternary catchment scale. Where more detailed spatial information is required, alternative methods should be used.

- Once sufficient microbial data are available, it is recommended that the numerical methods are calibrated, and the maps replotted.

- The surface water and groundwater maps should be used in the assessments of water quality for each water management area.

5. REFERENCES

Aller, L., Bennet, T., Lehr, J.H. and Petty, R.J. (1987). DRASTIC - a standardised system for evaluating groundwater pollution potential using hydrogeologic settings; United States Environmental Protection Agency Report EPA/600/2-87/035.

DWAF (1997). A protocol to manage the potential of groundwater contamination from on site sanitation; Edition 1, National Sanitation and Co-ordination Office and Directorate of Geohydrology, Department of Water Affairs and Forestry, Pretoria.

Goodmin. P and Wright, G. (1991). *Decision analysis for management judgement.* John Wiley & Sons Ltd., Chichester, UK. Pp 7 B 36.

Institute for Water Quality Studies, (1996). *A National Microbiological Monitoring Programme to assess faecal Pollution of South African Surface Water Resources: Conceptual Monitoring Design*. Report to Department of Water Affairs and Forestry, PRETORIA, pp 71

Murray, K. (1998). *National Microbial Monitoring Programme Implementation Manual Version 2 (for discussion purposes).* Draft Report to WRC. pp 92.

Lynch, S.D., Reynders, A.G. and Schulze, R.E. (1994). Preparing input data for a national scale groundwater vulnerability map of South Africa; Water SA, Vol. 20 No. 3, pp 239 - 246.

Lynch, S.D., Reynders, A.G. and Schulze, R.E. (1997). A DRASTIC approach to groundwater vulnerability in South Africa; SA Jour. Sci., Vol. 93, pp 56 - 60.

Parsons, R.P. and Conrad, J.E. (1998). Explanatory notes for the aquifer classification map of South Africa; Report prepared for the Water Research Commission, Department of Water Affairs and Forestry and the SA Oil Industry Environment Committee by Parsons & Associates Specialist Groundwater Consultants cc and the CSIR (Environmentek).

Reynders, A.G. and Lynch, S.D. (1993). Compilation of a national groundwater vulnerability map of South Africa; Conf. Proc. AAfrica Needs Ground Water@ Johannesburg, Sept. 1993, Poster Paper No. 75.

Reynders, A.G. (1997). An investigation of aquifer vulnerability and pollution risk in formulating a ground-water quality protection strategy for South Africa; *unpublished Ph.D thesis in preparation*, University of Orange Free State, Bloemfontein.

Vegter, J.R. (1995). An explanation of a set of national groundwater maps; Report TT 74/95, Water Research Commission, Pretoria.
Venter, F (1998). Personal communication.

Wright, A.H., (1995). Septic tank systems in the South African coastal zone; WRC Report No. 597/1/95, Water Research Commission, Pretoria.

Xu, Y. and Braune, E. (1995). A guideline for groundwater protection for the community water supply and sanitation programme; First Edition, Department of Water Affairs and Forestry, Pretoria.

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX G.3

SEDIMENTATION DATA PER QUATERNARY CATCHMENT

QUAT	Catchment Area km^2	Sediment yield t/a	25yr sediment volume m^3
R10A	138	25494	698528
R10B	222	41106	1126318
R10C	125	23214	636060
R10D	178	33011	904495
R10E	198	36662	1004536
R10F	71	13083	358480
R10G	169	31253	856319
R10H	243	45010	1233285
R10J	179	33075	906250
R10K	603	111506	3055262
R10L	395	73027	2000943
R10M	176	32643	894425
R20A	139	25788	706596
R20B	155	28627	784373
R20C	121	22390	613498
R20D	258	47790	1309444
R20E	249	46147	1264439
R20F	261	48270	1322610
R20G	103	19097	523261
R30A	426	78709	2156629
R30B	527	97504	2671597
R30C	507	93807	2570306
R30D	151	27867	763553
R30E	472	87241	2390404
R30F	209	38599	1057606
R40A	333	61515	1685521
R40B	326	60326	1652930
R40C	195	36009	986643
R50A	394	72851	1996112
R50B	413	76351	2092018
S10A	258	47666	1306041
S10B	399	73754	2020867
S10C	236	43731	1198219
S10D	317	58608	1605857
S10E	240	44480	1218743
S10F	301	55684	1525729
S10G	377	69802	1912581
S10H	473	87501	2397538
S10J	324	59954	1642739
S20A	298	99863	2736236
S20B	447	82665	2265026
S20C	552	102139	2798605
S20D	310	57279	1569434
S31A	409	75640	2072546
S31B	400	74015	2028008
S31C	606	112092	3071311

QUAT	Catchment Area km^2	Sediment yield t/a	25yr sediment volume m^3
S31D	331	61233	1677788
S31E	440	81488	2232759
S31F	226	41745	1143820
S31G	240	44386	1216185
S32A	324	60002	1644043
S32B	559	103489	2835598
S32C	526	97241	2664417
S32D	307	56840	1557421
S32E	295	54589	1495738
S32F	327	60508	1657906
S32G	238	44008	1205818
S32H	345	63766	1747201
S32J	239	44145	1209568
S32K	399	73808	2022334
S32L	287	53057	1453753
S32M	407	75251	2061888
S40A	446	82568	2262364
S40B	438	81119	2222649
S40C	327	60475	1657011
S40D	121	22347	612305
S40E	502	92933	2546376
S40F	335	62059	1700425
S50A	224	41435	1135306
S50B	334	61708	1690790
S50C	383	70923	1943302
S50D	396	73162	2004651
S50E	448	82865	2270490
S50F	87	16064	440155
S50G	501	92714	2540373
S50H	375	69345	1900057
S50J	685	126745	3472808
S60A	328	60594	1660273
S60B	264	48848	1338438
S60C	216	39931	1094111
S60D	265	49084	1344905
S60E	215	39726	1088499
S70A	339	62735	1718938
S70B	267	49448	1354885
S70C	198	36547	1001386
S70D	514	95018	2603494
S70E	481	88920	2436413
S70F	359	66350	1817983
T11A	330	60994	1671244
T11B	415	76717	2102057
T11C	386	71315	1954018
T11D	343	63373	1736415
T11E	233	43077	1180314
T11F	275	50907	1394849
T11G	291	53797	1474030
T11H	216	39992	1095793
T12A	279	51586	1413444
T12B	230	42510	1164787
T12C	284	52475	1437803

QUAT	Catchment Area km^2	Sediment yield t/a	25yr sediment volume m^3
T12D	320	59263	1623813
T12E	412	76232	2088752
T12F	346	64036	1754593
T12G	276	51108	1400371
T13A	288	53182	1457188
T13B	285	52778	1446123
T13C	318	58879	1613286
T13D	358	66107	1811321
T13E	168	30984	848970
T20A	481	88947	2437155
T20B	405	74959	2053871
T20C	320	59149	1620694
T20D	388	71697	1964509
T20E	350	64642	1771196
T20F	443	81957	2245621
T20G	213	39388	1079240
T31A	222	40941	1121785
T31B	284	53000	1452200
T31C	291	53757	1472935
T31D	353	65214	1786873
T31E	509	94102	2578391
T31F	605	111861	3064999
T31G	209	38551	1056302
T31H	617	114005	3123742
T31J	507	93693	2567180
T32A	348	64208	1759306
T32B	307	56698	1553529
T32C	373	68990	1890314
T32D	351	64783	1775057
T32E	383	70679	1936613
T32F	297	54889	1503949
T32G	438	80984	2218949
T32H	453	83649	2291978
T33A	672	124306	3405979
T33B	602	111349	3050971
T33C	367	67880	1859901
T33D	461	85285	2336807
T33E	267	49417	1354032
T33F	437	80852	2215335
T33G	503	92969	2547340
T33H	517	95463	2615683
T33J	457	84443	2313733
T33K	169	31279	857034
T34A	242	44676	1224130
T34B	246	45524	1247359
T34C	282	52158	1429132
T34D	342	63163	1730671
T34E	268	49609	1359291
T34F	238	43973	1204867
T34G	358	66234	1814804
T34H	591	109173	2991347
T34J	297	54812	1501859
T34K	333	61593	1687657

QUAT	Catchment Area km^2	Sediment yield t/a	25yr sediment volume m^3
T35A	475	87894	2408292
T35B	396	73198	2005629
T35C	306	56635	1551788
T35D	348	64335	1762790
T35E	492	90980	2492864
T35F	359	66352	1818052
T35G	575	106281	2912098
T35H	520	96069	2632295
T35J	188	34846	954780
T35K	625	115584	3167009
T35L	340	62921	1724039
T35M	305	56337	1543634
T36A	462	85461	2341618
T36B	265	48910	1340135
T60A	547	100924	2765309
T60B	528	97490	2671217
T60C	363	67078	1837928
T60D	415	76575	2098147
T60E	198	36608	1003046
T60F	464	85698	2348123
T60G	360	66487	1821747
T60H	322	59493	1630105
T60J	294	54282	1487323
T60K	242	44761	1226464
T70A	314	58098	1591877
T70B	277	51129	1400942
T70C	198	36558	1001696
T70D	333	61476	1684452
T70E	228	42206	1156452
T70F	265	48954	1341342
T70G	269	49632	1359921
T80A	213	39376	1078911
T80B	234	43197	1183605
T80C	315	58160	1593583
T80D	280	51843	1420510
T90A	329	60769	1665065
T90B	402	74393	2038371
T90C	367	67795	1857596
T90D	374	69249	1897424
T90E	412	76190	2087613
T90F	282	52128	1428304
T90G	460	85146	2332994

APPENDIX G.4

GROUNDWATER RESOURCES OF SOUTH AFRICA

1. BACKGROUND

The Department of Water Affairs and Forestry (DWAF) has decided to conduct a Water Situation Assessment Study for South Africa to give a broad overview of national water requirements and water resources. These studies will enable the DWAF to utilize the Water Situation Assessment Model (WSAM), to assist in the decision making process when doing long term water resources planning.

WSM (Pty) Ltd was appointed to undertake the Situation Assessment Study of the Ground Water Resources of South Africa. This study took the form of a desk study evaluating all relevant existing data and reports at a reconnaissance level. The study area consists of all the quaternary sub-catchments of South Africa and the adjoining sub-catchments of the neighbouring states.

This report gives the findings of the study.

2. STUDY OBJECTIVES

The objective of the study is mainly to provide quantitative information on the Ground Water Resources on a quaternary catchment basis for the whole of South Africa for input into the WSAM. The information provided will consist of the following, viz :-

- ground water resource potential or harvest potential
- ground water resources available to be exploited or exploitation potential
- interaction between ground water and surface water ie the portion of ground water that contributes to stream flow (base flow)
- present ground water use
- a ground water balance identifying quaternary catchments where over exploitation occurs as well as catchments having a potential for increased ground water development
- ground water quality evaluation, determining the portion of ground water which is potable

3. METHODOLOGY

This study is a reconnaissance study making use of existing available information.

The quantification of the ground water resources is probably one of the most difficult aspects of ground water to access. Information on recharge to the ground water systems, storage capacity of the ground water systems, the hydraulic conductivity and thickness of these ground water systems, the interaction with surface water and water quality is required. Once the ground water resources are quantified a ground water balance is set up, comparing the resource with the existing use, to determine areas of over exploitation and identify areas which have a potential for further ground water exploitation. These parameters have been evaluated and the methodology is given below.

3.1 Harvest Potential

The evaluation of the mean annual recharge and storage on a national scale has been done by Vegter, 1995. This information together with a rainfall reliability factor (20th percentile precipitation divided by the median precipitation), which gives an indication of the possible drought length, has been utilized by Seward and Seymour, 1996, to produce the Harvest Potential of South Africa.

The Harvest Potential is defined as the maximum volume of ground water that may be abstracted per area without depleting the aquifers. The Harvest Potential as determined by Seward and Seymour, 1996 has been used as the starting point for the determination of the Ground Water Resources of South Africa.

3.2 Exploitation Potential

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 average yields were then divided into 5 groups and an exploitation factor allocated to each group as follows, viz:-

AVERAGE BOREHOLE YIELD	EXPLOITATION FACTOR
>3.0 ℓ/s	0.7
1.5 - 3.0 ℓ/s	0.6
0.7 - 1.5 ℓ/s	0.5
0.3 - 0.7 ℓ/s	0.4
<0.3 ℓ/s	0.3

This factor was then multiplied by the Harvest Potential of each quaternary catchment to obtain the exploitation potential. The exploitation potential is considered to be a conservative estimate of the groundwater resources available for exploitation.

3.3 Ground Water, Surface Water Interaction

In order to avoid double counting the water resources, the interaction between Surface and Ground Water needs to be quantified. At a workshop held at the DWAF where ground and surface water specialists were represented, it was agreed that the baseflow, be regarded as the portion of water common to both ground and surface water for the purposes of this study.

- ***Baseflow***

  The baseflow has been considered as that portion of ground water which contributes to the low flow of streams. 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 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. The baseflow has been calculated by Schultz and Barnes, 2001.

- ***Baseflow factor***

  The baseflow factor gives an indication of the portion of ground water which contributes to base flow and has been calculated by dividing the baseflow by the Harvest Potential.

If baseflow = 0, then ground water does not contribute to baseflow and the baseflow factor is therefore also = 0.

If baseflow ≥ harvest potential then all ground water can be abstracted as surface water and the baseflow factor is therefore ≥ 1. As the contribution of the Harvest Potential to baseflow cannot be greater than the Harvest Potential, the baseflow factor has therefore been corrected to equal 1 where it was > 1.

- ***Impact of Ground Water Abstraction on Surface Water Resources***

  The impact that ground water abstraction will have on surface water resources has been evaluated qualitatively by using the corrected baseflow factor ie,

  - negligible where corrected baseflow factor is = 0
  - low where the corrected baseflow factors is ≤ 0.3
  - moderate where the corrected baseflow factor is ≤ 0.8
  - high where the corrected baseflow factor is > 0.8

- ***Contribution of Ground Water to the Total Utilization Water Resource***

  This assessment of the interaction of groundwater and the base flow component of the surface water can however, not be used directly to determine the additional contribution of groundwater abstraction to the total utilizable water resource without also taking account of the effect of surface water storage capacity and the reduction in surface water runoff that is caused by the increase of groundwater recharge (induced recharge) that results from groundwater abstraction. For the purpose of this water resources assessment the proportion of the utilizable groundwater not contributing to the base flow of the surface water that can be added to the utilizable surface water to estimate the total utilizable resources has therefore been ignored.

3.4 Existing Ground Water Use

Data on existing ground water use was not readily accessible especially the main use sectors, viz agriculture and mining. Available borehole information was thus utilized to give a first estimate.

This was done by adding all the estimated yields or blow yields of all the boreholes for an 8 hr/day pumping period, 365 days per year.

Ground Water use was also evaluated from work done by Jane Baron (Baron and Seward, 2000). The use was evaluated for the following sectors, ie

- Municipal Use

  This data was obtained from a study done by DWAF in 1990 with additional information obtained from DWAF hydrogeologists and town clerk /engineers.

- Rural Use

  Rural use was estimated from the DWAF, Water Services Database linking water source to population and allowing for 25 ℓ/capita/day.

- Livestock use

  The number of equivalent large livestock units per quaternary catchment was taken from the WSAM and multiplied by 45 ℓ/day and then multiplied by the % reliance on ground water obtained from the Glen College Food Survey (1990).

- Irrigation Use

  The total irrigation use per quaternary catchment was taken from the WSAM. This use was then multiplied by the % reliance on ground water obtained from the Glen College Food Survey (1990).

The total use was determined by summation of the municipal, rural, livestock and irrigation use. It must be noted that information on mining and industrial use was not available and has not been included in the total use.

Workshops held in each of the Water Management Area's by the Water Resources Situation Assessment teams, provided local input to the water use numbers. These numbers were then adjusted by applying a factor to the Baron & Seward (2000) number to give the final ground water use figures.

3.5 Ground Water Balance

The Ground Water Balance was calculated for each quaternary catchment to determine the extent to which the ground water resources have been developed. This was done by means of comparing the values of Harvest Potential and Exploitation Potential with adjusted ground water use (as determined by Baron and Seward, 2000).

The following scenarios were mapped, viz :-

- If the total use was greater than the Harvest Potential then the catchment was considered to be over utilized.

- If the total use was greater than the Exploitation Potential but less than the Harvest Potential then the catchment was considered to be heavily utilized.

- If the total use was less than the Exploitation Potential but greater than 66% of the Exploitation Potential then the catchment was considered to be moderately utilized.

- If the total use was less than 66% of the Exploitation Potential the catchment was considered under utilized.

3.6 Water Quality

The ground water quality is one of the main factors affecting the development of available ground water resources. Although there are numerous problems associated with water quality, some of which are easily remediated, total dissolved solids (TDS), nitrates (NO_3 as N) and fluorides (F) are thought to represent the majority of serious water quality problems that occur.

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, sulfate and calcium using the Quality of Domestic Water Supplies, Volume I (DWAF, 1998).

The TDS is described in terms of a classification system developed for this water resources situation assessment. The uses that were taken into account were domestic use and irrigation. It was assumed that if the water quality met the requirements for domestic and irrigation use it would in most cases satisfy the requirements of other uses. The South African Water Quality Guidelines for the Department of Water Affairs and

Forestry (1996) for these two uses were combined into a single classification system as shown in Table 3.6.1

TABLE 3.6.1: CLASSIFICATION SYSTEM FOR MINERALOGICAL WATER QUALITY

Class	Colour Code	Description	TDS Range (mg/l)
0	Blue	Ideal water quality	<260
1	Green	Good water quality	260 – 600
2	Yellow	Marginal water quality	601 – 1800
3	Red	Poor water quality	1801 – 3400
4	Purple	Completely unacceptable water quality	>3400

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) according to the Quality of Domestic Water Supplies, Volume I (DWAF, 1998). Water classified as poor and unacceptable has been considered **not** potable.

In catchments where no information was available estimates of the portion potable were made using Vegters maps (Vegter 1995).

4. DATA LIMITATIONS

It must be noted that this evaluation was done using existing available information. The evaluation is based on the harvest potential map which was derived from interpretations of limited existing information on recharge and a very broad qualitative assessment of storage capacity. The comparison of base flow with the harvest potential indicates that the harvest potential could be significantly underestimated in the wetter parts of the country. It is thought that this is due to an under estimation of the storage capacity.

Although yield data on some 91000 boreholes was used the accuracy of this data in some instances is questionable, as it was not known whether the yield was a blow yield estimated during drilling, or a yield recommended by a hydrogeologist from detailed pumping test results. In general, however, the yields do highlight areas of higher and lower yield potential such as the dolomite areas but in some areas such as catchment W70 appear to grossly underestimate the yield. Underestimation of the yield would negatively impact on the calculation of exploitation potential.

Information on ground water use was obtained mainly from indirect qualitative evaluations. Further, mining and industrial use was not available and was therefore not included in the total usage. This could have a significant effect on the ground water balance in specifically the gold mining areas.

Water quality data should also only be used to give regional trends. In many catchments data at only a few sample points were available. As a catchment could be underlain by numerous different lithologies, a large range in water quality can occur. The samples used in the analysis could thus be non representative of the catchment as a whole.

In general this study should be seen as a first quantitative estimate of the ground water resources of South Africa.

5. OVERVIEW OF THE GROUNDWATER RESOURCES OF SOUTH AFRICA

In over 90% of the surface area of South Africa, ground water occurs in secondary openings such as pores in weathered rock and faults, fractures, fissures and dissolution channels in so-called hard rock. These rocks consist of igneous, metamorphic and sedimentary rocks and range in age from Jurassic (± 140 x 10^6 yrs) to Swazian (3750 x 10^6 yrs).

In the remaining 10% of the surface area of South Africa ground water occurs in primary openings i.e., intergranular pores in mainly unconsolidated classic rocks. These rocks are generally recent in age (< 65 x 10^6 yrs) and consist of the Kalahari beds, the alluvial strip along some rivers and cenozoic deposits fringing the coast line, mainly in Northern Kwa Zulu Natal and the Southern and Western Cape.

The total Harvest Potential for South Africa has been calculated as 19100 x $10^6 m^3$/annum and varies from less than 0.5 mm/annum in quaternary catchment D82J to more than 352 mm/annum in quaternary catchment W12J.

Borehole yields vary considerably. The highest boreholes yields (up to 100 ℓ/s) have been found in the Malmani Dolomites. Other high borehole yielding (> 10 ℓ/s) lithostratigraphic units include the Table Mountain Quartsites of the Southern Cape, Basement Granites in the Pietersburg Dendron and Coetzerdam area, coastal deposits along Northern Natal, the eastern southern and western Cape, and alluvial deposits along certain sections of some of the major rivers such as the Limpopo River.

Moderate to good yields (> 5 ℓ/s) are found in the Letaba Basalt formation and where the Ecca has been intruded by dolerite dykes and sheets.

The total exploitation potential for South Africa has been calculated as 10100 x $10^6 m^3$/annum and varies from less than 0.2 mm/annum in quaternary catchment D82G to more than 211 mm/annum in quaternary catchment W12J.

The ground water use, excluding mines and industries, has been estimated to be some 1040 x $10^6 m^3$/annum and is concentrated in a few isolated areas.

The ground water balance shows that in general ground water is underutilized except for a few areas where over or heavy utilization occurs.

The extreme north western parts of South Africa show the poorest quality with TDS > 20000 mg/ℓ. The higher rainfall eastern parts have the best water quality, TDS < 100 mg/ℓ. The potability ranges between 0% in the extreme north-western parts of South Africa and 100% in the central and eastern areas. The main problems being brackish water and high nitrates and fluorides.

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER USE PER QUATERNARY CATCHMENT

QUATERNARY	AREA (km^2)	HARVEST POTENTIAL (mm)	oGHPi HARVEST POTENTIAL (x 10^6 m^3/a)	AVERAGE YIELD BOREHOLES (ℓ/s, 8hrs/day)	fGECi EXPLOITA-TION FACTOR	EXPLOITA-TION POTENTIAL (mm)	oGEPo EXPLOITATION POTENTIAL (x 10^6 m^3/a)	NO OF BORES WITH YIELD DATA	SUM OF YIELDS (ℓ/s)	SUM OF BOREHOLE YIELDS (x 10^6 m^3/a)	MUNICIPAL USE (x 10^6 m^3/a)	RURAL USE (x 10^6 m^3/a)	LIVESTOCK USE (x 10^6 m^3/a)	IRRIGATION USE (x 10^6 m^3/a)	TOTAL USE FACTOR	oGWSo TOTAL USE (x 10^6 m^3/a)	TOTAL USE (mm/a)
R10A	138	17.7	2.44	1.55	0.6	10.6	1.47	20	31.04	0.33	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R10B	222	17.7	3.93	0.57	0.4	7.1	1.57	7	3.97	0.04	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.1
R10C	125	17.7	2.21	0.78	0.5	8.9	1.11	17	13.34	0.14	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R10D	178	17.7	3.15	0.98	0.5	8.9	1.58	24	23.62	0.25	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R10E	198	17.7	3.50	1.20	0.5	8.9	1.75	37	44.28	0.47	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R10F	71	17.7	1.26	0.50	0.4	7.1	0.50	7	3.50	0.04	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.4
R10G	169	17.7	2.99	1.18	0.5	8.9	1.50	44	51.77	0.54	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R10H	243	17.7	4.30	1.57	0.6	10.6	2.58	46	71.99	0.76	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.1
R10J	179	17.7	3.17	1.56	0.6	10.6	1.90	18	28.00	0.29	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R10K	603	17.7	10.67	1.28	0.5	8.9	5.34	87	111.55	1.17	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.0
R10L	395	17.7	6.99	0.98	0.5	8.9	3.50	25	24.48	0.26	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.1
R10M	176	17.7	3.12	1.42	0.5	8.9	1.56	15	21.35	0.22	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R20A	139	17.7	2.46	2.28	0.6	10.6	1.48	11	25.13	0.26	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R20B	155	17.7	2.74	1.42	0.5	8.9	1.37	34	48.40	0.51	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R20C	121	17.7	2.14	1.12	0.5	8.9	1.07	18	20.18	0.21	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.2
R20D	258	17.7	4.57	1.17	0.5	8.9	2.28	76	89.11	0.94	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.1
R20E	249	17.7	4.41	1.26	0.5	8.9	2.20	65	82.07	0.86	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.1
R20F	261	17.7	4.62	0.77	0.5	8.9	2.31	36	27.82	0.29	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.1
R20G	103	17.7	1.82	0.46	0.4	7.1	0.73	6	2.73	0.03	0.0000	0.0300	0.0004	0.0000	1.0000	0.0304	0.3
R30A	426	17.7	7.54	1.86	0.6	10.6	4.52	21	39.10	0.41	0.0000	0.0300	0.0024	0.0617	1.2000	0.1129	0.3
R30B	527	17.7	9.33	1.15	0.5	8.9	4.66	73	84.21	0.89	0.0000	0.0300	0.0029	0.0668	1.2000	0.1196	0.2
R30C	507	17.7	8.97	1.18	0.5	8.9	4.49	53	62.68	0.66	0.0000	0.0300	0.0057	0.0716	1.2000	0.1288	0.3
R30D	151	17.7	2.67	0.59	0.4	7.1	1.07	10	5.93	0.06	0.0000	0.0300	0.0008	0.0347	1.0000	0.0655	0.4
R30E	472	17.7	8.35	1.70	0.6	10.6	5.01	138	234.43	2.46	0.0000	0.0300	0.0040	0.0000	1.0000	0.0340	0.1

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER USE PER QUATERNARY CATCHMENT

QUATERNARY	AREA (km²)	HARVEST POTENTIAL (mm)	oGHPi HARVEST POTENTIAL (x 10^6 m^3/a)	AVERAGE YIELD BOREHOLES (ℓ/s, 8hrs/day)	fGECi EXPLOITA-TION FACTOR	EXPLOITA-TION POTENTIAL (mm)	oGEPo EXPLOITATION POTENTIAL (x 10^6 m^3/a)	NO OF BORES WITH YIELD DATA	SUM OF YIELDS (ℓ/s)	SUM OF BOREHOLE YIELDS (x 10^6 m^3/a)	MUNICIPAL USE (x 10^6 m^3/a)	RURAL USE (x 10^6 m^3/a)	LIVESTOCK USE (x 10^6 m^3/a)	IRRIGATION USE (x 10^6 m^3/a)	TOTAL USE FACTOR	oGWSo TOTAL USE (x 10^6 m^3/a)	TOTAL USE (mm/a)
R30F	209	17.7	3.70	0.68	0.4	7.1	1.48	24	16.24	0.17	0.0000	0.0300	0.0011	0.0000	1.0000	0.0311	0.1
R40A	333	17.7	5.89	0.82	0.5	8.9	2.95	69	56.43	0.59	0.0000	0.0300	0.0017	0.0000	1.0000	0.0317	0.1
R40B	326	17.7	5.77	1.41	0.5	8.9	2.89	73	102.69	1.08	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.1
R40C	195	17.7	3.45	1.01	0.5	8.9	1.73	65	65.92	0.69	0.0000	0.0300	0.0001	0.0000	1.0000	0.0301	0.2
R50A	394	17.6	6.92	1.93	0.6	10.5	4.15	74	142.54	1.50	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.1
R50B	413	9.1	3.75	1.47	0.5	4.5	1.87	143	210.52	2.21	0.0000	0.0300	0.0000	0.0000	1.0000	0.0300	0.1
S10A	258	13.6	3.51	1.26	0.5	6.8	1.75	14	17.70	0.19	0.0000	0.0000	0.0486	0.1718	1.1500	0.2535	1.0
S10B	399	14.4	5.73	1.80	0.6	8.6	3.44	12	21.58	0.23	0.0000	0.0000	0.0070	0.2494	1.1500	0.2949	0.7
S10C	236	15.6	3.69	0.85	0.5	7.8	1.85	4	3.38	0.04	0.0000	0.0000	0.0010	0.0000	1.1500	0.0012	0.0
S10D	317	14.8	4.69	2.99	0.6	8.9	2.81	17	50.80	0.53	0.0000	0.0000	0.0000	0.2091	1.1500	0.2405	0.8
S10E	240	17.7	4.25	5.32	0.7	12.4	2.97	8	42.53	0.45	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S10F	301	14.5	4.36	2.00	0.6	8.7	2.62	0	0.00	0.00	0.0000	0.0000	0.0005	0.0000	1.1500	0.0006	0.0
S10G	377	16.5	6.21	2.00	0.6	9.9	3.72	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S10H	473	17.7	8.37	1.97	0.6	10.6	5.02	4	7.87	0.08	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S10J	324	17.7	5.73	2.08	0.6	10.6	3.44	6	12.45	0.13	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S20A	298	13.8	4.12	0.85	0.5	6.9	2.06	110	93.12	0.98	0.0130	0.0000	0.0187	0.0000	1.1500	0.0365	0.1
S20B	447	16.0	7.16	0.81	0.5	8.0	3.58	43	34.79	0.37	0.0000	0.0000	0.0135	0.0000	1.1500	0.0155	0.0
S20C	552	16.8	9.29	0.40	0.4	6.7	3.72	2	0.80	0.01	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S20D	310	17.7	5.49	2.86	0.6	10.6	3.29	3	8.59	0.09	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S31A	409	13.3	5.42	1.93	0.6	8.0	3.25	92	177.73	1.87	0.0756	0.0000	0.0538	0.6735	1.1500	0.9233	2.3
S31B	400	12.7	5.06	1.61	0.6	7.6	3.04	93	149.98	1.58	0.0000	0.0000	0.0690	0.7247	1.1500	0.9128	2.3
S31C	606	12.7	7.70	2.00	0.6	7.6	4.62	51	102.05	1.07	0.0000	0.0000	0.0685	1.7039	1.1200	1.9851	3.3
S31D	331	16.7	5.53	2.35	0.6	10.0	3.32	62	145.39	1.53	0.0000	0.0000	0.0825	0.8047	1.1500	1.0203	3.1
S31E	440	17.6	7.75	4.24	0.7	12.3	5.43	126	534.71	5.62	0.0000	0.0000	0.1027	4.0284	1.1000	4.5442	10.3
S31F	226	17.5	3.95	3.13	0.7	12.2	2.76	108	338.53	3.56	0.0000	0.0000	0.0478	0.0000	1.1500	0.0550	0.2

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER USE PER QUATERNARY CATCHMENT

QUATERNARY	AREA (km^2)	HARVEST POTENTIAL (mm)	oGHPi HARVEST POTENTIAL (x 10^6 m^3/a)	AVERAGE YIELD BOREHOLES (ℓ/s, 8hrs/day)	fGECi EXPLOITA-TION FACTOR	EXPLOITA-TION POTENTIAL (mm)	oGEPo EXPLOITATION POTENTIAL (x 10^6 m^3/a)	NO OF BORES WITH YIELD DATA	SUM OF YIELDS (ℓ/s)	SUM OF BOREHOLE YIELDS (x 10^6 m^3/a)	MUNICIPAL USE (x 10^6 m^3/a)	RURAL USE (x 10^6 m^3/a)	LIVESTOCK USE (x 10^6 m^3/a)	IRRIGATION USE (x 10^6 m^3/a)	TOTAL USE FACTOR	oGWSo TOTAL USE (x 10^6 m^3/a)	TOTAL USE (mm/a)
S31G	240	17.7	4.25	3.18	0.7	12.4	2.97	163	518.80	5.45	0.0000	0.0000	0.0695	0.0000	1.1500	0.0799	0.3
S32A	324	17.7	5.73	2.36	0.6	10.6	3.44	4	9.44	0.10	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S32B	559	15.6	8.72	4.58	0.7	10.9	6.10	53	242.83	2.55	0.0000	0.0000	0.0014	0.8052	1.1500	0.9276	1.7
S32C	526	17.7	9.31	2.67	0.6	10.6	5.59	106	283.16	2.98	0.0000	0.0000	0.0177	0.0000	1.1500	0.0204	0.0
S32D	307	17.7	5.43	3.16	0.7	12.4	3.80	2	6.32	0.07	0.0000	0.0000	0.0041	0.0000	1.1500	0.0047	0.0
S32E	295	17.7	5.22	1.12	0.5	8.9	2.61	7	7.82	0.08	0.0000	0.0000	0.0017	0.0000	1.1500	0.0020	0.0
S32F	327	17.7	5.79	1.04	0.5	8.9	2.89	81	83.86	0.88	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S32G	238	17.7	4.21	1.74	0.6	10.6	2.53	36	62.51	0.66	0.0000	0.0000	0.0026	0.0000	1.1500	0.0030	0.0
S32H	345	17.7	6.11	1.99	0.6	10.6	3.66	93	185.33	1.95	0.0000	0.0000	0.0514	0.0000	1.1500	0.0591	0.2
S32J	239	17.7	4.23	6.12	0.7	12.4	2.96	33	201.80	2.12	0.0000	0.0000	0.0132	0.0000	1.1500	0.0152	0.1
S32K	399	17.7	7.06	2.82	0.6	10.6	4.24	67	188.62	1.98	0.0000	0.0000	0.1234	0.0000	1.1500	0.1419	0.4
S32L	287	17.7	5.08	1.44	0.5	8.9	2.54	16	23.02	0.24	0.0000	0.0000	0.0874	0.0000	1.1500	0.1005	0.4
S32M	407	17.7	7.20	1.00	0.5	8.9	3.60	17	17.07	0.18	0.0000	0.0000	0.0510	0.1103	1.1500	0.1855	0.5
S40A	446	17.7	7.89	1.26	0.5	8.9	3.95	60	75.75	0.80	0.0000	0.0000	0.0417	0.0459	1.1500	0.1007	0.2
S40B	438	17.7	7.75	1.09	0.5	8.9	3.88	31	33.84	0.36	0.0000	0.0000	0.0285	0.0241	1.1500	0.0605	0.1
S40C	327	17.7	5.79	1.92	0.6	10.6	3.47	72	137.92	1.45	0.0000	0.0000	0.0467	0.1420	1.1500	0.2170	0.7
S40D	121	17.7	2.14	1.14	0.5	8.9	1.07	2	2.28	0.02	0.0000	0.0000	0.0006	0.0457	1.1500	0.0532	0.4
S40E	502	17.7	8.89	0.71	0.5	8.9	4.44	36	25.41	0.27	0.0000	0.0000	0.0049	0.1863	1.1500	0.2199	0.4
S40F	335	17.7	5.93	0.95	0.5	8.9	2.96	58	55.18	0.58	0.0000	0.0000	0.0059	0.2341	1.1500	0.2760	0.8
S50A	224	14.6	3.27	0.34	0.4	5.8	1.31	3	1.02	0.01	0.0000	0.0000	0.0038	0.0000	1.1500	0.0044	0.0
S50B	334	20.5	6.85	0.30	0.3	6.1	2.05	2	0.60	0.01	0.0000	0.0000	0.0050	0.0000	1.1500	0.0058	0.0
S50C	383	14.9	5.72	1.28	0.5	7.5	2.86	4	5.10	0.05	0.0000	0.0000	0.0081	0.0000	1.1500	0.0093	0.0
S50D	396	13.6	5.39	1.14	0.5	6.8	2.70	8	9.11	0.10	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S50E	448	16.5	7.39	2.28	0.6	9.9	4.43	2	4.55	0.05	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S50F	87	17.7	1.54	4.04	0.7	12.4	1.08	2	8.08	0.08	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER USE PER QUATERNARY CATCHMENT

QUATERNARY	AREA (km²)	HARVEST POTENTIAL (mm)	oGHPi HARVEST POTENTIAL (x 10^6 m³/a)	AVERAGE YIELD BOREHOLES (ℓ/s, 8hrs/day)	fGECi EXPLOITA-TION FACTOR	EXPLOITA-TION POTENTIAL (mm)	oGEPo EXPLOITATION POTENTIAL (x 10^6 m³/a)	NO OF BORES WITH YIELD DATA	SUM OF YIELDS (ℓ/s)	SUM OF BOREHOLE YIELDS (x 10^6 m³/a)	MUNICIPAL USE (x 10^6 m³/a)	RURAL USE (x 10^6 m³/a)	LIVESTOCK USE (x 10^6 m³/a)	IRRIGATION USE (x 10^6 m³/a)	TOTAL USE FACTOR	oGWSo TOTAL USE (x 10^6 m³/a)	TOTAL USE (mm/a)
S50G	501	17.7	8.87	0.51	0.4	7.1	3.55	6	3.05	0.03	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S50H	375	17.7	6.64	0.63	0.4	7.1	2.66	6	3.76	0.04	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S50J	685	17.7	12.12	0.84	0.5	8.9	6.06	5	4.22	0.04	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S60A	328	17.7	5.81	1.97	0.6	10.6	3.48	29	57.03	0.60	0.0000	0.0000	0.0062	0.0748	1.1500	0.0932	0.3
S60B	264	17.7	4.67	1.64	0.6	10.6	2.80	7	11.47	0.12	0.0000	0.0000	0.0088	0.2747	1.1500	0.3260	1.2
S60C	216	17.7	3.82	1.48	0.5	8.9	1.91	35	51.65	0.54	0.0000	0.0000	0.0064	0.1045	1.1500	0.1275	0.6
S60D	265	17.7	4.69	0.69	0.4	7.1	1.88	23	15.79	0.17	0.0000	0.0000	0.0093	0.2123	1.1500	0.2548	1.0
S60E	215	17.7	3.81	0.62	0.4	7.1	1.52	21	12.95	0.14	0.0240	0.0000	0.0097	0.0273	1.1500	0.0702	0.3
S70A	339	17.7	6.00	1.64	0.6	10.6	3.60	38	62.28	0.65	0.0982	0.0000	0.0025	0.0202	1.1500	0.1390	0.4
S70B	267	17.7	4.73	0.03	0.3	5.3	1.42	4	0.11	0.00	0.0000	0.0000	0.0005	0.0035	1.1500	0.0046	0.0
S70C	198	17.7	3.50	0.50	0.4	7.1	1.40	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S70D	514	17.7	9.10	0.50	0.4	7.1	3.64	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S70E	481	17.7	8.51	1.61	0.6	10.6	5.11	4	6.44	0.07	0.0000	0.0000	0.0000	0.0000	1.1500	0.0000	0.0
S70F	359	17.7	6.35	0.93	0.5	8.9	3.18	14	12.96	0.14	0.0000	0.0000	0.0012	0.0137	1.1500	0.0171	0.0
T11A	330	13.6	4.50	0.47	0.4	5.5	1.80	6	2.83	0.03	0.0000	0.0500	0.0074	0.0000	1.0000	0.0574	0.2
T11B	415	13.6	5.66	0.11	0.3	4.1	1.70	1	0.11	0.00	0.0000	0.0500	0.0101	0.0000	1.0000	0.0601	0.1
T11C	386	16.9	6.54	2.27	0.6	10.2	3.92	4	9.08	0.10	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.1
T11D	343	14.7	5.03	2.97	0.6	8.8	3.02	4	11.88	0.12	0.0000	0.0500	0.0019	0.0000	1.0000	0.0519	0.2
T11E	233	15.0	3.49	2.00	0.6	9.0	2.09	0	0.00	0.00	0.0000	0.0500	0.0004	0.0000	1.0000	0.0504	0.2
T11F	275	16.6	4.58	2.00	0.6	10.0	2.75	0	0.00	0.00	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T11G	291	17.7	5.15	2.27	0.6	10.6	3.09	3	6.81	0.07	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T11H	216	17.7	3.82	1.21	0.5	8.9	1.91	1	1.21	0.01	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T12A	279	16.1	4.50	1.49	0.5	8.1	2.25	5	7.45	0.08	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T12B	230	17.7	4.07	5.00	0.7	12.4	2.85	2	9.99	0.11	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T12C	284	17.7	5.03	2.52	0.6	10.6	3.02	14	35.27	0.37	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER USE PER QUATERNARY CATCHMENT

QUATERNARY	AREA (km^2)	HARVEST POTENTIAL (mm)	oGHPi HARVEST POTENTIAL (x 10^6 m^3/a)	AVERAGE YIELD BOREHOLES (ℓ/s, 8hrs/day)	fGECi EXPLOITA-TION FACTOR	EXPLOITA-TION POTENTIAL (mm)	oGEPo EXPLOITATION POTENTIAL (x 10^6 m^3/a)	NO OF BORES WITH YIELD DATA	SUM OF YIELDS (ℓ/s)	SUM OF BOREHOLE YIELDS (x 10^6 m^3/a)	MUNICIPAL USE (x 10^6 m^3/a)	RURAL USE (x 10^6 m^3/a)	LIVESTOCK USE (x 10^6 m^3/a)	IRRIGATION USE (x 10^6 m^3/a)	TOTAL USE FACTOR	oGWSo TOTAL USE (x 10^6 m^3/a)	TOTAL USE (mm/a)
T12D	320	17.7	5.66	1.94	0.6	10.6	3.40	5	9.71	0.10	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T12E	412	17.7	7.29	0.63	0.4	7.1	2.92	1	0.63	0.01	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.1
T12F	346	17.7	6.12	2.39	0.6	10.6	3.67	6	14.35	0.15	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.1
T12G	276	17.7	4.89	1.48	0.5	8.9	2.44	3	4.43	0.05	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T13A	288	17.7	5.10	0.25	0.3	5.3	1.53	1	0.25	0.00	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T13B	285	17.7	5.04	1.45	0.5	8.8	2.52	2	2.90	0.03	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T13C	318	17.7	5.63	2.32	0.6	10.6	3.38	5	11.58	0.12	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T13D	358	17.7	6.34	1.00	0.5	8.9	3.17	0	0.00	0.00	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.1
T13E	168	17.7	2.97	1.00	0.5	8.9	1.49	0	0.00	0.00	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.3
T20A	481	17.5	8.43	0.50	0.4	7.0	3.37	0	0.00	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.2
T20B	405	17.7	7.17	0.63	0.4	7.1	2.87	2	1.26	0.01	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.2
T20C	320	17.5	5.61	0.90	0.5	8.8	2.80	16	14.43	0.15	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.2
T20D	388	14.6	5.66	1.44	0.5	7.3	2.83	11	15.86	0.17	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.2
T20E	350	13.6	4.76	1.00	0.5	6.8	2.38	0	0.00	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.2
T20F	443	14.8	6.55	1.84	0.6	8.9	3.93	27	49.81	0.52	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.2
T20G	213	15.8	3.36	0.20	0.3	4.7	1.01	1	0.20	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.3
T31A	220	16.3	3.59	1.00	0.5	8.2	1.79	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T31B	284	17.7	5.03	1.76	0.6	10.6	3.02	14	24.61	0.26	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T31C	291	17.5	5.07	0.15	0.3	5.2	1.52	2	0.30	0.00	0.0000	0.0023	0.0000	0.0000	1.7500	0.0041	0.0
T31D	353	17.6	6.22	4.33	0.7	12.3	4.36	20	86.52	0.91	0.0000	0.0103	0.0000	0.0000	1.7500	0.0181	0.1
T31E	509	16.6	8.47	3.56	0.7	11.6	5.93	30	106.75	1.12	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T31F	605	17.2	10.41	2.87	0.6	10.3	6.25	75	215.24	2.26	1.0000	0.0540	0.0000	0.0000	1.7500	1.8445	3.0
T31G	209	15.6	3.26	3.03	0.7	10.9	2.28	8	24.26	0.26	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T31H	617	16.0	9.90	0.92	0.5	8.0	4.95	5	4.60	0.05	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T31J	507	13.6	6.90	1.30	0.5	6.8	3.45	6	7.77	0.08	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER USE PER QUATERNARY CATCHMENT

QUATERNARY	AREA (km^2)	HARVEST POTENTIAL (mm)	oGHPi HARVEST POTENTIAL (x 10^6 m^3/a)	AVERAGE YIELD BOREHOLES (ℓ/s, 8hrs/day)	fGECi EXPLOITA-TION FACTOR	EXPLOITA-TION POTENTIAL (mm)	oGEPo EXPLOITATION POTENTIAL (x 10^6 m^3/a)	NO OF BORES WITH YIELD DATA	SUM OF YIELDS (ℓ/s)	SUM OF BOREHOLE YIELDS (x 10^6 m^3/a)	MUNICIPAL USE (x 10^6 m^3/a)	RURAL USE (x 10^6 m^3/a)	LIVESTOCK USE (x 10^6 m^3/a)	IRRIGATION USE (x 10^6 m^3/a)	TOTAL USE FACTOR	oGWSo TOTAL USE (x 10^6 m^3/a)	TOTAL USE (mm/a)
T32A	348	15.1	5.26	2.98	0.6	9.1	3.15	25	74.43	0.78	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T32B	307	13.6	4.18	0.94	0.5	6.8	2.09	7	6.59	0.07	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T32C	373	13.6	5.07	2.59	0.6	8.2	3.04	25	64.82	0.68	0.0000	0.1180	0.0000	0.0000	1.7500	0.2065	0.6
T32D	351	13.6	4.77	2.57	0.6	8.2	2.86	54	138.53	1.46	0.0000	0.3540	0.0000	0.0000	1.7500	0.6195	1.8
T32E	383	13.6	5.21	1.00	0.5	6.8	2.60	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T32F	297	13.6	4.04	1.00	0.5	6.8	2.02	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T32G	438	13.6	5.96	1.00	0.5	6.8	2.98	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T32H	453	13.6	6.16	1.00	0.5	6.8	3.08	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33A	672	17.3	11.64	1.00	0.5	8.7	5.82	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33B	602	15.9	9.57	1.00	0.5	7.9	4.78	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33C	367	14.8	5.43	1.00	0.5	7.4	2.72	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33D	461	14.9	6.85	1.00	0.5	7.4	3.43	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33E	267	13.6	3.63	1.00	0.5	6.8	1.82	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33F	437	17.2	7.50	1.00	0.5	8.6	3.75	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33G	503	15.9	7.99	1.00	0.5	7.9	3.99	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33H	517	15.6	8.09	1.00	0.5	7.8	4.04	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33J	457	13.6	6.22	0.61	0.4	5.4	2.49	4	2.44	0.03	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T33K	169	13.6	2.30	1.18	0.5	6.8	1.15	3	3.54	0.04	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T34A	242	28.1	6.81	1.00	0.5	14.1	3.40	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T34B	246	13.5	3.33	1.00	0.5	6.8	1.66	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T34C	282	20.5	5.77	1.00	0.5	10.2	2.88	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T34D	342	14.4	4.93	1.00	0.5	7.2	2.46	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T34E	268	25.5	6.83	1.00	0.5	12.7	3.41	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T34F	238	13.8	3.29	1.00	0.5	6.9	1.64	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T34G	358	16.0	5.74	1.00	0.5	8.0	2.87	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER USE PER QUATERNARY CATCHMENT

QUATERNARY	AREA (km^2)	HARVEST POTENTIAL (mm)	oGHPi HARVEST POTENTIAL (x 10^6 m^3/a)	AVERAGE YIELD BOREHOLES (ℓ/s, 8hrs/day)	fGECi EXPLOITA-TION FACTOR	EXPLOITA-TION POTENTIAL (mm)	oGEPo EXPLOITATION POTENTIAL (x 10^6 m^3/a)	NO OF BORES WITH YIELD DATA	SUM OF YIELDS (ℓ/s)	SUM OF BOREHOLE YIELDS (x 10^6 m^3/a)	MUNICIPAL USE (x 10^6 m^3/a)	RURAL USE (x 10^6 m^3/a)	LIVESTOCK USE (x 10^6 m^3/a)	IRRIGATION USE (x 10^6 m^3/a)	TOTAL USE FACTOR	oGWSo TOTAL USE (x 10^6 m^3/a)	TOTAL USE (mm/a)
T34H	591	15.8	9.35	1.41	0.5	7.9	4.67	2	2.82	0.03	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T34J	297	14.6	4.35	1.99	0.6	8.8	2.61	2	3.98	0.04	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T34K	333	13.6	4.53	0.76	0.5	6.8	2.26	1	0.76	0.01	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35A	475	19.7	9.34	1.00	0.5	9.8	4.67	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35B	396	15.2	6.04	1.00	0.5	7.6	3.02	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35C	306	36.0	11.02	0.55	0.4	14.4	4.41	1	0.55	0.01	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35D	348	15.8	5.50	3.03	0.7	11.1	3.85	1	3.03	0.03	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35E	492	13.6	6.69	1.06	0.5	6.8	3.35	10	10.57	0.11	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35F	359	15.5	5.57	1.00	0.5	7.8	2.79	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35G	575	13.7	7.90	6.27	0.7	9.6	5.53	4	25.09	0.26	0.0000	0.0000	0.0001	0.0000	1.7500	0.0002	0.0
T35H	520	15.8	8.23	1.89	0.6	9.5	4.94	2	3.78	0.04	0.0000	0.0000	0.0004	0.0000	1.7500	0.0007	0.0
T35J	188	17.6	3.31	1.09	0.5	8.8	1.65	6	6.54	0.07	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35K	625	17.6	10.99	1.62	0.6	10.5	6.59	11	17.85	0.19	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35L	340	15.1	5.13	1.86	0.6	9.1	3.08	5	9.28	0.10	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T35M	305	13.7	4.17	1.58	0.6	8.2	2.50	2	3.15	0.03	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T36A	462	13.6	6.28	0.25	0.3	4.1	1.88	1	0.25	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T36B	265	13.6	3.61	1.00	0.5	6.8	1.80	0	0.00	0.00	0.0000	0.0000	0.0000	0.0000	1.7500	0.0000	0.0
T60A	547	34.4	18.82	5.11	0.7	24.1	13.17	2	10.22	0.11	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.2
T60B	528	13.6	7.18	1.00	0.5	6.8	3.59	0	0.00	0.00	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.2
T60C	363	24.3	8.84	1.00	0.5	12.2	4.42	0	0.00	0.00	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.2
T60D	415	86.6	35.95	1.00	0.5	43.3	17.97	0	0.00	0.00	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.2
T60E	198	13.6	2.69	1.14	0.5	6.8	1.35	1	1.14	0.01	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.5
T60F	464	13.6	6.31	1.14	0.5	6.8	3.16	4	4.55	0.05	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.2
T60G	360	51.3	18.48	0.14	0.3	15.4	5.54	2	0.28	0.00	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.3
T60H	322	78.6	25.32	1.00	0.5	39.3	12.66	0	0.00	0.00	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.3

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER USE PER QUATERNARY CATCHMENT

QUATERNARY	AREA (km^2)	HARVEST POTENTIAL (mm)	oGHPi HARVEST POTENTIAL (x 10^6 m^3/a)	AVERAGE YIELD BOREHOLES (ℓ/s, 8hrs/day)	fGECi EXPLOITA-TION FACTOR	EXPLOITA-TION POTENTIAL (mm)	oGEPo EXPLOITATION POTENTIAL (x 10^6 m^3/a)	NO OF BORES WITH YIELD DATA	SUM OF YIELDS (ℓ/s)	SUM OF BOREHOLE YIELDS (x 10^6 m^3/a)	MUNICIPAL USE (x 10^6 m^3/a)	RURAL USE (x 10^6 m^3/a)	LIVESTOCK USE (x 10^6 m^3/a)	IRRIGATION USE (x 10^6 m^3/a)	TOTAL USE FACTOR	oGWSo TOTAL USE (x 10^6 m^3/a)	TOTAL USE (mm/a)
T60J	294	20.4	6.01	1.00	0.5	10.2	3.00	0	0.00	0.00	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.3
T60K	242	15.7	3.81	1.00	0.5	7.9	1.90	0	0.00	0.00	0.0000	0.0900	0.0000	0.0000	1.0000	0.0900	0.4
T70A	314	13.8	4.35	1.64	0.6	8.3	2.61	2	3.28	0.03	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.2
T70B	277	14.6	4.04	1.00	0.5	7.3	2.02	0	0.00	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.3
T70C	198	13.6	2.69	1.00	0.5	6.8	1.35	0	0.00	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.4
T70D	333	16.9	5.63	1.00	0.5	8.5	2.82	0	0.00	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.2
T70E	228	13.6	3.10	0.38	0.4	5.4	1.24	1	0.38	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.3
T70F	265	14.6	3.86	1.00	0.5	7.3	1.93	0	0.00	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.3
T70G	269	15.8	4.25	1.00	0.5	7.9	2.13	0	0.00	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.3
T80A	213	17.7	3.77	1.00	0.5	8.9	1.89	0	0.00	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.3
T80B	234	17.4	4.07	1.00	0.5	8.7	2.04	0	0.00	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.3
T80C	315	17.3	5.46	3.04	0.7	12.1	3.82	1	3.04	0.03	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.2
T80D	280	17.7	4.96	0.30	0.3	5.3	1.49	1	0.30	0.00	0.0000	0.0722	0.0000	0.0000	1.0000	0.0722	0.3
T90A	329	17.7	5.82	2.00	0.6	10.6	3.49	1	2.00	0.02	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T90B	402	17.7	7.12	0.25	0.3	5.3	2.13	1	0.25	0.00	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.1
T90C	367	17.7	6.50	0.12	0.3	5.3	1.95	4	0.46	0.00	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.1
T90D	374	17.7	6.62	1.89	0.6	10.6	3.97	5	9.47	0.10	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.1
T90E	412	17.7	7.29	0.50	0.4	7.1	2.92	0	0.00	0.00	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.1
T90F	282	17.7	4.99	0.04	0.3	5.3	1.50	2	0.08	0.00	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.2
T90G	460	17.7	8.14	1.79	0.6	10.6	4.89	28	50.17	0.53	0.0000	0.0500	0.0000	0.0000	1.0000	0.0500	0.1
TOTALS	66211	-	1166,78	-	-	-	1821,00	3742	-	74,23	3,63	14,96	3,50	33,37	-	63,84	-

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

QUATERNARY	vMARi MEAN ANNUAL RUNOFF (x 10^6 m^3/a)	BASE FLOW SCHULTZ (mm/a)	BASE FLOW PITTMAN (mm/a)	BASE FLOW HUGHES (mm/a)	oGBFi BASE FLOW SCHULTZ (x 10^6 m^3/a)	BASE FLOW FACTOR	fGBDo CORRECTED BASE FLOW FACTOR	ESTIMATED EXTENT OF GROUND WATER UTILISATION	IMPACT OF GROUND WATER ABSRTACTION ON SURFACE WATER	fGPQi PORTION POTABLE	oGWMo MAX UTILISABLE GROUND WATER (x 10^6 m^3/a)
R10A	14.14	15.43	26.70	44.46	2.13	0.87	0.87	UNDER-UTILISED	HIGH	0.50	0.73
R10B	24.36	15.93	28.40	48.14	3.54	0.90	0.90	UNDER-UTILISED	HIGH	0.50	0.79
R10C	10.99	14.88	22.90	38.42	1.86	0.84	0.84	UNDER-UTILISED	HIGH	0.50	0.55
R10D	11.67	11.47	17.00	30.02	2.04	0.65	0.65	UNDER-UTILISED	MODERATE	0.50	0.79
R10E	6.11	2.43	5.50	10.60	0.48	0.14	0.14	UNDER-UTILISED	LOW	0.50	0.88
R10F	11.36	21.12	38.30	73.42	1.50	1.19	1.00	UNDER-UTILISED	HIGH	0.50	0.25
R10G	7.23	9.05	11.80	20.52	1.53	0.51	0.51	UNDER-UTILISED	MODERATE	0.85	1.27
R10H	6.18	1.98	4.70	8.69	0.48	0.11	0.11	UNDER-UTILISED	LOW	0.33	0.86
R10J	3.03	1.34	2.70	6.08	0.24	0.08	0.08	UNDER-UTILISED	LOW	0.50	0.95
R10K	16.33	2.14	4.70	9.62	1.29	0.12	0.12	UNDER-UTILISED	LOW	0.50	2.67
R10L	15.05	1.75	4.70	12.42	0.69	0.10	0.10	UNDER-UTILISED	LOW	0.50	1.75
R10M	11.21	3.08	8.00	20.10	0.54	0.17	0.17	UNDER-UTILISED	LOW	0.50	0.78
R20A	21.47	21.96	33.40	71.52	3.05	1.24	1.00	UNDER-UTILISED	HIGH	0.50	0.74
R20B	10.00	12.46	13.20	29.12	1.93	0.70	0.70	UNDER-UTILISED	MODERATE	0.50	0.69
R20C	11.40	16.51	19.20	40.42	2.00	0.93	0.93	UNDER-UTILISED	HIGH	0.50	0.54
R20D	7.13	2.51	6.30	13.46	0.65	0.14	0.14	UNDER-UTILISED	LOW	0.50	1.14
R20E	15.00	4.63	9.20	20.76	1.15	0.26	0.26	UNDER-UTILISED	LOW	1.00	2.20
R20F	18.40	3.49	9.50	26.09	0.91	0.20	0.20	UNDER-UTILISED	LOW	0.50	1.15
R20G	14.62	6.69	13.80	43.71	0.69	0.38	0.38	UNDER-UTILISED	MODERATE	0.50	0.36
R30A	55.74	7.97	15.60	43.06	3.39	0.45	0.45	UNDER-UTILISED	MODERATE	0.50	2.26
R30B	51.37	5.97	12.70	32.46	3.14	0.34	0.34	UNDER-UTILISED	MODERATE	0.63	2.91
R30C	31.13	4.20	9.60	20.93	2.13	0.24	0.24	UNDER-UTILISED	LOW	1.00	4.49
R30D	14.28	5.96	12.60	31.37	0.90	0.34	0.34	UNDER-UTILISED	MODERATE	0.50	0.53
R30E	26.80	3.02	9.40	23.32	1.42	0.17	0.17	UNDER-UTILISED	LOW	0.58	2.92

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

QUATERNARY	vMARi MEAN ANNUAL RUNOFF (x 10^6 m^3/a)	BASE FLOW SCHULTZ (mm/a)	BASE FLOW PITTMAN (mm/a)	BASE FLOW HUGHES (mm/a)	oGBFi BASE FLOW SCHULTZ (x 10^6 m^3/a)	BASE FLOW FACTOR	fGBDo CORRECTED BASE FLOW FACTOR	ESTIMATED EXTENT OF GROUND WATER UTILISATION	IMPACT OF GROUND WATER ABSRTACTION ON SURFACE WATER	fGPQi PORTION POTABLE	oGWMo MAX UTILISABLE GROUND WATER (x 10^6 m^3/a)
R30F	24.93	5.87	12.70	37.77	1.23	0.33	0.33	UNDER-UTILISED	MODERATE	0.50	0.74
R40A	40.38	6.04	12.20	37.41	2.01	0.34	0.34	UNDER-UTILISED	MODERATE	0.50	1.47
R40B	20.62	3.59	7.90	19.79	1.17	0.20	0.20	UNDER-UTILISED	LOW	0.50	1.44
R40C	16.12	4.32	9.30	25.63	0.84	0.24	0.24	UNDER-UTILISED	LOW	0.50	0.86
R50A	20.49	2.28	6.40	16.73	0.90	0.13	0.13	UNDER-UTILISED	LOW	0.50	2.08
R50B	21.71	2.32	6.40	16.95	0.96	0.26	0.26	UNDER-UTILISED	LOW	0.20	0.37
S10A	5.99	1.98	4.20	8.11	0.51	0.15	0.15	UNDER-UTILISED	LOW	0.85	1.49
S10B	12.45	2.26	5.20	10.61	0.90	0.16	0.16	UNDER-UTILISED	LOW	0.85	2.92
S10C	6.10	2.16	4.40	8.97	0.51	0.14	0.14	UNDER-UTILISED	LOW	0.85	1.57
S10D	9.86	2.36	5.30	10.64	0.75	0.16	0.16	UNDER-UTILISED	LOW	0.85	2.39
S10E	7.34	2.38	5.30	10.57	0.57	0.13	0.13	UNDER-UTILISED	LOW	0.70	2.08
S10F	9.65	2.19	5.30	10.76	0.66	0.15	0.15	UNDER-UTILISED	LOW	0.85	2.23
S10G	13.67	2.55	5.60	12.32	0.96	0.15	0.15	UNDER-UTILISED	LOW	0.70	2.61
S10H	18.06	3.17	5.10	13.38	1.50	0.18	0.18	UNDER-UTILISED	LOW	0.70	3.52
S10J	12.48	3.25	5.10	13.34	1.05	0.18	0.18	UNDER-UTILISED	LOW	0.70	2.41
S20A	11.40	7.45	10.70	17.85	2.22	0.54	0.54	UNDER-UTILISED	MODERATE	0.85	1.75
S20B	16.78	7.39	10.60	17.65	3.30	0.46	0.46	UNDER-UTILISED	MODERATE	0.85	3.04
S20C	21.83	7.56	10.80	18.33	4.17	0.45	0.45	UNDER-UTILISED	MODERATE	0.70	2.60
S20D	15.71	8.42	12.30	22.84	2.61	0.48	0.48	UNDER-UTILISED	MODERATE	0.70	2.30
S31A	8.35	1.90	4.10	7.48	0.78	0.14	0.14	UNDER-UTILISED	LOW	0.89	2.89
S31B	7.96	1.95	4.10	7.18	0.78	0.15	0.15	UNDER-UTILISED	LOW	0.88	2.66
S31C	10.10	1.73	3.40	6.26	1.05	0.14	0.14	UNDER-UTILISED	LOW	1.00	4.62
S31D	8.46	1.99	4.40	9.08	0.66	0.12	0.12	UNDER-UTILISED	LOW	0.70	2.32
S31E	7.06	1.64	3.40	5.98	0.72	0.09	0.09	MODERATELY-UTILISED	LOW	0.95	5.15
S31F	5.99	2.00	4.50	9.26	0.45	0.11	0.11	UNDER-UTILISED	LOW	0.70	1.94
S31G	4.53	1.75	3.50	6.65	0.42	0.10	0.10	UNDER-UTILISED	LOW	0.86	2.57

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

QUATERNARY	vMARi MEAN ANNUAL RUNOFF (x 10^6 m^3/a)	BASE FLOW SCHULTZ (mm/a)	BASE FLOW PITTMAN (mm/a)	BASE FLOW HUGHES (mm/a)	oGBFi BASE FLOW SCHULTZ (x 10^6 m^3/a)	BASE FLOW FACTOR	fGBDo CORRECTED BASE FLOW FACTOR	ESTIMATED EXTENT OF GROUND WATER UTILISATION	IMPACT OF GROUND WATER ABSRTACTION ON SURFACE WATER	fGPQi PORTION POTABLE	oGWMo MAX UTILISABLE GROUND WATER (x 10^6 m^3/a)
S32A	8.25	1.95	3.80	8.55	0.63	0.11	0.11	UNDER-UTILISED	LOW	0.70	2.41
S32B	6.97	0.80	2.30	4.06	0.45	0.05	0.05	UNDER-UTILISED	LOW	0.70	4.27
S32C	8.83	0.86	3.50	5.41	0.45	0.05	0.05	UNDER-UTILISED	LOW	0.85	4.73
S32D	29.57	22.68	33.10	47.30	6.96	1.28	1.00	UNDER-UTILISED	HIGH	0.70	2.66
S32E	21.71	18.41	28.20	37.04	5.43	1.04	1.00	UNDER-UTILISED	HIGH	0.70	1.83
S32F	8.97	2.11	3.90	9.30	0.69	0.12	0.12	UNDER-UTILISED	LOW	0.70	2.03
S32G	5.09	1.89	3.60	7.41	0.45	0.11	0.11	UNDER-UTILISED	LOW	0.70	1.77
S32H	5.37	0.87	2.90	5.10	0.30	0.05	0.05	UNDER-UTILISED	LOW	0.74	2.70
S32J	8.93	1.38	3.90	11.30	0.33	0.08	0.08	UNDER-UTILISED	LOW	0.91	2.69
S32K	12.53	1.36	3.70	9.57	0.54	0.08	0.08	UNDER-UTILISED	LOW	0.85	3.60
S32L	9.40	1.36	3.70	10.13	0.39	0.08	0.08	UNDER-UTILISED	LOW	0.70	1.78
S32M	18.47	1.47	5.20	13.69	0.60	0.08	0.08	UNDER-UTILISED	LOW	0.50	1.80
S40A	14.66	1.81	3.90	10.47	0.81	0.10	0.10	UNDER-UTILISED	LOW	0.70	2.76
S40B	15.01	1.85	3.90	11.07	0.81	0.10	0.10	UNDER-UTILISED	LOW	0.70	2.71
S40C	14.05	1.92	5.20	13.49	0.63	0.11	0.11	UNDER-UTILISED	LOW	1.00	3.47
S40D	7.60	2.22	8.40	18.57	0.27	0.13	0.13	UNDER-UTILISED	LOW	0.70	0.75
S40E	27.91	3.95	7.80	19.17	1.98	0.22	0.22	UNDER-UTILISED	LOW	0.70	3.11
S40F	20.41	4.11	7.90	20.83	1.38	0.23	0.23	UNDER-UTILISED	LOW	0.50	1.48
S50A	20.76	9.12	15.30	33.58	2.04	0.62	0.62	UNDER-UTILISED	MODERATE	0.85	1.11
S50B	41.45	10.31	20.50	43.12	3.44	0.50	0.50	UNDER-UTILISED	MODERATE	0.85	1.75
S50C	25.18	8.15	12.00	24.75	3.12	0.55	0.55	UNDER-UTILISED	MODERATE	0.85	2.43
S50D	31.17	8.48	14.10	29.10	3.36	0.62	0.62	UNDER-UTILISED	MODERATE	0.85	2.29
S50E	58.20	4.56	18.00	41.34	2.04	0.28	0.28	UNDER-UTILISED	LOW	0.70	3.10
S50F	6.35	4.49	12.60	24.42	0.39	0.25	0.25	UNDER-UTILISED	LOW	0.70	0.75
S50G	34.92	4.50	12.20	23.91	2.25	0.25	0.25	UNDER-UTILISED	LOW	0.70	2.48
S50H	19.65	4.17	10.20	18.56	1.56	0.24	0.24	UNDER-UTILISED	LOW	0.70	1.86

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

	vMARi				oGBFi		fGBDo			fGPQi	oGWMo
QUATERNARY	MEAN ANNUAL RUNOFF	BASE FLOW SCHULTZ	BASE FLOW PITTMAN	BASE FLOW HUGHES	BASE FLOW SCHULTZ	BASE FLOW FACTOR	CORRECTED BASE FLOW FACTOR	ESTIMATED EXTENT OF GROUND WATER UTILISATION	IMPACT OF GROUND WATER ABSRTACTION ON SURFACE WATER	PORTION POTABLE	MAX UTILISABLE GROUND WATER
	(x 10⁶ m³/a)	(mm/a)	(mm/a)	(mm/a)	(x 10⁶ m³/a)						(x 10⁶ m³/a)
S50J	45.62	4.38	11.40	22.91	3.00	0.25	0.25	UNDER-UTILISED	LOW	0.70	4.24
S60A	39.27	32.22	57.30	82.27	10.57	1.82	1.00	UNDER-UTILISED	HIGH	0.50	1.74
S60B	22.51	30.11	37.30	51.16	7.95	1.70	1.00	UNDER-UTILISED	HIGH	0.50	1.40
S60C	16.23	12.65	22.70	34.35	2.73	0.71	0.71	UNDER-UTILISED	MODERATE	0.70	1.34
S60D	16.80	12.00	18.90	28.68	3.18	0.68	0.68	UNDER-UTILISED	MODERATE	0.50	0.94
S60E	15.87	5.16	9.70	25.26	1.11	0.29	0.29	UNDER-UTILISED	LOW	0.50	0.76
S70A	30.69	7.96	12.40	31.26	2.70	0.45	0.45	UNDER-UTILISED	MODERATE	1.00	3.60
S70B	17.05	10.34	17.00	27.83	2.76	0.58	0.58	UNDER-UTILISED	MODERATE	0.50	0.71
S70C	16.26	7.74	11.30	28.85	1.53	0.44	0.44	UNDER-UTILISED	MODERATE	0.70	0.98
S70D	47.87	8.30	12.30	32.47	4.27	0.47	0.47	UNDER-UTILISED	MODERATE	0.70	2.55
S70E	30.84	10.43	17.10	27.81	5.01	0.59	0.59	UNDER-UTILISED	MODERATE	0.50	2.55
S70F	32.55	13.19	23.30	37.55	4.74	0.75	0.75	UNDER-UTILISED	MODERATE	0.50	1.59
T11A	34.17	9.19	15.60	35.95	3.03	0.67	0.67	UNDER-UTILISED	MODERATE	0.85	1.53
T11B	45.88	9.49	15.70	38.17	3.94	0.70	0.70	UNDER-UTILISED	MODERATE	0.85	1.44
T11C	66.40	11.51	24.00	57.46	4.44	0.68	0.68	UNDER-UTILISED	MODERATE	0.85	3.34
T11D	58.56	10.91	23.80	56.44	3.74	0.74	0.74	UNDER-UTILISED	MODERATE	0.85	2.56
T11E	51.24	11.22	33.80	72.37	2.61	0.75	0.75	UNDER-UTILISED	MODERATE	0.85	1.78
T11F	56.90	11.55	28.70	67.86	3.18	0.69	0.69	UNDER-UTILISED	MODERATE	0.85	2.33
T11G	36.30	9.88	15.70	42.93	2.87	0.56	0.56	UNDER-UTILISED	MODERATE	0.70	2.16
T11H	24.40	9.18	14.40	39.31	1.98	0.52	0.52	UNDER-UTILISED	MODERATE	0.70	1.34
T12A	40.37	9.25	23.70	50.03	2.58	0.57	0.57	UNDER-UTILISED	MODERATE	0.70	1.57
T12B	24.19	8.61	15.50	37.08	1.98	0.49	0.49	UNDER-UTILISED	MODERATE	0.70	1.99
T12C	28.27	8.33	15.60	35.54	2.37	0.47	0.47	UNDER-UTILISED	MODERATE	0.70	2.11
T12D	31.23	8.43	14.50	34.86	2.70	0.48	0.48	UNDER-UTILISED	MODERATE	0.70	2.38
T12E	44.41	8.96	14.50	37.79	3.69	0.51	0.51	UNDER-UTILISED	MODERATE	0.70	2.04
T12F	40.50	9.09	15.70	40.52	3.15	0.51	0.51	UNDER-UTILISED	MODERATE	0.85	3.12

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

QUATERNARY	vMARi MEAN ANNUAL RUNOFF (x 10^6 m^3/a)	BASE FLOW SCHULTZ (mm/a)	BASE FLOW PITTMAN (mm/a)	BASE FLOW HUGHES (mm/a)	oGBFi BASE FLOW SCHULTZ (x 10^6 m^3/a)	BASE FLOW FACTOR	fGBDo CORRECTED BASE FLOW FACTOR	ESTIMATED EXTENT OF GROUND WATER UTILISATION	IMPACT OF GROUND WATER ABSRTACTION ON SURFACE WATER	fGPQi PORTION POTABLE	oGWMo MAX UTILISABLE GROUND WATER (x 10^6 m^3/a)
T12G	26.58	8.70	12.30	34.08	2.40	0.49	0.49	UNDER-UTILISED	MODERATE	0.70	1.71
T13A	41.70	10.95	15.70	49.74	3.15	0.62	0.62	UNDER-UTILISED	MODERATE	0.85	1.30
T13B	35.44	10.33	14.10	43.06	2.95	0.58	0.58	UNDER-UTILISED	MODERATE	0.40	1.01
T13C	42.72	10.76	14.50	46.31	3.42	0.61	0.61	UNDER-UTILISED	MODERATE	0.30	1.01
T13D	45.58	17.76	32.00	53.22	6.36	1.00	1.00	UNDER-UTILISED	HIGH	0.30	0.95
T13E	27.88	21.41	36.70	67.13	3.60	1.21	1.00	UNDER-UTILISED	HIGH	0.30	0.45
T20A	126.50	34.01	46.10	113.38	16.36	1.94	1.00	UNDER-UTILISED	HIGH	0.85	2.87
T20B	88.84	30.86	40.50	95.50	12.50	1.74	1.00	UNDER-UTILISED	HIGH	0.85	2.44
T20C	43.78	24.75	31.50	63.42	7.92	1.41	1.00	UNDER-UTILISED	HIGH	0.85	2.38
T20D	28.92	14.38	19.90	35.47	5.58	0.99	0.99	UNDER-UTILISED	HIGH	0.85	2.41
T20E	34.47	16.63	25.70	44.29	5.82	1.22	1.00	UNDER-UTILISED	HIGH	0.85	2.02
T20F	32.81	14.22	19.90	35.50	6.30	0.96	0.96	UNDER-UTILISED	HIGH	0.85	3.34
T20G	33.89	21.81	38.30	65.39	4.65	1.38	1.00	UNDER-UTILISED	HIGH	0.30	0.30
T31A	39.57	9.18	25.40	55.71	2.02	0.56	0.56	UNDER-UTILISED	MODERATE	0.85	1.53
T31B	39.17	8.52	20.80	43.65	2.42	0.48	0.48	UNDER-UTILISED	MODERATE	0.85	2.56
T31C	39.66	8.43	20.80	43.32	2.45	0.48	0.48	UNDER-UTILISED	MODERATE	0.85	1.29
T31D	32.16	7.49	15.50	30.70	2.64	0.42	0.42	UNDER-UTILISED	MODERATE	0.85	3.70
T31E	50.77	7.63	16.60	33.00	3.88	0.46	0.46	UNDER-UTILISED	MODERATE	0.85	5.04
T31F	48.20	7.79	14.30	27.86	4.71	0.45	0.45	UNDER-UTILISED	MODERATE	1.00	6.25
T31G	26.45	9.30	19.20	41.25	1.94	0.60	0.60	UNDER-UTILISED	MODERATE	0.95	2.17
T31H	74.06	8.82	19.40	42.46	5.44	0.55	0.55	UNDER-UTILISED	MODERATE	0.85	4.21
T31J	48.44	9.97	21.00	36.77	5.06	0.73	0.73	UNDER-UTILISED	MODERATE	0.85	2.93
T32A	37.16	12.24	20.90	35.34	4.26	0.81	0.81	UNDER-UTILISED	HIGH	1.00	3.15
T32B	37.41	13.16	21.20	39.95	4.04	0.97	0.97	UNDER-UTILISED	HIGH	1.00	2.09
T32C	42.93	13.29	19.50	38.32	4.96	0.98	0.98	UNDER-UTILISED	HIGH	0.88	2.66
T32D	31.40	10.44	19.70	36.25	3.66	0.77	0.77	UNDER-UTILISED	MODERATE	0.88	2.51

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

QUATERNARY	vMARi MEAN ANNUAL RUNOFF (x 10^6 m^3/a)	BASE FLOW SCHULTZ (mm/a)	BASE FLOW PITTMAN (mm/a)	BASE FLOW HUGHES (mm/a)	oGBFi BASE FLOW SCHULTZ (x 10^6 m^3/a)	BASE FLOW FACTOR	fGBDo CORRECTED BASE FLOW FACTOR	ESTIMATED EXTENT OF GROUND WATER UTILISATION	IMPACT OF GROUND WATER ABSRTACTION ON SURFACE WATER	fGPQi PORTION POTABLE	oGWMo MAX UTILISABLE GROUND WATER (x 10^6 m^3/a)
T32E	44.37	13.90	24.50	47.67	5.32	1.02	1.00	UNDER-UTILISED	HIGH	0.85	2.21
T32F	46.32	15.39	34.20	61.31	4.57	1.13	1.00	UNDER-UTILISED	HIGH	0.85	1.72
T32G	54.90	14.63	25.90	50.56	6.41	1.08	1.00	UNDER-UTILISED	HIGH	0.92	2.74
T32H	62.84	14.86	29.40	55.59	6.73	1.09	1.00	UNDER-UTILISED	HIGH	0.85	2.62
T33A	97.78	10.13	16.70	35.02	6.81	0.58	0.58	UNDER-UTILISED	MODERATE	0.85	4.95
T33B	98.79	10.68	19.20	38.50	6.43	0.67	0.67	UNDER-UTILISED	MODERATE	0.85	4.07
T33C	52.29	9.83	16.90	34.21	3.61	0.66	0.66	UNDER-UTILISED	MODERATE	0.85	2.31
T33D	60.99	9.68	15.50	32.23	4.46	0.65	0.65	UNDER-UTILISED	MODERATE	0.85	2.91
T33E	23.90	7.49	15.70	33.42	2.00	0.55	0.55	UNDER-UTILISED	MODERATE	0.85	1.54
T33F	54.47	8.41	19.10	44.20	3.68	0.49	0.49	UNDER-UTILISED	MODERATE	0.85	3.19
T33G	68.61	8.96	19.20	48.11	4.51	0.56	0.56	UNDER-UTILISED	MODERATE	0.85	3.39
T33H	44.22	11.14	19.50	36.26	5.76	0.71	0.71	UNDER-UTILISED	MODERATE	1.00	4.04
T33J	33.86	10.96	16.80	32.64	5.01	0.81	0.81	UNDER-UTILISED	HIGH	0.85	2.11
T33K	21.62	13.09	25.70	51.08	2.21	0.96	0.96	UNDER-UTILISED	HIGH	0.85	0.98
T34A	50.56	22.44	44.30	82.22	5.43	0.80	0.80	UNDER-UTILISED	MODERATE	0.85	2.89
T34B	45.26	21.08	43.90	73.84	5.19	1.56	1.00	UNDER-UTILISED	HIGH	0.85	1.41
T34C	44.18	20.02	39.50	64.58	5.65	0.98	0.98	UNDER-UTILISED	HIGH	0.85	2.45
T34D	64.28	21.43	43.40	75.35	7.33	1.49	1.00	UNDER-UTILISED	HIGH	0.85	2.09
T34E	55.40	22.39	44.10	81.23	6.00	0.88	0.88	UNDER-UTILISED	HIGH	0.85	2.90
T34F	48.09	22.55	43.80	79.69	5.37	1.63	1.00	UNDER-UTILISED	HIGH	0.85	1.40
T34G	68.58	24.65	44.70	83.87	8.83	1.54	1.00	UNDER-UTILISED	HIGH	0.95	2.73
T34H	108.70	25.11	44.00	82.03	14.84	1.59	1.00	UNDER-UTILISED	HIGH	0.85	3.97
T34J	25.54	9.70	19.30	35.74	2.88	0.66	0.66	UNDER-UTILISED	MODERATE	0.85	2.22
T34K	23.98	9.44	17.20	31.05	3.14	0.69	0.69	UNDER-UTILISED	MODERATE	0.85	1.92
T35A	105.30	24.54	44.70	92.59	11.66	1.25	1.00	UNDER-UTILISED	HIGH	0.85	3.97
T35B	88.51	24.54	44.80	93.60	9.72	1.61	1.00	UNDER-UTILISED	HIGH	0.85	2.57

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

QUATERNARY	vMARi MEAN ANNUAL RUNOFF (x 10^6 m^3/a)	BASE FLOW SCHULTZ (mm/a)	BASE FLOW PITTMAN (mm/a)	BASE FLOW HUGHES (mm/a)	oGBFi BASE FLOW SCHULTZ (x 10^6 m^3/a)	BASE FLOW FACTOR	fGBDo CORRECTED BASE FLOW FACTOR	ESTIMATED EXTENT OF GROUND WATER UTILISATION	IMPACT OF GROUND WATER ABSRTACTION ON SURFACE WATER	fGPQi PORTION POTABLE	oGWMo MAX UTILISABLE GROUND WATER (x 10^6 m^3/a)
T35C	84.95	27.07	50.40	113.28	8.28	0.75	0.75	UNDER-UTILISED	MODERATE	0.85	3.75
T35D	62.41	22.76	39.30	77.58	7.92	1.44	1.00	UNDER-UTILISED	HIGH	0.85	3.27
T35E	115.08	25.26	45.00	98.00	12.43	1.86	1.00	UNDER-UTILISED	HIGH	0.85	2.84
T35F	69.01	25.14	41.30	82.16	9.03	1.62	1.00	UNDER-UTILISED	HIGH	0.85	2.37
T35G	82.12	22.32	35.70	64.18	12.84	1.62	1.00	UNDER-UTILISED	HIGH	0.85	4.70
T35H	100.31	25.52	40.60	83.18	13.27	1.61	1.00	UNDER-UTILISED	HIGH	0.85	4.20
T35J	45.95	27.86	45.30	103.90	5.24	1.58	1.00	UNDER-UTILISED	HIGH	0.85	1.41
T35K	105.11	25.58	36.80	78.04	15.99	1.45	1.00	UNDER-UTILISED	HIGH	0.85	5.60
T35L	27.91	11.89	19.10	35.14	4.04	0.79	0.79	UNDER-UTILISED	MODERATE	0.85	2.62
T35M	40.71	14.14	25.80	53.22	4.31	1.03	1.00	UNDER-UTILISED	HIGH	0.85	2.12
T36A	66.29	22.86	35.30	61.93	10.56	1.68	1.00	UNDER-UTILISED	HIGH	0.85	1.60
T36B	56.03	28.54	45.30	86.41	7.56	2.10	1.00	UNDER-UTILISED	HIGH	0.40	0.72
T60A	73.30	23.92	36.70	64.01	13.08	0.70	0.70	UNDER-UTILISED	MODERATE	0.95	12.46
T60B	76.84	25.06	38.50	68.59	13.23	1.84	1.00	UNDER-UTILISED	HIGH	0.92	3.30
T60C	64.08	26.85	43.80	80.13	9.75	1.10	1.00	UNDER-UTILISED	HIGH	0.94	4.13
T60D	104.61	31.23	59.00	105.57	12.96	0.36	0.36	UNDER-UTILISED	MODERATE	0.95	17.07
T60E	28.69	25.00	37.20	69.65	4.95	1.84	1.00	UNDER-UTILISED	HIGH	0.92	1.24
T60F	80.61	27.15	42.30	81.11	12.60	2.00	1.00	UNDER-UTILISED	HIGH	0.92	2.92
T60G	101.59	34.37	64.70	119.43	12.37	0.67	0.67	UNDER-UTILISED	MODERATE	0.95	5.27
T60H	127.48	57.25	89.40	161.14	18.43	0.73	0.73	UNDER-UTILISED	MODERATE	0.70	8.86
T60J	78.31	45.07	62.80	118.11	13.25	2.20	1.00	UNDER-UTILISED	HIGH	0.70	2.10
T60K	60.40	44.03	59.10	111.37	10.65	2.80	1.00	UNDER-UTILISED	HIGH	0.30	0.57
T70A	35.67	18.81	29.30	49.95	5.91	1.36	1.00	UNDER-UTILISED	HIGH	0.85	2.22
T70B	50.64	25.78	39.90	74.90	7.14	1.77	1.00	UNDER-UTILISED	HIGH	0.40	0.81
T70C	28.97	22.25	35.40	61.57	4.41	1.64	1.00	UNDER-UTILISED	HIGH	0.85	1.14
T70D	66.38	26.31	42.10	80.64	8.76	1.56	1.00	UNDER-UTILISED	HIGH	0.30	0.84

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA
GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

	vMARi				oGBFi		fGBDo			fGPQi	oGWMo
QUATERNARY	MEAN ANNUAL RUNOFF (x 10^6 m^3/a)	BASE FLOW SCHULTZ (mm/a)	BASE FLOW PITTMAN (mm/a)	BASE FLOW HUGHES (mm/a)	BASE FLOW SCHULTZ (x 10^6 m^3/a)	BASE FLOW FACTOR	CORRECTED BASE FLOW FACTOR	ESTIMATED EXTENT OF GROUND WATER UTILISATION	IMPACT OF GROUND WATER ABSRTACTION ON SURFACE WATER	PORTION POTABLE	MAX UTILISABLE GROUND WATER (x 10^6 m^3/a)
T70E	22.60	17.37	26.50	44.81	3.96	1.28	1.00	UNDER-UTILISED	HIGH	0.85	1.05
T70F	38.44	22.19	35.30	61.11	5.88	1.52	1.00	UNDER-UTILISED	HIGH	0.40	0.77
T70G	40.76	22.55	36.70	63.61	6.07	1.43	1.00	UNDER-UTILISED	HIGH	0.30	0.64
T80A	43.06	21.41	42.10	79.37	4.56	1.21	1.00	UNDER-UTILISED	HIGH	0.30	0.57
T80B	37.84	19.89	35.20	65.10	4.65	1.14	1.00	UNDER-UTILISED	HIGH	0.30	0.61
T80C	31.28	14.48	22.20	43.26	4.56	0.83	0.83	UNDER-UTILISED	HIGH	0.30	1.15
T80D	50.90	20.89	38.60	72.05	5.85	1.18	1.00	UNDER-UTILISED	HIGH	0.30	0.45
T90A	18.05	11.49	14.70	25.84	3.78	0.65	0.65	UNDER-UTILISED	MODERATE	0.30	1.05
T90B	71.41	24.19	38.60	71.15	9.73	1.37	1.00	UNDER-UTILISED	HIGH	0.30	0.64
T90C	48.19	18.87	32.30	54.51	6.92	1.07	1.00	UNDER-UTILISED	HIGH	0.40	0.78
T90D	32.84	15.33	23.40	38.11	5.73	0.87	0.87	UNDER-UTILISED	HIGH	0.50	1.99
T90E	54.66	18.87	32.40	54.85	7.77	1.07	1.00	UNDER-UTILISED	HIGH	0.50	1.46
T90F	47.97	22.35	40.00	68.07	6.30	1.26	1.00	UNDER-UTILISED	HIGH	0.50	0.75
T90G	50.42	17.10	29.40	46.09	7.87	0.97	0.97	UNDER-UTILISED	HIGH	0.50	2.44
TOTALS	21 721,47	-	-	-	2 481,34	-	-	-	-	-	1 352,27

MZIMVUBU TO KEISKAMMA WATER MANAGEMENT AREA

APPENDIX G.5

WATER QUALITY INFORMATION

Quaternary	Station No	Mean (mg/l)	Maximum (mg/l)	Mean colour	Maximum colour	Overall colour
R10A	R1H017Q01	270.3	875	Green	Yellow	Yellow
R10B	R1H017Q01	270.3	875	Green	Yellow	Yellow
R10C	R1H005Q01	174.7	439	Blue	Green	Green
R10D	R1H015Q01	250.8	366	Blue	Green	Green
R10E	R1H015Q01	250.8	366	Blue	Green	Green
R10F	R1H014Q01	60.4	84	Blue	Blue	Blue
R10G	R1R003Q01	122.8	421	Blue	Green	Green
R10H	R1H015Q01	250.8	366	Blue	Green	Green
R10J	R1H015Q01	250.8	366	Blue	Green	Green
R10K	R1H015Q01	250.8	366	Blue	Green	Green
R10L	R1H015Q01	250.8	366	Blue	Green	Green
R10M	R1H015Q01	250.8	366	Blue	Green	Green
R20A	R2H001Q01	67.8	274	Blue	Green	Green
R20B	R2H006Q01	254.8	513	Blue	Green	Green
R20C	R2H005Q01	339.5	857	Green	Yellow	Yellow
R20D	R2H010Q01	491.4	837	Green	Yellow	Yellow
R20E	R2H015Q01	658.2	1300	Yellow	Yellow	Yellow
R20F	R2R001Q01	274.4	401	Green	Green	Green
R20G	NO					
R30A	NO					
R30B	NO					
R30C	R3H001Q01	273.9	512	Green	Green	Green
R30D	R3H001Q01	273.9	512	Green	Green	Green
R30E	R3H002R01	220.3	383	Blue	Green	Green
R30F	R3H002R01	220.3	383	Blue	Green	Green
R40A	NO					
R40B	NO					
R40C	NO					
R50A	NO					
R50B	NO					
S10A	NO					
S10B	NO					
S10C	NO					
S10D	NO					
S10E	NO					
S10F	NO					
S10G	NO					
S10H	NO					
S10J	NO					
S20A	S2R002Q01	296.6	369	Green	Green	Green
S20B	S2R002Q01	296.6	369	Green	Green	Green
S20C	S2R002Q01	296.6	369	Green	Green	Green
S20D	S2R002Q01	296.6	369	Green	Green	Green
S31A	S3H006Q01	297.1	521	Green	Green	Green
S31B	S3H006Q01	297.1	521	Green	Green	Green
S31C	S3H006Q01	297.1	521	Green	Green	Green
S31D	S3H006Q01	297.1	521	Green	Green	Green

Quaternary	Station No	Mean (mg/l)	Maximum (mg/l)	Mean colour	Maximum colour	Overall colour
S31E	S3H006Q01	297.1	521	Green	Green	Green
S31F	S3H006Q01	297.1	521	Green	Green	Green
S31G	S3H006Q01	297.1	521	Green	Green	Green
S32A	NO					
S32B	S3H004Q01	507.6	1053	Green	Yellow	Yellow
S32C	S3H004Q01	507.6	1053	Green	Yellow	Yellow
S32D	NO					
S32E	NO					
S32F	S3H012Q01	469.9	806	Green	Yellow	Yellow
S32G	S3H012Q01	469.9	806	Green	Yellow	Yellow
S32H	S3H004Q01	507.6	1053	Green	Yellow	Yellow
S32J	NO					
S32K	S3H004Q01	507.6	1053	Green	Yellow	Yellow
S32L	NO					
S32M	S3H004Q01	507.6	1053	Green	Yellow	Yellow
S40A	NO					
S40B	NO					
S40C	NO					
S40D	NO					
S40E	NO					
S40F	NO					
S50A	S5H002Q01	179.4	279	Blue	Green	Green
S50B	S5H002Q01	179.4	279	Blue	Green	Green
S50C	S5H002Q01	179.4	279	Blue	Green	Green
S50D	S5H002Q01	179.4	279	Blue	Green	Green
S50E	S5H002Q01	179.4	279	Blue	Green	Green
S50F	S5H002Q01	179.4	279	Blue	Green	Green
S50G	S5H002Q01	179.4	279	Blue	Green	Green
S50H	S5H002Q01	179.4	279	Blue	Green	Green
S50J	S5H002Q01	179.4	279	Blue	Green	Green
S60A	S6H004Q01	65.0	129	Blue	Blue	Blue
S60B	S6H001Q01	83.5	206	Blue	Blue	Blue
S60C	S6H003Q01	202.2	322	Blue	Green	Green
S60D	S6H003Q01	202.2	322	Blue	Green	Green
S60E	S6H003Q01	202.2	322	Blue	Green	Green
S70A	S7H004Q01	303.3	560	Green	Green	Green
S70B	S7H004Q01	303.3	560	Green	Green	Green
S70C	S7H004Q01	303.3	560	Green	Green	Green
S70D	S7H004Q01	303.3	560	Green	Green	Green
S70E	S7H004Q01	303.3	560	Green	Green	Green
S70F	S7H004Q01	303.3	560	Green	Green	Green
T11A	NO					
T11B	NO					
T11C	NO					
T11D	NO					
T11E	NO					
T11F	NO					
T11G	NO					
T11H	NO					
T12A	NO					
T12B	NO					
T12C	NO					
T12D	NO					

Quaternary	Station No	Mean (mg/l)	Maximum (mg/l)	Mean colour	Maximum colour	Overall colour
T12E	NO					
T12F	NO					
T12G	NO					
T13A	NO					
T13B	NO					
T13C	NO					
T13D	NO					
T13E	NO					
T20A	NO					
T20B	NO					
T20C	NO					
T20D	NO					
T20E	NO					
T20F	NO					
T20G	NO					
T31A	T3H008Q01	58.4	87	Blue	Blue	Blue
T31B	T3H008Q01	58.4	87	Blue	Blue	Blue
T31C	T3H008Q01	58.4	87	Blue	Blue	Blue
T31D	T3H008Q01	58.4	87	Blue	Blue	Blue
T31E	T3H008Q01	58.4	87	Blue	Blue	Blue
T31F	T3H008Q01	58.4	87	Blue	Blue	Blue
T31G	T3H008Q01	58.4	87	Blue	Blue	Blue
T31H	T3H008Q01	58.4	87	Blue	Blue	Blue
T31J	T3H008Q01	58.4	87	Blue	Blue	Blue
T32A	T3H004Q01	113.8	152	Blue	Blue	Blue
T32B	T3H004Q01	113.8	152	Blue	Blue	Blue
T32C	T3H004Q01	113.8	152	Blue	Blue	Blue
T32D	T3H004Q01	113.8	152	Blue	Blue	Blue
T32E	T3H004Q01	113.8	152	Blue	Blue	Blue
T32F	T3H004Q01	113.8	152	Blue	Blue	Blue
T32G	T3H004Q01	113.8	152	Blue	Blue	Blue
T32H	T3H004Q01	113.8	152	Blue	Blue	Blue
T33A	T3H002Q01	160.8	352	Blue	Green	Green
T33B	T3H002Q01	160.8	352	Blue	Green	Green
T33C	T3H002Q01	160.8	352	Blue	Green	Green
T33D	T3H002Q01	160.8	352	Blue	Green	Green
T33E	T3H002Q01	160.8	352	Blue	Green	Green
T33F	T3H002Q01	160.8	352	Blue	Green	Green
T33G	T3H002Q01	160.8	352	Blue	Green	Green
T33H	T3H007Q01	181.5	259	Blue	Blue	Blue
T33J	T3H007Q01	181.5	259	Blue	Blue	Blue
T33K	T3H007Q01	181.5	259	Blue	Blue	Blue
T34A	T3H005Q01	102.6	141	Blue	Blue	Blue
T34B	T3H005Q01	102.6	141	Blue	Blue	Blue
T34C	T3H005Q01	102.6	141	Blue	Blue	Blue
T34D	T3H005Q01	102.6	141	Blue	Blue	Blue
T34E	T3H005Q01	102.6	141	Blue	Blue	Blue
T34F	T3H005Q01	102.6	141	Blue	Blue	Blue
T34G	T3H005Q01	102.6	141	Blue	Blue	Blue
T34H	T3H005Q01	102.6	141	Blue	Blue	Blue
T34J	T3H005Q01	102.6	141	Blue	Blue	Blue
T34K	T3H005Q01	102.6	141	Blue	Blue	Blue
T35A	T3H009Q01	63.9	98	Blue	Blue	Blue

Quaternary	Station No	Mean (mg/l)	Maximum (mg/l)	Mean colour	Maximum colour	Overall colour
T35B	T3H009Q01	63.9	98	Blue	Blue	Blue
T35C	T3H009Q01	63.9	98	Blue	Blue	Blue
T35D	T3H009Q01	63.9	98	Blue	Blue	Blue
T35E	T3H009Q01	63.9	98	Blue	Blue	Blue
T35F	T3H009Q01	63.9	98	Blue	Blue	Blue
T35G	T3H009Q01	63.9	98	Blue	Blue	Blue
T35H	T3H009Q01	63.9	98	Blue	Blue	Blue
T35J	T3H009Q01	63.9	98	Blue	Blue	Blue
T35K	T3H009Q01	63.9	98	Blue	Blue	Blue
T35L	T3H009Q01	63.9	98	Blue	Blue	Blue
T35M	T3H009Q01	63.9	98	Blue	Blue	Blue
T36A	NO					
T36B	NO					
T60A	NO					
T60B	NO					
T60C	NO					
T60D	NO					
T60E	NO					
T60F	NO					
T60G	NO					
T60H	NO					
T60J	NO					
T60K	NO					
T70A	T7H001Q01	216.8	674	Blue	Yellow	Green
T70B	T7H001Q01	216.8	674	Blue	Yellow	Green
T70C	NO					
T70D	NO					
T70E	NO					
T70F	NO					
T70G	NO					
T80A	NO					
T80B	NO					
T80C	NO					
T80D	NO					
T90A	NO					
T90B	NO					
T90C	NO					
T90D	NO					
T90E	NO					
T90F	NO					
T90G	NO					

APPENDIX H

WATER RESOURCES

APPENDIX H.1

DATA SOURCES

Data type	Responsible organisation
Afforestation	CSIR
Alien vegetation	CSIR
Industrial, urban and strategic water use	WRSA consultants
Groundwater	WSM Consulting Engineers
Dams	DWAF
Transfer schemes	WRSA consultants
Run-of-river yields	Arcus Gibb
Population	Markdata
Ecological Reserve	IWR, Prof Hughes
Irrigation - Areas and crop types - Efficiency and losses - Evapotranspiration and crop factors	 WRSA consultant WRSA consultant WRP
Storage-draft-frequency curves	WRP

APPENDIX H.2

DATA DEFAULT VALUES USED IN THE WRSA REPORT

PARAMETER	DESCRIPTION	DEFAULT VALUE
FBMLi	Mining losses (factor)	0,1
FBOLi	Other industrial losses (factor)	0,1
FBSLi	Strategic losses (factor)	0,05
FIHCi	Irrigation conveyance losses- High category irrigation (factor)	0,1
FIMCi	Irrigation conveyance losses- Medium category irrigation (factor)	0,1
FILCi	Irrigation conveyance losses- Low category irrigation (factor)	0,1
FIPLi	Irrigation efficiency Low category irrigation (factor)	0,75
FilPMi	Irrigation efficiency Medium category irrigation (factor)	0,75
FilPHi	Irrigation efficiency High category irrigation (factor)	0,75
ORTLi	Rural losses (factor)	0,2

THE DATA AT QUATERNARY CATCHMENT RESOLUTION

For the record – not part of appendix

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D11A	278	278	7	10	203	56434	0.0565	0.0426	255	71024	0.0712	0.0536
D11B	236	236	7	10	203	47908	0.0480	0.0589	255	60294	0.0604	0.0741
D11C	292	292	7	10	203	59276	0.0594	0.0549	255	74601	0.0748	0.0691
D11D	319	319	7	10	203	64757	0.0649	0.0774	255	81499	0.0817	0.0975
D11E	322	322	7	10	203	65366	0.0655	0.1018	255	82266	0.0824	0.1281
D11F	413	413	7	10	203	83839	0.0840	0.0749	255	105514	0.1057	0.0943
D11G	320	320	7	10	203	64960	0.0651	0.1368	255	81755	0.0819	0.1722
D11H	359	359	7	10	203	72877	0.0730	0.1420	255	91718	0.0919	0.1787
D11J	440	440	7	10	203	89320	0.0895	0.1485	255	112412	0.1126	0.1869
D11K	381	381	7	10	203	77343	0.0775	0.1565	255	97339	0.0975	0.1970
0	**3360**	**3360**				**682080**	**0.6834**	**0.0863**		**858423**	**0.8601**	**0.1087**
D12A	369	369	6	13	335	123615	0.1239	0.2878	422	155574	0.1559	0.3622
D12B	385	385	6	13	335	128975	0.1292	0.1969	422	162320	0.1626	0.2478
D12C	343	343	6	13	335	114905	0.1151	0.5597	422	144612	0.1449	0.7044
D12D	355	355	6	12	335	118925	0.1192	0.6649	422	149671	0.1500	0.8368
D12E	712	712	6	12	335	238520	0.2390	0.7200	422	300186	0.3008	0.9062
D12F	803	803	6	13	335	269005	0.2695	0.9797	422	338553	0.3392	1.2330
0	**2967**	**2967**				**993945**	**0.9959**	**0.4791**		**1250916**	**1.2534**	**0.6030**
D13A	475	475	6	13	335	159125	0.1594	0.2239	422	200265	0.2007	0.2817
D13B	533	533	6	13	335	178555	0.1789	0.2420	422	224718	0.2252	0.3046
D13C	517	517	6	13	335	173195	0.1735	0.3160	422	217972	0.2184	0.3977
D13D	635	635	6	13	335	212725	0.2132	0.3679	422	267722	0.2683	0.4630
D13E	1031	1031	6	13	335	345385	0.3461	0.2673	422	434680	0.4355	0.3364
D13F	970	970	6	13	335	324950	0.3256	0.3358	422	408961	0.4098	0.4226
D13G	1125	1125	6	13	335	376875	0.3776	0.7118	422	474311	0.4753	0.8958
D13H	1144	1144	6	13	335	383240	0.3840	1.2843	422	482322	0.4833	1.6163
D13J	1167	1167	6	13	335	390945	0.3917	1.1828	422	492019	0.4930	1.4886

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D13K	397	397	6	13	335	132995	0.1333	0.2641	422	167379	0.1677	0.3324
D13L	682	682	6	13	335	228470	0.2289	0.9037	422	287538	0.2881	1.1373
D13M	678	678	6	13	335	227130	0.2276	1.0546	422	285851	0.2864	1.3272
0	**9354**	**9354**				**3133590**	**3.1399**	**0.4499**		**3943737.7**	**3.9516**	**0.5662**
D14A	764	764	6	12	335	255940	0.2565	1.0205	422	322110	0.3228	1.2843
D14B	324	324	6	13	335	108540	0.1088	1.3492	422	136602	0.1369	1.6981
D14C	722	722	6	13	335	241870	0.2424	1.3106	422	304402	0.3050	1.6494
D14D	680	680	6	13	335	227800	0.2283	1.9450	422	286695	0.2873	2.4479
D14E	663	663	6	13	335	222105	0.2225	2.1580	422	279527	0.2801	2.7159
D14F	541	541	6	13	335	181235	0.1816	1.2767	422	228091	0.2285	1.6067
D14G	605	605	6	13	335	202675	0.2031	1.0383	422	255074	0.2556	1.3068
D14H	697	697	6	13	335	233495	0.2340	1.5790	422	293862	0.2944	1.9872
D14J	515	515	6	13	335	172525	0.1729	1.5681	422	217129	0.2176	1.9735
D14K	634	634	6	13	335	212390	0.2128	1.6937	422	267301	0.2678	2.1316
0	**6145**	**6145**				**2058575**	**2.0627**	**1.4136**		**2590792**	**2.5960**	**1.7790**
D15A	437	437	7	10	203	88711	0.0889	0.0749	255	111646	0.1119	0.0942
D15B	393	393	7	10	203	79779	0.0799	0.0773	255	100405	0.1006	0.0973
D15C	276	276	7	10	203	56028	0.0561	0.1036	255	70513	0.0707	0.1304
D15D	437	437	7	12	203	88711	0.0889	0.0842	255	111646	0.1119	0.1060
D15E	619	619	7	12	203	125657	0.1259	0.1097	255	158144	0.1585	0.1380
D15F	352	352	7	12	203	71456	0.0716	0.2366	255	89930	0.0901	0.2978
D15G	485	485	7	12	203	98455	0.0987	0.3474	255	123909	0.1242	0.4372
D15H	361	361	7	12	203	73283	0.0734	0.4943	255	92229	0.0924	0.6221
0	**3360**	**3360**				**682080**	**0.6834**	**0.1199**		**858422.63**	**0.8601**	**0.1509**
D16A	159	159	7	10	203	32277	0.0323	0.0762	255	40622	0.0407	0.0960
D16B	249	249	7	10	203	50547	0.0506	0.0925	255	63615	0.0637	0.1164
D16C	438	438	7	10	203	88914	0.0891	0.2732	255	111902	0.1121	0.3438
D16D	339	339	7	10	203	68817	0.0690	0.1114	255	86609	0.0868	0.1402
D16E	434	434	7	10	203	88102	0.0883	0.1763	255	110880	0.1111	0.2219
D16F	277	277	7	10	203	56231	0.0563	0.1105	255	70769	0.0709	0.1391
D16G	290	290	7	10	203	58870	0.0590	0.1269	255	74090	0.0742	0.1597
D16H	345	345	7	10	203	70035	0.0702	0.2191	255	88142	0.0883	0.2758

Quat. Number	**Gross area (km2)**	**Net area (km2)**	**Sediment region**	**Erodibility index**	**Sediment (t/km2/a)**	**Sediment yield (t/a)**	**Sediment vol(MCM)**	**Volume (%MAR)**	***Sediment (t/km2/a)***	***Sediment yield (t/a)***	***Sediment vol(MCM)***	***Volume (%MAR)***
D16J	374	374	7	10	203	75922	0.0761	0.1584	255	95551	0.0957	0.1993
D16K	329	329	7	10	203	66787	0.0669	0.1116	255	84054	0.0842	0.1404
D16L	533	533	7	10	203	108199	0.1084	0.1819	255	136172	0.1364	0.2290
D16M	753	753	7	10	203	152859	0.1532	0.1152	255	192379	0.1928	0.1450
0	**4520**	**4520**				**917560**	**0.9194**	**0.1369**		**1154782.8**	**1.1571**	**0.1722**
D17A	638	638	7	10	203	129514	0.1298	0.0629	255	162998	0.1633	0.0791
D17B	442	442	7	10	203	89726	0.0899	0.0710	255	112923	0.1131	0.0894
D17C	525	525	7	10	203	106575	0.1068	0.1379	255	134129	0.1344	0.1735
D17D	748	748	7	10	203	151844	0.1521	0.1356	255	191101	0.1915	0.1707
D17E	605	605	7	10	203	122815	0.1231	0.1276	255	154567	0.1549	0.1606
D17F	582	582	7	10	203	118146	0.1184	0.2451	255	148691	0.1490	0.3084
D17G	849	849	7	10	203	172347	0.1727	0.1584	255	216905	0.2173	0.1994
D17H	852	852	7	10	203	172956	0.1733	0.1701	255	217671	0.2181	0.2140
D17J	437	437	7	10	203	88711	0.0889	0.0890	255	111646	0.1119	0.1120
D17K	383	383	7	10	203	77749	0.0779	0.1533	255	97850	0.0980	0.1929
D17L	590	590	7	10	203	119770	0.1200	0.1611	255	150735	0.1510	0.2027
D17M	528	528	7	10	203	107184	0.1074	0.1475	255	134895	0.1352	0.1857
0	**7179**	**7179**				**1457337**	**1.4603**	**0.1241**		**1834111.9**	**1.8378**	**0.1562**
D18A	599	599	7	10	203	121597	0.1218	0.1259	255	153034	0.1533	0.1584
D18B	327	327	7	10	203	66381	0.0665	0.1668	255	83543	0.0837	0.2100
D18C	466	466	7	12	203	94598	0.0948	0.1972	255	119055	0.1193	0.2482
D18D	766	766	7	10	203	155498	0.1558	0.1393	255	195700	0.1961	0.1753
D18E	376	376	7	10	203	76328	0.0765	0.1376	255	96062	0.0963	0.1731
D18F	446	446	7	12	203	90538	0.0907	0.2071	255	113945	0.1142	0.2607
D18G	492	492	7	13	203	99876	0.1001	0.1160	255	125698	0.1259	0.1460
D18H	384	384	7	13	203	77952	0.0781	0.1551	255	98105	0.0983	0.1952
D18J	859	859	7	12	203	174377	0.1747	0.1561	255	219460	0.2199	0.1964
D18K	935	935	7	13	203	189805	0.1902	0.1290	255	238877	0.2394	0.1623
D18L	610	610	7	12	203	123830	0.1241	0.1919	255	155845	0.1562	0.2415
0	**6260**	**6260**				**1270780**	**1.2733**	**0.1486**		**1599323.1**	**1.6025**	**0.1871**
D21A	309	309	6	10	335	103515	0.1037	0.1688	422	130277	0.1305	0.2124
D21B	394	394	6	10	335	131990	0.1323	0.1495	422	166114	0.1664	0.1882

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D21C	212	212	6	9	335	71020	0.0712	0.2287	422	89381	0.0896	0.2878
D21D	252	252	6	9	335	84420	0.0846	0.2762	422	106246	0.1065	0.3476
D21E	268	268	6	9	335	89780	0.0900	0.3430	422	112991	0.1132	0.4317
D21F	480	480	6	9	335	160800	0.1611	0.4945	422	202373	0.2028	0.6223
D21G	278	278	6	9	335	93130	0.0933	0.4354	422	117208	0.1174	0.5480
D21H	381	381	6	9	335	127635	0.1279	0.3292	422	160633	0.1610	0.4143
D21J	359	359	6	10	335	120265	0.1205	0.1620	422	151358	0.1517	0.2039
D21K	326	326	6	10	335	109210	0.1094	0.1772	422	137445	0.1377	0.2230
D21L	304	304	6	9	335	101840	0.1020	0.2519	422	128169	0.1284	0.3170
0	**3563**	**3563**				**1193605**	**1.1960**	**0.2357**		**1502195.6**	**1.5052**	**0.2967**
D22A	636	636	6	9	335	213060	0.2135	0.5977	422	268144	0.2687	0.7522
D22B	457	457	6	9	335	153095	0.1534	0.4794	422	192676	0.1931	0.6033
D22C	486	486	6	9	335	162810	0.1631	0.3321	422	204902	0.2053	0.4180
D22D	628	628	6	9	335	210380	0.2108	0.5729	422	264771	0.2653	0.7211
D22E	498	498	6	10	335	166830	0.1672	0.3266	422	209962	0.2104	0.4111
D22F	633	633	6	9	335	212055	0.2125	0.4105	422	266879	0.2674	0.5166
D22G	969	969	6	9	335	324615	0.3253	0.6144	422	408540	0.4094	0.7733
D22H	541	541	6	9	335	181235	0.1816	0.5043	422	228091	0.2285	0.6347
D22J	652	652	6	10	335	218420	0.2189	0.3533	422	274890	0.2754	0.4447
D22K	324	324	6	10	335	108540	0.1088	0.3859	422	136602	0.1369	0.4857
D22L	376	376	6	11	335	125960	0.1262	0.5836	422	158525	0.1588	0.7345
0	**6200**	**6200**				**2077000**	**2.0812**	**0.4551**		**2613980.5**	**2.6192**	**0.5728**
D23A	608	608	6	12	335	203680	0.2041	0.5334	422	256339	0.2569	0.6713
D23B	597	597	6	12	335	199995	0.2004	0.4911	422	251701	0.2522	0.6181
D23C	861	861	3	12	82	70602	0.0707	0.1730	103	88855	0.0890	0.2177
D23D	565	565	6	12	335	189275	0.1897	0.8614	422	238210	0.2387	1.0841
D23E	702	702	6	12	335	235170	0.2356	0.8219	422	295970	0.2966	1.0343
D23F	352	352	6	12	335	117920	0.1182	0.6037	422	148407	0.1487	0.7598
D23G	512	512	6	12	335	171520	0.1719	0.6553	422	215864	0.2163	0.8248
D23H	776	776	6	12	335	259960	0.2605	1.3243	422	327169	0.3278	1.6667
D23J	534	534	6	12	335	178890	0.1792	1.1169	422	225140	0.2256	1.4057

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0	**5507**	**5507**				**1627012**	**1.6303**	**0.6465**		**2047654.1**	**2.0517**	**0.8136**
D24A	310	310	6	12	335	103850	0.1041	0.5452	422	130699	0.1310	0.6862
D24B	470	470	6	12	335	157450	0.1578	0.6896	422	198157	0.1986	0.8679
D24C	398	398	6	12	335	133330	0.1336	0.9886	422	167801	0.1681	1.2442
D24D	598	598	6	12	335	200330	0.2007	1.3334	422	252123	0.2526	1.6781
D24E	489	489	6	12	335	163815	0.1641	1.3315	422	206167	0.2066	1.6757
D24F	567	567	6	12	335	189945	0.1903	1.0849	422	239053	0.2395	1.3653
D24G	626	626	6	13	335	209710	0.2101	0.9379	422	263928	0.2645	1.1804
D24H	736	736	6	12	335	246560	0.2471	1.3026	422	310305	0.3109	1.6394
D24J	1032	1032	6	12	335	345720	0.3464	1.6795	422	435101	0.4360	2.1137
D24K	877	877	6	12	335	293795	0.2944	1.7489	422	369752	0.3705	2.2011
D24L	511	511	6	12	335	171185	0.1715	1.8793	422	215443	0.2159	2.3651
0	**6614**	**6614**				**2215690**	**2.2201**	**1.1787**		**2788526.9**	**2.7941**	**1.4834**
D31A	1160	1160	5	12	30	34800	0.0349	0.2128	38	43797	0.0439	0.2678
D31B	996	757	5	13	30	22710	0.0228	0.5438	38	28581	0.0286	0.6844
D31C	677	677	5	12	30	20310	0.0204	0.4541	38	25561	0.0256	0.5715
D31D	1108	833	5	12	30	24990	0.0250	0.2575	38	31451	0.0315	0.3241
D31E	969	969	5	12	30	29070	0.0291	0.3395	38	36586	0.0367	0.4273
0	**4910**	**4396**				**131880**	**0.1321**	**0.3048**		**165975.8**	**0.1663**	**0.3836**
D32A	716	716	5	12	30	21480	0.0215	0.5253	38	27033	0.0271	0.6611
D32B	582	582	5	13	30	17460	0.0175	0.3693	38	21974	0.0220	0.4648
D32C	850	850	5	12	30	25500	0.0256	0.5117	38	32093	0.0322	0.6440
D32D	851	851	5	12	30	25530	0.0256	0.5400	38	32130	0.0322	0.6796
D32E	1157	1157	5	13	30	34710	0.0348	0.9054	38	43684	0.0438	1.1395
D32F	1443	1443	5	13	30	43290	0.0434	0.5841	38	54482	0.0546	0.7351
D32G	1045	1045	5	12	30	31350	0.0314	0.4304	38	39455	0.0395	0.5417
D32H	572	572	5	12	30	17160	0.0172	0.4476	38	21596	0.0216	0.5634
D32J	1114	1041	5	12	30	31230	0.0313	0.5128	38	39304	0.0394	0.6454
D32K	824	824	5	12	30	24720	0.0248	0.4606	38	31111	0.0312	0.5797
0	**9154**	**9081**				**272430**	**0.2730**	**0.5204**		**342863.12**	**0.3435**	**0.6550**
D33A	593	472	5	12	30	14160	0.0142	0.9903	38	17821	0.0179	1.2463
D33B	1018	323	5	12	30	9690	0.0097	1.1770	38	12195	0.0122	1.4813

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D33C	805	520	5	12	30	15600	0.0156	0.9679	38	19633	0.0197	1.2182
D33D	952	311	5	12	30	9330	0.0093	1.4309	38	11742	0.0118	1.8008
D33E	1554	343	5	12	30	10290	0.0103	1.3347	38	12950	0.0130	1.6797
D33F	863	77	5	12	30	2310	0.0023	1.7295	38	2907	0.0029	2.1766
D33G	1406	400	5	12	30	12000	0.0120	1.7610	38	15102	0.0151	2.2163
D33H	1054	468	5	7	80.7	37767.6	0.0378	4.0585	102	47532	0.0476	5.1077
D33J	865	200	5	12	30	6000	0.0060	2.1668	38	7551	0.0076	2.7270
D33K	488	290	5	12	30	8700	0.0087	1.6299	38	10949	0.0110	2.0513
0	**9598**	**3404**				**125847.6**	**0.1261**	**1.6044**		**158383.81**	**0.1587**	**2.0191**
D34A	794	794	5	12	30	23820	0.0239	0.2193	38	29978	0.0300	0.2760
D34B	706	706	5	12	30	21180	0.0212	0.2960	38	26656	0.0267	0.3725
D34C	760	760	5	12	30	22800	0.0228	0.3641	38	28695	0.0288	0.4583
D34D	599	599	5	12	30	17970	0.0180	0.3348	38	22616	0.0227	0.4214
D34E	519	519	5	12	30	15570	0.0156	0.2834	38	19595	0.0196	0.3566
D34F	692	692	5	12	30	20760	0.0208	0.3868	38	26127	0.0262	0.4868
D34G	950	950	5	12	30	28500	0.0286	0.2593	38	35868	0.0359	0.3264
0	**5020**	**5020**				**150600**	**0.1509**	**0.2924**		**189535.61**	**0.1899**	**0.3680**
D35A	254	254	6	12	335	85090	0.0853	1.9440	422	107089	0.1073	2.4465
D35B	260	260	6	13	335	87100	0.0873	2.1655	422	109619	0.1098	2.7253
D35C	943	943	6	13	335	315905	0.3165	2.9344	422	397578	0.3984	3.6931
D35D	586	586	6	13	335	196310	0.1967	3.5307	422	247063	0.2476	4.4435
D35E	312	312	6	13	335	104520	0.1047	2.6773	422	131542	0.1318	3.3695
D35F	557	557	6	12	335	186595	0.1870	2.1607	422	234837	0.2353	2.7193
D35G	552	552	6	13	335	184920	0.1853	3.7217	422	232729	0.2332	4.6839
D35H	498	498	6	12	335	166830	0.1672	2.7651	422	209962	0.2104	3.4800
D35J	1002	1002	5	12	30	30060	0.0301	0.3909	38	37832	0.0379	0.4920
D35K	674	674	5	12	30	20220	0.0203	0.2947	38	25448	0.0255	0.3709
0	**5638**	**5638**				**1377550**	**1.3803**	**2.1929**		**1733697.1**	**1.7372**	**2.7599**
0	0	0										
TOTALS	**99349**	**92568**				**20367562**	**20.4083**	**0.3027**		**25633321**	**25.6846**	**0.3810**

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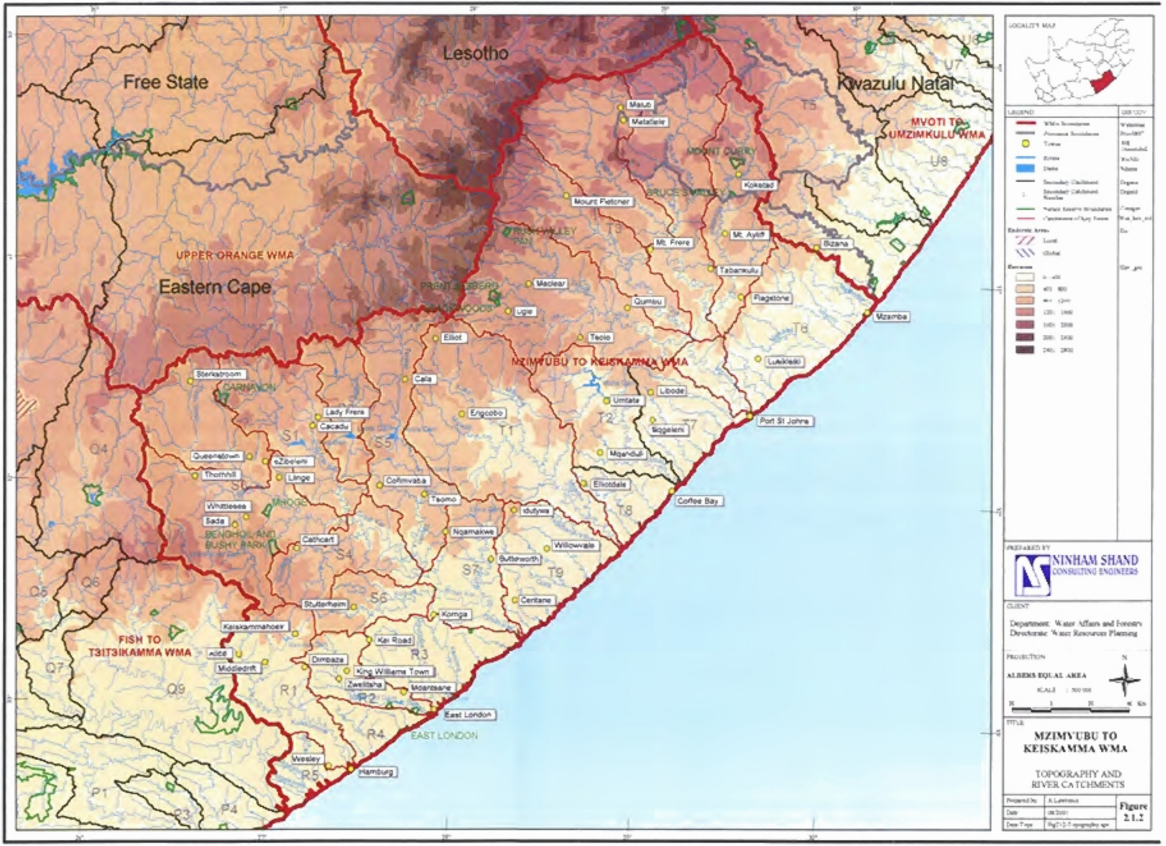
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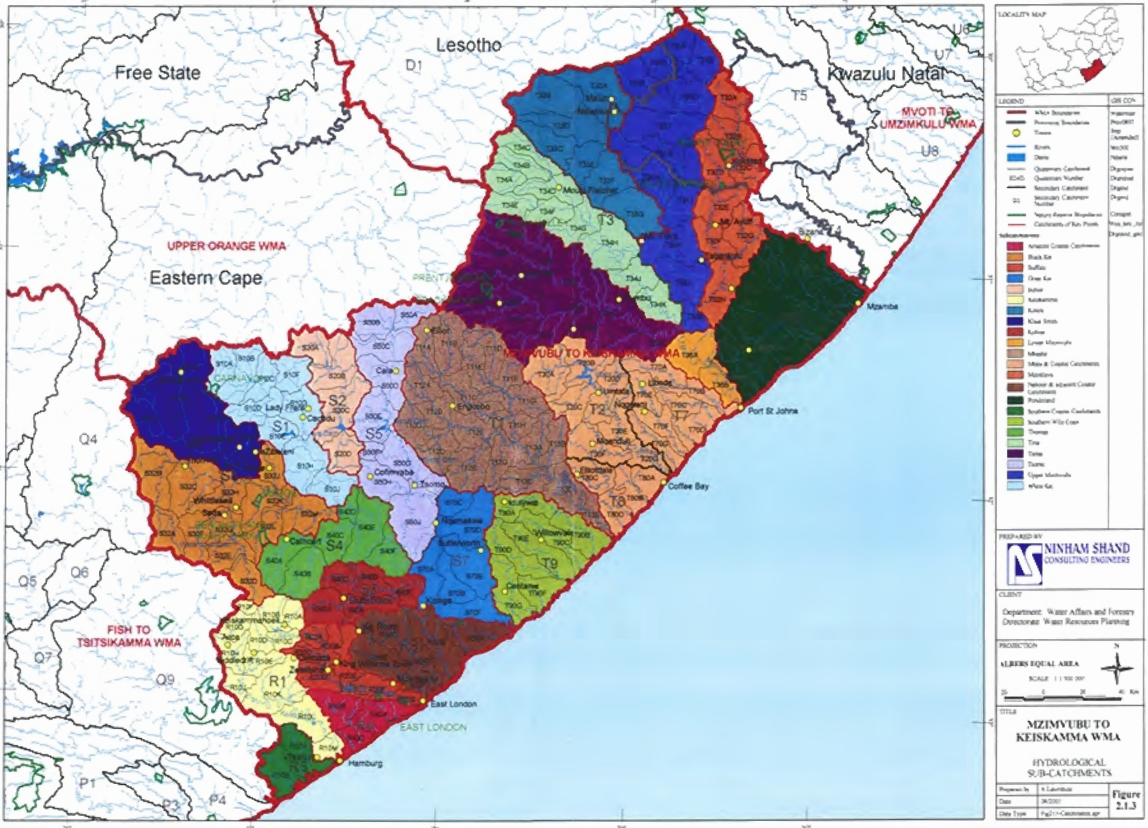

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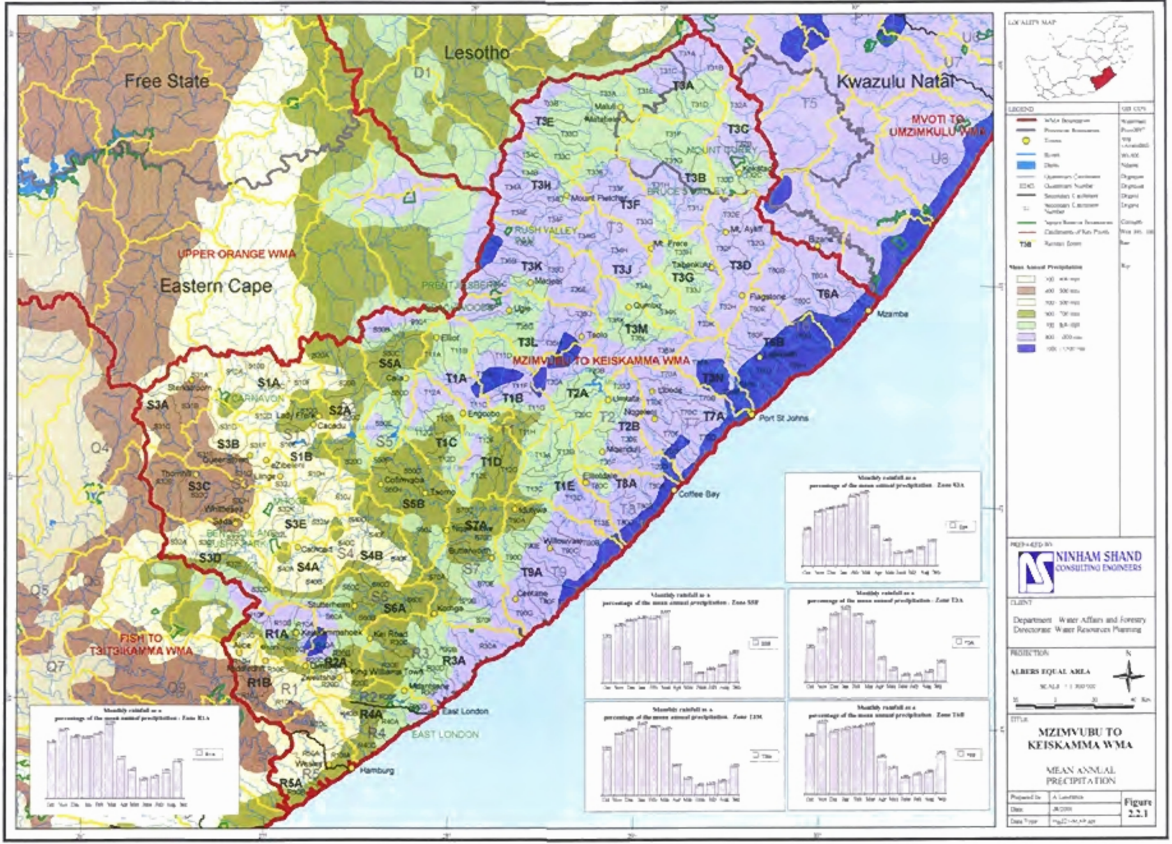

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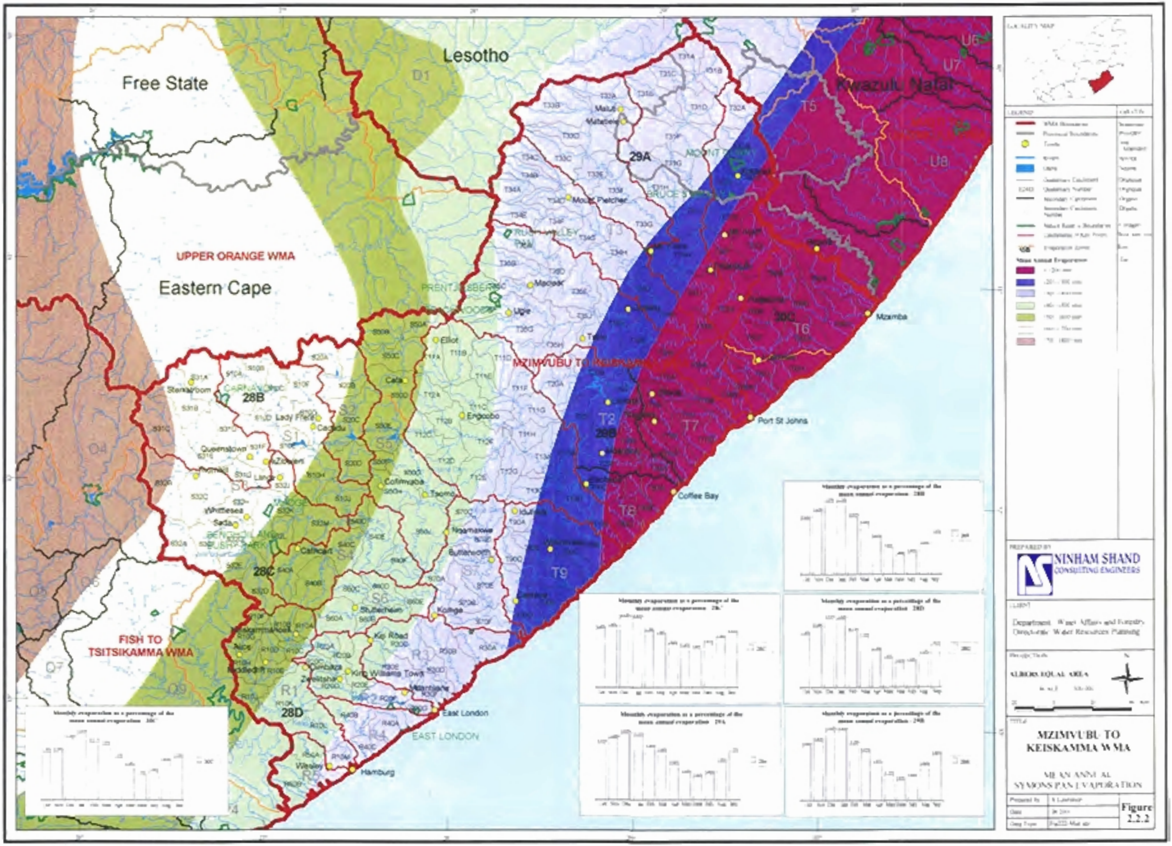

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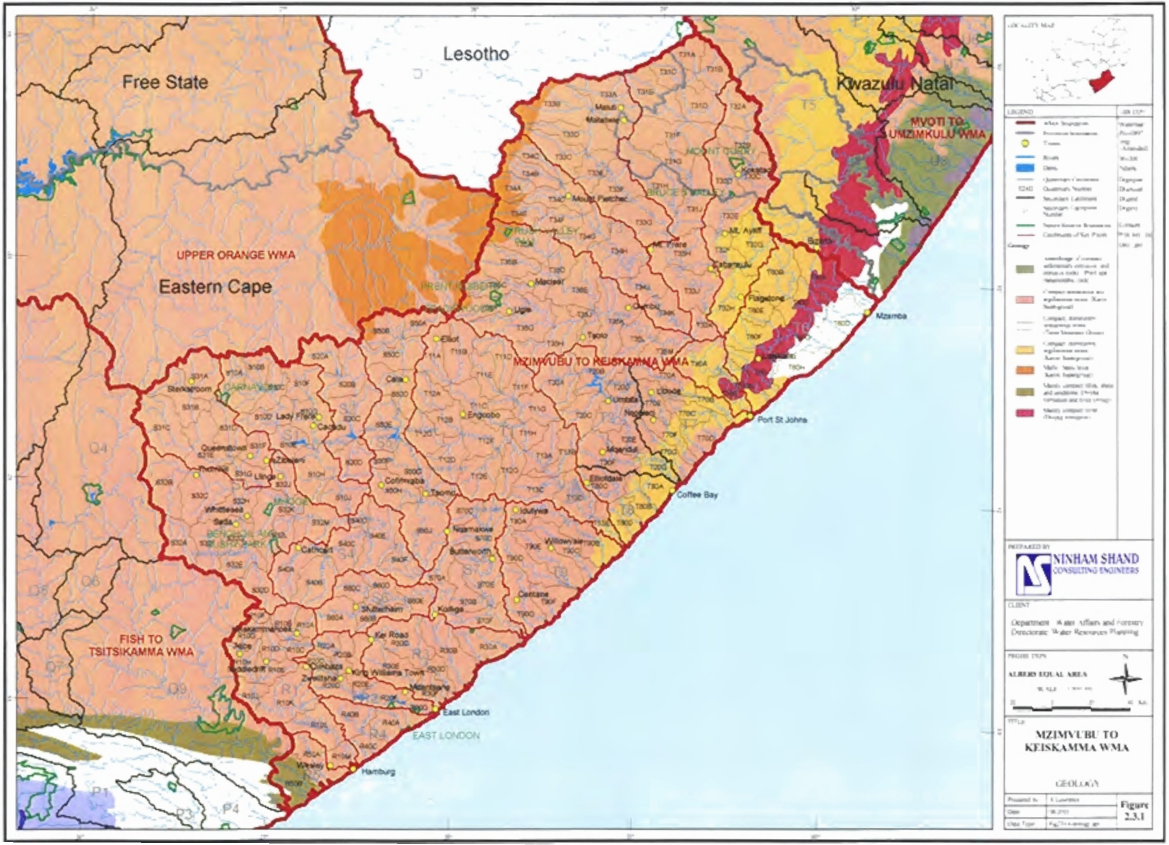
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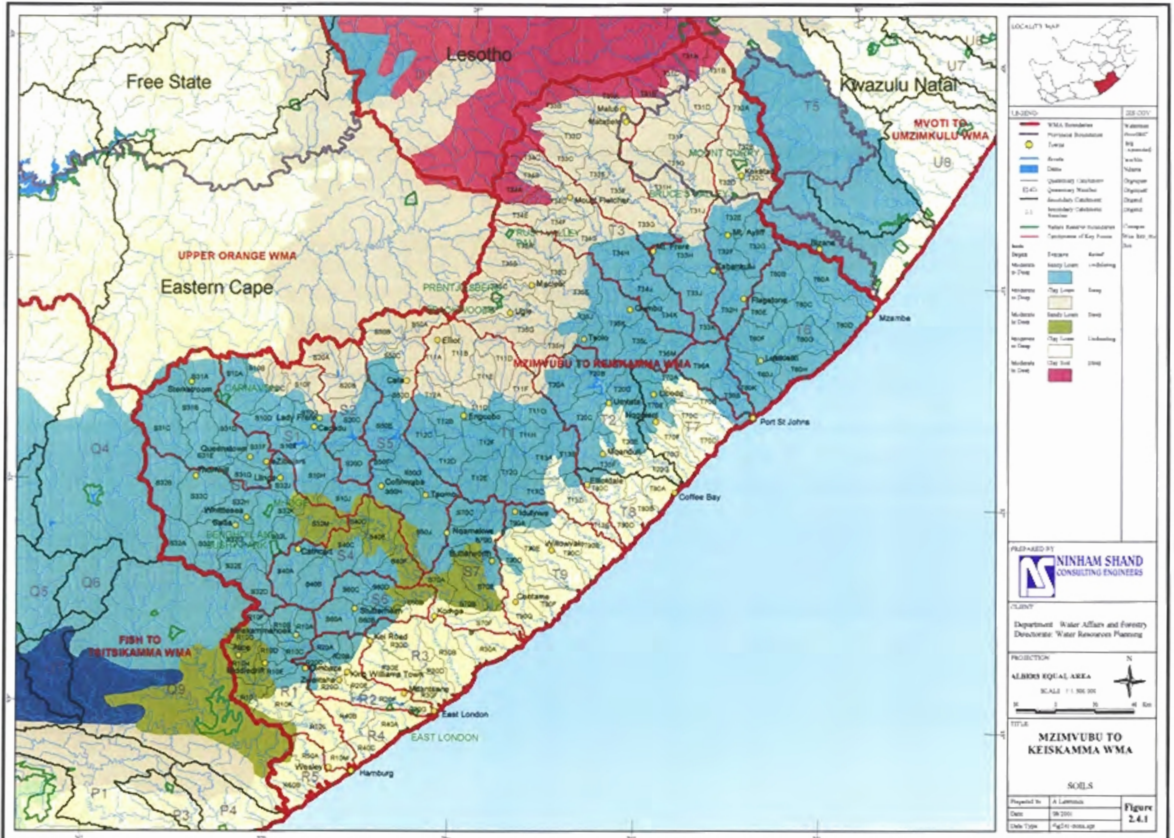

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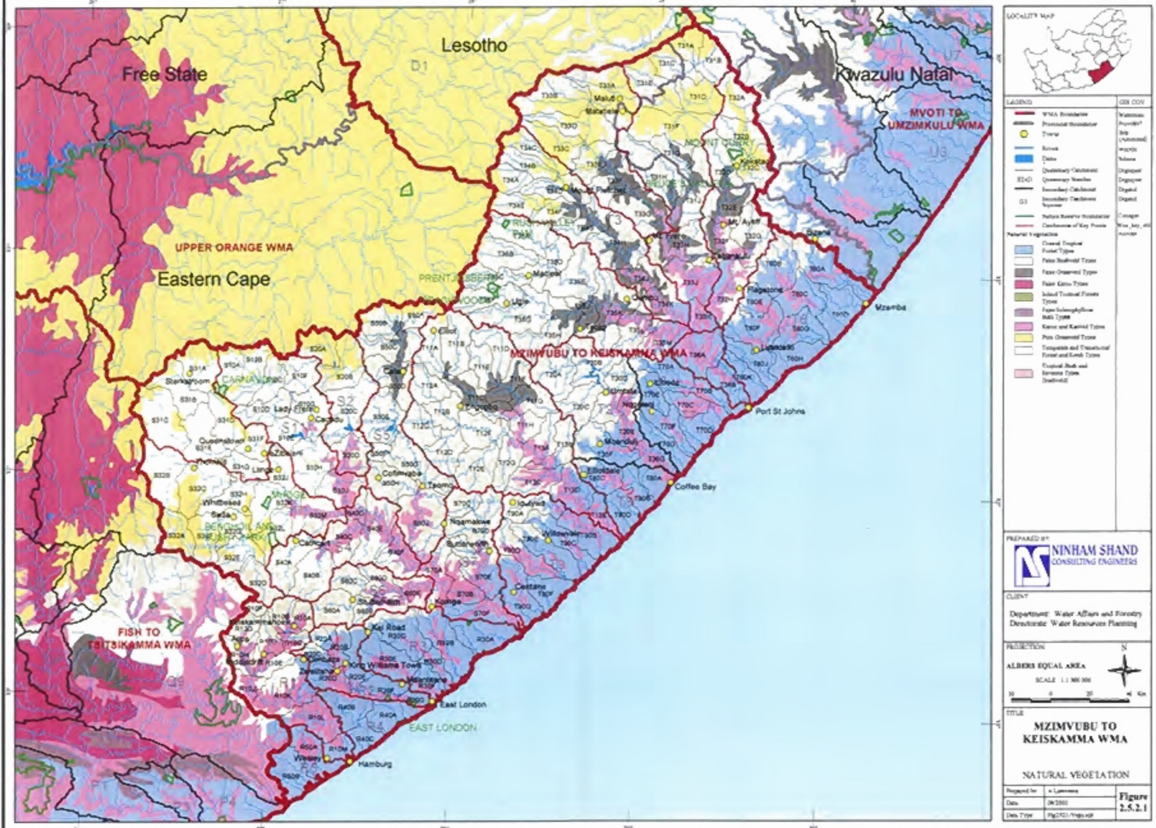
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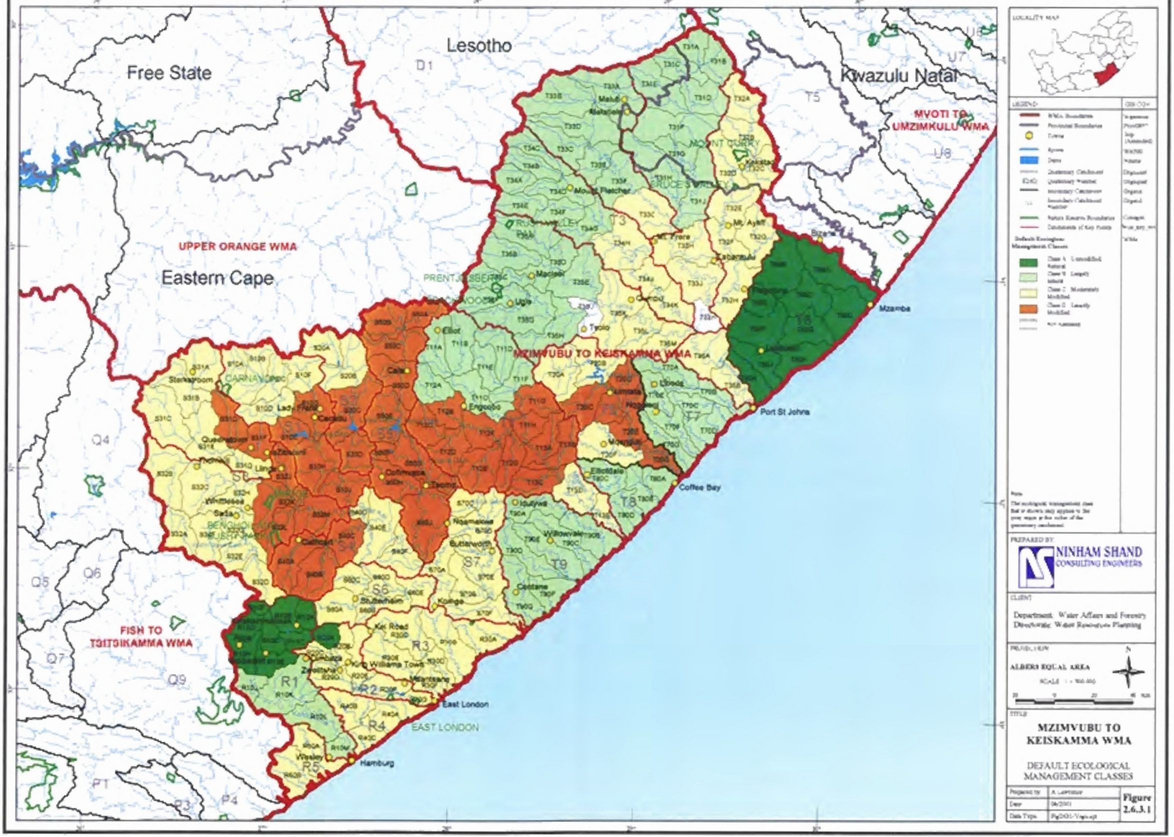
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Sihlontlweni
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Nxaxo
Kobonqaba
Ngogwane
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Nyara
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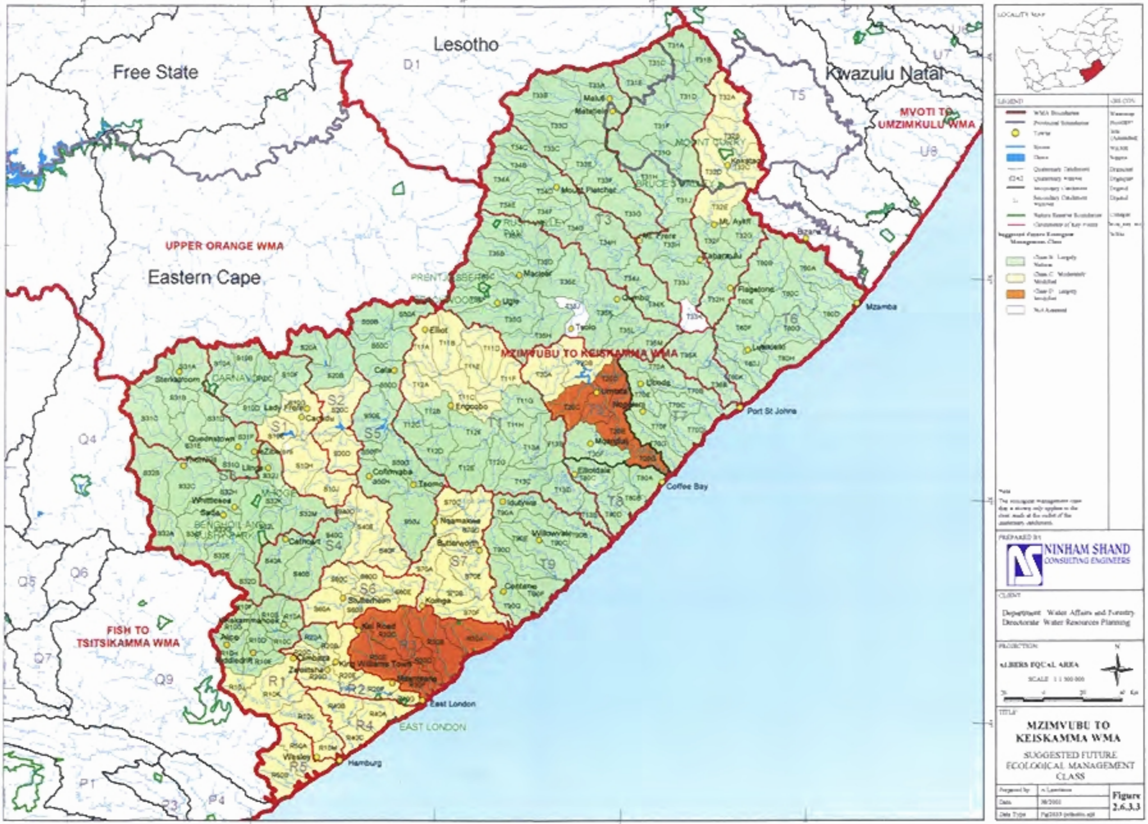
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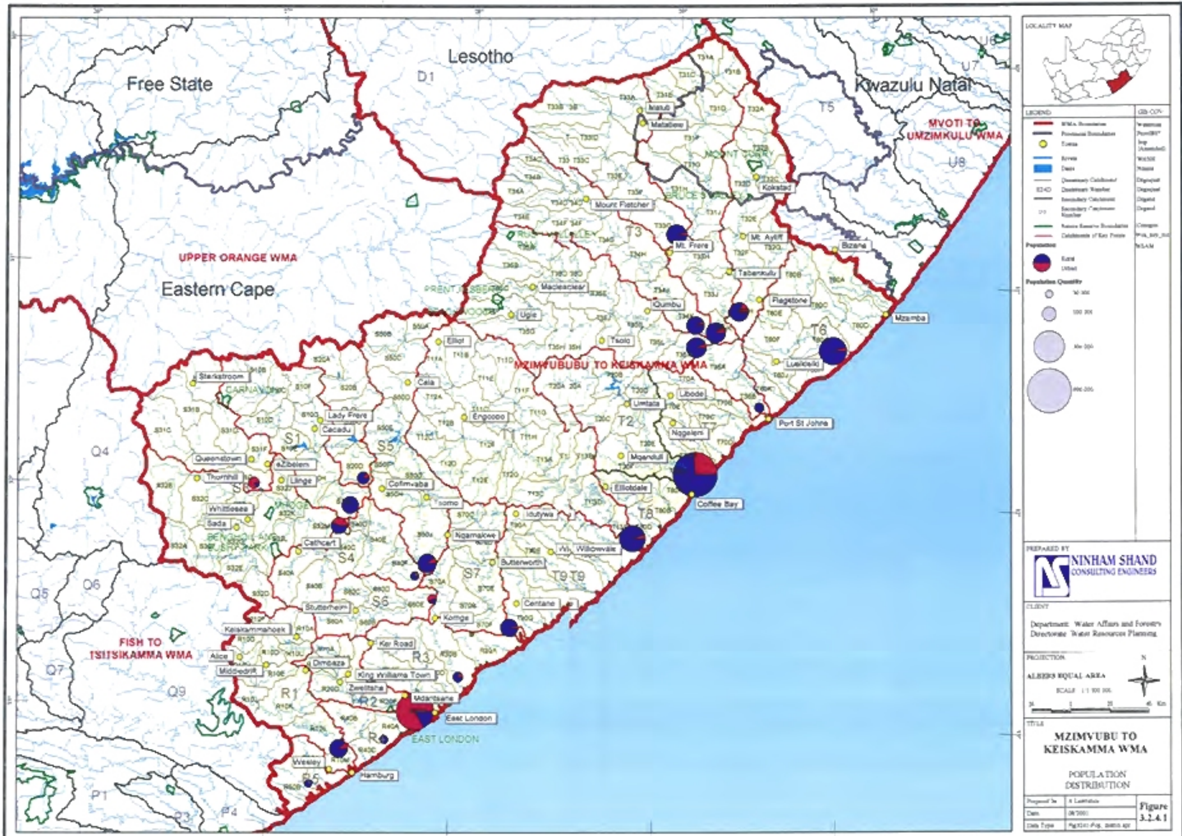

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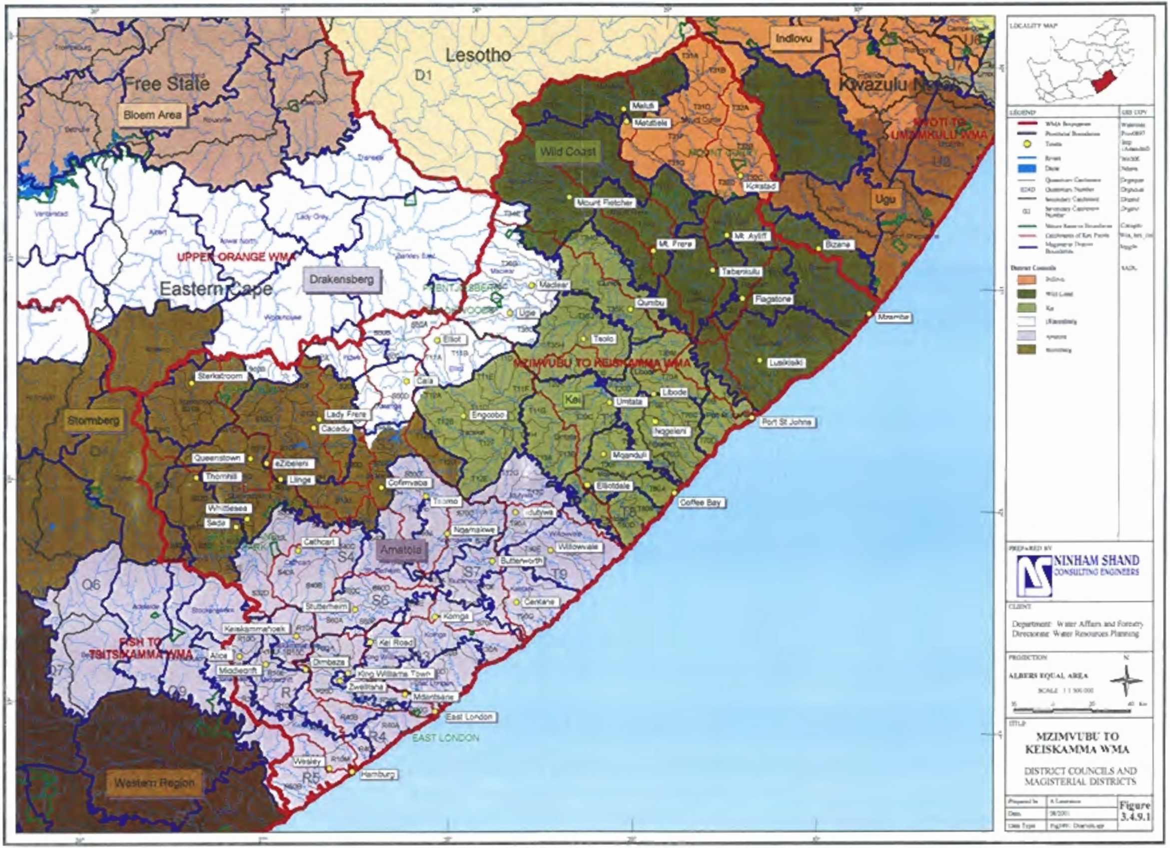
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MZIMVUBU TO KEISKAMMA WMA
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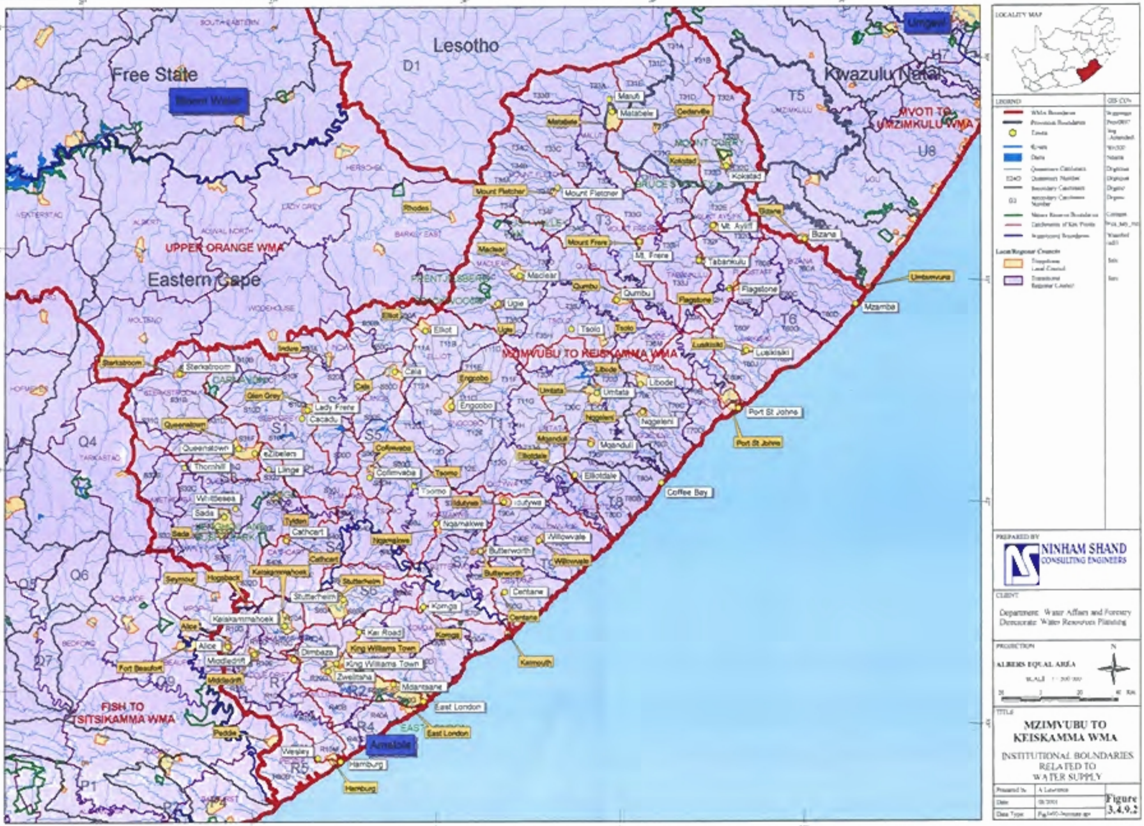

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Bizana
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Mount Frere
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Tabankulu
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Qumbu
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Ugie
Tsolo
Elliot
Mzamba
Umtamvuna
Lusikisiki
Sterkstroom
Indwe
Cala
Engcobo
Libode
Umtata
Ngqeleni
Port St Johns
Lady Frere
Cacadu
Glen Grey
Queenstown
eZibeleni
Thornhill
Ilinge
Cofimvaba
Tsomo
Mqanduli
Elliotdale
Coffee Bay
Whittlesea
Sada
Idutywa
Ngqamakwe
Cathcart
Tylden
Willowvale
Butterworth
Centane
Stutterheim
Keiskammahoek
Seymour
Hogsback
Komga
Kei Road
Alice
Middledrift
Fort Beaufort
Dimbaza
King Williams Town
Zwelitsha
Mdantsane
East London
Kei Mouth
Peddie
Wesley
Hamburg
Rhodes
LOCALITY MAP
LEGEND
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Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
INSTITUTIONAL BOUNDARIES RELATED TO WATER SUPPLY
Figure 3.4.9.2

Lesotho
Free State
Kwazulu Natal
Eastern Cape
UPPER ORANGE WMA
MZIMVUBU TO KEISKAMMA WMA
MVOTI TO UMZIMKULU WMA
FISH TO TSITSIKAMMA WMA
Umgeni
Amatola
Mount Fletcher
Matatiele
Kokstad
Bizana
Mt. Frere
Maclear
Qumbu
Tabankulu
Flagstaff
Ugie
Tsolo
Elliot
Lusikisiki
Libode
Umtata
Engcobo
Cala
Lady Frere
Cacadu
Queenstown
Whittlesea
Sada
Cathcart
Stutterheim
Keiskammahoek
Alice
Middledrift
Fort Beaufort
Dimbaza
King Williams Town
Zwelitsha
Mdantsane
East London
Komga
Kei Road
Centane
Butterworth
Idutywa
Ngqamakwe
Willowvale
Tsomo
Cofimvaba
Elliotdale
Mqanduli
Ngqeleni
Port St Johns
Coffee Bay
Kei mouth
Mzamba
Umtamvuna
Hamburg
Wesley
Peddie
Starkstroom
Sterkstroom
Indwe
Tylden
Hogsback
Seymour
Rhodes
Mt. Ayliff
Flagstone
LOCALITY MAP
LEGEND
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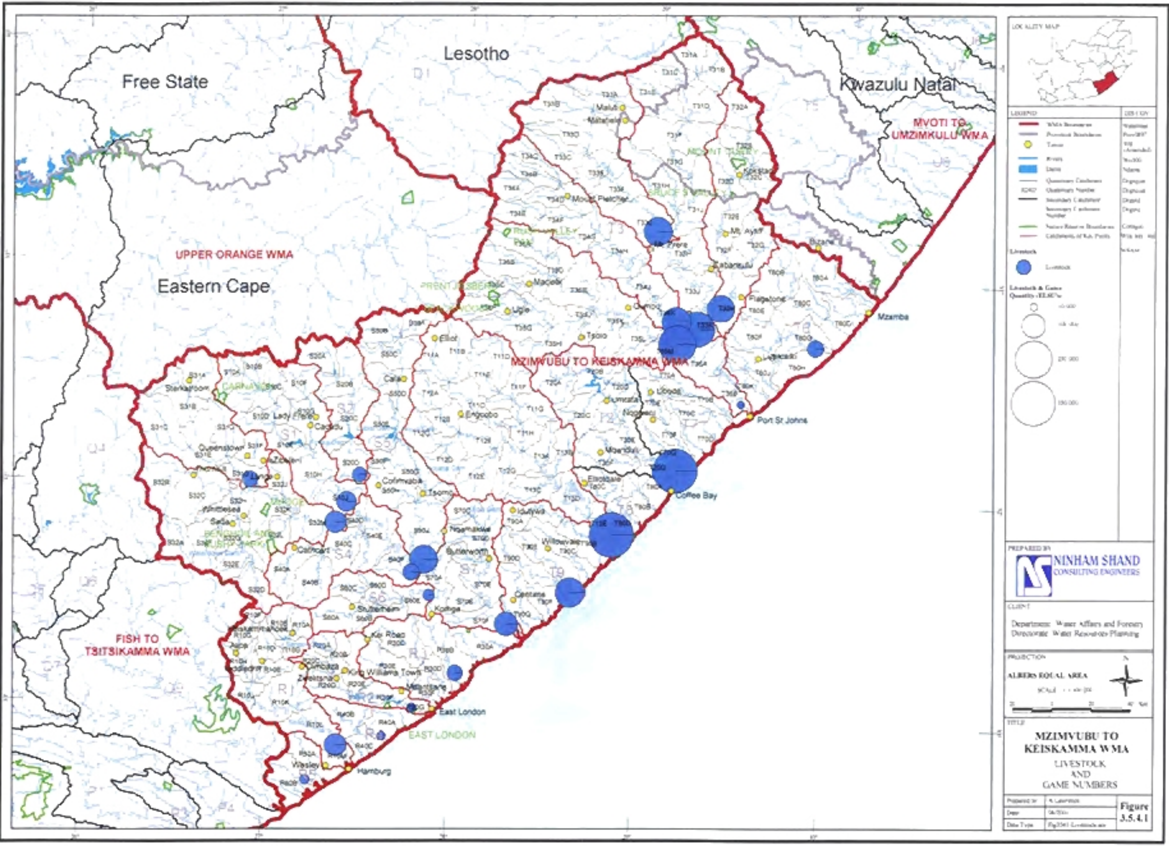
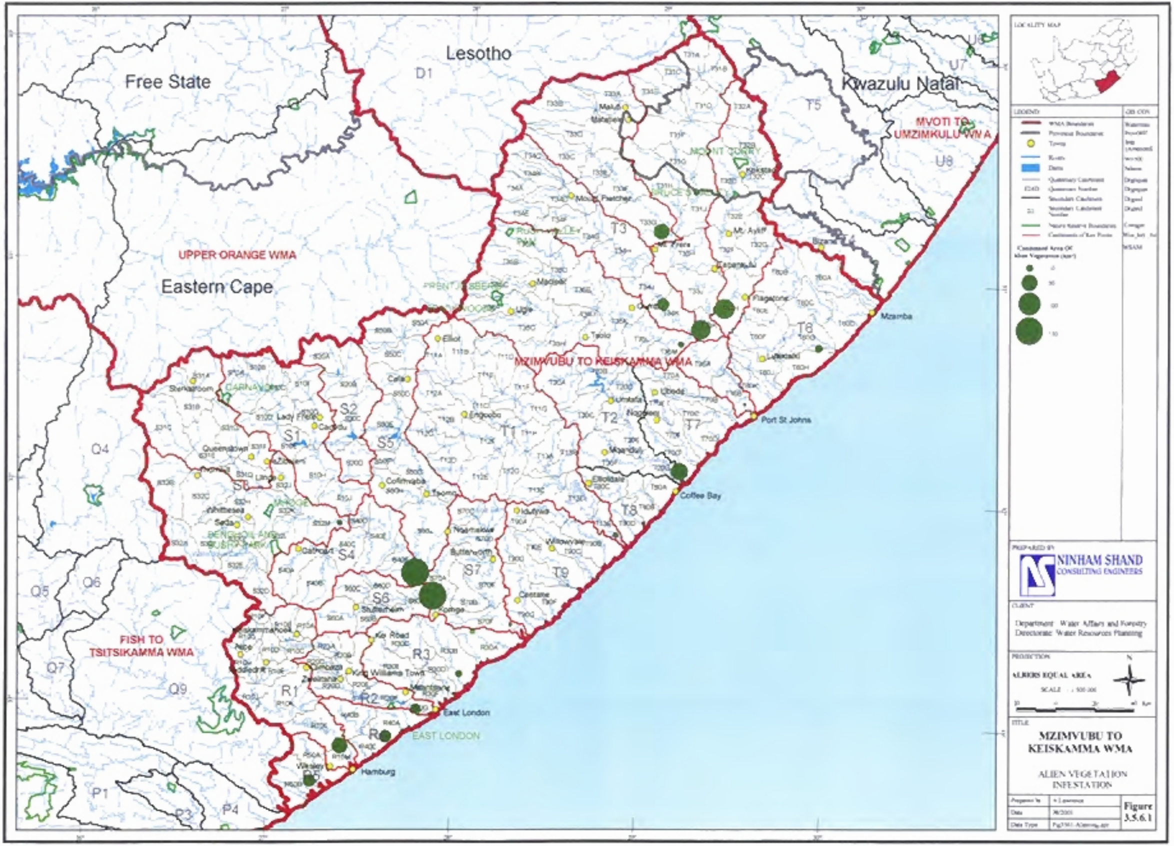
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
INSTITUTIONAL BOUNDARIES RELATED TO WATER SUPPLY
Figure 3.4.9.2



MZIMVUBU TO KEISKAMMA WMA

LIVESTOCK AND GAME NUMBERS

Figure 3.5.4.1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Free State
Kwazulu Natal
Eastern Cape
UPPER ORANGE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Port St Johns
Coffee Bay
East London
Hamburg
Mzamba
Queenstown
Lady Frere
Cofimvaba
Engcobo
Umtata
Butterworth
King Williams Town
Stutterheim
Komga
Cathcart
Whittlesea
Elliot
Cala
Idutywa
Willowvale
Ugie
Maclear
Tsolo
Flagstaff
Lusikisiki
Bizana
Mount Fletcher
Mt Ayliff
Mt Frere
Kokstad
Matatiele
Maluti
Elliotdale
Mqanduli
Libode
Ngqeleni
Qumbu
Sterkstroom
Tarkastad
Dordrecht
Peddie
Zwelitsha
Alice
Keiskammahoek
Centane
Ngqamakwe
Tsomo
Kei Road
Mdantsane
Wesley
Seda
T1
T2
T3
T6
T7
T8
T9
S1
S2
S4
S5
S6
S7
R1
R2
R3
Q4
Q5
Q6
Q7
Q9
P1
P3
P4
U8
T5
D1
LOCALITY MAP
LEGEND
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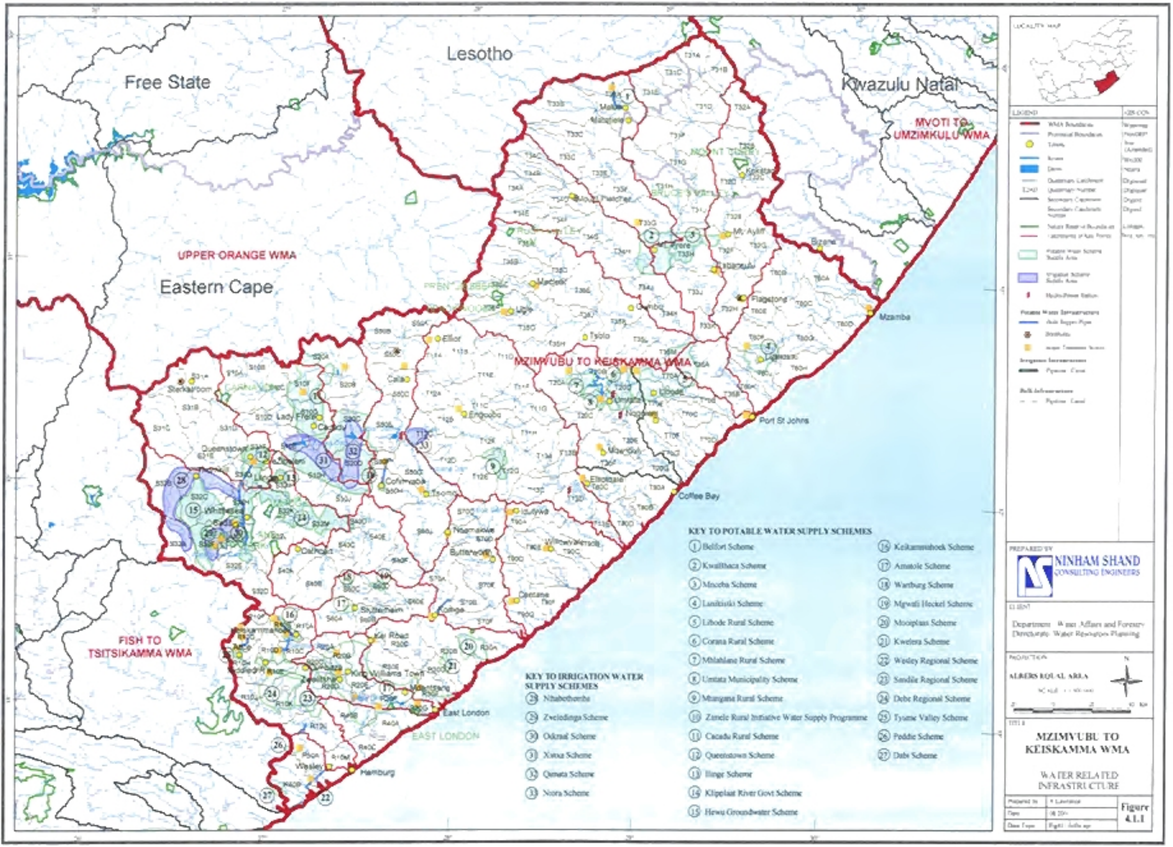
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
ALIEN VEGETATION INFESTATION
Figure 3.5.6.1



Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Port St Johns
Coffee Bay
Mzamba
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Queenstown
Lady Frere
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Cofimvaba
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Butterworth
Idutywa
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Peddie
Keiskammahoek
Alice
Fort Beaufort
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Maclear
Ugie
Tsolo
Qumbu
Tabankulu
Bizana
Lusikisiki
Libode
Ngqeleni
Mqanduli
Elliotdale
Tsomo
Ngqamakwe
Sterkstroom
Matatiele
Maluti
Mount Fletcher
Mount Frere
Kokstad
Cacadu
Lukhanji
KEY TO POTABLE WATER SUPPLY SCHEMES
1 Belfort Scheme
2 Kwabhaca Scheme
3 Mncebu Scheme
4 Lusikisiki Scheme
5 Libode Rural Scheme
6 Corana Rural Scheme
7 Mhlahlane Rural Scheme
8 Umtata Municipality Scheme
9 Mtangana Rural Scheme
10 Zimele Rural Initiative Water Supply Programme
11 Cacadu Rural Scheme
12 Queenstown Scheme
13 Ilinge Scheme
14 Klipplaat River Govt Scheme
15 Hewu Groundwater Scheme
16 Keiskammahoek Scheme
17 Amatole Scheme
18 Wartburg Scheme
19 Mgwali Heckel Scheme
20 Mooiplaas Scheme
21 Kwelera Scheme
22 Wesley Regional Scheme
23 Sandile Regional Scheme
24 Debe Regional Scheme
25 Tyume Valley Scheme
26 Peddie Scheme
27 Dabi Scheme
KEY TO IRRIGATION WATER SUPPLY SCHEMES
28 Nthabethemba
29 Zweledinga Scheme
30 Oxkraal Scheme
31 Xonxa Scheme
32 Qamata Scheme
33 Ncora Scheme
LOCALITY MAP
LEGEND
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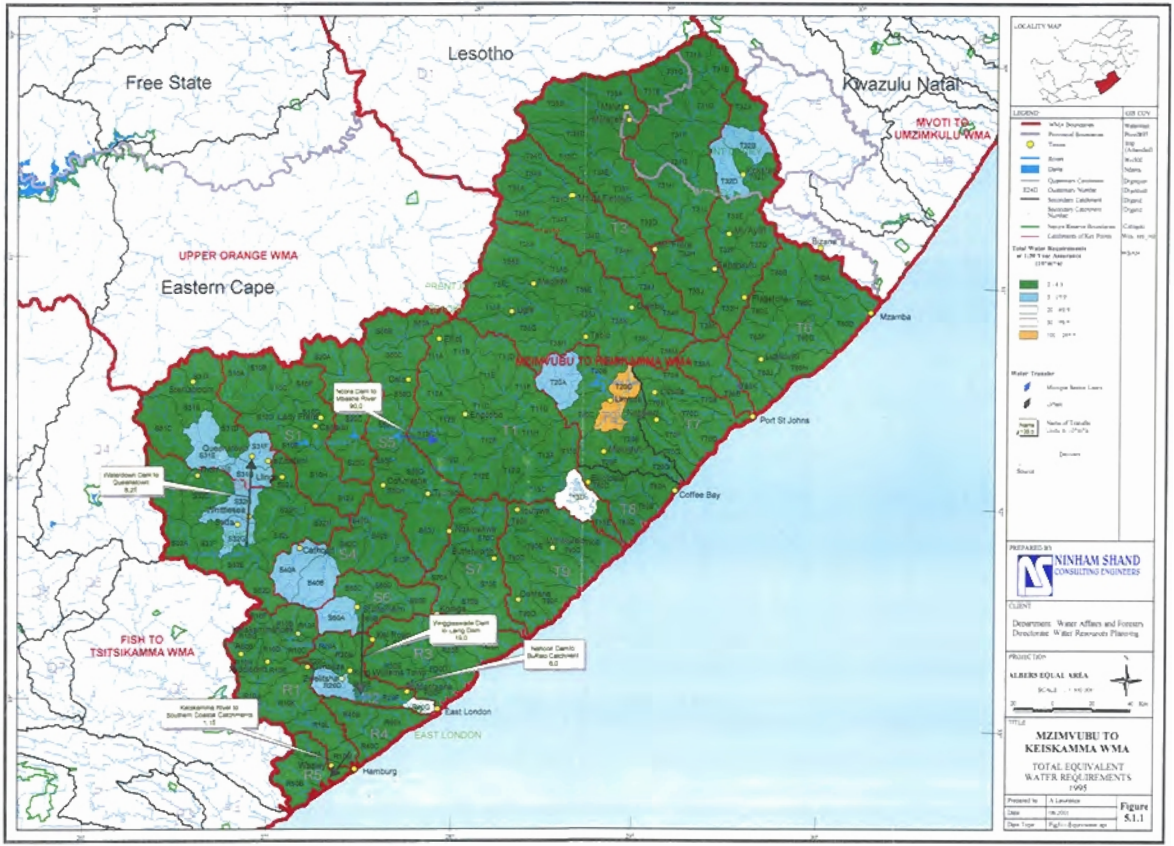
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
WATER RELATED INFRASTRUCTURE
Figure 4.1.1



Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Mzamba
Port St Johns
Coffee Bay
East London
Hamburg
Bizana
Queenstown
Cathcart
King Williams Town
Ncora Dam to Mbashe River 90,0
Waterdown Dam to Queenstown 8,27
Wriggleswade Dam to Laing Dam 19,0
Nahoon Dam to Buffalo Catchment 6,0
Keiskamma River to Southern Coastal Catchments 1,15
LOCALITY MAP
LEGEND
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PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
TOTAL EQUIVALENT WATER REQUIREMENTS 1995
Figure 5.1.1


Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
Mzamba
Port St Johns
Coffee Bay
East London
EAST LONDON
Hamburg
Total Water Requirements
PREPARED BY
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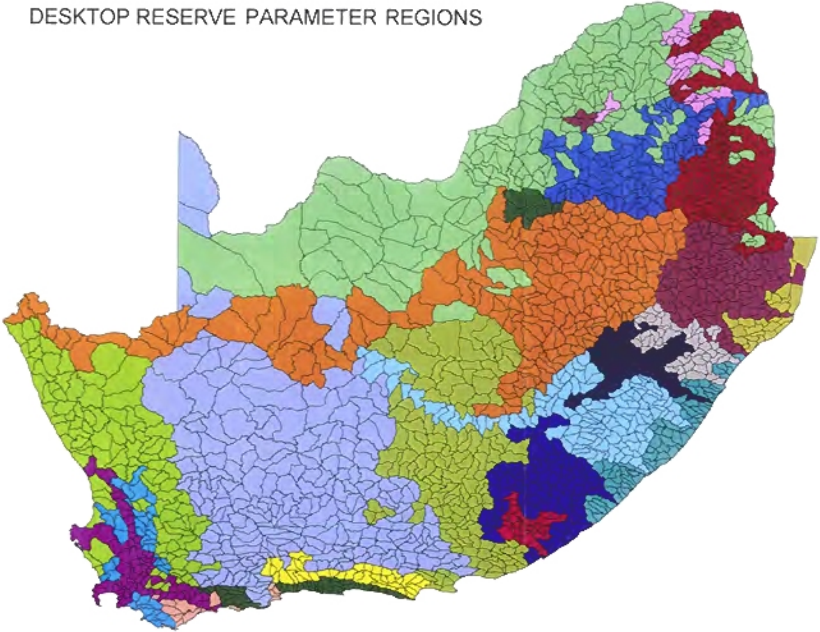
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
WATER REQUIREMENTS AT 1:50 YEAR ASSURANCE PER USER SECTOR 1995
Figure 5.1.2

DESKTOP RESERVE PARAMETER REGIONS



LEGEND

1. Western Cape (wet)
2. Western Cape (dry)
3. Western Karoo
4. Eastern Karoo
5. Southern Cape (dry)
6. Southern Karoo
7. Southern Cape (wet)
8. Eastern Cape (arid)
9. Eastern Cape
10. Amatola
11. T Drainage Region
12. T Drainage Region (coast)
13. Drakensberg
14. Southern Natal
15. Northern Natal
16. Zululand
17. Eastern Escarpment
18. Lowveld
19. Eastern Foothills
20. Vaal
21. Olifants

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PROJECTION

SCALE

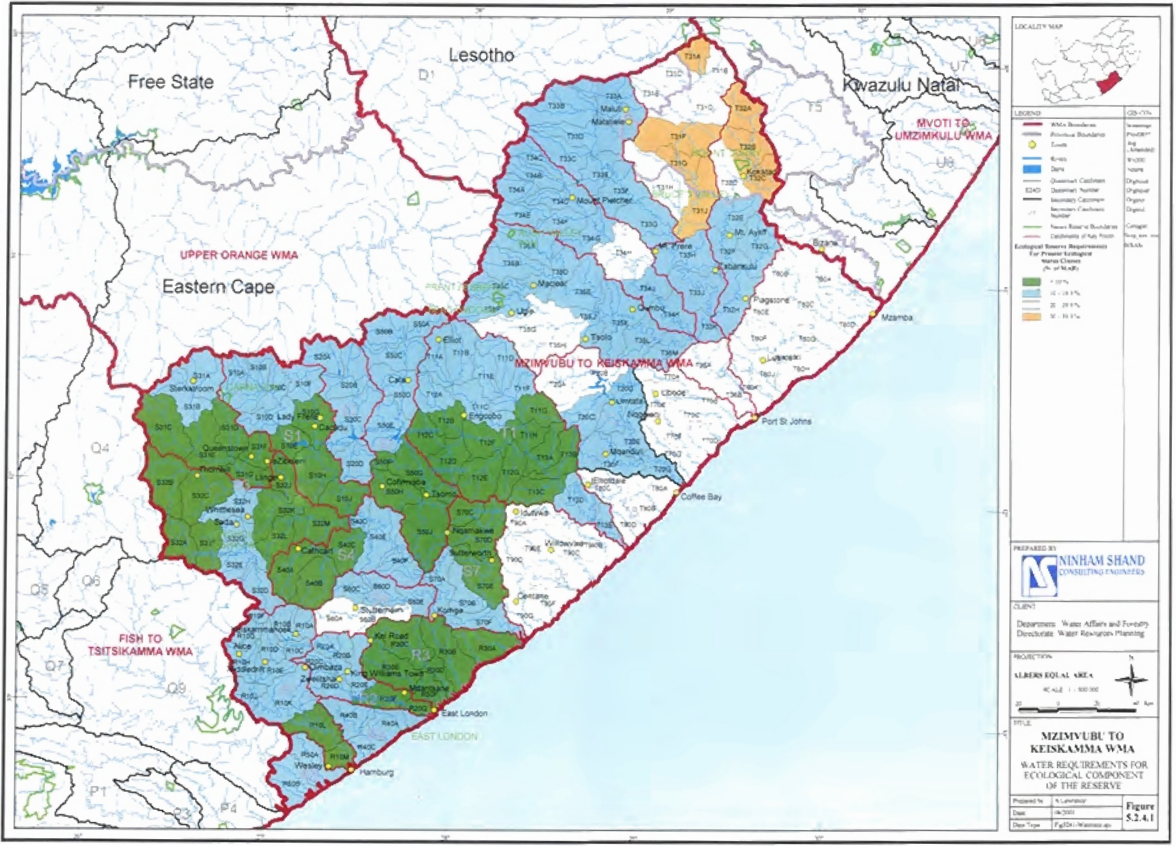
N

TITLE

MZIMVUBU TO KEISKAMMA WMA

DESKTOP RESERVE PARAMETER REGIONS

Prepared by	A Lawrence	Figure 5.2.1.1
Date	08/2001	
Data Type		



Lesotho
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Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Mzamba
Port St Johns
Coffee Bay
East London
Hamburg
King Williams Town
Queenstown
Cathcart
Butterworth
Ngamakwe
Elliot
Cala
Engcobo
Umtata
Bizana
Mt. Ayliff
Mount Fletcher
Maclear
Tsolo
Qumbu
Flagstaff
Lusikisiki
Libode
Elliotdale
Idutywa
Willowvale
Centane
Komga
Stutterheim
Kei Road
Zwelitsha
Dimbaza
Mdantsane
Wesley
Alice
Keiskammahoek
Whittlesea
Sada
Cofimvaba
Tsomo
Lady Frere
Sterkstroom
Matatiele
Maluti
Kokstad
Tabankulu
Ugie
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
Ecological Reserve Requirements For Present Ecological Status Classes (% of MAR)
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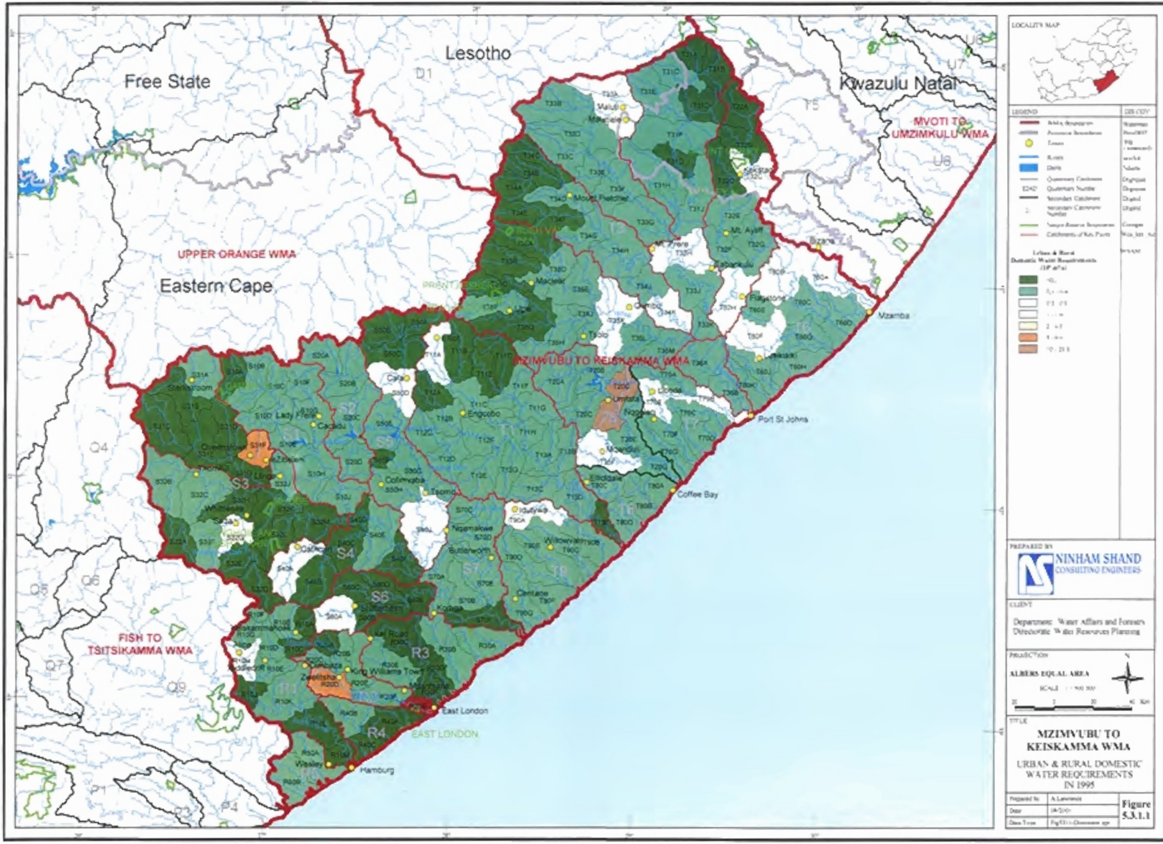
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE
Figure 5.2.4.1


Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Mount Fletcher
Maclear
Ugie
Mt. Ayliff
Flagstaff
Tsolo
Qumbu
Lusikisiki
Port St Johns
Mzamba
Umtata
Engcobo
Cala
Lady Frere
Cacadu
Queenstown
Whittlesea
Cathcart
Cofimvaba
Tsomo
Idutywa
Ngqamakwe
Butterworth
Willowvale
Centane
Komga
Stutterheim
King Williams Town
Zwelitsha
East London
Hamburg
Coffee Bay
Elliotdale
Mqanduli
Libode
Ngqeleni
LOCALITY MAP
LEGEND
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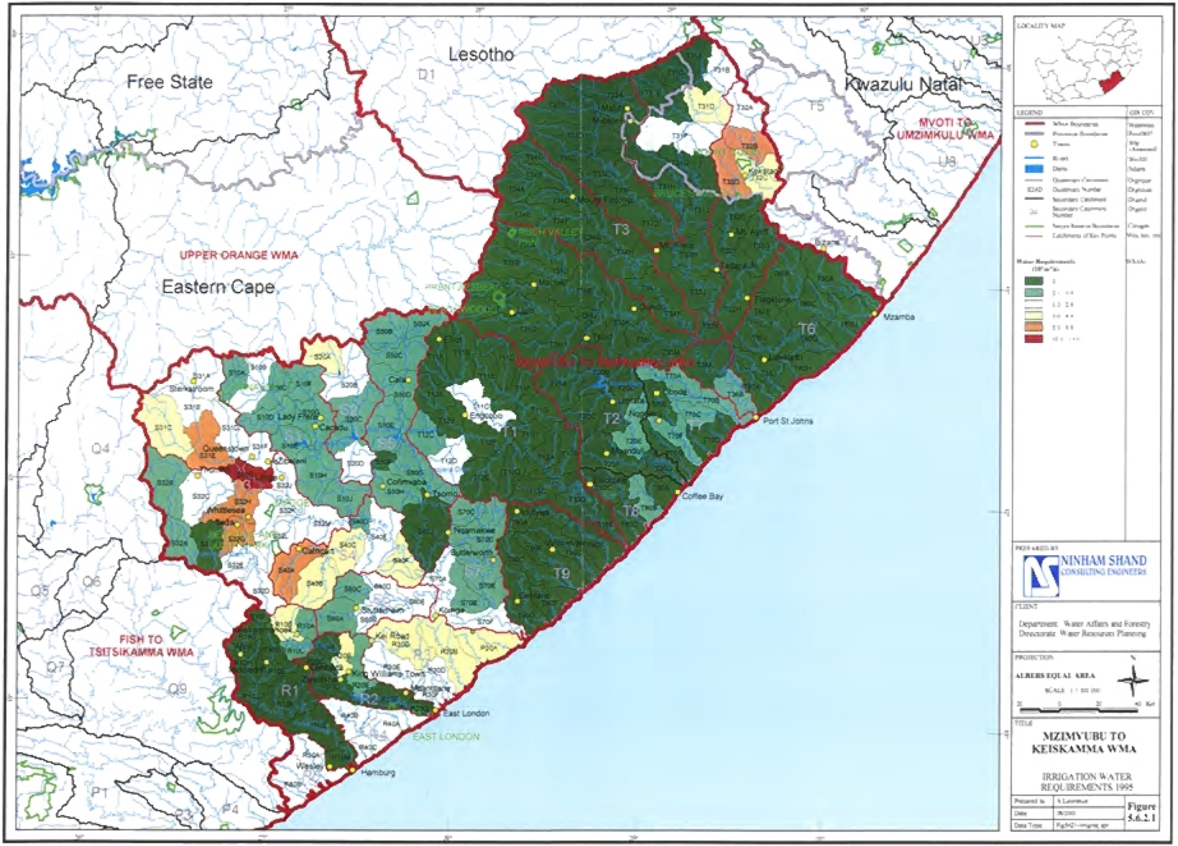
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
URBAN & RURAL DOMESTIC WATER REQUIREMENTS IN 1995
Prepared by
A. Lawrence
Date
Figure 5.3.1.1


Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
FISH TO TSITSIKAMMA WMA
EAST LONDON
T3
T6
T1
T2
T9
R1
R2
Mzamba
Port St Johns
Coffee Bay
East London
Hamburg
King Williams Town
Queenstown
Cala
Engcobo
Butterworth
LOCALITY MAP
LEGEND
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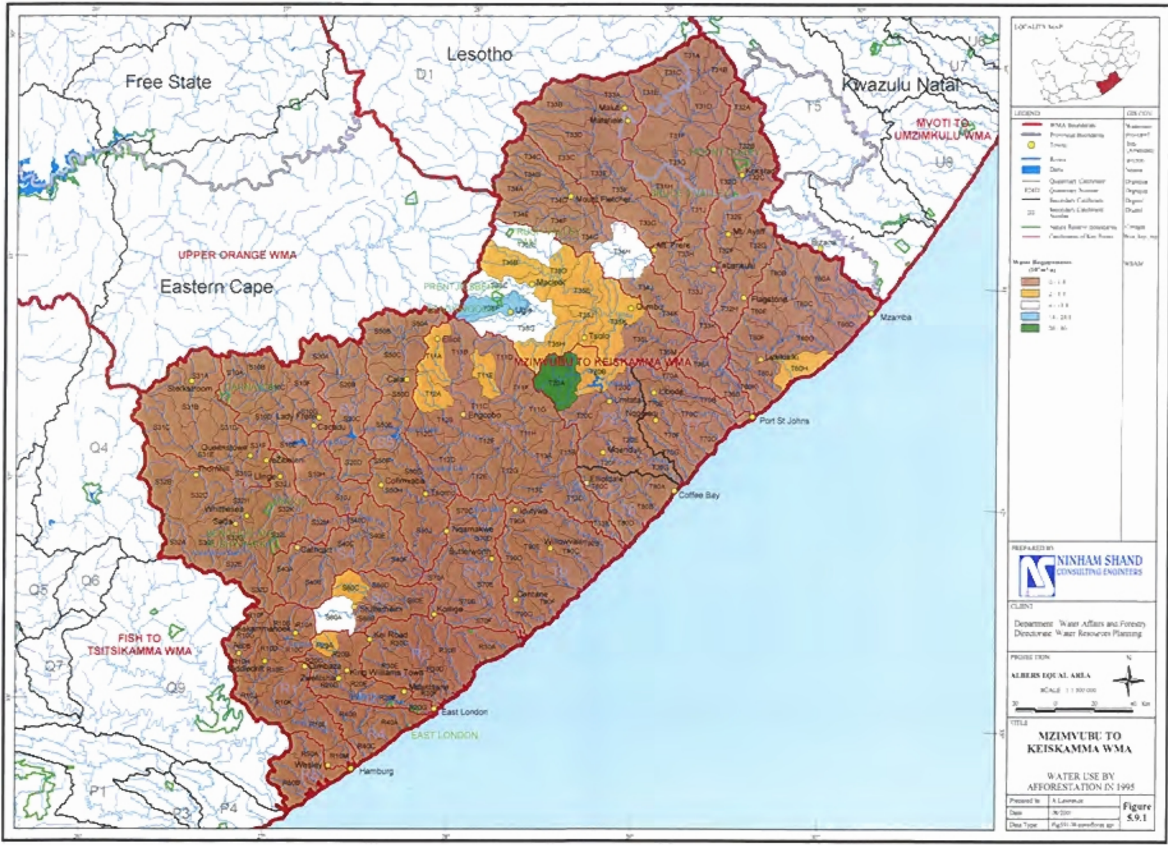
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
IRRIGATION WATER REQUIREMENTS 1995
Figure 5.6.2.1



Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
Mount Fletcher
Mt Frere
Maclear
Ugie
Tsolo
Qumbu
Flagstaff
Mzamba
Port St Johns
Coffee Bay
Elliot
Cala
Engcobo
Umtata
Libode
Mqanduli
Elliotdale
Idutywa
Willowvale
Butterworth
Ngqamakwe
Centane
Komga
Tsomo
Cofimvaba
Queenstown
Lady Frere
Cacadu
Sterkstroom
Whittlesea
Cathcart
Stutterheim
Keiskammahoek
Zwelitsha
King Williams Town
Mdantsane
East London
Wesley
Hamburg
Kei Road
Mt Ayliff
Tabankulu
Lusikisiki
Kokstad
Matatiele
Maluti
Bizana
EAST LONDON
LOCALITY MAP
LEGEND
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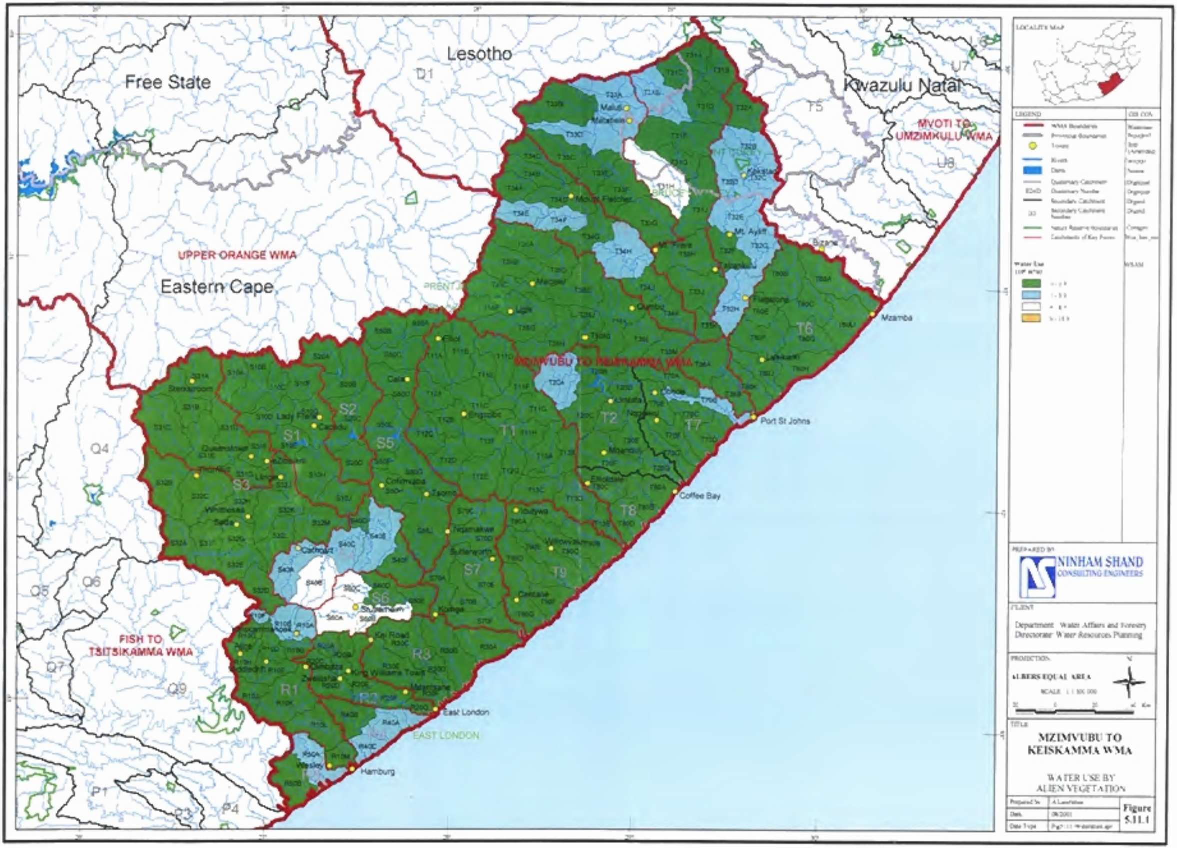
ALBERS EQUAL AREA
MZIMVUBU TO KEISKAMMA WMA
WATER USE BY AFFORESTATION IN 1995
Figure 5.9.1


Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Matatiele
Mount Fletcher
Mt. Frere
Mt. Ayliff
Kokstad
Bizana
Tabankulu
Flagstaff
Mzamba
Lusikisiki
Port St Johns
Coffee Bay
Elliotdale
Mqanduli
Umtata
Ngqeleni
Libode
Tsolo
Qumbu
Ugie
Maclear
Elliot
Cala
Engcobo
Lady Frere
Cacadu
Queenstown
Whittlesea
Sada
Cathcart
Cofimvaba
Tsomo
Idutywa
Ngamakwe
Butterworth
Willowvale
Centane
Komga
Stutterheim
Keiskammahoek
Kei Road
King Williams Town
Zwelitsha
Dimbaza
Alice
Middledrift
Mdantsane
East London
Wesley
Hamburg
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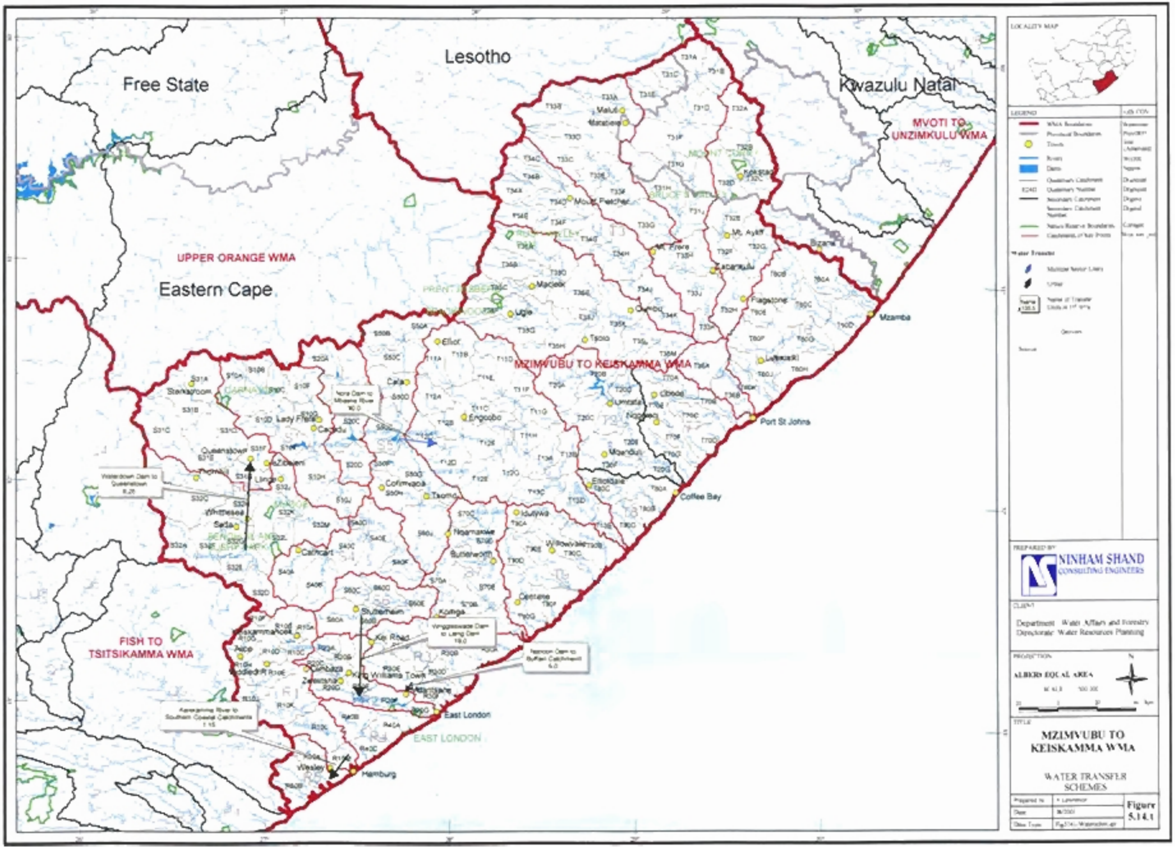
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
WATER USE BY ALIEN VEGETATION
Figure 5.11.1



Lesotho
Free State
Kwazulu Natal
MVOTI TO UNZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Mzamba
Port St Johns
Coffee Bay
East London
Hamburg
Queenstown
King Williams Town
Stutterheim
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Maclear
Mount Fletcher
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Mt Ayliff
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Ngqamakwe
Cofimvaba
Lady Frere
Sterkstroom
Whittlesea
Keiskammahoek
Alice
Zwelitsha
Dimbaza
Mdantsane
Kei Road
Komga
Wesley
Bizana
Tabankulu
LOCALITY MAP
LEGEND
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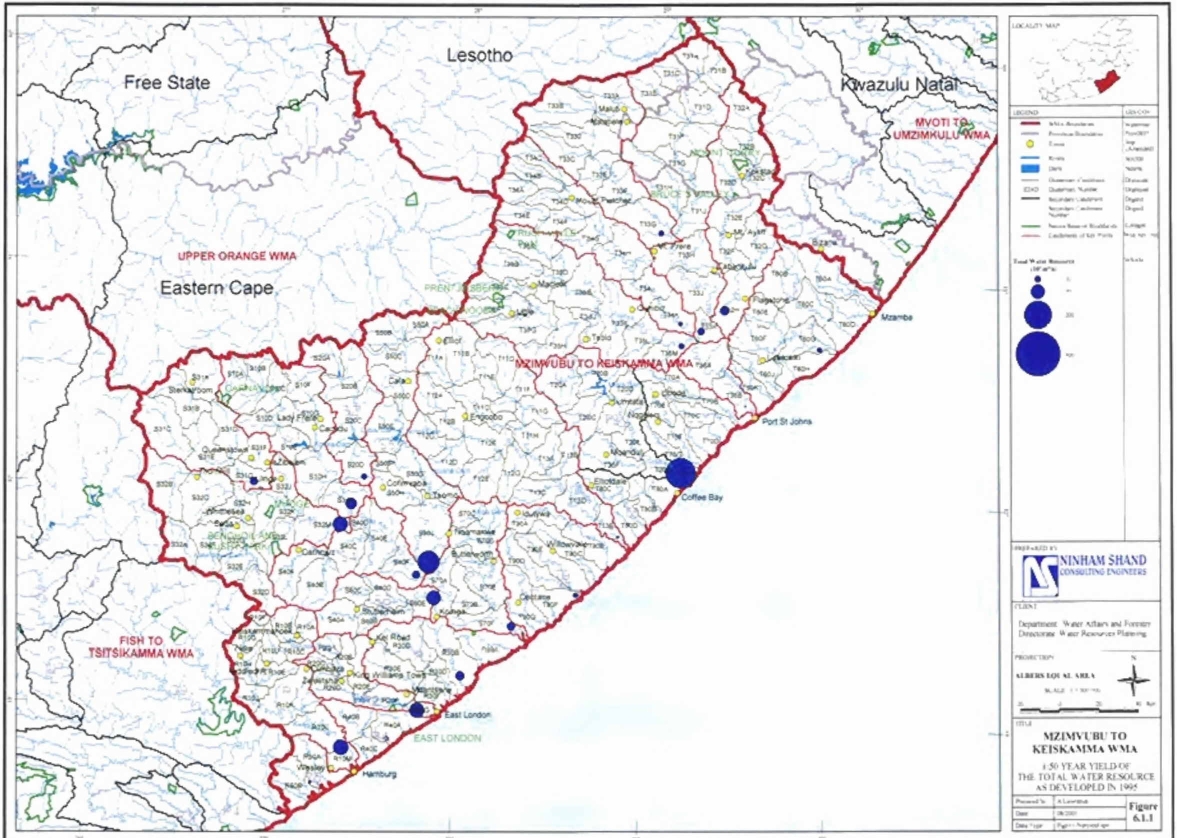
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
WATER TRANSFER SCHEMES
Figure 5.14.1



Lesotho
Free State
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MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
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Engcobo
Lady Frere
Cofimvaba
Butterworth
Idutywa
Komga
Stutterheim
Willowvale
Elliotdale
Bizana
LOCALITY MAP
LEGEND
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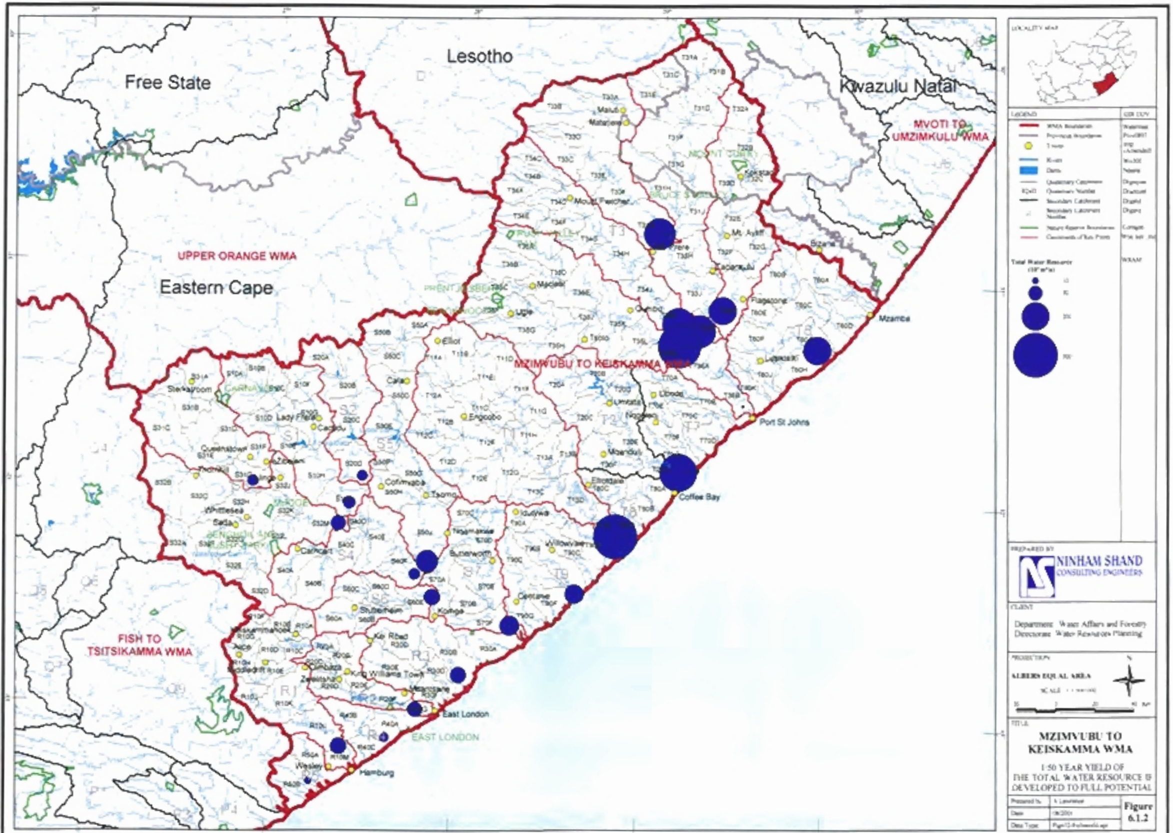
ALBERS EQUAL AREA
N
TITLE
MZIMVUBU TO KEISKAMMA WMA
1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE AS DEVELOPED IN 1995
Figure 6.1.1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Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
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Stutterheim
King Williams Town
Komga
Butterworth
Willowvale
Idutywa
Centane
Mt. Ayliff
Flagstaff
Bizana
Lusikisiki
Qumbu
Tsolo
Umtata
Mqanduli
Elliotdale
Ugie
Maclear
Mount Fletcher
Matatiele
Kokstad
Tsomo
Cofimvaba
Sterkstroom
Wesley
Keiskammahoek
Alice
Middledrift
Zwelitsha
Dimbaza
Mdantsane
Total Water Resource
PREPARED BY
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Directorate: Water Resources Planning
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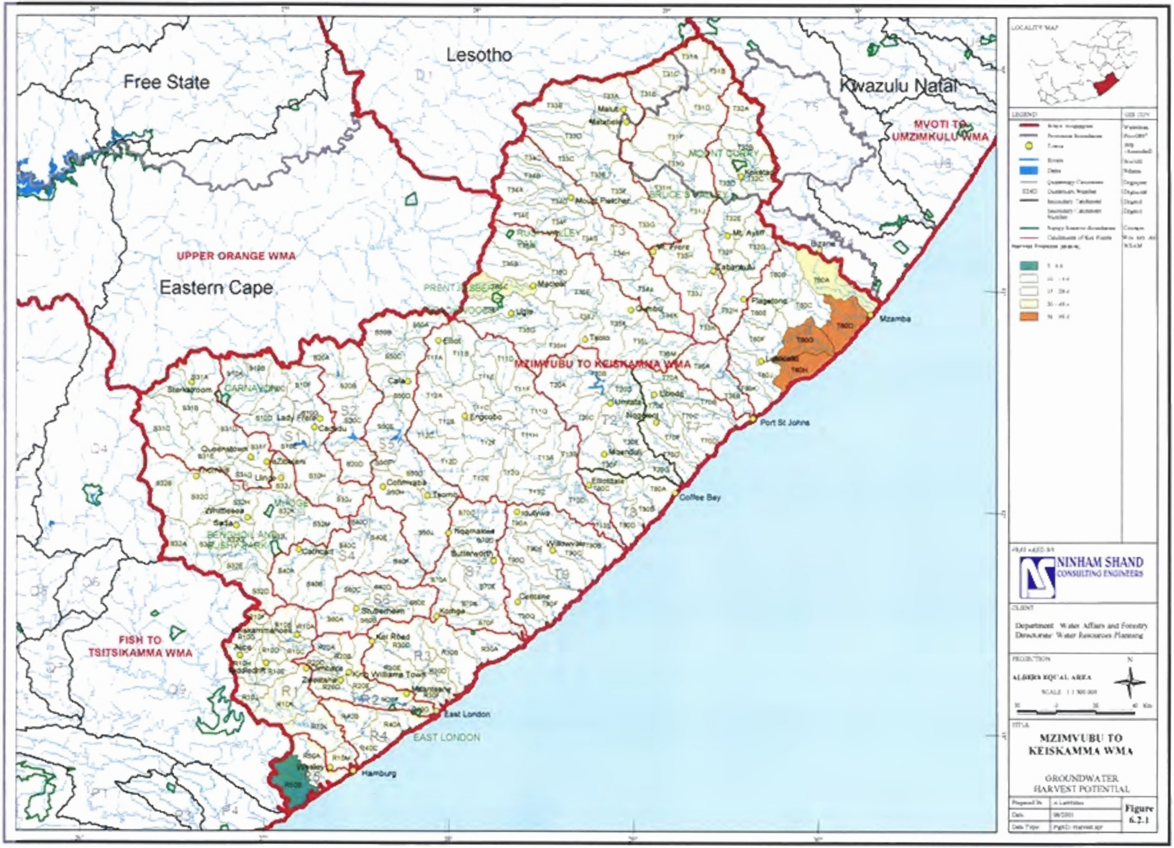
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE IF DEVELOPED TO FULL POTENTIAL
Figure 6.1.2



Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
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MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
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Bizana
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Flagstaff
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Libode
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Mqanduli
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Centane
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Nqamakwe
Engcobo
Tsomo
Cofimvaba
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Lady Frere
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Queenstown
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Cathcart
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Kei Road
King William's Town
Zwelitsha
Dimbaza
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Maclear
Ugie
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Qumbu
Mt. Frere
Mt. Ayliff
Tabankulu
Kokstad
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Maluti
Matatiele
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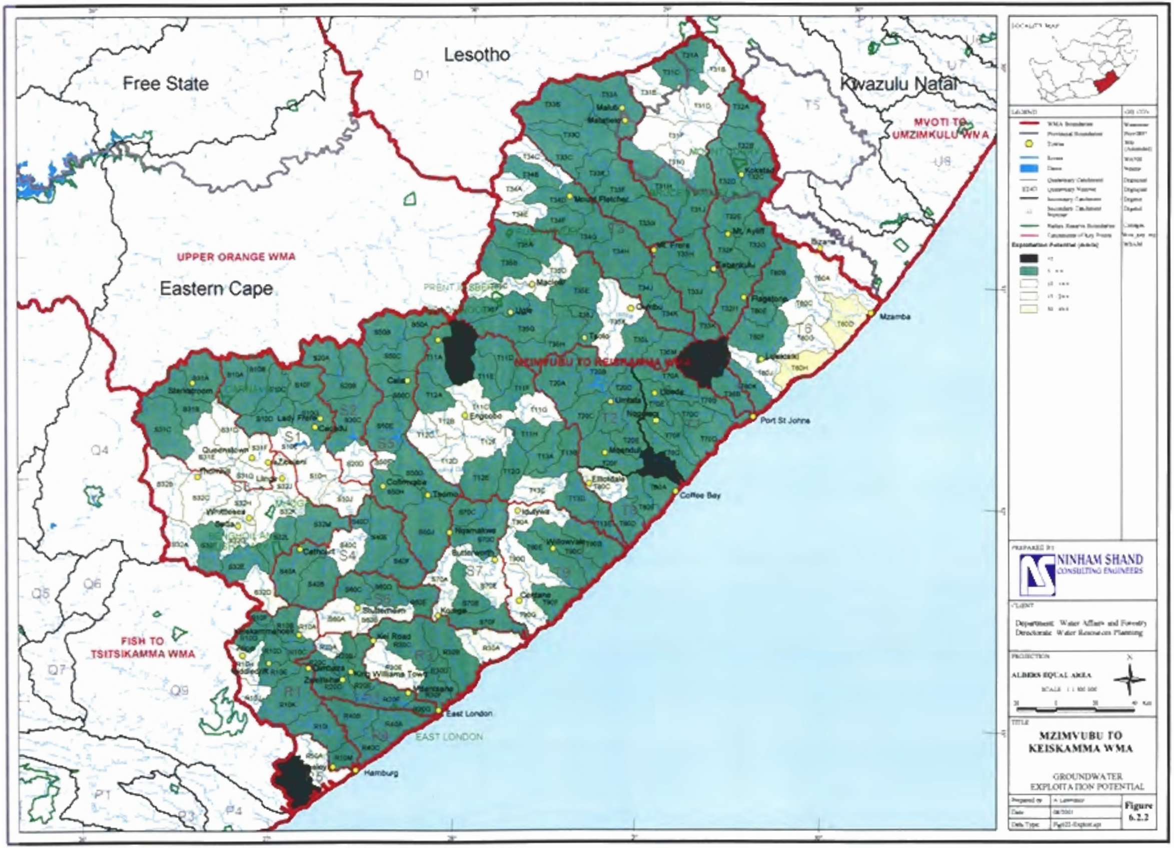
ALBERS EQUAL AREA
MZIMVUBU TO KEISKAMMA WMA
GROUNDWATER HARVEST POTENTIAL
Figure 6.2.1



Lesotho
Free State
Kwazulu Natal
Eastern Cape
UPPER ORANGE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
Mzamba
Port St Johns
Coffee Bay
East London
EAST LONDON
Hamburg
Kokstad
Mount Fletcher
Mt Frere
Mt Ayliff
Flagstaff
Lusikisiki
Bizana
Maclear
Ugie
Tsolo
Umtata
Engcobo
Cala
Lady Frere
Queenstown
Whittlesea
Cathcart
Cofimvaba
Tsomo
Idutywa
Ngqamakwe
Butterworth
Willowvale
Centane
Elliotdale
Mqanduli
Libode
Stutterheim
Komga
Keiskammahoek
King Williams Town
Zwelitsha
Dimbaza
Mdantsane
Peddie
Sterkstroom
Tabankulu
Qumbu
Matatiele
Maluti
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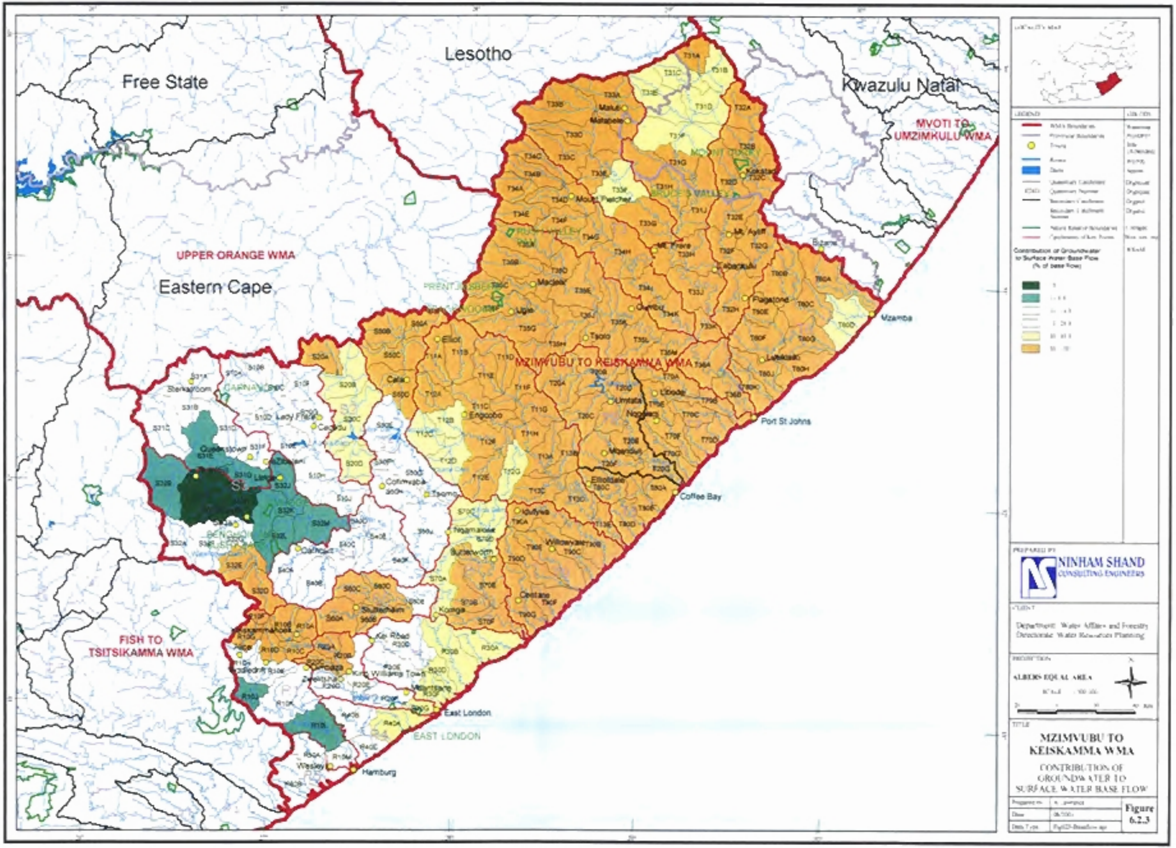
Directorate: Water Resources Planning
ALBERS EQUAL AREA
MZIMVUBU TO KEISKAMMA WMA
GROUNDWATER EXPLOITATION POTENTIAL
Figure 6.2.2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Coffee Bay
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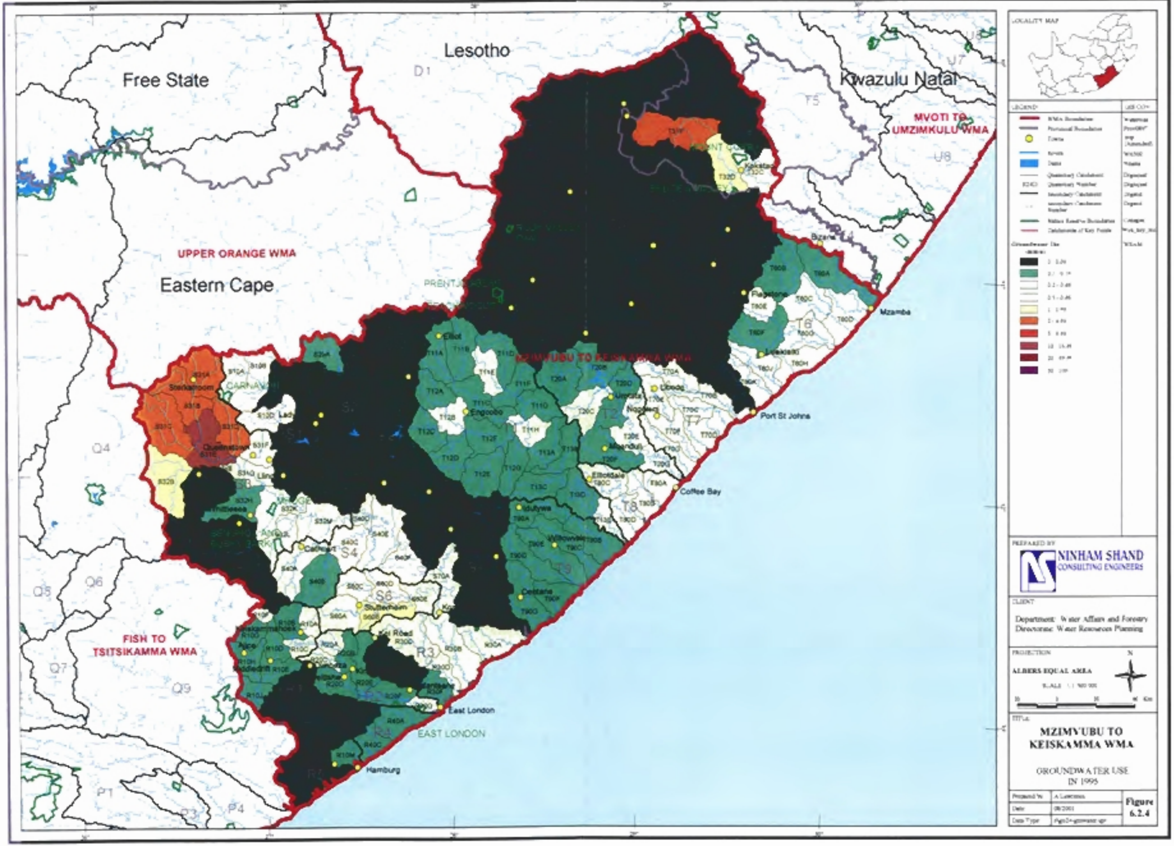
Hamburg
Queenstown
Umtata
Engcobo
Cala
Elliot
Ugie
Maclear
Tsolo
Butterworth
Komga
King Williams Town
Stutterheim
Cathcart
Kokstad
Mt. Ayliff
Mt. Frere
Lusikisiki
Flagstaff
Libode
Ngqeleni
Mqanduli
Elliotdale
Idutywa
Willowvale
Centane
Wesley
Keiskammahoek
Lady Frere
Sterkstroom
Contribution of Groundwater to Surface Water Base Flow (% of base flow)
NINHAM SHAND CONSULTING ENGINEERS
ALBERS EQUAL AREA
MZIMVUBU TO KEISKAMMA WMA
CONTRIBUTION OF GROUNDWATER TO SURFACE WATER BASE FLOW
Figure 6.2.3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Port St Johns
Coffee Bay
East London
Hamburg
Queenstown
Engcobo
Idutywa
Willowvale
Centane
Stutterheim
Flagstaff
Lusikisiki
Elliot
Kokstad
Bizana
Elliotdale
Mqanduli
Umtata
Libode
Ngqeleni
Cathcart
Whittlesea
Sterkstroom
Keiskammahoek
Alice
Middledrift
Kei Road
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PROJECTION
ALBERS EQUAL AREA
N
TITLE
MZIMVUBU TO KEISKAMMA WMA
GROUNDWATER USE IN 1995
Figure 6.2.4


Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Mzamba
Port St Johns
Coffee Bay
East London
Hamburg
King Williams Town
Queenstown
Lady Frere
Cala
Elliot
Engcobo
Butterworth
Cathcart
Whittlesea
Stutterheim
Komga
Centane
Willowvale
Idutywa
Umtata
Libode
Ngqeleni
Mqanduli
Elliotdale
Flagstaff
Lusikisiki
Bizana
Mt. Ayliff
Mt. Frere
Tabankulu
Qumbu
Tsolo
Ugie
Maclear
Mount Fletcher
Matatiele
Maluti
Kokstad
Sterkstroom
Cofimvaba
Tsomo
Nqamakwe
Keiskammahoek
Zwelitsha
Kei Road
Mdantsane
Peddie
Wesley
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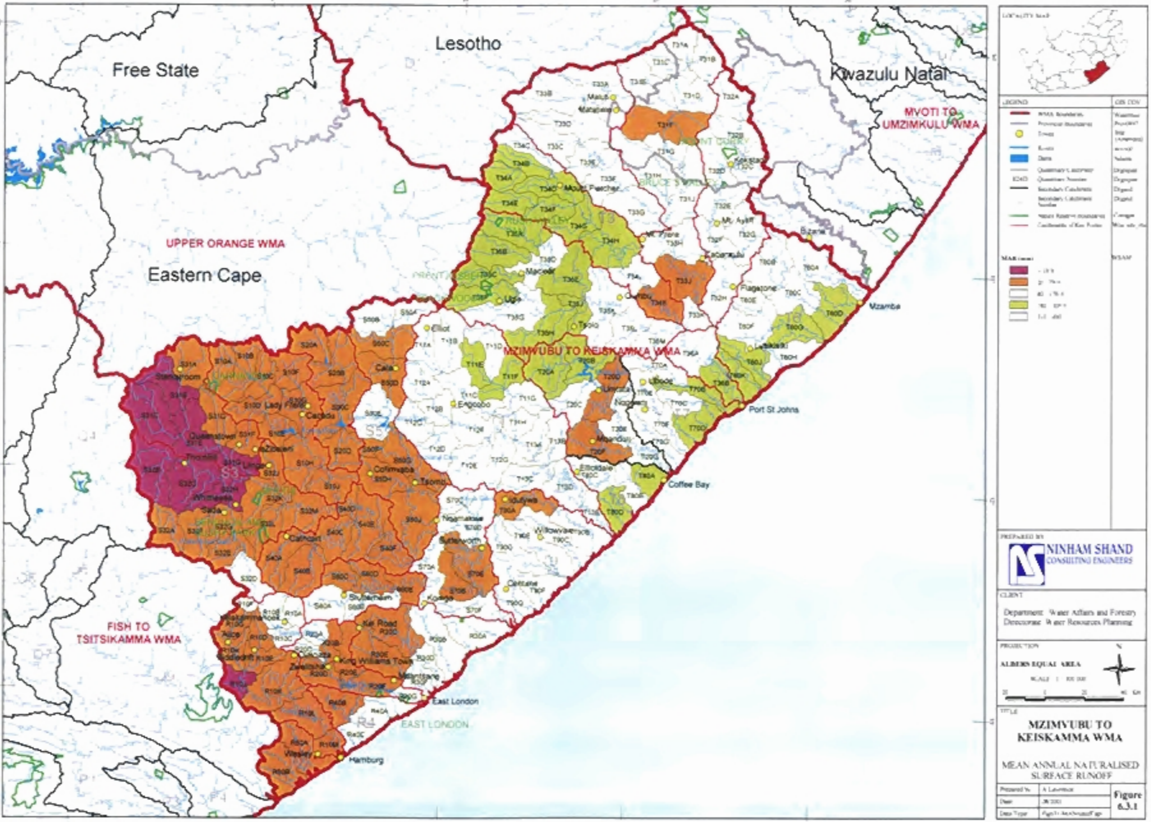
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
EXTENT OF GROUNDWATER UTILISATION IN 1995
Figure 6.2.5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Kwazulu Natal
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UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Port St Johns
Coffee Bay
Mzamba
Queenstown
Lady Frere
Cala
Elliot
Engcobo
Cofimvaba
Tsomo
Cathcart
Stutterheim
King Williams Town
East London
Hamburg
Keiskammahoek
Alice
Zwelitsha
Mdantsane
Butterworth
Idutywa
Willowvale
Centane
Komga
Umtata
Ugie
Maclear
Mount Fletcher
Mt Ayliff
Bizana
Flagstaff
Lusikisiki
Libode
Ngqeleni
Mqanduli
Elliotdale
Whittlesea
Sada
Tarkastad
Sterkstroom
Wesley
NINHAM SHAND
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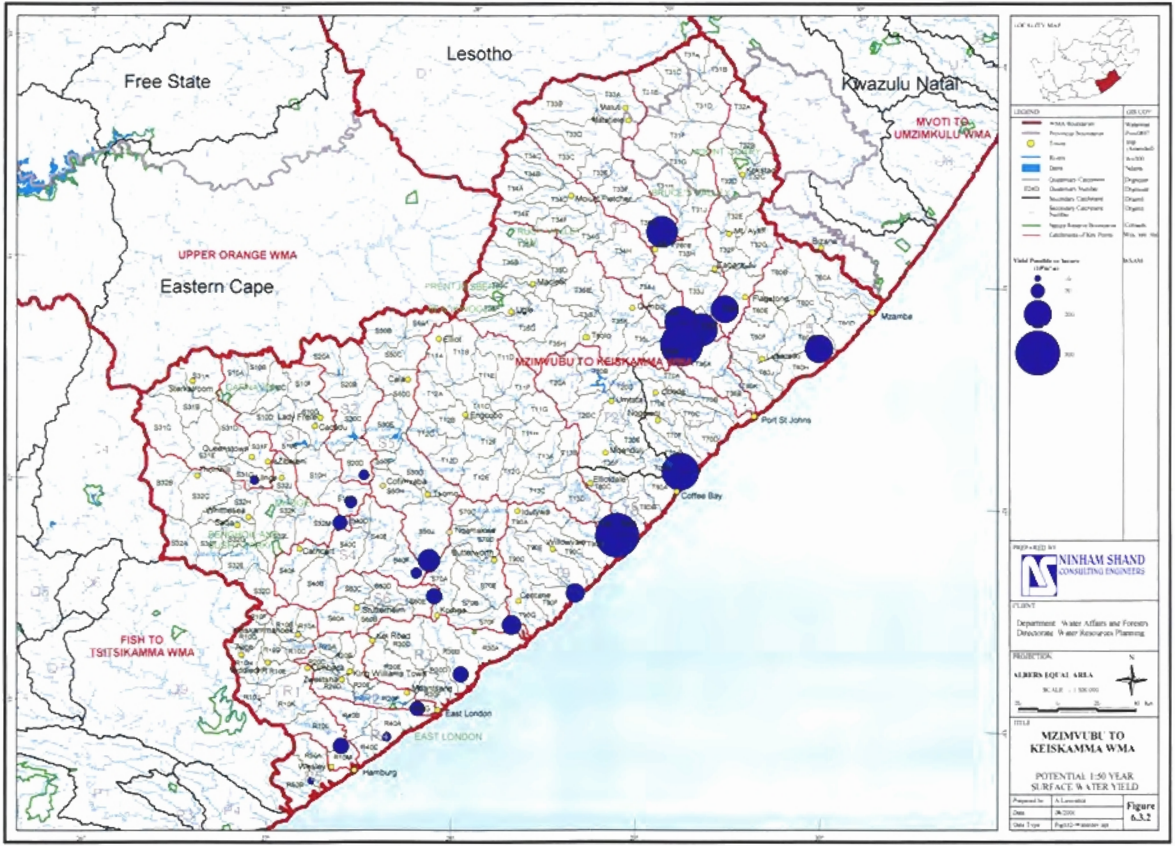
Directorate: Water Resources Planning
ALBERS EQUAL AREA
MZIMVUBU TO KEISKAMMA WMA
MEAN ANNUAL NATURALISED SURFACE RUNOFF
Figure 6.3.1



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Kwazulu Natal
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UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Mzamba
Port St Johns
Coffee Bay
East London
Hamburg
King Williams Town
Lady Frere
Engcobo
Elliot
Cala
Butterworth
Mount Fletcher
Maclear
Ugie
Flagstaff
Mt Ayliff
Bizana
Umtata
Idutywa
Cathcart
Stutterheim
Keiskammahoek
Sterkstroom
Queenstown
Cofimvaba
Kei Road
Tsomo
Komga
Centane
Elliotdale
Tsolo
Qumbu
Matatiele
Maluti
Kokstad
Mqanduli
Willowvale
Nqamakwe
Peddie
Whittlesea
Tarkastad
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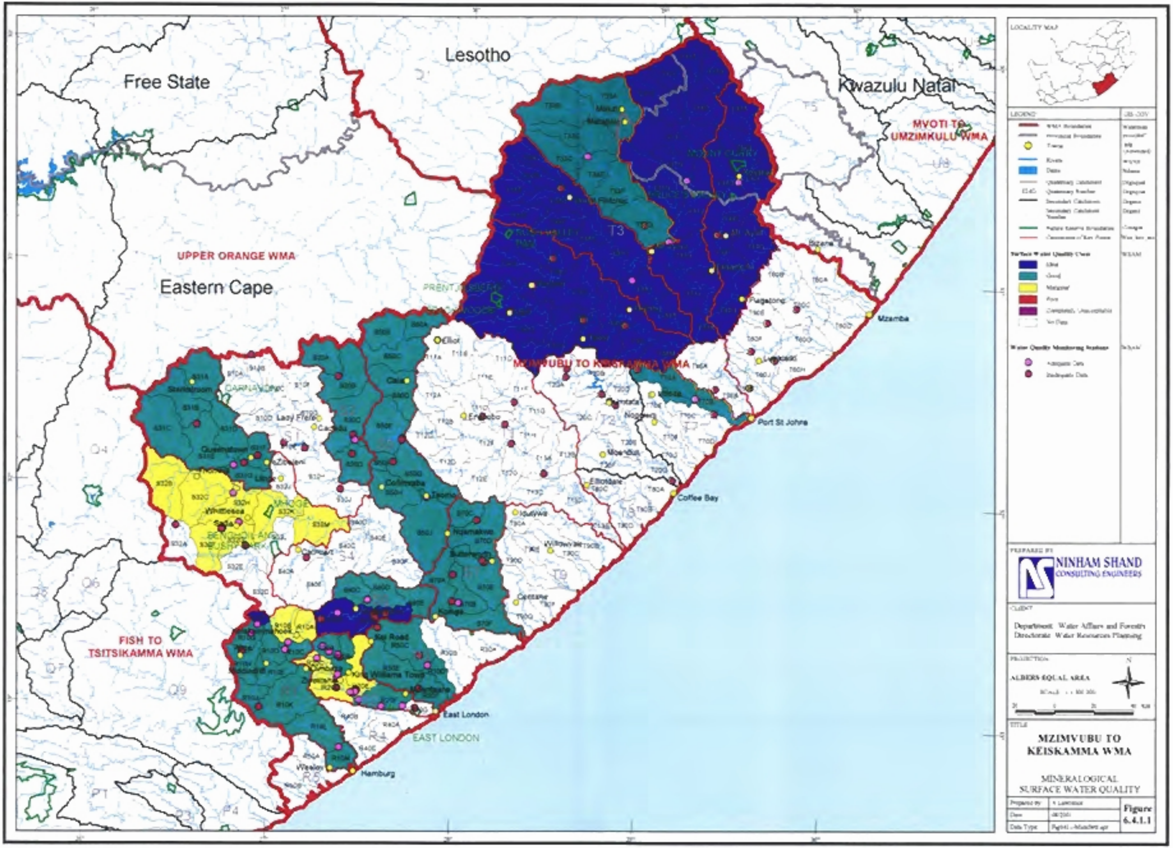
ALBERS EQUAL AREA
MZIMVUBU TO KEISKAMMA WMA
POTENTIAL 1:50 YEAR SURFACE WATER YIELD
Figure 6.3.2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Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
T3
Mzamba
Port St Johns
Coffee Bay
East London
Hamburg
Elliot
Cala
Lady Frere
Queenstown
Whittlesea
Cofimvaba
Ngqamakwe
Butterworth
Idutywa
Willowvale
Centane
Komga
King Williams Town
Mdantsane
Flagstaff
Lusikisiki
Mthatha
Engcobo
Tsomo
LOCALITY MAP
LEGEND
Surface Water Quality Class
Water Quality Monitoring Stations
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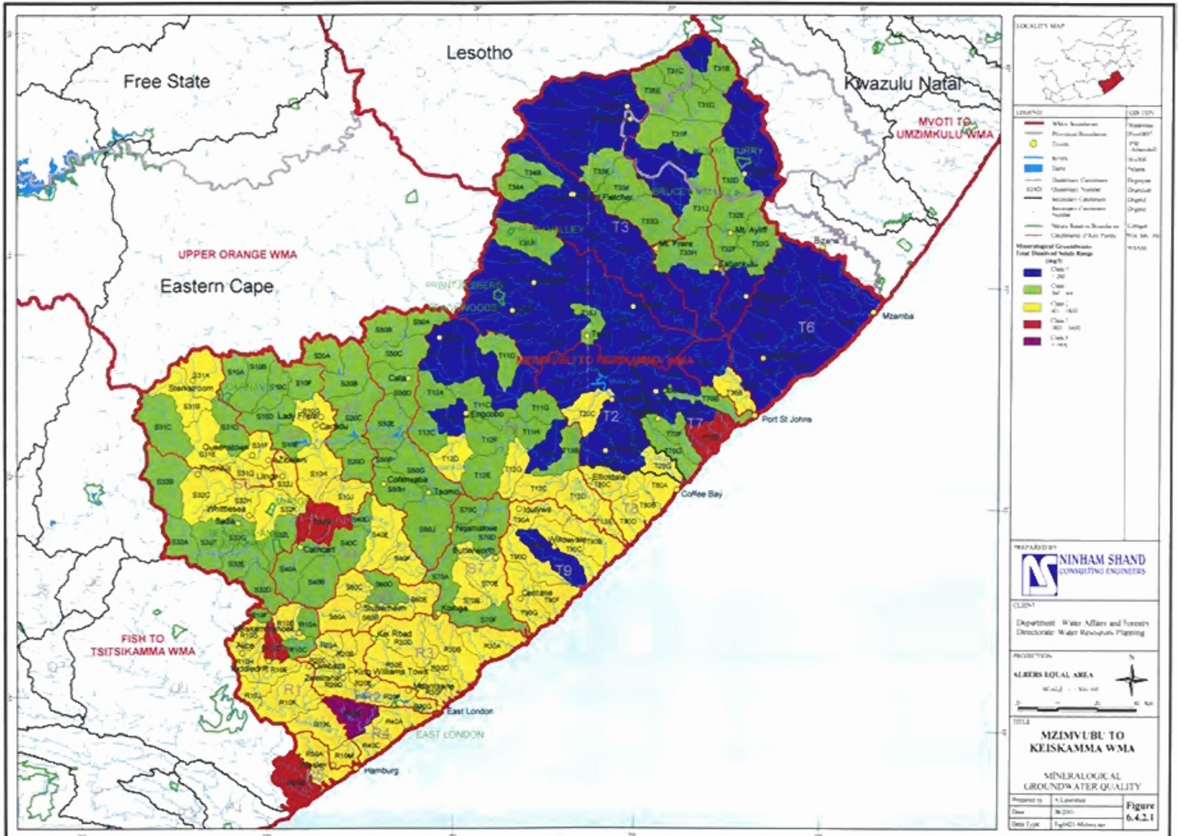
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
MINERALOGICAL SURFACE WATER QUALITY
Figure 6.4.1.1


Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
FISH TO TSITSIKAMMA WMA
T3
T6
T2
T7
T8
T9
R1
R3
R4
Mzamba
Port St Johns
Coffee Bay
East London
EAST LONDON
Hamburg
Mt Fletcher
Mt Ayliff
Mt Frere
Engcobo
Lady Frere
Queenstown
Whittlesea
Cathcart
Cofimvaba
Tsomo
Ngamakwe
Butterworth
Idutywa
Willowvale
Centane
Elliotdale
Stutterheim
Komga
King Williams Town
Zwelitsha
Alice
Peddie
Sterkstroom
Cala
Bizana
NINHAM SHAND
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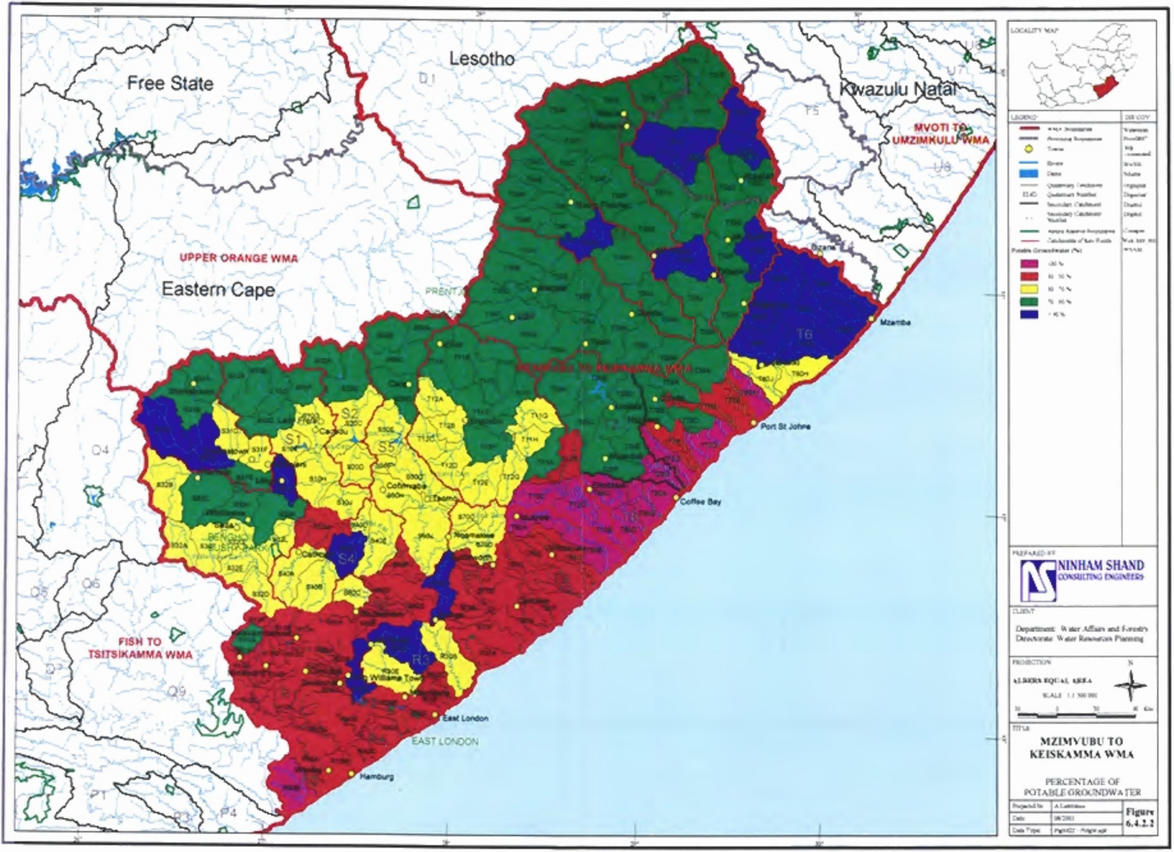
ALBERS EQUAL AREA
MZIMVUBU TO KEISKAMMA WMA
MINERALOGICAL GROUNDWATER QUALITY
Figure 6.4.2.1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UPPER ORANGE WMA
Eastern Cape
FISH TO TSITSIKAMMA WMA
T6
S1
S2
S5
S4
R3
Mzamba
Port St Johns
Coffee Bay
East London
EAST LONDON
Hamburg
LOCALITY MAP
PREPARED BY
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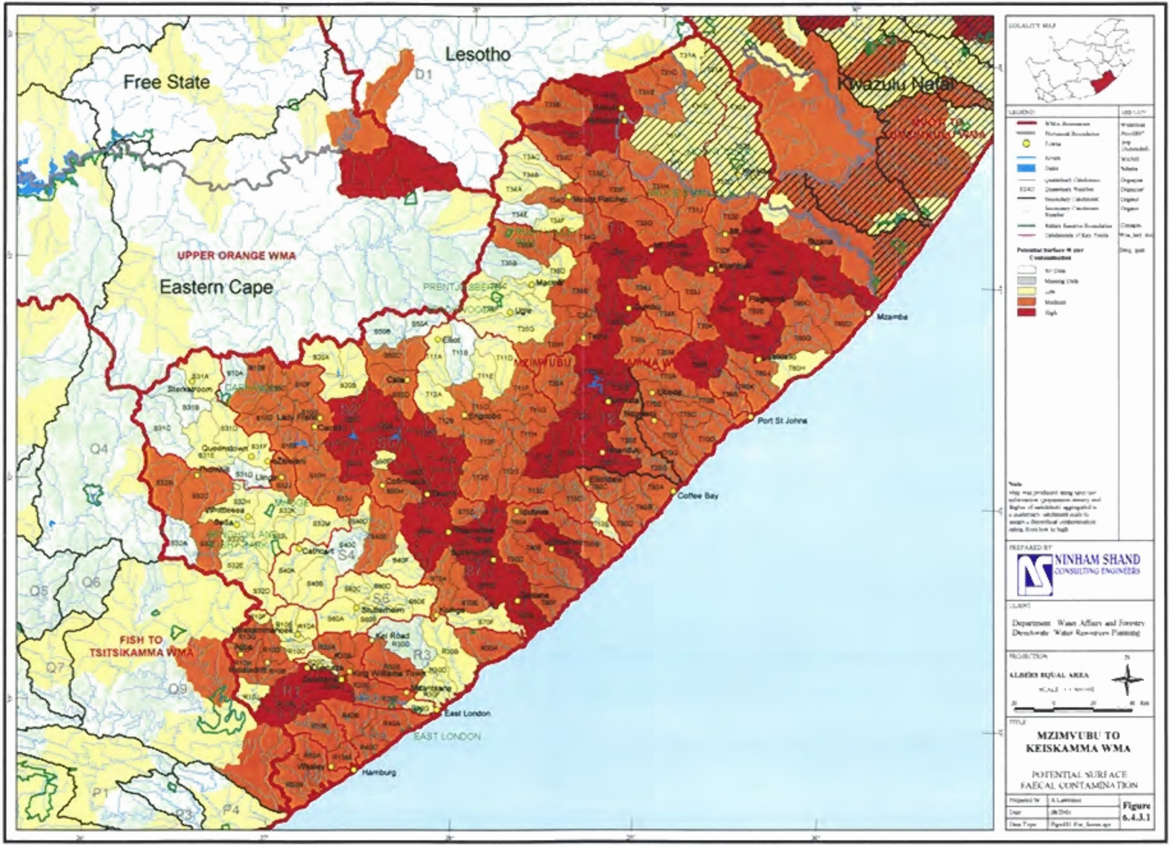
PROJECTION
ALBERS EQUAL AREA
N
TITLE
MZIMVUBU TO KEISKAMMA WMA
PERCENTAGE OF POTABLE GROUNDWATER
Date
Figure 6.4.2.2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UPPER ORANGE WMA
Eastern Cape
FISH TO TSITSIKAMMA WMA
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Mzamba
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Coffee Bay
East London
Hamburg
King Williams Town
Queenstown
Cathcart
Stutterheim
Cala
Elliot
Ugie
Maclear
Mount Fletcher
Engcobo
Lady Frere
Cofimvaba
Idutywa
Kei Road
Whittlesea
Sterkstroom
Mthatha
Flagstaff
Lusikisiki
Bizana
Whaley
Potential Surface Water Contamination
No Data
Missing Data
Low
Medium
High
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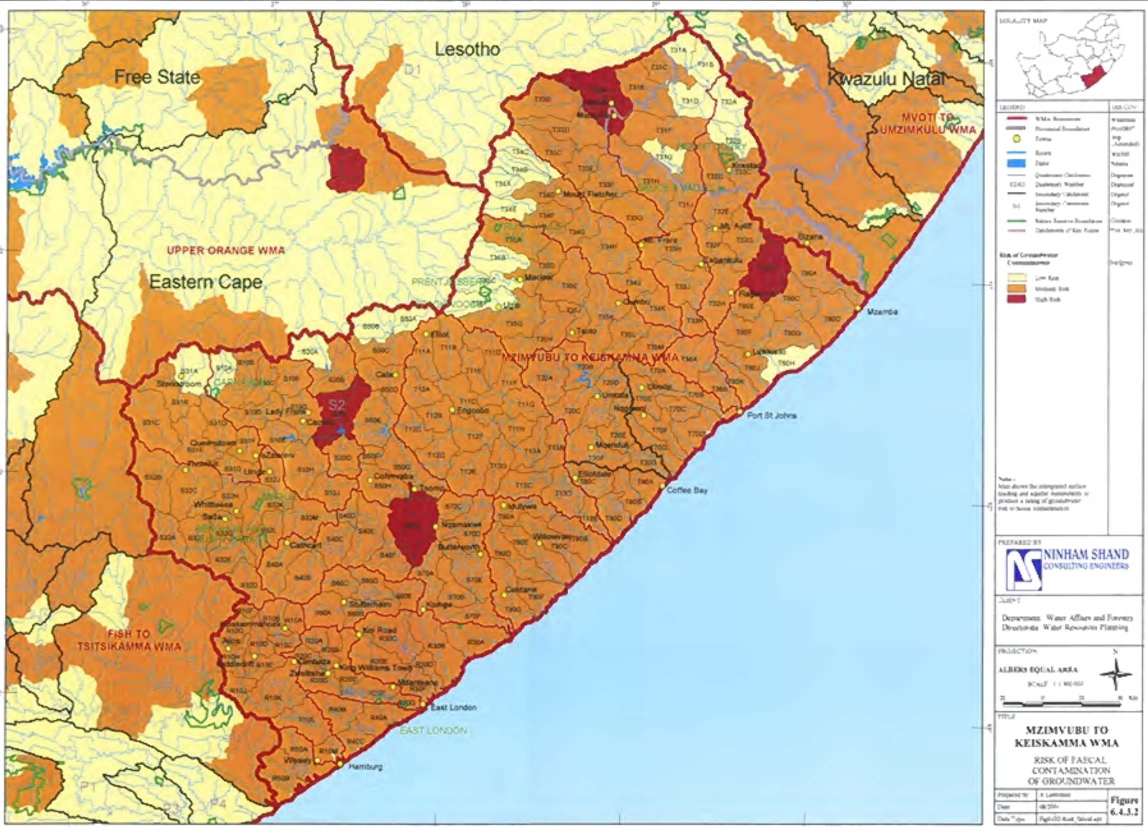
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
POTENTIAL SURFACE FAECAL CONTAMINATION
Figure 6.4.3.1


Lesotho
Free State
Kwazulu Natal
MVOTI TO UMZIMKULU WMA
UPPER ORANGE WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
EAST LONDON
Mzamba
Port St Johns
Coffee Bay
East London
Hamburg
King Williams Town
Butterworth
Idutywa
Engcobo
Elliot
Cala
Lady Frere
Queenstown
Whittlesea
Cathcart
Stutterheim
Kei Road
Mount Fletcher
Kokstad
Mt Ayliff
Bizana
Maclear
Ugie
Umtata
Willowvale
Centane
Komga
Tsomo
Cofimvaba
Nqamakwe
Lusikisiki
Libode
Ngqeleni
Mqanduli
Elliotdale
Mt Frere
Tabankulu
Qumbu
Tsolo
Flagstaff
Sterkstroom
Tarkastad
Alice
Peddie
Wesley
Dimbaza
Zwelitsha
Mdantsane
Keiskammahoek
S2
Risk of Groundwater Contamination
Low Risk
Medium Risk
High Risk
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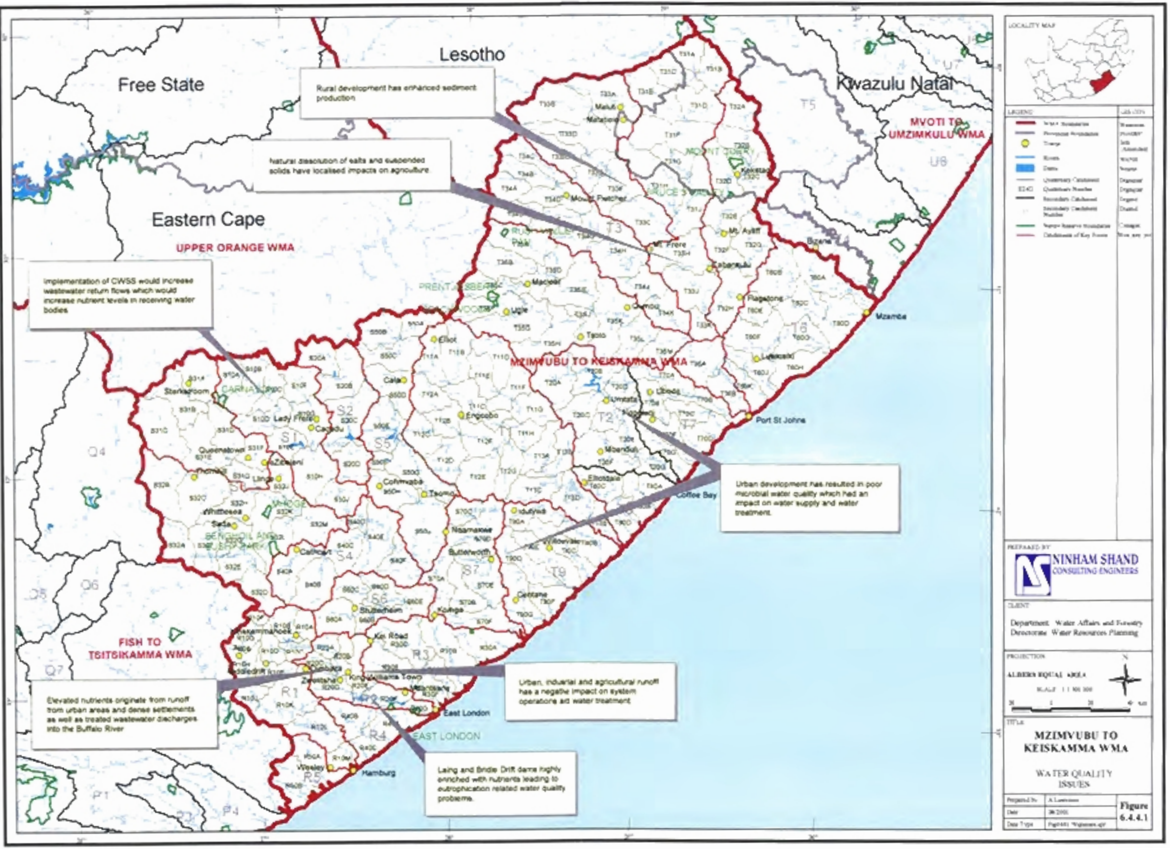
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
RISK OF FAECAL CONTAMINATION OF GROUNDWATER
Figure 6.4.3.2


Lesotho
Free State
Kwazulu Natal
Eastern Cape
UPPER ORANGE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
Rural development has enhanced sediment production
Natural dissolution of salts and suspended solids have localised impacts on agriculture
Implementation of CWSS would increase wastewater return flows which would increase nutrient levels in receiving water bodies
Urban development has resulted in poor microbial water quality which had an impact on water supply and water treatment
Urban, industrial and agricultural runoff has a negative impact on system operations ad water treatment
Elevated nutrients originate from runoff from urban areas and dense settlements as well as treated wastewater discharges into the Buffalo River
Laing and Bridle Drift dams highly enriched with nutrients leading to eutrophication related water quality problems
Mzamba
Port St Johns
Coffee Bay
East London
Hamburg
EAST LONDON
Queenstown
Umtata
Butterworth
King Williams Town
Stutterheim
Cathcart
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Engcobo
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Flagstaff
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Ugie
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Tsomo
Cofimvaba
Lady Frere
Cacadu
Whittlesea
Sada
Keiskammahoek
Zwelitsha
Mdantsane
Wesley
LOCALITY MAP
LEGEND
PREPARED BY
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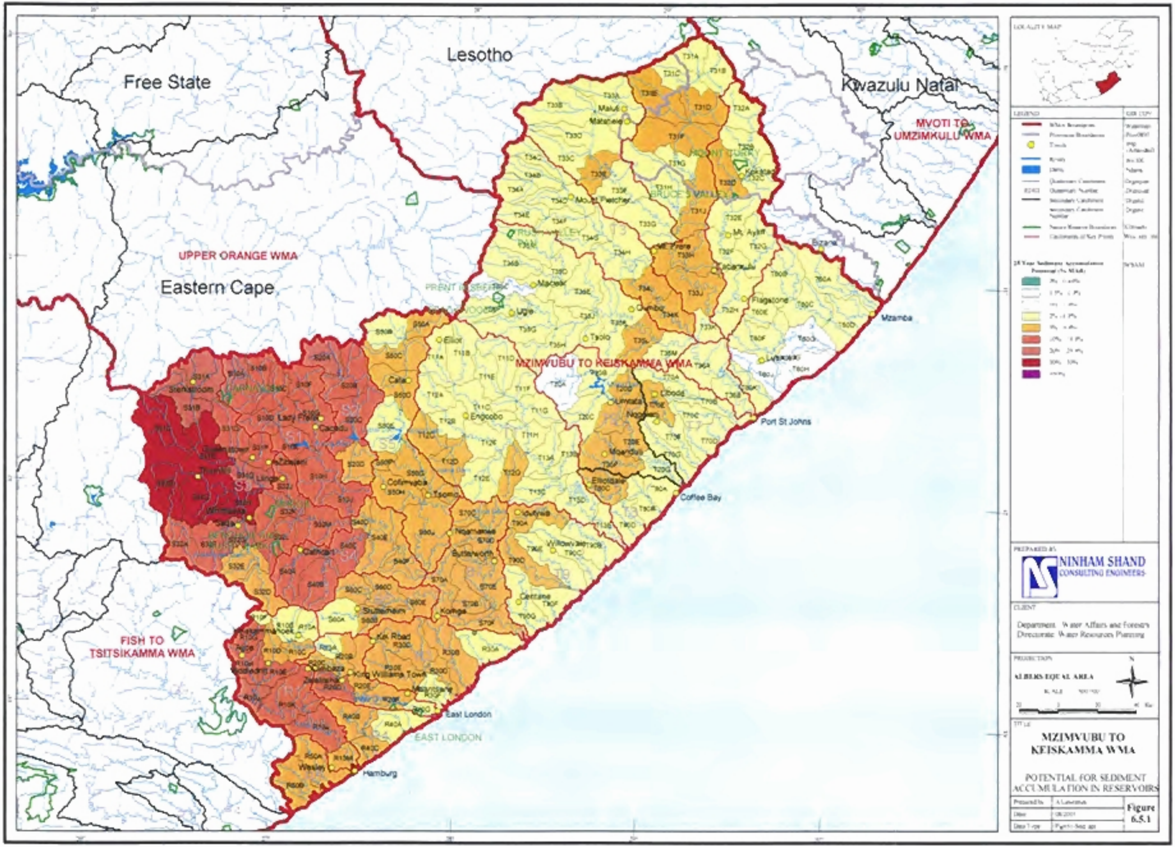
PROJECTION
ALBERS EQUAL AREA
N
TITLE
MZIMVUBU TO KEISKAMMA WMA
WATER QUALITY ISSUES
Prepared by
Date
Data Type
Figure 6.4.4.1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UPPER ORANGE WMA
Eastern Cape
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FISH TO TSITSIKAMMA WMA
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East London
EAST LONDON
Hamburg
Bizana
Flagstaff
Lusikisiki
Mount Fletcher
Maclear
Ugie
Elliot
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Engcobo
Cofimvaba
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Willowvale
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Cathcart
Queenstown
Whittlesea
Sterkstroom
Lady Frere
Cacadu
Mthatha
Libode
Ngqeleni
Mqanduli
Elliotdale
King Williams Town
Zwelitsha
Alice
Keiskammahoek
Peddie
Wesley
Kei Road
Matatiele
Maluti
Mt. Ayliff
Mt. Frere
Cedarville
Kokstad
MOUNT CURRY
BRUCE'S VALLEY
PREPARED BY
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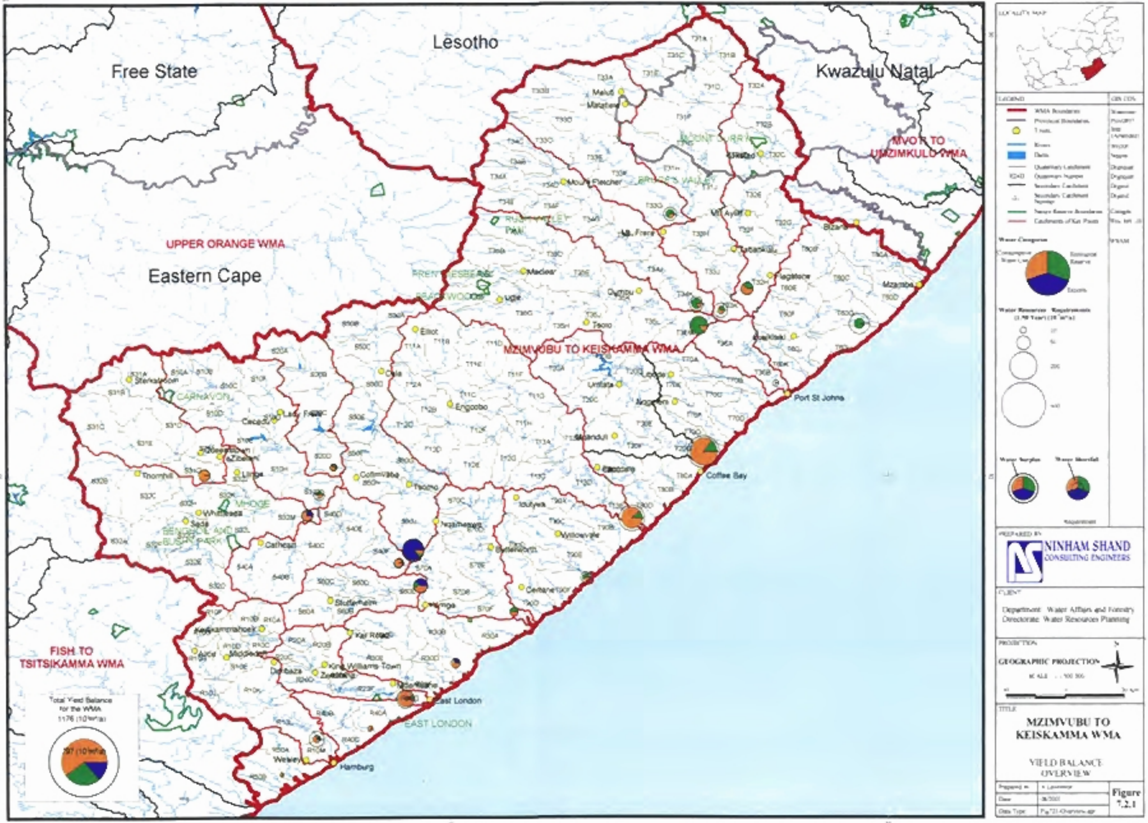
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
MZIMVUBU TO KEISKAMMA WMA
POTENTIAL FOR SEDIMENT ACCUMULATION IN RESERVOIRS
Figure 6.5.1



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Kwazulu Natal
Eastern Cape
UPPER ORANGE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA WMA
FISH TO TSITSIKAMMA WMA
Elliot
Engcobo
Port St Johns
Coffee Bay
Mzamba
Hamburg
East London
EAST LONDON
King Williams Town
Total Yield Balance for the WMA
NINHAM SHAND
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GEOGRAPHIC PROJECTION
MZIMVUBU TO KEISKAMMA WMA
YIELD BALANCE OVERVIEW
Figure 7.2.1