REPORT No. P 16000/00/0101

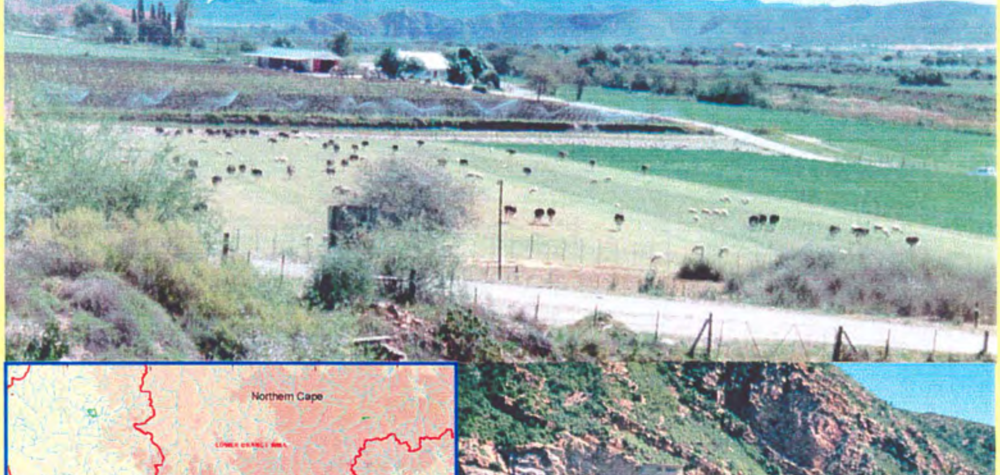
DEPARTMENT: WATER AFFAIRS AND FORESTRY

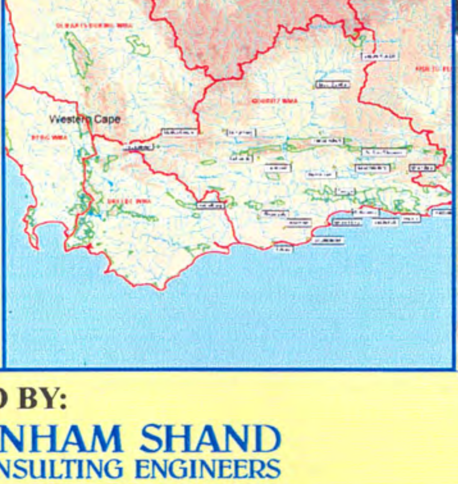
Directorate: Water Resources Planning

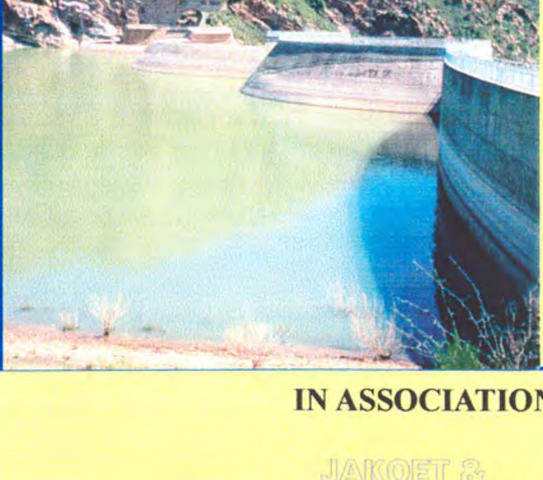
GOURITZ WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

MAIN REPORT: VOLUME 1
JUNE 2002







COMPILED BY:

NINHAM SHAND
CONSULTING ENGINEERS

IN ASSOCIATION WITH:

JAKOET & ASSOCIATES

Title	:	**Gouritz Water Management Area : Water Resources Situation Assessment - Main Report - Volume 1 of 2**
Authors	:	J Larsen, R Blackhurst, A Spinks, J N Rossouw and authors of standard texts provided by DWAF
Project Name	:	Water Resources Situation Assessment
DWAF Report No.	:	P16000/00/0101
Status of Report	:	Final
First Issue	:	February 2002
Final Issue	:	June 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

GOURITZ 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 Gouritz Water Management Area, which occupies portions of the Western Cape Province, Eastern Cape and Northern Cape Provinces. 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 resource 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 resource 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 resource 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 resource 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 resource 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 Gourtiz 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 Gouritz WMA by the national demographic study 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 Gouritz Water Management Area, is included in the appropriate sections of the report.

2. CHARACTERISTICS OF THE WMA

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

Physical Characteristics

- The Gouritz WMA covers an area of 53 139 km^2 in which the mean annual precipitation ranges from 160 mm in the northern interior, where the climate is semi-arid, to more than 1 500 mm in the coastal mountains in the south-east, where rainfall occurs throughout the year.

- The geology of the WMA consists of Karoo sediments in the interior and sandstones, quartzites and conglomerates of the Cape Supergroup along the coast. Thus, water can be expected to have naturally elevated TDS concentrations in the interior and low concentrations along the coast.

- The rivers of the coastal catchments are of high to very high ecological importance and sensitivity, and consequently have high ecological flow requirements. The Gamka River and its tributaries in the vicinity of Calitzdorp are also of high ecological importance. Most of the other rivers are of moderate ecological importance and sensitivity and have correspondingly lower ecological flow requirements.

Development Status

- The population of the WMA in 1995 was approximately 424 000 people. Some 54% of the population lived in the coastal zone to the east of the Gouritz River mouth, and 83% of the total population lived in the towns of the WMA.

- Much of the economic activity is concentrated in the south-eastern portion of the WMA, with the George, Oudtshoorn, Knysna and Mossel Bay areas contributing 66% of the GGP in 1997. The GGP of the whole WMA was R4,9 billion in 1997, with the most important economic sectors, in terms of their contributions to GGP, being Trade (19,3%), Government (18,1%), Agriculture (17,2%) and Financial Services (14,2%). Agriculture has a high comparative advantage relative to other WMAs.

Land-use

- Land-use is predominantly for rough grazing for livestock. Some 514 km^2, or 1% of the surface area of the WMA is used for irrigated crops, but only about 280 km^2 of land is irrigated in average years, with larger areas irrigated occasionally when rainfall is favourable in the semi-arid areas. Afforestation, mainly in the south-eastern coastal strip covers some 600 km^2, and 4 100 km^2 of land consists of nature reserves. Alien vegetation other than the afforestation covered an equivalent condensed area of 1 357 km^2.

- There were about 1 450 000 head of livestock in the WMA in 1995. Sheep and goats made up 80% of the livestock numbers, with sheep predominating. Ostriches made up 10% of the total number, and the remainder were mainly cattle, horses, donkeys and pigs.

Water Related Infrastructure

- Water related infrastructure is well developed, particularly in the southern half of the WMA, where most of the water requirements occur.

- Town bulk water supply schemes were generally adequate in 1995, but the requirements from many of them were approaching their capacities and supplies are likely to require augmentation soon.

- The Klein Karoo Rural Water Supply Scheme, which supplies water for livestock and rural domestic use in the vicinities of Oudtshoorn and Calitzdorp was fully utilised in 1995. As the requirements from the scheme and the requirements of the urban areas not supplied by the scheme are continuing to grow, and the water resources of the area are fully utilised, the identification of an additional raw water source for urban and rural domestic supplies is required.

- Allocations of water for irrigation from Government Water Supply Schemes total 137 million m^3/a, which is 44% of the average irrigation water requirement of 311 million m^3/a. Therefore, it appears that more than half of the irrigation water requirements in the WMA are provided from what were "private" sources prior to 1998. Information on the capacities of these sources and the quantities of water used from them is not well documented, but may be required in the future for specific areas where the need to further develop the water resources occurs.

Water Requirements

- Water requirements in 1995 were estimated to total 586 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 agriculture, which required 319 million m^3/a, or 54% of the total consumptive requirement (i.e. excluding the ecological Reserve). The next biggest water user was alien vegetation, at 20% of the total consumptive requirement, followed by afforestation (15%) and urban and rural domestic requirements (9%). 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 921 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 406 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 Gouritz WMA was 1 678 million m^3/a and the yield developed from surface water resources in 1995 was 272 million m^3/a at 1:50 year assurance. Some 40% of the developed yield was from farm dams and run-of-river abstractions, and 60% from major dams. In addition, boreholes with an estimated yield of 64 million m^3/a had been developed, bringing the total developed yield to 336 million m^3/a at 1:50 year assurance.

- The maximum potential yield of the water resources of the WMA is estimated to be 535 million m^3/a, which is 199 million m^3/a more than the developed yield in 1995. The reliability of this estimate is uncertain because of a lack of reliable information of the ecological flow requirements of the estuaries.

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

Water Balance

- Comparison of the equivalent 1:50 year assurance water requirements of 406 million m^3/a with the developed yield of 336 million m^3/a shows a deficit of 70 million m^3/a, but re-used return flows of 16 million m^3/a reduce the deficit to 54 million m^3/a. Deficits occur in most key areas and are attributable mainly to the requirements of the ecological Reserve, except in the Upper Gamka and Buffles key areas where they are a result of water requirements for irrigation exceeding the available water supply. The equivalent 1:50 year assurance irrigation requirements in these areas may have been over-estimated as, in practice, irrigation methods have been adapted to suit the available water supply.

- The yield balance is at a low level of confidence because of uncertainty regarding the true run-of-river yields and the true impacts of the ecolgocial Reserve, afforestation and alien vegetation on the 1:50 year yields of the various key areas. It is, nevertheless, known that throughout the WMA water use has been adapted to the availability of water, so that the system is generally in balance. This is particularly true of the use of water for irrigation where the availability of land suitable for irrigation exceeds the area that can be supplied from the water resources and irrigation practices have been adapted accordingly. The ecological Reserve was not implemented in 1995 and the yield balance suggests that the water resources in most areas of the WMA will be stressed when the ecological Reserve is implemented.

- The impact of alien vegetation on the 1:50 year developed yield in 1995 was estimated to be some 36 million m^3/a, which is 67% of the yield balance deficit of 54 million m^3/a and equal to the estimated impact on yield of the ecological Reserve. Therefore, it appears that the removal of alien vegetation before the ecological Reserve is implemented would contribute significantly to restoring the yield balance in the WMA.

Costs of Water Resources Development

- The cost of developing the resources to their full potential was estimated to be R5 950 million at year 2000 prices, including VAT. This estimate is based on the development of surface water resources only, on the conservative assumption that groundwater is directly linked to surface water. The cost may be significantly lower if groundwater is developed in some areas instead of surface water, but there was insufficient readily available information on groundwater and its relationship to surface water to verify this in this study.

- The high cost of developing the full surface water potential in the Gouritz River catchment in particular may make it more economical to develop groundwater, provided that this did not reduce the yields of existing surface water developments. In the Outeniqua catchments, surface water development is likely to be more economical than groundwater in most cases.

3. CONCLUSIONS AND RECOMMENDATIONS

It is concluded from the above that water requirements in the Gouritz WMA in 1995 were generally in balance with the available supplies. Considerably more water would be used for irrigated agriculture if it could be made available at an affordable cost. However, it appears that the cost of building additional dams to increase the yield obtained from the surface water resources is too high in relation to the returns obtained from irrigated agriculture for it to be economically viable.

It became apparent in the course of carrying out this assessment that 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 quantity of untreated "leiwater" used in towns for irrigation of gardens. (While the quantity is likely to be small in relation to total irrigation requirements, it may be a significant part of urban water requirements. Therefore, it needs to be determined for information on urban water requirements to be comprehensive).

- 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).

- The relationship between groundwater and surface water in order to be able to predict the extent, if any, to which increased groundwater abstraction will reduce developed surface water yield.

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.

It appears from the information collected for this situation assessment that, until such time as the ecological Reserve is implemented, water use and availability will remain roughly in balance, except in two areas where growing requirements are likely to require further action to be taken. These are :

- The Olifants River catchment where the water resources are fully utlised, the ecological Reserve has not been implemented in the past, and urban domestic and rural water requirements are continuing to grow. In addition, drought cycles and economic pressure on farming activities result in efforts to increase the output of the agricultural sector which results in increasing requirements for water.

- The coastal strip to the east of the Gouritz River mouth (the Outeniqua coastal catchments) where growing urban requirements are likely to require additional sources of raw water in the near future, and where the yield balance suggests that there may be a deficit in 1:50 year yield of some 24 million m^3/a when the ecological Reserve is implemented. There is strong public pressure for the implementation of the ecological Reserve in this area as soon as possible.

A large number of alternative schemes for supplementing the yield of the Klein Karoo Regional Water Supply Scheme, which supplies water for livestock and rural domestic use in the Olifants River valley, were investigated in 1999. The yield of the scheme is only about 1 million m^3/a, and is small in relation to the total water use in the area. However, the recommendations made in the report on the investigation recommended further actions, some of which related to the regional water supply situation as a whole. The recommendations were :

- A review of water resources in the Olifants River Valley and the area in the vicinity of Calitzdorp as a whole.

- Encouraging the municipalities of Calitzdorp and Oudtshoorn to link to the Klein Karoo Rural Water Supply Scheme, thereby creating an integrated scheme for the area.

- Improving the efficiency of water use by both the urban and agricultural sectors as appropriate through lining of canals, reduction in leakage from reticulation systems and tariff structures.

- Investigation of the possibilities of purchasing irrigation water rights for use in augmenting urban water supplies.

- Detailed investigation of the environmental and social impacts of the probable effects of increased groundwater abstraction on surface water flow to enable informed decisions to be taken on further development.

- Reliable determination of the 1:50 year yield of the Klein Karoo Rural Water Supply Scheme.

It is suggested that the above recommendations should be implemented and, if the results show it to be necessary, investigations of the most favourable schemes identified in the 1999 study should be refined to identify the most appropriate means of augmenting urban and rural domestic water supplies in the Olifants River Valley.

With regard to urban water supplies in the Outeniqua coastal catchments, the following actions are recommended to ensure that the raw water supplies can be augmented timeously when required :

- A detailed review of present and expected future water requirements, and the capacities of existing raw water supply schemes should be carried out.

- Dates when augmentations of raw water supplies are likely to be required should be determined and potential sources of the additional water identified.

- The catchments in which these sources occur should, together with the catchments of the existing sources, be given priority for the eradication of alien vegetation.

- After the alien vegetation has been removed the ecological flow requirements of the rivers and the estuaries should be determined.

- Existing water use in the catchments should be determined.

- Using the information obtained above, the amount of additional yield that could be developed after providing for the ecological flow requirements should be determined.

LIST OF CONTENTS

Page No.

OVERVIEW OF THE WRSA

SYNOPSIS

ABBREVIATIONS

GLOSSARY OF TERMS

CHAPTER 1 : INTRODUCTION 1

1.1 PURPOSE OF THE STUDY 1
1.2 APPROACH TO THE STUDY 1
1.3 REPORT LAYOUT AND CONTENT 2

CHAPTER 2 : PHYSICAL FEATURES 4

2.1 THE STUDY AREA 4
2.2 CLIMATE 8
2.3 GEOLOGY 9
2.4 SOILS 9
2.5 NATURAL VEGETATION 10

2.5.1 Introduction 10
2.5.2 Natural Vegetation Types within the Gouritz Water Management Area 10

2.6 ECOLOGICALLY SENSITIVE SITES 13

2.6.1 Sensitive Ecosystems 13
2.6.2 River Classification 14
2.6.3 Aquatic Ecosystems of Concern to the Study 19
2.6.4 Natural Heritage Sites, Proclaimed Game and Nature Reserves, Wilderness Areas 20

2.7 CULTURAL AND HISTORICAL SITES 22

CHAPTER 3 : DEVELOPMENT STATUS 24

3.1 HISTORICAL DEVELOPMENT OF WATER RELATED INFRASTRUCTURE 24
3.2 DEMOGRAPHY 25

3.2.1 Introduction 25
3.2.2 Methodology 25
3.2.3 Historical Population Growth Rate 26
3.2.4 Population Size and Distribution in 1995 26

LIST OF CONTENTS

Page No.

3.3 MACRO-ECONOMICS 28

3.3.1 Introduction 28
3.3.2 Data Sources 28
3.3.3 Methodology 29
3.3.4 Status of Economic Development 30
3.3.5 Comparative Advantages 32

3.4 LEGAL ASPECTS AND INSTITUTIONAL ARRANGEMENTS FOR WATER SUPPLY 33

3.4.1 Past History 33
3.4.2 National Water Act 34
3.4.3 Strategies 34
3.4.4 Environmental Protection 35
3.4.5 Recognition of Entitlements 35
3.4.6 Licensing 35
3.4.7 Other Legislation 36
3.4.8 Institutions Created Under the National Water Act 38
3.4.9 Institutions Responsible for Communities' Water Supplies 39

3.5 LAND-USE 41

3.5.1 Introduction 41
3.5.2 Irrigation 44
3.5.3 Dryland Farming 48
3.5.4 Livestock and Game Farming 48
3.5.5 Afforestation 49
3.5.6 Alien Vegetation 49
3.5.7 Urban Areas 53

3.6 MAJOR INDUSTRIES AND POWER STATIONS 54
3.7 MINES 54
3.8 WATER RELATED INFRASTRUCTURE 54

CHAPTER 4 : WATER RELATED INFRASTRUCTURE 55

4.1 OVERVIEW 55
4.2 REGIONAL WATER SUPPLY SCHEMES 58

4.2.1 The Klein Karoo Rural Water Supply Scheme (KKRWSS) 58
4.2.2 Duiwenhoks Rural Water Supply Scheme 58

4.3 TOWN WATER SUPPLY SCHEMES 59

4.3.1 Gouritz River Catchment 59
4.3.2 Coastal Rivers West of the Gouritz River 61
4.3.3 Coastal Rivers East of the Gouritz River 61

LIST OF CONTENTS

Page No.

4.4 CONTROLLED IRRIGATION SCHEMES 62
4.5 HYDRO-POWER AND PUMPED STORAGE 63

CHAPTER 5 : WATER REQUIREMENTS 64

5.1 SUMMARY OF WATER REQUIREMENTS 64
5.2 ECOLOGICAL COMPONENT OF THE RESERVE 65

5.2.1 Introduction 65
5.2.2 Quantifying the Water Requirements 66
5.2.3 Comments on the Results 68
5.2.4 Presentation of Results 69
5.2.5 Discussion and Conclusions 70

5.3 URBAN AND RURAL 72

5.3.1 Introduction 72
5.3.2 Urban 74
5.3.3 Rural 78

5.4 BULK WATER USE 77
5.5 NEIGHBOURING STATES 81
5.6 IRRIGATION 81

5.6.1 General 81
5.6.2 Water Use Patterns 81
5.6.3 Water Losses 83
5.6.4 Return Flows 84

5.7 DRYLAND SUGAR CANE 85
5.8 WATER LOSSES FROM RIVERS, WETLANDS AND DAMS 85
5.9 AFFORESTATION 86
5.10 HYDRO-POWER AND PUMPED STORAGE 87
5.11 ALIEN VEGETATION 87
5.12 WATER CONSERVATION AND DEMAND MANAGEMENT 89

5.12.1 Introduction 89
5.12.2 Background 91
5.12.3 Legal and Regulatory Framework 92
5.12.4 The Role of Water Conservation and Demand Management 93
5.12.5 Planning Considerations 94
5.12.6 Water Conservation and Demand Management Measures 95
5.12.7 Objectives of the National Water Conservation and Demand Management Strategy 95
5.12.8 Water Conservation in South Africa 95
5.12.9 Water Conservation in the Gouritz Water Management Area 97

LIST OF CONTENTS

Page No.

5.13 WATER ALLOCATIONS 97

5.13.1 Introduction 97
5.13.2 Permits and Other Allocations in the Gouritz WMA 100
5.13.3 Allocations in Relation to Water Requirements and Availability 101

5.14 EXISTING WATER TRANSFERS 101
5.15 SUMMARY OF WATER LOSSES AND RETURN FLOWS 102

CHAPTER 6 : WATER RESOURCES 104

6.1 EXTENT OF WATER RESOURCES 104
6.2 GROUNDWATER 106
6.3 SURFACE WATER RESOURCES 109
6.4 WATER QUALITY 120

6.4.1 Mineralogical Surface Water Quality 120
6.4.2 Mineralogical Groundwater Quality 123
6.4.3 Microbiological Water Quality 124
6.4.4 Water Quality Issues 125

6.5 SEDIMENTATION 125

CHAPTER 7 : WATER BALANCE 128

7.1 METHODOLOGY 128

7.1.1 Water Situation Assessment Model 128
7.1.2 Estimating the Water Balance 128
7.1.3 Estimating the Water Requirements 129
7.1.4 Estimating the Water Resources 130

7.2 OVERVIEW 130

CHAPTER 8 : COSTS OF WATER RESOURCE DEVELOPMENT 136

CHAPTER 9 : CONCLUSIONS AND RECOMMENDATIONS 141

REFERENCES 146

APPENDICES

LIST OF CONTENTS

Page No.

TABLES

2.1.1 KEY AREAS WITHIN THE GOURITZ WMA 7

2.2.1 TEMPERATURE DATA 8

2.5.1.1 A LIST OF THE DETAILED AND SIMPLIFIED ACOCKS VELD TYPES 11

2.6.4.1 PROTECTED NATURAL AREAS AND NATURAL HERITAGE SITES WITHIN THE GOURITZ WMA 21

3.2.4.1 POPULATION IN 1995 27

3.5.1.1 LAND USE BY DRAINAGE AREAS 42

3.5.1.2 LAND USE BY PROVINCE AND DISTRICT COUNCIL 43

3.5.2.1 IRRIGATION LAND USE 45

3.5.2.2 ASSURANCE CATEGORIES OF IRRIGATION WATER FOR CROP TYPES 46

3.5.4.1 LIVESTOCK AND GAME 50

3.5.5.1 AREAS OF AFFORESTATION AND INDIGENOUS FOREST 51

3.5.6.1 INFESTATION BY ALIEN VEGETATION 53

4.1.1 COMBINED CAPACITIES OF INDIVIDUAL TOWN AND REGIONAL POTABLE WATER SUPPLY SCHEMES IN 1995 BY DRAINAGE AREA 56

4.1.2 COMBINED CAPACITIES OF INDIVIDUAL TOWN AND REGIONAL POTABLE WATER SUPPLY SCHEMES BY DISTRICT COUNCIL AREAS 56

4.1.3 MAIN DAMS IN THE GOURITZ WMA 57

4.2.1 THE KLEIN KAROO RURAL WATER SUPPLY SCHEME 58

4.3.1 POTABLE WATER SUPPLY SCHEMES IN THE GOURITZ WMA IN 1995 60

4.4.1 CONTROLLED IRRIGATION SCHEMES IN THE GOURITZ WMA 63

5.1.1 WATER REQUIREMENTS PER USER GROUP IN 1995 64

LIST OF CONTENTS

Page No.

5.2.4.1 WATER REQUIREMENTS FOR THE ECOLOGICAL COMPONENT OF THE RESERVE 69

5.3.1.1 URBAN AND RURAL DOMESTIC WATER REQUIREMENTS IN 1995 73

5.3.2.1 DIRECT WATER USE : CATEGORIES AND ESTIMATED UNIT WATER USE........ 75

5.3.2.2 CLASSIFICATION OF URBAN CENTRES RELATED TO INDIRECT WATER USE........ 75

5.3.2.3 INDIRECT WATER USE AS A COMPONENT OF TOTAL DIRECT WATER USE........ 76

5.3.2.4 URBAN WATER REQUIREMENTS BY DRAINAGE AREA IN 1995........ 77

5.3.3.1 PER CAPITA WATER REQUIREMENTS IN RURAL AREAS IN 1995 79

5.3.3.2 RURAL DOMESTIC WATER REQUIREMENTS BY DRAINAGE AREA IN 1995........ 80

5.6.2.1 IRRIGATION WATER REQUIREMENTS IN 1995........ 82

5.6.2.2 TYPICAL ANNUAL FIELD EDGE IRRIGATION REQUIREMENTS........ 83

5.6.3.1 ESTIMATED IRRIGATION CONVEYANCE LOSSES 84

5.6.4.1 ESTIMATED IRRIGATION RETURN FLOWS AS PERCENTAGES OF FIELD EDGE IRRIGATION REQUIREMENTS 84

5.8.1 EVAPORATION LOSSES FROM DAMS 86

5.9.1 WATER USE BY AFFORESTATION IN 1995 88

5.11.1 WATER USE BY ALIEN VEGETATION IN 1995 90

5.13.1.1 IRRIGATION DISTRICTS IN THE GOURITZ WMA 99

5.13.2.1 SECTION 63 SCHEDULING AND QUOTAS FROM GOVERNMENT WATER SCHEMES IN THE GOURITZ WMA........ 100

5.13.2.2 SECTION 56(3) ALLOCATIONS FROM GOVERNMENT WATER SCHEMES........ 100

5.14.1 AVERAGE TRANSFERS WITHIN AND OUT OF THE GOURITZ WMA AT 1995 DEVELOPMENT LEVELS 102

LIST OF CONTENTS

Page No.

5.15.1 SUMMARY OF WATER REQUIREMENTS, LOSSES AND RETURN FLOWS 102

6.1.1 WATER RESOURCES 105

6.2.1 GROUNDWATER RESOURCES AT 1:50 YEAR ASSURANCE OF SUPPLY 108

6.3.1 SURFACE WATER RESOURCES 112

6.3.2 ESTIMATES OF MAXIMUM FEASIBLE STORAGE (EXPRESSED AS A PERCENTAGE OF MAR) 115

6.3.3 CALCULATION OF POTENTIAL MAXIMUM YIELD IN THE GOURITZ WMA 118

6.4.1.1 CLASSIFICATION SYSTEM FOR MINERALOGICAL WATER QUALITY 121

6.4.1.2 OVERALL CLASSIFICATION 121

6.4.1.3 SUMMARY OF MINERALOGICAL SURFACE WATER QUALITY OF THE GOURITZ WMA 122

6.5.1 RECORDED RESERVOIR SEDIMENTATION RATES FOR RESERVOIRS IN THE GOURITZ WMA 126

7.2.1 KEY POINTS FOR YIELD DETERMINATION 131

7.2.2 AVERAGE WATER REQUIREMENTS BY DRAINAGE AREA IN 1995 132

7.2.3 WATER REQUIREMENTS IN 1995 AT 1:50 YEAR ASSURANCE 133

7.2.4 WATER REQUIREMENTS AND AVAILABILITY IN 1995 134

8.1 CAPITAL COSTS OF DAMS 137

8.2 COSTS OF FUTURE WATER RESOURCE DEVELOPMENT)AT YEAR 2000 PRICE LEVELS INCLUDING VAT) 140

DIAGRAMS

2.6.2.1 Procedure followed to determine the river classifications 16
2.6.2.2 Descriptions of EISC, DEMC, DESC, PESC and AEMC 17
3.3.4.1 Contribution by Sector to Economy of Gouritz WMA, 1988 and 1997 (%) 30
3.3.4.2 Compound Annual Economic Growth by Sector of Gourtiz WMA and South Africa, 1988 - 1997 32
3.3.5.1 Gouritz Gross Geographic Product Location Quotient by Sector, 1997 33
5.15.1 Category loss as a proportion of the total losses in the Gouritz WMA 103
5.15.2 Category return flow as a proportion of the total return flow in the Gouritz WMA 103
6.3.1 Dam storage limits 116
8.1 Capital cost of dams 138

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 Sensitivity Class
DWAF	Department of Water Affairs and Forestry
EA	Enumerator area
EC	Electrical Conductivity
EISC	Ecological Importance and Sensitivity Class
ELSU	Equivalent large stock unit
GGP	Gross geographic product
GIS	Geographical Information System
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MD	Magisterial District
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
WRC	Water Research Commission
WRSA	Water Resources Situation Assessment
WSAM	Water Situation Assessment Model
WUA	Water User Association
ha	hectare
km^2	square kilometres
m^3	cubic metre
$10^6 m^3$	million cubic metres
$10^6 m^3/a$	million cubic metres per year
%	percent

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 flow normally occurs for only a few days or weeks after rain.
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 utilization 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 Gouritz Water Management Area, which occupies portions of the Western Cape, Eastern Cape and Northern Cape Provinces. 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 Gouritz 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 Gouritz 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 Gouritz 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 Gouritz Water Management Area which is shown on Figure 2.1.1 and covers an area of 53 140 km^2. The area includes the catchment area of the Gouritz River and its major tributaries, as well as the catchments of the smaller coastal rivers that lie to the east and west of the Gouritz River mouth.

Four other Water Management Areas bound the Gouritz Water Management Area. The Breede Water Management Area lies to the west, the Olifants/Doring and Lower Orange Water Management Areas to the north, the Fish to Tsitsikamma Water Mangement Area to the east, with the Indian Ocean to the south.

The Water Management Area lies within the boundaries of three provinces. Most of the area falls within the Western Cape Province, small portions of the upper catchment of the Olifants River fall in the Eastern Cape Province, and small portions of the upper catchments of the Gamka and Groot Rivers fall within the Northern Cape Province.

The topography of the WMA is shown in Figure 2.1.2. It is characterised by the flat open plains of the Great Karoo, interrupted by steep mountain ranges orientated in an east-west direction which enclose the Klein (Little) Karoo to the south of the Great Karoo. The Outeniqua, Tsitsikamma and Langeberg Mountains separate the Klein Karoo from the coastal plains. The coastal areas to the west of the Gouritz River mouth consist of rolling hills and sand dunes, with large endoreic areas (areas from which there is no flow of surface water to downstream catchments or the sea) occurring there.

The main rivers are the Gouritz and its major tributaries, the Groot, Gamka and Olifants Rivers. The two main coastal rivers to the west of the Gouritz are the Duiwenhoks and Goukou Rivers. Some of the main rivers to the east are the Hartenbos, Groot-Brak, Kaaimans and Keurbooms Rivers.

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 J23C, may be interpreted as follows. The letter J denotes Drainage Region J (sometimes referred to as a primary catchment). The number 2 denotes secondary catchment 2 of Drainage Region J. The number 3 shows that the secondary catchment has, in this case, been sub-divided into tertiary catchments and that the tertiary catchment is the third in sequence downstream from the head of secondary catchment J2. The letter C shows that the quaternary catchment is the third in sequence downstream from the head of tertiary catchment J23.

The Gouritz Water Management Area consists of a portion of drainage region H (H8 and H9 only) the whole of drainage area J, and portions of drainage region K(K1 to K7). It contains a total of 130 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 2.1.2. Many of the features themselves are not shown on the figure because the scale of mapping is too small.

The Gouritz River and its major tributaries drain an area of 45 702 km^2. The main stem of the river is 267 km long from its source in the Great Karoo to Gouritzmond where it enters the Indian Ocean (J40E). There are four sub-basins, as described below.

The Gouritz River

The Groot River

- The Touws River (a major tributary of the Groot River) rises in the Matroosberg Mountains near Verkeerdevlei (J12A and B). It flows in an east-south-easterly direction through the town of Touwsrivier (J12B) and then to the south of the Witteberge and Anysberge into the Klein Karoo, where it joins the Groot River (J12M).

- The Buffels River rises in the Great Karoo (J11A to F) and flows southwards through Laingsburg (J11E), (which was devastated by the 1981 flood), into Floriskraal Dam (J11F). Below Floriskraal Dam, the Buffels River passes through the Klein Swartberg Mountains (J11H) into the Klein Karoo (J11J and K), and becomes the Groot River which continues for some 50 km to its confluence with the Touws River (J11K).

- Downstream of its confluence with the Touws River (J11K and J12M), the Groot River (J13A to C) flows eastwards, past the town of Van Wyksdorp, and then on to its confluence with the Gouritz River.

The Gamka River

- The main tributaries of the Gamka River rise in the Great Karoo. They are the Dwyka River (J24A to F), the Koekemoers River (J22A to E), the Leeuw River (J22G, H , J and K) and the Gamka River (J21A to E). These tributaries join at Leeu Gamka and flow southwards as the Gamka River (J23A to J) into Gamkapoort Dam (J23J and J24F). From Gamkapoort Dam, it cuts through the Swartberg Mountains to join the Olifants River south of Calitzdorp and becomes the Gouritz River.

The Olifants River

- The northern tributaries of the Olifants River rise in the Great Karoo to the north of the Swartberg Mountains.

- The Olifants River itself rises to the east (J31A to D) and flows westwards to the confluence with the northern triburaties (J31D and J32E). From here, it flows between the Swartberg and Kammanassie Mountains into Stompdrift Dam (J33A and B), and on to its confluence with its Groot River tributary. This is not the same Groot River that is described above, but a much smaller river that drains from the Karoo to the north of the Swartberg and flows through Meiringspoort to join the Olifants River a short distance downstream of Stompdrift Dam (J33C and D).

- The Kango, Grobbelaars, Wynands, Kansa and Vlei Rivers all drain the southern slopes of the Swartberg (J33E and F and J35A,D,E and F), and flow perennially into the Olifants River.

- The Kammanassie River rises in the Outeniqua and Kammanassie Mountains, and in the mountains to the east of Uniondale (J34A) and flows into the Kammanassie Dam. It joins the Olifants River a short distance downstream of the dam.

The Gouritz River

- The Gouritz River flows from the confluence of the Gamka and Olifants Rivers (J40A), past the confluence with the Groot River and through the Langeberg Mountains (J40B). Then it cuts through the coastal plain (J40C,D and E) and flows into the sea near the resort town of Gouritzmond (J40E). Part of the coastal plain is an endoreic area (J40E).

The Coastal Rivers

Coastal Rivers west of the Gouritz River

- The Duiwenhoks River is situated immediately to the east of the Breede River. It rises in the Langeberg Mountains (H80A and B), flows through the town of Heidelberg, situated on the N2 (H80C), and thence through the coastal plain to the sea (H80D and E).

- The Goukou River also rises in the Langeberg Mountains (H90A and B), and flows past the town of Riversdale, situated on the N2. The river then cuts through the coastal plain (H90D and E) and flows into the sea at the coastal resort town of Stilbaai (H90E).

- Portions of the local coastal catchments between the Breede River and the Gouritz River mouths are endoreic (H70J and K, H80E and F and H90D and E).

Coastal Rivers east of the Gouritz River

- The Hartenbos River (K10B) rises in the coastal plain and enters the sea at Hartenbos.

- The Little Brak River rises in the Outeniqua Mountains and its course cuts through the coastal plain to the sea (K10C to F).

- The Great Brak River (K20A) rises in the Outeniqua Mountains and enters the sea at the resort town of Groot-Brakrivier.

- The Maalgaten (K30A) and Gwaing Rivers (K30B) both rise in the Outeniqua Mountains and exit to the sea near Herolds Bay.

- The Kaaimans River (K30C) also rises in the Outeniqua Mountains. Its main tributary, the Swart River, passes the town of George (K30B and C), and joins the Kaaimans itself just before it enters the sea near the coastal resort town of Wilderness (K30D).

- The Touw River (K30D) flows into the Wilderness lagoon. It is connected to the Langvlei by the Serpentine River channel, which in turn is connected by a channel to the Bo Langvlei. Rondevlei is not connected.

- The Diep (K40A), Hoëkraal (K40B) and Karatara (K40C) Rivers drain into Swartvlei, which enters the sea close to the town of Sedgefield on the N2 (K40D).

- The Goukamma River (K40E) enters the sea near the holiday resort town at Buffelsbaai.

- The Knysna River (K50A and B) drains into the Knysna lagoon.

- A few minor streams drain the coastal strip between Knysna and Plettenberg Bay (K60G). The Piesangs River (K60G) enters the sea at Plettenberg Bay.

- The Bitou River (K60F) and the Keurbooms River (K60A to E) flow into the sea via the Keurbooms lagoon.

- The Maatjies River (K70A) is a minor river that drains into the sea at Keurboomstrand. The Sout River (K70A) enters the sea just west of Nature's Valley, and the Groot River (K70A) flows into the sea slightly further east at Nature's Valley.

- The Bloukrantz River (K70B) enters the sea in the Tstisikamma Forest and Coastal National Park.

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 Gouritz 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 GOURITZ WMA

CATCHMENT					DESCRIPTION
PRIMARY		SECONDARY		QUATERNARY	
No.	Description	No.	Area	No.	
H (Part)	Coastal catchments to the west of the Gouritz River mouth	H8 and H9	Duiwenhoks, Goukou	H80A to F, H90A to E	Coastal rivers between Breede and Gouritz
J	Gouritz	J2	Upper Gamka River	J24A to F	Gamka and Dwyka Rivers upstream of their confluence
			Lower Gamka River	J25A to E	Gamka River between its confluence with the Olifants and Dwyka Rivers
		J3	Upper Olifants River	J31A to D, J32A to E, J33A to F	Olifants River above its confluence with the Kammanassie River
			Kammanassie River	J34A to F	Kammanassie River above its confluence with the Olifants River
			Lower Olifants River	J35A to F	Olifants River between its confluences with the Gamka River and the Kammanassie
		J1	Buffels River	J11A to K	Buffels River above its confluence with the Touws River
			Touws River	J12A to L	Touws River above its confluence with the Buffels River
			Groot River	J13A to C	Groot River between its confluences with the Gouritz and Buffels Rivers
		J4	Lower Gouritz	J40A to E	Gouritz River between its mouth and the Gouritz/Olifants confluence
K (Part)	Coastal rivers to the east of the Gouritz River mouth (Outeniqua coastal catchments)	K1, K2, K3 (part)	Mossel Bay to George	K10A, K10B to F, K20A, K30A to B, K30C	Coastal rivers from Mossel Bay to George
		K3 (part), K4	Wilderness	K30D, K40A to E	Coastal rivers from George to Knysna
		K5, K6, K7	Knysna to Blaaukrantz	K50A to B, K60A to G, K70A, K70B	Coastal rivers from Knysna to Blaaukrantz

The boundaries of these key areas are shown and described on Figure 2.1.3 and shown on most of the other figures in the report. The key areas are also used in many of the tables.

2.2 CLIMATE

The Gouritz WMA is the second largest WMA in the Western Cape Province and comprises two distinct climatic zones. The northern and central portions form part of the Great and Little Karoo, with their associated hot, dry climate, whereas the southern coastal strip has a more temperate climate with significantly higher rainfall.

Temperature

The mean annual temperature ranges between 16ºC along the south-east coast to 17ºC in the interior, with an average of 17ºC for the WMA as a whole. Maximum temperatures are experienced in February and minimum temperatures usually occur in July. Table 2.2.1 summarises temperature data for the Gouritz WMA.

TABLE 2.2.1: TEMPERATURE DATA

MONTH	TEMPERATURE	AVERAGE (ºC)	RANGE (ºC)
January	Mean temperature	21	18 - 24
	Maximum temperature	36	33 - 41
	Minimum temperature	10	10 - 11
	Diurnal range	12	8 - 7
July	Mean temperature	12	11 - 14
	Maximum temperature	27	24 - 28
	Minimum temperature	2	0 - 4
	Diurnal range	13	8 - 18

Frost occurs along the Central Karoo toward the western region of Riversdale in winter, typically over the period of June to August.

Rainfall

The northern portion of the Gouritz WMA is classified as a very late summer rainfall region, with a large proportion of annual precipitation falling between March and May. The southern portion is classified as an all year round rainfall region. Along the south coast, rain is experienced throughout the year with the highest precipitation being during spring (August to November) and again during late summer (February and March). Precipitation is generally from cold fronts approaching from the south-west. The Karoo region (i.e. central region) normally receives most of its rainfall during the period from February to April. Along the south-west portion of the water management area, high rainfall occurs in the months of April to August. The mean lighting flash density is 0 - 1 per km^2 per annum.

As a result of the influence of the mountains, a large spatial variability in the mean annual precipitation (MAP) is experienced. The variation in MAP for the WMA is shown in Figure 2.2.1. The MAP of the study area decreases from east to west with MAPs ranging from as high as 1 500 mm in the south-east in the coastal mountains to as low as 160 mm toward the north of the water management area. The average coefficient of variation (CV) ranges from 30% to 40%. (Midgley *et al*, 1994).

For the wettest year in five (20% exceedance probability), the annual rainfall for the southern half is 1 000 mm, but can be as low as 400 mm in places. For the northern half of the WMA, the annual rainfall is 400 mm but can be as low as 100 mm in places.

Humidity and Evaporation

The relative humidity is higher in winter than in summer throughout the WMA. Humidity is highest in June (the daily mean over the Gouritz WMA ranges from 63% to the north and 68% to the south), and the lowest in January (daily mean over the Gouritz WMA ranges from 59% to the north and 68% to the south).

The variation in gross mean annual evaporation (MAE) is shown in Figure 2.2.2. Average potential gross mean annual evaporation (as measured by Symons-pan) ranges from 1500 mm in the north to 2 100 mm towards the central region, and 1 600 mm in the south along the coast (see Figure 2.2.2). The highest gross Symons-pan evaporation is in January ranging from 340 mm to 360 mm towards the north and 200 mm to 300 mm in the south along the coastal areas. The lowest gross Symons-pan evaporation is in June (78 to 90 mm).

The gross irrigation requirement (based on rainfall and A-pan evaporation) for the whole WMA ranges between 1 800 to 2 000 mm/annum in the north and between 800 to 1 300 mm/annum, in the southern central/south coastal areas. The minimum monthly requirement is in June (ranges from 35mm to 70 mm) and the maximum monthly requirement is in January (200 mm to 300 mm) (Schulze *et al*, 1997). The gross irrigation requirements are based on the assumption of a perennial crop with a uniform crop factor of 0,8. The requirement takes into account effective rainfall plus conveyance losses and spray drift losses (both assumed to be 10%).

2.3 GEOLOGY

The geology of the area is shown in simplified form on Figure 2.3.1. The northern portion of the WMA consists of flat plains and low hills formed by Karoo sediments and doleritic intrusions. The southern portion is mountainous terrain consisting of sandstones, shales and tillites of the Cape Supergroup. The Klein Karoo, in the vicinity of Oudtshoorn, consists of sandstones, quartzite and conglomerates of the Malmesbury Group, overlain in the valley floors by alluvial deposits. Rocks of the Malmesbury Group are also exposed along the coastal strip between Mossel Bay and Plettenberg Bay.

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 Gouritz Water Management Area :

- Moderately deep to deep sandy soil occurs in undulating terrain in a localised area in the south-western corner of the WMA in the region of Stilbaai and Albertinia (H80E and F, H90D and E, J40D and E).
- Moderately deep to deep sandy loams occur in undulating terrain along a 10 to 20 km wide coastal strip along the southern edge of the WMA (H8, H9, J40, K1 to K7).
- Shallow sandy loam in undulating terrain in the central region of the WMA.
- Moderately deep to deep sandy loam in undulating terrain in the central Karoo areas to the north of the WMA (J2).
- Moderately deep to deep sandy loam on the steep slopes of the mountains in the north-west of the WMA (J11).
- Moderately deep to deep clayey loam in the undulating terrain along the Kammanassie River (J34).

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 range 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 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 is rather broad.

2.5.2 Natural Vegetation Types within the Gouritz WMA

The Gouritz WMA is located mainly within the Western Cape, and the vegetation within this province is dominated by Karoo and Karroid Types, Temperate and Transitional Forest and Scrub Types, and Sclerophyllous Bush Types. In addition to the aforementioned veld types, False Karoo Types, Coastal Topical Forest Types and False Schlerophyllous Bush Types can also be found within this WMA. The veld types occurring within the Gouritz WMA are described in more detail below and illustrated in Figure 2.5.2.1.

Coastal Tropical Forest
A relatively large band of Coastal Tropical Forest occurs adjacent to the coastline in the south of the Gouritz WMA. This veld type is typically confined to the coastal area or immediate vicinity, and includes areas 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.

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 Karoo	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
Highveld 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	53	
Turf Highveld to Highland Sourveld Transition	54	
Bakenveld to Turf Highveld Transition	55	
Highland Sourveld to Cymbopogon – Themeda Veld	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**

Karoo and Karroid Bushveld

This veld type dominates within the Gouritz WMA, occupying some 75% to 80% of its area. 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 mm and 500 mm, but does reach a maximum of up to 900 mm in some of the river valleys. Karoo and Karroid Bushveld occurs at any altitude from sea level to 1 200 m above mean sea level (MSL).

False Karoo

Broad bands of this veld type occur along the western and northern boundaries, as well as centrally within the Gouritz WMA. Similar to Karoo and Karroid Bushveld, the False Karoo vegetation type is typified by low vegetation, but in contrast contains more grassy elements. The areas occupied by this veld type are typically very arid and in parts may receive less than 100 mm of rainfall per annum. This veld type generally occurs below 1 200 m in elevation.

Temperate and Transitional Forest and Scrub

A large patch of this vegetation type occurs towards the south-western boundary of the Gouritz 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 can occur from sea level to up to 1 350 m. Rainfall is typically high ranging from 650 to 1 150 mm per annum, although it may be somewhat lower within the coastal renosterveld and fynbos elements of this veld type, where it typically ranges between 300 to 500 mm per annum.

Sclerophyllous Bush
Isolated patches of Sclerophyllous Bush, continuous with those of within the Breede WMA, occur in the western region of this WMA. This vegetation type, also referred to as Fynbos, contains a bewildering array of species which are characteristically small leafed (hence the term Sclerophyllous Bush). No single species dominates and there is a tremendous spatial turnover in species composition.

False Sclerophyllous Bush
This veld type occurs in relatively large bands throughout the central parts of the Gouritz WMA. False Sclerophyllous Bush is typically indistinguishable from true Fynbos. It is usually dominated by Asteracous elements (daisies). The areas occupied by the False Sclerophyllous Bush are typically fairly moist, receiving in excess of 500 mm, and up to 1 500 mm, of rainfall per annum.

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 basic 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 1999). 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.

The procedure for establishing the ecological Reserve requires each water resource to be classified and the resource quality objectives to be set as initial steps towards determining the ecological Reserve.

As estimates of the quantity of water required for the ecological component of the Reserve are an essential requirement if a meaningful assessment of water resources is to be carried out, and the process of classifying all the water resources has not yet been completed, rapid preliminary classifications were made and used to make rough estimates of the ecological Reserve for purposes of the situation assessments.

The procedure followed to classify the rivers is described in Section 2.6.2, below, and the use of the classifications to make rough estimates of the quantity of water required for the ecological component of the Reserve for each of the quaternary catchments in the WMA is described in Section 5.2.

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.

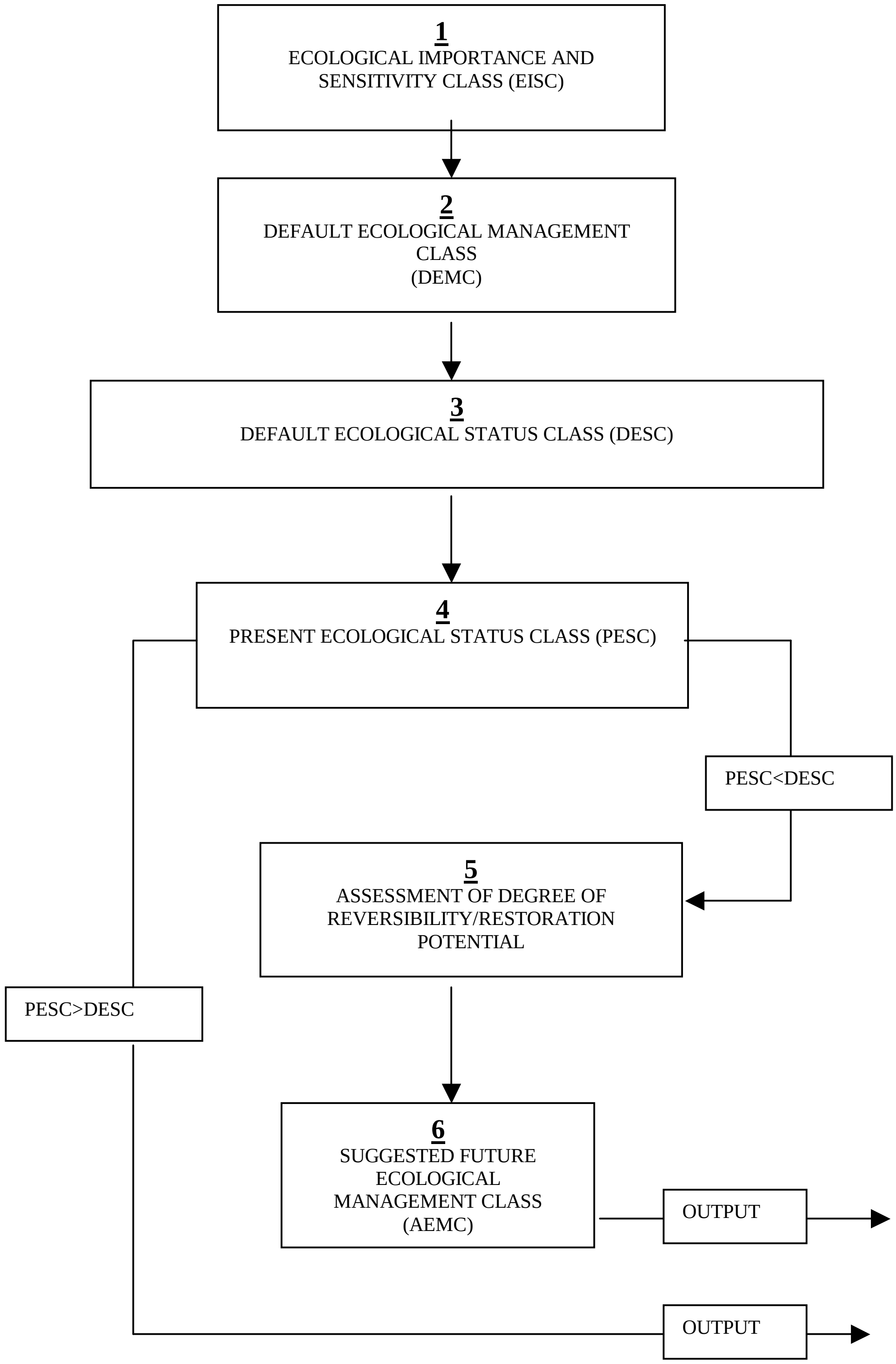


Diagram 2.6.2.1: Procedure followed to determine the river classifications

EISC		DEMC and DESC
Very high	→ No human induced hazards	→ Class A: Unmodified natural
High	→ Small risk allowed	→ Class B: Largely natural
Moderate	→ Moderate risk allowed	→ Class C: Moderately modified
Low/marginal	→ Large risk allowed	→ Class D: Largely modified

PESC	PESC: SUGGESTED ATTAINABLE IMPROVEMENT Acceptable range of AEMC:
Class A: Unmodified natural	Class A: Unmodified natural
Class B: Largely natural	Class B: Largely natural
Class C: Moderately modified	Class C: Moderately modified
Class D: Largely modified	Class D: Largely modified
Class E: Seriously modified	Class E: Seriously modified
Class F: Critically 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.

The Gouritz WMA derives its name from the Gouritz River which is the dominant river system within the WMA. Other major rivers within this WMA include the Buffels, Dwyka, Gamka, Groot, Kammanassie, Leeuw, Olifants and Touws Rivers.

The ecological significance/conservation importance of the river systems falling within the Gouritz WMA, as exemplified by their Ecological Importance and Sensitivity Classes

(EISC), is summarised in Figure 3.4 of Appendix F6. 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. As evident from Figure 3.4 of Appendix F6, the vast majority of river reaches within the Gouritz WMA exhibit a "moderate" EISC, evidence of some degree of anthropogenic manipulation of the various river reaches. The exceptions are some reaches of the Duiwenhoks, Goukou and Gamka Rivers (H80A-C, H90A-C, J11J, J23J and J25A-D) which exhibit a "high" EISC and those river reaches within the Keurbooms, Knysna, South Cape Coastal system (K10A-E, K20A, K30A-D, K40A-E, K50A-B, K60A-E and K70A-B) which exhibit a "very high" EISC. Accordingly, for these latter river reaches, human manipulation of the system would require strong motivation.

Figures 2.6.3.1 and 2.6.3.2 show respectively the Default Ecological Management Classes and the Present Ecological Status Class. Figure 2.6.3.3 shows the Suggested Ecological Management Classes that the assessment carried out for this study proposed that it would be practical to achieve through management of the flow in the rivers. Comparison of this figure with the Present Ecological Status Classes depicted on Figure 2.6.3.2, shows that it was considered to be impractical to improve the status of any of the areas.

This overview of the ecological significance and conservation importance of the river systems within the Gouritz WMA is of necessity superficial. However, the assessment of the EISC and Default Ecological Management 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 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 projects, 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 wetlands and groundwater systems, has to date not been assessed within the Gouritz WMA. Similarly, the estuarine system is not well studied, but is ecologically important and sensitive to reduced flows and changes in water quality, especially salinity. Accordingly, it is imperative that if any future development of the water resources in the Gouritz WMA is considered, a comprehensive study of these other aquatic systems, to ascertain the environmental acceptability of the development.

2.6.4 Natural Heritage Sites, Proclaimed Game and Nature Reserves, 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 Gouritz 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, Protected Land/Seascapes.

Table 2.6.4.1 contains a list of the protected areas within the Gouritz WMA and Figure 2.6.3.2 shows the positions of some of them. All water resource development and utilisation should take cognisance of these sites and it is the developer's responsibility 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.

TABLE 2.6.4.1: PROTECTED NATURAL AREAS AND NATURAL HERITAGE SITES WITHIN THE GOURITZ WMA

AREA NAME	CATEGORY	GRID REFERENCE
Attakwaskloof Nature Reserve	Habitat and Wildlife Management Areas	33º50'S 21º58'E
Beervlei Forest	Sustainable Use Area	33º55'S 22º45'E
Bergplaas State Forest	Habitat and Wildlife Management Areas	33º51'S 22º43'E
Buffelsnek State Forest	Habitat and Wildlife Management Areas	33º53'S 23º08'E
Buffelspoort	Natural Heritage Site	33º26'S 21º00'E
Diepwalle Forest	Sustainable Use Area	33º57'S 23º10'E
Doringrivier Wilderness Area	Habitat and Wildlife Management Areas	33º55'S 22º20'E
Farleigh Forest	Sustainable Use Area	33º54'S 22º54'E
Featherbed	Natural Heritage Sites	34º05'S 23º03'E
Gamka Mountain Nature Reserve	Habitat and Wildlife Management Areas	33º40'S 21º48'E
Gamkapoort Nature Reserve	Habitat and Wildlife Management Areas	33º12'S 21º30'E
Goudveld Forest	Sustainable Use Area	33º55'S 22º58'E
Goukamma Nature Reserve	Habitat and Wildlife Management Areas	34º01'S 22º50'E
Gouna Forest	Sustainable Use Area	33º57'S 23º05'E
Groot Swartberg State Forest	Habitat and Wildlife Management Areas	33º25'S 22º00'E
Grootkop	Natural Heritage Sites	33º34'S 22º14'E
Harkerville Forest	Sustainable Use Area	34º04'S 23º13'E
Hawequas State Forest	Habitat and Wildlife Management Areas	33º45'S 22º25'E
Hek se Bos	Natural Heritage Sites	34º55'S 23º23'E
Jongesfontein State Forest	Habitat and Wildlife Management Areas	33º27'S 21º20'E
Jonkersberg State Forest	Habitat and Wildlife Management Areas	33º55'S 22º15'E
Jubilee Creek Nature Reserve	Sustainable Use Area	33º54'S 22º57'E
Kaffirkop Indigenous Forest	Sustainable Use Area	34º00'S 23º10'E
Kammanassie Nature Reserve	Habitat and Wildlife Management Areas	33º40'S 22º45'E
Karatara Block A	Habitat and Wildlife Management Areas	33º54'S 22º49'E
Keurbooms River Nature Reserve	Habitat and Wildlife Management Areas	33º56'S 23º22'E
Klein Swartberg State Forest	Habitat and Wildlife Management Areas	33º25'S 21º20'E
Kleinberg Private Nature Reserve	Natural Heritage Sites	33º24'S 21º34'E
Knysna National Lakes Area	National Parks and Equivalent Reserves	34º07'S 23º04'E
Langkloof State Forest	Habitat and Wildlife Management Areas	33º52'S 22º25'E
Lelievlei Nature Reserve	Habitat and Wildlife Management Areas	33º57'S 23º02'E
Millwoood Nature Reserve	Habitat and Wildlife Management Areas	33º53'S 23º00'E
Moordkuil Nature Reserve	Habitat and Wildlife Management Areas	33º50'S 22º03'E
Mountain Catchment Area 1	Habitat and Wildlife Management Areas	33º50'S 22º03'E
Mountain Catchment Area 2	Habitat and Wildlife Management Areas	33º50'S 22º03'E
Nietgenaamd Nature Reserve	Habitat and Wildlife Management Areas	33º25'S 23º12'E
Petrus Brand Nature Reserve	Habitat and Wildlife Management Areas	33º59'S 23º12'E
Rietvlei	Natural Heritage Site	33º31'S 22º28'E
Robberg Nature Reserve	Habitat and Wildlife Management Areas	34º05'S 23º22'E
Rooiberg State Forest	Habitat and Wildlife Management Areas	33º40'S 21º25'E
Ruiterbos State Forest	Habitat and Wildlife Management Areas	33º50'S 22º03'E
Sinclair Nature Reserve	Habitat and Wildlife Management Areas	34º05'S 23º09'E
Sterboom	Natural Heritage Site	33º26'S 21º16'E

AREA NAME	CATEGORY	GRID REFERENCE
Stilbaai East State Forest	Habitat and Wildlife Management Areas	34º22'S 21º30'E
Swartberg East State Forest	Habitat and Wildlife Management Areas	33º20'S 22º45'E
Tierberg	Natural Heritage Sites	33º10'S 22º17'E
Tor Doone	Natural Heritage Sites	33º55'S 23º23'E
Whiskey Creek Nature Reserve	Habitat and Wildlife Management Areas	33º57'S 23º23'E
Wilderness National Lakes Area	National Parks and Equivalent Reserves	34º00'S 22º42'E
Wilderness Lake	RAMSAR Sites	33º59'S 22º40'E
Witfontein Nature Reserve	Habitat and Wildlife Management Areas	33º55'S 22º28'E
Woodville Forest	Habitat and Wildlife Management Areas	33º56'S 22º41'E
Ysternek Nature Reserve	Habitat and Wildlife Management Areas	33º55'S 23º10'E
Ysternek Nature Reserve	Habitat and Wildlife Management Areas	33º56'S 23º09'E

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 that he or she is familiar with the most recent status of protected areas within the Gouritz WMA.

2.7 CULTURAL AND HISTORICAL SITES

Development of water supplies and services can have a negative impact on the archaeological and cultural heritage by way of development of dams, pipelines, canals, water services infrastructure and enterprises following on the provision of water.

Any given development may have an impact on archaeological or cultural heritage sites. It is essential therefore that potential impacts of any water supply and services related development should be assessed at the earliest possible phase of project planning.

Permission for the development to proceed is granted by the South African Heritage Resources Agency (formerly the National Monuments Council) once it is satisfied that steps have been taken to safeguard archaeological or cultural heritage sites, or that they have been adequately recorded and/or sampled.

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 Gouritz WMA and accordingly could influence the further development and utilisation of water resources within this WMA. 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. The Environment Conservation Act (No. 73 of 1989) provides for the integration of cultural resources into environmental management processes.

No general listing of the sites of palaeontological, archaeological and historical significance within the Gouritz WMA is available. The South African Heritage Resources Agency 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. Also, developers should take cognisance of the fact that the National Heritage Resources Act superseded the National Monuments Act in April 2000, and should familiarise themselves with the contents of the new Act.

CHAPTER 3: DEVELOPMENT STATUS

3.1 HISTORICAL DEVELOPMENT OF WATER RELATED INFRASTRUCTURE

Many towns in the Gouritz WMA have developed their water supplies themselves from local sources. This infrastructure was often linked with the provision of water for irrigation. The first dam of significant size to be constructed in the catchment was the Springfontein farm dam near Beaufort West which was completed in 1880. This was followed by the Verkeerdevlei Dam (J12B), built in 1889. The Calitzdorp Dam (J25D) was constructed in 1917 to supply water for irrigation as well as domestic water to the town of Calitzdorp. Bellair Dam (J12K) was built in 1922.

One of the major developments in the Klein Karoo was the building of the Kammanassie Dam in 1923 and the extensive canal system to supply irrigation water to farmers in the Olifants River valley. The Stompdrift Dam was built in 1965 to supplement the supply to this scheme.

The town of Oudtshoorn relied initially on a run-of-river diversion from Rust en Vrede on the Kango River, a tributary of the Olifants River. Increasing water requirements led to the construction of Melville Dam in 1942 and Koos Raubenheimer Dam in 1971.

The Oukloof Dam (J23E) was built in 1929. The Swart River Dam was constructed in 1938 and later raised in 1953 to supply water to the town of George. This source of supply was later augmented by a run-of-river pumpstation on the Kaaimans River. Both of these sources were replaced with the Garden Route Dam (K30C) on the Swart River, which was built in 1980.

Four large dams were constructed in the WMA in the 1950s. The Gamka Dam (J21A) was built in 1954, and the Ernest Robertson Dam (K20A) in 1955. The Floriskraal Dam (J11F, G, H) was built in 1957 and the Leeu Gamka Dam (J22K) in 1959.

The Korentepoort Dam (H90B), the Duiwenhoks Dam (H80A), and the Stompdrift Dam (J33B) (mentioned previously) were constructed in 1965. The Duiwenhoks Dam supplies the town of Heidelberg with potable water, irrigation water to the local Irrigation Board, and, via the Overberg Water Board's treatment works, water for livestock and household use to farms and coastal towns.

Three large dams were constructed in 1969, namely the Doornboomsfontein Dam (J22G), The Gamkapoort Dam (J25A) and the Hartebeeskuil Dam (K10B).

The Koos Raubenheimer Dam (mentioned previously) was the only large dam constructed in the WMA in the 1970s.

Two large dams were constructed in the WMA in the 1980s, namely the Garden Route Dam (K30C) (mentioned previously) in 1980, and the Klipheuwel Dam (K10F) in 1981.

The most recently constructed large dam is the Wolwedans Dam (K20A) which supplies the Petro S A Refinery and will supply Mossel Bay with domestic water in future. This was constructed in 1990.

The Klein Karoo Rural Water Supply Scheme is a groundwater supply scheme which was built by DWAF. This became operational in 1993 to supply potable water to Dysselsdorp and for domestic purposes and stock watering to farmers and small rural communities in the Klein Karoo area from De Rust to Calitzdorp.

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 because published data from the national population census are given per magisterial district. As the boundaries of the magisterial districts do not coincide with the WMA boundaries, the population of the WMA has to be estimated, based on the assumption that the rural population is evenly distributed over the magisterial districts.

It appears from the 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 2,2% per year. The overall increase in urban population was about 3,4% per year. This varied from as high as 5,9% per year for the coastal magisterial district of George, to negative growth rates as low as -1,5% per year for the magisterial district of Uniondale. The overall non-urban population decreased by about 0,6% per year. The largest decrease was 6,6% per year for the magisterial district of Prince Albert. The exceptions were a few magisterial districts that experienced small increases in population over this period, for example Heidelberg (+0,8%per year), Knysna (+0,9% per year) and Ladismith (+1,1% per year). The trend seems to be one of migration from the rural to the urban areas, particularly the coastal resort towns in the WMA.

3.2.4 Population Size and Distribution in 1995

In 1995, approximately 424 000 people lived in the WMA. About 352 000 (83%) of these lived in urban or peri-urban areas, and the remaining 17% in rural areas. The distribution of the population is shown in Table 3.2.4.1 and in Figure 3.2.4.1, where it can be seen that the population is concentrated along the coastal strip (61%). Approximately 54% of the population lives in the coastal catchments to the east of the Gouritz River mouth, and 7% in the coastal catchments to the west of the Gouritz River mouth. The remaining 39% of the population lives in the Gouritz River catchment, which consists of parts of the Great and Little Karoo.

TABLE 3.2.4.1: POPULATION IN 1995

CATCHMENT						URBAN POPULATION	RURAL POPULATION	TOTAL
PRIMARY		SECONDARY		TERTIARY / QUATERNARY				
No.	Description	No.	Description	No.	Description	(Number)	(Number)	(Number)
H (part)	Breede – Gouritz	H8, H9	Duiwenhoks, Goukou	None	-	20 300	8 000	28 300
	TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)					**20 300**	**8 000**	**28 300**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N. Cape) Upper Gamka (W. Cape)	0 32 300	131 4 968	131 37 268
				J25	Lower Gamka (all W. Cape)	6 550	4 402	10 952
			Sub-total (Northern Cape)			**0**	**131**	**131**
			Sub-total (Western Cape)			**38 850**	**9 370**	**48 220**
			Total for Gamka catchment			**38 850**	**9 501**	**48 351**
		J3	Olifants	J31 to J33	Upper Olifants (E. Cape) Upper Olifants (W. Cape)	0 10 800	720 6 887	720 17 687
				J34	Kammanassie (all W. Cape)	3 250	4 335	7 585
				J35	Lower Olifants (all W. Cape)	53 800	8 740	62 540
			Sub-total (Eastern Cape)			**0**	**720**	**720**
			Sub-total (Western Cape)			**67 850**	**19 962**	**87 812**
			Total for Olifants catchment			**67 850**	**20 683**	**88 533**
		J1	Groot	J11	Buffels (N. Cape) Buffels (W. Cape)	0 6 550	156 3 636	156 10 186
				J12	Touws (all W. Cape)	6 200	3 730	9 930
				J13	Groot (all W. Cape)	400	791	1 191
			Sub-total (Northern Cape)			**0**	**156**	**156**
			Sub-total (Western Cape)			**13 150**	**8 157**	**21 307**
			Total for Groot River catchment			**13 150**	**8 313**	**21 463**
		J4	Lower Gouritz	None	-	3 650	3 798	7 448
			Total for Lower Gouritz incremental catchment (all Western Cape)			**3 650**	**3 798**	**7 448**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					**0**	**287**	**287**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0**	**720**	**720**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**123 500**	**41 288**	**164 788**
	TOTAL IN GOURITZ CATCHMENT					**123 500**	**42 295**	**165 795**
K (part)	Outeniqua Coastal	K1, K2, Part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (all W Cape)	**153 650**	10 738	164 388
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	7 800	5 530	13 330
		K5, K5, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	0 46 250	78 6 023	78 52 273
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0**	**78**	**78**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**207 700**	**22 291**	**22 991**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**207 700**	**22 369**	**230 069**
TOTAL IN WMA IN NORTHERN CAPE						**0**	**287**	**287**
TOTAL IN WMA IN EASTERN CAPE						**0**	**798**	**798**
TOTAL IN WMA IN WESTERN CAPE						**351 500**	**71 579**	**423 079**
TOTAL IN WMA						**351 500**	**72 664**	**424 164**

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 Gouritz Water Management Area (WMA) in terms of the following aspects:

- The present economic development of the Gouritz WMA on a sectoral basis, taking into account the context of economic development in South Africa.
- The comparative advantages of the Gouritz 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, 1991). 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 (CSS 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, 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 Gouritz WMA was R4,9bn in 1997. The most important magisterial districts in terms of contribution to GGP in this WMA are shown below:

- George 27,1%
- Oudtshoorn 17,9%
- Knysna 10,9%
- Mossel Bay 10,3%
- Beaufort-West 10,1%
- Other 23,7%

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

- Trade 19,3%
- Government 18,1%
- Agriculture 17,2%
- Financial Services 14,2%
- Manufacturing 11,0%
- Other 22,2%

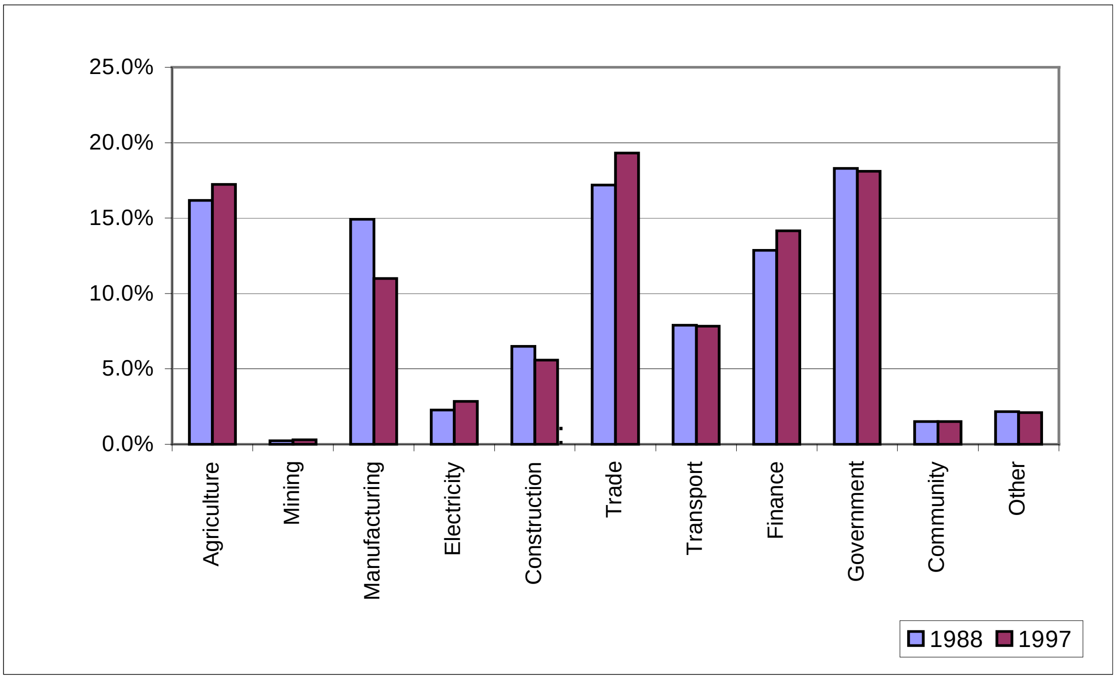


Diagram 3.3.4.1: Contribution by Sector to Economy of Gouritz Water Management Area, 1988 and 1997 (%)

The agricultural sector is rooted in a wide range of products for example fruit, vegetables, grains, dairy, timber and fish/shell fish, tobacco, sheep, cattle, goats and hops. The Southern Cape area is the only region that is suitable for the production of hops. Approximately half of the hops required by the South Africa brewing industry is cultivated in the George district. In the little Karoo area, particularly the Oudtshoorn area, the ostrich industry plays an important function in the region's economy. However, this industry is experiencing strain since the market is flooded by cheaper products from other areas in the world and the international market demand is currently relatively stagnant.

Forestry and timber are one of the strongest components of agricultural production in the region and also provide a wide array of processing and manufacturing activities. Wooden furniture made from high quality indigenous wood is one of the most important export articles of the Southern Cape region.

The trade sector is supported by a strong transport industry, the service orientated nature of the majority of the urban settlements in the area, as well as a growing tourism market.

The financial sector is supported by the strong property market along the coastal areas, especially in places like Plettenberg Bay, Knysna and Sedgefield and east of Mossel Bay. The financial sector is also focused on supporting the agricultural and trade sectors in the financing of machinery and equipment.

Manufacturing occurs to the greatest extent in Mossel Bay and George, and also, but to a lesser extent in Oudtshoorn. At Mossel Bay the Mossgas natural gas extraction and refinery project plays a large role in the manufacturing industry. In Mossel Bay the manufacturing and transport sectors are also supported by a harbour.

A wide variety of government, social and financial services are located in the major towns such as Mossel Bay, Knysna, Plettenberg Bay, Oudsthoorn and George.

Economic Growth

Compound annual economic growth by sector is shown in Diagram 3.3.4.2. The following sectors recorded the highest average annual growth rates between 1987 and 1997:

- Agriculture 2,3%
- Mining 4,1%
- Electricity 4,1%
- Construction 2,9%
- Finance 2,6%

Forestry and timber is an important element in the agricultural sector and as long as large portions of land are available, growth can be expected.

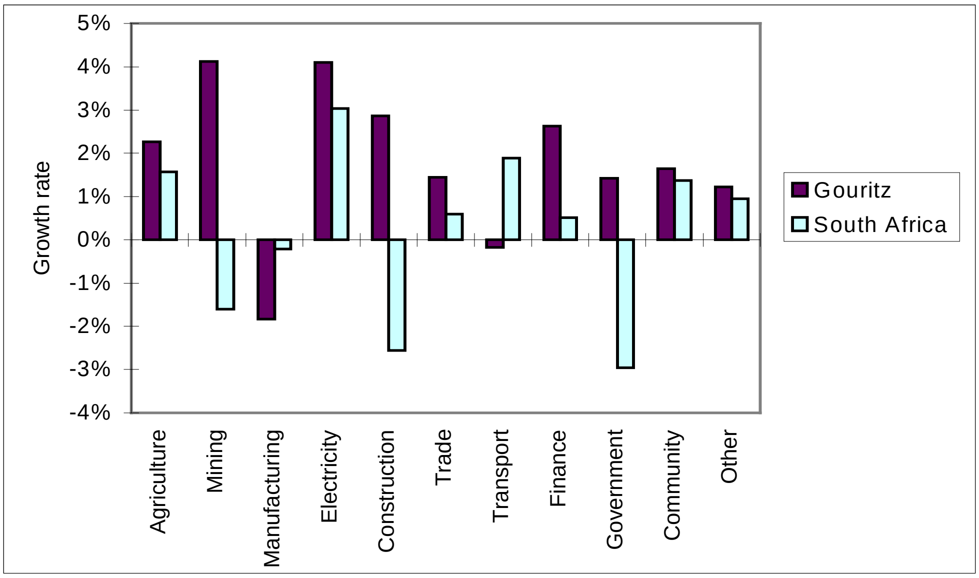


Diagram 3.3.4.2: Compound Annual Economic Growth by Sector of Gouritz Water Management Area and South Africa, 1988-1997

Labour

Of the total labour force of 191 000 in 1994, 15,1% were unemployed, which is lower than the national average of 29,3%. Sixty six percent (66%) are active in the formal economy. Twenty nine percent (29,2%) of the formally employed labour force work for the government. The second largest percentage, 17%, are involved in agriculture, and 14,9% in the construction sectors.

Employment growth was recorded in the mining sector (18,1% per annum); financial services (5,9% per annum); and the construction sector (6,8% per annum). The high growth rate of the mining sector is largely the result of the growth from a small base, since this sector was not a significant employment provider.

3.3.5 Comparative Advantages

A geographic area is said to have a comparative advantage in the production of certain goods and services if it can produce them at a lower cost per unit than another region while maintaining the same quality. When this is the case, production of such goods tends to become relatively more concentrated in the region which has the comparative advantage. The location quotient is a measure of the relative concentration of economic activities in a region as compared with another region, or as compared with a larger region of which it forms part. A location quotient for an economic sector with a value of more than one implies that the sector contributes a larger percentage to a sub-region's GGP than that sector contributes to the larger area of which the sub-region forms part. The location quotient can, however, not be equated with comparative advantage, and provides only an indication.

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

- Agriculture 3,8
- Construction 1,9

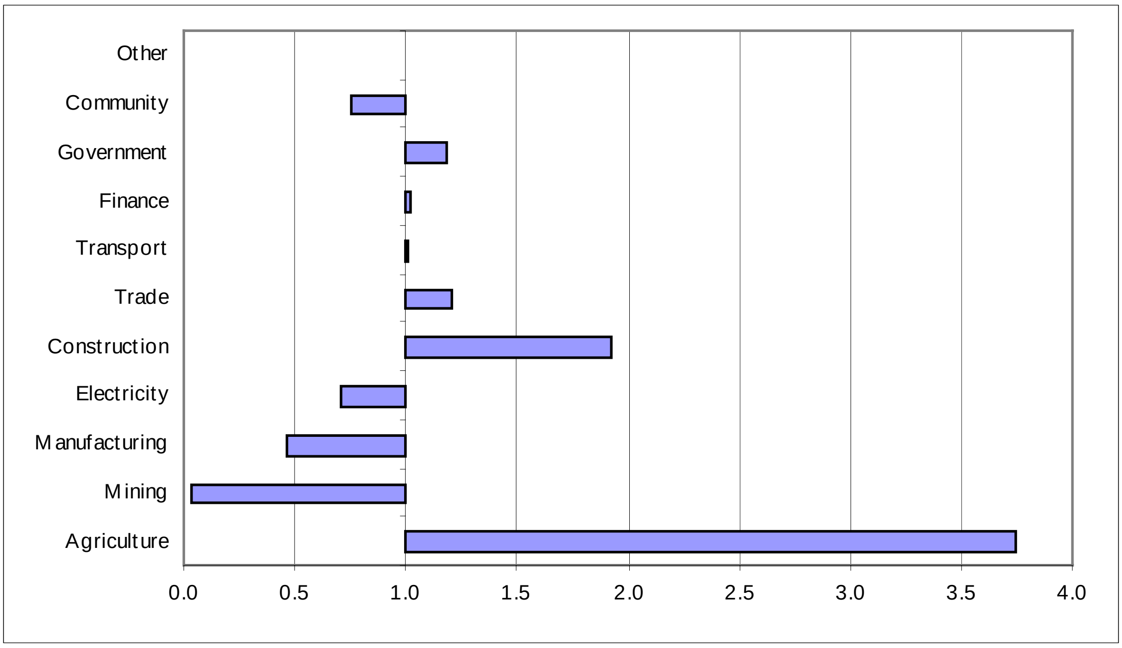


Diagram 3.3.5.1: Gouritz Gross Geographic Product Location Quotient by Sector, 1997

The comparative advantage of the agricultural sector can be attributed to the large variety of products found in this area, especially products from the ostrich, hops and timber industries contribute to the high comparative advantage of this sector in this region.

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 19th 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 bodies 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 Communities' Water Supplies

The Water Services Act, (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, only the institutional arrangements prior to the re-restructuring are reported on here.

The Gouritz WMA was fortunate in that 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 and the surrounding area. 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 rural councils that are also shown on Figure 3.4.9.2. In the interior, these areas are generally nature reserves or farmland where the owners of the land are responsible for their own water supplies, or, in the case of the rural areas adjacent to Heidelberg and Riversdale, are supplied by the Overberg Water Board. In these areas, neither the transitional rural councils nor the district councils were Water Services

Authorities, but closer to the coast there are small settlements and numerous smallholdings for which the transitional rural councils or the Southern Cape District Council were the Water Services Authorities. There were 33 Water Services Authorities in all in the WMA. The Overberg Water Board is the only water board operating in the Gouritz WMA and it also operates in the Breede WMA. It was established primarily to provide domestic water supplies to farming communities.

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 sub-divisions of land for general administrative purposes, but they have no connection with water supplies. The boundaries of some magisterial districts crossed the boundaries of district council areas.

Some of the district council areas fall fully within the Gourtiz WMA, and, similarly, several of the magisterial districts extend outside the WMA.

The district council areas and the magisterial districts entirely or partially within them were :

Eastern Cape
- The Western Region District Council

Northern Cape
- The Hantam District Council

Western Cape
- The Breede River District Council
- The Central Karoo District Council
- The Southern Cape District Council
- The Klein Karoo District Council
- The Overberg District Council

The boundaries of the areas of jurisdiction of the District Councils are shown on Figure 3.4.9.1. For general administrative purposes, but not for water supply, each District Council area is subdivided into magisterial districts, the boundaries of which are also shown on Figure 3.4.9.1.

The relevant magisterial districts are:

- Within the Western Region District Council Area
  - Willowmore (portion)

- Within the Hantam District Council Area
  - Sutherland (small portion)
  - Fraserburg (small portion)

- Within the Breede River District Council Area
  - Ceres (small portion)
  - Worcester (portion)
  - Montagu (portion)

- Within the Central Karoo District Council Area
  - Laingsburg
  - Prince Albert
  - Beaufort West (portion)

- Within the Southern Cape District Council Area
  - Heidelberg (portion)
  - Riversdale
  - Mossel Bay
  - George
  - Knysna

- Within the Klein Karoo District Council Area
  - Calitzdorp
  - Oudtshoorn
  - Uniondale
  - Ladismith

- Within the Overberg District Council Area
  - Swellendam (small portion)

3.5 LAND-USE

3.5.1 Introduction

Analysis of satellite images of the area (CSIR, 1999) shows that approximately 514 km^2 of the total land area of the Gourtiz WMA is irrigated. Lucerne is the predominant crop, with vines and orchards present where sufficient water is available and the climate is suitable.

The total area of afforestation is 600 km^2, concentrated in the south-eastern coastal region due to high rainfall there. Indigenous forest occurs along the coastal boundaries covering a total area of 560 km^2. The main vegetation types covering the management area are Karoo and the Karroid types. Coastal Tropical Forest, Temperate and Transitional Forest and Scrub occur in the coastal areas. Other vegetation types present are False Karoo, Sclerophyllous and False Sclerophyllous Bush.

Approximately 4 100 km^2 of land is nature reserve.

Urban areas occupy 92 km^2 of the total land larea. Situated very close to Mossel Bay is the Petro SA Refinery, a gas to oil conversion plant. Livestock farming utilises a significant area of cultivated pasture. There were about 1 450 000 head of livestock in the WMA in 1995, of which 80% were sheep or goats, and 10% were ostriches.

Statistics on the main categories of land-use are summarised in Table 3.5.1.1 and the spatial distribution of different types of land-use is shown on Figure 3.5.1.1.

Individual categories of land-use are discussed in greater detail below.

TABLE 3.5.1.1: LAND USE BY DRAINAGE AREAS

DRAINAGE AREA	IRRIGATION [1] (km²)	DRYLAND SUGAR CANE (km²)	OTHER [1] DRYLAND CROPS (km²)	AFFORESTATION [2] (km²)	INDIGENOUS FORESTS [2] (km²)	ALIEN VEGETATION [3] (km²)	NATURE RESERVES [4] (km²)	URBAN CENTRES [5] (km²)	OTHER [6] (km²)	TOTAL AREA [7] (km²)
Coastal rivers west of Gouritz mouth (H8 and 9)	38,22	0	906,00	27,02 (21,00) [8]	0,45	432,19	174,2	7,16	1 413,76	**2 978,00**
Gamka River (J2)	63,00	0	25,70	0,00	0,00	68,15	770,3	13,78	18 110,07	19 051,00
Olifants River (J3)	218,00	0	519,70	1,12	0,08	224,73	983,6	16,40	9 053,38	11 017,00
Groot River (J1)	98,00	0	187,70	0,65	0,00	156,51	477,4	3,86	12 388,87	13 313,00
Gouritz River (J4)	24,38	0	687,80	0,07	0,00	95,15	71,3	0,90	1 441,4	2 321,00
Sub-total : Gouritz River at mouth (J1, J2, J3, J4)	403,38	0	1420,90	1,84	0,08	544,54	2 302,6	34,95	40 993,72	**45 702,00**
Coastal rivers Mossel Bay to George (K1, K2, part of K3)	19,44	0	310,10	142,42 (2,70) [8]	27,70 (21,18) [8]	28,05	378,0	35,33	686,64	1 604,00
Coastal rivers Wilderness (part of K3, K4)	19,26	0	1,90	203,75 (203,60) [8]	161,62 [8] (158,10) [8]	76,35	568,8	3,83	201,19	875,00
Coastal rivers Knysna to Blaaukrantz (K5, K6, K7)	33,30	0	18,60	225,90 (172,00) [8]	370,46 (240,70) [8]	276,38	678,8	11,17	778,09	1 980,00
Sub-total : Outeniqua coastal rivers (east of Gouritz mouth)	72,00	0	330,60	572,07 (378,30) [8]	559,78 (419,98) [8]	380,78	1 625,6	50,33	1 665,92	**4 459,00**
TOTAL GOURITZ WMA	**513,60**	**0**	**2 657,50**	**600,94 (399,30 [8]**	**559,86 (419,98) [8]**	**1 357,51**	**4 102,4**	**92,44**	**44 073,70**	**53 139,00**

SOURCE OF DATA :
1. Analysis of satellite image of the area (CSIR, 1999), in conjunction with listed areas obtained from DWAF Regional Office staff.
2. CSIR, 1996
3. WRC, 1998
4. Measured off DWAF GIS coverage of Nature Reserve boundaries
5. CSIR land use maps (CSIR, 1996)
6. Remaining land after all other land uses in this table were allocated.
7. WSAM database
8. Areas of indigenous forest or afforestation falling within nature reserves and, in order to avoid double counting, not included in the "Total Area" column.

NOTE : Values are reported to 2 decimal places for the purposes of cross-checking with other values in the 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

TYPE OF LAND USE	AREAS IN WESTERN CAPE PROVINCE						AREAS IN EASTERN CAPE PROVINCE	AREAS IN NORTHERN CAPE PROVINCE	TOTAL AREA (km^2)
	BREEDE RIVER DISTRICT COUNCIL (km^2)	CENTRAL KAROO DISTRICT COUNCIL (km^2)	OVERBERG DISTRICT COUNCIL (km^2)	SOUTHERN CAPE DISTRICT COUNCIL (km^2)	KLEIN KAROO DISTRICT COUNCIL (km^2)	TOTAL FOR WESTERN CAPE (km^2)	WESTERN REGION DISTRICT COUNCIL (km^2)	HANTAM DISTRICT COUNCIL (km^2)	
Irrigation	12,28	55,77	7,59	162,90	267,57	506,11	4,26	3,23	513,60
Dryland sugar cane	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Other dryland Crops	98,72	64,14	24,22	1 991,14	473,17	2 650,93	5,15	1,42	2 657,50
Afforestation	0,00	0,00	0,11	587,55 (399,30) (1)	10,00	597,67 (399,30)	3,27	0,00	600,94
Nature reserves	50,74	839,29	42,76	2 018,98	1 065,35	4 017,12	82,44	2,83	4 102,40
Indigenous forests	0,08	0,00	0,01	559,78 (419,98) (1)	0,00	559,86 (419,98) (1)	0,41	0,00	559,86 (419,98) (1)
Alien vegetation	2,32	44,33	0,64	1 000,73	295,01	1 343,11	12,50	1,90	1 357,51
Urban centres	1,06	14,51	0,00	58,56	18,31	92,44	0,00	0,00	92,44
Other	2 641,21	23 412,90	990,36	6 018,76	8 023,05	40 906,36	1 744,61	1 422,73	44 073,70
TOTAL AREA	**2 625,96**	**24 430,93**	**1 065,68**	**11 579,11**	**10 152,56**	**49 854,24**	**1 852,64**	**1 432,11**	**53 139,00**

NOTE :

- The values in this table were estimated based on the data appearing in Table 3.5.1.1, which were adjusted to the District Council boundaries. Certain assumptions were necessary for this process, which result in a loss of accuracy.
- The values are reported to 2 decimal places for the purposes of cross-checking with other values in the report. This does not mean that the values are accurate to this level.

(1) Areas of indigenous forest or afforestation falling within nature reserves and, in order to avoid double counting, not included in the "Total Area" row at the bottom of the table.

3.5.2 Irrigation

Irrigated areas

The total irrigated area and various crop areas for each sub-catchment are shown in Table 3.5.2.1. A map depicting the extent of the existing irrigation is shown in Figure 3.5.1.1.

The areas were obtained from various sources, depending on their reliability in the different areas. Data for most catchments were sourced from the CSIR land-use maps or from data provided by the Department of Agriculture at Elsenburg. More detailed information was used where available. Scheduled areas from the Klein Karoo Government Water Supply Scheme (KKRWSS) were used for the following quaternary catchments : J25D and E and J34A - E.

A factor of 0,75 was applied to the areas obtained from the land-use maps to allow for uncultivated areas that are too small to be identified from the satellite images used to develop the land-use maps, but that fall within the areas identified as irrigated. The factor of 0,75 was obtained from comparison of the land-use map data with more detailed studies carried out in the Berg River catchment for the Voëlvlei Augmentation Feasibility Study (DWAF, 1999b). However, the accuracy of the values is uncertain and they should, therefore, be used with caution.

It is estimated that a total area of about 514 km^2 of land is under irrigation, but much of this is used on an opportunistic basis only in years when water is plentiful. Consequently, it is estimated that an average area of about 280 km^2 of crops grown under irrigation is harvested.

The distribution of crop types shown in Table 3.5.2.1 was derived from information provided by the Western Cape Province Department of Agriculture. It is indicative of typical crop mixes and is not necessarily accurate for the individual sub-catchments.

It can be seen from Table 3.5.2.1 that the predominant crops occurring in the WMA are lucerne and pastures, which make up 34% of the irrigated area. Approximately 19% of the irrigated land in the WMA is under vineyards for the production of wine, table grapes and raisins.

About 10% of the irrigated area is under deciduous fruit orchards. A small quantity of vegetables is grown. Approximately 92 km^2, or 33% of the total irrigated area is shown as being under other crops. These are areas for which information on the type of crops grown was not readily available. It is probable that some of these crops fall into the other categories shown in the table.

It is generally recognised that future growth in irrigation will be severely limited by the availability of water and economic efficiency. In more water-scarce areas it may even become necessary to curtail some irrigation to meet the growing requirements of domestic and urban water use. In order to do this, it will be necessary to base such decisions on sound economic principles that include the economic return per unit of water. Although acknowledged to be fairly generalised, it is suggested that only three income categories of irrigated crops be used for this purpose. These income categories also represent an appropriate grouping for the purpose of assurance of irrigation water supply. Table 3.5.2.2 shows the typical crops within each category.

TABLE 3.5.2.1: IRRIGATION LAND USE

CATCHMENT						TOTAL [1] IRRIGATED AREA (km^2)	AREA IRRIGATED IN AVERAGE YEARS (km^2)							
PRIMARY		SECONDARY		TERTIARY			Stone Fruit	Grapes (Wine, Table, Raisins)	Citrus	Lucerne & Pastures	Potatoes	Other Vegetables	Other Crops	TOTAL
No.	Description	No.	Description	No.	Description									
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	38,2	0,0	21,0	0	3,8	0	1,9	11,5	38,2
		TOTAL IN BREEDE - GOURITZ (ALL WESTERN CAPE)				**38,2**	**0,0**	**21,0**	**0**	**3,8**	**0**	**1,9**	**11,5**	**38,2**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	0,0 29,5	0,0 9,3	0,0 9,3	0 0	0,0 0,0	0 0	0,0 0,0	0,0 9,5	0,0 28,1
				J25	Lower Gamka (all W Cape)	33,4	0,0	3,2	0	28,6	0	0,0	0,0	31,7
			Sub-total (Northern Cape)			**0,0**	**0,0**	**0,0**	**0**	**0,0**	**0**	**0,0**	**0,0**	**0,0**
			Sub-total (Western Cape)			**62,9**	**9,3**	**12,4**	**0**	**28,6**	**0**	**0,0**	**9,5**	**59,8**
			Total for Gamka catchment			**63,0**	**9,3**	**12,4**	**0**	**28,6**	**0**	**0,0**	**9,5**	**59,8**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	3,3 76,9	0,0 0,8	0,1 0,9	0 0	0,6 15,2	0 0	0,0 0,0	0,1 0,1	0,7 16,9
				J34	Kammanassie (all W Cape)	35,3	0,4	0,4	0	7,0	0	0,0	0,0	7,8
				J35	Lower Olifants (all W Cape)	102,5	1,1	1,1	0	20,3	0	0,0	0,0	22,6
			Sub-total (Eastern Cape)			**3,3**	**0,0**	**0,1**	**0**	**0,6**	**0**	**0,0**	**0,1**	**0,7**
			Sub-total (Western Cape)			**214,7**	**2,3**	**2,4**	**0**	**42,4**	**0**	**0,0**	**0,1**	**47,2**
			Total for Olifants catchment			**218,0**	**2,3**	**2,5**	**0**	**43,0**	**0**	**0,0**	**0,2**	**48,0**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	3,2 41,2	0,0 6,2	0,0 6,2	0 0	0,0 0,0	0 0	0,0 0,0	0,0 4,1	0,0 16,5
				J12	Touws (all W Cape)	34,1	6,1	6,1	0	0,0	0	0,0	1,4	13,6
				J13	Groot (all W Cape)	19,5	3,5	3,5	0	0,0	0	0,0	0,8	7,8
			Sub-total (Northern Cape)			**3,2**	**0,0**	**0,0**	**0**	**0,0**	**0**	**0,0**	**0,0**	**0,0**
			Sub-total (Western Cape)			**94,8**	**15,8**	**15,8**	**0**	**0,0**	**0**	**0,0**	**6,3**	**37,9**
			Total for Groot Catchment			**98,0**	**15,8**	**15,8**	**0**	**0,0**	**0**	**0,0**	**6,3**	**37,9**
		J4	Lower Gouritz	None	---	24,4	0,0	2,4	0	19,5	0	0,0	2,4	24,4
			Total for Lower Gouritz incremental catchment (all Western Cape)			**24,4**	**0,0**	**2,4**	**0**	**19,5**	**0**	**0,0**	**2,4**	**24,4**
		TOTAL IN GOURITZ CATCHMENT IN THE N CAPE				**3,2**	**0,0**	**0,0**	**0**	**0,0**	**0**	**0,0**	**0,0**	**0,0**
		TOTAL IN GOURITZ CATCHMENT IN THE E CAPE				**3,3**	**0,0**	**0,1**	**0**	**0,6**	**0**	**0,0**	**0,1**	**0,7**
		TOTAL IN GOURITZ CATCHMENT IN W CAPE				**396,8**	**27,4**	**33,1**	**0**	**90,5**	**0**	**0,0**	**18,3**	**169,3**
		TOTAL IN GOURITZ CATCHMENT				**403,4**	**27,4**	**33,2**	**0**	**91,1**	**0**	**0,0**	**18,4**	**170,2**
K (part)	Outeniqua Coastal	K1, K2 Part of K3	Mossel Bay - George	K10, K20 & K30A to C	Coastal rivers (all W Cape)	19,4	0,0	0,0	0	**0,0**	0	0,0	19,4	19,4
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	19,3	0,0	0,0	0	**0,0**	0	0,0	19,3	19,3
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	1,0 32,3	0,0 1,3	0,0 0,0	0 0	**0,0** **0,0**	0 0	0,3 8,4	0,7 22,6	1,0 32,3
		TOTAL IN OUTENIQUA CATCHMENTS IN E CAPE				**1,00**	**0,0**	**0,0**	**0**	**0,0**	**0**	**0,3**	**0,7**	**1,0**
		TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN W CAPE				**71,0**	**1,3**	**0,0**	**0**	**0,0**	**0**	**8,4**	**61,3**	**71,0**
		TOTAL IN OUTENIQUA CATCHMENTS				**72,0**	**1,3**	**0,0**	**0**	**0,0**	**0**	**8,7**	**62,0**	**72,0**
		TOTAL IN WMA IN NORTHERN CAPE				3,2	0,0	0,0	0	0,0	0	0,0	0,0	0,0
		TOTAL IN WMA IN EASTERN CAPE				4,3	0,0	0,1	0	0,6	0	0,3	0,7	1,7
		TOTAL IN WMA IN WESTERN CAPE				506,1	28,7	54,1	0	94,3	0	10,3	91,1	278,6
		TOTAL IN WMA				**513,6**	**28,7**	**54,2**	**0**	**94,9**	**0**	**10,6**	**91,9**	**280,3**

DATA SOURCES

1. CSIR land-use maps (CSIR, 1999) amended in consultation with officials from the DWAF Western Cape Regional Office.
2. Data on crop types provided by the Department of Agriculture at Elsenberg.
   Scheduled areas from the KKGWSS were used for the following quaternary catchments : J25D and E, J34A to E.

TABLE 3.5.2.2: ASSURANCE CATEGORIES OF IRRIGATION WATER FOR CROP TYPES

CATEGORY	CROP EXAMPLES
Low	Lucerne and pasture for small stock
Medium	Vegetables, potatoes, lucerne and pasture for dairying and ostriches
High	Citrus, deciduous fruit and nuts, grapes and speciality vegetables

Irrigation methods

Information on irrigation methods was not readily available. However, the irrigation methods used for a specific crop type do not vary significantly. The most common methods used are flood irrigation, sprinkler systems and drip systems. Flood irrigation is used widely in the WMA, particularly for lucerne and other pastures, and also in many areas for high value crops such as orchards and vineyards.

A more detailed description of the type of crops irrigated used in the different areas of the WMA is given below.

The Gouritz River

- ***The Touws River***
  - The catchment is mainly underlain by Karoo sediments and the sparse natural Karooveld is used as rough grazing for sheep.
  - Some opportunistic irrigation of lucerne takes place in the lower reaches of the Touws River upstream of the confluence with the Groot River (J12L and M) and along the mountain foothill steams. Small fruit orchards and lucerne are irrigated below the Bellair and Prins River Dams in the catchment.
  - Close to the town of Touws River (J12B), crops consisting mainly of lucerne are irrigated using groundwater and water from Verkeerdevlei Dam.

- ***The Groot River***
  - The catchment upstream of Floriskraal Dam (J11F) is underlain by Karoo sediments and covered with sparse Karoo scrub that is used as rough grazing for sheep.
  - Minor irrigation of lucerne takes place along the banks of the Buffels River utilising water abstracted form the river and its alluvial bed (J11E and F). Irrigation releases from Floriskraal Dam are diverted into canals by low weirs and utilised to irrigate lucerne (J11H, J and K), vineyards and deciduous fruit orchards.
  - Perennial streams rising in the Klein Swartberg Mountains (J11H) and its south facing foothills (J11J) provide irrigation for small fruit orchards and lucerne.

- ***The Gamka River***
  - The tributaries of the Gamka River rise in the Great Karoo, which is underlain by Karoo formations, and is sparsely covered with Karoo scrub which is mainly utilised for grazing sheep.
  - When the Leeu Gamka Dam (J21D) contains water, it provides opportunistic irrigation, mainly of lucerne, along the river floodplain below the dam. Some lucerne is also irrigated from groundwater.

- The perennial flows in the small streams rising in the north facing slopes of the Swartberg Mountains (J24F and J23E, F, H and J) are utilised to irrigate small fruit orchards.
- The Gamkapoort Dam (J23J and J24F) releases water through the Gamkapoort (J25A), for irrigation of vineyards and some fruit in the vicinity of Calitzdorp in the Klein Karoo (J25C, D and E) and upstream of its confluence with the Olifants River (J25E).
- The Calitzdorp Dam on the Nels River tributary also provides irrigation water and serves the town as well as the "leiwater" system within the town.

• ***The Olifants River***
  - The northern tributaries of the Olifants River rise in the Great Karoo to the north of the Swartberg Mountains where the sparse natural veld is utilised for grazing sheep (J23A to E). Streams in the north facing foothills of the Swartberg are utilised for local irrigation.
  - The Olifants River itself rises to the east (J31A to D) and flows westward to the confluence with the northern tributaries (J31D and J32E). From here it flows between the Swartberg and Kammanassie Mountains into Stompdrift Dam (J33A and B). There is local run-of-river irrigation from the tributary streams.
  - Stompdrift Dam, and Kammanassie Dam in the Kammanassie River, supply irrigation water to the Stompdrift/Kammanassie Canal system which serves irrigators throughout the Olifants River Valley (J33E and F, J34F and J35B to F) from the dams to near the confluence with the Gamka River (J25E and J35F). The allocations and assurance of supply to irrigators immediately below these dams are higher than further downstream and reduce with distances from the dams. Lucerne is the main crop under irrigation and is utilised for feed by ostrich farmers who dominate agriculture in the area.
  - The Kango, Grobbelaars, Wynands, Kansa and Vlei Rivers all drain the southern slopes of the Swartberg (J33E and F and J35A, D, E and F), and have perennial flows which are utilised for run-of-river irrigation mainly of lucerne. Most of this irrigation results in high losses as the canal systems are unlined and the distribution is based on flood irrigation turns.
  - The Kammanassie River rises in the Outeniqua and Kammanassie Mountains. Run-of-river irrigation takes place on the tributaries and along the main river channel which is heavily infested with alien vegetation (J34A to E).
  - The other tributaries draining the northern slopes of the Outeniqua Mountains (J34F and J35B and C) are partially dammed to provide water for irrigation of fruit and hops (J35B), or are utilised on a run-of-river basis.
  - Throughout the Klein Karoo cultivation only takes place in the valleys, and the rest of the area is either mountainous or foothills covered in Karoo scrub.

• ***The Gouritz River***
  - Irrigation of mainly lucerne and pasture and a few vineyards takes place on the banks of the Gouritz River (J40A to E).

The Coastal Rivers

• ***Coastal Rivers west of the Gouritz River***
  - The Duiwenhoks Dam (H80A), in the upper reaches of the Duiwenhoks River, releases water for irrigation along the river and for the town of Heidelberg (H80C).

- Two tributaries of the Goukou River, the Korente and Vette Rivers have been dammed. Water from these dams combined with flow from Kristalkloof (draining the mountains from Garcia Pass) supply water for irrigation of vineyards, deciduous fruit, pasture and vegetables, and the town of Riversdale situated on the N2 (H90C).
- The flatter areas between the coast and the foothills are partially cultivated as wheatlands and combined with planted grazing for sheep farming. This is predominantly dry-land cultivation, with minimal irrigation.

- ***Coastal Catchments east of the Gouritz River***
  - The Little Brak River rises in the Outeniqua Mountains and its course cuts through the coastal plain to the sea (K10C to F). Some irrigation takes place along the western tributary.
  - The Great Brak River (K20A) also rises in the Outeniqua Mountains and is dammed near its headwaters and by Wolwedans Dam (K10A). Some irrigation takes place upstream of the Dam.
  - The Maalgaten (K30A) and Gwang (K30B) Rivers both rise in the Outeniqua Mountains. Farm dams have been constructed for irrigation purposes but water is also abstracted for irrigation on a run-of-river basis.
  - Water is abstracted for irrigation from small dams in the catchment of the Knysna River (K50A and B).
  - Roodefontein Dam on the Piesangs River (K60G) provides water for irrigation and for the town of Plettenberg Bay, although the quality is poor due to the high iron content.
  - The Bitou River (K60F) and the Keurbooms River (K60A to E) flow into the sea via the Keurbooms lagoon. Fairly extensive irrigation, mainly on a run-of-river basis and afforestation takes place in both catchments.
  - Water is abstracted from the catchments of the Maatjies and Sout Rivers (K70A) for irrigation and to serve the small town at Kurland.
  - The coastal plain from Mossel Bay westward is utilised for mixed farming where it is not afforested. Cultivation is mainly dry-land with limited irrigation.

Details of the types of crops irrigated in this area were not obtained in this study.

3.5.3 Dryland Farming

The existing area of dryland cultivation in the WMA is estimated to be 2 658 km^2. The distribution of this total area among the sub-catchments is shown in Table 3.5.1.1. No information on the types of dryland crops was obtained in this study.

3.5.4 Livestock and Game Farming

The distribution of the main types of livestock found in the WMA is shown in Table 3.5.4.1, which also shows the Equivalent Large Stock Units (ELSU).

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 mature cattle, or 1 horse, or 6,5 sheep, or 4 pigs. One ELSU has been taken to be equivalent to 3 ostriches. A detailed table for use in converting mature livestock and game populations to ELSU is included in Appendix D. The numbers of livestock shown in Table 3.5.4.1 are approximate only because the information was obtained from the 1994 livestock census (Department of Agriculture, 1994), which gives information in terms of magisterial districts and not hydrological catchments. The data was converted to hydrological catchments by assuming the distribution of livestock to be proportional to land area.

The climate in most of the WMA is arid, with the result that conditions are better suited to sheep than to cattle. This is reflected in Table 3.5.4.1, where it can be seen that sheep and goats account for 47% of the estimated total number of livestock of approximately 384 079. Ostrich farming is extensively practiced in the Little Karoo, with ostriches making up 12% of stock numbers.

The distribution of livestock, expressed in terms of ELSUs, is shown diagrammatically on Figure 3.5.4.1.

3.5.5 Afforestation

The areas of indigenous forests and commercial timber plantations are given in Table 3.5.5.1. Indigenous forest areas occur along the coastal strip, particularly around Knysna. The total area of indigenous forest is approximately 560 km^2.

Afforestation in the Gouritz WMA is limited by climatic conditions to only a few areas, as shown in Figure 3.5.1.1. The majority of afforested areas occur in the coastal catchments to the east of the Gouritz River mouth, with small pockets in the coastal catchments to the west. Afforestation in the Gouritz River Basin is negligible.

The total area of timber plantations is 600,9 km^2, consisting mainly of pine plantations. This comprises 1,1% of the land area of the WMA.

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 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 is 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.

TABLE 3.5.4.1: LIVESTOCK AND GAME

CATCHMENT							NUMBERS OF LIVESTOCK AND GAME				NO. OF ELSU
PRIMARY		SECONDARY		TERTIARY			Cattle and Horses and Donkeys (1)	Sheep and Goats (1)	Pigs (1)	Ostriches (2)	
No.	Description	No.	Description	No.	Description	Area (km^2)					
H (part)	Breede-Gouritz	H8, H9	Duiwenhoks, Goukou	None	---		22 077	179 776	730	4 650	55 333
		TOTAL IN BREEDE-GOURITZ CATCHMENT (ALL WESTERN CAPE)					**22 077**	**179 776**	**730**	**4 650**	**55 333**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)		99 1 293	17 128 251 203	17 259	41 6 349	2 769 42 349
				J25	Lower Gamka (all W Cape)		2 937	10 300	146	14 254	9 828
			Sub-total (Northern Cape)				**99**	**17 128**	**17**	**41**	**2 769**
			Sub-total (Western Cape)				**4 230**	**261 503**	**405**	**20 604**	**52 177**
			Total for Gamka Catchment				**4 329**	**278 630**	**422**	**20 645**	**54 946**
		M^3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)		548 5 541	42 940 86 478	71 793	3 092 33 041	8 299 31 035
				J34	Kammanassie (all W Cape)		10 353	47 828	876	12 241	23 838
				J35	Lower Olifants (all W Cape)		8 936	29 011	861	35 571	27 048
			Sub-total (Eastern Cape)				**548**	**42 940**	**71**	**3 092**	**8 299**
			Sub-total (Western Cape)				**24 830**	**163 316**	**2 530**	**8 085**	**81 921**
			Total for Olifants catchment				**25 378**	**206 257**	**2 600**	**83 945**	**90 220**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)		46 1 728	4 139 56 995	7 206	0 2 448	693 11 669
				J12	Touws (all W Cape)		13 974	136 002	3 738	4 819	39 904
				J13	Groot (all W Cape)		5 283	30 106	222	2 690	11 799
			Sub-total (Northern Cape)				**46**	**4 139**	**7**	**0**	**693**
			Sub-total (Western Cape)				**20 984**	**223 103**	**4 166**	**9 957**	**63 372**
			Total for Groot River catchment				**21 030**	**227 243**	**4 173**	**9 957**	**64 064**
		J4	Lower Gouritz	None	---		23 382	132 734	1 003	9 417	51 319
			Total for Lower Gouritz incremental catchment (all Western Cape)				**23 382**	**132 734**	**1 003**	**9 417**	**51 319**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE						**145**	**21 267**	**24**	**41**	**3 462**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE						**548**	**42 940**	**71**	**3 092**	**8 299**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE						**73 427**	**780 657**	**8 103**	**120 831**	**248 788**
	TOTAL IN GOURITZ CATCHMENT						**74 119**	**844 864**	**8 198**	**123 964**	**260 549**
K (part)	Outeniqua coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 & K30A to C	Coastal rivers (all W Cape)		21 001	104 814	1 090	4 859	42 725
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)		5 817	15 087	253	1 018	9 568
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)		183 9 015	367 25 491	0 134	5 3 210	274 15 631
		TOTAL IN OUTENIQUA COASTAL CATCHMENT IN E CAPE					**183**	**367**	**0**	**5**	**274**
		TOTAL IN OUTENIQUA COASTAL CATCHMENT IN W CAPE					**35 833**	**145 392**	**1 477**	**9 086**	**67 923**
		TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**36 017**	**145 760**	**1 478**	**9 091**	**68 197**
TOTAL IN WMA IN NORTHERN CAPE							**145**	**21 267**	**24**	**41**	**3 462**
TOTAL IN WMA IN EASTERN CAPE							**731**	**43 308**	**71**	**3 097**	**8 573**
TOTAL IN WMA IN WESTERN CAPE							**131 337**	**1 105 825**	**10 311**	**134 477**	**372 044**
TOTAL IN WMA						**NUMBER** **ELSU** **% OF TOTAL**	**132 213** **155 544** **40%**	**1 170 400** **180 062** **47%**	**10 406** **2 602** **1%**	**137 616** **45 872** **12%**	**---** **384 079** **100%**

SOURCE OF DATA : (1) 1994 Livestock census (Department of Agriculture, 1994); (2) Estimates provided by personal communication with Mr P van Zyl, Department of Agriculture, Oudtshoorn, November 2001.

TABLE 3.5.5.1: AREAS OF AFFORESTATION AND INDIGENOUS FOREST

CATCHMENT						AREA OF AFFORESTATION [1] (km^2)	AREA OF INDIGENOUS FOREST [1] (km^2)
PRIMARY		SECONDARY		TERTIARY			
No.	Description	No.	Description	No.	Description		
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	**27,02**	0,45
		TOTAL IN BREEDE - GOURITZ CATCHMENTS (All Western Cape)				27,02	**0,45**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	0,00 0,00	0,00 0,00
				J25	Lower Gamka (W Cape)	0,00	0,00
			Sub-total (Northern Cape)			**0,00**	**0,00**
			Sub-total (Western Cape)			**0,00**	**0,00**
			Total for Gamka catchment			**0,00**	**0,00**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	0,00 0,00	0,00 0,00
				J34	Kammanassie (all W Cape)	1,20	0,00
				J35	Lower Olifants (all W Cape)	0,00	0,08
			Sub-total (Eastern Cape)			**0,00**	**0,00**
			Sub-total (Western Cape)			**1,12**	**0,08**
			Total for Olifants catchment			**1,12**	**0,08**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	0,00 0,00	0,00 0,00
				J12	Touws (all W Cape)	0,65	0,00
				J13	Groot (all W Cape)	0,00	0,00
			Sub-total (Northern Cape)			**0,00**	**0,00**
			Sub-total (Western Cape)			**0,65**	**0,00**
			Total for Groot River catchment			**0,65**	**0,00**
		J4	Lower Gouritz	None	---	0,07	0,00
			Total for Lower Gouritz incremental catchment (all Western Cape)			**0,07**	**0,00**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					**0,00**	**0,00**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0,00**	**0,00**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**1,84**	**0,08**
	TOTAL IN GOURITZ CATCHMENT					**1,84**	**0,08**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 & K30A to C	Coastal rivers (all W Cape)	142,42	27,70
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	203,75	161,62
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	0,00 225,90	8,46 362,00
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0,00**	**8,46**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**572,07**	**551,32**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**572,07**	**559,78**
TOTAL IN WMA IN NORTHERN CAPE						**0,00**	**0,00**
TOTAL IN WMA IN EASTERN CAPE						**0,00**	**8,46**
TOTAL IN WMA IN WESTERN CAPE						**600,94**	**551,85**
TOTAL IN WMA						**600,94**	**560,31**

SOURCE OF DATA : (1) CSIR, 1996.

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 the expert information was 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. This work was done as part of a study commissioned by the Water Research Commission (WRC, 1998).

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. 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.

It is apparent that the most severe infestation by alien vegetation occurs in the coastal catchments (H and K), mainly to the east of the Gouritz River mouth (K). Infestation by alien vegetation in the Gouritz River catchment (J) is limited to the Kammanassie River catchment (J34) and the Gouritz River incremental catchment (J4).

TABLE 3.5.6.1: INFESTATION BY ALIEN VEGETATION

CATCHMENT						CONDENSED AREA OF ALIEN VEGETATION [(1)] (km²)
PRIMARY		SECONDARY		TERTIARY		
No.	Description	No.	Description	No.	Description	
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	432,19
		TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)				**432,19**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	0,00 42,28
				J25	Lower Gamka (W Cape)	25,87
			Sub-total (Northern Cape)			**0,00**
			Sub-total (Western Cape)			**68,15**
			Total for Gamka catchment			**68,15**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	0,00 54,13
				J34	Kammanassie (all W Cape)	132,57
				J35	Lower Olifants (all W Cape)	38,03
			Sub-total (Eastern Cape)			**0,00**
			Sub-total (Western Cape)			**224,73**
			Total for Olifants catchment			**224,73**
		J1	Groot	J11	Buffels (N Cape) Buffles (W Cape	0,00 1,66
				J12	Touws (all W Cape)	16,93
				J13	Groot (all W Cape)	137,92
			Sub-total (Northern Cape)			**0,00**
			Sub-total (Western Cape)			**156,51**
			Total for Groot River catchment			**156,51**
		J4	Lower Gouritz	None	---	95,15
			Total for Lower Gouritz incremental catchment (all Western Cape)			95,15
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					**0,00**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0,00**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**544,54**
	TOTAL IN GOURITZ CATCHMENT					**544,54**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 & K30A to C	Coastal rivers (all W Cape)	28,05
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	76,35
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	0,00 276,38
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0,00**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**380,78**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**380,78**
TOTAL IN WMA IN NORTHERN CAPE						**0,00**
TOTAL IN WMA IN EASTERN CAPE						**0,00**
TOTAL IN WMA IN WESTERN CAPE						**1357,51**
TOTAL IN WMA						**1357,51**

SOURCE OF DATA :
(1) Provided by the CSIR from data obtained for the WRC Study (WRC, 1998).

3.5.7 Urban Areas

The data on urban areas was obtained from the CSIR land-use maps (CSIR, 1996). The total urban area in the WMA is approximately 92 km^2, which is 0,17% of the WMA. The urban area is small, but about 351 500 people (83%) of the total population in 1995 (424 164 people) lived in the towns. The largest town in the WMA is George which had a 1995 population of 103 8000. The towns are shown on Figure 3.5.1.1.

3.6 MAJOR INDUSTRIES AND POWER STATIONS

Industries in the WMA are small and the majority of them are concerned with the processing of agricultural products. The one exception is Petro SA gas to oil refinery, which is situated close to Mossel Bay.

There are no major powerstations in the WMA.

3.7 MINES

A limited amount of mining takes place in the WMA. It is confined to three small areas in the Southern Cape District Council. There are four mines near to Albertinia (J40D and H90D) which mine kaolin, silcrete, Fullers Earth and mineral pigment, and one mine in the catchment of the Klein Brak River which mines kaolin. There is one mine near Heidelberg (H80C) which mines bentonite.

3.8 WATER RELATED INFRASTRUCTURE

The urban and rural domestic water supplies in the Gouritz WMA were generally adequate in 1995, but some needed improvement in the near future to meet expected increases in water requirements.

Infrastructure for irrigation, both private and State owned, is well developed.

The water related infrastructure is described in detail in Chapter 4.

CHAPTER 4: WATER RELATED INFRASTRUCTURE

4.1 OVERVIEW

Water related infrastructure is well developed in the WMA, particularly in the southern portion, where most of the water use occurs. The main features of the water related infrastructure are shown in Figure 4.1.1. The sources of data in this section are tabulated in Appendix E.

The inland portion of the WMA, consisting of parts of the Great and Little Karoo, is extremely water scarce. Surface water sources are generally fully utilised and groundwater sources are developed to a large extent. The two sources are used conjunctively throughout this portion of the catchment, depending on relative availability, quality, and cost of supply. The coastal strip has considerably higher rainfall and therefore has more plentiful surface water sources. Consequently, groundwater is less developed in this portion of the WMA.

The main water supply schemes in the inland region are the domestic supply for the town of Oudtshoorn, and the Klein Karoo Rural Water Supply Scheme, which supplies the town of Dysselsdorp and rural users. The coastal strip has major supply schemes for the towns, for example Mossel Bay, George and Plettenberg Bay, as well as the Petro SA Refinery.

Reliable data on capacities of water supply schemes and the number of people supplied was not available. Therefore, the information shown in Table 4.1.1 should be regarded as indicative only of the true situation. In spite of the uncertainty regarding population figures, they have not been rounded off because it is easier to correlate them with the values in the Water Situation Assessment Model in their unrounded format.

Table 4.1.1 shows the average availability of water to those supplied by town and regional schemes to be 199 ℓ/c/d. This indicates that, in general, water supplies are well above the minimum Reconstruction and Development Programme requirement of 25 ℓ/c/d. Nevertheless, the potable water distribution systems were inadequate in some areas of some towns, and some rural areas, and this resulted in 8% of the population of the WMA having access to water supplies of less than 25 ℓ/c/d in 1995 (DWAF, 2000d).

Information similar to that presented in Table 4.1.1 but disaggregated on a provincial basis, is shown in Table 4.1.2. As in the case of Table 4.1.1, the reliability of the data is not high.

There are numerous dams in the WMA, 23 of which are detailed in Table 4.1.3. The names, locations and capacities of the dams are shown as well as the purpose for which the water is used. The dams listed have a combined capacity of approximately 300 million m^3. An indication of the yield of each dam is also given in the table. This information was not readily available, so most yields were calculated using a combination of WR90 monthly inflows and WR90 yield-storage curves. Where more accurate yields were available from more detailed studies, these were used in preference to the aforementioned method.

One transfer out to another WMA takes place in the catchment. Approximately 0,4 million m^3 is estimated to have been transferred from the Duiwenhoks Dam in quaternary catchment H80A to the Breede River WMA for rural domestic and livestock watering requirements supplied by the Duiwenhoks Rural Water Supply Scheme.

TABLE 4.1.1: COMBINED CAPACITIES OF INDIVIDUAL TOWN AND REGIONAL POTABLE WATER SUPPLY SCHEMES IN 1995 BY DRAINAGE AREA

DRAINAGE AREA	POPULATION	TOWN AND REGIONAL WATER SUPPLY SCHEMES		CAPACITY [(1)]	
		NO. OF PEOPLE SUPPLIED	% OF DRAINAGE AREA POPULATION	(million m^3/a)	(ℓ/c/d)
H	28 300	20 300	71%	3,18	429
J2	48 351	38 850	80%	1,47	104
J3	88 533	79 650	90%	6,94	239
J1	21 463	13 386	62%	2,18	446
J4	7 448	3 650	49%	0,36	270
Total for J	165 795	135 536	81%	10,95	221
K1, K2, part of K3	164 388	159 600	97%	11,6	199
Part of K3, K4	13 330	3 850	29%	1,85	1 316
K5, K6, K7	52 351	46 250	88%	6,01	356
Total for K	230 069	207 600	90%	19,46	257
TOTAL FOR WMA	424 164	**365 536**	**86%**	**33,59**	252

1. Where capacities are not known, they are assumed to equal the 1995 water requirement (see Table 4.3.1).

TABLE 4.1.2: COMBINED CAPACITIES OF INDIVIDUAL TOWN AND REGIONAL POTABLE WATER SUPPLY SCHEMES BY DISTRICT COUNCIL AREAS

PROVINCE	DISTRICT COUNCIL AREA	AREA WITHIN GOURITZ WMA (km^2)	POPULATION	TOWN AND REGIONAL WATER SUPPLY SCHEMES			
				Number of People Supplied	% of Population	CAPACITY	
						(million m^3/a)	(ℓ/c/d)
Western Cape	Breede River	2 625	8149	6 200	76	0,68 [1]	300
	Central Karoo	23 886	43 162	34 786	81	1,95 [2]	154
	Southern Cape	11 227	267 044	234 050	88	23,03 [1]	270
	Klein Karoo	10 528	103 813	90 500	87	7,94 [1]	240
	Overberg	1 063	911	0	0	---	---
TOTAL FOR WESTERN CAPE		49 329	423 147	363 436	86	29,9 [1]	225
Eastern Cape	Western Region	1 860	798	---	0	---	---
TOTAL FOR EASTERN CAPE		1 860	798	---	0	---	---
Northern Cape	Hantam	1 424	287	---	0	---	---
TOTAL FOR NORTHERN CAPE		1 424	287	---	0	---	---
TOTAL FOR WMA		**52 613**	**424 164**	**365 536**	**86**	**33,59[1]**	**252**

1. Where capacity was not known, it was assumed to be equal to 1995 water requirement (see Table 4.3.1).

TABLE 4.1.3: MAIN DAMS IN THE GOURITZ WMA

QUATERNARY CATCHMENT	NAME	RIVER	LIVE [5] STORAGE CAPACITY (million m^3)	YIELD (million m^3/a)				USE	OWNER
				DOMESTIC SUPPLIES	IRRIGATION [6]	OTHER	TOTAL YIELD [1]		
H80A	Duiwenhoks River	Duiwenhoks	6,4	1,2	3,7	0,00	9,80 [1]	Heidelberg town supply, Duiwenhoks Rural Water Supply Scheme and irrigation	DWAF
H90B	Korente-vet	Korente Poort	8,3	1,5	2,2	0,00	5,80 [1]	Riversdale town supply Irrigation	DWAF
J11F, G, H	Floriskraal	Buffels	50,3	0,0	8,7	0,00	6,50 [1]	Irrigation	DWAF
J12B	Verkeerdevlei	Donkies	5,5	2,3	0,0	0,00	1,30 [1]	Touws River town supply Irrigation	DWAF
J12G	Prins River	Prins	2,7	--	1,0	--	1,00 [1]	Irrigation	Prins River Irrigation Board
J12K	Bellair	Brak	10,1	--	1,6	--	1,60 [1]	Irrigation	DWAF
J21A	Gamka	Gamka	1,8	0,2	0,0	0,00	0,60 [1]	Beaufort West town supply	DWAF
J22G	Doornfontein	Leeuw	4,4	--	--	--	Not known	Irrigation	Private
J22K	Leeu Gamka	Leeuw	14,3	--	2,8	--	2,80 [1]	Irrigation	DWAF
J23E	Oukloof	Dorps (tributary of Gamka)	4,2	--	1,4	--	1,40 [1]	Irrigation	DWAF
J25A	Gamkapoort	Gamka	44,2	--	11,0	--	11,00 [4]	Irrigation, domestic, livestock	DWAF
J25D	Calitzdorp	Nels	4,8	0,2	2,5	--	2,70 [4]	Calitzdorp town supply, irrigation	DWAF
J33B	Stompdrift	Olifants	55,3	--	15,0	--	15,00 [4]	Irrigation	DWAF
J34E	Kammanassie	Kammanassie	35,8	--	18,0	--	18,00 [4]	Irrigation	DWAF
J35A	Koos Raubenheimer	Klein Le Roux (tributary of Grobbelaars)	9,2	2,2	--	--	2,20 [4]	Oudtshoorn Town Supply	Oudtshoorn
J35A	Melville		0,4	1,3	--	--	1,30 [4]		Oudtshoorn
K10B	Haartebeeskuil	Haartenbos	7,2	--	0,90	--	0,85 (firm yield) [2]	Irrigation, stock watering	DWAF
K10F	Klipheuwel	Klein Brak (off channel)	4,2	4,0	--	--	4,00 [2]	Mossel Bay	Mossel Bay
K20A	Wolwedans	Great Brak	24,4 (gross) [2] 23,0 (live) [2]	5,4 (1:200) [2] 6,9 (1:50) [2]	--	4,80 (1:200) [2]	11,7 (mixed assurance) [2] 10.2 (1:200) [2] 13,0 (1:50)	Existing Petro SA Refinery Water Supply, future supply for Mossel Bay	DWAF
K20A	Ernerst Robertson	Great Brak	0,42	1,8	--	--	1,80 [2]	Mossel Bay Town Supply	Mossel Bay
K30C	Garden Route	Swart	8,0	5,8 [3]	--	--	5,80 [3]	George Town Supply	George Municipality
K60G	Roodefontein Dam	Piesangs	1,4	0,15 [7]	0,54	0,31 (IFR)	1,00	Irrigation and Plettenberg Bay Town Supply	DWAF
TOTALS	--	--	299,22	--	--	--	107,45	--	--

1. Note: these yields were calculated from WR90 1:50 year yield-storage curves unless otherwise indicated. The allocations shown are not formal, but have been shown in this table to give an indication of how the yields are used on the basis of domestic and industrial requirements taking priority over irrigation requirements.
2. White Paper on Wolwedans Dam (DWAF, 1988)
3. George Alien Vegetation Study (Working for Water, 2001)
4. Klein Karoo Rural Water Supply Scheme Augmentation Study (DWAF, 1999b)
5. Storage volume above lowest drawdown level.
6. Actual allocations are larger quantities of water, generally supplied at less than 1:50 year assurance.
7. Plettenberg Bay Coastal Catchments Study System Yield Analysis (DWAF, 1996).

4.2 REGIONAL WATER SUPPLY SCHEMES

4.2.1 The Klein Karoo Rural Water Supply Scheme (KKRWSS)

The Klein Karoo Rural Water Supply Scheme (KKRWSS) is owned by DWAF and operated by Overberg Water. It supplies potable water for domestic and stock watering purposes to the following areas :

- The town of Dysselsdorp
- Rural communities and farms in the Olifants River valley downstream of the Stompdrift and Kammanassie Dams
- Rural communities and farms in the Gamka River valley downstream of the Calitzdorp and Gamkapoort Dams, up to the confluence of the Olifants and Gamka Rivers.

Raw water for the scheme is obtained from groundwater sources which currently have a capacity of 1,1 million m^3/a. The raw water is treated in two water treatment works. The Western Works is located near Calitzdorp and has a design capacity of 0,9 million m^3/a, and operated at less than 0,1 million m^3/a in 1995. The Eastern Works is situated close to Dysselsdorp and has a design capacity of 3,5 million m^3/a and is currently being loaded at 1,0 million m^3/a.

The water is used for the following purposes (1997/98 figures) :

Dysselsdorp	44,5%
Rural domestic	28,5%
Stock watering	12%
Losses	13%
Waterworks	2%

Details of this regional water supply scheme are summarised in Table 4.2.1.

TABLE 4.2.1: THE KLEIN KAROO RURAL WATER SUPPLY SCHEME

TREATMENT WORKS			RAW WATER SOURCE					
NAME	CAPACITY (Mℓ/day)	OWNER/ OPERATOR	NAME	YIELD (million m^3/a)	ASSURANCE OF SUPPLY	ADDITIONAL YIELD ALLOCATED TO OTHER USERS	OWNER	OPERATOR
KKRWSS Eastern Water Treatment Works	4,5	DWAF/Overberg Water	Boreholes	1,1	Unknown	None	DWAF	Overberg Water
KKRWSS Western Water Treatment Works	17,0							

4.2.2 Duiwenhoks Rural Water Supply Scheme

The Duiwenhoks Scheme was originally owned by the State, but is now owned by Overberg Water. It supplies approximately 280 farms to the east of the Breede River in both the Breede and Gouritz WMAs. About 145 of these are in the Breede WMA. It also supplies the town of Witsand in the Breede WMA. Water requirements in 1995 were estimated to have been about 1,1 million m^3/a, of which approximately 0,4 million m^3/a were in the Breede WMA (derived from White Paper N-81).

4.3 TOWN WATER SUPPLY SCHEMES

The supply of potable water to the various towns in each catchment is discussed below. The principal features of the town water supplies are summarised in Table 4.3.1. It can be seen from Table 4.3.1 that the estimated water requirements of many of the towns exceeded the yields of the supplies at 1:50 year assurance.

4.3.1 Gouritz River Catchment

Touws River Catchment

- The town of Touwsrivier (J12B) is the only town or settlement of any significance in this catchment. It is situated adjacent to the N1 National Road, and is supplied with water from a small off-channel dam fed from a spring.

- Matjiesfontein (J12G) is a small resort situated adjacent to the N1 National Road. It relies on groundwater for the resort's water supply.

Groot River Catchment

- The town of Laingsburg (J11E/F) is also situated adjacent to the N1 National Road. It obtains reasonable quality water from springs in the bed of the Wilgenhout River, a tributary of the Buffels River, and from alluvium in the Buffels River.

- The source of water for the town of Ladismith (J11J) is a local mountain stream.

- The source of water for the town of Vanwyksdorp (J13B) is a local stream.

Gamka River Catchment

- Beaufort West (J21A) is the largest town in this catchment. It is situated adjacent to the N1 National Road and obtains its water supply from a small dam in the upper reaches of the Gamka River and the State owned Gamka Dam, in conjunction with 18 boreholes.

- Leeu Gamka (J22F) is a very small settlement adjacent to the N1 at its crossing of the Leeu and Gamka Rivers, and it obtains water from boreholes.

- Prince Albert (J23F) is a small agricultural and resort town in the foothills of the Swartberg which obtains its water supply from a local mountain stream.

- The source of water for the settlements of Merweville (J25B) and Zoar (J25D) is the Tierkloof Dam in the Seweweekspoort River.

- Calitzdorp (J25D) obtains its water mainly from the Calitzdorp Dam, and also has some boreholes which are used to a lesser extent.

Olifants River Catchment

- Uniondale (J34A) is situated in the upper reaches of the catchment of the Kammanassie River and obtains its water from a local stream.

TABLE 4.3.1: POTABLE WATER SUPPLY SCHEMES IN THE GOURITZ WMA IN 1995

DRAINAGE REGION		QUATERNARY CATCHMENT	SCHEME NAME	RAW WATER SOURCE	POPULATION SUPPLIED [1]	WATER REQUIREMENTS IN 1995[1] (million m^3/a)	SCHEME CAPACITY [5]		
							million m^3/a	ℓ/c/d	LIMITING FACTOR
H		H80C	Heidelberg	Duiwenhoks Dam	6 800	0,85	1.20[2]	483	Source
		H80F & H90E	Stillbaai	Not Known	4 300 + 200 = 4 500	0.58	0,58 [3]	352 [3]	Not Known
		H90C	Riversdale	Korente-vet Dam	9 000	1,12	1,40	426	Source
		Totals for H			20 300	2,55	3.18[3]	429[3]	--
J	J1	J11E	Laingsburg	Boreholes in Wilgenhout and Buffels Rivers	2 250	0,21	0,89	1084	Source
		J11J	Ladismith	Local mountain stream	4 300	0,58	0,58 [3]	321 [3]	Source
		J12B/C	Touwsrivier	Small off channel dam fed from a spring	6 200	0,68	0,68 [3]	261 [3]	Not Known
		J12G	Maatjiesfontein	Boreholes	236	0,01	0,01	116	Source
		J13B	Vanwyksdorp	Local mountain stream	400	0,03	0,03 [3]	178[3]	Not Known
		Total for J1			13 386	1,51	2.18[3]	446[3]	--
	J2	J21A	Beaufort West	Gamka Dam and 18 boreholes	26 350	3,60	0,61	63	Source
		J22F	Leeu Gamka	Boreholes	1 350	0,12	0,05	101	Source
		J23F	Prince Albert	Local mountain stream	3 800	0,35	0,31	224	Source
		J24B	Merweville	Tierkloof Dam	800	0,08	0,08 [3]	238 [3]	Not Known
		J25B	Zoar	Tierkloof Dam	3 100	0,25	0,25 [3]	192 [3]	Not Known
		J25D	Calitzdorp	Caltizdorp Dam and boreholes	3 450	0,40	0,17	135	Source
		Total for J2			38 850	4,80	1,47[3]	104[3]	--
	J3	J35A	Oudtshoorn	Koos Raubenheimer and Mellville Dams	53 800	7,81	5,40	275	Source
		J33E	De Rust	Huis River Weir	1 900	0,14	0,14	202	Source
		J33F	Dysselsdorp	Klein Karoo Rural Water Supply Scheme (boreholes)	8 900 + rural users = +/- 20 700?	0,95	1,10	146	Wellfield capacity
		J34A	Uniondale	Local mountain stream	3 250	0,30	0,30 [3]	220[3]	Not Known
		Total for M^3			79 650	9,20	6,94[3]	239[3]	--
	J4	J40C	Herbertsdale	Langtou River alluvium	400	0,04	0,04 [3]	238 [3]	Not Known
		J40D	Albertina	Boreholes	3 250	0,32	0,32 [3]	234 [3]	Not Known
		Total for J4			3 650	0,36	0,36[3]	270[3]	--
	Total for J				135 536	15,87	10.95[3]	221[3]	--
K	K1,2, part of K3	K10A&F, K20A	Mossel Bay, Hartenbos, Kleinbrakrivier and Grootbrakrivier	Klipheuwel & E Robertson Dams at present, Wolwedans Dam in future	41 450 + 1 400+ 6 900 = 49 750	5,80 [4]	4,0 (Klipheuwel) +1,8 (E Robertson) = 5,8 6,9 available from Wolwedans for future use	319	Treatment
		K30C	George	Garden Route Dam	103 800	10,57	5,80	145	Source
		K30D	Wilderness		3 950	0,59			
		K40D	Wilderness East		2 100	0,29			
		Total for K1,2,3			159 600	17,25	11,60	199	--
	Part of K3, K4	K40D	Sedgefield	Local surface supplies	2 100	0,72 [4]	1,50[4]	1 957	Source
		K40E	Buffalo Bay	Goukamma River	1 750	0,60 [4]	0,35[4]	548	Treatment Works
	K5,6,7	K50B	Knysna, Belvidere	Knysna River, Gouna River, boreholes	30 650	3,44	4,22	377	Treatment Works
		K60G	Plettenberg Bay	Keurbooms River, Roodefontein Dam, 4 boreholes	15 600	2,48	1,79 (1,33 + 0,15 + 0,31)	314	Conveyance
		Total for K5,6,7			46 250	5,92	6,01	356	--
	Total for K				209 700	24,49	19,46	254	--
TOTALS FOR WMA					**365 536**	**40,36**	**33,59[3]**	**252**	--

DATA SOURCES:

1. WSAM Database unless otherwise shown
2. White Paper on Duiwenhoks Rural Water Supply Scheme (N-81). Estimate made from data in the White Paper.
3. Where scheme capacities are not known, they are assumed to be equal to water requirements in 1995.
4. Data from applicable municipality.
5. At approximately 1:50 year assurance.

- The small town of De Rust (J33E) obtains its supply on a run of river basis using a weir on the Huis River.

- Oudtshoorn (J35A and J33F) is supplied from the Melville and Koos Raubenheimer Dams on the Klein Le Roux River, a tributary of the Grobbelaars River.

- The small town of Dysselsdorp (J33F), in the Little Karoo, and farm communities in the Olifants River Valley and tributary valleys, and in the Gamka River Valley downstream of Calitzdorp are supplied by the Klein Karoo Rural Water Supply Scheme, which is a regional scheme. Water is obtained from 18 boreholes located in six wellfields, and is distributed via two water treatment works and 300 km of pipeline. Water use in 1995 was about 1 million m^3/a. The scheme results in the transfer of groundwater from catchments J33E, J33F, and J25C to catchments J25E and J35A to F.

Lower Gouritz River Catchment

- The small towns of Herbertsdale (J40C) and Albertinia (J40D) obtain their water supplies respectively from the bed of the Langtou River and from boreholes.

- The resort town of Gouritzmond (J40E) is situated on the coast at the mouth of the Gouritz River and is supplied with water by pipeline from the Petro SA Refinery.

4.3.2 Coastal Rivers West of the Gouritz River

- The town of Heidelberg (H80C) is located adjacent to the N2 National Road, and the Duiwenhoks River flows through the town. Water supplies are obtained from the Duiwenhoks Dam situated in the upper reaches of the River. The dam also supplies irrigation water to farms along the river.

- The town of Riversdale (H90C) is also situated adjacent to the N2 National Road. Water supplies are obtained from the Korente-Vet Dam as well as from Kristalkloof, which drains the mountains from Garcia Pass.

- The Korente and Vette Rivers are tributaries of the Goukou River which flows into the sea at the coastal resort town of Stilbaai (H90E). Stillbaai obtains its water from wells in the coastal dunes.

4.3.3 Coastal Rivers East of the Gouritz River

- The town of Mossel Bay (K10A) adjacent to the N2 National Road currently obtains its water supply from two surface water sources. One is the Ernest Robertson Dam, a small dam in the upper reaches of the Great Brak River, and the other is an off-channel dam adjacent to the Little Brak River called Klipheuwel Dam. There is a water treatment works situated adjacent to the settlement of Klein-Brakrivier (K10F), which also receives water from these sources, as does the settlement of Hartenbos. Future water supplies will come from an allocation out of the Wolvedans Dam on the Great Brak River, which currently supplies the Petro SA Refinery.

- About 5,7 million m^3/a of water is transferred from the Wolwedans Dam in Catchment K20A to the Petro SA Refinery in catchment K10A.

- The town of George/Pacaltsdorp (K30B and C) and the coastal resort towns of Wilderness (K30D), Victoria Bay and Herolds Bay are supplied with water from the Garden Route Dam (K30C) on the Swart River.

- The towns of Sedgefield and Karatara (K40D) obtain their water supplies from separate abstraction points on the nearby Karatara River.

- The Hamtini River (K40E) supplies water to the settlement at Rheenendal.

- The holiday resort town of Buffalo Bay obtain water from the Goukamma River (K40E).

- The resort towns of Knysna and Brenton obtain water from an abstraction point close to the lagoon on the Knysna River, and from the Gouna River, on a run of river basis. The 1:50 year yield of the raw water sources is 7,3 million m^3/a and the treatment works have a capacity of 4 million m^3/a, allowing for seasonal peaks in requirements.

- Belvidere is supplied from boreholes.

- Plettenberg Bay (K60G) obtains its main supply of water from the Keurbooms River (K60E) and to a lesser extent from the Roodefontein Dam on the Piesangs River (K60G).

- Water is abstracted from the catchments of the Maatjies and Sout Rivers (K70A) for irrigation and to serve the small town at Kurland, and from the Groot River (K70A) to serve the resort town of Nature's Valley.

4.4 CONTROLLED IRRIGATION SCHEMES

Releases from Stompdrift Dam (J33B) on the Olifants River and Kammanassie Dam (J34E) on the Kammanassie River are controlled by the Stompdrift – Kammanassie Irrigation Board. Irrigation water is supplied to the extensive Stompdrift/Kammanassie Canal system that serves irrigators throughout the Olifants River Valley (J33E and F, J34F and J35B to F) from the dams to near the confluence with the Gamka River (J25E and J35F). The allocations and assurance of supply to irrigators immediately below these dams are higher and reduce with distances from the dams. Lucerne is the main crop under irrigation and is utilised for feed by ostrich farmers who dominate agriculture in the area. The total quantity of water supplied from the dams is 33 million m^3/a, 15 million m^3/a from Stompdrift Dam and 18 million m^3/a from Kammanassie Dam.

There are several other irrigation schemes where water is released from dams into the river channel and diverted by means of weirs further downstream into privately owned off-channel storage dams, or directly onto irrigated lands.

There is also a considerable amount of private irrigation along the tributaries of the main rivers in the southern half of the WMA.

It can be seen from Table 4.4.1 that the theoretical irrigation water requirements in the Little Karoo exceed the available quantities of water by large margins (the first three schemes listed in the Table). Investigations have shown that the cost of providing the additional water required by increasing storage capacity would not be affordable. Therefore, irrigation practices have been adapted to suit the available supply.

TABLE 4.4.1: CONTROLLED IRRIGATION SCHEMES IN THE GOURITZ WMA

SCHEME NAME	SCHEDULED AREA (ha)	CURRENT IRRIGATED AREA (ha)	PRODUCE	SUPPLY SOURCE	AVAILABLE 1: 50 YEAR YIELD (million m^3/a)	THEORETICAL REQUIREMENT OF AREA IRRIGATED IN 1995 (million m^3/a)
Olifants River Govt Water Scheme	13 505,0	13 513,0	Lucerne 85% Deciduous fruit 15%	Stompdrift & Kammanassie Dams	33,0 [1]	130,0
Calitzdorp Irrigation District	520,0	520,0	Deciduous fruit	Calitzdorp Dam	2,5 [1]	5,7
Gamka River and Buffelsvlei Irrigation Districts	1 907,0	1 907,0	Lucerne 80% Deciduous fruit 20%	Gamkapoort Dam	11,0 [1]	20,0
Brand River Irrigation District	134,1	134,1	Not known	Miertjieskraal Dam	Not known	0,8
Leeu Gamka River Irrigation	685,6	685,6	Lucerne	Leeugamka Dam	2,8 [2]	Not known
Cordiers River Scheme	255,0	Not known	Not known	Oukloof Dam	1,4 [2]	1,6
Buffels River Irrigation Scheme	2 208,9	Not known	Lucerne Deciduous fruit	Floriskraal Dam	8,7 [2]	16,8
Duiwenhoks River Government Scheme	1 303,4	Not known	Not known	Duiwenhoks Dam	3,7 [2]	7,8
Korente-Vette Irrigation Scheme	826,7	Not known	Not known	Korente-Vette Dam	2,2 [2]	5,8

1 –From KKRWSS Augmentation Study, (DWAF, 1999b).
2 – Estimated using WR90 1:50 year yield storage curves.

4.5 HYDRO-POWER AND PUMPED STORAGE

There are no hydro-power stations or pumped storage schemes in the WMA.

CHAPTER 5: WATER REQUIREMENTS

5.1 SUMMARY OF WATER REQUIREMENTS

Water requirements in the Gouritz WMA totalled an estimated 921 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 335,1 million m³/a, accounted for 36% of total water requirements, and agriculture, which required an estimated 318,8 million m³/a (35%) to sustain it. Alien vegetation used a substantial 121,3 million m^3/a, and afforestation used 86,9 million m^3/a. Urban and domestic water use was relatively small at 60,0 million m³/a (7%), and the remaining groups of bulk water use, water transfer, neighbouring states and hydro power required 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 one decimal place 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 one decimal place.

The agricultural water requirements shown in Table 5.1.1 represent irrigation and livestock watering requirements. Livestock accounts for 7,3 million m³/a.

The distribution of total water requirements at 1:50 year assurance is shown on Figure 5.1.1, and water requirements per user group are shown in 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)	335,1	36	35,9 (6)	9
Domestic (1)	53,2	6	53,2	13
Bulk water use (4)	5,7	<1	5,7	1
Neighbouring States	0,0	0	0,0	0
Agriculture (2)	318,8	35	260,5	64
Afforestation	86,9	9	14,5 (6)	4
Alien vegetation	121,3	13	35,9 (6)	9
Water transfers (3)	0,4	<0,1	0,4	<1
Hydropower	0,0	0	0,0	0
TOTALS	921,4	100	406,1	100

(1) Includes urban and rural domestic requirements (excluding stock watering) and commercial, institutional and municipal requirements.
(2) Includes requirements for irrigation, dryland sugarcane, 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 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 equivalent requirement for the ecological Reserve from the 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 equivalent requirements from the developed 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. Furthermore, 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 Gouritz Water Management Area fall largely within the Eastern Karoo region with a small section to the west falling within the western Karoo region and a section to the south falling within the southern Karoo region. The coastal area falls within the Southern Cape (wet) region (see Figure 5.2.1.1).

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 lowest 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 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 :

- Accuracy of assessments was facilitated by the diverse number of specialists involved in the process. However, some considered the fact that, in most cases, only one specialist in each field was present made it difficult to verify the results obtained.

- A lack of knowledge of inland and mid-eastern (e.g. Klein Karoo) areas as well as the Gouritz area made it difficult to assess these areas accurately.

- The upgrading of rivers to a higher class is decided by possible improvements through flow modification. This leaves uncertainty as to how other factors should be addressed. It was felt, for instance, that in some instances catchment management options such as removing invasive alien vegetation and reducing bulldozing of river beds would improve conditions, yet these options were not addressed. Very few rivers have the potential to be upgraded over a five-year period and the majority require upgrading over ten years or more.

- Groupings of various catchments are rather big, leading to very broad based assessments which could result in inaccuracies. A number of quaternary catchments were linked together, but only the main stem river was taken into account. The tributaries could be ecologically more important than the main stem, in which case the class determined for the main stem might not be accurate for the quaternary overall.

- Confidence levels need to be attached to all the classes determined.

- Ideally, rivers should be grouped according to ecotones rather than quaternary catchments, as the latter are ecologically inappropriate, but it is acknowledged that this would not meet the requirements of the water balance component of the study.

5.2.4 Presentation of Results

The results of the assessment are shown in Table 5.2.4.1 where the requirements of the ecological component of the Reserve are shown 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 catchments and are points of particular interest from the water resources point of view. They are the outlets of the key areas shown in Table 2.1.1.

The long term average total ecological flow requirement for the whole WMA is 335,1 million m^3/a, or 20% of the total 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 in the WMA. The highest requirement in terms of percentage of MAR is for the coastal rivers from Knysna to Blaaukrantz (K5, K6 and K7) where 33,9% is required in total. This is because of the high conservation value of these Coastal Rivers. The coastal rivers in the Wilderness area (K30D, K4) also have a high IFR requirement (32,1% of MAR). The majority of the remaining quaternaries have PESC of C, except for most of the catchment of the Olifants River, and J11J which have PESCs of D.

Information on the EISC of individual quaternary catchments and on the groupings of quaternary catchments used in the assessment is given in Appendix F6, and ecological flow requirements are shown diagramatically on Figure 5.2.4.1.

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

KEY POINT	PRESENT ECOLOGICAL STATUS CLASS (PESC)	RIVERINE ECOLOGICAL WATER REQUIREMENTS FOR PESC			CUMULATIVE VIRGIN MAR (million m^3/a)
		% VIRGIN MAR	LONG-TERM AVERAGE REQUIREMENT (million m^3/a)	IMPACT ON 1:50 YEAR YIELD (million m^3/a)	
Breede – Gouritz (H8, H9)	C	16,7	35,4	5,3 (1)	212,1
Gamka at confluence with Olifants (J2)	C	6,0	13,6	2,5	226,6
Olifants at confluence with Gamka (J3)	D	7,7	17,6	2,7	228,6
Groot at confluence with Gouritz (J1)	C	7,5	7,9	0,9	105,4
Gouritz River mouth (J4)	C	10,3	71,6	6,1 (1)	695,1
Mossel Bay – George (K1, K2 part of K3)	C	22,0	55,5	8,0 (1)	251,4
Wilderness (part of K3, K4)	B	32,1	65,5	11,0 (1)	204,0
Knysna – Blaaukrantz (K5, K6, K7)	B/C	33,9	107,1	5,5 (1)	315,9
TOTAL FOR WMA (H8, 9, J, K1 to 7)	---	20,0	335,1	35,9	1 678,5

(1) Impacts included in total for WMA.

5.2.5 Discussion and Conclusions

The determination of the impact of the ecological flow requirements on the 1:50 year yield in the Gouritz WMA is complex because there are several dams of significant size and there is also use of run-of-river yield in some areas. The estimated impact on the total 1:50 year yield of the WMA is 35,9 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 considerably higher than estimated.

The estimates are a combination of impacts on the yields of dams, calculated as described in Section 7.1.3, and impacts on developed run-of-river yield derived from annual 1:50 year assurance ecological flow requirements calculated by means of the simulation model described in Section 5.2.2. Descriptions of the derivations of the estimates for each of the key points follow :

- In Catchment H8 the impact on the 1:50 year yield of Duiwenhoks Dam was estimated to be — 2,3 million m^3/a

  (Impacts on run-of-river yield downstream of the dam reach an estimated maximum of 2,2 million m^3/a. Therefore, it is assumed that these requirements would be provided by the releases from the dam causing the 2,3 million m^3/a impact on its yield. Therefore, the total impact on yield in H8 is assumed to be 2,3 million m^3/a).

  In Catchment H9, the impact on the 1:50 year yield of the Korentepoort Dam was estimated to be — 3,0 million m^3/a

  Hence the total impact for Catchments H8 and H9 is — 5,3 million m^3/a

- In Catchment J2, the combined impacts on the yields of the dams upstream of Gamkapoort Dam would, at 0,81 million m^3/a, be less than the impact of ecological releases on the yield of Gamkapoort Dam of 2,29 million m^3/a. As ecological releases from the upstream dams would flow into Gamkapoort, the governing value is the impact on the yield of Gamkapoort of — 2,29 million m^3/a

  Further downstream, impact on run-of-river yields in tributaries in J25D and J25B are not provided for by releases from Gamkapoort and total — 0,17 million m^3/a

  Hence the total impact at the outlet of Catchment J2 is — 2,46 million m^3/a

- In Catchment J3, most of the dams are on separate tributaries,with the result that the ecological releases do not contribute to the yields of dams further downstream. Thus, the impact of these releases on the system yield is made up of the sum of the impacts on the yields of several dams :

Stompdrift Dam	0,83 million m^3/a
Kamanassie Dam	1,47 million m^3/a
Melville and Raubenheimer Dams	0,40 million m^3/a
Total	2,70 million m^3/a

- In Catchment J1, most of the dams are also on separate tributaries, with the result that ecological releases do not contribute to the yields of dams further downstream. Thus, the impact of these releases on the system yield is also made up of the sum of the impacts on the yields of several dams :

	0,58 million m^3/a
Floriskraal Dam	0,18 million m^3/a
Verkeerdevlei Dam	0,14 million m^3/a
Bellair Dam	0,90 million m^3/a
Total	

As there is negligible 1:50 year run-of-river yield in the catchment the impact on the yields of the dams is the sole impact on yield.

- There are no large dams in the Gouritz River catchment between its confluence with the Olifants River and the estuary of the Gouritz (J4). The incremental 1:50 year run-of-river ecological flow requirement has been estimated to be zero using the simulation model. Therefore, the impact of the ecological flow requirements on the yield of the Gouritz River at its mouth has been assumed to be the sum of the impacts in Catchments J1, J2 and J3, i.e.

J1	2,46 million m^3/a
J2	0,90 million m^3/a
J3	2,70 million m^3/a

Hence, the total impact on the 1:50 year yield of the Gouritz River Catchment is 6,06 million m^3/a

- For the catchments of the coastal strip between Mossel Bay and George, the estimated impacts on run-of-river yield have been the determining factors, except that they have been reduced to equal the developed yield in 1995 where it is less than the estimated impact on yield. In the case of the Great Brak River Catchment, the impact on the yield of Wolwedans Dam was used, and the impact on the yield of Hartebeeskraal Dam was used in K10B.

The estimated individual impacts are :

K10A	(full estimated run-of-river impact)	0,06 million m^3/a
K10B	(impact on yield of Hartebeeskuil Dam)	0,17 million m^3/a
K10F	(full estimated run-of-river impact)	0,70 million m^3/a
K20A	(impact on yield of Wolwedans Dam)	2,90 million m^3/a
K30A	(developed run-of-river yield)	0,18 million m^3/a
K30B	(developed run-of-river yield)	0,13 million m^3/a
K30C	(full estimated run-of-river impact)	3,90 million m^3/a
Total		8,04 million m^3/a

- The impact on the yield in the Wilderness area was determined in a similar way :

K30D	(full estimated run-or-river impact)	2,5 million m^3/a
K40D	(developed run-of-river yield)	6,6 million m^3/a
K40E	(developed run-of-river yield)	1,9 million m^3/a
Total		11,0 million m^3/a

- Similarly, for the Knysna to Blaaukrantz area, the total impact was derived as follows :

K50B	(developed run-of-river yield)	3,4 million m^3/a
K60F	(developed run-of-river yield)	0,3 million m^3/a
K60G	(estimated total impact on run-of-river yield)	1,1 million m^3/a
K70A	(developed run-of-river yield)	0,1 million m^3/a
K70B	(developed run-of-river yield)	0,6 million m^3/a
Total		5,5 million m^3/a

It should be noted that the impact of the ecological flow requirements on the 1:50 year yield of the system would increase if more dams were to be developed or the developed run-of-river yield increased.

It is emphasised that the estimates of the ecological Reserve originating from the procedure used in this study should be used only for broad, very general planning purposes. The confidence levels in the management classes determined for individual quaternary catchments are highly variable, as they depend on the levels of knowledge of the individuals of the specialist team. This should be borne in mind when using the data. In all cases where information requirements go beyond the general planning level, the procedures developed for the determination of the ecological Reserve at the Rapid, Intermediate, or Comprehensive levels should be applied.

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.

The total combined requirement in 1995 was estimated to be 53,2 million m^3/a, of which approximately 46,8 million m^3/a was required by the towns and 6,4 million m^3/a by domestic consumers in the rural areas. Most of the water requirements in these categories occur in the Western Cape Province. It was assumed that the full requirement is at 1:50 year assurance.

The table also shows the Human Reserve requirement, calculated on the basis of 25ℓ/person/day for the total population, and totalling 0,66 million m^3/a for the WMA. This requirement is included in the requirements shown in the other columns of Table 5.3.1.1

TABLE 5.3.1.1: URBAN AND RURAL DOMESTIC WATER REQUIREMENTS IN 1995

CATCHMENT						URBAN REQUIREMENTS (1) (million m^3/a)	RURAL DOMESTIC WATER REQUIREMENTS (2) (million m^3/a)	COMBINED URBAN AND RURAL DOMESTIC REQUIREMENTS (3) (million m^3/a)	REQUIREMENTS AT 1:50 YEAR ASSURANCE (million m^3/a)	HUMAN RESERVE (million m^3/a)
PRIMARY		SECONDARY		TERTIARY						
No.	Description	No.	Description	No.	Description					
H (part)	Breede-Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	2,54	0,84	3,38	3,38	0,073
		TOTAL IN BREEDE-GOURITZ CATCHMENT (All Western Cape)				**2,54**	**0,84**	**3,38**	**3,38**	**3,630**
J	Gouritz/	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	0,00 4,15	0,01 0,43	0,01 4,58	0,01 4,58	Negligible 0,047
				J25	Lower Gamka (All W Cape)	0,65	0,39	1,04	1,04	0,040
			Sub-total (Northern Cape)			**0,00**	**0,01**	**0,01**	**0,01**	**Negligible**
			Sub-total (Western Cape)			**4,80**	**0,81**	**5,61**	**5,61**	**0,087**
			Total for Gamka Catchment			**4,80**	**0,82**	**5,62**	**5,62**	**0,087**
		M3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	0,00 1,09	0,05 0,54	0,05 1,63	0,05 1,63	Negligible 0,069
				J34	Kammanassie (all W Cape)	0,30	0,34	0,64	0,64	0,040
				J35	Lower Olifants (all W Cape)	7,81	0,68	8,49	8,49	0,080
			Sub-total (Eastern Cape)			**0,00**	**0,05**	**0,05**	**0,05**	**Negligible**
			Sub-total (Western Cape)			**9,20**	**1,55**	**10,75**	**10,75**	**0,189**
			Total for Olifants Catchment			**9,20**	**1,60**	**10,80**	**10,80**	**0,189**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	0,00 0,79	0,03 0,51	0,03 1,30	0,03 1,30	Negligible 0,035
				J12	Touws (all W Cape)	0,68	0,53	1,21	1,21	0,340
				J13	Groot (all W Cape)	0,03	0,11	0,14	0,14	0,007
			Sub-total (Northern Cape)			**0,00**	**0,03**	**0,03**	**0,03**	**Negligible**
			Sub-total (Western Cape)			**1,50**	**1,15**	**2,65**	**2,65**	**0,076**
			Total for Groot River catchment			**1,50**	**1,18**	**2,68**	**2,68**	**0,076**
		J4	Lower Gouritz	None	---	0,36	0,40	0,76	0,76	0,035
			Total for Lower Gouritz incremental catchment (all Western Cape)			**0,36**	**0,40**	**0,76**	**0,76**	**0,035**
	TOTAL IN GOURITZ CATCHME NT IN NORTHERN CAPE					**0,00**	**0,04**	**0,04**	**0,04**	**Negligible**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0,00**	**0,05**	**0,05**	**0,05**	**Negligible**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**15,86**	**3,91**	**19,77**	**19,77**	**0,386**
	TOTAL IN GOURITZ CATCHMENT					**15,86**	**4,00**	**19,86**	**19,86**	**0,386**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (all W Cape)	21,55	0,74	22,29	22,29	0,098
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	0,00	0,38	0,38	0,38	0,050
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	0,00 5,80	Negligible 0,41	Negligible 6,21	Negligible 6,21	Negligible 0,560
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0,00**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**28,40**	**1,53**	**29,93**	**29,93**	**0,204**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**28,40**	**1,54**	**29,94**	**29,94**	**0,204**
TOTAL IN WMA IN NORTHERN CAPE						**0,00**	**0,04**	**0,04**	**0,04**	**Negligible**
TOTAL I WMA IN EASTERN CAPE						**0,00**	**0,06**	**0,06**	**0,06**	**Negligible**
TOTAL IN WMA IN WESTERN CAPE						**46,80**	**6,29**	**53,09**	**53,09**	**0,663**
TOTAL IN WMA						**46,80**	**6,38**	**53,18**	**53,18**	**0,663**

NOTE : The values in this table include water losses as shown in Table 5.3.2.1 and 5.3.2.2.

1. including losses of 25%
2. including livestock and game water use and losses of 20%
3. including losses.

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.

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 CENTER 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 was not available for the towns in the Gouritz WMA. Therefore, the appropriate ratios of those shown in the above tables were used to estimate the split between direct and indirect water use.

It can be seen from Table 5.3.2.4 that all of the urban water requirements of 46,8 million m^3/a in 1995 occurred in the Western Cape Province, chiefly in the coastal catchments, where the coastal resort towns of George, Mossel Bay, Knysna and Plettenberg Bay are situated.

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.

It can be deduced from the figures shown in the table that conveyance and distribution losses account for approximately 25% of the estimated total urban requirements in the WMA. The reasons for this are discussed in the following section.

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 the water treatment works.

TABLE 5.3.2.4: URBAN WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

CATCHMENT						URBAN WATER REQUIRMENTS (10^6 m^3/a)					TOTAL AT 1:50 YEAR ASSURANCE	RETURN FLOWS			
PRIMARY		SECONDARY		TERTIARY		DIRECT (million m^3/a)	INDIRECT (million m^3/a)	DISTRIBUTION AND BULK CONVEYANCE LOSSES		TOTAL		EFFLUENT	IMPERVIOUS URBAN AREA (1)	TOTAL RETURN FLOW	RETURN FLOW AT 1:50 YEAR ASSURANCE
No.	Description	No.	Description	No.	Description			(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)
H (part)	Breede-Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	1,30	0,63	0,61	25	2,54	2,54	0,86	0,33	1,20	1,20
	TOTAL IN BREEDE-GOURITZ CATCHMENT(All Western Cape)					**1,30**	**0,63**	**0,61**	**25**	**2,54**	**2,54**	**0,86**	**0,33**	**1,20**	**1,20**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape)	0,00	0,00	0,00	0	0,00	0,00	0,00	0,00	0,00	0,00
					Upper Gamka (W Cape)	1,85	1,26	1,04	25	4,15	4,15	1,64	0,28	1,92	1,92
				J25	Lower Gamka (All W Cape)	0,35	0,14	0,16	25	0,65	0,65	0,28	0,02	0,30	0,30
			Sub-total (Northern Cape)			**0,00**	**0,00**	**0,00**	**0**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
			Sub-total (Western Cape)			**2,20**	**1,40**	**1,20**	**25**	**4,80**	**4,80**	**1,92**	**0,30**	**2,22**	**2,22**
			Total for Gamka Catchment			**2,20**	**1,40**	**1,20**	**25**	**4,80**	**4,80**	**1,92**	**0,30**	**2,22**	**2,22**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape)	0,00	0,00	0,00	0	0,00	0,00	0,00	0,00	0,00	0,00
					Upper Olifants (W Cape)	0,59	0,23	0,27	25	1,09	1,09	0,33	0,10	0,43	0,43
				J34	Kammanassie (all W Cape)	0,16	0,06	0,08	25	0,30	0,30	0,03	0,07	0,10	0,10
				J35	Lower Olifants (all W Cape)	3,35	2,51	1,95	25	7,81	7,81	2,96	0,44	3,41	3,41
			Sub-total (Eastern Cape)			**0,00**	**0,00**	**0,00**	**0**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
			Sub-total (Western Cape)			**4,10**	**2,80**	**2,30**	**25**	**9,20**	**9,20**	**3,33**	**0,61**	**3,94**	**3,94**
			Total for Olifants catchment			**4,10**	**2,80**	**2,30**	**25**	**9,20**	**9,20**	**3,33**	**0,61**	**3,94**	**3,94**
		J1	Groot	J11	Buffels (N Cape)	0,00	0,00	0,00	0	0,00	0,00	0,00	0,00	0,00	0,00
					Buffels (W Cape)	0,42	0,16	0,21	25	0,79	0,79	0,32	0,06	0,38	0,38
				J12	Touws (all W Cape)	0,36	0,14	0,18	25	0,68	0,68	0,29	0,03	0,32	0,32
				J13	Groot (all W Cape)	0,01	0,01	0,01	0	0,03	0,03	0,00	0,01	0,01	0,01
			Sub-total (Northern Cape)			**0,00**	**0,00**	**0,00**	**0**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
			Sub-total (Western Cape)			**0,80**	**0,30**	**0,40**	**25**	**1,50**	**1,50**	**0,62**	**0,09**	**0,70**	**0,70**
			Total for Groot River catchment			**0,80**	**0,30**	**0,40**	**25**	**1,50**	**1,50**	**0,62**	**0,09**	**0,70**	**0,70**
		J4	Lower Gouritz	None	---	0,20	0,07	0,09	25	0,36	0,36	0,11	0,04	0,15	0,15
			Total for Lower Gouritz incremental catchment (all Western Cape)			**0,20**	**0,07**	**0,09**	**25**	**0,36**	**0,36**	**0,11**	**0,04**	**0,15**	**0,15**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					**0,00**	**0,00**	**0,00**	**0**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0,00**	**0,00**	**0,00**	**0**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**7,30**	**4,57**	**3,99**	**25**	**15,86**	**15,86**	**5,98**	**1,04**	**7,02**	**7,02**
	TOTAL IN GOURITZ CATCHMENT					**7,30**	**4,57**	**3,99**	**25**	**15,86**	**15,86**	**5,98**	**1,04**	**7,02**	**7,02**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (all W Cape)	9,31	6,85	5,39	25	21,55	21,55	5,96	1,65	7,61	7,61
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers, (all W Cape)	0,53	0,26	0,26	25	0,00	0,00	0,16	0,19	0,35	0,35
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape)	0,00	0,00	0,00	0	5,80	5,80	0,00	0,00	0,00	0,00
					Coastal rivers (W Cape)	2,96	1,39	1,45	25			1,25	0,75	2,00	2,00
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0,00**	**0,00**	**0,00**	**0**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**12,80**	**8,50**	**7,10**	**25**	**28,40**	**28,40**	**7,37**	**2,59**	**9,96**	**9,96**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**12,80**	**8,50**	**7,10**	**25**	**28,40**	**28,40**	**7,37**	**2,59**	**9,96**	**9,96**
TOTAL IN WMA IN NORTHERN CAPE						**0,00**	**0,00**	**0,00**	**0**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
TOTAL IN WMA IN EASTERN CAPE						**0,00**	**0,00**	**0,00**	**0**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
TOTAL IN WMA IN WESTERN CAPE						**21,40**	**13,70**	**11,70**	**25**	**46,80**	**46,80**	**14,22**	**3,96**	**18,18**	**18,18**
TOTAL IN WMA						**21,40**	**13,70**	**11,70**	**25**	**46,80**	**46,80**	**14,22**	**3,96**	**18,18**	**18,18**

(1) Although assumed to be at 1:50 year assurance for the purposes of this situation assessment, it is probable that the quantity at that assurance is negligible.

Further losses occur between the bulk treated water storage reservoirs and consumers, mainly as a result of leaking of 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. The assumed values are shown in Table 5.3.2.4. The total estimated distribution and bulk conveyance loss is 11,7 million m^3/a, which is 25% of the total urban water use of 46,8 million m^3/a.

Return Flows

In the context of the overall water resources of the WMA, 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.

Reliable information on return flows was not available for most of the towns in the WMA. Return flows of 50% of the direct and indirect water requirements (excluding losses) were assumed for the bigger towns, and less for the smaller towns that do not have extensive water borne sewage systems.

The return flows are shown in Table 5.3.2.4 where no distinction is made between re-usable return flows and those that are made directly to the sea and are not, therefore, considered to be re-usable. It is estimated that about 10 million m^3/a of the return flows are not re-usable for that reason.

Where there are large 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. The increased runoff from paved areas amounts to 3,96 million m^3/a. For consistency with the assumptions made in drawing up the National Water Resource Strategy, it has been assumed that the increased runoff from paved areas is at 1:50 year assurance, but this may be incorrect and it is probable that the quantity 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. No detailed information on rural water use was found, but it is known that water use patterns vary widely, depending on the economic circumstances of the consumers.

In order to obtain an estimate of the total water requirements, consumers were considered to fall into three economic categories, with associated unit water requirements. These categories are "Rural", being people living far from towns and not part of the communities of large commercial farms, "Developing Urban" being people of the lower income group living close to towns and typically on smallholdings, and "Commercial farming" being the owners of large commercial farms and their workers.

The assumed unit water requirements are shown in Table 5.3.3.1. For want of better information, losses were assumed to be 20% of total water requirements, including losses.

TABLE 5.3.3.1: PER CAPITA WATER REQUIREMENTS IN RURAL AREAS IN 1995

USER CATEGORY	UNIT WATER REQUIREMENTS			
	Direct Use (ℓ/c/d)	Distribution losses		Total (ℓ/c/d)
		(ℓ/c/d)	(%)	
Rural	75	19	20	94
Developing urban	150	38	20	188
Commercial farming	175	44	20	219

Rural water requirements were calculated from the estimated number of people in each user category in each quaternary catchment. Detailed estimates are given in Appendix F and the results are summarised in Table 5.3.3.2.

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

The distribution of water requirements for livestock is shown in Table 5.3.3.2 where it can also be seen that all rural water requirements were estimated to total 13,70 million m^3/a in 1995, including distribution losses, which were assumed to be 20% of requirements net of losses.

The "Small scale irrigation" column in Table 3.5.4.1 is intended to cover the use of "leiwater" for watering of gardens and irrigation on smallholdings. It is known that this occurs in towns such as Oudtshoorn and Ladismith, but information on the quantities of water used was not readily available. Therefore, the column has been left blank.

It was assumed that the supply of water for all the rural requirements is at 1:50 year assurance.

Return flows from rural users are assumed to be negligible.

5.4 BULK WATER USE

This section deals with industries, mines and thermal powerstations having individual bulk water supplies or direct supplies from DWAF. The only water user in this category is Mossref near Mossel Bay which receives water by pipeline from the Wolwedans Dam on the Great Brak River (see Section 4.4). In 1995 the water requirement at the plant was 5,4 million m^3/a. Allowing an assumed 5% for conveyance losses brings the total requirement to 5,7 million m^3/a.

The wastewater from the plant is recycled via a reclamation plant and the brine obtained from the process is evaporated. Consequently, there is no return flow from the plant.

There are no thermal powerstations in the WMA.

TABLE 5.3.3.2: RURAL DOMESTIC WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

CATCHMENT						RURAL WATER REQUIRMENTS (10^6 m^3/a)							RETURN FLOWS	
PRIMARY		SECONDARY		TERTIARY/QUATERNARY		DOMESTIC (million m^3/a) (1)	SMALL SCALE IRRIGATION (million m^3/a) (2)	LIVESTOCK AND GAME	LOSSES (3)		TOTAL	TOTAL AT 1:50 YR ASSURANCE	NORMAL	TOTAL AT 1:50 YR ASSURANCE
No.	Description	No.	Description	No.	Description			(million m^3/a)	(million m^3/a)	%	(million m^3/a)	(million m^3/a)	(million m^3/a)	(million m^3/a)
H (part)	Breede-Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	0,67	--	0,91	0,32	20	1,90	1,90	0	0
	TOTAL IN BREEDE-GOURITZ CATCHMENT (All Western Cape)					**0,67**	**--**	**0,91**	**0,32**	**20**	**1,90**	**1,90**	**0**	**0**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	0,01 0,34	-- --	0,05 0,70	0,01 0,21		0,07 1,25	0,07 1,25	0	0
				J25	Lower Gamka (all W Cape)	0,31	--	0,16	0,09	20	0,56	0,56	0	0
			Sub-total (Northern Cape)			**0,01**	**--**	**0,05**	**0,01**	**20**	**0,07**	**0,07**	**0**	**0**
			Sub-total (Western Cape)			**0,65**	**--**	**0,86**	**0,30**	**20**	**1,81**	**1,81**	**0**	**0**
			Total for Gamka catchment			**0,66**	**--**	**0,90**	**0,31**	**20**	**1,87**	**1,87**	**0**	**0**
		M3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	0,04 0,43	--	0,14 0,51	0,04 0,19	20	0,22 1,13	0,22 1,13	0	0
				J34	Kammanassie (all W Cape)	0,27	--	0,39	0,13	20	0,79	0,79	0	0
				J35	Lower Olifants (all W Cape)	0,54	--	0,44	0,20	20	1,18	1,18	0	0
			Sub-total (Eastern Cape)			**0,04**	**--**	**0,14**	**0,04**	**20**	**0,22**	**0,22**	**0**	**0**
			Sub-total (Western Cape)			**1,24**	**--**	**1,35**	**0,52**	**20**	**3,10**	**3,10**	**0**	**0**
			Total for O lifants catchment			**1,28**	**--**	**1,48**	**0,55**	**20**	**3,32**	**3,32**	**0**	**0**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	0,02 0,41	-- --	0,01 0,19	0,01 0,12	20	0,03 0,72	0,03 0,72	0	0
				J12	Touws (all W Cape)	0,42	--	0,66	0,22	20	1,29	1,29	0	0
				J13	Groot (all W Cape)	0,09	--	0,19	0,06	20	0,34	0,34	0	0
			Sub-total (Northern Cape)			**0,02**	**--**	**0,01**	**0,01**	**20**	**0,03**	**0,03**	**0**	**0**
			Sub-total (Western Cape)			**0,92**	**--**	**1,04**	**0,39**	**20**	**2,36**	**2,36**	**0**	**0**
			Total for Groot River catchment			**0,94**	**--**	**1,05**	**0,40**	**20**	**2,39**	**2,39**	**0**	**0**
		J4	Lower Gouritz	None	---	0,32	--	0,84	0,23	20	1,40	1,40	0	0
			Total for Lower Gouritz incremental catchment (all Western Cape)			**0,32**	**--**	**0,84**	**0,23**	**20**	**1,40**	**1,40**	**0**	**0**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					**0,03**	**--**	**0,06**	**0,02**	**20**	**0,10**	**0,10**	**0**	**0**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0,04**	**--**	**0,14**	**0,04**	**20**	**0,22**	**0,22**	**0**	**0**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**3,13**	**--**	**4,09**	**1,44**	**20**	**8,67**	**8,67**	**0**	**0**
	TOTAL IN GOURITZ CATCHMENT					**3,20**	**--**	**4,28**	**1,50**	**20**	**8,98**	**8,98**	**0**	**0**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (all W Cape)	0,59	--	0,70	0,26	20	1,55	1,55	0	0
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	0,30	--	0,16	0,09	20	0,55	0,55	0	0
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	0,00 0,33	--	0,00 0,26	0,00 0,12	20	0,01 0,70	0,01 0,70	0	0
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0,00**	**--**	**0,00**	**0,00**	**20**	**0,01**	**0,01**	**0**	**0**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**1,22**	**--**	**1,12**	**0,47**	**20**	**2,81**	**2,81**	**0**	**0**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**1,23**	**--**	**1,12**	**0,47**	**20**	**2,82**	**2,82**	**0**	**0**
TOTAL IN WMA IN NORTHERN CAPE						**0,03**	**--**	**0,06**	**0,02**	**20**	**0,10**	**0,10**	**0**	**0**
TOTAL IN WMA IN EASTERN CAPE						**0,05**	**--**	**0,14**	**0,04**	**20**	**0,23**	**0,23**	**0**	**0**
TOTAL IN WMA IN WESTERN CAPE						**5,03**	**--**	**6,12**	**2,23**	**20**	**13,37**	**13,37**	**0**	**0**
TOTAL IN WMA						**5,10**	**--**	**6,31**	**2,28**	**20**	**13,70**	**13,70**	**0**	**0**

(1) Household use
(2) Use of "leiwater" for watering of gardens and smallholdings falls into this category. This is known to occur in towns such as Oudtshoorn and Ladismith but information on quantities used is not readily available.
(3) Assumed to be 20% of requirements net of losses.

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 are not available. Therefore, irrigation water requirements were estimated from available information on irrigated areas, typical quotas and assurances of supply.

The estimated irrigated areas are 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 Western 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 canal or river losses, estimated on-farm conveyance losses, and estimated return flows.

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 5.6.2.1: IRRIGATION WATER REQUIREMENTS IN 1995

CATCHMENT						FIELD EDGE WATER REQUIRE-MENT	ASSUMED CANAL OR RIVER LOSSES		ON FARM CONVEYANCE LOSSES		TOTAL WATER REQUIRE-MENT	TOTAL WATER REQUIRE-MENT AT 1:50 YR ASSURANCE	RETURN FLOWS				
PRIMARY		SECONDARY		TERTIARY									LEACHING BEYOND THE ROOT ZONE	ADDITIONAL RETURN FLOW FROM LANDS	FROM CONVEYANCE LOSSES	TOTAL RETURN FLOW (million m³/a)	
No.	Description	No.	Description	No.	Description	(million m³/a)	(million m³/a)	%	(million m³/a)	%	(million m³/a)	(million m³/a)	(million m³/a)	(milion m³/a)	(million m³/a)	NORMAL	AT 1:50 YR ASSURANCE
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	28,1	5,6	16	1,4	4	35,1	28,4	0	1,4	0,4	1,8	1,4
	TOTAL IN BREEDE-GOURITZ CATCHMENT (All Western Cape)					**28,1**	**5,6**	**16**	14,0	4	**35,1**	28,4	**0**	**1,4**	**0,4**	**1,8**	**1,4**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	0,0 45,71	0,0 11,4	0 19	0,0 2,3	0 4	0,0 59,4	0,0 46,9	0 0	0,0 0,0	0,0 0,0	0,0 0,0	0,0 0,0
				J25	Lower Gamka (all W Cape)	2,2	0,6	19	0,1	4	2,9	2,3	0	0,0	0,0	0,0	0,0
			Sub-total (Northern Cape)			**0,0**	**0,0**	**0**	**0,0**	0	**0,0**	0,0	**0**	**0,0**	**0,0**	**0,0**	**0,0**
			Sub-total (Western Cape)			**47,9**	**12,0**	**19**	**2,4**	4	**62,3**	49,2	**0**	**0,0**	**0,0**	**0,0**	**0,0**
			Total for Gamka catchment			**47,9**	**12,0**	**19**	**2,4**	4	**62,3**	49,2	**0**	**0,0**	**0,0**	**0,0**	**0,0**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	0,0 18,2	0,0 4,5	0 19	0,0 0,9	0 4	0,0 23,6	0,0 19,4	0 0	0,0 0,9	0,0 0,3	0,0 1,2	0,0 1,0
				J34	Kammanassie (all W Cape)	0,1	0,0	19	0,0	0	0,1	0,1	0	0,0	0,0	0,0	0,0
				J35	Lower Olifants (all W Cape)	39,5	9,9	19	2,0	4	51,4	42,1	0	2,0	0,6	2,6	2,1
			Sub-total (Eastern Cape)			**0,0**	**0,0**	**0**	**0,0**	0	**0,0**	0,0	**0**	**0,0**	**0,0**	**0,0**	**0,0**
			Sub-total (Western Cape)			**57,8**	**14,4**	**19**	**2,9**	4	**75,1**	61,6	**0**	**2,9**	**0,9**	**3,8**	**3,1**
			Total for Olifants catchment			**57,8**	**14,4**	**19**	**2,9**	4	**75,1**	61,6	**0**	**2,9**	**0,9**	**3,8**	**3,1**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	0,0 20,5	0,0 5,1	0 19	0,0 1,0	0 4	0,0 26,6	0,0 21,3	0 0	0,0 0,0	0,0 0,0	0,0 0,0	0,0 0,0
				J12	Touws (all W Cape)	17,6	4,4	19	0,9	4	22,9	18,3	0	0,0	0,0	0,0	0,0
				J13	Groot (all W Cape)	8,9	2,2	19	0,4	4	11,6	9,3	0	0,0	0,0	0,0	0,0
			Sub-total (Northern Cape)			**0,0**	**0,0**	**0**	**0,0**	0	**0,0**	0,0	**0**	**0,0**	**0,0**	**0,0**	**0,0**
			Sub-total (Western Cape)			**47,0**	**11,8**	**19**	**2,4**	4	**61,1**	48,9	**0**	**0,0**	**0,0**	**0,0**	**0,0**
			Total for Groot River catchment			**47,0**	**11,8**	**19**	**2,4**	4	**61,1**	48,9	**0**	**0,0**	**0,0**	**0,0**	**0,0**
		J4	Lower Gouritz	None	---	22,0	4,4	16	1,1	4	27,5	22,3	0	1,1	0,3	1,4	1,1
			Total for Lower Gouritz incremental catchment (all W Cape)			**22,0**	**4,4**	**16**	**1,1**	4	**27,5**	22,3	**0**	**1,1**	**0,3**	**1,4**	**1,1**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					**0,0**	**0,0**	**0**	**0,0**	0	**0,0**	0,0	**0**	**0,0**	**0,0**	**0,0**	**0,0**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0,0**	**0,0**	**0**	**0,0**	0	**0,0**	0,0	**0**	**0,0**	**0,0**	**0,0**	**0,0**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**174,7**	**42,6**	**19**	**8,7**	4	**226,0**	182,0	**0**	**4,0**	**1,1**	**5,1**	**4,2**
	TOTAL IN GOURITZ CATCHMENT					**174,7**	**42,6**	**19**	**8,7**	4	**226,0**	182,0	**0**	**4,0**	**1,1**	**5,1**	**4,2**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A	Coastal rivers (all W Cape)	28,8	0,0	0	0,0	0	28,8	24,5	0	1,4	0,0	1,4	1,2
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	18,9	0,0	0	0,0	0	18,9	16,0	0	0,9	0,0	0,9	0,8
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	0,0 2,7	0,0 0,0	0 0	0,0 0,0	0 0	0,0 2,7	0,0 2,3	0 0	0,0 0,1	0,0 0,0	0,0 0,1	0,0 0,1
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0,0**	**0,0**	**0**	**0,0**	0	**0,0**	0,0	**0**	**0,0**	**0,0**	**0,0**	**0,0**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**50,4**	**0,0**	**0**	**0,0**	0	**50,4**	42,8	**0**	**2,5**	**0,0**	**2,5**	**2,1**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**50,4**	**0,0**	**0**	**0,0**	0	**50,4**	42,8	**0**	**2,5**	**0,0**	**2,5**	**2,1**
TOTAL IN WMA IN NORTHERN CAPE						**0,0**	**0,0**	**0**	**0,0**	0	**0,0**	0,0	**0**	**0,0**	**0,0**	**0,0**	**0,0**
TOTAL IN WMA IN EASTERN CAPE						**0,0**	**0,0**	**0**	**0,0**	0	**0,0**	0,0	**0**	**0,0**	**0,0**	**0,0**	**0,0**
TOTAL IN WMA IN WESTERN CAPE						**253,2**	**48,2**	**15**	**10,1**	3	**311,5**	253,2	**0**	**7,9**	**1,5**	**9,4**	**7,8**
TOTAL IN WMA						**253,2**	**48,2**	**15**	**10,1**	3	**311,5**	253,2	**0**	**7,9**	**1,5**	**9,4**	**7,8**

TABLE 5.6.2.2: TYPICAL ANNUAL FIELD EDGE IRRIGATION REQUIREMENTS

<table>
<tr><th colspan="2" rowspan="2">AREA</th><th rowspan="2">QUATERNARY CATCHMENTS</th><th rowspan="2">PREDOMINANT CROP</th><th colspan="2">FIELD EDGE WATER REQUIREMENT (m^3/ha/a)</th></tr>
<tr><th>TYPICAL</th><th>ASSUMED AVERAGE</th></tr>
<tr><td>Breede-Gouritz</td><td>Breede Gouritz</td><td>H8, H9</td><td>Grapes</td><td>--</td><td>7 000</td></tr>
<tr><td rowspan="2">Gamka</td><td>Upper Gamka</td><td>J21 - J24</td><td>Grapes, stone fruit</td><td>12 000</td><td rowspan="2">7 980</td></tr>
<tr><td>Lower Gamka</td><td>J25</td><td>Lucerne and pastures</td><td>6 000</td></tr>
<tr><td>Olifants</td><td>Upper Olifants
Kammanassie
Lower Olifants</td><td>J31 - J33
J34
J35</td><td>Lucerne and pastures
grapes, stone fruit</td><td>--</td><td>12 035</td></tr>
<tr><td>Groot</td><td>Buffels
Touws
Groot</td><td>J11
J12
J13</td><td>Grapes, stone fruit</td><td>--</td><td>12 062</td></tr>
<tr><td>Gouritz</td><td>Lower Gouritz</td><td>J4</td><td>Lucerne and pastures, grapes</td><td>--</td><td>8 000</td></tr>
<tr><td>Outeniqua Coastal</td><td>Mossel Bay
Wilderness
Knysna - Blaaukrantz</td><td>K10, K20, K30A to C
K30D, K40D
K50, K60, K70</td><td>Mixed crops
Mixed crops
Mixed crops, vegetables</td><td>--</td><td>7 000</td></tr>
</table>

With the exception of the wetter coastal catchments, irrigation is confined to small run-of-river schemes in the upper reaches of rivers, or to extensive controlled irrigation schemes consisting of dams and associated canal systems. The main irrigated crops are pastures which are irrigated on an opportunistic basis whenever the water is available in wetter years. Where irrigation water is available at a sufficiently high assurance (for example, immediately downstream of dams) grapes and stone fruit are grown.

Total average irrigation water use in 1995 is estimated to have been 311,5 million m^3/a, including conveyance losses. The distribution of irrigation water requirements is shown diagrammatically on Figure 5.6.2.1.

5.6.3 Water Losses

Irrigation water losses are considered in two categories, namely :

- Canal or rivers 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.

The main river conveyance losses occur in the Gouritz WMA through channel losses and evaporation.

As reliable information on farm conveyance losses is not available, estimates of canal and river losses and on farm conveyance losses were provided by officials of the DWAF Western Cape Regional Office. These are shown in Table 5.6.3.1.

TABLE 5.6.3.1: ESTIMATED IRRIGATION CONVEYANCE LOSSES

AREA	CATCHMENTS	CONVEYANCE LOSS FACTORS (%)	
		ASSUMED CANAL OR RIVER LOSSES	ON FARM CONVEYANCE LOSSES
Breede-Gouritz	H8, H9	16	4
Gamka	J2	19	4
Olifants	J3	19	4
Groot	J1	19	4
Gouritz (incremental)	J4	16	4
Outeniqua coastal	K1 - K7	0	0

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 Gouritz 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 Western Cape Regional Office, of the percentages of field edge applications that become return flows were used to obtain an indication of the volume of return flows generated. The assumed percentages are shown in Table 5.6.4.1.

Return flows in the arid areas of the WMA are negligible because the low soil moisture contents and high evaporation losses prevent excess irrigation water from reaching the watercourses.

TABLE 5.6.4.1: ESTIMATED IRRIGATION RETURN FLOWS AS PERCENTAGES OF FIELD EDGE IRRIGATION REQUIREMENTS

AREA	CATCHMENTS	RETURN FLOWS (% OF FIELD EDGE IRRIGATION REQUIREMENTS)
Great Karoo	J11A to H, J12A to G J21 J22 J23 J24 J32	0%
Klein Karoo	J11J to K, J12H to M, J13 J25, J31, J33, J34, J35	5%
Coastal areas	H80, J40 K10, K20, K30, K40, K50, K60, K70A and B	5%

5.7 DRYLAND SUGARCANE

No sugarcane is grown commercially in the Gouritz WMA.

5.8 WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

No information is available on water losses from rivers and wetlands.

Evaporation from the approximately 140 dams (including farm dams) in the WMA has been estimated to amount to 50,5 million m^3/a, on average.

The four largest dams in the catchment each have capacities over 30 million m^3/a, and account for 16,7 million m^3/a (40%) of the losses mentioned previously. These four dams are listed below with their capacities, surface areas, and estimated evaporation losses.

	CAPACITY (million m^3/a)	SURFACE AREA AT FULL SUPPLY LEVEL (km^2)	MEAN EVAPORATION LOSS (million m^3/a)	ESTIMATED NET YIELD (1) (million m^3/a)
Floriskraal Dam (J11H)	50,3	7,6	5,3	8,7
Stompdrift Dam (J33B)	49,6	6,2	4,9	15,0
Gamkapoort Dam (J25A)	41,6	6,2	4,2	11,0
Kammanassie Dam (J34E)	34,8	3,5	2,3	18,0
TOTALS	**176,3**	**23,5**	**16,7**	**52,7**

(1) From Table 4.1.3.

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.

TABLE 5.8.1: EVAPORATION LOSSES FROM DAMS

CATCHMENT						EVAPORATION LOSSES FROM DAMS (million m^3/a)
PRIMARY		**SECONDARY**		**TERTIARY/QUATERNARY**		
No.	**Description**	**No.**	**Description**	**No.**	**Description**	
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	1,42
	TOTAL IN BREEDE-GOURITZ CATCHMENT (All Western Cape)					**1,42**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	0,00 9,95
				J25	Lower Gamka (all W Cape)	13,03
			Sub-total (Northern Cape)			**0,00**
			Sub-total (Western Cape			**22,98**
			Total for Gamka catchment			**22,98**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	0,00 6,34
				J34	Kammanassie (all W Cape	2,98
				J35	Lower Olifants (all W Cape)	1,21
			Sub-total (Eastern Cape)			**0,00**
			Sub-total (Western Cape)			**10,53**
			Total for Olifants catchment			**10,53**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape	0,00 5,81
				J12	Touws (all W Cape)	7,12
				J13	Groot (all W Cape)	0,03
			Sub-total (Northern Cape)			**0,00**
			Sub-total (Western Cape)			**12,95**
			Total for Groot River catchment			**12,95**
		J4	Lower Gouritz	None	---	0,07
			Total for Lower Gouritz incremental catchment (all W Cape)			**0,07**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					**0,00**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0,00**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**46,53**
	TOTAL IN GOURITZ CATCHMENT					**46,53**
K	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (all W Cape)	2,09
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	0,15
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	0,32
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0,00**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**2,56**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**2,56**
TOTAL IN WMA IN NORTHERN CAPE						**0,00**
TOTAL IN WMA IN EASTERN CAPE						**0,00**
TOTAL IN WMA IN WESTERN CAPE						**50,51**
TOTAL IN WMA						**50,51**

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).

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.

The details of the water use by afforestation per key point is shown in Table 5.9.1. Only small areas of the Gouritz WMA are climatically suited to commercial timber plantations. Some 95% of the reduction in runoff due to afforestation occurs in the coastal catchments east of the Gouritz River mouth, and the remaining 5% of the reduction in runoff in the coastal catchments west of the Gouritz River mouth. Less than 0,1% of the reduction occurs in the Great and Little Karoo (J).

The total reduction in runoff by afforestation is estimated to be 87 million m^3/a. The corresponding reduction in the 1:50 year yield is 14,5 million m^3/a. This information is shown diagrammatically on Figure 5.9.1.

5.10 HYDRO-POWER AND PUMPED STORAGE

No such activities take place in the WMA.

5.11 ALIEN VEGETATION

Tertiary and quaternary catchment information on 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.

TABLE 5.9.1: WATER USE BY AFFORESTATION IN 1995

CATCHMENT						AVERAGE WATER USE		REDUCTION IN SYSTEM 1:50 YEAR YIELD	
PRIMARY		SECONDARY		TERTIARY/QUATERNARY					
No.	Description	No.	Description	No.	Description	(million m^3/a)	(mm/a)[1]	(million m^3/a)	(mm/a)[1]
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	4,570	169	0,90	33
	TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)					**4,570**	**169**	**0,90**	**33**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	0,000 0,000	0 0	0,00 0,00	0 0
				J25	Lower Gamka (all W Cape)	0,000	0	0,00	0
			Sub-total (Northern Cape)			**0,000**	**0**	**0,00**	**0**
			Sub-total (Western Cape)			**0,000**	**0**	**0,00**	**0**
			Total for Gamka catchment			**0,000**	**0**	**0,00**	**0**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	0,000 0,000	0 0	0,00 0,00	0 0
				J34	Kammanassie (all W Cape)	0,070	67	0,00	0
				J35	Lower Olifants (all W Cape)	0,000	0	0,00	0
			Sub-total (Eastern Cape)			**0,000**	**0**	**0,00**	**0**
			Sub-total (Western Cape)			**0,070**	**67**	**0,00**	**0**
			Total for Olifants catchment			**0,070**	**67**	**0,00**	**0**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	0,000 0,000	0 0	0,00 0,00	0 0
				J12	Touws (all W Cape)	0,005	7	0,00	0
				J13	Groot (all W Cape)	0,000	0	0,00	0
			Sub-total (Northern Cape)			**0,000**	**0**	**0,00**	**0**
			Sub-total (Western Cape)			**0,005**	**7**	**0,00**	**0**
			Total for Groot River catchment			**0,005**	**7**	**0,00**	**0**
		J4	Lower Gouritz	None	---	0,010	78	0,00	15
			Total for Lower Gouritz incremental catchment (all Western Cape)			**0,010**	**78**	**0,00**	**15**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE)					**0,000**	**0**	**0,00**	**0**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0,000**	**0**	**0,00**	**0**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**0,080**	**46**	**0,00**	**1**
	TOTAL IN GOURITZ CATCHMENT					**0,080**	**46**	**0,00**	**1**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (all W Cape	25,580	180	4,23	30
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	31,160	153	5,15	25
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	0,000 25,500	0 113	0,00 4,22	0 19
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0,000**	**0**	**0,00**	**0**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**82,240**	**144**	**13,60**	**24**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**82,240**	**144**	**13,60**	**24**
TOTAL IN WMA IN NORTHERN CAPE						**0,000**	**0**	**0,00**	**0**
TOTAL IN WMA IN EASTERN CAPE						**0,000**	**0**	**0,00**	**0**
TOTAL IN WMA IN WESTERN CAPE						**86,890**	**145**	**14,50**	**24**
TOTAL IN WMA						**86,890**	**145**	**14,50**	**24**

(1)Based on total catchment area

The distribution of alien vegetation in the Gouritz 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 most of the reduction in runoff caused by alien vegetation occurs in the coastal catchments to the east of the Gouritz River mouth (K). These areas account for 53% of the total reduction in runoff of 121,26 million m^3/a. The coastal catchments to the west of the Gouritz River mouth (H) account for 31% of the total reduction, while the Great and Little Karoo (J) make up the remaining 16%. The main areas of reduction in the latter catchment are the Kammanassie River catchment (J34, 6,58 million m^3/a) and the Gouritz River incremental catchment (J4, 5,86 million m^3/a).

The total reduction in the system 1:50 year yield is 36,0 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.

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.

TABLE 5.11.1: WATER USE BY ALIEN VEGETATION IN 1995

CATCHMENT						AVERAGE REDUCTION IN RUNOFF		REDUCTION IN SYSTEM 1:50 YEAR YIELD	
PRIMARY		SECONDARY		TERTIARY/QUATERNARY					
No.	Description	No.	Description	No.	Description	(million m^3/a)	(mm/a)[1]	(million m^3/a)	(mm/a)[1]
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	37,34	86	8,64	20
	TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)					37,34	86	8,64	20
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	0,00 1,69	0 40	0,00 0,26	0 6
				J25	Lower Gamka (all W Cape)	0,23	9	0,04	1
			Sub-total (Northern Cape)			**0,00**	**0**	**0,00**	**0**
			Sub-total (Western Cape)			**1,92**	**28**	**0,30**	**4**
			Total for Gamka catchment			**1,92**	**28**	**0,30**	**4**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	0,00 1,41	0 26	0,00 0,69	0 13
				J34	Kammanassie (all W Cape)	6,58	50	3,22	24
				J35	Lower Olifants (all W Cape)	0,38	10	0,19	5
			Sub-total (Eastern Cape)			**0,00**	**0**	**0,00**	**0**
			Sub-total (Western Cape)			**8,37**	**37**	**4,10**	**18**
			Total for Olifants catchment			**8,37**	**37**	**4,10**	**18**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	0,00 0,02	0 14	0,00 0,01	0 4
				J12	Touws (all W Cape)	0,34	20	0,10	6
				J13	Groot (all W Cape)	3,15	23	0,90	7
			Sub-total (Northern Cape)			**0,00**	**0**	**0,00**	**0**
			Sub-total (Western Cape)			**3,51**	**22**	**1,00**	**6**
			Total for Groot River catchment			**3,51**	**22**	**1,00**	**6**
		J4	Lower Gouritz	None	---	5,86	62	1,36	14
			Total for Lower Gouritz incremental catchment (all Western Cape)			5,86	**62**	**1,36**	**14**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE)					**0,00**	**0**	**0,00**	**0**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**0,00**	**0**	**0,00**	**0**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**19,68**	**36**	**6,76**	**12**
	TOTAL IN GOURITZ CATCHMENT					**19,68**	**36**	**6,76**	**12**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (all W Cape	5,48	195	1,75	62
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	15,19	199	4,85	63
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	0,00 43,58	0 158	0,00 13,90	0 50
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**0,00**	**0**	**0,00**	**0**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN WESTERN CAPE					**64,25**	**169**	**20,50**	**54**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**64,25**	**169**	**20,50**	**54**
TOTAL IN WMA IN NORTHERN CAPE						**0,00**	**0**	**0,00**	**0**
TOTAL IN WMA IN EASTERN CAPE						**0,00**	**0**	**0,00**	**0**
TOTAL IN WMA IN WESTERN CAPE						**121,26**	**89**	**35,90**	**26**
TOTAL IN WMA						**121,26**	**89**	**35,90**	**26**

(1) Based on total catchment area

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.

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 54% of total consumptive water requirements (i.e. excluding the requirements of the ecological reserve) in the Gouritz Water Management Area. Irrigation losses are often quite significant and it is estimated that often no more than 70% 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 15% of total consumptive water requirements in the Gouritz 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 title 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 Gouritz 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.

Statistics on the results of water conservation measures in the Gouritz WMA are not readily available and are not, therefore, included in this report. There appears to be considerable scope for water conservation in both the urban and the irrigation user sectors.

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 Groundwater 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 Groundwater 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 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 rights. In all other areas rights could be allocated only by a Water Court, primarily in proportion to the extent of irrigable riparian land.

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

With the implementation of the National Water Act, Act No. 36 of 1998, Government Water Control Areas no longer exist.

In the Gouritz WMA, the following areas were Government Water Control Areas:

- the upper reaches of the Duiwenhoks River (H80A, B, C)
- portions of the catchments of the Korente and Vet Rivers (H90A, B, C)
- part of the Groot River around and downstream of Floriskraal Dam (J11G, H, J, K, J12M, J13A)
- part of the catchment of the Gamka River in the vicinity of Gamka Dam near Beaufort West (J21A)
- part of the catchment of the Leeu River in the vicinity of Leeu Gamka Dam (J22K)
- an area in the vicinity of Oukloof Dam near Prince Albert (J23D, E, F)
- part of the catchment of the Gamka River around and downstream of Gamkapoort Dam (J23G, H, J, J24E, F, J25A, B, C, D, E)
- a small portion of catchment J12J
- most of the catchment of the Olifants River and its tributaries (J31, J32, J33, J34, J35)
- portions of catchments J40D and J40E.

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 25 irrigation districts in the Gouritz WMA. They are listed in Table 5.13.1.1. A number of the irrigation districts were within Government Water Control Areas, and some received some, or all, of their water from Government Water Schemes. Those that did so are marked by asterisks in Table 5.13.1.1.

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 during the low flow months. 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 GOURITZ WMA

NAME (1)	CATCHMENT (2)	SCHEDULED AREA (4) (ha)	QUOTA (3) (m^3/ha/a)	ALLOCATION (million m^3/a)	SOURCE OF WATER (4)
Bleshoek	J1K	131,58	Not known	Not known	Not known
Brand River *	J12M	134,10	6 100	0,82	Brand River flow. Miertjieskraal Dam
Buffelskloof	J11J	431,85	Not known	Not known	Not known
Buffelsvlei * - Gamka	J25C	343,80	7 900	2,72	Gamkapoort Dam
Buffels River *	J13A	2208,90	7 620	16,83	Groot River, Floriskraal Dam
Calitzdorp	J25C, J25D	520,50	3 160 approx.	1,7 approx.	Calitzdorp Dam, Nels River
Duiwenhoks * River	H80A, B, C	1272,00	6 000	7,6	Duiwenhoks River Dam
Gamka River *	J25E	1563,10	6 240 supplied 7 900 official	9,75	Gamkapoort-Dam, Buffelsvlei-Gamka and Gamka Rivers
Grootbosberg	H90D, E	384,00	7 000	2,69	Goukou River (run-of-river)
Hoeko	J25B	672,80	Not known	Not known	Mountain streams (Kobus and Weltevrede Rivers)
Huis River	J11K	128,90	Not known	Not known	Spring, river
Jan Fourieskraal*	J33F	1281,87	6 500	8,3	Olifants River, Stompdrift and Kammanassie Dams
Keurbos River	K30C	200,00	5 000	1,0	Keurbos River
Klip River	J35A	814,70	4 800 and 8 000	Not known	Bos River Dam and mountain streams
Korente-Vette *	H90A, B, C	826,70	7 000	5,8	Korente-vet River Dam
Kweekvallei	J23F	168,81	Portion of flow	--	Springs in Swartberg
Leeu-Gamka *	J22K	685,60	Not known	Not known	Leeu Gamka Dam
Modder River	K30B	300,00	Portion of flow	--	Modder and Nornga Rivers
Opzoek	J25B	231,50	Portion of flow	--	Tributaries of Gamka River
Oukloof *	J23D, E, F	255,00	6 330	1,61	Oukloof Dam
Prins River *	J12G	361,60	Not known	Not known	Prins River Dam
Stompdrift - Kammanassie *	J31, J32, J33, J34, J35	10871,28	6 500	70,7	Kammanassie Dam, Stompdrift Dam, Olifants and Kammanassie Rivers
Van Wyksdorp	J13B	89,62	Portion of flow	--	Tributary of Groot River
Verkeerdevlei	J12B	281,60	Not known	Not known	Verkeerdevlei Dam
Wynands River	J35A	768,01	Not known	Not known	Grobbelaars River, Koos Raubenheimer Dam
TOTALS		24927,82	--	--	--

(1) * Irrigation districts that receive water partially or entirely from Government Water Schemes are marked with an asterisk.
(2) Confidence in the accuracy of this data is low and verification of the catchments indicated is required.
(3) Where quotas are shown as "Portion of flow" water is supplied from run of river flow diversion on the basis of "turns" lasting for prescribed periods of time. The data on quotas in m^3/ha/a was obtained from DWAF files.
(4) Data obtained from DWAF files or discussions with officials of the Western Cape Regional Office.

5.13.2 Permits and Other Allocations in the Gouritz WMA

Information on allocations from Government Water Schemes is summarised in Tables 5.13.2.1. and 5.13.2.2.

TABLE 5.13.2.1: SECTION 63 SCHEDULING AND QUOTAS FROM GOVERNMENT WATER SCHEMES IN THE GOURITZ WMA

SCHEME	QUATERNARY CATCHMENTS	SCHEDULING (1) (ha)	QUOTA (1)	ALLOCATION
			(m^3/ha/a)	(10^6 m^3/a)
Brand River (Miertjieskraal Dam)	J12M	134,1	6 100	0,8
Duiwenhoks River (Duiwenhoks Dam)	H80A, B, C	1 303,4	6 000	7,8
Korente-Vette (Korente-Vet Dam)	H90B, C	826,7	7 000	5,8
Buffels River (Floriskraal Dam)	J11F, G, H, J, K J12M, J13A	2 208,9	7 620	16,8
Ou Kloof (Ou Kloof Dam, Prins Albert)	J23D, E, F	255,0	6 330	1,6
Olifants (Stompdrift and Kammanassie Dams)	J31, J32, J33, J34, J35	13 494,1	6 500	87,7
TOTALS		18 222,12	**--**	**120,5**

(1) From DWAF records

Table 5.13.2.1. shows allocations to irrigation under Section 63 of the Water Act of 1956. The scheduled areas and quotas in the table were obtained from a list supplied by DWAF. The total scheduled area of 18 222 ha is 73% of the total area scheduled in the irrigation districts listed in Table 5.13.1.1.

Water is allocated from Gamkapoort Dam under Section 88 of the Water Act of 1956. The scheduled area is 1 563,1 ha at a quota of 7 900 m^3/ha/a, giving a total allocation of 12,3 million m^3/a (DWAF, 1999).

TABLE 5.13.2.2: SECTION 56(3) ALLOCATIONS FROM GOVERNMENT WATER SCHEMES

SCHEME	QUATERNARY CATCHMENTS	ALLOCATION ((10^6 m^3/a)					
		HOUSEHOLD & STOCK WATERING	MUNICIPALITIES	BULK STRATEGIC	BULK MINING	IRRIGATION	TOTAL
Buffels River (Floriskraal Dam)	J11H	24×10^{-6}	0,00	0,0	0	0,00	24×10^{-6}
Duiwenhoks River	H80C	0,00	0,73	0,0	0	0,26	0,99
Gamka River (Gamkapoort Dam)	J25A	0,25	0,00	0,0	0	0,00	0,25
Korente-Vet River (Korente-Vet Dam)	H89A, B,C	0,11	1,20	0,0	0	0,34	1,65
Mossgas (Wolwedans Dam)	K20A, K10A	0,01	0,00	1,0 (3)	0	0,16	1,17
TOTALS (2)		**0,37**	**1,93**	**1,0**	**0**	**0,76**	**4,06**

(1) Data supplied by DWAF
(2) Values are rounded to two decimal places
(3) Quantity supplied is 5,7 million m^3/a

Table 5.13.2.2 shows allocations under Article 56(3) of the Water Act of 1956. The allocations under municipalities are to Heidelberg (0,73 million m^3/a) and Riversdale (1,20 million m^3/a). The allocation to the Duiwenhoks Rural Water Supply Scheme from the Duiwenhoks River Dam does not appear to have been made under Section 56(3). The allocation of 1 million m^3/a under bulk industrial is to the Petro SA Refinery. The quantity of water actually supplied is higher at about 5,7 million m^3/a, including estimated conveyance losses.

5.13.3 Allocations in Relation to Water Requirements and Availability

The allocations from Government Water Schemes listed above totalled 137 million m^3/a, including the Section 88 allocations from Gamkapoort dam. The total water requirements, as shown in Table 5.1.1, amount to 378,1 million m^3/a if the requirements on yield of the ecological Reserve, afforestation, and alien vegetation are not included in the total. Thus, the listed allocations from Government Water Schemes account for some 36% of the requirements. However, the list of allocations may not be comprehensive, as none for the state owned dams of Gamka (Beaufort West), Bellair, Leeu Gamka, Prins River and Hartebeeskuil appear in the lists of allocations obtained. The estimated 1:50 year yields of these dams (Table 4.1.3) total appromximately 6,9 million m^3/a and their 1:10 year yields can be expected to be about 11 million m^3/a.

The allocation of 87,7 million m^3/a from Stompdrift and Kammanassie Dams combined is 266% of their combined 1:50 year yield of 33 million m^3/a. Because of this, considerably less than the allocated quantities of water are supplied to irrigators each year.

The allocations from the other dams shown in Table 5.13.2.1. are close to the estimated 1:50 year yields of the dams. However, when coneyance losses are added to the allocations, requirements generally exceed the 1:50 year yields. Nevertheless, the full allocations can be provided in most years and it is only during severe droughts that reduced quantities of water are supplied, which is general irrigation water supply practice.

5.14 EXISTING WATER TRANSFERS

The following water transfers occur in the Gouritz WMA :

- The transfer of 0,4 million m^3/a from the Duiwenhoks Dam (H80A) to the Breede WMA for domestic use.
- The transfer of 5,7 million m^3/a from Wolwedans Dam (K20A) to the Petro SA Refinery (K10A).
- The transfer of 1,8 million m^3/a from Ernest Robertson Dam (K20A) to Mossel Bay (K10A).
- The transfer of 4 million m^3/a from Klipheuwel Dam (K10F) to Mossel Bay (K10A).
- The transfer of 1,33 million m^3/a from the Keurbooms River (K60E) to Plettenberg Bay (K60G).

There are no imports of water to the Gouritz WMA.

Information on these transfers is summarised in Table 5.14.1, and they are shown diagramatically on Figure 5.14.1.

TABLE 5.14.1: AVERAGE TRANSFERS WITHIN AND OUT OF THE GOURITZ WMA AT 1995 DEVELOPMENT LEVELS

DESCRIPTION OF TRANSFER	SOURCE QUATERNARY	DESTINATION AND QUATERNARY	QUANTITY (million m^3/a)
Duiwenhoks Dam to Breede WMA	H60B	H70J	0,40
Wolwedans Dam to Petro SA Refinery	K20A	K10A	5,70
Ernest Robertson Dam to Mossel Bay	K20A	K10A	1,80
Klipheuwel Dam to Mossel Bay	K10F	K10A	4,00
Keurboomms River to Plettenberg Bay	K60E	K60G	1,33

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 RETURNFLOWS

CATEGORY		ON-SITE WATER REQUIREMENTS (million m^3/a)	LOSSES		RETURN FLOW	
			(million m^3/a)	% OF TOTAL REQUIREMENT	(million m^3/a)	% OF TOTAL REQUIREMENT
Irrigation		253,2	58,3	18	9,4	4
Urban		35,1	11,7	25	18,2	52
Rural		11,4	2,3	20	0,0	0
Bulk	a) Strategic	0,0	0,0	0	0,0	0
	b) Mining	0,0	0,0	0	0,0	0
	c) Other (Petro SA Refinery)	5,4	0,3	5	0,0	0
Hydro-power		0,0	0,0	0	0,0	0
Rivers, wetlands, dams		0,0	50,5	--	0,0	0
TOTAL		**305,1**	**123,1**	**19**	**27,6**	**7**

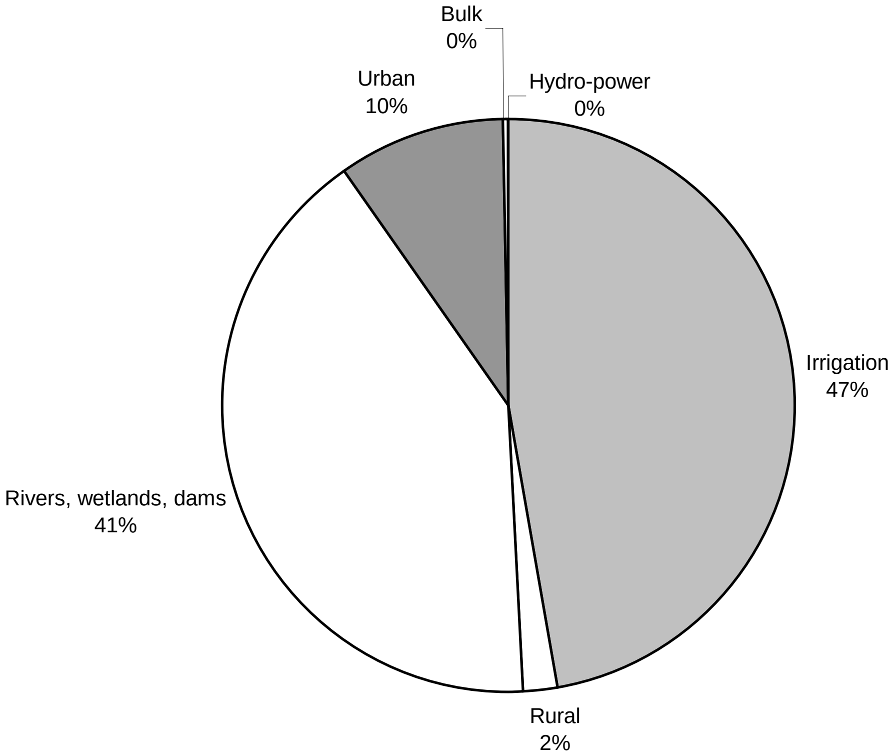


Diagram 5.15.1: Category loss as a proportion of the total losses in the Gouritz WMA

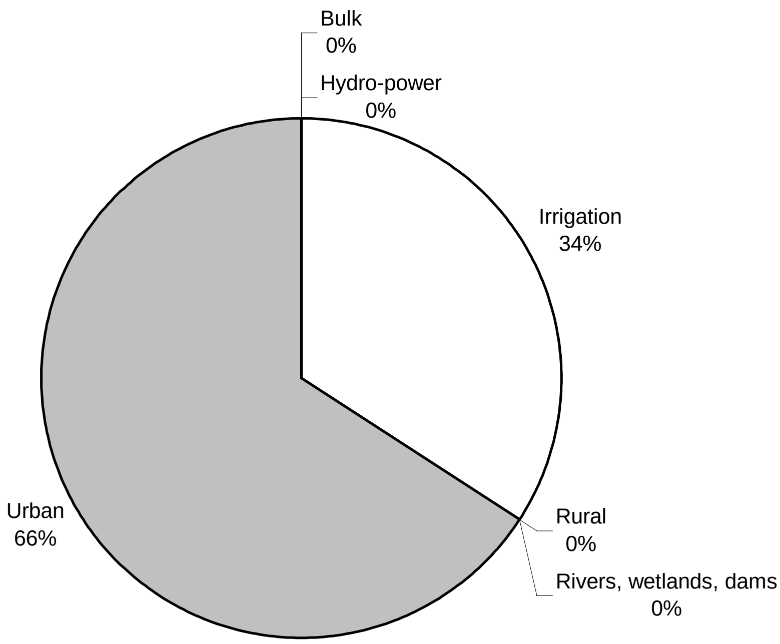


Diagram 5.15.2 : Category return flow as a proportion of the total return flow in the Gouritz WMA

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), and adjusted as described in Section 6.3, that, under virgin conditions, the total MAR of the Gouritz WMA was 1 678 million m^3. Approximately 41% of this, or 695 million m^3/a, occurred in the catchment of the Gouritz River (Drainage Region J).

The remainder of the natural runoff, totalling 983 million m^3/a on average, came from the catchments comprising the coastal strips to the east (H8 and 9) and west (K1, 2, 3, 4, 5, 6, 7) of the Gouritz estuary. (Note : this is the gross MAR. The quantity reaching the sea is lower owing to the endoreic areas that occur in the coastal strip (H8 and H9).)

The natural runoff has been reduced by the construction of dams, the pumping of water from rivers and by the effects of timber plantations and alien vegetation. The present day MAR at the Gouritz estuary is not known, but is roughly estimated from the water requirements, evaporation losses and return flows given in this report to be 390 million m^3. The reduction in runoff from the coastal catchments has also been severe, and their present day gross MAR is probably about 680 million m^3. Thus, the total present day gross MAR is estimated to be 1 070 million m^3, which is 64% of the natural MAR. Nineteen major dams and about 122 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 272 million m^3/a can be obtained from the surface water resources under 1:50 year drought conditions. The distribution of this yield amongst the catchments making up the WMA is shown in Table 6.1.1 as the "1:50 year developed 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 471 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 many areas of the WMA. Consequently, more detailed investigations of surface water development potential may show the economically utilisable yield to be significantly less than 471 million m^3/a.

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 ecological 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. However, it has been estimated, as described in Chapter 7, that the effect of making releases for the ecological Reserve, once the details of the releases have been determined and become a legal requirement, will be to reduce the 1:50 year yield available for other users by only about 36 million m^3/a under 1995 conditions.

TABLE 6.1.1: WATER RESOURCES

CATCHMENT						SURFACE WATER RESOURCES (million m^3/a)			SUSTAINABLE GROUNDWATER EXPLOITATION POTENTIAL (million m^3/a) [(5)]		TOTAL WATER RESOURCE (million m^3/a)	
PRIMARY		SECONDARY		TERTIARY/QUATERNARY		GROSS CUMULATIVE NATURAL MAR	1:50 YEAR DEVELOPED YIELD IN 1995	1:50 YEAR TOTAL POTENTIAL YIELD	DEVELOPED IN 1995	TOTAL POTENTIAL	1:50 YEAR DEVELOPED IN 1995	1:50 YEAR TOTAL POTENTIAL
No.	Description	No.	Description	No.	Description							
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	212,20	39,78	71,8	0,89	52,77	40,67	72,7
	TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)					**212,20**	**39,78**	**71,8**	**0,89**	**52,77**	**40,67**	**72,7**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	192,67	7,76	27,7	0,04 20,78	3,99 59,78	28,58	48,5
				J25	Lower Gamka (all W Cape)	33,93	15,07	15,0	3,07	32,03	18,14	18,1
			Sub-total (Northern Cape)			--	---	---	**0,04**	**3,99**	---	---
			Sub-total (Western Cape			--	---	---	**23,89**	**91,81**	---	---
			Total for Gamka catchment			**226,60**	**22,83**	**42,7**	**23,89**	**95,80**	**46,72**	**66,6**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	89,28	18,56	18,6	1,15 11,48	13,50 80,46	31,19	31,2
				J34	Kammanassie (all W Cape)	56,52	20,90	20,9	0,42	51,30	21,32	21,3
				J35	Lower Olifants (all W Cape)	82,84	16,65	21,6	2,00	61,37	18,65	23,6
			Sub-total (Eastern Cape)			--	---	---	**1,15**	**13,30**	---	---
			Sub-total (Western Cape)			--	---	---	**13,91**	**193,31**	---	---
			Total for Olifants catchment			**228,64**	**56,11**	**61,1**	**15,06**	**206,63**	**71,17**	**76,2**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	37,90	8,43	8,4	0,04 1,96	2,83 29,13	10,43	10,4
				J12	Touws (all W Cape)	54,44	7,27	7,3	12,81	62,85	20,08	20,1
				J13	Groot (all W Cape)	13,01	2,10	2,1	8,40	19,85	10,50	10,5
			Sub-total (Northern Cape)			--	---	---	**0,04**	**2,83**	---	---
			Sub-total (Western Cape)			--	---	---	**23,16**	**111,83**	---	---
			Total for Groot River catchment			**105,35**	**17,80**	**17,8**	**23,20**	**114,66**	**41,01**	**41,0**
		J4	Lower Gouritz	None	---	695,13	24,07	40,1	0,14	41,36	24,21	40,2
			Total for Lower Gouritz incremental catchment (all Western Cape)			**695,13**	**24,07**	**40,1**	**0,14**	**41,36**	**24,21**	**40,2**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					---	---	---	**0,08**	**6,82**	---	---
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					--	---	---	**1,15**	**13,50**	---	---
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					--	---	---	**61,06**	**438,12**	---	---
	TOTAL IN GOURITZ CATCHMENT					**695,13**	**120,80**	**161,7**	**62,29**	**458,44**	**183,10**	**224,0**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (allW Cape)	251,39	58,48	88,8	0,00	37,83	58,48	88,8
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	203,95	26,90	62,0	0,00	29,23	26,90	62,0
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	315,94	25,76	86,4	0,00 1,06	3,85 96,05	26,82	87,5
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					--	---	---	**0,00**	**3,85**	---	---
	TOTAL IN OUTENIQUA COASTAL CATCHMENT IN WESTERN CAPE					--	---	---	**1,06**	**163,12**	---	---
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**771,28**	**111,14**	**237,2**	**1,06**	**166,97**	**106,2**	**238,3**
TOTAL IN WMA IN NORTHERN CAPE						--	---	---	**0,08**	**3,85**	---	---
TOTAL IN WMA IN EASTERN CAPE						--	---	---	**1,15**	**166,97**	---	---
TOTAL IN WMA IN WESTERN CAPE						--	---	---	**63,02**	**654,02**	---	---
TOTAL IN WMA						**1678,50**	**271,72**	**470,7**	**64,25**	**678,18**	**335,97**	**535,0**

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 or 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 Gouritz 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 toal 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 developed water resource in 1995 was estimated to have a yield, at 1:50 year assurance, of 336 million m^3/a (272 million m^3/a from surface water and 64 million m^3/a from groundwater). The total potential yield at 1:50 year assurance is estimated to be 535 million m^3/a. (471 million m^3/a from surface water and 64 million m^3/a from groundwater). The distribution of the yield in 1995 is shown diagrammatically on Figure 6.1.1 and Figure 6.1.2 shows the total potential yield.

The total potential groundwater yield is, at 678 million m^3/a, greater than the potential surface water yield, but it is estimated that only 455 million m^3/a of this is of low enough salinity to be potable. Therefore, the maximum potential yield has been assumed to be the total potential surface water yield plus the groundwater yield that was developed in 1995. In practice, it might be more economical to obtain the maximum potential yield through a combination of surface water and groundwater development. It should also be noted that a maximum yield of 678 million m^3/a could probably be developed if it were to become economical to desalinate the groundwater.

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 exploitation potential for the whole WMA was estimated to be 678 million m^3/a. However, because of poor water quality (generally high natural salinity) in some areas, the potable exploitation potential was estimated to be 455 million m^3/a.

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 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. This is a conservative assumption as the impact of groundwater abstraction on surface water yields is rated "negligible" or "low" in most areas except in the coastal strip between Mossel Bay and Sedgefield, where it is rated "high", and between Sedgefield and Plettenberg Bay, where it is rated "moderate".

The existing groundwater use was determined by Baron and Seward (2000). Estimates of groundwater use were also made at a workshop held on the Gouritz 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 6.2.3.

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 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

CATCHMENT						UTILISABLE GROUNDWATER EXPLOITATION POTENTIAL (million m^3/a)	GROUND-WATER USE IN 1995	UNUSED GROUNDWATER EXPLOITATION POTENTIAL IN 1995	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)	POTABLE GROUND-WATER POTENTIAL (million m^3/a)
PRIMARY		SECONDARY		TERTIARY/QUATERNARY							
No.	**Description**	**No.**	**Description**	**No.**	**Description**						
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	52,77	0,89	51,88	14,81	37,96	26,58
	TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)					**52,77**	**0,89**	**51,88**	**14,81**	**37,96**	**26,58**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	3,99 59,78	0,04 20,78	3,95 39,00	0,41	63,36	48,35
				J25	Lower Gamka (all W Cape)	32,03	3,07	28,96	0,79	31,24	28,09
			Sub-total (Northern Cape)			**3,99**	**0,04**	**3,95**	**--**	**--**	**--**
			Sub-total (Western Cape			**91,81**	**23,89**	**67,96**	**--**	**--**	**--**
			Total for Gamka catchment			**95,80**	**23,89**	**71,91**	**1,20**	**94,60**	**76,44**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	13,50 80,46	1,15 11,48	12,34 68,97	2,47	91,49	54,35
				J34	Kammanassie (all W Cape)	51,30	0,42	50,88	1,59	49,71	39,06
				J35	Lower Olifants (all W Cape)	61,37	2,00	59,37	3,67	57,70	40,79
			Sub-total (Eastern Cape)			**13,30**	**1,15**	**12,34**	**--**	**--**	**--**
			Sub-total (Western Cape)			**193,13**	**13,91**	**179,22**	**--**	**--**	**--**
			Total for Olifants catchment			**206,63**	**15,06**	**191,57**	**7,73**	**198,90**	**134,20**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	2,83 29,13	0,04 1,96	2,80 27,17	0,02	31,94	23,98
				J12	Touws (all W Cape)	62,85	12,81	50,04	0,12	62,73	33,52
				J13	Groot (all W Cape)	19,85	8,40	11,45	0,08	19,77	6,15
			Sub-total (Northern Cape)			**2,83**	**0,04**	**2,80**	**--**	**--**	**--**
			Sub-total (Western Cape)			**111,83**	**23,16**	**88,66**	**--**	**--**	**--**
			Total for Groot River catchment			**114,66**	**23,20**	**91,46**	**0,22**	**114,44**	**63,65**
		J4	Lower Gouritz	None	---	41,36	0,14	41,21	4,41	36,95	22,57
			Total for Lower Gouritz incremental catchment (all Western Cape)			**41,36**	**0,14**	**41,21**	**4,41**	**36,95**	**22,57**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					**6,82**	**0,08**	**6,74**	**--**	**--**	**--**
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					**13,50**	**1,15**	**12,34**	**--**	**--**	**--**
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					**438,12**	**61,06**	**377,06**	**--**	**--**	**--**
	TOTAL IN GOURITZ CATCHMENT					**458,44**	**62,29**	**396,15**	**13,56**	**444,89**	**296,87**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (all W Cape)	37,83	0,00	37,83	25,51	12,31	16,57
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	29,23	0,00	29,23	19,67	9,56	24,74
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	3,85 96,05	0,00 1,06	3,85 94,98	40,77	59,12	90,08
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					**3,85**	**0,00**	**3,85**	**--**	**--**	**--**
	TOTAL IN OUTENIQUA COASTAL CATCHMENT IN WESTERN CAPE					**163,12**	**1,06**	**162,05**	**--**	**--**	**--**
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**166,97**	**1,06**	**165,90**	**85,97**	**81,00**	**131,39**
TOTAL IN WMA IN NORTHERN CAPE						**3,85**	**0,08**	**6,74**	**--**	**--**	**--**
TOTAL IN WMA IN EASTERN CAPE						**166,97**	**1,15**	**16,19**	**--**	**--**	**--**
TOTAL IN WMA IN WESTERN CAPE						**654,02**	**63,02**	**591,00**	**--**	**--**	**---**
TOTAL IN WMA						**678,18**	**64,25**	**613,93**	**114,34**	**563,85**	**454,82**

In the Gouritz WMA, groundwater was considered to be under-utilised generally, the exceptions being:

- Catchments J22K and J23A in the vicinity of Leeu-Gamka, where it is over-utilised.
- The upper Olifants River valley (J32D, J33B to J33E) where it is heavily utilised.
- The vicinity of Prince Albert (J23F) where it is heavily utilised.

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 Gouritz WMA the increase was between 0% and 10%.

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. It is recommended that a sensitivity analysis can be done in order to determine whether these limitations have a significant effect on the results.

Several detailed studies of the hydrology of portions of the Gouritz WMA have been carried out in the past. Brief descriptions of them follow.

- Klein Karoo Rural Water Supply Scheme Augmentation Study (DWAF, 1999c), carried out by Ninham Shand included hydrological modelling of the Olifants and Gamka Rivers.
- Investigation into the effect of alien vegetation on water resources planning for the town of George (Working for Water, 2001) undertaken by ASCH and Ninham Shand modelled the hydrology of the Swart, Kaaimans and Malgas (tributary of the Gwang) Rivers on the Garden Route.
- The Plettenberg Bay Coastal Catchment Study (DWAF, 1996a), undertaken by Ninham Shand and BKS covered the water resources for the Keurbooms River, the Piesangs River and some other minor coastal rivers west of Plettenberg Bay.

The results of the above studies were used to derive most of 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, the appropriate storage-draft-frequency curves from WR90 were used to estimate the yields of the main dams.

The run-of-river yields were estimated in consultation with officials of the DWAF Western Cape Regional Office 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 irrigation requirements that is not provided for from Government Water Schemes is provided from farm dams and run-of-river yield. It was also assumed that all other consumptive water requirements (i.e. excluding the ecological Reserve) not provided from Government Water Schemes were provided from run-of-river yield or minor dams. Thus, the combined run-of-river yield and yield from minor dams was calculated by subtracting the yields of major dams from the total equivalent 1:50 year water requirement after adjusting it for re-used return flows and subtracting the impact on yield of the ecological Reserve. In the Upper Gamka catchment and the Buffels River catchment this approach gave yields from farm dams and run-of-river abstractions that were excessively high in relation to equivalent yields estimated from the deficient flow-duration-frequency curves given in WR90. These yields were, therefore, reduced to the values derived from WR90.

The developed 1:50 year yield in 1995 shown in Table 6.3.1 is based on the following assumptions:

- In the coastal catchments to the west of the Gouritz River mouth :
  - the yield of 9,8 million m^3/a from Duiwenhoks Dam (H80F),
  - the yield of 5,8 million m^3/a from Korentepoort Dam (H90E),
  - an estimated yield of 24,2 million m^3/a from farm dams and run-of-river flow,
  - giving a total of 39,8 million m^3/a.

- In the Upper Gamka catchment :
  - the yield of 0,6 million m^3/a from Gamka Dam (J21A),
  - the yield of 7,8 million m^3/a from Leeu Gamka Dam (J22K),
  - the yield of 1,4 million m^3/a from Oukloof Dam (J23E),
  - an estimated yield of 4,36 million m^3/a from farm dams and run-of-river flow,
  - giving a total of 7,76 million m^3/a.

TABLE 6.3.1: SURFACE WATER RESOURCES

CATCHMENT						INCREMENTAL CATCHMENT AREA (km^2)	MEAN ANNUAL PRECIPITATION (mm/a)	MEAN ANNUAL EVAPORATION (mm/a)	GROSS NATURAL MAR [(1)] (million m^3/a)		INCREMENTAL YIELD (1:50 YEAR)	
PRIMARY		SECONDARY		TERTIARY/QUATERNARY								
No.	Description	No.	Description	No.	Description				INCRE-MENTAL	CUMU-LATIVE	DEVELOPED IN 1995	TOTAL POTENTIAL
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	2 978	498	1 404	212,20	212,20	39,78	71,8
	TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)					**2 978**	**498**	**1 404**	**212,20**	**212,20**	**39,78**	**71,8**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka (N Cape) Upper Gamka (W Cape)	874 16 749	181	2 231	192,67	192,67	7,76	27,7
				J25	Lower Gamka (all W Cape)	1 429	301	1 926	33,93	33,93	15,07	15,0
			Sub-total (Northern Cape)			874	--	--	--	--	---	---
			Sub-total (Western Cape			18 178	--	--	--	--	---	---
			Total for Gamka catchment			**19 051**	**190**	**2 208**	**226,60**	**226,60**	**22,83**	**42,7**
		J3	Olifants	J31 to J33	Upper Olifants (E Cape) Upper Olifants (W Cape)	1 786 4 820	287	1 987	89,28	89,28	18,56	18,6
				J34	Kammanassie (all W Cape)	1 845	509	1 620	56,52	56,52	20,90	20,9
				J35	Lower Olifants (all W Cape)	2 566	382	1 769	82,84	82,84	16,65	21,6
			Sub-total (Eastern Cape)			1 786	--	--	--	--	---	---
			Sub-total (Western Cape)			9 231	--	--	--	--	---	---
			Total for Olifants catchment			**11 017**	**346**	**1 875**	**228,64**	**228,64**	**56,11**	**61,1**
		J1	Groot	J11	Buffels (N Cape) Buffels (W Cape)	537 5 109	230	2 025	37,90	37,90	8,43	8,4
				J12	Touws (all W Cape)	6 312	276	1 750	54,44	54,44	7,27	7,3
				J13	Groot (all W Cape)	1 355	316	1 594	13,01	13,01	2,10	2,1
			Sub-total (Northern Cape)			537	--	--	--	--	---	---
			Sub-total (Western Cape)			12 776	--	--	--	--	---	---
			Total for Groot River catchment			**13 313**	**261**	**1 851**	**105,35**	**105,35**	**17,80**	**17,8**
		J4	Lower Gouritz	None	---	2 321	452	1 444	134,54	695,13	24,07	40,1
			Total for Lower Gouritz incremental catchment (all Western Cape)			**2 321**	**452**	**1 444**	**134,54**	**695,13**	**24,07**	**40,1**
	TOTAL IN GOURITZ CATCHMENT IN NORTHERN CAPE					1 410	--	--	--	--	---	---
	TOTAL IN GOURITZ CATCHMENT IN EASTERN CAPE					1 786	--	--	--	--	---	---
	TOTAL IN GOURITZ CATCHMENT IN WESTERN CAPE					42 506	--	--	--	--	---	---
	TOTAL IN GOURITZ CATCHMENT					**45 702**	**262**	**1 985**	**695,13**		**120,81**	**161,7**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers (all W Cape)	1 604	613	1 400	251,39	251,39	58,48	88,8
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers (all W Cape)	875	809	1 614	203,95	203,95	26,90	62,0
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers (E Cape) Coastal rivers (W Cape)	67 1 913	823	1 419	315,94	315,94	25,76	86,4
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS IN EASTERN CAPE					67	--	--	--	--	---	---
	TOTAL IN OUTENIQUA COASTAL CATCHMENT IN WESTERN CAPE					4 392	--	--	--	--	---	---
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**4 459**	**745**	**1 450**	**771,28**	**771,28**	**111,14**	**237,2**
TOTAL IN WMA IN NORTHERN CAPE						1 410	--	--	--	--	---	---
TOTAL IN WMA IN EASTERN CAPE						1 853	--	--	--	--	---	---
TOTAL IN WMA IN WESTERN CAPE						49 876	--	--	--	--	---	---
TOTAL IN WMA						**53 139**	**315**	**1 907**	**1678,50**	**1678,50**	**271,72**	**470,7**

(1) The gross MAR includes runoff in endoreic areas which does not reach the sea.

- In the Lower Gamka catchment :
  - the yield of 11 million m^3/a from Gamkapoort Dam (J25A),
  - the yield of 2,7 million m^3/a from Calitzdorp Dam (J25D),
  - an estimated yield of 1,37 million m^3/a from farm dams and run-of-river flow,
  - giving a total of 15,07 million m^3/a.

- In the Upper Olifants catchment :
  - the yield of 15 million m^3/a from Stompdrift Dam (J21A),
  - an estimated yield of 3,56 million m^3/a from farm dams and run-of-river flow,
  - giving a total of 18,56 million m^3/a.

- In the Kammanassie catchment :
  - the yield of 18 million m^3/a from Kammanassie Dam,
  - an estimated yield of 2,90 million m^3/a from farm dams and run-of-river flow,
  - giving a total of 20,9 million m^3/a.

- In the Lower Olifants catchment :
  - the yield of 2,2 million m^3/a from Koos Raubenheimer Dam (J35A),
  - the yield of 1,3 million m^3/a from Mellville Dam (J35A),
  - an estimated yield of 13,15 million m^3/a from farm dams and run-of-river flow,
  - giving a total of 16,65 million m^3/a.

- In the Buffels catchment :
  - the yield of 6,5 million m^3/a from Floriskraal Dam (J11F, G and H),
  - an estimated yield of 1,93 million m^3/a from farm dams and run-of-river flow,
  - giving a total of 8,43 million m^3/a.

- In the Touws catchment :
  - the yield of 1,3 million m^3/a from Verkeerdevlei (J12B),
  - the yield of 1,0 million m^3/a from Prins River Dam (J12G),
  - the yield of 1,6 million m^3/a from Bellair Dam (J12K),
  - an estimated yield of 3,37 million m^3/a from farm dams and run-of-river flow,
  - giving a total of 7,27 million m^3/a.

- In the Groot catchment :
  - an estimated yield of 2,10 million m^3/a from farm dams and run-of-river flow.

- In the Lower Gouritz catchment :
  - an estimated yield of 24,07 million m^3/a from farm dams and run-of-river flow.

- In the coastal catchments from Mossel Bay to George (K1, K2, K30A - C) :
  - the yield of 0,85 million m^3/a from Hartebeeskuil Dam (K10B),
  - the yield of 4,0 million m^3/a from Klipheuwel Dam (K10F),
  - the yield of 13,0 million m^3/a from Wolwedans Dam (K20A),
  - the yield of 1,8 million m^3/a from Ernest Robertson Dam (K20A),
  - the yield of 5,8 million m^3/a from Garden Route Dam (K30C),
  - an estimated yield of 33,03 million m^3/a from farm dams and run-of-river yield,
  - giving a total of 58,48 million m^3/a.

- In the coastal catchments near Wilderness (K30D, K4) :
  - an estimated yield of 26,90 million m^3/a from farm dams and run-of-river yield.

- In the coastal catchments from Knysna to Blaaukrantz (K5, 6, 7) :
  - the yield of 1,0 million m^3/a from Roodefontein Dam (K60G),
  - an estimated yield of 30,76 million m^3/a from farm dams and run-of-river yield,
  - giving a total of 31,76 million m^3/a:

Thus, the total developed yield of the surface water resources in 1995 is estimated to have been 272 million m^3/a, distributed as shown in Table 6.3.1. This estimate is at a low level of confidence because of uncertainty regarding the true yield obtained from farm dams and run-of-river flow, estimated to have been 165 million m^3/a.

There is very little readily available information regarding the potential future development of surface and groundwater resources in the Gouritz WMA. The Klein Karoo Rural Water Supply Augmentation Study (DWAF,1999) investigated a number of potential surface water and groundwater schemes, but all of these would involve buying out existing irrigation rights, mostly from existing dams, so were not considered here. Oudtshoorn Municipality will be investigating the potential for accessing groundwater from the Table Mountain Group (TMG) aquifer, but information regarding this is not currently available.

Information about developing the future water resources for the town of Plettenberg Bay is available (DWAF, 1996a), the favoured schemes being:

- raising of Roodefontein Dam (K60G) to provide an additional yield of 0,39 million m^3/a
- new dam on Keurbooms River (K60E) to provide an additional yield of 3 million m^3/a.

The White Paper on the Wolwedans Dam (K20A) (DWAF,1988) gives the maximum yield of Wolwedans as 11,7 million m^3/a at mixed assurance which is roughly equivalent to 13,0 million m^3/a at 1:50 year assurance.

The George Alien Vegetation Study investigated a dam in the upper reaches of the Malgas River (K30C) (tributary of the Gwaing River) with a potential yield of 6,2 million m^3/a.

None of the abovementioned surface water developments is designed to obtain the maximum potential yield from the catchments, so 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 100%, 125%, 150%, 200%, or 300% of the MAR, as appropriate.

The relevant hydro zones and maximum storage values are summarised in Table 6.3.2. These range from 100% of the MAR in the higher rainfall quaternary catchments to 300% of the MAR in the drier quaternary catchments within the WMA.

TABLE 6.3.2: ESTIMATES OF MAXIMUM FEASIBLE STORAGE (EXPRESSED AS A PERCENTAGE OF MAR)

WR 90 HYDRO ZONE	PERCENTAGE OF MAR	CATCHMENTS IN WMA LYING WITHIN HYDRO ZONE
B	100	K70B Bloukrantz
D	125	K20A Great Brak K30A Witels, Kruis and Moeras K30B Gwaing K30C Kaaimans K30D Touws K40D Diep, Hoekraal and Karatara K40E Goukamma K50B Knysna K60E Keurbooms K60F Bietou K60G Piesangs K70A Sout and Groot
K	200	J40E Gouritz K10A Riet K10B Hartenbos K10F Klein Brak
M	200	H80F Duiwenhoks H90E Korente-vet
N	250	J34F Kammanassie
P	200	J25E Gamka J33F Upper Olifants J35F Lower Olifants
W	300	J11K Buffels J12L Touws J13C Groot
Z	300	J24F Gamka and Dwyka

This information is extracted from a report by Stewart Scott prepared for DWAF for this study. (DWAF 1999d)

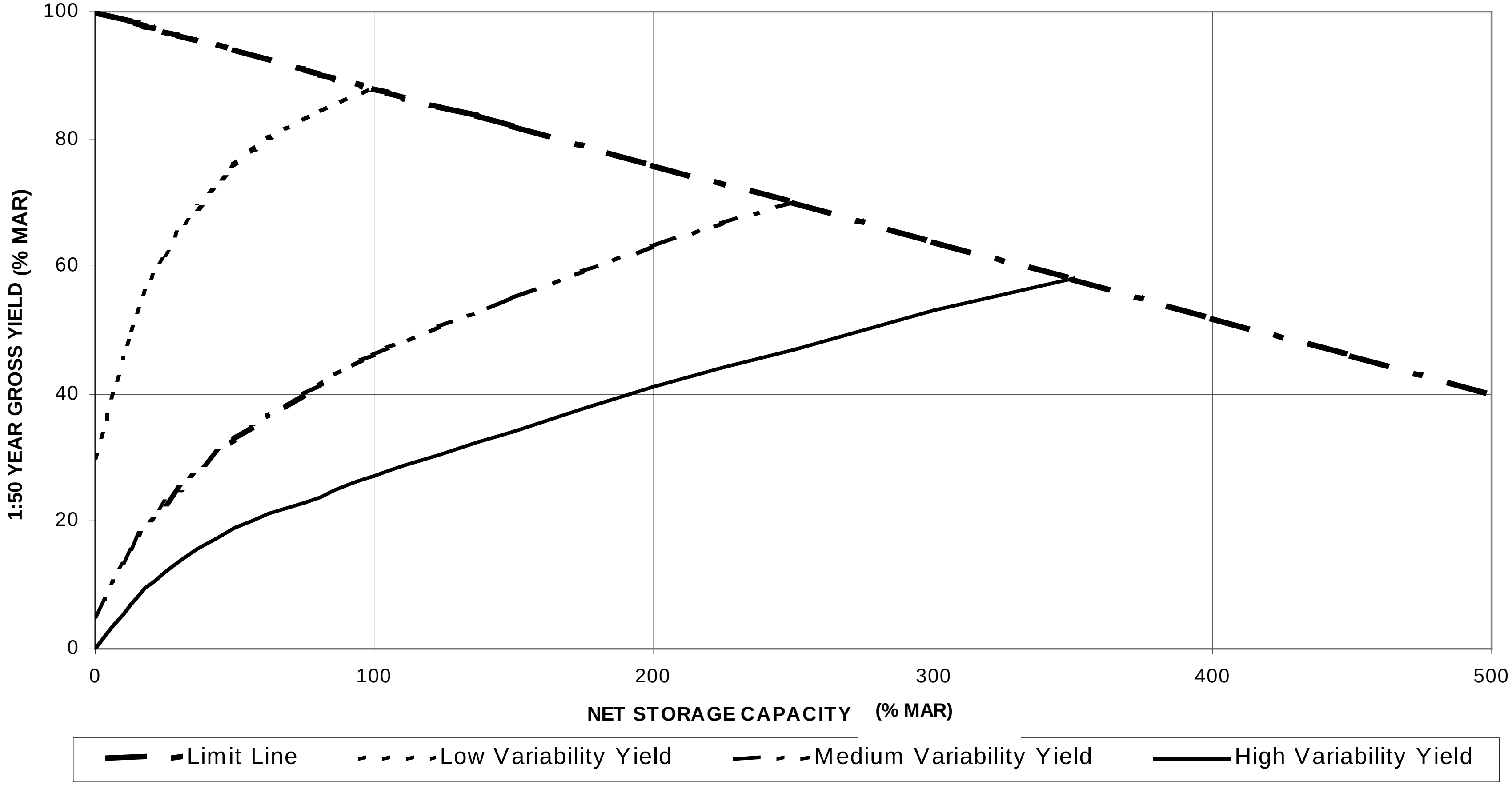


DIAGRAM 6.3.1: DAM STORAGE LIMITS

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 maximum feasible storage capacity and corresponding 1:50 year gross yield from WR90. The values were estimated to be 3 143 million m^3 and 1 021 million m^3/a respectively for the WMA as a whole. These values are the sums of separate values calculated for each key area. The calculations are shown in Table 6.3.3.

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 (Gamkapoort Dam, Kammanassie Dam and Garden Route Dam) as calculated in previous more detailed studies, with gross yields calculated using the WR90 curves. The ratios of net yields, allowing for evaporation losses, to gross yields ranged from 0,478 for Gamkapoort, through 0,612 for Kammanassie, to 0,811 for Garden Route Dam.

The appropriate one of these three 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 718 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 107 million m^3/a for the WMA), farm dams and developed run-of-river yield (totalling 165 million m^3/a) and developed groundwater (totalling 64 million m^3/a) were subtracted from the estimated potential maximum yield of 718 million m^3/a.

The calculation was performed for each key area. In the coastal catchments, 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. 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 6.3.3, where it can be seen that the potential undeveloped yield of the WMA is estimated to be 199 million m^3/a, and that, if developed, this would bring the total yield obtainable from the water resources of the WMA to 535 million m^3/a. A quantity of 64 million m^3/a of this total yield is obtained from existing boreholes. Therefore the maximum potential of the surface water resources is estimated to be 471 million m^3/a.

It was assumed that there is no further potential for the significant development of surface water resources in the following key areas:

- the Lower Gamka catchment (J25)
- the Upper Olifants catchment (J31 to J33)
- the Kammanassie catchment (J34)
- the Buffels catchment (J11)
- the Touws catchment (J12)
- the Groot catchment (J13)

This assumption was made because the existing equivalent storage (i.e. the equivalent storage that would provide the yield obtained from dams, groundwater and run-of-river abstractions) was close to the maximum economical size shown in Table 6.3.2.

TABLE 6.3.3: CALCULATION OF POTENTIAL MAXIMUM YIELD IN THE GOURITZ WMA

Key Point	River	Most D/S quat	WR90 Hydro Zone IV-?	Maximum Feasible Storage Capacity	Incremental MAR	IFR fEMPi	IFR fEMPi	Incremental MAR less IFR	Maximum Feasible Storage Capacity	1:50 year RI Gross Draft as % MAR (from WR90 Storage-Draft-Frequency curves)	Potential Maximum Yield (WR90 1:50 Yield)	Ratio used for Allowance for Evaporative Losses (see Note 2 below)	Net Potential Maximum Yield (WR90 1:50 Yield)	Yield of Major Dams in 1995	Total Ground-water use in 1995	Run of River & minor Dam Yield in 1995	Interim potential developable yield	Adjusted Potential Developable Yield (See Note 1 below)	Accepted Potential Developable Yield (-ve values zeroed)	Final Net Potential Maximum Yield (WR90 1:50 Yield)
Description				% MAR	10^6 m^3	%	10^6 m^3/a	10^6 m^3	10^6 m^3	% MAR	10^6 m^3/a		10^6 m^3/a	10^6 m^3/a	10^6 m^3/a	10^6 m^3/a	10^6 m^3/a	10^6 m^3/a	10^6 m^3/a	10^6 m^3/a
Breede to Gouritz	Duivenhoks	H80F	M	200.0	105.7	14.2	15.0	90.7	211.4	70	66.2	0.811	53.7	9.8						
	Korente-Vet	H90E	M	200.0	106.4	19.2	20.4	86.0	212.8	70	62.8	0.811	50.9	5.8						
		H9			212.1		35.4	176.7	424.2		129.0	---	104.6	15.6	0.9	24.2	63.9	32.0	32.0	72.7
Upper Gamka (J21 to J24)	Gamka & Dwyka	J24F	Z	300.0	192.7	9.2	17.7	174.9	578.0	60	104.5	0.478	50.5	4.8	20.8	4.4	20,0	20,0	20.0	48.5
Lower Gamka (at confluence with Olifants) (J2)	Gamka	J25E	P or W	200.0	33.9	6.0	2.0	31.9	67.9	70	22.5	0.478	10.8	13.7	3.1	1.4	-7.4	-7.4	0.0	18.1
		J2			226.6		19.8	206.8	645.9		124.0	---	59.3	18.5	23.9	5.8	11.1	11.1	20.0	66.6
Upper Olifants (J31 to J33)	Olifants	J33F	P or W	200.0	89.3	6.7	6.0	83.3	178.6	70	58.7	0.612	35.9	15.0	12.6	3.6	4.7	4.7	0.0	31.2
Kammanassie (J34)	Kammanassie	J34F	N	250.0	56.5	9.1	5.1	51.4	141.3	70	36.2	0.612	22.2	18.0	0.4	2.9	0.8	0.8	0.0	21.3
Lower Olifants(J3)	Olifants	J35F	P	200.0	82.8	7.7	6.4	76.5	165.7	70	53.9	0.612	33.0	3.5	2.0	13.1	14.3	14.3	5.0	23.6
		M3			228.6		17.5	211.1	485.5		148.9	---	91.1	36.5	15.1	19.6	19.9	19.9	5.0	76.2
Buffels (J11)	Buffels	J11K	W	300.0	37.9	7.0	2.7	35.2	113.7	60	22.6	0.478	10.8	6.5	2.0	1.9	0.4	0.4	0.0	10.4
Touws (J12)	Touws	J12L	W	300.0	54.4	7.8	4.2	50.2	163.3	60	32.1	0.478	15.4	3.9	12.8	3.4	-4.7	-4.7	0.0	20.1
Groot (J1)	Groot	J13C	W	300.0	13.0	7.5	1.0	12.0	39.0	60	7.7	0.478	3.7	0.0	8.4	2.1	-6.8	-6.8	0.0	10.4
		J1			105.4		7.9	97.5	316.1		62.4	---	29.8	10.4	23.2	7.4	-11.1	-11.1	0.0	41.0
Gouritz River mouth (J4)	Gouritz	J40E	K	200.0	134.5	10.3	13.9	120.7	269.1	80	91.7	0.612	56.1	0.0	0.1	24.1	31.9	16.0	16.0	40.2
Lower Gouritz (J)					695.1		59.0	636.1	1716.5		426.9	---	236.3	65.4	62.3	56.9	51.7	41,0	41.0	224.1
Mossel Bay to George (K1, K2, K30A-C)	Riet?	K10A	K	200.0	6.1	14.4	0.9	5.2	12.2	80	4.0	0.811	3.2	0.0			3.2			
	Hartenbos	K10B	K	200.0	5.7	14.4	0.8	4.9	11.4	80	3.7	0.811	3.0	0.9			2.2			
	Klein Brak	K10F	K	200.0	52.8	17.8	9.4	43.4	105.6	80	33.0	0.811	26.8	4.0			22.8			
	Great Brak	K20A	D	125.0	39.5	23.5	9.3	30.2	49.4	90	26.2	0.811	21.2	14.8			7.7			
	Witels, Kruis & Moeras	K30A	D	125.0	52.0	23.8	12.4	39.6	65.0	90	34.3	0.811	27.8	0.0			27.8			
	Gwaing	K30B	D	125.0	41.7	24.1	10.1	31.7	52.2	90	27.4	0.811	22.2	0.0			22.2			
	Kaaimans	K30C	D	125.0	53.6	23.7	12.7	40.9	67.0	90	35.3	0.811	28.7	5.8			22.9			
					251.4		55.5	195.9	362.7		163.8	---	132.9	25.5	0.0	33.0	74.4	37.2	30.3	88.8
Wilderness (K30D, K4)	Touws	K30D	D	125.0	37.1	32.9	12.2	24.9	46.3	90	21.5	0.811	17.4	0.0			17.4			
	Diep, Hoekraal &	K40D	D	125.0	112.7	33.6	37.9	74.8	140.9	90	64.7	0.811	52.5	0.0			52.5			
	Karatara Goukamma	K40E	D	125.0	54.2	28.4	15.4	38.8	67.7	90	33.6	0.811	27.2	0.0			27.2			
					204.0		65.4	138.5	254.9		119.8	----	97.2	0.0	0.0	26.9	70.3	35.1	35.1	62.0
Knysna to Blaaukrantz (K5,6,7)	Knysna	K50B	D	125.0	104.4	33.5	35.0	69.4	130.5	90	60.0	0.811	48.7	0.0			48.7			
	Keurbooms	K60E	D	125.0	105.0	32.8	34.4	70.6	131.2	90	61.0	0.811	49.5	0.0			49.5			
	Bietou	K60F	D	125.0	21.4	35.4	7.6	13.8	26.8	90	12.0	0.811	9.7	0.0			9.7			
	Piesangs	K60G	D	125.0	19.5	35.2	6.9	12.7	24.4	90	10.9	0.811	8.9	1.0			7.9			
	Sout & Groot	K70A	D	125.0	24.7	34.5	8.5	16.2	30.9	90	14.0	0.811	11.3	0.0			11.3			
	Bloukrantz	K70B	B	100.0	40.9	35.9	14.7	26.2	40.9	90	23.3	0.811	18.9	0.0			18.9			
					315.9		107.1	208.9	384.7		181.3	---	147.1	1.0	1.1	24.8	121.3	60.6	60.6	87.5
Outeniqua catchments					771.3		228.0	543.2	1002.3		464.9	---	377.1	26.5	1.1	84.7	271.9	136.0	126.0	238.3
TOTALS					1678.5		322.5	1356.1	3143.1		1020.8	---	718.0	107.5	64.2	165.8	386.5	203.8	199.1	535.1

Note 1: 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 Groot Brak, where the Wolwedans Dam was built in 1993, presumably to maximum capacity.

Note 2: Allowance for evaporation losses from Dams: One of 3 ratios was taken, based on a comparison of the WR90 1:50 year yields with net yields obtained in studies of the following dams:

Gamkapoort Dam 11/23 = 0,478 Kammanassie Dam 18/29.4 = 0.612 Garden Route Dam (5.8+1.74)/9.3 = 0.811.

There is potential for the development of additional groundwater yield in all of the above catchments. However, on the basis of the assumption made for this assessment that an increase in groundwater abstraction would cause a corresponding reduction in surface water yield, either in the particular key area, or in the surface water potential in the Lower Gouritz catchment, the unused groundwater potential has not been included in the total potential yields shown in Table 6.1.1.

Thus, it has been assumed that the undeveloped utilisable yield of 199 million m^3/a could be developed as follows:

- Additional yield of 32 million m^3/a from additional dams in the catchments to the west of the Gouritz River mouth (H8, H9) which would bring the total equivalent storage in those catchments to 2 x MAR.

- Additional yield of 18,5 million m^3/a from dams which would bring the equivalent storage in the Upper Gamka catchment to 3 x MAR.

- Additional yield of 5 million m^3/a from a new 6,5 million m^3 capacity dam on the Grobbelaars River (J35A), as investigated by Oudtshoorn Municipality.

- Additional yield of 16 million m^3/a from new dams in the Lower Gouritz catchment (J4) to bring the equivalent storage to 2 x MAR.

- Additional yield of 30 million m^3/a in the Mossel Bay to George coastal strip from new dams in catchments K10A, K10B and K10F to bring the equivalent storage to 2 x MAR and dams in catchments K20A, K30A, K30B and K30C that would bring the equivalent storage to 1,25 MAR. (The proposed Malgas Dam (K30B) with a yield of 6,2 million m^3/a is included).

- Additional yield of 35 million m^3/a in the Wilderness area from new dams in catchments K30D, K40D and K40E that would bring the equivalent storage to 1,25 x MAR.

- Additional yield of 61 million m^3/a from the catchments between Knysna and Blaaukrantz through the following potential developments:

    - raising Roodefontein Dam (K60G) to give 0,39 million m^3/a
    - a new dam on the Keurbooms River (K60E) to give 3 million m^3/a
    - new dams in catchments K50B (Knysna River), K60E (Keurbooms River), K60F (Bietou River), K60G (Piesangs River), K70A (Sout and Groot Rivers) to bring the total equivalent storage to 1,25 x MAR
    - new dams in catchment K70B (Bloukrantz River) to bring the equivalent storage to 1 x MAR.

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 Gouritz 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. Water quality monitoring points are poorly distributed in some parts of the Gouritz WMA. In the H80 catchment (Duiwenhoks River) there were four routine water quality monitoring points of which three could be used to characterise the catchment, in the H90 catchment (Gouka River) there were seven routine monitoring points of which six had adequate data records. In the J10 catchment (Buffels, Touws and Groot Rivers) there were 23 monitoring points of which 12 had adequate data records, six of which met the criteria to characterise the catchment. In the J20 catchment (Leeu, Gamka and Dykwa Rivers) there were 16 routine monitoring points, of which 15 had moderate data records and only six met the criteria to characterise water quality in quaternary catchments. In the J35 catchment (Olifants, Traka and Kammanassie Rivers) there were 20 routine monitoring stations of which 12 had adequate data records, 9 of which met the criteria to characterise the catchment water quality. In the J40 catchment (Gouritz River), all three monitoring points met the criteria and two were used to characterise the catchment. In the coastal rivers of the K10 to K60 catchments, there were sufficient routine monitoring points that met the data criteria to characterise each of the six catchments. In the K10 catchment (Hartenbos and other rivers) there were 23 monitoring points, of which 9 had adequate data records and three were used to characterise the water quality status. In the K20 catchment (Groot Brak River) there were seven monitoring points, five had adequate data records and one was used to characterise the water quality status. In the K30 catchment (Kaaimans, Touws, Rooi and other rivers), there were 14 monitoring points, 12 had adequate data records and 4 were used to characterise the water quality status in the four quaternary catchments. In the K40 catchment (Karatrara, Goukamma and other rivers), there were 14 monitoring points, 11 had adequate data records and 3 were used to characterise the water quality status in the five quaternary catchments. In the K50 catchment (Knysna River), all three routine monitoring stations had adequate data and one was used to characterise the water quality status in the two quaternary catchments. In the K60 catchment (Keurbooms, Bitou, Piesang and Kwaai Rivers), there were 18 monitoring points, of which 3 had adequate data records and 1 was used to characterise the water quality status in three of the five quaternary catchments.

Only data sets that had data for the period 1994 to 1998 were used. The data sets were filtered to monthly data. 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 should be used to derive the mean and maximum TDS concentrations. Due to the poor status of water quality monitoring in some areas of the WMA, the whole 5-year data set of monthly TDS values was used in those cases to characterise the water quality because there were few monitoring points in the secondary catchment which fully met the criteria.

Details of the TDS 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 (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 Red
Green	Green Yellow Red Purple	Green Yellow Yellow Red
Yellow	Yellow Red Purple	Yellow Red Purple
Red	Red Purple	Red Purple
Purple	Purple	Purple

The water quality of the Gouritz Water Management Area is summarised in Table 6.4.1.3 and is shown in Figure 6.4.1.1.

TABLE 6.4.1.3: SUMMARY OF MINERALOGICAL SURFACE WATER QUALITY OF THE GOURITZ WATER MANAGEMENT AREA

SECONDARY CATCHMENT	NO OF QUATERNARY CATCHMENTS	NO OF QUATERNARY CATCHMENTS IN CLASS					
		BLUE	GREEN	YELLOW	RED	PURPLE	NO DATA
H80	6	0	0	0	0	0	6
H90	5	2	0	1	0	0	2
J10	25	1	2	1	7	4	10
J20	35	1	5	2	0	0	27
J30	27	1	10	2	0	3	11
J40	5	0	1	0	0	2	2
K10	6	4	0	1	0	0	1
K20	1	0	0	1	0	0	0
K30	4	2	1	1	0	0	0
K40	5	2	0	1	0	0	2
K50	2	1	0	0	0	0	1
K60	7	4	1	0	0	0	2

The mineralogical surface water quality of the Gouritz Water Management Area is quite variable.

Water quality in the H90 catchment (Gouka River) is classified as ideal in the upper catchments (H90A and B) but is regraded as marginal in the lower reaches (H90C catchment).

Water quality in the J1 catchment (Buffels, Touws and Groot Rivers) is poor. Salinity is high in the J11 catchment. At the Prins River Dam water quality is classified as poor and very high TDS concentrations have been recorded. In the upper reaches of the Touws River (J12A) water quality is classified as ideal but due to the dry nature of the catchment and saline geology of the catchment, TDS increases in a downstream direction where the quality changes from good (J12G and H) to completely unacceptable (J12J and K). Water quality in the Groot River (J13 catchment), is classified as completely unacceptable with very high TDS concentrations, probably from natural sources.

Water quality in the J2 catchment (Gamka, Leeu and Dykwa) ranges from ideal in the upper reaches to marginal. The quality of the Calitzdorp Dam in the J25 sub-catchment is classified as ideal but in the rest of the J20 catchment, water quality is classified as either good or marginal. The source of elevated salinity is probably natural processes.

Water quality in the J3 catchment (Olifants, Kammanassie and Traka Rivers) ranges from ideal in the Little Le Roux River in the upper reaches of the J35A sub-catchment to completely unacceptable in the lower reaches of the Olifants River in the J35F sub-catchment. However, water quality in most of the J30 sub-catchments has been classified as good to marginal, and the reason for elevated salinity is probably natural (evaporation and geological processes). Water quality in the lower Gouritz River (J40 catchment) is classified as unacceptable due to high salinity.

Water quality in the coastal river catchments (all the rivers in the K catchment area) is generally classified as ideal and suitable for all domestic and irrigation water users. The exceptions are water quality in the Brandwag River (K10B), in the Groot Brak River (K20A), in the Maalgate River (K30A) and in the Hoekraal River (K40B) where water quality is classified as marginal for domestic and irrigation water users. The origin of elevated salts in these catchments is probably the catchment geology. Water quality of the Plettenberg Bay coastal rivers was investigated in detail in the mid-1990s as part of the Plettenberg Bay Coastal Catchments Study (DWAF, 1996b). It was found that all the rivers (Piesang, Bietou and Keurbooms Rivers) had similar background quality characteristics; brown colour, low pH and TDS, and elevated dissolved organic carbon (DOC) and iron concentrations. However, manmade activities have caused water quality changes. The Piesang River experiences elevated turbidity, the Keurbooms, Bitou and Groot River estuaries all had elevated *E. coli* counts during the summer months. In the upper Keurbooms River, TDS, chloride and sulphate concentrations showed increasing long-term trends (DWAF, 1996b).

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 Gouritz WMA is given in Figure 6.4.3.1. Over most of the WMA, there was insufficient data to assess the risk of surface water contamination. However, with the exception of the K30C catchment where a medium risk was identified, there is only a low risk of contamination over the remainder of the WMA where sufficient data was available for the risk to be identified. The low population density and low surface water runoff contribute to the low overall risk.

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 Gouritz 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 risk of faecal contamination of groundwater ranged from low in many of the coastal catchments (H80F, H90E, J40E, K10A, B and F, K40A, D and E, K50B and K60B-G), to medium for the largest proportion of the WMA to high in a small number of catchments (H80B, H90B and C, J21C and E, J22F and J, J23A and B and J40B).

Conclusion 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

Very little is known about water quality in the Gouritz WMA, specifically on the Gouritz River and its major tributaries (Drainage Region J). It was therefore difficult to identify site or region specific water quality issues in the Gouritz River catchment. Some investigations have been done on the coastal rivers of the Drainage Region K. During the mid-1990s, the Plettenburg Bay coastal rivers were investigated intensively in a study that focused on the water resources in the Plettenburg Bay area (DWAF, 1996b).

Elevated salinity over large parts of the catchment is the result of the geology of the WMA as well as the arid nature of the catchment which leads to high evaporation and the accumulation of salts in the catchment.

The Plettenberg Bay Coastal Catchments study (DWAF, 1996b) found that water quality was already affected by catchment developments. In the Piesang River, it was found that domestic, irrigation, recreation and the environment was already affected and the variables of concern were *E.coli*, suspended sediment, dissolved organic carbon (DOC), iron, chloride and nutrients. In the Keurbooms River, domestic, irrigation, and recreational users and the aquatic ecology were affected. The variables of concern were *E.coli*, TDS, dissolved organic carbon (DOC), iron, chloride and nutrients. In the Bitou River domestic, recreational users and the aquatic ecology were affected and the variables of concern were *E.coli* and nutrients.

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 Gouritz WMA is shown in Table 6.5.1.

Data is available for 16 reservoirs in the WMA, and it can be seen that the yields vary considerably. The lowest yield is recorded for Melville Dam (1 t/km^2.a), which is situated high up in the catchment of the Grobbelaars River, with no development upstream. Four of the dams have yields of above 100t/km^2.a. These dams are Calitzdorp Dam, Prinsrivier Dam, Leeu Gamka Dam and Floriskraal Dam. The relatively high value (169 t/km^2.a) for Floriskraal Dam could be attributed to the extreme flood that occurred in 1981.

TABLE 6.5.1: RECORDED RESERVOIR SEDIMENTATION RATES FOR RESERVOIRS IN THE GOURITZ 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)
H800	Duiwenhoks	Duiwenhoks	148	1965-1979	0,058	0,112	20
H900	Korente	Korentepoort	37	1965-1983	0,028	0,045	33
J100	Buffels	Floriskraal	4 001	1957 - 1981	15,486	25	169
J100	Brak	Bellair	558	1920 - 1981	0,933	0,7	34
J100	Prins	Prinsrivier	757	1916 - 1981	4,189	3,813	136
J200	Gamka	Gamka	98	1955 - 1980	0,187	0,253	70
J200	Leeu	Leeu Gamka	2 088	1959 - 1981	7,478	10,818	140
J200	Cordiers	Oukloof	141	1929 - 1984	0,293	0,283	54
J200	Gamka	Gamkapoort	17 076	1969 - 1981	10,122	21,849	35
J200	Nels	Calitzdorp	170	1917 - 1981	0,997	0,85	135
J300	Olifants	Stompdrift	5 235	1965 - 1981	6,438	11,265	58
J300	Kammanassie	Kammanassie	1 505	1923 - 1981	3,584	3	54
J300	L/Le Roux	Raubenheimer	43	1973 - 1984	0,005	0,011	7
J300	L/Le Roux	Melville	18	1945 - 1984	0,001	0,001	1
K100	Hartenbos	Hartebeeskuil	100	1969 - 1981	0,011	0,024	7
K100	Groot Brak	Ernest Robertson	10	1955 - 1985	0,004	0,004	12

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)* (Midgely *et al*, 1994), 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 Gouritz WMA, calculated from the WR90 estimates range from a low of 3 t/km^2.a in the coastal catchments of the south-eastern corner of the WMA to 75 t/km^2.a in the central interior. 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 natural 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 accurately 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 Gouritz WMA, WSAM did not appear to determine the run of river yield, and hence the water balance, reliability. 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 as 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. The reason for this is that the WSAM seems to determine the impact of afforestation and alien vegetation on yield in a realistic manner. However, it does not report correctly on what this impact is. This problem was resolved by adopting zero afforestation and alien vegetation in the catchments when running the WSAM and calculating these impacts external to the model.

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		QUATERNARY CATCHMENT	
NO.	NAME		
H	Breede to Gouritz	H80F, H90E	Hypothetical point for coastal rivers
J	Upper Gamka River	J24F	Gamka River downstream of its confluence with the Dwyka River
	Lower Gamka River	J25E	Gamka River at its confluence with the Olifants River
	Upper Olifants River	J33F	Olifants River at its confluence with the Kammanassie River
	Kammanassie River	J34F	Kammanassie River at its confluence with the Olifants River
	Lower Olifants River	J35F	Olifants River at its confluence with the Gamka River
	Buffels River	J11K	Buffels River at its confluence with the Touws River
	Touws River	J12L	Touws River at its confluence with the Buffels River
	Groot River	J13C	Groot River at its confluence with the Gouritz River
	Gouritz River mouth	J40E	Gouritz River mouth
K	Mossel Bay to George	K10A, K10F, K20A, K30B, K30C	Hypothetical point for coastal rivers
	Wilderness	K30D, K40D, K40E	Hypothetical point for coastal rivers
	Knysna to Blaaukrantz	K50B, K60G, K70A, K70B	Hypothetical point for coastal rivers

In Table 7.2.2 the average water requirements at the key points and in some sub-catchments of the key point catchments 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 921,4 million m^3/a. This value includes the provision of 335,1 million m^3/a for the ecological Reserve. A quantity of 461,9 million m^3/a, or 48% of the total requirements occur in the coastal catchments to the east of the Gouritz River. The requirement for the Gouritz River itself is approximately 37% or 342,3 million m^3/a.

Within the Gouritz catchment, 26% of the consumptive requirements (i.e. excluding the ecological Reserve) are in the Gamka River, 36% in the Olifants River, 25% are in the catchment of the Groot River tributary, and the remaining 13% are in the lower Gouritz catchment.

The coastal catchments to the west of the Gouritz River mouth require 117,2 million m^3/a, or 13% of the total requirements.

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 56% from 921,4 million m^3/a to 406,1 million m^3/a.

In the Gouritz WMA, where 46% of the total developed yield in 1995 was estimated to be obtained from farm dams and run-of-river yield and only 35% 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 transfer of 0,4 million m^3/a of water out of the WMA which is shown as part of the total water requirements in Table 7.2.3 is shown separately in Table 7.2.4, and, therefore, is not included in the "Water requirements at 1:50 year assurance" column.

TABLE 7.2.2: AVERAGE WATER REQUIREMENTS BY DRAINAGE AREA IN 1995 (in million m^3/a)

CATCHMENT						STREAMFLOW REDUCTION ACTIVITIES		WATER USE		WATER REQUIREMENT						ECOLOGICAL RESERVE	TOTAL[(7)]
PRIMARY		SECONDARY		TERTIARY/QUATERNARY		AFFORE-STATION	DRYLAND SUGAR CANE	ALIEN VEGETATION	RIVER LOSSES	BULK [1]	IRRI-GATION [2]	RURAL [3]	URBAN [4]	HYDRO-POWER	WATER TRANSFERS OUT OF WMA		
No.	Description	No.	Description	No.	Description												
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	4,6	0	37,3	0	0,0	35,1	1,9	2,5	0	0,4	35,4	117,2
	TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)					4,6	**0**	**37,3**	**0**	**0,0**	**35,1**	**1,9**	**2,5**	**0**	**0,4**	**35,4**	**117,2**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka	0,0	0	1,7	0	0,0	59,3	1,3	4,1	0	0,0	17,7	62,1
				J25	Lower Gamka	0,0	0	0,2	0	0,0	2,9	0,6	0,7	0	0,0	13,6	40,1
			Total for Gamka catchment			**0,0**	**0**	**1,9**	**0**	**0,0**	**62,2**	**1,9**	**4,8**	**0**	**0,0**	**13,6**	**84,5**
		J3	Olifants	J31 to J33	Upper Olifants	0,0	0	1,4	0	0,0	23,6	1,3	1,1	0	0,0	6,0	25,3
				J34	Kammanassie	0,1	0	6,6	0	0,0	0,1	0,8	0,3	0	0,0	5,1	21,1
				J35	Lower Olifants	0,0	0	0,4	0	0,0	51,3	1,2	7,8	0	0,0	17,6	78,4
			Total for Olifants catchment			**0,1**	**0**	**8,4**	**0**	**0,0**	**75,1**	**3,3**	**9,2**	**0**	**0,0**	**17,6**	**113,7**
		J1	Groot	J11	Buffels	0,0	0	0,0	0	0,0	26,7	0,8	0,8	0	0,0	2,6	30,9
				J12	Touws	0,0	0	0,3	0	0,0	23,0	1,3	0,7	0	0,0	4,2	29,5
				J13	Groot	0,0	0	3,2	0	0,0	11,6	0,3	0,0	0	0,0	7,9	23,0
			Total for Groot River catchment			**0,0**	**0**	**3,5**	**0**	**0,0**	**61,2**	**2,4**	**1,5**	**0**	**0,0**	**7,9**	**76,5**
		J4	Lower Gouritz	None	---	0,0	0	5,9	0	0,0	27,5	1,4	0,4	0	0,0	71,6	106,8
			Total for Lower Gouritz incremental catchment			**0,0**	**0**	**5,9**	**0**	**0,0**	**27,5**	**1,4**	**0,4**	**0**	**0,0**	**71,6**	**106,8**
		TOTAL IN GOURITZ CATCHMENT				**0,1**	**0**	**19,7**	**0**	**0,0**	**226,0**	**9,0**	**15,9**	**0**	**0,0**	**71,6**	**342,3**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers	25,6	0	5,5	0	5,7	28,8	1,6	21,6	0	0,0	**55,5**	144,3
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers	31,2	0	15,2	0	0,0	18,9	0,6	1,1	0	0,0	65,5	132,5
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers	25,5	0	43,6	0	0,0	2,7	0,7	5,8	0	0,0	107,1	185,4
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**82,2**	**0**	**64,2**	**0**	**5,7**	**50,4**	**2,8**	**28,4**	**0**	**0,0**	**228,1**	**461,9**
TOTAL IN WMA						**86,9**	**0**	**121,3**	**0**	**5,7**	**311,5**	**13,7**	**46,8**	**0**	**0,4**	**335,1[(6)]**	**921,4**

(1) Requirements of wet industries, mines, thermal powerstations and any other bulk users supplied individually by a water board or DWAF.
(2) Includes conveyance and distribution losses.
(3) Requirements for rural household use, livestock and game watering, and subsistence irrigation, including losses.
(4) Requirements for urban residential, commercial, municipal and institutional use, and requirements of industries supplied by local authorities, all including water losses.
(5) Cumulative IFR requirements.
(6) Total of Breede-Gouritz, Gouritz, and Outeniqua Coastal Catchments.
(7) IFR requirements included in these values are cumulative. Therefore only the values at outlets to the sea can be summed to obtain a total value for the WMA i.e. the sum of values for inland sub-catchments do not equal the value for the whole catchment.

TABLE 7.2.3: WATER REQUIREMENTS IN 1995 AT 1:50 YEAR ASSURANCE (in million m^3/a)

CATCHMENT						STREAMFLOW REDUCTION ACTIVITIES		WATER USE		WATER REQUIREMENT						ECOLOGICAL RESERVE [5] (million m^3/a)	TOTAL (million m^3/a)
PRIMARY		SECONDARY		TERTIARY/QUATERNARY		AFFORE-STATION [(5)] (million m^3/a)	DRYLAND SUGAR CANE (million m^3/a)	ALIEN VEGETATION[(5)] (million m^3/a)	RIVER LOSSES (million m^3/a)	BULK [1] (million m^3/a)	IRRI-GATION [2] (million m^3/a)	RURAL [3] (million m^3/a)	URBAN [4] (million m^3/a)	HYDRO-POWER (million m^3/a)	WATER TRANSFERS OUT OF WMA (million m^3/a)		
No.	Description	No.	Description	No.	Description												
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	0,90	0	8,60	0	0,0	28,4	1,9	2,5	0	0,4	5,30	48,00
	TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)					**0,90**	**0**	**8,60**	**0**	**0,0**	**28,4**	**1,9**	**2,5**	**0**	**0,4**	**5,30**	**48,00**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka	0,00	0	0,34	0	0,0	29,4	1,3	4,1	0	0,0	0,00	35,10
				J25	Lower Gamka	0,00	0	0,04	0	0,0	19,8	0,6	0,7	0	0,0	2,50	23,64
			Total for Gamka catchment			**0,00**	**0**	**0,30**	**0**	**0,0**	**49,2**	**1,9**	**4,8**	**0**	**0,0**	**2,50**	**58,70**
		J3	Olifants	J31 to J33	Upper Olifants	0,00	0	0,69	0	0,0	12,7	1,3	1,1	0	0,0	0,83	16,62
				J34	Kammanassie	0,00	0	3,22	0	0,0	6,8	0,8	0,3	0	0,0	1,47	12,59
				J35	Lower Olifants	0,00	0	0,19	0	0,0	42,1	1,2	7,8	0	0,0	0,40	51,69
			Total for Olifants catchment			**0,00**	**0**	**4,10**	**0**	**0,0**	**61,6**	**3,3**	**9,2**	**0**	**0,0**	**2,70**	**80,90**
		J1	Groot	J11	Buffels	0,00	0	0,01	0	0,0	21,3	0,8	0,8	0	0,0	0,58	23,49
				J12	Touws	0,00	0	0,10	0	0,0	18,3	1,3	0,7	0	0,0	0,32	20,72
				J13	Groot	0,00	0	0,90	0	0,0	9,3	0,3	0	0	0,0	0,00	10,50
			Total for Groot River catchment			**0,00**	**0**	**1,01**	**0**	**0,0**	**48,9**	**2,4**	**1,5**	**0**	**0,0**	**0,90**	**54,70**
		J4	Lower Gouritz	None	---	0,00	0	1,36	0	0,0	22,3	1,4	0,4	0	0,0	6,10	31,56
			Total for Lower Gouritz incremental catchment				**0**	**1,36**	**0**	**0,0**	**22,3**	**1,4**	**0,4**	**0**	**0,0**	**6,10**	**31,60**
		TOTAL IN GOURITZ CATCHMENT				**0,00**	**0**	**6,81**	**0**	**0,0**	**182,0**	**9,0**	**15,9**	**0**	**0,0**	**6,10**	**219,80**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers	4,23	0	1,75	0	5,7	24,5	1,6	21,6	0	0,0	8,00	67,38
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers	5,15	0	4,85	0	0,0	16,0	0,6	1,1	0	0,0	11,00	38,70
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers	4,22	0	13,90	0	0,0	2,3	0,7	5,8	0	0,0	5,50	32,42
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**13,60**	**0**	**20,50**	**0**	**5,7**	**42,8**	**2,8**	**28,4**	**0**	**0,0**	**24,50**	**138,30**
TOTAL IN WMA						**14,50**	**0**	**35,90**	**0**	**5,7**	**253,2**	**13,7**	**46,8**	**0**	**0,4**	**35,90**	**406,10**

(1)Requirements of wet industries, mines, thermal powerstations and any other bulk users supplied individually by a water board or DWAF.
(2)Includes conveyance and distribution losses.
(3)Requirements for rural household use, livestock and game watering, and subsistence irrigation, including losses.
(4)Requirements for urban residential, commercial, municipal and institutional use, and requirements of industries supplied by local authorities, all including water losses.
(5)Impacts on the 1:50 year yield of the system.

TABLE 7.2.4: WATER REQUIREMENTS AND AVAILABILITY IN 1995

CATCHMENT						UTILISED 1:50 YEAR YIELD IN 1995			WATER TRANSFERS AT 1:50 YEAR ASSURANCE		RETURN FLOWS AT 1:50 YEAR ASSURANCE		WATER REQUIREMENTS AT 1:50 YEAR ASSURANCE (million m^3/a)	YIELD BALANCE AT 1:50 YEAR ASSURANCE [2] (million m^3/a)
PRIMARY		SECONDARY		TERTIARY/QUATERNARY		SURFACE WATER (million m^3/a)	GROUNDWATER (million m^3/a)	TOTAL (million m^3/a)	IMPORTS (million m^3/a)	EXPORTS (million m^3/a)	RE-USABLE (million m^3/a)	TO SEA (million m^3/a)		
No.	Description	No.	Description	No.	Description									
H (part)	Breede - Gouritz	H8, H9	Duiwenhoks, Goukou	None	---	39,78	0,89	40,67	0,00	0,40[1]	2,33	0,27	47,60	- 5,00
	TOTAL IN BREEDE - GOURITZ CATCHMENT (All Western Cape)					**39,78**	**0,89**	**40,67**	**0,00**	**0,40[1]**	**2,33**	**0,27**	**47,60**	**- 5,00**
J	Gouritz	J2	Gamka	J21 to J24	Upper Gamka	7,76	20,82	28,58	0,00	2,70 [3]	1,92	0,00	35,10	- 7,30
				J25	Lower Gamka	15,07	3,07	18,14	2,70 [3]	0,00	0,30	0,00	23,64	- 2,50
			Total for Gamka catchment			**22,83**	**23,89**	**46,72**	**0,00**	**0,00**	**2,22**	**0,00**	**58,74**	**- 9,80**
		J3	Olifants	J31 to J33	Upper Olifants	18,56	12,63	31,19	0,00	15,70	1,13	0,00	16,62	0,00
				J34	Kammanassie	20,90	0,42	21,32	0,00	9,13	0,40	0,00	12,59	0,00
				J35	Lower Olifants	16,65	2,00	18,65	24,83	0,00	5,51	0,00	51,69	- 2,70
			Total for Olifants catchment			**56,11**	**15,06**	**71,17**	**0,00**	**0,00**	**7,04**	**0,00**	**80,90**	**-2,70**
		J1	Groot	J11	Buffels	8,43	2,00	10,43	0,00	0,00	0,38	0,00	23,49	- 12,68
				J12	Touws	7,27	12,81	20,08	0,00	0,00	0,32	0,00	20,72	- 0,32
				J13	Groot	2,10	8,40	10,50	0,00	0,00	0,01	0,00	10,50	+ 0,01
			Total for Groot River catchment			**17,80**	**23,21**	**41,01**	**0,00**	**0,00**	**0,71**	**0,00**	**54,71**	**- 12,99**
		J4	Lower Gouritz	None	---	24,07	0,14	24,21	0,00	0,00	1,25	0,00	31,56	- 6,10
			Total for Lower Gouritz incremental catchment			24,07	**0,14**	**24,21**	**0,00**	0,00	1,25	0,00	31,56	**- 6,10**
		TOTAL IN GOURITZ CATCHMENT				**120,80**	**62,30**	**183,10**	**0,00**	**0,00**	**11,22**	**0,00**	**219,76**	**- 25,44**
K (part)	Outeniqua Coastal	K1, K2, part of K3	Mossel Bay - George	K10, K20 and K30A to C	Coastal rivers	58,48	0,00	58,48	0,00	0,00	1,20	7,61	67,38	- 7,70
		Part of K3, K4	Wilderness	K30D, K40	Coastal rivers	26,90	0,00	26,90	0,00	0,00	0,80	0,35	38,70	- 11,00
		K5, K6, K7	Knysna - Blaaukrantz	K50, K60, K70	Coastal rivers	25,76	1,06	26,82	0,00	0,00	0,10	2,00	32,42	- 5,50
	TOTAL IN OUTENIQUA COASTAL CATCHMENTS					**111,14**	**1,06**	**112,20**	**0,00**	**0,00**	**2,10**	**9,96**	**138,50**	**- 24,20**
TOTAL IN WMA						**271,72**	**64,25**	**335,97**	**0,00**	**0,40**	**15,65**	**10,23**	**405,86**	**- 54,64**

(1) Exports to Breede WMA via Duiwenhoks Rural Water Supply Scheme. This quantity is included with the water requirements in Table 7.2.3. but is shown separately in Table 7.2.4.
(2) Surpluses indicated by a+ and deficits by a -.
(3) Supply from Gamkapoort Dam to irrigators downstream.

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 developed 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 deficit in 1:50 year yield of approximately 55 million m^3/a. Deficits occur in most of the key areas and are attributable mainly to the requirements of the ecological Reserve. This is to be expected from the calculation of the yield obtained from minor dams and run-of-river abstractions as the difference between the consumptive water requirements and the 1:50 year yield of the major dams.

In the Upper Gamka and Buffels River key areas the impacts of the ecological Reserve on yield are negligible and the deficits are a result of the equivalent 1:50 year assurance water requirements for irrigation being bigger than the available yield at 1:50 year assurance. (When calculating the run-of-river yields in these areas by the method referred to above, it became clear that the results obtained were unrealistically high. Therefore, the estimates were reduced to more realistic values).

The deficit in the Olifants catchment is only 2,7 million m^3/a because operating rules for irrigated agriculture have been adapted to suit the available quantity of water. The allocations from the Stompdrift and Kammanassie Dams to land scheduled under them in this area exceeds their combined 1:50 year yield by 97 million m^3/a (DWAF 1999c). The areas of land irrigated and types of crops grown have been adapted to the available water supply and the shortfall is attributable to the ecological Reserve requirements which have not been provided from the dams in the past.

The available 1:50 year run-of-river yield in the Outeniqua coastal catchments may not have been fully utilised in 1995, and it is possible that the requirements of the ecological Reserve could be provided in this area without reducing the quantity of water available to consumptive users. However, this needs to be confirmed by more detailed investigations. In the other areas of the WMA it is probable that the implementation of the ecological Reserve would reduce the quantity of water available for consumptive use.

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 3 140 million m^3 was described in Section 6.3. The capacities of the existing major and minor dams per key area were subtracted from this capacity. The capacity was reduced to 2 794 million m^3.

An allowance for 1 in 25 year sediment accumulation in the dams was made, increasing the required capacity to 2 859 million m^3.

The full capacities of the dams were used for costing purposes because they are required to enable the release of the environmental flow requirements. 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.

In those key areas where the combined existing yields of major dams, minor dams and run-of-river yield, and developed groundwater yield equalled or exceeded the theoretical maximum potential surface water yield, it was assumed that there is no further surface water development potential and costs were set to zero.

A further adjustment was made in the Lower Olifants key area, where the hypothetical dam was replaced with a possible new dam on the Grobbelaars River. This dam was investigated by the Oudtshoorn Municipality and would have a yield of 5 million m^3/a, from a capacity of 6,5 million m^3. The cost in 1998 was R36,5 million, and has been adjusted to 2000 prices by applying a factor of 1.21.

The total cost of developing the hypothetical dams is estimated to be R5 950 million (2000 prices, including VAT at 14%). The combined gross capacity of these dams would be 2 214 million m^3, with a potential yield of 199 million m^3/a. A summary of the hypothetical dam capacities, yields and costs is given in Table 8.2.

The costs per million m^3/a of yield range from R8,8 million in the lower Olifants River valley, through R33 million in the Gouritz River catchment downstream of the Olifants/Gamka confluence, to R40 million in the upper Gamka catchment (J21 to J24). The costs in the upper Gamka catchment are so high that it is unlikely to be economically viable to fully develop the estimated remaining surface water capacity of 20 million m^3/a, particularly as the same yield could be obtained by fully developing the potential groundwater potential at an estimated cost of R3 million per million m^3/a of yield. The high cost of developing the surface water in the catchment arises from the very high ratio of storage volume to yield required to develop the maximum potential.

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	CAPACITY OF EXISTING MINOR DAMS million ^{m3}	HYPOTHETICAL DAM CAPACITY (LIVE) million m^3	1 IN 25 YR SEDIMENT YIELD million m^3	HYPOTHETICAL DAM CAPACITY (GROSS) million m^3	COST OF HYPOTHETICAL DAMS 39,3* CAP ^{0,467} R Million	ACCEPTED POTENTIAL DEVELOPABLE YIELD (See Note 1 below) million m^3/a	ADJUSTED COST OF HYPOTHETICAL DAMS (See Note 2 Below) R Million
Breede to Gouritz	H80F	211	6							
	H90E	213	8							
	H8, H9	424	14	6	404	1	405	648	32	648
Upper Gamka (J21 to J24)	J24F	578	25	5	548	36	584	770	20	770
Lower Gamka (at confluence with Olifants) (J2)	J25E	68	49	2	17	1	18	151	0	0
	J2	646	74	7	565	37	602	921	20	770
Upper Olifants (J31 to J33)	J33F	178	55	5	118	6	124	373	0	0
Kammanassie (J34)	J34F	141	36	4	101	1	102	341	0	0
Lower Olifants (J3)	J35F	166	10	2	154	2	156	415	5	44
	J35F	485	101	11	373	9	382	1129	5	44
Buffels (J11)	J11K	114	50	1	63	10	73	291	0	0
Touws (J12)	J12Mℓ	163	15	15	133	6	139	394	0	0
Groot (J13)	J13C	39	0	0	39	1	40	220	0	0
	J13C	316	65	16	235	17	252	905	0	0
Gouritz River mouth (J4)	J40E	269	0	0	269	1	270	537	16	537
Gouritz (J)	J40E	1716	240	34	1442	64	1506	3492	41	1351
Mossel Bay to George (K1, K2, K30A-C)	K10A	12	0	0	12	0	12	127		
	K10B	11	7	0	4	0	4	78		
	K10F	105	4	4	97	0	97	333		
	K20A	49	23	1	25	0	25	177		
	K30A	65	0	2	63	0	63	272		
	K30B	52	0	0	52	0	52	249		
	K30C	67	8	0	59	0	59	264		
		361	42	7	312	0	312	1500	30	1500
Wilderness (K30D, K4)	K30D	46	0	0	46	0	46	236		
	K40D	141	0	0	141	0	141	396		
	K40E	68	0	0	68	0	68	282		
		255	0	0	255	0	255	914	35	914
Knysna to Blaaukrantz (K5,6,7)	K50B	130	0	1	129	0	129	382		
	K60E	131	0	0	131	0	131	384		
	K60F	27	0	0	27	0	27	183		
	K60G	24	1	1	23	0	23	170		
	K70A	31	0	0	30	0	30	195		
	K70B	41	0	0	41	0	41	223		
		384	1	2	381	0	381	1537	61	1537
Outeniqua catchments		1000	43	9	948	0	948	3951	126	3951
TOTAL WMA		**3140**	**297**	**49**	**2794**	**65**	**2859**	**8091**	**199**	**5950**

NOTE 1 : In some key areas the combined existing yields of major dams, minor dams and run-of-river yield and groundwater equalled or exceeded the theoretical maximum potential surface water yield. In those cases it was assumed that there is no further surface water development potential. Im the Olifants River key area (J33, J34, J35), detailed studies have shown that the development of only another 5 million m^3/a of yield is affordable and this value has been substituted for the theoretical value of 20 million m^3/a.

NOTE 2 : Costs were zeroed where yield is already fully developed. For the Lower Olifants, the new dam on the Grobbelaars River, the cost of R36,5 million was a 1998 cost from the Oudtshoorn NS Report No. 2843, which was converted to a 2000 cost by applying a fact of 1,21 (an average rate of escalation of 7% per annum).

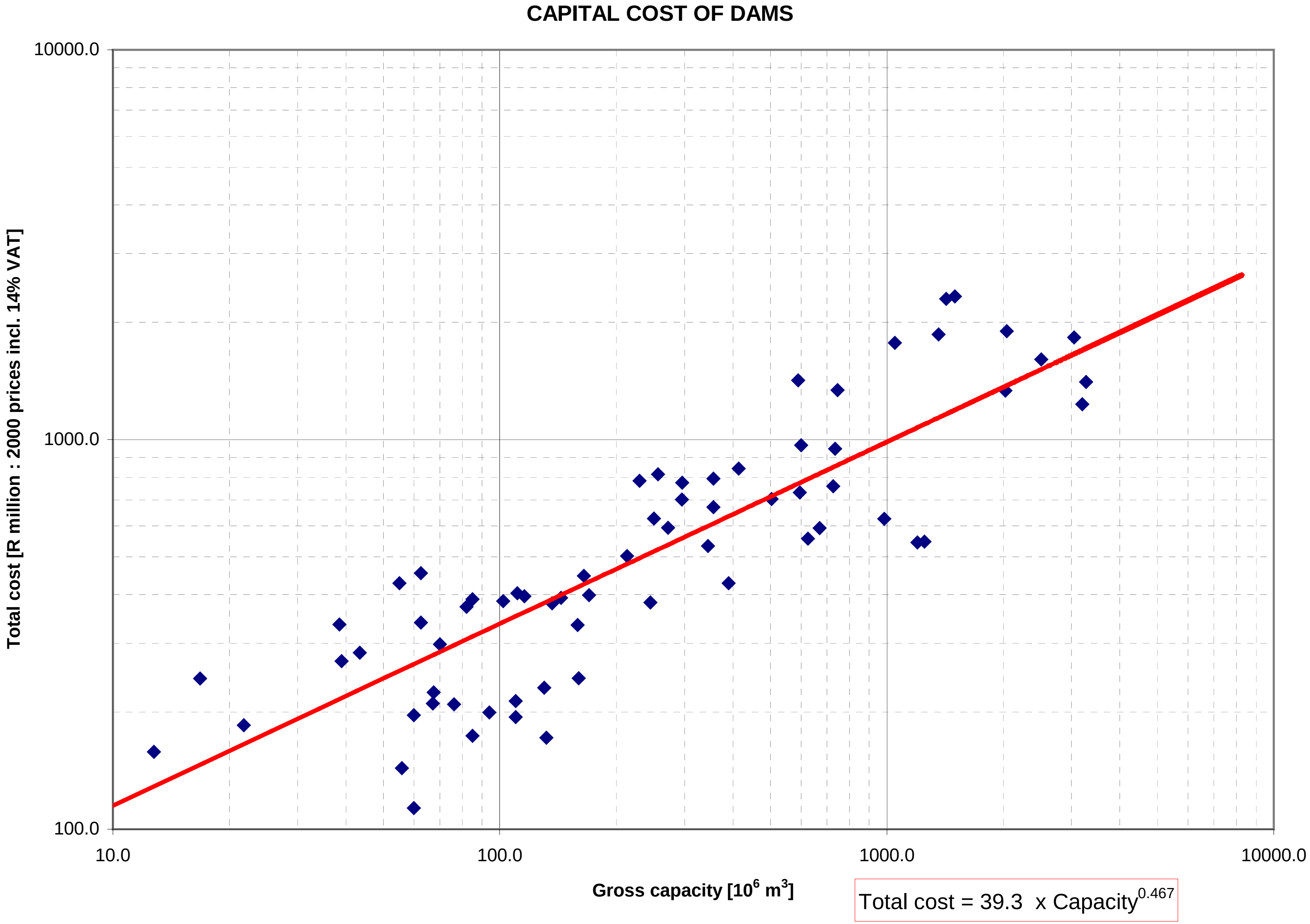


Diagram 8.1: Capital cost of dams

There is significant potential for further groundwater development in most of the interior key areas. However, if the conservative assumption, discussed in Chapter 6, that further increase in groundwater use would result in a corresponding reduction in developed surface water yield is applied, the remaining potable groundwater potential is less than the undeveloped surface water potential. Nevertheless, it is likely that the development of the available potable groundwater potential in the interior key areas, even though a smaller quantity, would be a more viable option than the development of the equivalent surface water yield, provided that the groundwater was available close to the areas where the water was required. It is apparent from the above that the cost estimates given in Table 8.2 are at a low level of confidence and that considerably more detailed investigations are required to improve their reliability.

It should also be noted, in this regard, that the assumptions made regarding the impact on the potential surface water yield of the coastal catchments of the ecological flow requirements of estuaries has a significant effect on the estimated costs of water resources development. Consequently, more detailed investigations are also required to improve the reliability of these estimates.

TABLE 8.2: COSTS OF FUTURE WATER RESOURCE DEVELOPMENT (AT YEAR 2000 PRICE LEVELS INCLUDING VAT)

KEY AREA	CATCHMENT NO	SCHEME	STORAGE VOLUME (million m^3/a)	INCREMENTAL SURFACE WATER YIELD (million m^3/a)	WELLFIELD YIELD (million m^3/a)	COSTS (R million)				
						DAMS	WELLFIELDS	TREATMENT	WEIRS,CANALS AND PIPELINES	TOTALS
Breede to Gouritz	H8 & H9	Hypothetical dams on Duiwenhoks and Goukou Rivers	Combined storage of 405	32	-	648	-	-	-	648
Upper Gamka	J24F	Hypothetical dam on Upper Gamka	584	20	-	770	-	-	-	770
Lower Gamka	J25E	No Scheme	0	0	-	-	-	-	-	-
Upper Olifants	J33F	No Scheme	0	0	-	-	-	-	-	-
Kammanassie	K34F	No Scheme	0	0	-	-	-	-	-	-
Lower Olifants	J35F	Potential dam on Grobbelaars River	6,5	5	-	44	-	-	-	44
Buffels	J11K	No Scheme	0	0	-	-	-	-	-	-
Touws	J11K	No Scheme	0	0	-	-	-	-	-	-
Groot	J13C	No Scheme	0	0	-	-	-	-	-	-
Gouritz	J40E	Hypothetical dam on the Gouritz	270	16	-	537	-	-	-	537
Mossel Bay to George	K1, K2, K30 A-C		312	30		1500				1500
Wilderness	K30D, K4		255	35		914				914
Knysna to Bloukrantz	K5, 6, K7		381	61		1537				1537
TOTALS			2214	199		5950				5950

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

A number of conclusions, as set out below, can be drawn from the information gathered in this situation assessment :

(i) The Gouritz WMA covers an area of 53 139 km^2 in which the mean annual precipitation ranges from 160 mm in the northern interior, where the climate is semi-arid, to more than 1 500 mm in the coastal mountains in the south-east, where rainfall occurs throughout the year.

(ii) The geology of the WMA consists of Karoo sediments in the interior and sandstones, quartzites and conglomerates of the Cape Supergroup along the coast. Thus, water can be expected to have naturally elevated TDS concentrations in the interior and low concentrations along the coast.

(iii) The rivers of the coastal catchments are of high to very high ecological importance and sensitivity, and consequently have high ecological flow requirements. The Gamka River and its tributaries in the vicinity of Calitzdorp are also of high ecological importance. Most of the other rivers are of moderate ecological importance and sensitivity and have correspondingly lower ecological flow requirements.

(iv) The population of the WMA in 1995 was approximately 424 000 people. Some 54% of the population lived in the coastal zone to the east of the Gouritz River mouth, and 83% of the total population lived in the towns of the WMA.

(v) Much of the economic activity is concentrated in the south-eastern portion of the WMA, with the George, Oudtshoorn, Knysna and Mossel Bay areas contributing 66% of the GGP in 1997. The GGP of the whole WMA was R4,9 billion in 1997, with the most important economic sectors, in terms of their contributions to GGP, being Trade (19,3%), Government (18,1%), Agriculture (17,2%) and Financial Services (14,2%). Agriculture has a high comparative advantage relative to other WMAs.

(vi) Land-use is predominantly for rough grazing for livestock. Some 514 km^2, or 1% of the surface area of the WMA is used for irrigated crops, but only about 280 km^2 of land is irrigated in average years, with larger areas irrigated occasionally when rainfall is favourable in the semi-arid areas. Afforestation, mainly in the south-eastern coastal strip covers some 600 km^2, and 4 100 km^2 of land consists of nature reserves. Alien vegetation other than the afforestation covered an equivalent condensed area of 1 357 km^2.

(vii) There were about 1 450 000 head of livestock in the WMA in 1995. Sheep and goats made up 80% of the livestock numbers, with sheep predominating. Ostriches made up 10% of the total number, and the remainder were mainly cattle, horses, donkeys and pigs.

(viii) Water related infrastructure is well developed, particularly in the southern half of the WMA, where most of the water requirements occur.

(ix) Town bulk water supply schemes were generally adequate in 1995, but the requirements from many of them were approaching their capacities and supplies are likely to require augmentation soon.

(x) The Klein Karoo Rural Water Supply Scheme, which supplies water for livestock and rural domestic use in the vicinities of Oudtshoorn and Calitzdrop was fully utilised in

1995. As the requirements from the scheme and the requirements of the urban areas not supplied by the scheme are continuing to grow, and the water resources of the area are fully utilised, the identification of an additional raw water source for urban and rural domestic supplies is required.

(xi) Allocations of water for irrigation from Government Water Supply Schemes total 137 million m^3/a, which is 44% of the average irrigation water requirement of 311 million m^3/a. Therefore, it appears that more than half of the irrigation water requirements in the WMA are provided from what were "private" sources prior to 1998. Information on the capacities of these sources and the quantities of water used from them is not well documented, but may be required in the future for specific areas where the need to further develop the water resources occurs.

(xii) Water requirements in 1995 were estimated to total 586 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 agriculture, which required 319 million m^3/a, or 54% of the total consumptive requirement (i.e. excluding the ecological Reserve). The next biggest water user was alien vegetation, at 20% of the total consumptive requirement, followed by afforestation (15%) and urban and rural domestic requirements (9%). 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 921 million m^3/a.

(xiii) 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 406 million m^3/a. The estimates of the impacts on yield are at a low level of confidence.

(xiv) The natural MAR of the Gouritz WMA was 1 678 million m^3/a and the yield developed from surface water resources in 1995 was 272 million m^3/a at 1:50 year assurance. Some 40% of the developed yield was from farm dams and run-of-river abstractions, and 60% from major dams. In addition, boreholes with an estimated yield of 64 million m^3/a had been developed, bringing the total developed yield to 336 million m^3/a at 1:50 year assurance.

(xv) Comparison of the equivalent 1:50 year assurance water requirements of 406 million m^3/a with the developed yield of 336 million m^3/a shows a deficit of 70 million m^3/a, but re-used return flows of 16 million m^3/a reduce the deficit to 54 million m^3/a. Deficits occur in most key areas, and are attributable mainly to the requirements of the ecological Reserve, except in the upper Gamka and Buffels key areas where they are a result of water requirements for irrigation exceeding the available water supply.

(xvi) The yield balance is at a low level of confidence because of uncertainty regarding the true run-of-river yields and the true impacts of the ecolgocial Reserve, afforestation and alien vegetation on the 1:50 year yields of the various key areas. It is, nevertheless, known that throughout the WMA water use has been adapted to the availability of water, so that the system is generally in balance. This is particularly true of the use of water for irrigation where the availability of land suitable for irrigation exceeds the area that can be supplied from the water resources and irrigation practices have been adapted accordingly. The ecological Reserve was not implemented in 1995 and the yield balance suggests that the water resources in most areas of the WMA will be stressed when the ecological Reserve is implemented.

(xvii) The impact of alien vegetation on the 1:50 year developed yield in 1995 was estimated to be some 36 million m^3/a, which is 67% of the yield balance deficit of 54 million m^3/a and equal to the estimated impact on yield of the ecological Reserve. Therefore, it appears that the removal of alien vegetation before the ecological Reserve is implemented would contribute significantly to restoring the yield balance in the WMA.

(xviii) The maximum potential yield of the water resources of the WMA is estimated to be 535 million m^3/a, which is 199 million m^3/a more than the developed yield in 1995. The reliability of this estimate is uncertain because of a lack of reliable information of the ecological flow requirements of the estuaries.

(xix) The high cost of developing the full surface water potential in the Gouritz River catchment may make it more economical to develop groundwater, provided that this did not reduce the yields of existing surface water developments. In the Outeniqua catchments, surface water development is likely to be more economical than groundwater in most cases. The cost of developing the resources to their full potential was estimated to be R5 950 million at year 2000 prices, including VAT. This estimate is based on the development of surface water resources only, on the conservative assumption that groundwater is directly linked to surface water. The cost may be significantly lower if groundwater is developed in some areas instead of surface water, but there was insufficient readily available information on groundwater and its relationship to surface water to verify this in this study.

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

It became apparent in the course of carrying out this assessment that 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 quantity of untreated "leiwater" used in towns for irrigation of gardens. (While the quantity is likely to be small in relation to total irrigation requirements, it may be a significant part of urban water requirements. Therefore, it needs to be determined for information on urban water requirements to be comprehensive).

- 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. (This is not of high priority because the numbers, and hence the water requirements, are likely to be small. Nevertheless, the information should be obtained for completeness of the data on the water requirements of livestock and game).

- The relationship between groundwater and surface water in order to be able to predict the extent, if any, to which increased groundwater abstraction will reduce developed surface water yield.

Ideally, all the information referred to above should be available to facilitate the efficient management of the water resources of the Gouritz 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.

It appears from the information collected for this situation assessment that, until such time as the ecological Reserve is implemented, water use and availability will remain roughly in balance, except in two areas where growing requirements are likely to require further action to be taken. These are :

- The Olifants River catchment where the water resources are fully utlised, the ecological Reserve has not been implemented in the past, and urban domestic and rural water requirements are continuing to grow. In addition, drought cycles and economic pressure on farming activities result in efforts to increase the output of the agricultural sector which results in increasing requirements for water.

- The coastal strip to the east of the Gouritz River mouth (the Outeniqua coastal catchments) where growing urban requirements are likely to require additional sources of raw water in the near future, and where the yield balance suggests that there may be a deficit in 1:50 year yield of some 24 million m^3/a when the ecological Reserve is implemented. There is strong public pressure for the implementation of the ecological Reserve in this area as soon as possible.

A large number of alternative schemes for supplementing the yield of the Klein Karoo Regional Water Supply Scheme, which supplies water for livestock and rural domestic use in the Olifants River valley, were investigated in 1999 (DWAF, 1999c). The yield of the scheme is only about 1 million m^3/a, and is small in relation to the total water use in the area. However, the recommendations made in the report on the investigation recommended further actions, some of which related to the regional water supply situation as a whole. The recommendations were :

- A review of water resources in the Olifants River Valley and the area in the vicinity of Calitzdorp as a whole.

- Encouraging the municipalities of Calitzdorp and Oudtshoorn to link to the Klein Karoo Rural Water Supply Scheme, thereby creating an integrated scheme for the area.

- Improving the efficiency of water use by both the urban and agricultural sectors as appropriate through lining of canals, reduction in leakage from reticulation systems and tariff structures.

- Investigation of the possibilities of purchasing irrigation water rights for use in augmenting urban water supplies.

- Detailed investigation of the environmental and social impacts of the probable effects of increased groundwater abstraction on surface water flow to enable informed decisions to be taken on further development.

- Reliable determination of the 1:50 year yield of the Klein Karoo Rural Water Supply Scheme.

It is suggested that the above recommendations should be implemented and, if the results show it to be necessary, investigations of the most favourable schemes identified in the 1999 study should be refined to identify the most appropriate means of augmenting urban and rural domestic water supplies in the Olifants River Valley.

With regard to urban water supplies in the Outeniqua coastal catchments, the following actions are recommended to ensure that the raw water supplies can be augmented timeously when required :

- A detailed review of present and expected future water requirements, and the capacities of existing raw water supply schemes should be carried out.

- Dates when augmentations of raw water supplies are likely to be required should be determined and potential sources of the additional water identified.

- The catchments in which these sources occur should, together with the catchments of the existing sources, be given priority for the eradication of alien vegetation.

- After the alien vegetation has been removed the ecological flow requirements of the rivers and the estuaries should be determined.

- Existing water use in the catchments should be determined.

- Using the information obtained above, the amount of additional yield that could be developed after providing for the ecological flow requirements should be determined.

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. 1996. Satelite Image of the Gouritz WMA in 1995.

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.

Development Bank of Southern Africa. 1991. A Regional Profile of the Southern Africa Population and its Urban and Non-urban Distribution. 1970 - 1990.

Department of Water Affairs and Forestry, South Africa. 1996b. Plettenberg Bay Coastal Catchment Study. Water Quality Summary Assessment, Volume 1: *Main Report*. Report No. 10 of 12. DWAF Report No. PK 000/00/1096.

Department of Water Affairs and Forestry, South Africa. 1996a. *System Yield Analysis*. Prepared by Ninham Shand and BKS for DWAF and Plettenberg Bay Municipality as part of the Plettenberg Bay Coastal Catchments Study. DWAF Report No. P K000/00/0796, Report No. 7 of 12.

Department of Water Affairs and Forestry, South Africa. 1998 White Paper on Wolwedans Dam : Report on the Proposed Mossel Bay (Wolwedans Dam) Government Water Scheme. WP 3-88.

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. 1999a. *Eco Info Database*. Prepared and held by DWAF Institute for Water Quality Studies.

Department of Water Affairs and Forestry, South Africa. 1999b. *Voëlvlei Augmentation Scheme Feasibility Study.* First Draft Report No. PB 100/03/1399. Gibb Africa/FST.

Department of Water Affairs and Forestry, South Africa. 1999c. *Surface and other Augmentation Options.* Prepared by E J Larsen of Ninham Shand Inc. as part of the Klein Karoo Rural Water Supply Scheme Augmentation Study. DWAF Report No. B J000/00/0999.

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. 2000c. *Reconnaissance investigation into the development and utilisation of Table Mountain Group artesian groundwater, using the E10 catchment as a pilot study area.* Prepared by Umvoto Africa/SRK Consulting Joint Venture.

Department of Water Affairs and Forestry, South Africa. 2000d. *Profile on Water Management in the Berg, Breede, Gouritz and Olifants/Doring Water Management Areas : The Utilization and Availability of Water*. Pamphlet compiled by Ninham Shand on behalf of the Department of Water Affairs and Forestry.

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.

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.

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

Oudtshoorn Municipality. 1998. *Herevaluering van Waterbronne - Uitgebreide Oorsig van Aanvullende Skemas*. Verslag Nr. 2843/6848. Deur Ninham Shand Raadgewende Ingenieurs vir Munisipaliteit Oudtshoorn. 1998.

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.

Seward, P and Syemour, 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

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.

Working for Water. 2001. *The effect of alien vegetation on Water Resources Planning for the Town of George*. Prepared by E J Larsen of Ninham Shand and C Marais of Working for Water in association with ASCH.

APPENDICES

LIST OF CONTENTS

APPENDIX A	**Demographic Data**
APPENDIX B	**Supplementary Economic Data**
APPENDIX C	**Legal Aspects**
APPENDIX D	**Land Use Data**
APPENDIX E	**Water Related Infrastructure**
APPENDIX F	**Water Requirements**
APPENDIX G	**Water Resources**
APPENDIX H	**Water Balance**

NOTE: BLANKS INDICATE THAT DATA WAS NOT READILY AVAILABLE

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 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
Mm^3/a	million cubic metres per annum
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 annum
%	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.

GOURITZ WATER MANAGEMENT AREA

APPENDIX A

DEMOGRAPHIC DATA PER QUATERNARY CATCHMENT

QUATERNARY CATCHMENT	OPOPi URBAN POPULATION	oPORi RURAL POPULATION	TOTAL POPULATION
	Number	Number	Number
H80A	0	235	235
H80B	0	290	290
H80C	6 800	537	7 337
H80D	0	483	483
H80E	0	581	581
H80F	200	289	489
H90A	0	718	718
H90B	0	378	378
H90C	9 000	1 917	10 917
H90D	0	1 693	1 693
H90E	4 300	880	5 180
J11A	0	125	125
J11B	0	131	131
J11C	0	53	53
J11D	0	243	243
J11E	2 250	772	3 022
J11F	0	197	197
J11G	0	260	260
J11H	0	377	377
J11J	4 300	882	5 182
J11K	0	754	754
J12A	0	520	520
J12B	0	310	310
J12C	6 200	136	6 336
J12D	0	446	446
J12E	0	95	95
J12F	0	244	244
J12G	0	111	111
J12H	0	94	94
J12J	0	789	789
J12K	0	134	134
J12L	0	593	593
J12M	0	260	260
J13A	0	243	243
J13B	400	361	761
J13C	0	188	188
J21A	26 350	340	26 690
J21B	0	110	110
J21C	0	115	115
J21D	0	150	150
J21E	0	110	110
J22A	0	57	57
J22B	0	45	45
J22C	0	79	79
J22D	0	107	107
J22E	0	109	109
J22F	1 350	1 292	2 642
J22G	0	95	95
J22H	0	160	160
J22J	0	66	66
J22K	0	120	120
J23A	0	238	238
J23B	0	121	121
J23C	0	65	65
J23D	0	92	92
J23E	0	95	95
J23F	3 800	121	3 921
J23G	0	36	36
J23H	0	89	89
J23J	0	84	84
J24A	0	154	154
J24B	800	120	920

APPENDIX A

DEMOGRAPHIC DATA PER QUATERNARY CATCHMENT

QUATERNARY CATCHMENT	OPOPi	oPORi	TOTAL POPULATION
	URBAN POPULATION	RURAL POPULATION	
	Number	Number	Number
J24C	0	131	131
J24D	0	140	140
J24E	0	429	429
J24F	0	228	228
J25A	0	266	266
J25B	3 100	2 013	5 113
J25C	0	215	215
J25D	3 450	255	3 705
J25E	0	1 652	1 652
J31A	0	256	256
J31B	0	110	110
J31C	0	54	54
J31D	0	234	234
J32A	0	49	49
J32B	0	277	277
J32C	0	111	111
J32D	0	68	68
J32E	0	456	456
J33A	0	449	449
J33B	0	1 085	1 085
J33C	0	260	260
J33D	0	357	357
J33E	1 900	1 431	3 331
J33F	8 900	2 412	11 312
J34A	3 250	458	3 708
J34B	0	718	718
J34C	0	869	869
J34D	0	523	523
J34E	0	596	596
J34F	0	1 172	1 172
J35A	53 800	2 014	55 814
J35B	0	2 722	2 722
J35C	0	441	441
J35D	0	1 114	1 114
J35E	0	806	806
J35F	0	1 644	1 644
J40A	0	214	214
J40B	0	120	120
J40C	400	1 079	1 479
J40D	3 250	1 429	4 679
J40E	0	957	957
K10A	41 450	856	42 306
K10B	0	568	568
K10C	0	159	159
K10D	0	987	987
K10E	0	1 095	1 095
K10F	1 400	1 017	2 417
K20A	6 900	912	7 812
K30A	0	2 393	2 393
K30B	0	1 862	1 862
K30C	103 900	888	104 788
K30D	3 950	1 064	5 014
K40A	0	263	263
K40B	0	574	574
K40C	0	913	913
K40D	2 100	1 354	3 454
K40E	1 750	1 362	3 112
K50A	0	558	558
K50B	30 650	508	31 158
K60A	0	424	424
K60B	0	322	322
K60C	0	356	356
K60D	0	420	420
K60E	0	287	287
K60F	0	1 606	1 606

APPENDIX A

DEMOGRAPHIC DATA PER QUATERNARY CATCHMENT

QUATERNARY CATCHMENT	OPOPi	oPORi	TOTAL POPULATION
	URBAN POPULATION	RURAL POPULATION	
	Number	Number	Number
K60G	15 600	1 262	16 862
K70A	0	241	241
K70B	0	118	118
TOTALS	**351 500**	**72 664**	**424 164**

APPENDIX B

SUPPLEMENTARY ECONOMIC DATA

APPENDIX B.1	**Graph 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**

APPENDICES

SUPPLEMENTARY ECONOMIC INFORMATION

APPENDIX B.1
DESCRIPTION OF GRAPHS

Diagram No	Graphic Illustration	Description
	• **Gross Geographic Product**:	
B.1	⇨ Contribution by Magisterial District to Gouritz 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.
	• **Labour Force Characteristics**:	
B.3	⇨ Composition of Gouritz 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 Gouritz Employment, 1980 and 1994 (%)	Shows the sectoral composition of the formal WMA labour force.
B.5	⇨ Contribution by Sectors of Gouritz 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 Gouritz versus South Africa, 1988 to 1994 (%)	Annual compound growth by sector is shown for the period 1980 to 1994.
	• **Shift-Share**:	
B.7	⇨ 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 Gouritz economy, 1997 (%)

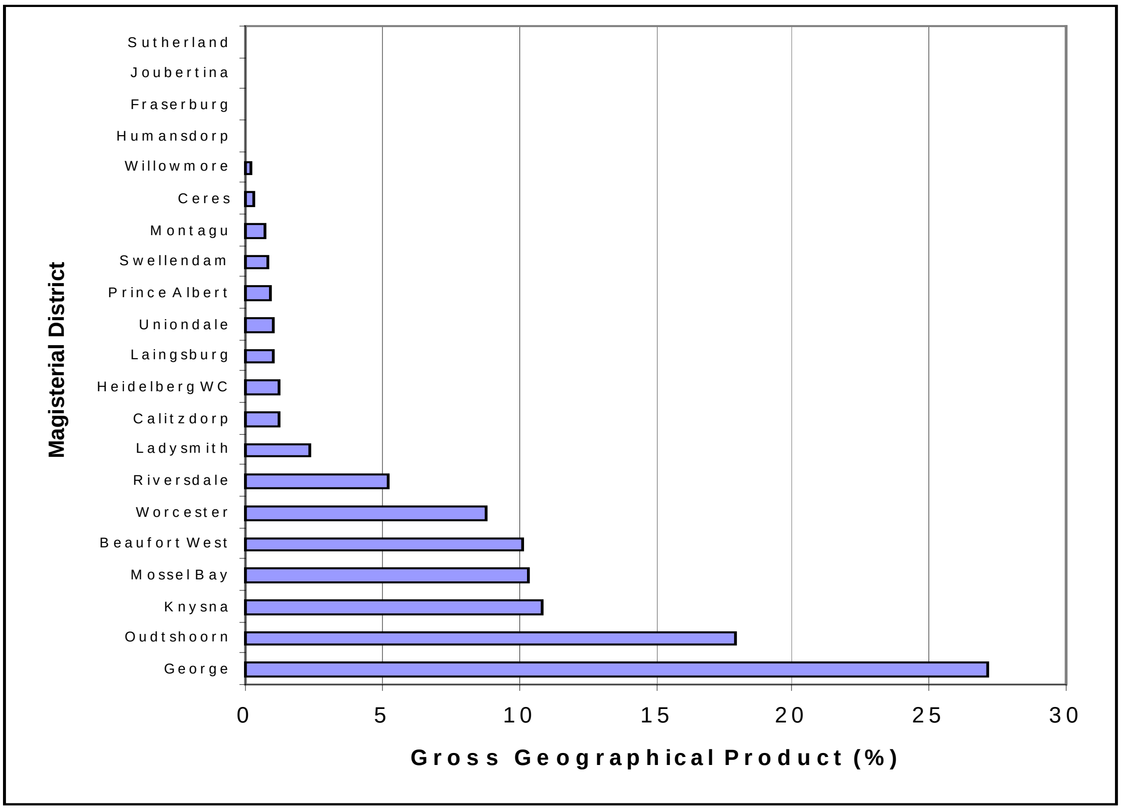


Figure B.2: Contribution by Sector to National Economy, 1988 and 1997 (%)

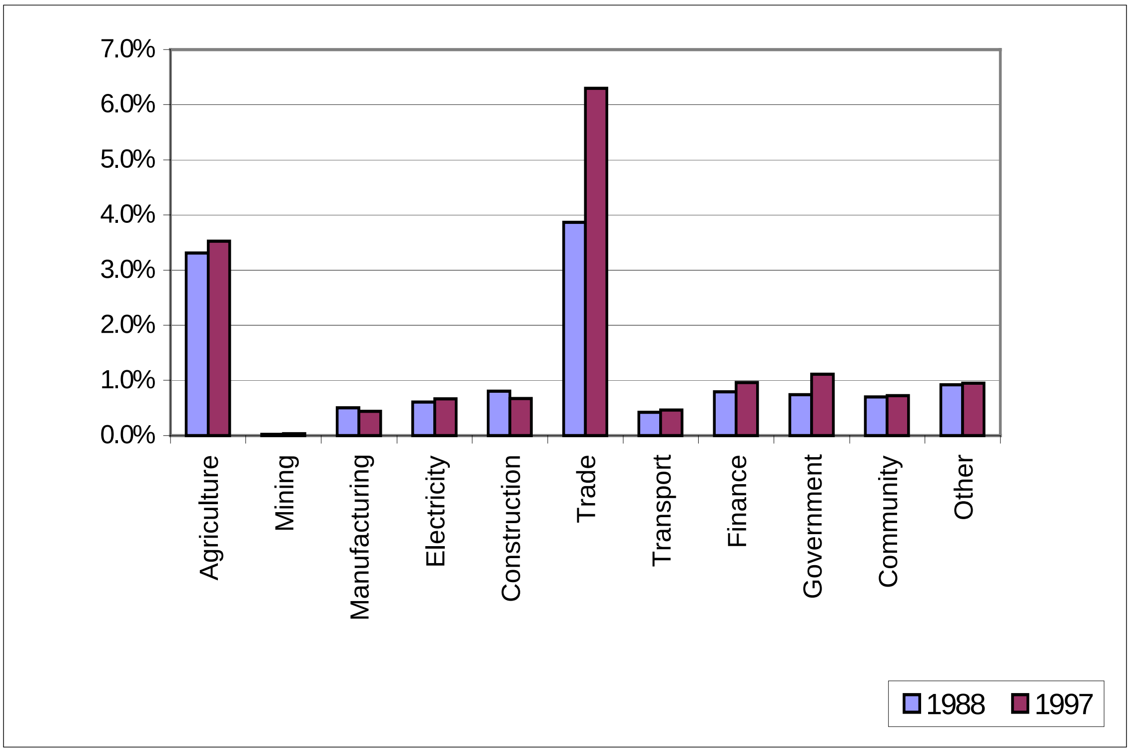


Figure B.3: Composition of Gouritz Labour Force, 1994 (%)

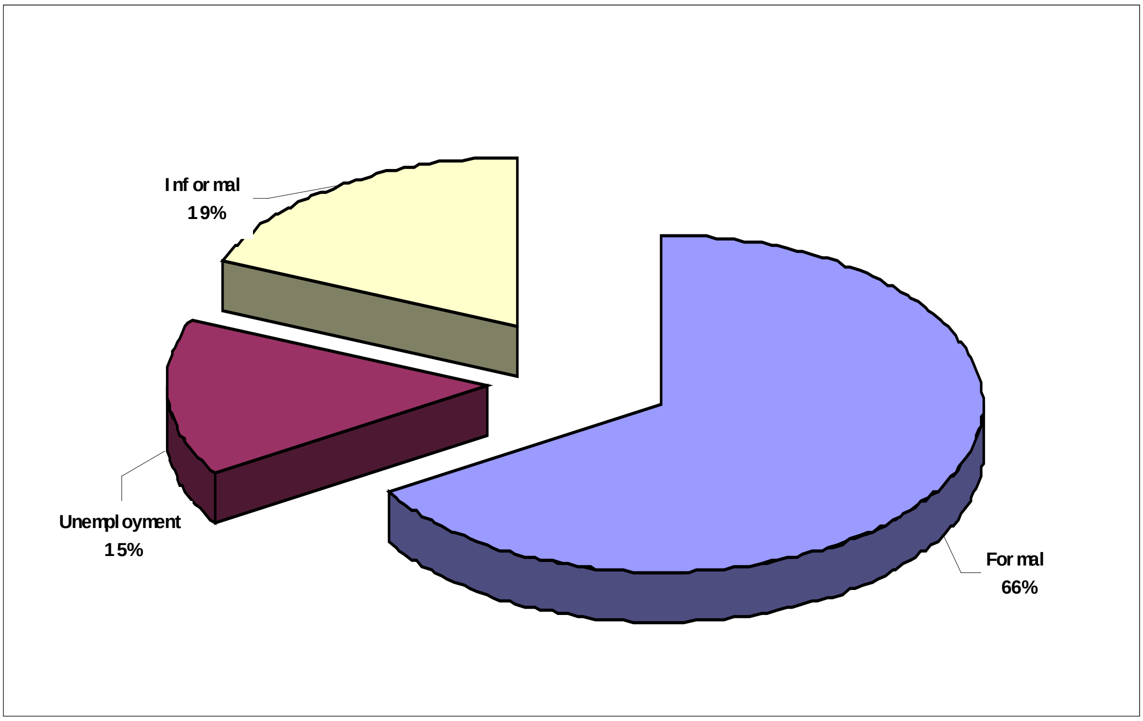


Figure B.4: Contribution by Sector to Gouritz Employment, 1980 and 1994(%)

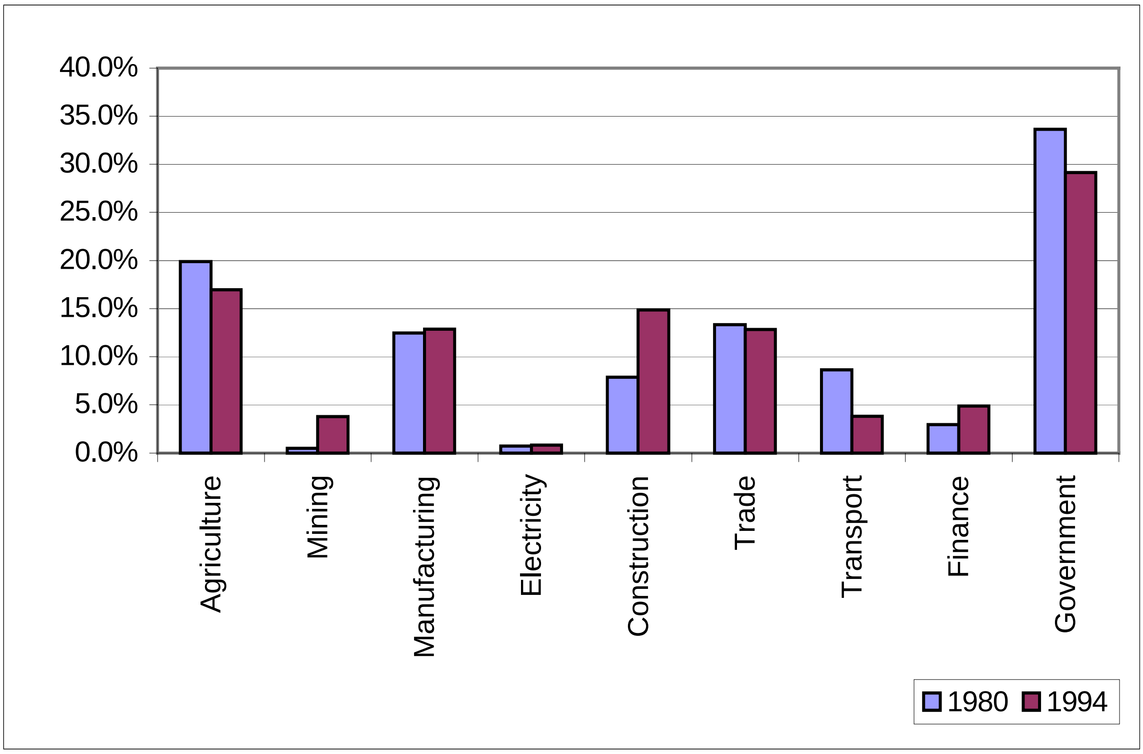


Figure B.5 : Contribution by Sectors of Gouritz Employment to National Sectoral Employment, 1980 and 1994 (%)

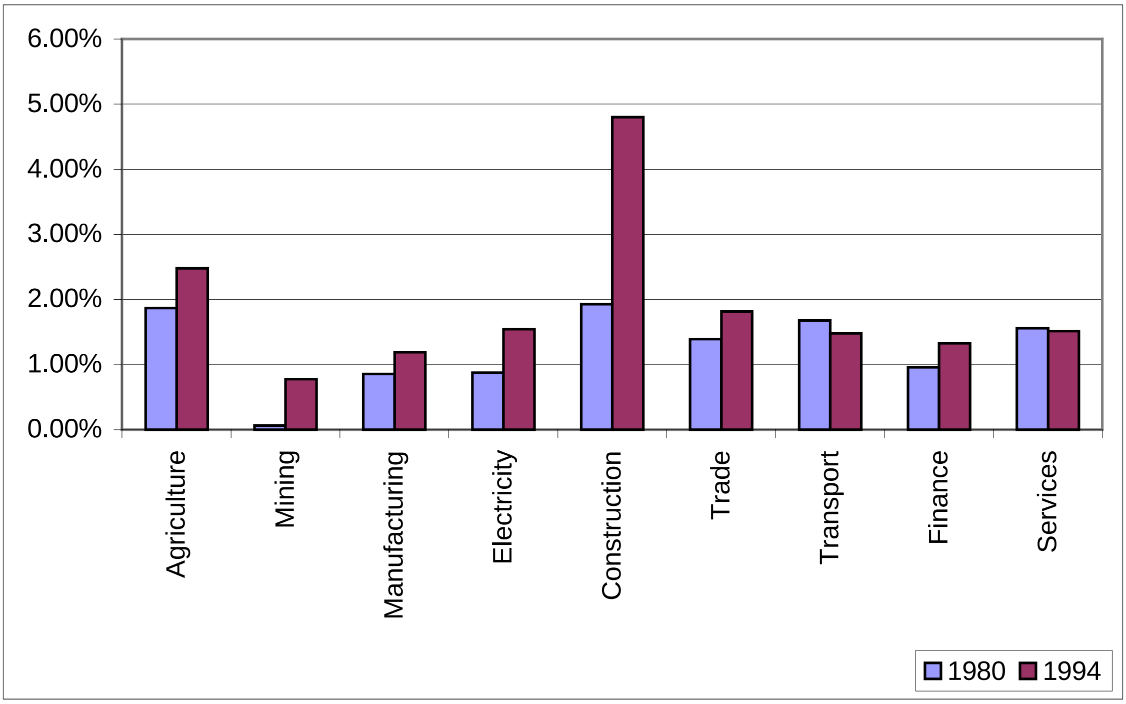


Figure B.6: Average Annual Employment Growth by Sector of Gouritz versus South Africa, 1980 to 1994 (%)

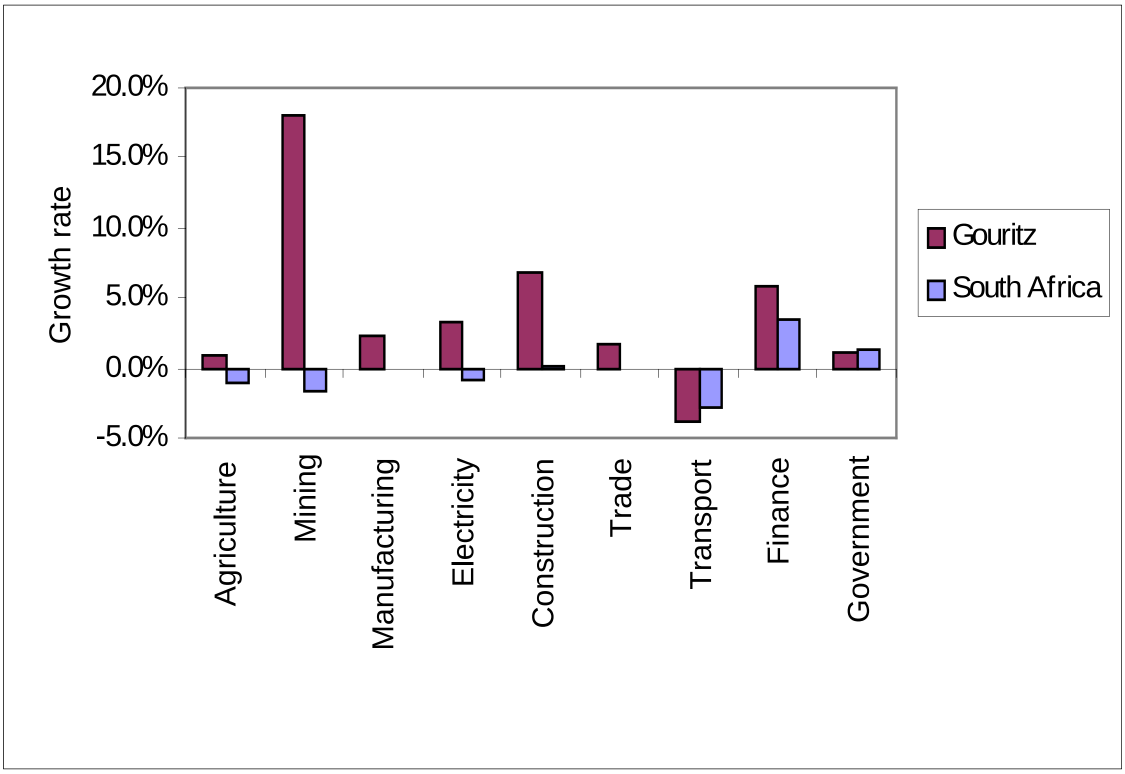
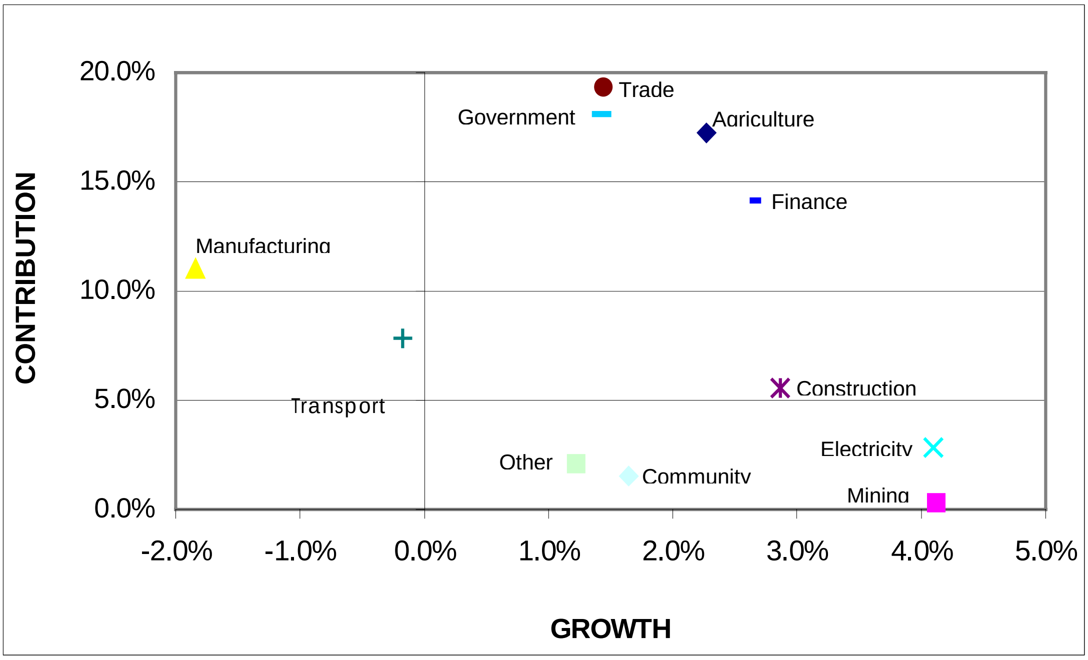


Figure B.7: Shift-Share Analysis, 1997



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

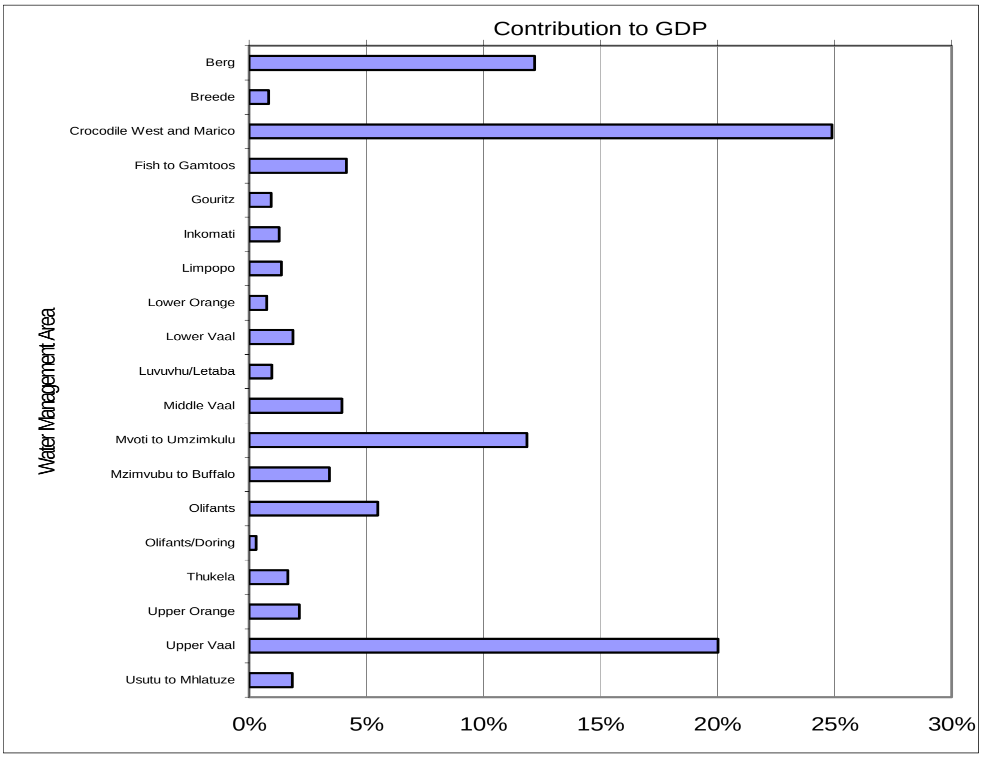
- The largest contribution to the national economy is made by the Crocodile West and Marico WMA which contributes (19.1%) to GDP. This WMA comprises, inter alia, magistrates districts of Pretoria, Johannesburg, Germiston, Kempton Park, Benoni, Thabazimbi and Lichtenburg.

- 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.

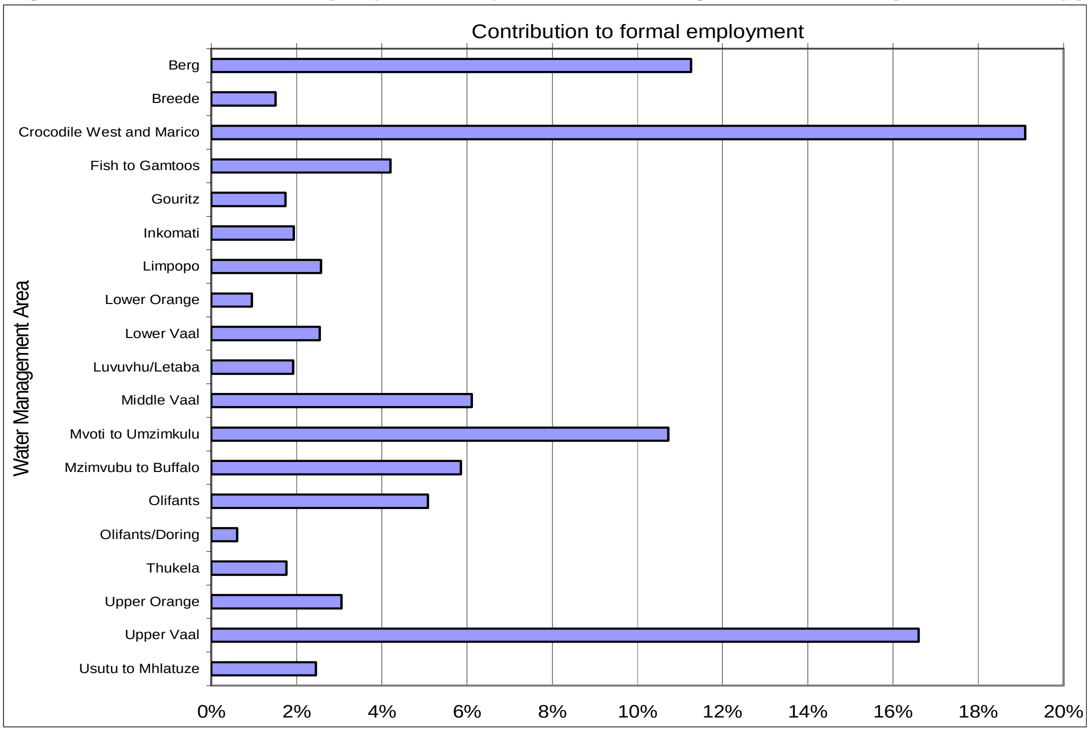
Figure B.1: Total GGP by Water Management Area (% of Country)



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.

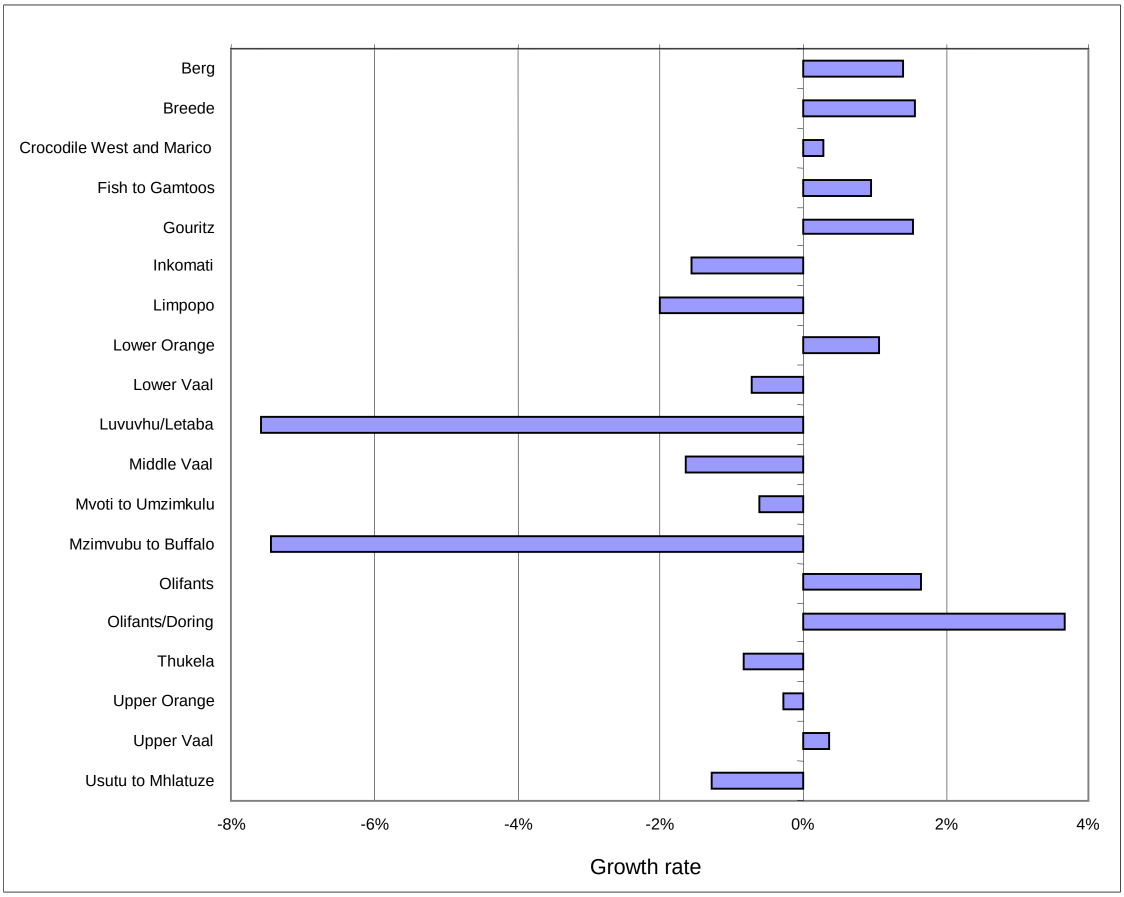
Figure B.2: Formal Employment by Water Management Area (% of country)



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.

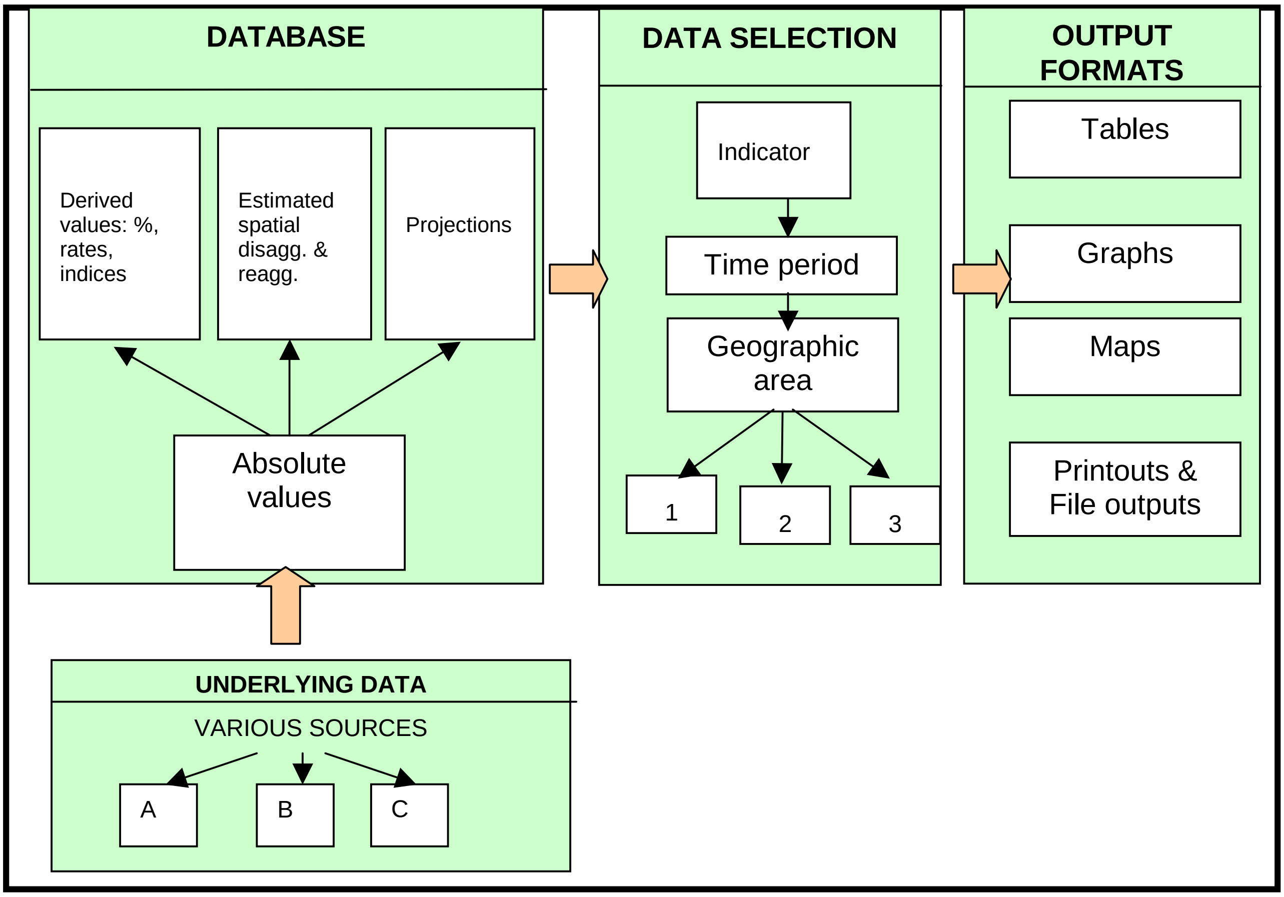
Indicator	Categories	Timespan	Geographic detail
Gross geographic product	Major sectors	1972-1997	Magisterial districts
Labour distribution	Employment/un-employment Major sectors	1980, 1991, 1994	Magisterial districts
Electricity consumption	Economic sectors, domestic	1988-1997	Local authority area, service 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.**

GOURITZ MANAGEMENT AREA

APPENDIX D.1

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	Field area irrigated	Urban Areas	Number of large stock units
	km^2	km^2	km^2	km^2	km^2	Number
H80A	2.32	0.40	0	0.105	0	3446
H80B	2.02	3.39	0.45	2.040	0	2871
H80C	2.39	0	0	5.270	1.74	6694
H80D	8.27	0	0	5.300	0	4933
H80E	85.26	0	0	0	0	6787
H80F	44.57	0	0	0	0.09	3411
H90A	12.69	6.31	0	5.175	0	3006
H90B	6.66	16.92	0	1.155	0	2071
H90C	7.71	0	0	17.630	2.88	3699
H90D	111.10	0	0	1.190	0	10107
H90E	149.20	0	0	0.350	2.44	8310
J11A	0	0	0	0.917	0	447
J11B	0	0	0	0.069	0	1621
J11C	0	0	0	0	0	660
J11D	0	0	0	7.075	0	1174
J11E	0	0	0	0.495	1.37	1833
J11F	0.16	0	0	1.272	0	777
J11G	0.18	0	0	0	0	1364
J11H	0.03	0	0	6.285	0	1488
J11J	0.12	0	0	23.288	0	1387
J11K	1.17	0	0	5.006	1.27	1611
J12A	1.23	0	0	1.265	0	647
J12B	0.60	0	0	0	0.85	1166
J12C	0	0	0	2.558	0.20	1808
J12D	0	0	0	4.277	0	4148
J12E	0	0	0	0	0	1067
J12F	0	0	0	1.705	0	2613
J12G	0	0	0	0	0	1739
J12H	4.38	0	0	2.434	0	1784
J12J	0	0	0	6.759	0	6576
J12K	0	0	0	1.293	0	5490
J12L	0.23	0	0	3.941	0	7937
J12M	10.49	0.65	0	9.829	0	4929
J13A	40.47	0	0	5.212	0	3328
J13B	51.17	0	0	2.861	0.17	3859
J13C	46.28	0	0	11.460	0	4612

Quaternary Catchment	aAAAi	aFCAi	aFINi	aISAi	aNAEi	oRSUi
	Area under alien vegetation	Area under Afforestation	Indigenous forest area	Field area irrigated	Urban Areas	Number of large stock units
	km^2	km^2	km^2	km^2	km^2	Number
J21A	12.82	0	0	2.287	10.90	2744
J21B	0.14	0	0	0.180	0	1703
J21C	0.22	0	0	0.150	0	1690
J21D	0.12	0	0	0.510	0	2064
J21E	0	0	0	0.240	0	1443
J22A	0	0	0	0	0	1481
J22B	3.46	0	0	0.067	0	1089
J22C	0	0	0	0	0	1172
J22D	0	0	0	0.105	0	2183
J22E	0	0	0	0.240	0	2662
J22F	5.93	0	0	0.525	0	652
J22G	0	0	0	0	0	1893
J22H	0	0	0	0	0	2593
J22J	0	0	0	0.097	0	1212
J22K	0	0	0	3.517	0	1374
J23A	3.20	0	0	6.930	0	1559
J23B	0.08	0	0	1.207	0	1617
J23C	1.76	0	0	0	0	1052
J23D	0	0	0	0	0	1447
J23E	0	0	0	5.017	0	490
J23F	4.12	0	0	4.470	1.06	980
J23G	0	0	0	0	0	492
J23H	2.47	0	0	1.305	0	544
J23J	2.29	0	0	1.520	0	468
J24A	0	0	0	0	0	2054
J24B	0	0	0	0	1.19	2042
J24C	0.59	0	0	0	0	1854
J24D	0	0	0	0	0	2017
J24E	0.92	0	0	0	0	1913
J24F	4.16	0	0	1.215	0	637
J25A	4.18	0	0	0	0	1717
J25B	1.09	0	0	6.725	0	1371
J25C	2.87	0	0	2.400	0	1138
J25D	0	0	0	5.200	0.64	2509
J25E	17.73	0	0	19.090	0	3092
J31A	0.71	0	0	0.851	0	4181
J31B	9.22	0	0	0.010	0	2098
J31C	0	0	0	1.232	0	862
J31D	6.50	0	0	1.442	0	3096
J32A	0	0	0	0	0	849
J32B	0	0	0	0.471	0	1628
J32C	0	0	0	0.391	0	1980
J32D	0	0	0	0.240	0	1347
J32E	1.14	0	0	1.302	0	4573

Quaternary Catchment	aAAAi	aFCAi	aFINi	aISAi	aNAEi	oRSUi
	Area under alien vegetation	Area under Afforestation	Indigenous forest area	Field area irrigated	Urban Areas	Number of large stock units
	km^2	km^2	km^2	km^2	km^2	Number
J33A	7.81	0	0	3.315	0	4574
J33B	9.82	0	0	16.527	0	5811
J33C	0.03	0	0	7.362	0	906
J33D	0.35	0	0	3.396	0	899
J33E	2.88	0	0	11.469	0.50	3083
J33F	15.67	0	0	32.153	2.50	3448
J34A	47.21	0	0	1.663	1.42	2638
J34B	18.25	0	0	2.785	0.04	3642
J34C	38.02	1.12	0	4.247	0	4491
J34D	25.11	0	0	1.492	0	5224
J34E	2.58	0	0	2.644	0	3816
J34F	1.40	0	0	22.497	0	4027
J35A	0	0	0	8.013	11.94	3985
J35B	16.41	0	0	47.809	0	7675
J35C	4.61	0	0	5.399	0	2547
J35D	0	0	0	16.968	0	4764
J35E	0	0	0	8.474	0	2120
J35F	17.01	0	0	15.846	0	5956
J40A	0.23	0	0	0.860	0	3992
J40B	1.49	0.07	0	0.600	0	6463
J40C	0.92	0	0	13.210	0	11420
J40D	9.44	0	0	1.190	0.90	14345
J40E	83.07	0	0	8.520	0	15098
K10A	0	0	0	0	8.77	6058
K10B	0	0	0	2.501	0.15	5922
K10C	0.33	7.59	0	5.242	0	5478
K10D	0	0	0	6.652	0	5672
K10E	11.75	25.66	0	0.981	0	4512
K10F	0	0.39	0	4.064	0.74	3656
K20A	0.55	28.81	0	0	0.76	3541
K30A	0.10	25.89	0	0	0.37	2945
K30B	0.81	19.17	0	0	7.07	2079
K30C	14.51	34.92	0	0	17.47	2862
K30D	12.57	22.20	0	5.053	1.27	2656
K40A	2.39	42.73	0	0.319	0.41	1317
K40B	6.69	27.71	0	7.474	0	1274
K40C	2.21	19.69	0	0.544	0.52	768
K40D	13.93	36.63	0	2.711	1.64	1523
K40E	38.56	54.79	0	3.162	0	2029
K50A	14.53	57.20	0	1.900	0	1795
K50B	15.91	48.27	15.97	0	6.06	1519
K60A	27.91	0	0	2.773	0	2153
K60B	33.95	0	0	1.105	0	1496
K60C	4.17	11.17	0	2.763	0	1357
K60D	130.3	2.79	0	0	0	2141
K60E	8.20	15.80	0	9.414	0	754

Quaternary Catchment	aAAAi	aFCAi	aFINi	aISAi	aNAEi	oRSUi
	Area under alien vegetation	**Area under Afforestation**	**Indigenous forest area**	**Field area irrigated**	**Urban Areas**	**Number of large stock units**
	km^2	**km^2**	**km^2**	**km^2**	**km^2**	**Number**
K60F	0.38	41.93	0	10.655	0	1821
K60G	2.77	30.58	0.71	2.879	4.28	1231
K70A	27.26	12.17	0	0	0.84	1269
K70B	11.00	5.99	0.78	1.813	0	367
TOTALS	**1357.51**	**600.94**	**17.91**	**513.597**	**92.44**	**384079**

GOURITZ WATER MANAGEMENT AREA

APPENDIX D.2

CONVERSION OF MATURE LIVESTOCK 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
Ostriches	L	3

* Groups (in terms of water consumption)
L = Cattle and horses; S = Small livestock

GOURITZ WATER MANAGEMENT AREA

APPENDIX D.3

TREE SPECIES IN COMMERCIAL FORESTS PER QUATERNARY CATCHMENT

Quaternary Catchment	aFCAi Area under afforestation km^2	Species
H80A	0.40	pine
H80B	3.39	pine
H80C	0	
H80D	0	
H80E	0	
H80F	0	
H90A	6.31	pine
H90B	16.92	pine
H90C	0	
H90D	0	
H90E	0	
J11A	0	
J11B	0	
J11C	0	
J11D	0	
J11E	0	
J11F	0	
J11G	0	
J11H	0	
J11J	0	
J11K	0	
J12A	0	
J12B	0	
J12C	0	
J12D	0	
J12E	0	
J12F	0	
J12G	0	
J12H	0	
J12J	0	
J12K	0	
J12L	0	
J12M	0.65	pine
J13A	0	
J13B	0	
J13C	0	
J21A	0	
J21B	0	
J21C	0	
J21D	0	

Quaternary Catchment	aFCAi Area under afforestation km^2	Species
J21E	0	
J22A	0	
J22B	0	
J22C	0	
J22D	0	
J22E	0	
J22F	0	
J22G	0	
J22H	0	
J22J	0	
J22K	0	
J23A	0	
J23B	0	
J23C	0	
J23D	0	
J23E	0	
J23F	0	
J23G	0	
J23H	0	
J23J	0	
J24A	0	
J24B	0	
J24C	0	
J24D	0	
J24E	0	
J24F	0	
J25A	0	
J25B	0	
J25C	0	
J25D	0	
J25E	0	
J31A	0	
J31B	0	
J31C	0	
J31D	0	
J32A	0	
J32B	0	
J32C	0	
J32D	0	
J32E	0	
J33A	0	
J33B	0	
J33C	0	
J33D	0	
J33E	0	
J33F	0	

Quaternary Catchment	aFCAi Area under afforestation km^2	Species
J34A	0	
J34B	0	
J34C	1.12	pine
J34D	0	
J34E	0	
J34F	0	
J35A	0	
J35B	0	
J35C	0	
J35D	0	
J35E	0	
J35F	0	
J40A	0	
J40B	0.07	pine
J40C	0	
J40D	0	
J40E	0	
K10A	0	
K10B	0	
K10C	7.59	pine
K10D	0	
K10E	25.66	pine
K10F	0.39	pine
K20A	28.81	pine
K30A	25.89	pine
K30B	19.17	pine (86%) & Eucalyptus (14%)
K30C	34.92	pine (96%) & Eucalyptus (4%)
K30D	22.20	pine
K40A	42.73	pine
K40B	27.71	pine
K40C	19.69	pine (97%) & Eucalyptus (3%)
K40D	36.63	pine (97%) & Eucalyptus (3%)
K40E	54.79	pine (98%) & Eucalyptus (2%)
K50A	57.20	pine
K50B	48.27	pine(65%) & Eucalyptus(32%) & wattle(3%)
K60A	0	
K60B	0	
K60C	11.17	pine
K60D	2.79	pine
K60E	15.80	pine
K60F	41.93	pine (98%) & Eucalyptus (2%)
K60G	30.58	pine (70%) & Eucalyptus (26%) & wattle (4%)
K70A	12.17	pine
K70B	5.99	pine
TOTALS	**600.94**	

APPENDIX E

WATER RELATED INFRASTRUCTURE

APPENDIX E.1	**Existing water supply schemes**
APPENDIX E.2	**Main dams**
APPENDIX E.3	**Farm dam data per quaternary catchment**

APPENDIX E.1

EXISTING POTABLE WATER SUPPLY SCHEMES

DRAINAGE REGION		QUATERNARY CATCHMENT	SCHEME NAME	RAW WATER SOURCE	POPULATION SUPPLIED [1]	WATER REQUIREMENTS IN 1995[1] (million m^3/a)	SCHEME CAPACITY (5) million m^3/a	ℓ/c/d	LIMITING FACTOR
H		H80C	Heidelberg	Duiwenhoks Dam	6 800	0,85	1.20 (2)	483	Source
		H80F & H90E	Stillbaai	Not Known	4 300 + 200 = 4 500	0.58	0,58 (3)	352 (3)	Not Known
		H90C	Riversdale	Korente-vet Dam	9 000	1,12	1,40	426	Source
		Totals for H			20 300	2,55	3.18 (3)	429 (3)	--
J	J1	J11E	Laingsburg	Boreholes in Wilgenhout and Buffels Rivers	2 250	0,21	0,89	1084	Source
		J11J	Ladismith	Local mountain stream	4 300	0,58	0,58 (3)	321 (3)	Source
		J12B/C	Touwsrivier	Small off channel dam fed from a spring	6 200	0,68	0,68 (3)	261 (3)	Not Known
		J12G	Maatjiesfontein	Boreholes	236	0,01	0,01	116	Source
		J13B	Vanwyksdorp	Local mountain stream	400	0,03	0,03 (3)	178 (3)	Not Known
		Total for J1			13 386	1,51	2.18 (3)	446 (3)	--
	J2	J21A	Beaufort West	Gamka Dam and 18 boreholes	26 350	3,60	0,61	63	Source
		J22F	Leeu Gamka	Boreholes	1 350	0,12	0,05	101	Source
		J23F	Prince Albert	Local mountain stream	3 800	0,35	0,31	224	Source
		J24B	Merweville	Tierkloof Dam	800	0,08	0,08 (3)	238 (3)	Not Known
		J25B	Zoar	Tierkloof Dam	3 100	0,25	0,25 (3)	192 (3)	Not Known
		J25D	Calitzdorp	Caltizdorp Dam and boreholes	3 450	0,40	0,17	135	Source
		Total for J2			38 850	4,80	1,47 (3)	104 (3)	--
	J3	J35A	Oudtshoorn	Koos Raubenheimer and Mellville Dams	53 800	7,81	5,40	275	Source
		J33E	De Rust	Huis River Weir	1 900	0,14	0,14	202	Source
		J33F	Dysselsdorp	Klein Karoo Rural Water Supply Scheme (boreholes)	8 900 + rural users = +/- 20 700?	0,95	1,10	146	Wellfield capacity
		J34A	Uniondale	Local mountain stream	3 250	0,30	0,30 (3)	220 (3)	Not Known
		Total for M3			79 650	9,20	6,94 (3)	239 (3)	--
	J4	J40C	Herbertsdale	Langtou River alluvium	400	0,04	0,04 (3)	238 (3)	Not Known
		J40D	Albertina	Boreholes	3 250	0,32	0,32 (3)	234 (3)	Not Known
		Total for J4			3 650	0,36	0,36 (3)	270 (3)	--
	Total for J				135 536	15,87	10.95 (3)	221 (3)	--
K	K1,2, part of K3	K10A&F, K20A	Mossel Bay, Hartenbos, Kleinbrakrivier and Grootbrakrivier	Klipheuwel & E Robertson Dams at present, Wolwedans Dam in future	41 450 + 1 400+ 6 900 = 49 750	5,80 (4)	4,0 (Klipheuwel) +1,8 (E Robertson) = 5,8 6,9 available from Wolwedans for future use	319	Treatment
		K30C	George	Garden Route Dam	103 800	10,57	5,80	145	Source
		K30D	Wilderness		3 950	0,59			
		K40D	Wilderness East		2 100	0,29			
		Total for K1,2,3			159 600	17,25	11,60	199	--
	Part of K3, K4	K40D	Sedgefield	Local surface supplies	2 100	0,72 (4)	1,50 (4)	1 957	Source
		K40E	Buffalo Bay	Goukamma River	1 750	0,60 (4)	0,35 (4)	548	Treatment Works
	K5,6,7	K50B	Knysna, Belvidere	Knysna River, Gouna River, boreholes	30 650	3,44	4,22	377	Treatment Works
		K60G	Plettenberg Bay	Keurbooms River, Roodefontein Dam, 4 boreholes	15 600	2,48	1,79 (1,33 + 0,15 + 0,31)	314	Conveyance
		Total for K5,6,7			46 250	5,92	6,01	356	--
	Total for K				209 700	24,49	19,46	254	--
TOTALS FOR WMA					**365 536**	**40,36**	**33,59 (3)**	**252**	**--**

DATA SOURCES:

1. WSAM Database unless otherwise shown
2. White Paper on Duiwenhoks Rural Water Supply Scheme (N-81). Estimate made from data in the White Paper.
3. Where scheme capacities are not known, they are assumed to be equal to water requirements in 1995.
4. Data from applicable municipality.
5. At approximately 1:50 year assurance.

APPENDIX E.2
MAIN DAMS

QUATERNARY CATCHMENT	NAME	RIVER	LIVE [5] STORAGE CAPACITY (million m^3)	YIELD (million m^3/a)				USE	OWNER
				DOMESTIC SUPPLIES	IRRIGATION [6]	OTHER	TOTAL YIELD [1]		
H80A	Duiwenhoks River	Duiwenhoks	6,4	1,2	3,7	0,00	9,80 [1]	Heidelberg town supply, Duiwenhoks Rural Water Supply Scheme and irrigation	DWAF
H90B	Korente-vet	Korente Poort	8,3	1,5	2,2	0,00	5,80 [1]	Riversdale town supply Irrigation	DWAF
J11F, G, H	Floriskraal	Buffels	50,3	0,0	8,7	0,00	6,50 [1]	Irrigation	DWAF
J12B	Verkeerdevlei	Donkies	5,5	2,3	0,0	0,00	1,30 [1]	Touws River town supply Irrigation	DWAF
J12G	Prins River	Prins	2,7	--	1,0	--	1,00 [1]	Irrigation	Prins River Irrigation Board
J12K	Bellair	Brak	10,1	--	1,6	--	1,60 [1]	Irrigation	DWAF
J21A	Gamka	Gamka	1,8	0,2	0,0	0,00	0,60 [1]	Beaufort West town supply	DWAF
J22G	Doornfontein	Leeuw	4,4	--	--	--	Not known	Irrigation	Private
J22K	Leeu Gamka	Leeuw	14,3	--	2,8	--	2,80 [1]	Irrigation	DWAF
J23E	Oukloof	Dorps (tributary of Gamka)	4,2	--	1,4	--	1,40 [1]	Irrigation	DWAF
J25A	Gamkapoort	Gamka	44,2	--	11,0	--	11,00 [4]	Irrigation, domestic, livestock	DWAF
J25D	Calitzdorp	Nels	4,8	0,2	2,5	--	2,70 [4]	Calitzdorp town supply, irrigation	DWAF
J33B	Stompdrift	Olifants	55,3	--	15,0	--	15,00 [4]	Irrigation	DWAF
J34E	Kammanassie	Kammanassie	35,8	--	18,0	--	18,00 [4]	Irrigation	DWAF
J35A	Koos Raubenheimer	Klein Le Roux (tributary of Grobbelaars)	9,2	2,2	--	--	2,20 [4]	Oudtshoorn Town Supply	Oudtshoorn
J35A	Melville		0,4	1,3	--	--	1,30 [4]		Oudtshoorn
K10B	Haartebeeskuil	Haartenbos	7,2	--	0,90	--	0,85 (firm yield) [2]	Irrigation, stock watering	DWAF
K10F	Klipheuwel	Klein Brak (off channel)	4,2	4,0	--	--	4,00 [2]	Mossel Bay	Mossel Bay
K20A	Wolwedans	Great Brak	24,4 (gross) [2] 23,0 (live) [2]	5,4 (1:200) [2] 6,9 (1:50) [2]	--	4,80 (1:200) [2]	11,7 (mixed assurance) [2] 10.2 (1:200) [2] 13,0 (1:50)	Existing Petro SA Refinery Water Supply, future supply for Mossel Bay	DWAF
K20A	Ernerst Robertson	Great Brak	0,42	1,8	--	--	1,80 [2]	Mossel Bay Town Supply	Mossel Bay
K30C	Garden Route	Swart	8,0	5,8 [3]	--	--	5,80 [3]	George Town Supply	George Municipality
K60G	Roodefontein Dam	Piesangs	1,4	0,15 [7]	0,54	0,31 (IFR)	1,00	Irrigation and Plettenberg Bay Town Supply	DWAF
TOTALS	**--**	**--**	**299,22**	**--**	**--**	**--**	**107,45**	**--**	**--**

1. Note: these yields were calculated from WR90 1:50 year yield-storage curves unless otherwise indicated. The allocations shown are not formal, but have been shown in this table to give an indication of how the yields are used on the basis of domestic and industrial requirements taking priority over irrigation requirements.
2. White Paper on Wolwedans Dam (DWAF, 1988)
3. George Alien Vegetation Study (Working for Water, 2001)
4. Klein Karoo Rural Water Supply Scheme Augmentation Study (DWAF, 1999b)
5. Storage volume above lowest drawdown level.
6. Actual allocations are larger quantities of water, generally supplied at less than 1:50 year assurance.
7. Plettenberg Bay Coastal Catchments Study System Yield Analysis (DWAF, 1996).

.

GOURITZ WATER MANAGEMENT AREA

APPENDIX E.3

FARM DAM DATA
PER QUATERNARY CATCHMENT

Quaternary Catchment	oDISi	aDMli	oDIEo
	Full supply capacity	Full supply area	Evaporation Losses
	million m^3	km^2	million m^3/annum
H80A	0.10	0.02	0.016
H80B	0	0	0
H80C	0.37	0.06	0.050
H80D	0	0	0
H80E	0	0	0
H80F	0	0	0
H90A	0	0	0
H90B	0	0	0
H90C	0.36	0.10	0.086
H90D	0	0	0
H90E	0	0	0
J11A	0.09	0.06	0.086
J11B	0	0	0
J11C	0	0	0
J11D	0	0	0
J11E	0	0	0
J11F	0	0	0
J11G	0	0	0
J11H	0.22	0.05	0.078
J11J	0.66	0.21	0.294
J11K	0.30	0.06	0.085
J12A	0.29	0.04	0.046
J12B	0	0	0
J12C	1.23	0.44	0.579
J12D	0	0	0
J12E	8.21	1.01	0.517
J12F	0	0	0
J12G	1.00	0.20	0.290
J12H	0.06	0.01	0.014
J12J	0.29	0.06	0.070
J12K	0	0	0
J12L	2.50	0.74	0.888
J12M	1.53	0.25	0.268
J13A	0	0	0
J13B	0.12	0.03	0.033
J13C	0	0	0
J21A	2.73	1.56	2.746
J21B	0.06	0.02	0.036
J21C	0	0	0
J21D	0	0	0
J21E	0	0	0
J22A	0	0	0
J22B	0	0	0
J22C	0.41	0.09	0.144
J22D	0	0	0
J22E	0	0	0
J22F	0	0	0

Quaternary Catchment	oDISi	aDMli	oDIEo
	Full supply capacity	Full supply area	Evaporation Losses
	million m^3	km^2	million m^3/annum
J22G	1.00	0.50	0.826
J22H	0.13	0.13	0.220
J22J	0	0	0
J22K	0	0	0
J23A	0.09	0.06	0.109
J23B	0	0	0
J23C	0	0	0
J23D	0	0	0
J23E	0.18	0.05	0.077
J23F	0	0	0
J23G	0	0	0
J23H	0	0	0
J23J	0	0	0
J24A	0	0	0
J24B	0	0	0
J24C	0	0	0
J24D	0	0	0
J24E	0	0	0
J24F	0.07	0.02	0.034
J25A	0	0	0
J25B	1.90	0.35	0.487
J25C	0	0	0
J25D	0	0	0
J25E	0.06	0.02	0.027
J31A	0	0	0
J31B	0	0	0
J31C	0	0	0
J31D	0	0	0
J32A	0	0	0
J32B	0	0	0
J32C	0	0	0
J32D	0	0	0
J32E	0	0	0
J33A	0	0	0
J33B	0.67	0.17	0.209
J33C	0.28	0.08	0.120
J33D	0.25	0.02	0.026
J33E	3.74	0.81	0.996
J33F	0.25	0.04	0.051
J34A	0.37	0.09	0.096
J34B	0.19	0.04	0.041
J34C	0	0	0
J34D	0.14	0.02	0.021
J34E	2.40	0.45	0.440
J34F	0.59	0.09	0.096
J35A	0.52	0.07	0.092
J35B	1.83	0.44	0.455
J35C	0	0	0
J35D	0	0	0
J35E	0	0	0
J35F	0.05	0.02	0.026
J40A	0	0	0
J40B	0	0	0
J40C	0.09	0.03	0.024
J40D	0.10	0.02	0.017
J40E	0.08	0.03	0.026

Quaternary Catchment	oDISi	aDMli	oDIEo
	Full supply capacity	Full supply area	Evaporation Losses
	million m^3	km^2	million m^3/annum
K10A	0.12	0.03	0.026
K10B	0	0	0
K10C	0	0	0
K10D	0	0	0
K10E	0	0	0
K10F	4.46	0.45	0.382
K20A	0.60	0.09	0.061
K30A	1.72	0.25	0.165
K30B	0	0	0
K30C	0	0	0
K30D	0.40	0.10	0.067
K40A	0	0	0
K40B	0.24	0.08	0.047
K40C	0	0	0
K40D	0	0	0
K40E	0.18	0.03	0.035
K50A	0.80	0.24	0.140
K50B	0.15	0.05	0.028
K60A	0	0	0
K60B	0	0	0
K60C	0	0	0
K60D	0	0	0
K60E	0	0	0
K60F	0	0	0
K60G	0.89	0.21	0.120
K70A	0.25	0.06	0.031
K70B	0	0	0
TOTALS	**45.30**	**10.15**	**11.945**

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.**
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.**
APPENDIX F.7	**Assumed rural domestic per capita water requirements.**

GOURITZ WATER MANAGEMENT AREA

APPENDIX F.1

URBAN WATER REQUIREMENTS PER QUATERNARY CATCHMENT

Areas	fNuli	fUBLi	gUIRo	gUTRo	oNUQo	oPOPi	oUDRo	oUIRi	oURFo	oUTLo
	Distribution loss factor	Bulk loss factor	Indirect urban use	Total urban water use	Increased runoff due to urban areas	Urban Population	Direct urban use	Indirect urban use	Total Return flows	Total losses
	Factor	Factor	million m^3/a	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
H80A	0.20	0.05	0	0	0	0	0	0	0	0
H80B	0.20	0.05	0	0	0.08	0	0	0	0	0
H80C	0.20	0.05	0.285	0.85	0.29		0.38	0.26	0.39	0.21
H80D	0.20	0.05	0	0	0.24	0	0	0	0	0
H80E	0.20	0.05	0	0	0	0	0	0	0	0
H80F	0.20	0.05	0.004	0.02	0	200	0.01	0	0.01	0
H90A	0.20	0.05	0	0	0.22	0	0	0	0	0
H90B	0.20	0.05	0	0	0.05	0	0	0	0	0
H90C	0.20	0.05	0.243	1.12	0.79	9000	0.62	0.22	0.53	0.27
H90D	0.20	0.05	0	0	0.05	0	0	0	0	0
H90E	0.20	0.05	0.151	0.56	0.02	4300	0.28	0.14	0.26	0.13
J11A	0.20	0.05	0	0	0	0	0	0	0	0
J11B	0.20	0.05	0	0	0	0	0	0	0	0
J11C	0.20	0.05	0	0	0	0	0	0	0	0
J11D	0.20	0.05	0	0	0	0	0	0	0	0
J11E	0.20	0.05	0.045	0.21	0	2250	0.11	0.04	0.09	0.06
J11F	0.20	0.05	0	0	0	0	0	0	0	0
J11G	0.20	0.05	0	0	0	0	0	0	0	0
J11H	0.20	0.05	0	0	0	0	0	0	0	0
J11J	0.20	0.05	0.125	0.58	0	4300	0.31	0.12	0.29	0.16
J11K	0.20	0.05	0	0	0	0	0	0	0	0
J12A	0.20	0.05	0	0	0	0	0	0	0	0
J12B	0.20	0.05	0	0	0	0	0	0	0	0
J12C	0.20	0.05	0.146	0.68	0	6200	0.36	0.14	0.32	0.18

Areas	fNuli	fUBLi	gUIRo	gUTRo	oNUQo	oPOPi	oUDRo	oUIRi	oURFo	oUTLo
	Distribution loss factor	Bulk loss factor	Indirect urban use	Total urban water use	Increased runoff due to urban areas	Urban Population	Direct urban use	Indirect urban use	Total Return flows	Total losses
	Factor	Factor	million m^3/a	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
J12D	0.20	0.05	0	0	0	0	0	0	0	0
J12E	0.20	0.05	0	0	0	0	0	0	0	0
J12F	0.20	0.05	0	0	0	0	0	0	0	0
J12G	0.20	0.05	0	0	0	0	0	0	0	0
J12H	0.20	0.05	0	0	0	0	0	0	0	0
J12J	0.20	0.05	0	0	0	0	0	0	0	0
J12K	0.20	0.05	0	0	0	0	0	0	0	0
J12L	0.20	0.05	0	0	0	0	0	0	0	0
J12M	0.20	0.05	0	0	0	0	0	0	0	0
J13A	0.20	0.05	0	0	0	0	0	0	0	0
J13B	0.20	0.05	0.006	0.03	0	400	0.01	0.01	0.01	0.01
J13C	0.20	0.05	0	0	0	0	0	0	0	0
J21A	0.20	0.05	1.215	3.60	0	26350	1.55	1.15	1.75	0.90
J21B	0.20	0.05	0	0	0	0	0	0	0	0
J21C	0.20	0.05	0	0	0	0	0	0	0	0
J21D	0.20	0.05	0	0	0	0	0	0	0	0
J21E	0.20	0.05	0	0	0	0	0	0	0	0
J22A	0.20	0.05	0	0	0	0	0	0	0	0
J22B	0.20	0.05	0	0	0	0	0	0	0	0
J22C	0.20	0.05	0	0	0	0	0	0	0	0
J22D	0.20	0.05	0	0	0	0	0	0	0	0
J22E	0.20	0.05	0	0	0	0	0	0	0	0
J22F	0.20	0.05	0.025	0.12	0	1350	0.06	0.02	0.05	0.03
J22G	0.20	0.05	0	0	0	0	0	0	0	0
J22H	0.20	0.05	0	0	0	0	0	0	0	0
J22J	0.20	0.05	0	0	0	0	0	0	0	0
J22K	0.20	0.05	0	0	0	0	0	0	0	0
J23A	0.20	0.05	0	0	0	0	0	0	0	0
J23B	0.20	0.05	0	0	0	0	0	0	0	0
J23C	0.20	0.05	0	0	0	0	0	0	0	0

Areas	fNuli	fUBLi	gUIRo	gUTRo	oNUQo	oPOPi	oUDRo	oUIRi	oURFo	oUTLo
	Distribution loss factor	Bulk loss factor	Indirect urban use	Total urban water use	Increased runoff due to urban areas	Urban Population	Direct urban use	Indirect urban use	Total Return flows	Total losses
	Factor	Factor	million m^3/a	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
J23D	0.20	0.05	0	0	0	0	0	0	0	0
J23E	0.20	0.05	0	0	0	0	0	0	0	0
J23F	0.20	0.05	0.076	0.35	0	3800	0.19	0.07	0.09	0.09
J23G	0.20	0.05	0	0	0	0	0	0	0	0
J23H	0.20	0.05	0	0	0	0	0	0	0	0
J23J	0.20	0.05	0	0	0	0	0	0	0	0
J24A	0.20	0.05	0	0	0	0	0	0	0	0
J24B	0.20	0.05	0.018	0.08	0	800	0.04	0.02	0.03	0.02
J24C	0.20	0.05	0	0	0	0	0	0	0	0
J24D	0.20	0.05	0	0	0	0	0	0	0	0
J24E	0.20	0.05	0	0	0	0	0	0	0	0
J24F	0.20	0.05	0	0	0	0	0	0	0	0
J25A	0.20	0.05	0	0	0	0	0	0	0	0
J25B	0.20	0.05	0.055	0.25	0	3100	0.14	0.05	0.10	0.06
J25C	0.20	0.05	0	0	0	0	0	0	0	0
J25D	0.20	0.05	0.089	0.40	0	3450	0.22	0.08	0.20	0.10
J25E	0.20	0.05	0	0	0	0	0	0	0	0
J31A	0.20	0.05	0	0	0.03	0	0	0	0	0
J31B	0.20	0.05	0	0	0	0	0	0	0	0
J31C	0.20	0.05	0	0	0.04	0	0	0	0	0
J31D	0.20	0.05	0	0	0.05	0	0	0	0	0
J32A	0.20	0.05	0	0	0	0	0	0	0	0
J32B	0.20	0.05	0	0	0	0	0	0	0	0
J32C	0.20	0.05	0	0	0	0	0	0	0	0
J32D	0.20	0.05	0	0	0	0	0	0	0	0
J32E	0.20	0.05	0	0	0	0	0	0	0	0
J33A	0.20	0.05	0	0	0	0	0	0	0	0
J33B	0.20	0.05	0	0	0.63	0	0	0	0	0
J33C	0.20	0.05	0	0	0.29	0	0	0	0	0
J33D	0.20	0.05	0	0	0.13	0	0	0	0	0

Areas	fNuli	fUBLi	gUIRo	gUTRo	oNUQo	oPOPi	oUDRo	oUIRi	oURFo	oUTLo
	Distribution loss factor	**Bulk loss factor**	**Indirect urban use**	**Total urban water use**	**Increased runoff due to urban areas**	**Urban Population**	**Direct urban use**	**Indirect urban use**	**Total Return flows**	**Total losses**
	Factor	**Factor**	**million m^3/a**	**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**
J33E	0.20	0.05	0.028	0.14	0	1900	0.08	0.03	0.06	0.04
J33F	0.20	0.05	0.186	0.95	0	8900	0.51	0.20	0.38	0.24
J34A	0.20	0.05	0.059	0.30	0.01	3250	0.16	0.06	0.10	0.08
J34B	0.20	0.05	0	0	0	0	0	0	0	0
J34C	0.20	0.05	0	0	0	0	0	0	0	0
J34D	0.20	0.05	0	0	0	0	0	0	0	0
J34E	0.20	0.05	0	0	0	0	0	0	0	0
J34F	0.20	0.05	0	0	0	0	0	0	0	0
J35A	0.20	0.05	2.352	7.81	0	53800	3.35	2.51	3.41	1.95
J35B	0.20	0.05	0	0	1.90	0	0	0	0	0
J35C	0.20	0.05	0	0	0	0	0	0	0	0
J35D	0.20	0.05	0	0	0	0	0	0	0	0
J35E	0.20	0.05	0	0	0	0	0	0	0	0
J35F	0.20	0.05	0	0	0.67	0	0	0	0	0
J40A	0.20	0.05	0	0	0.06	0	0	0	0	0
J40B	0.20	0.05	0	0	0.04	0	0	0	0	0
J40C	0.20	0.05	0.008	0.04	0.73	400	0.02	0.01	0.01	0.01
J40D	0.20	0.05	0.069	0.32	0.07	3250	0.18	0.06	0.14	0.08
J40E	0.20	0.05	0	0	0.48	0	0	0	0	0
K10A	0.20	0.05	2.371	9.40	0	41450	4.03	3.01	3.17	2.35
K10B	0.20	0.05	0	0	0.17	0	0	0	0	0
K10C	0.20	0.05	0	0	0.38	0	0	0	0	0
K10D	0.20	0.05	0	0	0.53	0	0	0	0	0
K10E	0.20	0.05	0	0	0.07	0	0	0	0	0
K10F	0.20	0.05	0.042	0.22	0.29	1400	0.11	0.05	0.07	0.05
K20A	0.20	0.05	0.293	1.37	0	6900	0.65	0.38	0.51	0.34
K30A	0.20	0.05	0	0	0	0	0	0	0	0
K30B	0.20	0.05	0	0	0	0	0	0	0	0
K30C	0.20	0.05	2.660	10.57	0	103900	4.52	3.41	3.86	2.64
K30D	0.20	0.05	0.127	0.59	0.27	3950	0.28	0.16	0.21	0.15

Areas	fNuli	fUBLi	gUIRo	gUTRo	oNUQo	oPOPi	oUDRo	oUIRi	oURFo	oUTLo
	Distribution loss factor	Bulk loss factor	Indirect urban use	Total urban water use	Increased runoff due to urban areas	Urban Population	Direct urban use	Indirect urban use	Total Return flows	Total losses
	Factor	Factor	million m^3/a	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
K40A	0.20	0.05	0	0	0.02	0	0	0	0	0
K40B	0.20	0.05	0	0	0.36	0	0	0	0	0
K40C	0.20	0.05	0	0	0.03	0	0	0	0	0
K40D	0.20	0.05	0.048	0.29	0.13	2100	0.16	0.06	0.10	0.07
K40E	0.20	0.05	0.028	0.17	0.14	1750	0.09	0.04	0.05	0.04
K50A	0.20	0.05	0	0	0.06	0	0	0	0	0
K50B	0.20	0.05	0.553	3.32	0	30650	1.78	0.71	1.10	0.83
K60A	0.20	0.05	0	0	0	0	0	0	0	0
K60B	0.20	0.05	0	0	0	0	0	0	0	0
K60C	0.20	0.05	0	0	0	0	0	0	0	0
K60D	0.20	0.05	0	0	0	0	0	0	0	0
K60E	0.20	0.05	0	0	0	0	0	0	0	0
K60F	0.20	0.05	0	0	0	0	0	0	0	0
K60G	0.20	0.05	0.530	2.48	0.03	15600	1.18	0.68	0.90	0.62
K70A	0.20	0.05	0	0	0	0	0	0	0	0
K70B	0.20	0.05	0	0	0.04	0	0	0	0	0
TOTALS	**0.20**	**0.05**	**11.84**	**46.80**	**9.40**	**351500**	**21.40**	**13.70**	**18.18**	**11.70**

GOURITZ WATER MANAGEMENT AREA

APPENDIX F.2

RURAL WATER REQUIREMENTS PER QUATERNARY CATCHMENT

Areas	gRCRo	gRIRo	gRSRo	gRURo	oPORi	oRIRo	oRRFo	oRSUi	oRTLi
	Rural Water consumption rate	1:50 year small scale irrigation	Large stock units consumption rate	Total rural water use	Rural population	Small scale irrigation	Rural return flow	Number of large stock units	Rural loss factor
	ℓ/c/d	million m^3/a	ℓ/u/d	million m^3/a	Number	million m^3/a	million m^3/a	Number	Factor
H80A	105.20	0	45,0	0.09	235	0	0	3446	0.20
H80B	105.20	0	45,0	0.09	290	0	0	2871	0.20
H80C	105.40	0	45,0	0.19	537	0	0	6694	0.20
H80D	105.50	0	45,0	0.15	483	0	0	4933	0.20
H80E	61.30	0	45,0	0.19	581	0	0	6787	0.20
H80F	108.60	0	45,0	0.10	289	0	0	3411	0.20
H90A	105.20	0	45,0	0.13	718	0	0	3006	0.20
H90B	105.20	0	45,0	0.08	378	0	0	2071	0.20
H90C	105.30	0	45,0	0.27	1917	0	0	3699	0.20
H90D	105.70	0	45,0	0.37	1693	0	0	10107	0.20
H90E	106.00	0	45,0	0.25	880	0	0	8310	0.20
J11A	110.70	0	45,0	0.03	125	0	0	447	0.20
J11B	110.70	0	45,0	0.05	131	0	0	1621	0.20
J11C	110.70	0	45,0	0.02	53	0	0	660	0.20
J11D	110.70	0	45,0	0.06	243	0	0	1174	0.20
J11E	95.24	0	45,0	0.14	772	0	0	1833	0.20
J11F	110.70	0	45,0	0.04	197	0	0	777	0.20
J11G	110.70	0	45,0	0.06	260	0	0	1364	0.20
J11H	48.59	0	45,0	0.08	377	0	0	1488	0.20
J11J	110.00	0	45,0	0.15	882	0	0	1387	0.20
J11K	109.90	0	45,0	0.13	754	0	0	1611	0.20
J12A	108.90	0	45,0	0.08	520	0	0	647	0.20
J12B	70.81	0	45,0	0.07	310	0	0	1166	0.20
J12C	70.81	0	45,0	0.05	136	0	0	1808	0.20
J12D	108.90	0	45,0	0.14	446	0	0	4148	0.20
J12E	69.82	0	45,0	0.03	95	0	0	1067	0.20
J12F	108.50	0	45,0	0.08	244	0	0	2613	0.20
J12G	107.40	0	45,0	0.05	111	0	0	1739	0.20
J12H	108.20	0	45,0	0.05	94	0	0	1784	0.20
J12J	107.40	0	45,0	0.24	789	0	0	6576	0.20
J12K	107.40	0	45,0	0.13	134	0	0	5490	0.20
J12L	108.00	0	45,0	0.24	593	0	0	7937	0.20
J12M	108.00	0	45,0	0.13	260	0	0	4929	0.20
J13A	108.60	0	45,0	0.10	243	0	0	3328	0.20
J13B	108.60	0	45,0	0.13	361	0	0	3859	0.20
J13C	108.50	0	45,0	0.12	188	0	0	4612	0.20
J21A	110.90	0	45,0	0.08	340	0	0	2744	0.20
J21B	110.90	0	45,0	0.04	110	0	0	1703	0.20
J21C	110.90	0	45,0	0.04	115	0	0	1690	0.20
J21D	110.90	0	45,0	0.05	150	0	0	2064	0.20
J21E	110.90	0	45,0	0.04	110	0	0	1443	0.20

Areas	gRCRo	gRIRo	gRSRo	gRURo	oPORi	oRIRo	oRRFo	oRSUi	oRTLi
	Rural Water consumption rate	1:50 year small scale irrigation	Large stock units consumption rate	Total rural water use	Rural population	Small scale irrigation	Rural return flow	Number of large stock units	Rural loss factor
	ℓ/c/d	million m^3/a	ℓ/u/d	million m^3/a	Number	million m^3/a	million m^3/a	Number	Factor
J22A	110.90	0	45,0	0.03	57	0	0	1481	0.20
J22B	110.90	0	45,0	0.03	45	0	0	1089	0.20
J22C	110.90	0	45,0	0.03	79	0	0	1172	0.20
J22D	110.90	0	45,0	0.05	107	0	0	2183	0.20
J22E	110.90	0	45,0	0.06	109	0	0	2662	0.20
J22F	110.90	0	45,0	0.12	1292	0	0	652	0.20
J22G	110.90	0	45,0	0.05	95	0	0	1893	0.20
J22H	110.90	0	45,0	0.06	160	0	0	2593	0.20
J22J	110.90	0	45,0	0.03	66	0	0	1212	0.20
J22K	110.90	0	45,0	0.04	120	0	0	1374	0.20
J23A	48.78	0	45,0	0.05	238	0	0	1559	0.20
J23B	110.90	0	45,0	0.04	121	0	0	1617	0.20
J23C	110.90	0	45,0	0.03	65	0	0	1052	0.20
J23D	110.90	0	45,0	0.04	92	0	0	1447	0.20
J23E	109.90	0	45,0	0.02	95	0	0	490	0.20
J23F	110.80	0	45,0	0.03	121	0	0	980	0.20
J23G	110.90	0	45,0	0.01	36	0	0	492	0.20
J23H	110.80	0	45,0	0.02	89	0	0	544	0.20
J23J	110.80	0	45,0	0.02	84	0	0	468	0.20
J24A	110.90	0	45,0	0.05	154	0	0	2054	0.20
J24B	48.78	0	45,0	0.05	120	0	0	2042	0.20
J24C	110.90	0	45,0	0.05	131	0	0	1854	0.20
J24D	103.10	0	45,0	0.05	140	0	0	2017	0.20
J24E	110.90	0	45,0	0.07	429	0	0	1913	0.20
J24F	110.80	0	45,0	0.03	228	0	0	637	0.20
J25A	110.70	0	45,0	0.06	266	0	0	1717	0.20
J25B	56.04	0	45,0	0.19	2013	0	0	1371	0.20
J25C	110.60	0	45,0	0.04	215	0	0	1138	0.20
J25D	109.90	0	45,0	0.07	255	0	0	2509	0.20
J25E	110.60	0	45,0	0.20	1652	0	0	3092	0.20
J31A	110.40	0	45,0	0.10	256	0	0	4181	0.20
J31B	110.40	0	45,0	0.05	110	0	0	2098	0.20
J31C	110.40	0	45,0	0.02	54	0	0	862	0.20
J31D	110.40	0	45,0	0.08	234	0	0	3096	0.20
J32A	110.90	0	45,0	0.02	49	0	0	849	0.20
J32B	110.90	0	45,0	0.05	277	0	0	1628	0.20
J32C	110.90	0	45,0	0.05	111	0	0	1980	0.20
J32D	110.90	0	45,0	0.03	68	0	0	1347	0.20
J32E	95.34	0	45,0	0.12	456	0	0	4573	0.20
J33A	110.40	0	45,0	0.12	449	0	0	4574	0.20
J33B	71.66	0	45,0	0.20	1085	0	0	5811	0.20
J33C	72.06	0	45,0	0.04	260	0	0	906	0.20
J33D	110.00	0	45,0	0.04	357	0	0	899	0.20
J33E	110.10	0	45,0	0.17	1431	0	0	3083	0.20
J33F	110.10	0	45,0	0.25	2412	0	0	3448	0.20

Areas	gRCRo	gRIRo	gRSRo	gRURo	oPORi	oRIRo	oRRFo	oRSUi	oRTLi
	Rural Water consumption rate	1:50 year small scale irrigation	Large stock units consumption rate	Total rural water use	Rural population	Small scale irrigation	Rural return flow	Number of large stock units	Rural loss factor
	ℓ/c/d	million m^3/a	ℓ/u/d	million m^3/a	Number	million m^3/a	million m^3/a	Number	Factor
J34A	97.07	0	45,0	0.09	458	0	0	2638	0.20
J34B	108.50	0	45,0	0.13	718	0	0	3642	0.20
J34C	93.28	0	45,0	0.15	869	0	0	4491	0.20
J34D	93.28	0	45,0	0.14	523	0	0	5224	0.20
J34E	108.50	0	45,0	0.12	596	0	0	3816	0.20
J34F	100.90	0	45,0	0.17	1172	0	0	4027	0.20
J35A	109.90	0	45,0	0.23	2014	0	0	3985	0.20
J35B	101.80	0	45,0	0.35	2722	0	0	7675	0.20
J35C	78.09	0	45,0	0.08	441	0	0	2547	0.20
J35D	98.00	0	45,0	0.18	1114	0	0	4764	0.20
J35E	86.51	0	45,0	0.10	806	0	0	2120	0.20
J35F	94.19	0	45,0	0.24	1644	0	0	5956	0.20
J40A	109.90	0	45,0	0.10	214	0	0	3992	0.20
J40B	109.60	0	45,0	0.14	120	0	0	6463	0.20
J40C	63.53	0	45,0	0.33	1079	0	0	11420	0.20
J40D	86.49	0	45,0	0.43	1429	0	0	14345	0.20
J40E	109.40	0	45,0	0.39	957	0	0	15098	0.20
K10A	108.50	0	45,0	0.18	856	0	0	6058	0.20
K10B	108.50	0	45,0	0.15	568	0	0	5922	0.20
K10C	108.50	0	45,0	0.12	159	0	0	5478	0.20
K10D	85.68	0	45,0	0.18	987	0	0	5672	0.20
K10E	91.78	0	45,0	0.16	1095	0	0	4512	0.20
K10F	92.30	0	45,0	0.14	1017	0	0	3656	0.20
K20A	106.70	0	45,0	0.13	912	0	0	3541	0.20
K30A	113.10	0	45,0	0.22	2393	0	0	2945	0.20
K30B	106.70	0	45,0	0.16	1862	0	0	2079	0.20
K30C	106.70	0	45,0	0.11	888	0	0	2862	0.20
K30D	54.43	0	45,0	0.12	1064	0	0	2656	0.20
K40A	54.43	0	45,0	0.04	263	0	0	1317	0.20
K40B	106.70	0	45,0	0.06	574	0	0	1274	0.20
K40C	46.96	0	45,0	0.08	913	0	0	768	0.20
K40D	106.70	0	45,0	0.12	1354	0	0	1523	0.20
K40E	69.37	0	45,0	0.13	1362	0	0	2029	0.20
K50A	106.70	0	45,0	0.07	558	0	0	1795	0.20
K50B	46.96	0	45,0	0.06	508	0	0	1519	0.20
K60A	106.70	0	45,0	0.07	424	0	0	2153	0.20
K60B	106.70	0	45,0	0.05	322	0	0	1496	0.20
K60C	106.70	0	45,0	0.05	356	0	0	1357	0.20
K60D	32.02	0	45,0	0.07	420	0	0	2141	0.20
K60E	32.02	0	45,0	0.03	287	0	0	754	0.20
K60F	32.02	0	45,0	0.14	1606	0	0	1821	0.20
K60G	32.02	0	45,0	0.11	1262	0	0	1231	0.20
K70A	32.02	0	45,0	0.04	241	0	0	1269	0.20
K70B	106.60	0	45,0	0.01	118	0	0	367	0.20
TOTALS	**98.22**	**0**	45,0	**13.70**	**72664**	**0**	**0**	**384079**	**0.20**

GOURITZ WATER MANAGEMENT AREA

APPENDIX F.3

BULK WATER REQUIREMENTS PER QUATERNARY CATCHMENT

Areas	fBMFi	fBMLi	fBOFi	fBOLi	fBSFi	fBSLi	gBMRo	gBORo	gBSRo	oBMFo	oBMGi	oBMRi	oBOFo	oBOOi	oBSFo	oBSRi
	Return flow factor (mining)	Loss factor (mining)	Return flow factor (other)	Loss factor (other)	Return flow factor (strategic)	Loss factor (strategic)	Mining water use	Other water use	Strategic Water Use	Return flow (mining)	Groundwater decant/mine dewatering	On-site water use (mining)	Return flow (other)	On-site water use (other)	Return flow (strategic)	On-site water use (strategic)
	Factor	Factor	Factor	Factor	Factor	Factor	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	million m^3/a
H80A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H80B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H80C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H80D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H80E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H80F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H90A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H90B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H90C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H90D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
H90E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11G	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11H	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11J	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J11K	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0

Areas	fBMFi	fBMLi	fBOFi	fBOLi	fBSFi	fBSLi	gBMRo	gBORo	gBSRo	oBMFo	oBMGi	oBMRi	oBOFo	oBOOi	oBSFo	oBSRi
	Return flow factor (mining)	Loss factor (mining)	Return flow factor (other)	Loss factor (other)	Return flow factor (strategic)	Loss factor (strategic)	Mining water use	Other water use	Strategic Water Use	Return flow (mining)	Groundwater decant/mine dewatering	On-site water use (mining)	Return flow (other)	On-site water use (other)	Return flow (strategic)	On-site water use (strategic)
	Factor	Factor	Factor	Factor	Factor	Factor	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	million m^3/a
J12C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12G	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12H	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12J	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12K	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12L	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J12M	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J13A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J13B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J13C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J21A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J21B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J21C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J21D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J21E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22G	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22H	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22J	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J22K	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J23A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0

Areas	fBMFi	fBMLi	fBOFi	fBOLi	fBSFi	fBSLi	gBMRo	gBORo	gBSRo	oBMFo	oBMGi	oBMRi	oBOFo	oBOOi	oBSFo	oBSRi
	Return flow factor (mining)	Loss factor (mining)	Return flow factor (other)	Loss factor (other)	Return flow factor (strategic)	Loss factor (strategic)	Mining water use	Other water use	Strategic Water Use	Return flow (mining)	Groundwater decant/mine dewatering	On-site water use (mining)	Return flow (other)	On-site water use (other)	Return flow (strategic)	On-site water use (strategic)
	Factor	Factor	Factor	Factor	Factor	Factor	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	million m^3/a
J23B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J23C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J23D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J23E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J23F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J23G	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J23H	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J23J	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J24A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J24B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J24C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J24D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J24E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J24F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J25A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J25B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J25C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J25D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J25E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J31A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J31B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J31C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J31D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J32A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J32B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J32C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J32D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J32E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J33A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0

Areas	fBMFi	fBMLi	fBOFi	fBOLi	fBSFi	fBSLi	gBMRo	gBORo	gBSRo	oBMFo	oBMGi	oBMRi	oBOFo	oBOOi	oBSFo	oBSRi
	Return flow factor (mining)	Loss factor (mining)	Return flow factor (other)	Loss factor (other)	Return flow factor (strategic)	Loss factor (strategic)	Mining water use	Other water use	Strategic Water Use	Return flow (mining)	Groundwater decant/mine dewatering	On-site water use (mining)	Return flow (other)	On-site water use (other)	Return flow (strategic)	On-site water use (strategic)
	Factor	Factor	Factor	Factor	Factor	Factor	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	million m^3/a
J33B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J33C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J33D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J33E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J33F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J34A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J34B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J34C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J34D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J34E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J34F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J35A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J35B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J35C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J35D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J35E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J35F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J40A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J40B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J40C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J40D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
J40E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K10A	0	0.1	1.0	0.1	0	0.05	0	5.98	0	0	0	0	5.98	0	0	0
K10B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K10C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K10D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K10E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K10F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K20A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0

Areas	fBMFi	fBMLi	fBOFi	fBOLi	fBSFi	fBSLi	gBMRo	gBORo	gBSRo	oBMFo	oBMGi	oBMRi	oBOFo	oBOOi	oBSFo	oBSRi
	Return flow factor (mining)	**Loss factor (mining)**	**Return flow factor (other)**	**Loss factor (other)**	**Return flow factor (strategic)**	**Loss factor (strategic)**	**Mining water use**	**Other water use**	**Strategic Water Use**	**Return flow (mining)**	**Groundwater decant/mine dewatering**	**On-site water use (mining)**	**Return flow (other)**	**On-site water use (other)**	**Return flow (strategic)**	**On-site water use (strategic)**
	Factor	**Factor**	**Factor**	**Factor**	**Factor**	**Factor**	**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**	**million m^3/a**
K30A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K30B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K30C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K30D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K40A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K40B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K40C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K40D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K40E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K50A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K50B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K60A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K60B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K60C	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K60D	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K60E	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K60F	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K60G	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K70A	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
K70B	0	0.1	0	0.1	0	0.05	0	0	0	0	0	0	0	0	0	0
	0		0		0		0	0	0	0	0	0	0	0	0	0
TOTALS	**0**	**0.1**	**1**	**0.1**	**0**	**0.05**	**0**	**5.98**	**0**	**0**	**0**	**0**	**5.98**	**0**	**0**	**0**

GOURITZ 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
	Area under high category crops	Area under low category crops	Area under medium category crops	Green cover area	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 irrigators
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
H80A	0	0.11	0	0.11	25%	25%	25%	0	0.75	0	0.09
H80B	0	2.04	0	2.04	25%	25%	25%	0	0.75	0	1.72
H80C	0	5.27	0	5.27	25%	25%	25%	0	0.75	0	5.88
H80D	0	5.30	0	5.30	25%	25%	25%	0	0.80	0	4.94
H80E	0	0	0	0	25%	25%	25%	0	0	0	0
H80F	0	0	0	0	25%	25%	25%	0	0	0	0
H90A	0	5.18	0	5.18	25%	25%	25%	0	0.75	0	4.59
H90B	0	0.73	0.43	1.16	25%	25%	25%	0	0.75	0.75	1.05
H90C	0	17.63	0	17.63	25%	25%	25%	0	0.75	0	16.22
H90D	0	1.19	0	1.19	25%	25%	25%	0	0.75	0	1.12
H90E	0	0.35	0	0.35	25%	25%	25%	0	0.75	0	0.32
J11A	0	0	0.37	0.92	30%	30%	30%	0	0	0	0
J11B	0	0	0.03	0.07	30%	30%	30%	0	0	0.75	0.01
J11C	0	0	0	0	30%	30%	30%	0	0	0	0
J11D	0	0	2.83	7.08	30%	30%	30%	0	0	0.75	10.64
J11E	0.02	0.07	0.11	0.50	30%	30%	30%	0.85	0.75	0.75	0.71
J11F	0	0.22	0.29	1.27	30%	30%	30%	0	0.75	0.75	1.18
J11G	0	0	0	0	30%	30%	30%	0	0	0	0
J11H	0	0	2.05	6.28	30%	30%	30%	0.85	0	0.75	8.54
J11J	0	0	4.41	23.29	30%	30%	30%	0.75	0	0.75	28.49
J11K	0	0	1.89	5.01	30%	30%	30%	0.85	0	0.75	7.75
J12A	0.04	0.01	0.46	1.27	30%	30%	30%	0.85	0.75	0.75	1.57
J12B	0	0	0	0	30%	30%	30%	0	0	0	0

Quaternary catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	fIPHi	fIPLi	fIPMi	gIARo
	Area under high category crops	Area under low category crops	Area under medium category crops	Green cover area	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 irrigators
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
J12C	0.07	0.03	0.92	2.56	30%	30%	30%	0.85	0.75	0.75	4.77
J12D	0	0	1.71	4.28	30%	30%	30%	0	0	0.75	7.99
J12E	0	0	0	0	30%	30%	30%	0	0	0	0
J12F	0	0	0.68	1.71	30%	30%	30%	0	0	0.75	3.20
J12G	0	0	0	0	30%	30%	30%	0	0	0	0
J12H	0	0	0.97	2.43	30%	30%	30%	0	0	0.75	4.22
J12J	2.70	0	0	6.76	30%	30%	30%	0.85	0	0	7.54
J12K	0	0	0.52	1.29	30%	30%	30%	0	0	0.75	1.95
J12L	0.66	0	0.92	3.94	30%	30%	30%	0.84	0	0.75	5.02
J12M	0.04	2.30	1.59	9.83	30%	30%	30%	0.75	0.75	0.75	13.08
J13A	0	1.07	1.01	5.21	30%	30%	30%	0	0.75	0.75	7.23
J13B	0	0.74	0.41	2.86	30%	30%	30%	0	0.75	0.75	3.93
J13C	0	3.78	0.80	11.46	30%	30%	30%	0	0.75	0.75	13.76
J21A	0	0	2.17	2.29	30%	30%	30%	0	0	0.75	4.04
J21B	0	0	0.17	0.18	30%	30%	30%	0	0	0.75	0.30
J21C	0	0	0.14	0.15	30%	30%	30%	0	0	0.75	0.25
J21D	0	0	0.48	0.51	30%	30%	30%	0	0	0.75	0.84
J21E	0	0	0.23	0.24	30%	30%	30%	0	0	0.75	0.39
J22A	0	0	0	0	30%	30%	30%	0	0	0	0
J22B	0	0	0.06	0.07	30%	30%	30%	0	0	0.75	0.11
J22C	0	0	0	0	30%	30%	30%	0	0	0	0
J22D	0	0	0.10	0.11	30%	30%	30%	0	0	0.75	0.17
J22E	0	0	0.23	0.24	30%	30%	30%	0	0	0.75	0.38
J22F	0	0	0.50	0.53	30%	30%	30%	0	0	0.75	0.88
J22G	0	0	0	0	30%	30%	30%	0	0	0	0
J22H	0	0	0	0	30%	30%	30%	0	0	0	0
J22J	0	0	0.09	0.10	30%	30%	30%	0	0	0.75	0.16
J22K	0	0	3.34	3.52	30%	30%	30%	0	0	0.75	6.02

Quaternary catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	fIPHi	fIPLi	fIPMi	gIARo
	Area under high category crops	Area under low category crops	Area under medium category crops	Green cover area	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 irrigators
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
J23A	0	0	6.58	6.93	30%	30%	30%	0	0	0.75	11.52
J23B	0	0	1.15	1.21	30%	30%	30%	0	0	0.75	1.90
J23C	0	0	0	0	30%	30%	30%	0	0	0	0
J23D	0	0	0	0	30%	30%	30%	0	0	0	0
J23E	0	0	4.77	5.02	30%	30%	30%	0	0	0.75	7.02
J23F	0.35	0	3.90	4.47	30%	30%	30%	0.85	0	0.75	6.62
J23G	0	0	0	0	30%	30%	30%	0	0	0	0
J23H	1.24	0	0	1.31	30%	30%	30%	0.85	0	0	1.47
J23J	1.44	0	0	1.52	30%	30%	30%	0.85	0	0	1.60
J24A	0	0	0	0	30%	30%	30%	0	0	0	0
J24B	0	0	0	0	30%	30%	30%	0	0	0	0
J24C	0	0	0	0	30%	30%	30%	0	0	0	0
J24D	0	0	0	0	30%	30%	30%	0	0	0	0
J24E	0	0	0	0	30%	30%	30%	0	0	0	0
J24F	0	0	1.15	1.22	30%	30%	30%	0	0	0.75	1.83
J25A	0	0	0	0	30%	30%	30%	0	0	0	0
J25B	6.39	0	0	6.73	30%	30%	30%	0	0	0	0
J25C	2.28	0	0	2.40	30%	30%	30%	0.75	0	0	2.21
J25D	4.94	0	0	5.20	30%	30%	30%	0	0	0	0
J25E	18.14	0	0	19.09	30%	30%	30%	0	0	0	0
J31A	0	0	0.19	0.85	30%	30%	30%	0	0	0.80	0.95
J31B	0	0	0	0.01	30%	30%	30%	0	0	0.80	0.01
J31C	0	0	0.27	1.23	30%	30%	30%	0	0	0.80	1.56
J31D	0	0	0.32	1.44	30%	30%	30%	0	0	0.80	1.84
J32A	0	0	0	0	30%	30%	30%	0	0	0	0
J32B	0	0	0.10	0.47	30%	30%	30%	0	0	0	0
J32C	0	0	0.09	0.39	30%	30%	30%	0	0	0	0
J32D	0	0	0.05	0.24	30%	30%	30%	0	0	0	0
J32E	0	0	0.29	1.30	30%	30%	30%	0	0	0	0

Quaternary catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	fIPHi	fIPLi	fIPMi	gIARo
	Area under high category crops	Area under low category crops	Area under medium category crops	Green cover area	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 irrigators
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
J33A	0	0	0.73	3.32	30%	30%	30%	0	0	0	0
J33B	0	0	3.64	16.53	30%	30%	30%	0	0	0.75	22.45
J33C	0	0	1.62	7.36	30%	30%	30%	0	0	0.75	10.47
J33D	0	0	0.75	3.40	30%	30%	30%	0	0	0.75	4.72
J33E	0	0	2.52	11.47	30%	30%	30%	0	0	0	0
J33F	0	0	7.07	32.15	30%	30%	30%	0	0	0	0
J34A	0	0	0.37	1.66	30%	30%	30%	0	0	0.80	0.20
J34B	0	0	0.61	2.78	30%	30%	30%	0	0	0.80	0
J34C	0	0	0.93	4.25	30%	30%	30%	0	0	0	0
J34D	0	0	0.33	1.49	30%	30%	30%	0	0	0	0
J34E	0	0	0.58	2.64	30%	30%	30%	0	0	0	0
J34F	0	0	4.95	22.50	30%	30%	30%	0	0	0	0
J35A	0	0	1.76	8.01	30%	30%	30%	0	0	0	0
J35B	0	0	10.52	47.81	30%	30%	30%	0	0	0.75	67.40
J35C	0	0	1.19	5.40	30%	30%	30%	0	0	0	0
J35D	0	0	3.73	16.97	30%	30%	30%	0	0	0	0
J35E	0	0	1.86	8.47	30%	30%	30%	0	0	0	0
J35F	0	0	3.49	15.85	30%	30%	30%	0	0	0.75	23.86
J40A	0	0	0.86	0.86	25%	25%	25%	0	0	0.75	1.32
J40B	0	0.08	0.52	0.60	25%	25%	25%	0	0.75	0.75	0.84
J40C	0	13.21	0	13.21	25%	25%	25%	0	0.75	0	14.90
J40D	0	1.19	0	1.19	25%	25%	25%	0	0.75	0	1.35
J40E	0	7.96	0.56	8.52	25%	25%	25%	0	0.75	0.75	9.78
K10A	0	0	0	0	0%	0%	0%	0	0	0	0
K10B	0	2.50	0	2.50	0%	0%	0%	0	0.75	0.75	2.32
K10C	0	5.24	0	5.24	0%	0%	0%	0	0.75	0.75	5.15
K10D	0	0	6.65	6.65	0%	0%	0%	0	0	0.75	7.10
K10E	0	0	0.98	0.98	0%	0%	0%	0	0	0.75	0.96
K10F	0	0	4.06	4.06	0%	0%	0%	0	0	0.75	3.89

Quaternary catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	fIPHi	fIPLi	fIPMi	gIARo
	Area under high category crops	Area under low category crops	Area under medium category crops	Green cover area	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 irrigators
	km^2	km^2	km^2	km^2	Factor	Factor	Factor	Factor	Factor	Factor	million m^3/a
K20A	0	0	0	0	0%	0%	0%	0	0	0	0
K30A	0	0	0	0	0%	0%	0%	0	0	0	0
K30B	0	0	0	0	0%	0%	0%	0	0	0	0
K30C	0	0	0	0	0%	0%	0%	0	0	0	0
K30D	0	0	5.05	5.05	0%	0%	0%	0	0	0.75	3.58
K40A	0	0	0.32	0.32	0%	0%	0%	0	0	0.75	0.23
K40B	0	3.61	3.86	7.47	0%	0%	0%	0	0.75	0.75	4.81
K40C	0	0.36	0.19	0.54	0%	0%	0%	0	0.75	0.75	0.35
K40D	0	0	2.71	2.71	0%	0%	0%	0	0	0.75	1.81
K40E	0	1.26	1.90	3.16	0%	0%	0%	0	0.75	0.75	1.92
K50A	0	1.90	0	1.90	0%	0%	0%	0	0.75	0	0.86
K50B	0	0	0	0	0%	0%	0%	0	0	0	0
K60A	0	0	2.77	2.77	0%	0%	0%	0	0	0	0
K60B	0	0	1.11	1.11	0%	0%	0%	0	0	0	0
K60C	0	0	2.76	2.76	0%	0%	0%	0	0	0	0
K60D	0	0	0	0	0%	0%	0%	0	0	0	0
K60E	0	0	9.41	9.41	0%	0%	0%	0	0	0	0
K60F	0	0	10.65	10.65	0%	0%	0%	0	0	0	0
K60G	0	0	2.88	2.88	0%	0%	0%	0	0	0.80	0.35
K70A	0	0	0	0	0%	0%	0%	0	0	0	0
K70B	0	0	1.81	1.81	0%	0%	0%	0	0	0.75	0.61
TOTALS	**38.31**	**83.32**	**154.49**	**513.60**	**23%**	**23%**	**23%**	**0.08**	**0.16**	**0.36**	**410.79**

GOURITZ WATER MANAGEMENT AREA

APPENDIX F.5

STREAMFLOW REDUCTION ACTIVITY (SFRA) WATER REQUIREMENTS PER QUATERNARY CATCHMENT

Quaternary catchment	aAAAi	aCAUi	aFCAi	aFINi	oARDo	oCRDo	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
H80A	2.32	0	0.40	0.00	0.45	0	0.05	0
H80B	2.02	0	3.39	0.45	0.52	0	0.80	0
H80C	2.39	0	0.00	0.00	0.13	0	0.00	0
H80D	8.27	0	0.00	0.00	0.35	0	0.00	0
H80E	85.26	0	0.00	0.00	6.71	0	0.00	0
H80F	44.57	0	0.00	0.00	5.84	0	0.00	0
H90A	12.69	0	6.31	0.00	3.14	0	1.11	0
H90B	6.66	0	16.92	0.00	1.37	0	2.61	0
H90C	7.71	0	0.00	0.00	0.49	0	0.00	0
H90D	111.10	0	0.00	0.00	5.97	0	0.00	0
H90E	149.20	0	0.00	0.00	12.37	0	0.00	0
J11A	0.00	0	0.00	0.00	0.00	0	0.00	0
J11B	0.00	0	0.00	0.00	0.00	0	0.00	0
J11C	0.00	0	0.00	0.00	0.00	0	0.00	0
J11D	0.00	0	0.00	0.00	0.00	0	0.00	0
J11E	0.00	0	0.00	0.00	0.00	0	0.00	0
J11F	0.16	0	0.00	0.00	0.00	0	0.00	0
J11G	0.18	0	0.00	0.00	0.00	0	0.00	0
J11H	0.03	0	0.00	0.00	0.00	0	0.00	0
J11J	0.12	0	0.00	0.00	0.00	0	0.00	0
J11K	1.17	0	0.00	0.00	0.02	0	0.00	0
J12A	1.23	0	0.00	0.00	0.06	0	0.00	0
J12B	0.60	0	0.00	0.00	0.01	0	0.00	0
J12C	0.00	0	0.00	0.00	0.00	0	0.00	0
J12D	0.00	0	0.00	0.00	0.00	0	0.00	0
J12E	0.00	0	0.00	0.00	0.00	0	0.00	0
J12F	0.00	0	0.00	0.00	0.00	0	0.00	0
J12G	0.00	0	0.00	0.00	0.00	0	0.00	0
J12H	4.38	0	0.00	0.00	0.04	0	0.00	0
J12J	0.00	0	0.00	0.00	0.00	0	0.00	0
J12K	0.00	0	0.00	0.00	0.00	0	0.00	0
J12L	0.23	0	0.00	0.00	0.01	0	0.00	0
J12M	10.49	0	0.65	0.00	0.21	0	0.00	0
J13A	40.47	0	0.00	0.00	0.84	0	0.00	0
J13B	51.17	0	0.00	0.00	1.10	0	0.00	0
J13C	46.28	0	0.00	0.00	1.22	0	0.00	0
J21A	12.82	0	0.00	0.00	0.42	0	0.00	0
J21B	0.14	0	0.00	0.00	0.00	0	0.00	0
J21C	0.22	0	0.00	0.00	0.00	0	0.00	0
J21D	0.12	0	0.00	0.00	0.00	0	0.00	0

Quaternary catchment	aAAAi	aCAUi	aFCAi	aFINi	oARDo	oCRDo	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
J21E	0.00	0	0.00	0.00	0.00	0	0.00	0
J22A	0.00	0	0.00	0.00	0.00	0	0.00	0
J22B	3.46	0	0.00	0.00	0.14	0	0.00	0
J22C	0.00	0	0.00	0.00	0.00	0	0.00	0
J22D	0.00	0	0.00	0.00	0.00	0	0.00	0
J22E	0.00	0	0.00	0.00	0.00	0	0.00	0
J22F	5.93	0	0.00	0.00	0.78	0	0.00	0
J22G	0.00	0	0.00	0.00	0.00	0	0.00	0
J22H	0.00	0	0.00	0.00	0.00	0	0.00	0
J22J	0.00	0	0.00	0.00	0.00	0	0.00	0
J22K	0.00	0	0.00	0.00	0.00	0	0.00	0
J23A	3.20	0	0.00	0.00	0.04	0	0.00	0
J23B	0.08	0	0.00	0.00	0.00	0	0.00	0
J23C	1.76	0	0.00	0.00	0.03	0	0.00	0
J23D	0.00	0	0.00	0.00	0.00	0	0.00	0
J23E	0.00	0	0.00	0.00	0.00	0	0.00	0
J23F	4.12	0	0.00	0.00	0.08	0	0.00	0
J23G	0.00	0	0.00	0.00	0.00	0	0.00	0
J23H	2.47	0	0.00	0.00	0.05	0	0.00	0
J23J	2.29	0	0.00	0.00	0.10	0	0.00	0
J24A	0.00	0	0.00	0.00	0.00	0	0.00	0
J24B	0.00	0	0.00	0.00	0.00	0	0.00	0
J24C	0.59	0	0.00	0.00	0.01	0	0.00	0
J24D	0.00	0	0.00	0.00	0.00	0	0.00	0
J24E	0.92	0	0.00	0.00	0.01	0	0.00	0
J24F	4.16	0	0.00	0.00	0.03	0	0.00	0
J25A	4.18	0	0.00	0.00	0.17	0	0.00	0
J25B	1.09	0	0.00	0.00	0.05	0	0.00	0
J25C	2.87	0	0.00	0.00	0.01	0	0.00	0
J25D	0.00	0	0.00	0.00	0.00	0	0.00	0
J25E	17.73	0	0.00	0.00	0.01	0	0.00	0
J31A	0.71	0	0.00	0.00	0.03	0	0.00	0
J31B	9.22	0	0.00	0.00	0.24	0	0.00	0
J31C	0.00	0	0.00	0.00	0.00	0	0.00	0
J31D	6.50	0	0.00	0.00	0.10	0	0.00	0
J32A	0.00	0	0.00	0.00	0.00	0	0.00	0
J32B	0.00	0	0.00	0.00	0.00	0	0.00	0
J32C	0.00	0	0.00	0.00	0.00	0	0.00	0
J32D	0.00	0	0.00	0.00	0.00	0	0.00	0
J32E	1.14	0	0.00	0.00	0.01	0	0.00	0
J33A	7.81	0	0.00	0.00	0.18	0	0.00	0
J33B	9.82	0	0.00	0.00	0.25	0	0.00	0
J33C	0.03	0	0.00	0.00	0.00	0	0.00	0
J33D	0.35	0	0.00	0.00	0.03	0	0.00	0
J33E	2.88	0	0.00	0.00	0.22	0	0.00	0
J33F	15.67	0	0.00	0.00	0.34	0	0.00	0

Quaternary catchment	aAAAi	aCAUi	aFCAi	aFINi	oARDo	oCRDo	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
J34A	47.21	0	0.00	0.00	1.79	0	0.00	0
J34B	18.25	0	0.00	0.00	0.94	0	0.00	0
J34C	38.02	0	1.12	0.00	2.87	0	0.07	0
J34D	25.11	0	0.00	0.00	0.86	0	0.00	0
J34E	2.58	0	0.00	0.00	0.09	0	0.00	0
J34F	1.40	0	0.00	0.00	0.04	0	0.00	0
J35A	0.00	0	0.00	0.00	0.00	0	0.00	0
J35B	16.41	0	0.00	0.00	0.27	0	0.00	0
J35C	4.61	0	0.00	0.00	0.09	0	0.00	0
J35D	0.00	0	0.00	0.00	0.00	0	0.00	0
J35E	0.00	0	0.00	0.00	0.00	0	0.00	0
J35F	17.01	0	0.00	0.00	0.02	0	0.00	0
J40A	0.23	0	0.00	0.00	0.02	0	0.00	0
J40B	1.49	0	0.07	0.00	0.13	0	0.01	0
J40C	0.92	0	0.00	0.00	0.10	0	0.00	0
J40D	9.44	0	0.00	0.00	0.58	0	0.00	0
J40E	83.07	0	0.00	0.00	5.04	0	0.00	0
K10A	0.00	0	0.00	0.00	0.00	0	0.00	0
K10B	0.00	0	0.00	0.00	0.00	0	0.00	0
K10C	0.33	0	7.59	0.00	0.03	0	0.53	0
K10D	0.00	0	0.00	0.00	0.00	0	0.00	0
K10E	11.75	0	25.66	0.00	1.90	0	4.63	0
K10F	0.00	0	0.39	0.00	0.00	0	0.02	0
K20A	0.55	0	28.81	0.00	0.12	0	5.11	0
K30A	0.10	0	25.89	0.00	0.03	0	4.63	0
K30B	0.81	0	19.17	0.00	0.21	0	3.62	0
K30C	14.51	0	34.92	0.00	3.20	0	7.05	0
K30D	12.57	0	22.20	0.00	2.63	0	3.70	0
K40A	2.39	0	42.73	0.00	0.49	0	7.47	0
K40B	6.69	0	27.71	0.00	1.46	0	4.39	0
K40C	2.21	0	19.69	0.00	0.35	0	3.05	0
K40D	13.93	0	36.63	0.00	2.21	0	6.34	0
K40E	38.56	0	54.79	0.00	8.05	0	6.22	0
K50A	14.53	0	57.20	0.00	2.95	0	7.92	0
K50B	15.91	0	48.27	15.97	4.43	0	6.37	0
K60A	27.91	0	0.00	0.00	2.58	0	0.00	0
K60B	33.95	0	0.00	0.00	4.25	0	0.00	0
K60C	4.17	0	11.17	0.00	0.58	0	1.37	0
K60D	130.30	0	2.79	0.00	20.00	0	0.33	0
K60E	8.20	0	15.80	0.00	0.96	0	1.50	0
K60F	0.38	0	41.93	0.00	0.05	0	3.20	0
K60G	2.77	0	30.58	0.71	0.38	0	2.47	0
K70A	27.26	0	12.17	0.00	4.33	0	0.98	0
K70B	11.00	0	5.99	0.78	3.08	0	1.36	0
TOTALS	**1357.51**	**0**	**600.94**	**17.91**	**121.26**	**0.00**	**86.89**	**0.00**

APPENDIX F.6

WESTERN 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. 2949b/ 7970

April 2000

WESTERN CAPE WATER RESOURCES SITUATION ASSESSMENT

WORKSHOP ON ECOLOGICAL FLOW REQUIREMENTS PHASE 2: NOTES ON PROCEEDINGS

CONTENTS

1.	**INTRODUCTION**	1
1.1	BACKGROUND	1
1.2	PARTICIPANTS	1
1.3	PURPOSE AND STRUCTURE OF THIS REPORT	2
2.	**METHODOLOGY**	3
2.1	INTRODUCTION	3
2.2	QUATERNARY CATCHMENT GROUPINGS	3
3.	**RESULTS**	9
3.1	INTRODUCTION	9
3.2	MANAGEMENT CLASSES	9
4.	**DISCUSSION**	14
4.1	COMMENTS BY PARTICIPANTS	14
5.	**CONCLUSIONS**	16
5.1	CONCLUSIONS	16
REFERENCES		17

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

The Western 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

A two day workshop was held and a number of experts representing various disciplines relating to rivers and people knowledgeable of the Western Cape rivers were invited to attend. The workshop was held on 15 and 16 July 1999 at Ninham Shand in Cape Town and was facilitated by Mike Luger of Ninham Shand's Environmental Section. The delegates who took part in the workshop were as follows:

- Cate Brown of Southern Waters
- Rebecca Tharme of the Freshwater Research Unit at the University of Cape Town
- Charlie Boucher of Stellenbosch University's Botany Department
- Dean Impson of Cape Nature Conservation
- Wietsche Roets of Cape Nature Conservation
- Neels Kleynhans of DWAF (IWQS)
- Gareth McConkey of DWAF Water Quality Management (Western Cape Region)
- Gerrit van Zyl of DWAF (Western Cape Region)
- Jan van Staden of DWAF (Western Cape Region)
- Mike Luger of Ninham Shand
- Susie Tyson of Ninham Shand
- Liesl Nettmann 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 Western 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.

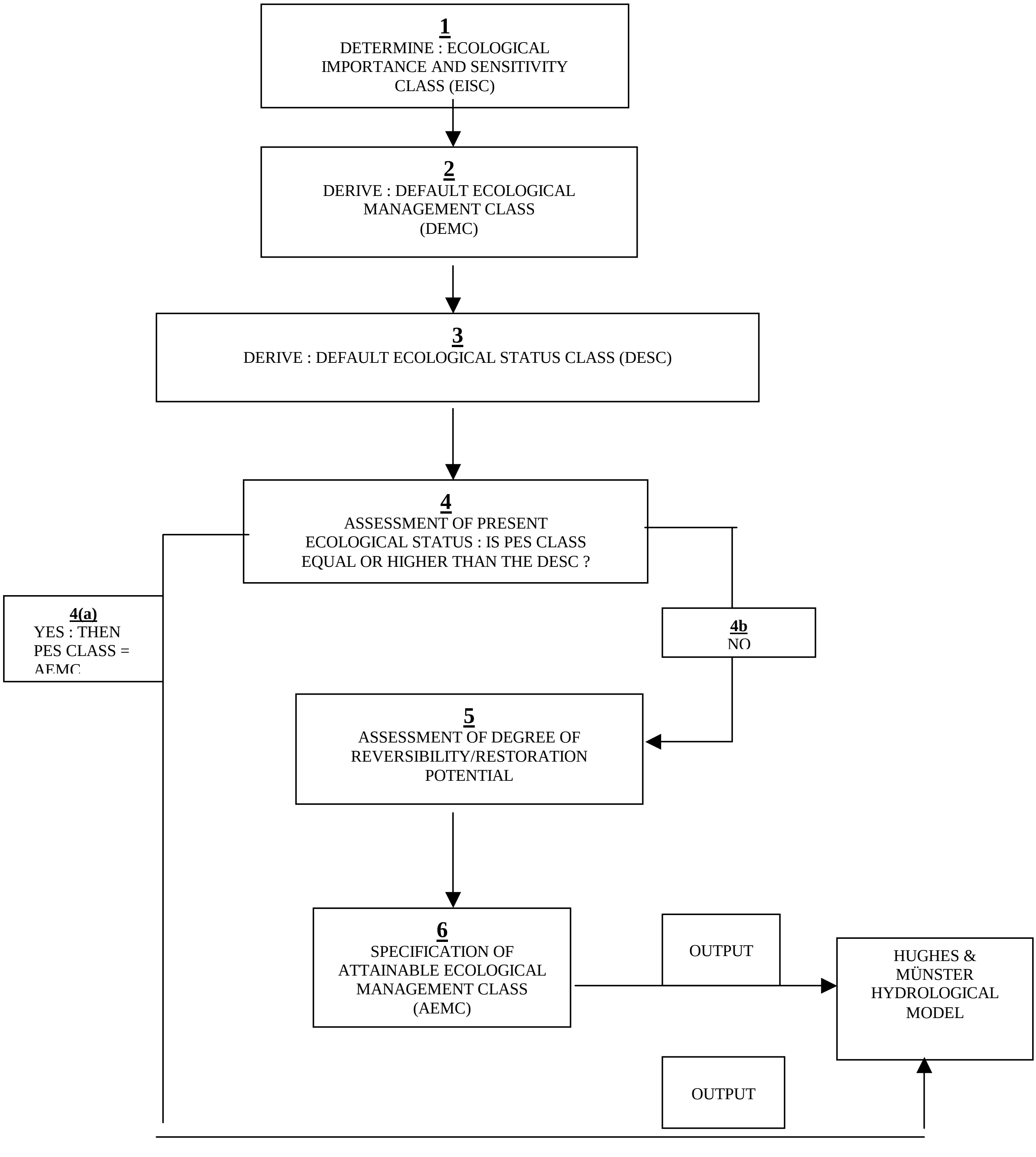


Figure 2.1 Flow diagram indicating the sequence of steps proposed for the determination of the Attainable Ecological Management Class.

- E10A, E10B
- E10C
- E10D, E10E, E10F, E10G, E10J
- E10K (gorge section and below)
- E21A, E21B, E21C, E21D
- E21E, E21F, E21G, E21H, E21J, E21K, E21L, E24A, E24B
- E22A, E22B, E22C, E22D, E22E, E22F, E23A, E23B, E23C, E23D, E23E, E23F, E23G, E23H, E23J, E23K, E24C, E24E, E24F, E24G, E24K
- E22G
- E24L, E24M, E24J, E24H
- E32A, E31B, E31C
- E33A, E33B, E33C, E33D, E31D, E31E, E31F, E31G, E31H, E32B, E32C, E32D, E32E
- E33F, E33G, E33H
- E40A, E40B
- E40C, E40D
- F60A, F60B, F60C, F60D, F60E, F40A, F40B, F40C, F40D, F40E, F40F, F40G, F40H, F50A, F50B, F50C, F50D, F50E, F50F, F50G
- G10A, G10B
- G10C
- G10D, G10F

- G10J (alone due to the presence of a downstream dam)
- G10E
- G10G
- G10L
- G10H
- G10K
- G10M (no rivers)
- G21A
- G21B
- G21D, G21C, G21E
- G21F
- G22A, G22B
- G22C, G22D
- G22E, G22G, G22H, G22J, G22K
- G22F
- G30B, G30C, G30D, G10H
- G30E, G30F, G30A
- G30G
- G30H (no rivers)
- G40A, G40B, G40D

- G40C
- G40E, G40F, G40G
- G40H, G40J, G40K, G40L
- G40M, G50A, G50B, G50C, G50D, G50E, G50F
- G50G, G50H, G50K
- G50J (no rivers)

- H10A, H10B, H10C
- H10D
- H10F, H10G
- H10E
- H10J, H10K
- H10L, H10H, H40C, H40D, H40E (mainstem of Breede River, before and after Hex River)
- H20A, H20B, H20C, H20D, H20E, H20F, H20G, H20H
- H30A, H30B
- H30E
- H40A, H40B, H30C, H30D
- H40F, H40G, H40H, H40J, H40K, H40L
- H50A, H50B, H70A
- H60A, H60B, H60C
- H60D, H60E, H60F, H60G, H60H

- H60J, H60K, H60L
- H70B, H70C, H70D, H70E, H70F
- H70G, H70H, H70J, H70K
- H80A, H80B, H80C, H90A, H90B, H90C
- H80D, H80E, H80F

- J11A, J11B, J11C, J11D, J11E, J11F, J11G, J11H, J11K, J12A, J12B, J12C, J12D, J12E, J12F, J12G, J12H, J12J, J12K, J12L, J12M, J13A, J13B, J13C (no data available for EI&SC)
- J11J
- J22A, J22B, J22C, J22D, J22E, J22F, J22G, J22H, J22J, J22K, J21A, J21B, J21C, J21D, J21E, J24A, J24B, J24C, J24D, J24E, J24F, J23A, J23B, J23C, J23D, J23E, J23F, J23G, J23H, J32A, J32B, J32C, J32D, J32E, J31A, J31B, J31C, J31D
- J23J, J25A, J25B, J25C, J25D (possibly B/ A due to pristine nature of tributaries and rugged terrain)
- J25E, J35A, J35B, J35C, J35D, J35E, J35F, J33A, J33B, J33C, J33D, J33E, J33F
- J34A, J34B, J34C, J34D, J34E, J34F
- J40A, J40B, J40C, J40D, J40E

- K10A, K10B, K10C, K10D, K10E, K10F, K20A, K30A, K30B, K30C
- K30D, K40A, K40B, K40C, K40D, K40E, K50A, K50B, K60A, K60B, K60C, K60D, K60E, K60F, K60G, K70A, K70B

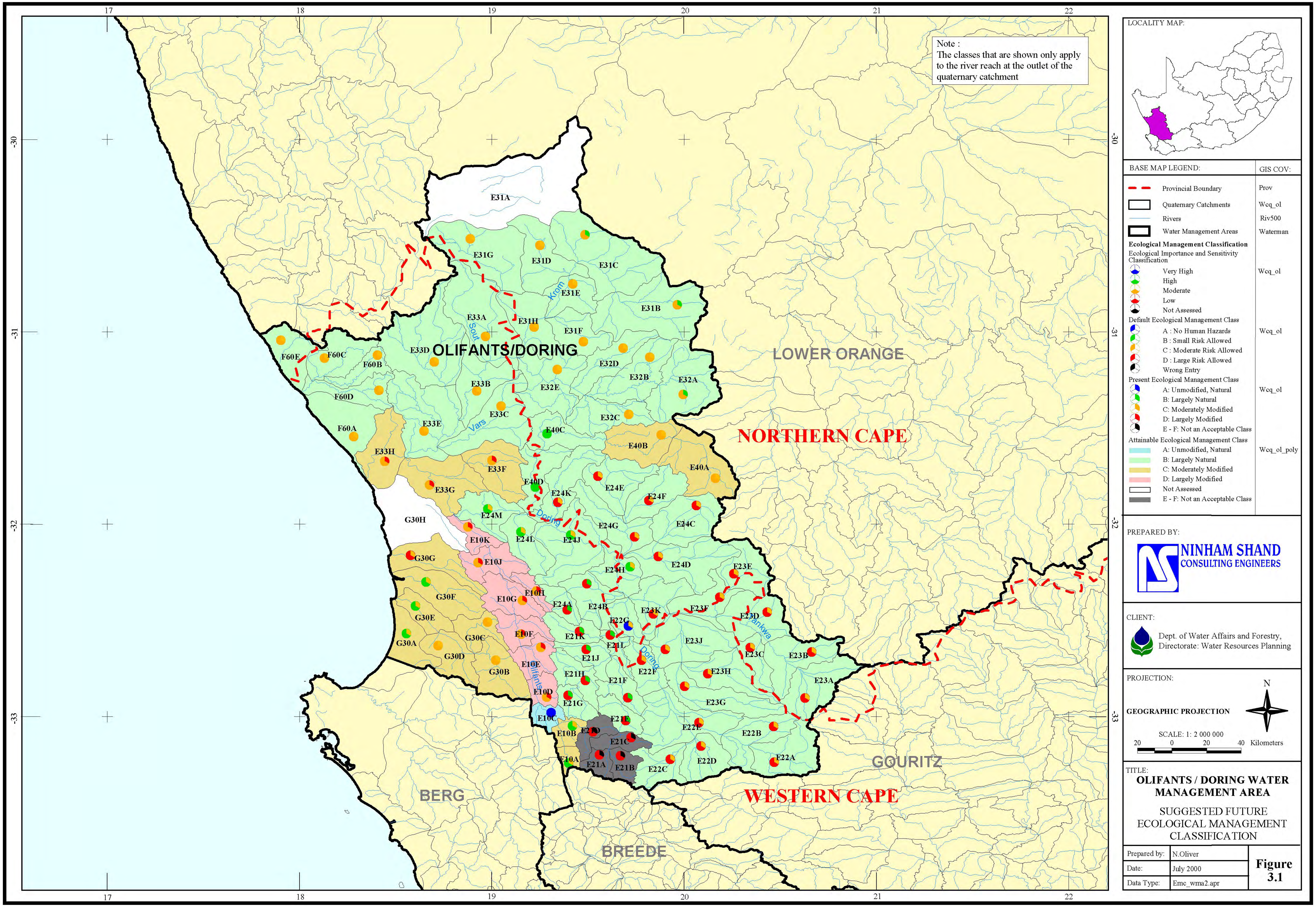
CHAPTER 3: RESULTS OF THE WORKSHOP

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 Western Cape.

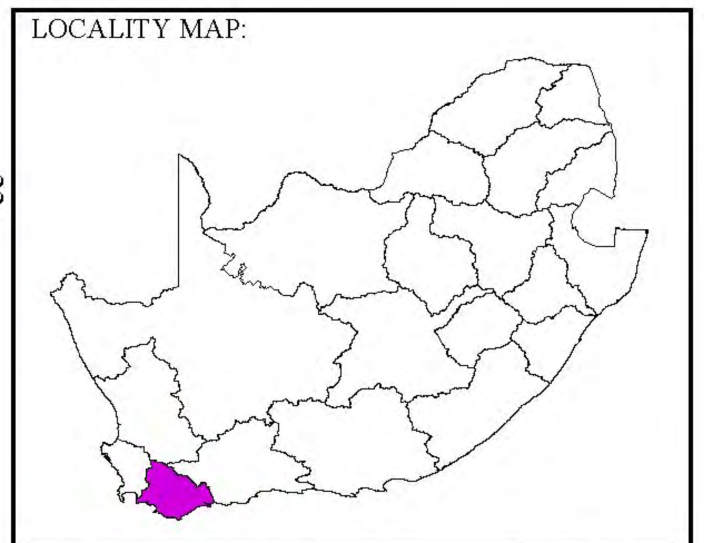
3.2 MANAGEMENT CLASSES

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 3.4) 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
OLIFANTS/DORING
LOWER ORANGE
NORTHERN CAPE
WESTERN CAPE
GOURITZ
BERG
BREEDE
LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
Provincial Boundary
Prov
Quaternary Catchments
Wcq_ol
Rivers
Riv500
Water Management Areas
Waterman
Ecological Management Classification
Ecological Importance and Sensitivity Classification
Very High
High
Moderate
Low
Not Assessed
Wcq_ol
Default Ecological Management Class
A : No Human Hazards
B : Small Risk Allowed
C : Moderate Risk Allowed
D : Large Risk Allowed
Wrong Entry
Wcq_ol
Present Ecological Management Class
A: Unmodified, Natural
B: Largely Natural
C: Moderately Modified
D: Largely Modified
E - F: Not an Acceptable Class
Wcq_ol
Attainable Ecological Management Class
A: Unmodified, Natural
B: Largely Natural
C: Moderately Modified
D: Largely Modified
Not Assessed
E - F: Not an Acceptable Class
Wcq_ol_poly
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:
OLIFANTS / DORING WATER MANAGEMENT AREA
SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASSIFICATION
Prepared by: N.Oliver
Date: July 2000
Data Type: Emc_wma2.apr
Figure 3.1


Note :
The classes that are shown only apply to the river reach at the outlet of the quaternary catchment
WESTERN CAPE
OLIFANTS / DOORN
BERG
GOURITZ
BREEDE
G30A
G10K
G10M
G10H
G10G
G10J
G10L
G10E
G10F
G21A
G21C
G21D
G10D
G21B
G21E
G21F
G10C
G10B
G22G
G22C
G10A
G22B
G22E
G22H
G22F
G22D
G22J
G22K
G40A
G22A
18
19
-33
-34
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
Wcqpnt1_berg_geo
Very High
High
Moderate
Low
Not Assessed
Default Ecological Management Class
Wcqpnt1_berg_geo
A : No Human Hazards
B : Small Risk Allowed
C : Moderate Risk Allowed
D : Large Risk Allowed
Wrong Entry
Present Ecological Status Class
Wcqpnt1_berg_geo
A: Unmodified, Natural
B: Largely Natural
C: Moderately Modified
D: Largely Modified
E - F: Not an Acceptable Class
Attainable Ecological Management Class
Wcqberg_sass_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:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
GEOGRAPHIC PROJECTION
N
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
TITLE:
BERG WATER MANAGEMENT AREA
SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASSIFICATION
Prepared by: N.Oliver
Date: July 2000
Data Type: Environmental.apr
Figure 3.2

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	Wcqpnt_brde_geo
Very High	
High	
Moderate	
Low	
Not Assessed	
Default Ecological Management Class	Wcqpnt -brde_geo
A : No Human Hazards	
B : Small Risk Allowed	
C : Moderate Risk Allowed	
D : Large Risk Allowed	
Wrong Entry	
Present Ecological Management Class	Wcqpnt_brde_geo
A: Unmodified, Natural	
B: Largely Natural	
C: Moderately Modified	
D: Largely Modified	
E - F: Not an Acceptable Class	
Attainable Ecological Management Class	Wcqpoly_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: 1 000 000

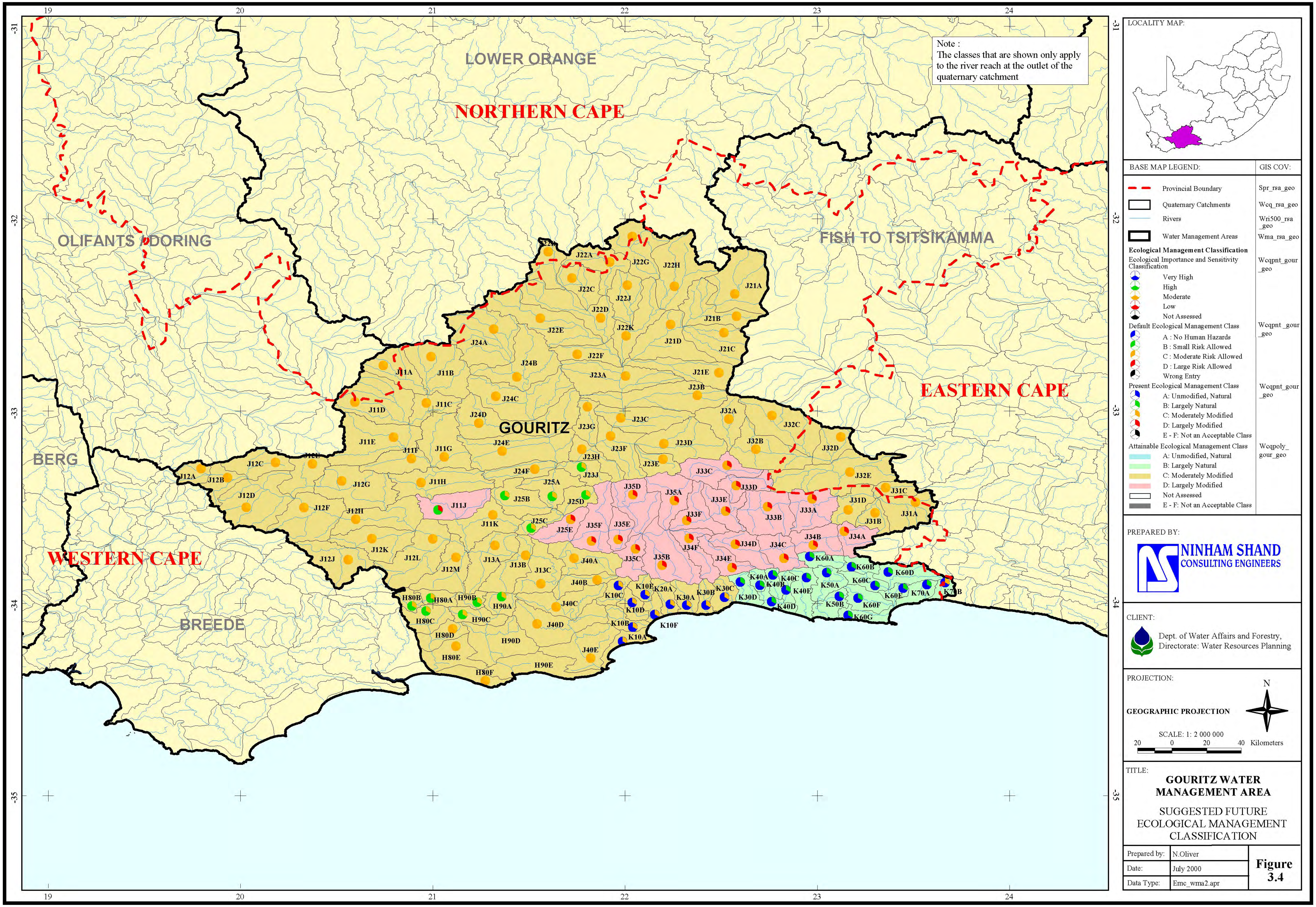
10 0 10 20 Kilometers

TITLE:

BREEDE WATER MANAGEMENT AREA

SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASSIFICATION

Prepared by:	N.Oliver	**Figure 3.3**
Date:	July 2000	
Data Type:	Eme_wma2.apr	



LOWER ORANGE
NORTHERN CAPE
OLIFANTS / DORING
FISH TO TSITSIKAMMA
EASTERN CAPE
GOURITZ
BERG
WESTERN CAPE
BREEDE
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
Wcq_rsa_geo
Rivers
Wri500_rsa_geo
Water Management Areas
Wma_rsa_geo
Ecological Management Classification
Ecological Importance and Sensitivity Classification
Wcqpnt_gour_geo
Very High
High
Moderate
Low
Not Assessed
Default Ecological Management Class
Wcqpnt_gour_geo
A : No Human Hazards
B : Small Risk Allowed
C : Moderate Risk Allowed
D : Large Risk Allowed
Wrong Entry
Present Ecological Management Class
Wcqpnt_gour_geo
A: Unmodified, Natural
B: Largely Natural
C: Moderately Modified
D: Largely Modified
E - F: Not an Acceptable Class
Attainable Ecological Management Class
Wcqpoly_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 3.4

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 Western Cape rivers.

- Accuracy of assessments was facilitated by the diverse number of experts involved in the decision-making process. However, it was viewed by some that in most cases only one expert per field was present which makes it difficult to verify the results obtained.

- A lack of knowledge of inland and middle-eastern (e.g. the Klein Karoo) areas as well as the Gouritz area has made it difficult to assess these areas accurately. The concern is that this will affect the overall accuracy of the results obtained. An in-depth study of the unfamiliar areas is necessary to improve the data. Areas rated with a confidence level of “1" or “2" are those quaternaries where there is a lack of information.

- A request by participants is that the information contained in the water quality database, as well as other information regarding the issues concerned, be expanded and made available for detailed research.

- The scoring system is regarded as being easy to use and general consensus regarding areas discussed was reached within a short time frame. However, greater clarification regarding the confidence scoring system is necessary in order to facilitate evaluation.

- The upgrading of rivers to a higher class is decided by the possible improvement of flow modification. This leaves doubt as to how the other criteria should be addressed. It was felt that by removing invasive vegetation and reducing bulldozing of river beds flow would improve, yet these options were not addressed. Very few rivers have the potential to be upgraded over the specified five year period as the majority require upgrading over ten years or more.

- Groupings of various catchments are too big, thus a very broad assessment was made resulting in inaccuracies. A number of quaternaries are linked together but only the main stem river was taken into account. This could result in the inaccurate scoring of the tributaries.

- The format of the methodology paper should be made clearer and user-friendly tables should be included, especially for EI&SC and DEMC. Furthermore, if the GIS layout of the results from the previous workshop had been available it would have aided the process greatly.

- The confidence levels need to be attached to all classes and a confidence level common denominator given.

- Ideally, rivers should be grouped according to ecotones rather than quaternary hydrological catchments as they are ecologically inappropriate, but it is acknowledged that this would not meet the requirements of the water balance model.

- The results should be reviewed by participants on a GIS database before the data is used for the national water balance.

- 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. *Western 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

GOURITZ WATER MANAGEMENT AREA

APPENDIX F.7

ASSUMED RURAL DOMESTIC PER CAPITA WATER REQUIREMENTS PER QUATERNARY

Quaternary	PER CAPITA PER DAY RURAL USAGE					
	30	30	30	100	l/c/d	
	Rural %	Advanced Rural %	Developing Urban %	Farming %	Comments	Average Consumption l/c/d
H80A				100		100
H80B				100		100
H80C				100		100
H80D				100		100
H80E		60		40	Vermaaklikheid	58
H80F				100		100
H90A				100		100
H90B				100		100
H90C				100		100
H90D				100		100
H90E				100		100
J11A				100		100
J11B				100		100
J11C				100		100
J11D				100		100
J11E			20	80	Matjiesfontein	86
J11F				100		100
J11G				100		100
J11H		80		20	Vleiland	44
J11J				100		100
J11K				100		100
J12A				100		100
J12B		50		50	Matroosberg, Kleinstraat	65
J12C		50		50	Die Draai, Jan de Boers, etc	65
J12D				100		100
J12E		50		50	Tweeside, Konstabel. etc	65
J12F				100		100
J12G				100		100
J12H				100		100
J12J				100		100
J12K				100		100
J12L				100		100
J12M				100		100
J13A				100		100
J13B				100		100
J13C				100		100
J21A				100		100
J21B				100		100
J21C				100		100
J21D				100		100

Quaternary	PER CAPITA PER DAY RURAL USAGE					
	30	30	30	100	l/c/d	
	Rural %	Advanced Rural %	Developing Urban %	Farming %	Comments	Average Consumption l/c/d
J21E				100		100
J22A				100		100
J22B				100		100
J22C				100		100
J22D				100		100
J22E				100		100
J22F				100		100
J22G				100		100
J22H				100		100
J22J				100		100
J22K				100		100
J23A			80	20	Leeu-Gamka	44
J23B				100		100
J23C				100		100
J23D				100		100
J23E				100		100
J23F				100		100
J23G				100		100
J23H				100		100
J23J				100		100
J24A				100		100
J24B			80	20	Merweville	44
J24C				100		100
J24D			10	90	Prince Albert Road	93
J24E				100		100
J24F				100		100
J25A				100		100
J25B		70		30	Droevlei, Zoar	51
J25C				100		100
J25D				100		100
J25E				100		100
J31A				100		100
J31B				100		100
J31C				100		100
J31D				100		100
J32A				100		100
J32B				100		100
J32C				100		100
J32D				100		100
J32E		20		80	Bloekomdraai	86
J33A				100		100
J33B		50		50	Vlakteplaas, Rooirivier, Rooiloop	65
J33C		50		50	Klaarstroom	65
J33D				100		100
J33E				100		100
J33F				100		100

Quaternary	PER CAPITA PER DAY RURAL USAGE					
	30	30	30	100	l/c/d	
	Rural %	Advanced Rural %	Developing Urban %	Farming %	Comments	Average Consumption l/c/d
J34A			15	85	Avontuur	89.5
J34B				100		100
J34C		20		80	Vaaldraai, Eensaamheid	86
J34D		20		80	Sheepwalk	86
J34E				100		100
J34F		10		90	Herold	93
J35A				100		100
J35B		10		90	Klipdrif	93
J35C		40		60	Volmoed	72
J35D		15		85	Matjiesrivier	89.5
J35E		30		70	Welbedacht	79
J35F		20		80	Vleirivier, Kruisrivier	86
J40A				100		100
J40B				100		100
J40C			60	40	Herbertsdale	58
J40D		30		70	Buysplaas	79
J40E				100		100
K10A				100		100
K10B				100		100
K10C				100		100
K10D		30		70	Modderdrif, Brandwag	79
K10E		20		80	Gannakraal	86
K10F		20		80	Molenrivier	86
K20A				100		100
K30A			20	100	Westlands	106
K30B				100		100
K30C				100		100
K30D			70	30	Hoekwil	51
K40A		70		30	Klleinplaat, Bergplaas	51
K40B				100		100
K40C		80		20	Karatara	44
K40D				100		100
K40E			50	50	Millwood	65
K50A				100		100
K50B			80	20	Belvedere, Buffalo Bay	44
K60A				100		100
K60B				100		100
K60C				100		100
K60D					No farming	0
K60E				100		100
K60F		20	60	20	Rietvlei, Harkerville, Wittedrif	44
K60G			80	20	Kranshoek	44

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.**

GOURITZ WATER MANAGEMENT AREA

APPENDIX G.1

HYDROLOGICAL DATA PER QUATERNARY CATCHMENT

Quaternary catchment	aMTCi	eMRTo	oMAEi	oMAPi	oMARi
	Catchment Area	Natural mean annual runoff (accumulative)	Mean annual evaporation	Mean annual precipitation	Natural mean annual runoff (incremental)
	km^2	million m^3	mm/a	mm/a	million m^3
H80A	149	31.07	1440	597	31.07
H80B	123	73.56	1440	792	42.49
H80C	285	81.73	1400	479	8.17
H80D	231	86.83	1400	412	5.10
H80E	373	96.21	1400	431	9.38
H80F	204	105.72	1400	533	9.51
H90A	179	41.20	1400	645	41.20
H90B	118	28.46	1400	664	28.46
H90C	218	75.23	1400	467	5.57
H90D	602	89.12	1400	425	13.89
H90E	496	106.40	1400	490	17.28
J11A	438	6.72	1965	295	6.72
J11B	738	7.01	2040	252	7.01
J11C	292	15.13	2110	204	1.40
J11D	801	6.53	2000	240	6.53
J11E	812	25.69	2060	188	4.03
J11F	344	28.13	2110	209	2.44
J11G	604	1.98	2140	167	1.98
J11H	651	32.54	2080	240	2.43
J11J	450	36.33	1915	304	3.79
J11K	516	37.90	1830	221	1.57
J12A	181	6.82	1690	437	6.82
J12B	251	9.22	1700	268	2.40
J12C	366	4.20	1800	287	4.20
J12D	831	23.23	1720	290	9.81
J12E	356	2.88	1880	307	2.88
J12F	710	30.61	1750	243	4.50
J12G	761	4.47	1960	277	4.47
J12H	549	39.37	1840	260	4.29
J12J	549	2.92	1610	250	2.92
J12K	517	4.50	1740	193	1.58
J12L	758	50.94	1690	314	7.07
J12M	483	54.44	1550	290	3.50
J13A	518	96.26	1650	295	3.92
J13B	402	99.67	1580	306	3.41
J13C	435	105.35	1540	351	5.68
J21A	854	14.81	2300	230	14.81
J21B	530	19.86	2305	188	5.05
J21C	526	4.42	2350	166	4.42
J21D	650	28.77	2305	155	4.49
J21E	504	32.07	2325	154	3.30

Quaternary catchment	aMTCi Catchment Area	eMRTo Natural mean annual runoff (accumulative)	oMAEi Mean annual evaporation	oMAPi Mean annual precipitation	oMARi Natural mean annual runoff (incremental)
	km^2	million m^3	mm/a	mm/a	million m^3
J22A	436	10.36	2130	233	10.36
J22B	322	5.41	2040	205	5.41
J22C	364	5.48	2110	197	5.48
J22D	680	27.08	2110	162	5.83
J22E	834	6.76	2090	159	6.76
J22F	863	65.84	2230	288	32.00
J22G	567	8.76	2150	221	8.76
J22H	807	22.75	2200	230	13.99
J22J	378	4.43	2180	187	4.43
J22K	479	30.25	2250	151	3.07
J23A	762	130.91	2295	127	2.75
J23B	782	135.36	2305	147	4.45
J23C	514	136.56	2250	124	1.20
J23D	708	1.45	2185	178	1.45
J23E	225	7.36	2120	329	7.36
J23F	478	149.73	2180	194	4.36
J23G	241	0.26	2250	98	0.26
J23H	264	152.58	2150	199	2.59
J23J	229	159.19	2105	308	6.61
J24A	926	16.34	2225	203	16.34
J24B	768	23.16	2250	160	6.82
J24C	861	27.03	2305	146	3.87
J24D	926	29.74	2310	128	2.71
J24E	862	32.67	2280	134	2.93
J24F	282	33.48	2220	222	0.81
J25A	354	201.36	2040	289	8.69
J25B	397	13.56	1950	326	13.56
J25C	181	216.00	1825	288	1.08
J25D	210	9.58	1945	365	9.58
J25E	287	226.60	1800	245	1.02
J31A	447	9.55	1780	441	9.55
J31B	200	2.31	1770	359	2.31
J31C	168	2.04	1890	369	2.04
J31D	304	15.90	1840	300	2.00
J32A	415	0.58	2250	154	0.58
J32B	643	1.61	2130	160	1.03
J32C	734	0.67	2215	136	0.67
J32D	302	2.76	2150	160	0.48
J32E	971	7.84	1990	234	5.08
J33A	449	28.85	1835	393	5.11
J33B	591	38.01	1830	437	9.16
J33C	428	2.56	2070	293	2.56
J33D	259	14.94	1980	379	12.38
J33E	329	77.54	1860	446	24.59
J33F	366	89.28	1840	343	11.74
J34A	252	5.59	1660	477	5.59
J34B	342	18.53	1665	569	12.94
J34C	319	39.80	1605	674	21.27

Quaternary catchment	aMTCi	eMRTo	oMAEi	oMAPi	oMARi
	Catchment Area	Natural mean annual runoff (accumulative)	Mean annual evaporation	Mean annual precipitation	Natural mean annual runoff (incremental)
	km^2	million m^3	mm/a	mm/a	million m^3
J34D	354	47.55	1620	471	7.75
J34E	258	51.85	1540	427	4.30
J34F	320	56.52	1620	415	4.67
J35A	428	22.73	1940	418	22.73
J35B	651	177.89	1590	411	9.36
J35C	265	2.85	1580	373	2.85
J35D	507	206.03	1900	407	25.29
J35E	215	210.31	1780	270	4.28
J35F	500	228.64	1820	341	18.33
J40A	454	487.18	1600	418	31.94
J40B	222	609.77	1450	431	17.24
J40C	436	648.84	1400	521	39.07
J40D	655	674.34	1400	446	25.50
J40E	554	695.13	1400	440	20.79
K10A	178	6.08	1400	450	6.08
K10B	171	5.70	1400	446	5.70
K10C	159	11.09	1400	493	11.09
K10D	164	16.84	1400	454	5.75
K10E	133	31.07	1400	679	31.07
K10F	106	52.80	1400	502	4.89
K20A	168	39.52	1400	722	39.52
K30A	196	51.99	1400	753	51.99
K30B	139	41.74	1400	787	41.74
K30C	190	53.56	1400	805	53.56
K30D	178	37.07	1400	724	37.07
K40A	87	17.45	1400	706	17.45
K40B	112	25.96	1400	846	25.96
K40C	100	35.42	1400	930	35.42
K40D	130	112.69	1400	757	33.86
K40E	268	54.19	2100	864	54.19
K50A	235	50.85	1400	850	50.85
K50B	203	104.39	1400	882	53.54
K60A	161	13.95	1540	664	13.95
K60B	143	31.35	1500	754	17.40
K60C	161	51.13	1400	744	19.78
K60D	292	44.40	1400	815	44.40
K60E	100	104.99	1400	775	9.46
K60F	242	21.42	1400	807	21.42
K60G	167	19.53	1400	860	19.53
K70A	170	24.69	1400	920	24.69
K70B	106	40.92	1400	997	40.92
TOTALS	**53139**	**-**	**-**	**-**	**1678.53**

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.

CONTENTS LIST

Summary
Glossary

		Page
1.	INTRODUCTION	1
2.	MAPPING SURFACE WATER RESOURCES	2
	2.1 Background	2
	2.2 Surface faecal contamination	4
	2.3 Results: GIS surface water mapping	4
3.	MAPPING GROUNDWATER RESOURCES	6
	3.1 Background	6
	3.2 Method	6
	3.3 Aquifer vulnerability map	9
	3.4 Groundwater faecal contamination	9
4.	CONCLUSIONS & RECOMMENDATIONS	13
5.	REFERENCES	14

LIST OF FIGURES

Figure 1: Rating of surface faecal contamination
Figure 2: Potential surface faecal contamination
Figure 3: Aquifer vulnerability
Figure 4: Aquifer vulnerability to faecal contamination
Figure 5: Aquifer vulnerability to faecal contamination
Figure 6: Rating of faecal contamination of aquifers

LIST OF TABLES

Table 1: DRASTIC factors

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 GroundwaterResources
- 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.

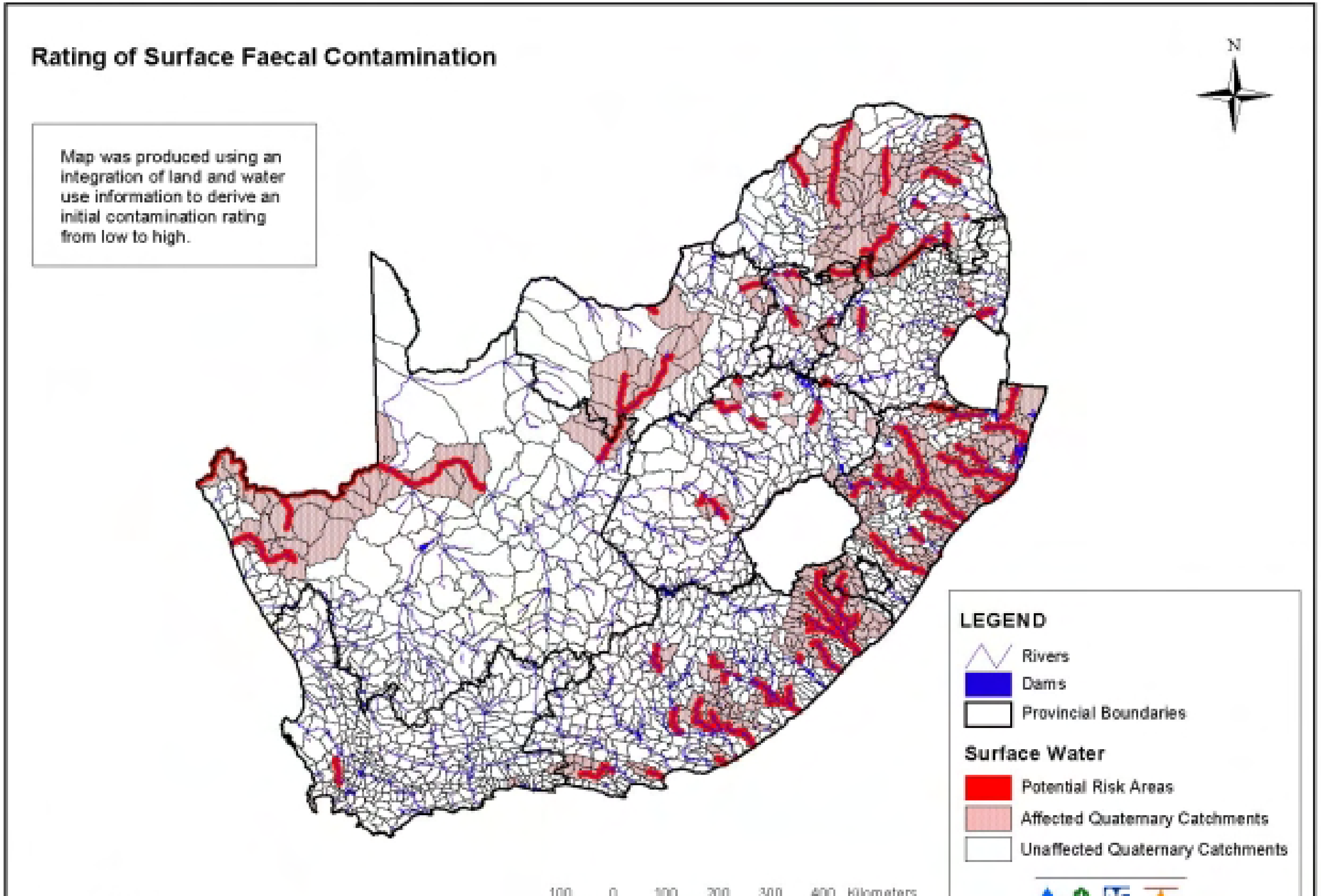

Rating of Surface Faecal Contamination
Map was produced using an integration of land and water use information to derive an initial contamination rating from low to high.
N
LEGEND
Rivers
Dams
Provincial Boundaries
Surface Water
Potential Risk Areas
Affected Quaternary Catchments
Unaffected Quaternary 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).

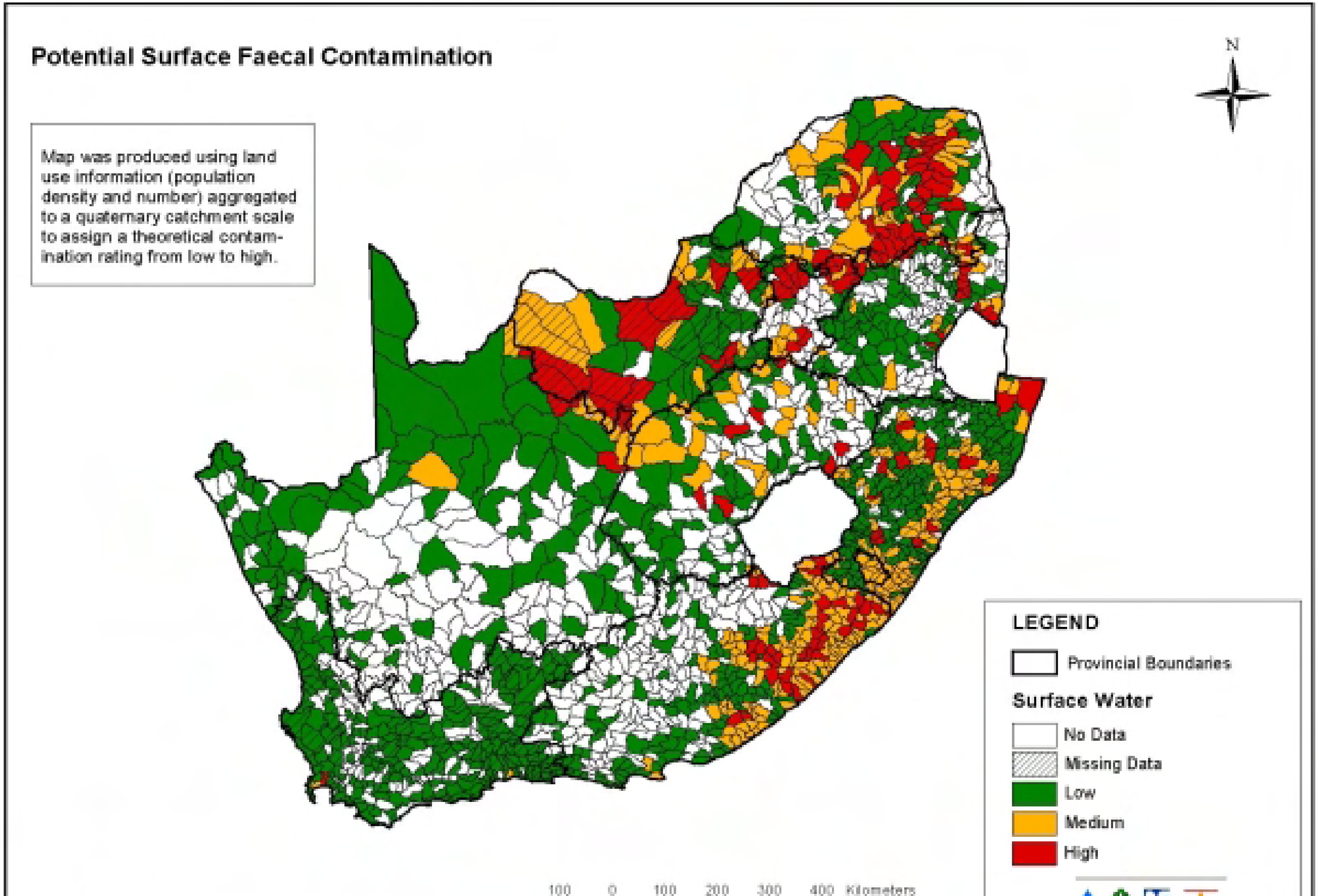

Potential Surface Faecal Contamination
Map was produced using land use information (population density and number) aggregated to a quaternary catchment scale to assign a theoretical contamination rating from low to high.
N
LEGEND
Provincial Boundaries
Surface Water
No Data
Missing Data
Low
Medium
High
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.

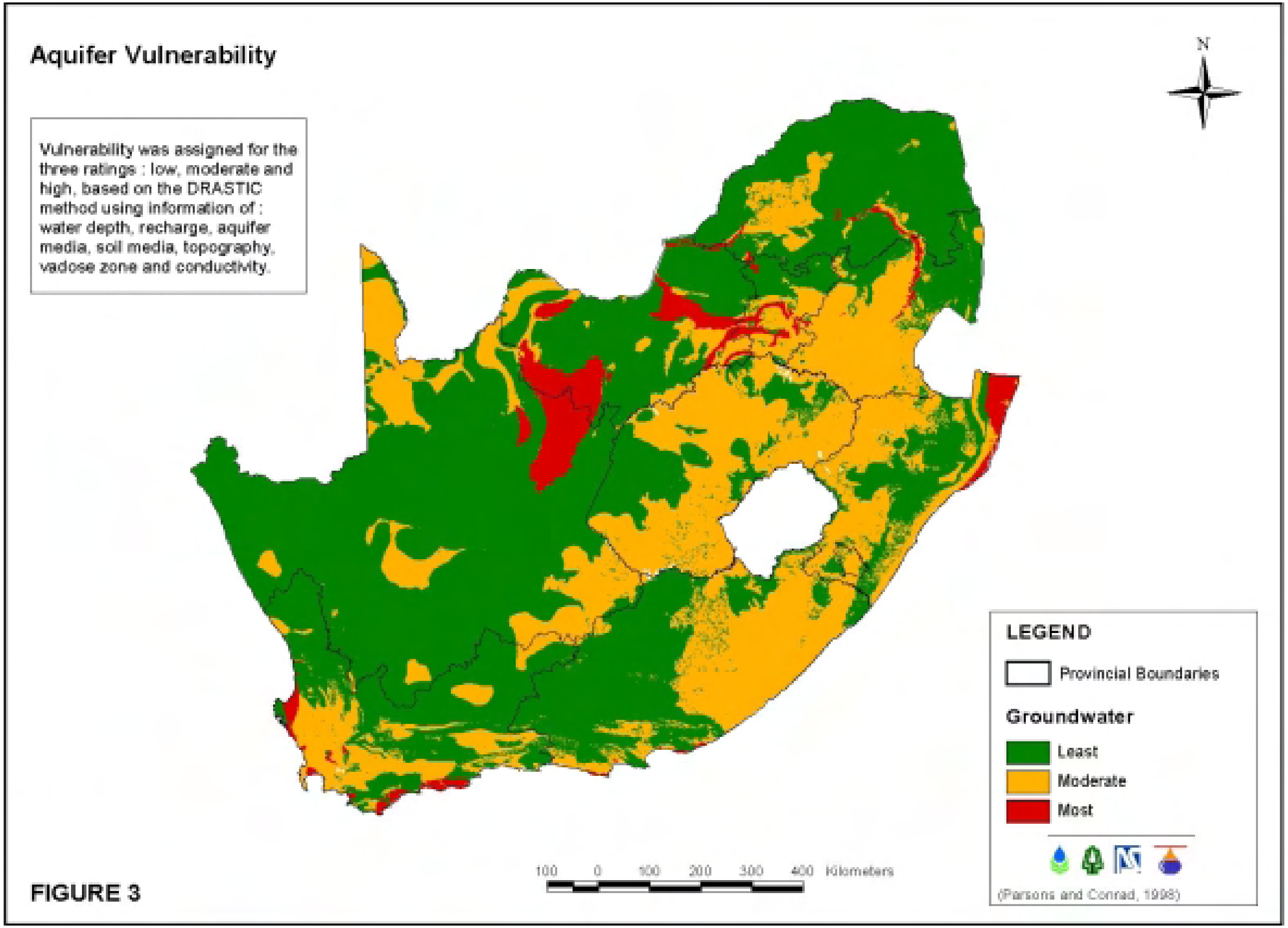
Microbial contamination of groundwater increases in high population density areas and areas with inadequate sanitation. Approximately three quarters of the population of South Africa do not have access to adequate sanitation.

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

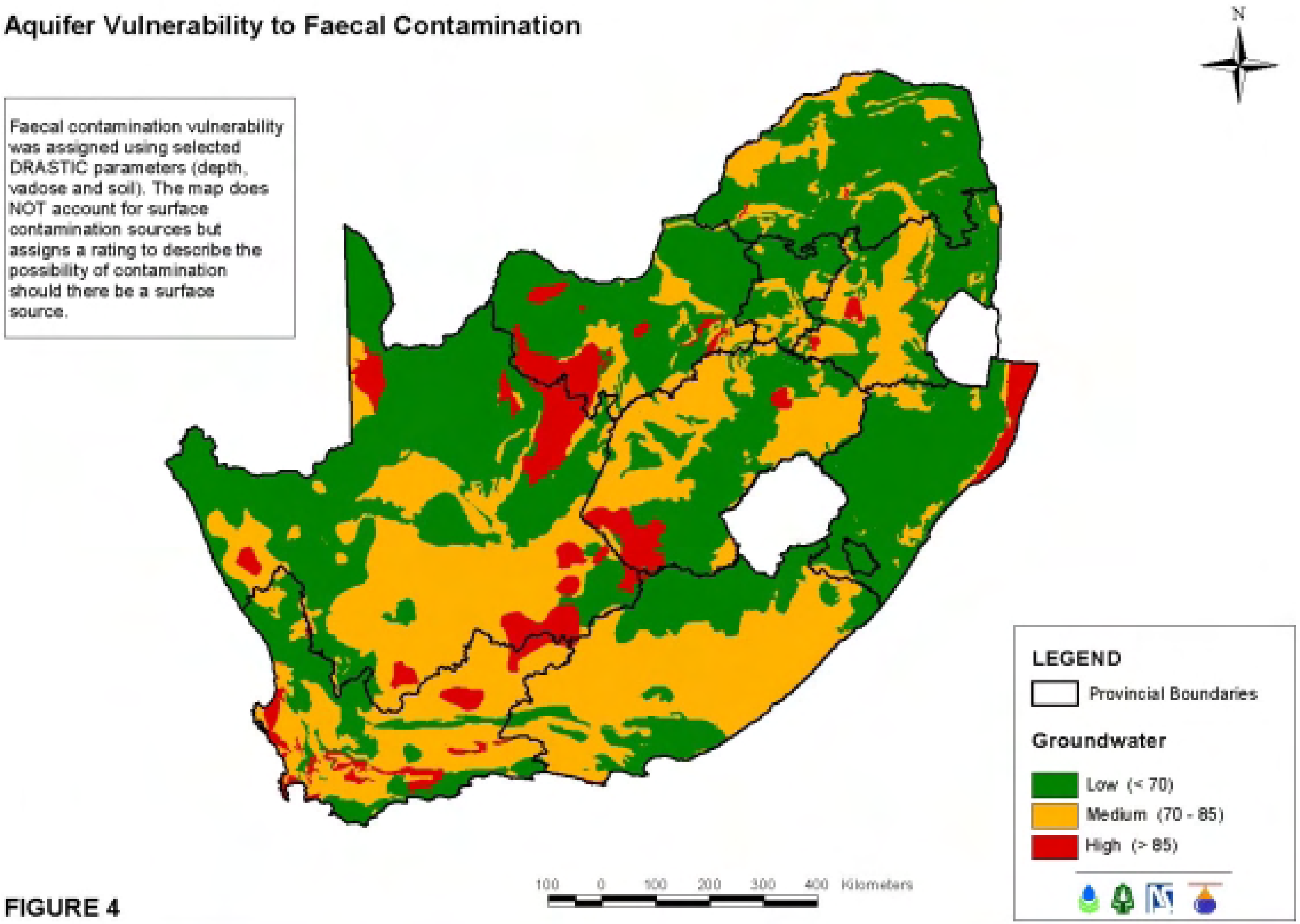
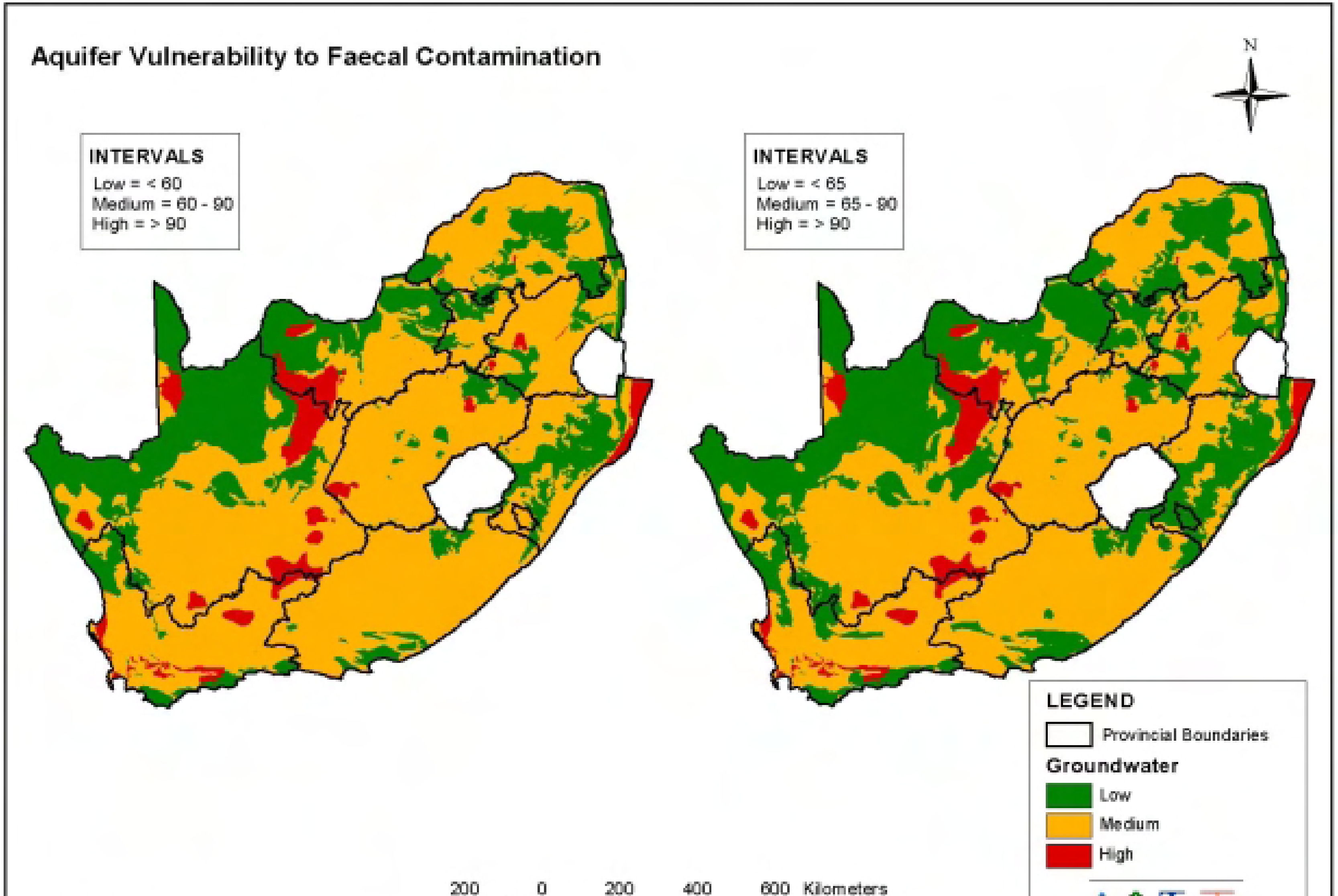


FIGURE 4



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

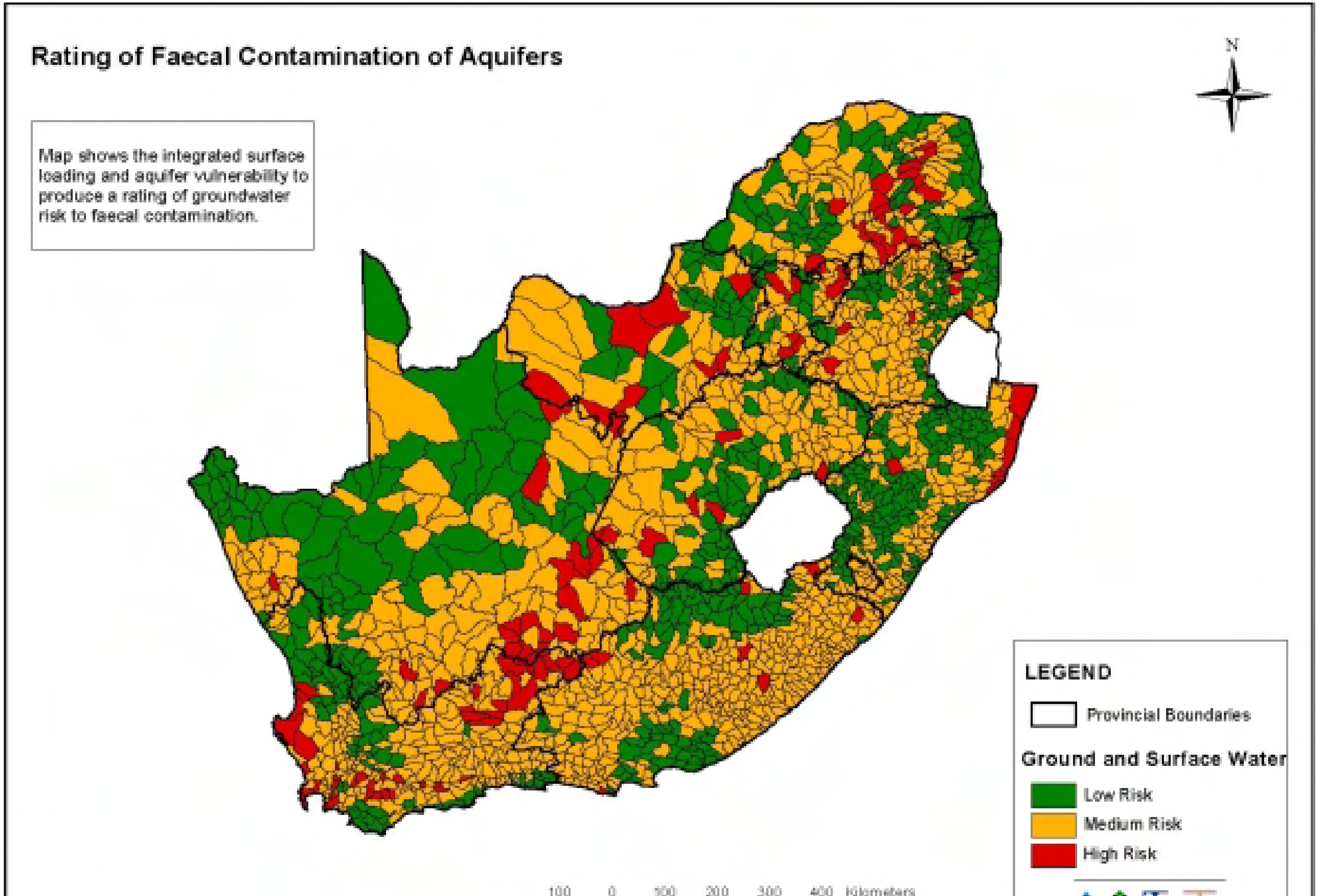

Rating of Faecal Contamination of Aquifers
Map shows the integrated surface loading and aquifer vulnerability to produce a rating of groundwater risk to faecal contamination.
N
LEGEND
Provincial Boundaries
Ground and Surface Water
Low Risk
Medium Risk
High Risk
100 0 100 200 300 400 Kilometers

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.

GOURITZ WATER MANAGEMENT AREA

APPENDIX G3

SEDIMENTATION DATA
PER QUATERNARY CATCHMENT

Quaternary Catchment	Area	Yield	25 year Sediment Volume
	km^2	tonnes/a	m^3
H80A	149	1000	27280
H80B	123	2000	54560
H80C	285	9000	245518
H80D	231	8000	218239
H80E	373	5000	136399
H80F	204	2000	54560
H90A	179	2000	54560
H90B	118	1000	27280
H90C	218	7000	190959
H90D	602	11000	300078
H90E	496	4000	109119
J11A	438	35000	954794
J11B	738	60000	1636789
J11C	292	24000	654716
J11D	801	65000	1773188
J11E	812	60000	1636789
J11F	344	17000	463757
J11G	604	48000	1309431
J11H	651	23000	627436
J11J	450	16000	436477
J11K	516	18000	491037
J12A	181	4000	109119
J12B	251	8000	218239
J12C	366	13000	354638
J12D	831	29000	791115
J12E	356	12000	327358
J12F	710	25000	681995
J12G	761	27000	736555
J12H	549	19000	518317
J12J	549	19000	518317
J12K	517	18000	491037
J12L	758	25000	681995
J12M	483	14000	381917
J13A	518	17000	463757
J13B	402	13000	354638
J13C	435	13000	354638
J21A	854	69000	1882307
J21B	530	43000	1173032
J21C	526	42000	1145752
J21D	650	52000	1418550

Quaternary Catchment	Area	Yield	25 year Sediment Volume
	km^2	tonnes/a	m^3
J21E	504	41000	1118472
J22A	436	35000	954794
J22B	322	26000	709275
J22C	364	29000	791115
J22D	680	55000	1500390
J22E	834	67000	1827748
J22F	863	24000	654716
J22G	567	46000	1254872
J22H	807	65000	1773188
J22J	378	30000	818394
J22K	479	39000	1063913
J23A	762	61000	1664069
J23B	782	63000	1718628
J23C	514	42000	1145752
J23D	708	55000	1500390
J23E	225	8000	218239
J23F	478	32000	872954
J23G	241	19000	518317
J23H	264	16000	436477
J23J	229	7000	190959
J24A	926	75000	2045986
J24B	768	62000	1691349
J24C	861	70000	1909587
J24D	926	75000	2045986
J24E	862	64000	1745908
J24F	282	8000	218239
J25A	354	12000	327358
J25B	397	14000	381917
J25C	181	6000	163679
J25D	210	7000	190959
J25E	287	10000	272798
J31A	447	13000	354638
J31B	200	6000	163679
J31C	168	6000	163679
J31D	304	11000	300078
J32A	415	15000	409197
J32B	643	22000	600156
J32C	734	26000	709275
J32D	302	11000	300078
J32E	971	34000	927514
J33A	449	14000	381917
J33B	591	16000	436477
J33C	428	15000	409197
J33D	259	9000	245518
J33E	329	10000	272798
J33F	366	12000	327358

Quaternary Catchment	Area	Yield	25 year Sediment Volume
	km^2	tonnes/a	m^3
J34A	252	5000	136399
J34B	342	8000	218239
J34C	319	7000	190959
J34D	354	8000	218239
J34E	258	6000	163679
J34F	320	9000	245518
J35A	428	15000	409197
J35B	651	15000	409197
J35C	265	6000	163679
J35D	507	18000	491037
J35E	215	8000	218239
J35F	500	18000	491037
J40A	454	14000	381917
J40B	222	2000	54560
J40C	436	9000	245518
J40D	655	20000	545596
J40E	554	8000	218239
K10A	178	3000	81839
K10B	171	6000	163679
K10C	159	3000	81839
K10D	164	5000	136399
K10E	133	2000	54560
K10F	106	4000	109119
K20A	168	4000	109119
K30A	196	5000	136399
K30B	139	3000	81839
K30C	190	4000	109119
K30D	178	3000	81839
K40A	87	1000	27280
K40B	112	1000	27280
K40C	100	2000	54560
K40D	130	3000	81839
K40E	268	4000	109119
K50A	235	3000	81839
K50B	203	3000	81839
K60A	161	2000	54560
K60B	143	1000	27280
K60C	161	1000	27280
K60D	292	2000	54560
K60E	100	2000	54560
K60F	242	4000	109119
K60G	167	2000	54560
K70A	170	4000	109119
K70B	106	2000	54560
TOTALS	**53139**	**-**	**68690576**

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.

GROUNDWATER USE PER QUATERNARY CATCHMENT

QUATERNARY	AREA	HARVEST POTENTIAL	HARVEST POTENTIAL	oGHPi HARVEST POTENTIAL	AVERAGE YIELD BOREHOLES	oGBYi AVERAGE YIELD BOREHOLES	fGECi EXPLOITA-TION FACTOR	EXPLOITA-TION POTENTIAL	EXPLOITA-TION POTENTIAL	oGEPo EXPLOITA-TION POTENTIAL	NO OF BORES WITH YIELD DATA	SUM OF YIELDS	SUM OF BOREHOLE YIELDS	oGBNi THEORETICAL NO OF PRODUCTION BOREHOLES	MUNICIPAL USE	RURAL USE	LIVE-STOCK USE	IRRIGATION USE	TOTAL USE FACTOR	oGWSo TOTAL USE	TOTAL USE
	(km^2)	($m^3/km^2/a$)	(mm)	($x10^6$ m^3/a)	(ℓ/s, 8hrs/day)	(ℓ/s, 24hrs/day)		($m^3/km^2/a$)	(mm)	($x10^6$ m^3/a)		(ℓ/s)	($x10^6$ m^3/a)		($x10^6$ m^3/a)	($x10^6$ m^3/a)	($x10^6$ m^3/a)	($x10^6$ m^3/a)		($x10^6$ m^3/a)	(mm/a)
H80A	149	68819	68.8	10.25	1.00	0.33	0.5	34410	34.4	5.13	0	0.00	0.00	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
H80B	123	97269	97.3	11.96	1.00	0.33	0.5	48635	48.6	5.98	0	0.00	0.00	8	0.0000	0.0000	0.0000	0.0741	1.2000	0.0889	0.7
H80C	285	58119	58.1	16.56	1.98	0.66	0.6	34871	34.9	9.94	4	7.92	0.08	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
H80D	231	12760	12.8	2.95	0.10	0.03	0.3	3828	3.8	0.88	15	1.47	0.02	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
H80E	373	44792	44.8	16.71	0.76	0.25	0.5	22396	22.4	8.35	9	6.86	0.07	1	0.0000	0.0000	0.0051	0.0000	1.0000	0.0051	0.0
H80F	204	72329	72.3	14.76	0.30	0.10	0.3	21699	21.7	4.43	1	0.30	0.00	2	0.0000	0.0000	0.0054	0.0000	1.0000	0.0054	0.0
H90A	179	48392	48.4	8.66	0.20	0.07	0.3	14517	14.5	2.60	0	0.00	0.00	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
H90B	118	69921	69.9	8.25	0.20	0.07	0.3	20976	21.0	2.48	0	0.00	0.00	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
H90C	218	58112	58.1	12.67	0.30	0.10	0.3	17434	17.4	3.80	3	0.90	0.01	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
H90D	602	17607	17.6	10.60	1.03	0.34	0.5	8803	8.8	5.30	29	29.93	0.31	1	0.0000	0.0000	0.0081	0.0000	1.0000	0.0081	0.0
H90E	496	11200	11.2	5.56	4.19	1.40	0.7	7840	7.8	3.89	50	209.63	2.20	18	0.7000	0.0000	0.0130	0.0000	1.1000	0.7843	1.6
J11A	438	9300	9.3	4.07	2.72	0.91	0.6	5580	5.6	2.44	5	13.60	0.14	1	0.0000	0.0000	0.0025	0.0000	11.8600	0.0297	0.1
J11B	738	8394	8.4	6.20	2.72	0.91	0.6	5037	5.0	3.72	12	32.67	0.34	3	0.0000	0.0000	0.0009	0.0069	12.0000	0.0936	0.1
J11C	292	7318	7.3	2.14	0.37	0.12	0.4	2927	2.9	0.85	3	1.10	0.01	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J11D	801	8262	8.3	6.62	1.56	0.52	0.6	4957	5.0	3.97	31	48.29	0.51	3	0.0000	0.0000	0.0039	0.0000	12.0000	0.0468	0.1
J11E	812	7393	7.4	6.00	3.33	1.11	0.7	5175	5.2	4.20	69	229.81	2.42	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J11F	344	6101	6.1	2.10	2.65	0.88	0.6	3661	3.7	1.26	22	58.26	0.61	66	0.1520	0.0000	0.0000	0.0000	12.0000	1.8240	5.3
J11G	604	5042	5.0	3.05	1.25	0.42	0.5	2521	2.5	1.52	27	33.79	0.36	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J11H	651	14374	14.4	9.36	2.18	0.73	0.6	8624	8.6	5.61	24	52.43	0.55	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J11J	450	18373	18.4	8.27	2.86	0.95	0.6	11024	11.0	4.96	40	114.34	1.20	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J11K	516	11027	11.0	5.69	2.32	0.77	0.6	6616	6.6	3.41	20	46.32	0.49	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J12A	181	48367	48.4	8.75	6.55	2.18	0.7	33857	33.9	6.13	3	19.65	0.21	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J12B	251	22368	22.4	5.61	4.30	1.43	0.7	15658	15.7	3.93	29	124.84	1.31	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J12C	366	9142	9.1	3.35	4.49	1.50	0.7	6399	6.4	2.34	49	220.03	2.31	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J12D	831	15287	15.3	12.70	5.06	1.69	0.7	10701	10.7	8.89	47	237.95	2.50	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J12E	356	8926	8.9	3.18	4.42	1.47	0.7	6248	6.2	2.22	17	75.16	0.79	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J12F	710	14510	14.5	10.30	2.08	0.69	0.6	8706	8.7	6.18	16	33.26	0.35	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J12G	761	12749	12.7	9.70	1.67	0.56	0.6	7649	7.6	5.82	19	31.70	0.33	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0

GROUNDWATER USE PER QUATERNARY CATCHMENT

J12H	549	19849	19.8	10.90	4.27	1.42	0.7	13894	13.9	7.63	33	140.92	1.48	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J12J	549	9407	9.4	5.16	3.71	1.24	0.7	6585	6.6	3.62	34	126.21	1.33	103	0.0000	0.0000	0.0001	0.3344	12.0000	4.0140	7.3
J12K	517	8400	8.4	4.34	1.86	0.62	0.6	5040	5.0	2.61	12	22.36	0.24	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J12L	758	12816	12.8	9.71	6.23	2.08	0.7	8971	9.0	6.80	24	149.53	1.57	39	0.0000	0.0000	0.0010	0.2110	12.0000	2.5440	3.4
J12M	483	19763	19.8	9.55	8.75	2.92	0.7	13834	13.8	6.68	2	17.50	0.18	68	0.0000	0.0000	0.0002	0.5248	11.9000	6.2475	12.9
J13A	518	19238	19.2	9.97	5.19	1.73	0.7	13467	13.5	6.98	40	207.58	2.18	154	0.7000	0.0000	0.0000	0.0000	12.0000	8.4000	16.2
J13B	402	18373	18.4	7.39	4.11	1.37	0.7	12861	12.9	5.17	24	98.59	1.04	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J13C	435	29517	29.5	12.84	1.79	0.60	0.6	17710	17.7	7.70	3	5.38	0.06	0	0.0000	0.0000	0.0000	0.0000	11.8600	0.0000	0.0
J21A	854	7133	7.1	6.09	4.25	1.42	0.7	4993	5.0	4.26	207	879.73	9.25	51	1.5450	0.0000	0.0439	2.3564	0.5730	2.2607	2.6
J21B	530	3919	3.9	2.08	6.57	2.19	0.7	2743	2.7	1.45	2	13.13	0.14	2	0.0000	0.0000	0.0279	0.2370	0.5730	0.1518	0.3
J21C	526	3000	3.0	1.58	2.15	0.72	0.6	1800	1.8	0.95	2	4.30	0.05	6	0.0000	0.0000	0.0277	0.1964	0.5730	0.1284	0.2
J21D	650	3000	3.0	1.95	1.00	0.33	0.5	1500	1.5	0.98	0	0.00	0.00	38	0.0000	0.0000	0.0336	0.6554	0.5730	0.3948	0.6
J21E	504	3000	3.0	1.51	1.00	0.33	0.5	1500	1.5	0.76	0	0.00	0.00	17	0.0000	0.0000	0.0220	0.2988	0.5730	0.1838	0.4
J22A	436	7838	7.8	3.42	1.00	0.33	0.5	3919	3.9	1.71	0	0.00	0.00	0	0.0000	0.0000	0.0088	0.0000	0.5730	0.0050	0.0
J22B	322	7528	7.5	2.42	1.95	0.65	0.6	4517	4.5	1.45	2	3.90	0.04	2	0.0000	0.0000	0.0065	0.0651	0.5730	0.0410	0.1
J22C	364	7278	7.3	2.65	2.00	0.67	0.6	4367	4.4	1.59	0	0.00	0.00	0	0.0000	0.0000	0.0178	0.0000	0.5730	0.0102	0.0
J22D	680	5272	5.3	3.59	2.00	0.67	0.6	3163	3.2	2.15	0	0.00	0.00	7	0.1000	0.0000	0.0334	0.1267	0.5730	0.1490	0.2
J22E	834	5182	5.2	4.32	2.00	0.67	0.6	3109	3.1	2.59	0	0.00	0.00	9	0.0000	0.0000	0.0397	0.2877	0.5730	0.1876	0.2
J22F	296	3000	3.0	0.89	2.00	0.67	0.6	1800	1.8	0.53	0	0.00	0.00	18	0.0000	0.0000	0.0083	0.6552	0.5730	0.3802	1.3
J22G	567	7796	7.8	4.42	4.03	1.34	0.7	5457	5.5	3.09	6	24.18	0.25	0	0.0000	0.0000	0.0165	0.0000	0.5730	0.0095	0.0
J22H	807	6638	6.6	5.36	2.00	0.67	0.6	3983	4.0	3.21	0	0.00	0.00	1	0.0000	0.0000	0.0409	0.0000	0.5730	0.0234	0.0
J22J	378	5406	5.4	2.04	2.00	0.67	0.6	3244	3.2	1.23	0	0.00	0.00	4	0.0000	0.0000	0.0197	0.1111	0.5730	0.0749	0.2
J22K	479	3521	3.5	1.69	4.05	1.35	0.7	2465	2.5	1.18	2	8.10	0.09	63	0.0000	0.0000	0.0209	4.6366	0.5730	2.6687	5.6
J23A	762	3000	3.0	2.29	4.44	1.48	0.7	2100	2.1	1.60	16	71.08	0.75	105	0.0000	0.0000	0.0187	8.5596	0.5730	4.9154	6.5
J23B	782	3000	3.0	2.35	3.58	1.19	0.7	2100	2.1	1.64	5	17.91	0.19	22	0.0000	0.0000	0.0196	1.4102	0.5730	0.8193	1.0
J23C	514	3000	3.0	1.54	3.15	1.05	0.7	2100	2.1	1.08	16	50.46	0.53	0	0.0000	0.0000	0.0126	0.0000	0.5730	0.0072	0.0
J23D	708	3902	3.9	2.76	1.20	0.40	0.5	1951	2.0	1.38	4	4.80	0.05	1	0.0000	0.0000	0.0174	0.0000	0.5730	0.0100	0.0
J23E	225	37087	37.1	8.34	13.00	4.33	0.7	25961	26.0	5.84	1	13.00	0.14	24	0.0000	0.0000	0.0056	5.6449	0.5730	3.2377	14.4
J23F	478	14629	14.6	6.99	2.76	0.92	0.6	8777	8.8	4.20	27	74.56	0.78	100	0.1000	0.0000	0.0118	4.9620	0.5730	2.9073	6.1
J23G	241	3000	3.0	0.72	0.57	0.19	0.4	1200	1.2	0.29	3	1.70	0.02	1	0.0000	0.0000	0.0059	0.0000	0.5730	0.0034	0.0
J23H	264	14229	14.2	3.76	1.85	0.62	0.6	8538	8.5	2.25	4	7.41	0.08	35	0.0000	0.0000	0.0065	1.1780	0.5730	0.6787	2.6
J23J	229	31189	31.2	7.14	2.00	0.67	0.6	18714	18.7	4.29	0	0.00	0.00	35	0.0000	0.0000	0.0056	1.2892	0.5730	0.7419	3.2

GROUNDWATER USE PER QUATERNARY CATCHMENT

J24A	926	7834	7.8	7.25	1.80	0.60	0.6	4700	4.7	4.35	7	12.63	0.13	0	0.0000	0.0000	0.0131	0.0000	0.5730	0.0075	0.0
J24B	768	4659	4.7	3.58	1.90	0.63	0.6	2795	2.8	2.15	1	1.90	0.02	1	0.0200	0.0000	0.0224	0.0000	0.5730	0.0243	0.0
J24C	861	3744	3.7	3.22	1.79	0.60	0.6	2247	2.2	1.93	9	16.15	0.17	0	0.0000	0.0000	0.0120	0.0000	0.5730	0.0069	0.0
J24D	926	4078	4.1	3.78	2.25	0.75	0.6	2447	2.4	2.27	38	85.50	0.90	0	0.0000	0.0000	0.0100	0.0000	0.5730	0.0057	0.0
J24E	862	3729	3.7	3.21	1.78	0.59	0.6	2237	2.2	1.93	49	87.33	0.92	0	0.0000	0.0000	0.0047	0.0000	0.5730	0.0027	0.0
J24F	282	10184	10.2	2.87	1.08	0.36	0.5	5092	5.1	1.44	1	1.08	0.01	69	0.0000	0.0000	0.0001	1.3652	0.5730	0.7823	2.8
J25A	354	37725	37.7	13.35	1.25	0.42	0.5	18862	18.9	6.68	2	2.50	0.03	173	0.0000	0.0000	0.0049	3.9718	0.5730	2.2786	6.4
J25B	397	33857	33.9	13.44	4.26	1.42	0.7	23700	23.7	9.41	53	225.80	2.37	0	0.0000	0.0000	0.0000	0.0000	0.5730	0.0000	0.0
J25C	181	40194	40.2	7.28	9.03	3.01	0.7	28136	28.1	5.09	18	162.48	1.71	1	0.0000	0.0000	0.0000	0.0939	0.5730	0.0538	0.3
J25D	210	33124	33.1	6.96	0.32	0.11	0.4	13250	13.2	2.78	2	0.64	0.01	210	0.1500	0.0000	0.0005	1.0821	0.5730	0.7063	3.4
J25E	287	40145	40.1	11.52	3.56	1.19	0.7	28102	28.1	8.07	7	24.90	0.26	1	0.0000	0.0000	0.0017	0.0505	0.5730	0.0299	0.1
J31A	447	46013	46.0	20.57	4.02	1.34	0.7	32209	32.2	14.40	26	104.59	1.10	7	0.1500	0.0000	0.0076	1.5380	0.1730	0.2933	0.7
J31B	200	39419	39.4	7.88	2.91	0.97	0.6	23651	23.7	4.73	7	20.37	0.21	0	0.0000	0.0000	0.0000	0.0000	0.1730	0.0000	0.0
J31C	168	41789	41.8	7.02	2.45	0.82	0.6	25073	25.1	4.21	22	53.85	0.57	17	0.0000	0.0000	0.0019	2.5170	0.1730	0.4358	2.6
J31D	304	17959	18.0	5.46	2.56	0.85	0.6	10775	10.8	3.28	23	58.85	0.62	19	0.0000	0.0000	0.0014	2.9720	0.1730	0.5144	1.7
J32A	415	3000	3.0	1.25	1.00	0.33	0.5	1500	1.5	0.62	0	0.00	0.00	0	0.0000	0.0000	0.0102	0.0000	0.1730	0.0018	0.0
J32B	643	3397	3.4	2.18	5.14	1.71	0.7	2378	2.4	1.53	4	20.56	0.22	3	0.0000	0.0000	0.0131	0.9084	0.1730	0.1594	0.2
J32C	734	3000	3.0	2.20	2.78	0.93	0.6	1800	1.8	1.32	21	58.37	0.61	5	0.0000	0.0000	0.0161	0.8447	0.1730	0.1489	0.2
J32D	302	3000	3.0	0.91	0.10	0.03	0.3	900	0.9	0.27	12	1.17	0.01	91	0.0000	0.0000	0.0000	0.5398	0.1730	0.0934	0.3
J32E	971	11940	11.9	11.59	0.99	0.33	0.5	5970	6.0	5.80	45	44.69	0.47	45	0.0000	0.0000	0.0052	2.6813	0.1730	0.4648	0.5
J33A	449	41174	41.2	18.49	2.03	0.68	0.6	24704	24.7	11.09	40	81.13	0.85	56	0.0000	0.0000	0.0022	6.9270	0.1730	1.1988	2.7
J33B	591	40653	40.7	24.03	4.12	1.37	0.7	28457	28.5	16.82	42	172.91	1.82	71	0.0000	0.0000	0.0005	17.7985	0.1730	3.0792	5.2
J33C	428	24810	24.8	10.62	3.16	1.05	0.7	17367	17.4	7.43	7	22.10	0.23	41	0.0000	0.0000	0.0106	7.7795	0.1730	1.3477	3.1
J33D	259	28089	28.1	7.27	0.70	0.23	0.4	11235	11.2	2.91	2	1.40	0.01	89	0.0000	0.0000	0.0066	3.7657	0.1730	0.6526	2.5
J33E	329	39123	39.1	12.87	5.25	1.75	0.7	27386	27.4	9.01	99	519.33	5.46	72	0.0000	0.0000	0.0002	23.0945	0.1730	3.9954	12.1
J33F	366	41119	41.1	15.05	5.09	1.70	0.7	28784	28.8	10.53	104	529.67	5.57	5	0.0000	0.0000	0.0010	1.4375	0.1730	0.2489	0.7
J34A	252	58764	58.8	14.81	1.26	0.42	0.5	29382	29.4	7.40	7	8.79	0.09	2	0.0000	0.0000	0.0006	0.1141	0.1730	0.0198	0.1
J34B	342	48241	48.2	16.50	1.36	0.45	0.5	24120	24.1	8.25	8	10.84	0.11	5	0.0000	0.0000	0.0008	0.4221	0.1730	0.0732	0.2
J34C	319	61988	62.0	19.77	2.06	0.69	0.6	37193	37.2	11.86	21	43.29	0.46	0	0.0000	0.0000	0.0000	0.0000	0.1730	0.0000	0.0
J34D	354	43824	43.8	15.51	2.62	0.87	0.6	26294	26.3	9.31	30	78.67	0.83	0	0.0000	0.0000	0.0000	0.0000	0.1730	0.0000	0.0
J34E	258	39516	39.5	10.20	1.61	0.54	0.6	23710	23.7	6.12	16	25.81	0.27	0	0.0000	0.0000	0.0000	0.0000	0.1730	0.0000	0.0
J34F	320	37319	37.3	11.94	5.33	1.78	0.7	26123	26.1	8.36	33	175.97	1.85	6	0.9000	0.0000	0.0010	1.0120	0.1730	0.3309	1.0

GROUNDWATER USE PER QUATERNARY CATCHMENT

J35A	428	31421	31.4	13.45	5.00	1.67	0.7	21994	22.0	9.41	36	180.13	1.89	17	2.3000	0.0000	0.0012	2.8518	0.1730	0.8915	2.1
J35B	651	38944	38.9	25.35	7.06	2.35	0.7	27261	27.3	17.75	99	698.52	7.34	7	0.0000	0.0000	0.0024	2.8200	0.1730	0.4883	0.8
J35C	265	43992	44.0	11.66	5.39	1.80	0.7	30795	30.8	8.16	34	183.27	1.93	1	0.0000	0.0000	0.0000	0.3151	0.1730	0.0545	0.2
J35D	507	28685	28.7	14.54	4.14	1.38	0.7	20080	20.1	10.18	23	95.29	1.00	5	0.0000	0.0000	0.0026	1.3427	0.1730	0.2327	0.5
J35E	215	36865	36.9	7.93	2.96	0.99	0.6	22119	22.1	4.76	16	47.43	0.50	3	0.0000	0.0000	0.0018	0.6030	0.1730	0.1046	0.5
J35F	500	37045	37.0	18.52	2.33	0.78	0.6	22227	22.2	11.11	65	151.45	1.59	10	0.0000	0.0000	0.0030	1.3420	0.1730	0.2327	0.5
J40A	454	29920	29.9	13.58	0.93	0.31	0.5	14960	15.0	6.79	15	13.99	0.15	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
J40B	222	54380	54.4	12.07	1.64	0.55	0.6	32628	32.6	7.24	5	8.21	0.09	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
J40C	436	35525	35.5	15.49	3.05	1.02	0.7	24867	24.9	10.84	9	27.46	0.29	0	0.0115	0.0000	0.0000	0.0000	1.2000	0.0138	0.0
J40D	655	13692	13.7	8.97	1.14	0.38	0.5	6846	6.8	4.48	15	17.11	0.18	10	0.1000	0.0000	0.0008	0.0000	1.2000	0.1210	0.2
J40E	554	36084	36.1	19.99	1.63	0.54	0.6	21650	21.7	11.99	64	104.04	1.09	1	0.0000	0.0000	0.0075	0.0000	1.2000	0.0090	0.0
K10A	178	18736	18.7	3.33	3.11	1.04	0.7	13115	13.1	2.33	20	62.19	0.65	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K10B	171	16748	16.7	2.86	2.85	0.95	0.6	10049	10.0	1.72	17	48.40	0.51	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K10C	159	58325	58.3	9.27	1.00	0.33	0.5	29163	29.2	4.64	0	0.00	0.00	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K10D	164	23660	23.7	3.88	1.37	0.46	0.5	11830	11.8	1.94	10	13.70	0.14	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K10E	133	58343	58.3	7.76	1.18	0.39	0.5	29172	29.2	3.88	6	7.10	0.07	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K10F	106	23477	23.5	2.49	1.91	0.64	0.6	14086	14.1	1.49	5	9.57	0.10	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K20A	168	50908	50.9	8.55	2.44	0.81	0.6	30545	30.5	5.13	6	14.63	0.15	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K30A	196	56681	56.7	11.11	0.55	0.18	0.4	22672	22.7	4.44	15	8.24	0.09	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K30B	139	43441	43.4	6.04	0.79	0.26	0.5	21721	21.7	3.02	8	6.35	0.07	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K30C	190	53858	53.9	10.23	0.66	0.22	0.4	21543	21.5	4.09	6	3.98	0.04	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K30D	178	57786	57.8	10.29	0.81	0.27	0.5	28893	28.9	5.14	4	3.23	0.03	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K40A	87	93460	93.5	8.13	1.25	0.42	0.5	46730	46.7	4.07	1	1.25	0.01	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K40B	112	71831	71.8	8.05	0.58	0.19	0.4	28732	28.7	3.22	2	1.15	0.01	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K40C	100	61938	61.9	6.19	1.40	0.47	0.5	30969	31.0	3.10	1	1.40	0.01	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K40D	130	31812	31.8	4.14	2.08	0.69	0.6	19087	19.1	2.48	3	6.25	0.07	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K40E	268	87265	87.3	23.39	3.57	1.19	0.7	61085	61.1	16.37	6	21.41	0.23	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K50A	235	103760	103.8	24.38	0.50	0.17	0.4	41504	41.5	9.75	0	0.00	0.00	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K50B	203	104684	104.7	21.25	0.31	0.10	0.4	41874	41.9	8.50	2	0.61	0.01	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K60A	161	73749	73.7	11.87	1.95	0.65	0.6	44249	44.2	7.12	6	11.72	0.12	4	0.0000	0.0000	0.0003	0.0722	1.2000	0.0870	0.5
K60B	143	85589	85.6	12.24	2.00	0.67	0.6	51353	51.4	7.34	0	0.00	0.00	0	0.0000	0.0000	0.0000	0.0045	1.2000	0.0054	0.0
K60C	161	105080	105.1	16.92	2.58	0.86	0.6	63048	63.0	10.15	3	7.73	0.08	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0

GROUNDWATER USE PER QUATERNARY CATCHMENT

K60D	292	100508	100.5	29.35	2.00	0.67	0.6	60305	60.3	17.61	0	0.00	0.00	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K60E	100	77518	77.5	7.75	0.36	0.12	0.4	31007	31.0	3.10	1	0.36	0.00	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K60F	242	85758	85.8	20.75	1.54	0.51	0.6	51455	51.5	12.45	3	4.62	0.05	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0
K60G	167	84341	84.3	14.08	2.76	0.92	0.6	50605	50.6	8.45	25	68.94	0.72	29	0.7000	0.0000	0.0000	0.0000	1.2000	0.8400	5.0
K70A	170	111250	111.2	18.91	1.00	0.33	0.5	55625	55.6	9.46	1	1.00	0.01	13	0.1100	0.0000	0.0000	0.0000	1.2000	0.1320	0.8
K70B	106	112455	112.5	11.92	1.00	0.33	0.5	56228	56.2	5.96	0	0.00	0.00	0	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0

GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

QUATERNARY	vMARi MEAN ANNUAL RUNOFF	fGBFi BASE FLOW INDEX	BASE-FLOW SCHULTZ	BASE-FLOW PITTMAN	BASE-FLOW HUGHES	oGBFi BASE-FLOW SCHULTZ	BASE-FLOW FACTOR	fGBDo CORRECTED BASEFLOW FACTOR	$_0$GBD$_0$ CONTRIBUTION TO BASEFLOW	$_0$GBD$_0$ CONTRIBUTION TO BASEFLOW	GROUND-WATER ONLY PORTION	EXPLOITABLE PORTION	BALANCE HARVEST POTENTIAL	BALANCE EXPLOITATION POTENTIAL	EXPLOITATION POTENTIAL DIVIDED BY TOTAL USE	ESTIMATED EXTENT OF GROUND-WATER UTILISATION	IMPACT OFGROUND-WATER ABSRTACTION ON SURFACE WATER	fGPQi PORTION POTABLE	$_0$GWM$_0$ MAX UTILISABLE GROUND WATER
	(x10^6 m^3/a)		(mm/a)	(mm/a)	(mm/a)	(x10^6 m^3/a)			(x10^6 m^3/a)	(mm/a)	(x10^6 m^3/a)	(x10^6 m^3/a)	(x10^6 m^3/a)	(X10^6 m^3/a)					(x10^6 m^3/a)
H80A	31.07	0.1902	39.66	31.60	107.51	5.91	0.58	0.58	5.91	39.66	4.34	2.17	10.25	5.13	#DIV/0!	UNDER-UTILISED	MODERATE	0.85	4.36
H80B	42.49	0.2310	79.80	52.80	184.35	9.82	0.82	0.82	9.82	79.80	2.15	1.07	11.88	5.89	67.27	UNDER-UTILISED	HIGH	0.30	1.79
H80C	8.17	0.0954	2.73	4.40	11.34	0.78	0.05	0.05	0.78	2.73	15.78	9.47	16.56	9.94	#DIV/0!	UNDER-UTILISED	LOW	0.30	2.98
H80D	5.10	0.0648	1.43	3.00	8.05	0.33	0.11	0.11	0.33	1.43	2.62	0.79	2.95	0.88	#DIV/0!	UNDER-UTILISED	LOW	0.30	0.27
H80E	9.38	0.0609	1.53	3.80	9.26	0.57	0.03	0.03	0.57	1.53	16.14	8.07	16.70	8.35	1637.98	UNDER-UTILISED	LOW	0.30	2.51
H80F	9.51	0.0630	2.94	5.80	16.66	0.60	0.04	0.04	0.60	2.94	14.16	4.25	14.75	4.42	819.73	UNDER-UTILISED	LOW	0.86	3.79
H90A	41.20	0.2199	50.61	36.20	118.41	9.06	1.05	1.00	8.66	48.39	0.00	0.00	8.66	2.60	#DIV/0!	UNDER-UTILISED	HIGH	0.40	1.04
H90B	28.46	0.2235	53.91	38.00	125.80	6.36	0.77	0.77	6.36	53.91	1.89	0.57	8.25	2.48	#DIV/0!	UNDER-UTILISED	MODERATE	0.85	2.10
H90C	5.57	0.1023	2.61	4.10	10.05	0.57	0.04	0.04	0.57	2.61	12.10	3.63	12.67	3.80	#DIV/0!	UNDER-UTILISED	LOW	0.30	1.14
H90D	13.89	0.0669	1.54	3.20	8.60	0.93	0.09	0.09	0.93	1.54	9.67	4.83	10.59	5.29	654.27	UNDER-UTILISED	LOW	0.69	3.64
H90E	17.28	0.0642	2.24	4.70	12.79	1.11	0.20	0.20	1.11	2.24	4.45	3.11	4.77	3.10	4.96	UNDER-UTILISED	LOW	0.76	2.95
J11A	6.72	0.0000	0.00	0.00	1.17	0.00	0.00	0.00	0.00	0.00	4.07	2.44	4.04	2.41	82.43	UNDER-UTILISED	NEGLIGABLE	0.70	1.71
J11B	7.01	0.0000	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	6.20	3.72	6.10	3.62	39.71	UNDER-UTILISED	NEGLIGABLE	0.95	3.52
J11C	1.40	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.14	0.85	2.14	0.85	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	1.00	0.85
J11D	6.53	0.0000	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	6.62	3.97	6.57	3.92	84.85	UNDER-UTILISED	NEGLIGABLE	1.00	3.97
J11E	4.03	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	4.20	6.00	4.20	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.68	2.88
J11F	2.44	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.10	1.26	0.27	-0.56	0.69	UNDER-UTILISED	NEGLIGABLE	0.40	0.50
J11G	1.98	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.05	1.52	3.05	1.52	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.68	1.04
J11H	2.43	0.0000	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	9.36	5.61	9.36	5.61	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.92	5.17
J11J	3.79	0.0078	0.07	0.00	0.96	0.03	0.00	0.00	0.03	0.07	8.24	4.94	8.27	4.96	#DIV/0!	UNDER-UTILISED	LOW	0.50	2.48
J11K	1.57	0.0000	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	5.69	3.41	5.69	3.41	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.55	1.86
J12A	6.82	0.0000	0.00	0.00	4.08	0.00	0.00	0.00	0.00	0.00	8.75	6.13	8.75	6.13	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.70	4.29
J12B	2.40	0.0000	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	5.61	3.93	5.61	3.93	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.31	1.21
J12C	4.20	0.0000	0.00	0.00	0.79	0.00	0.00	0.00	0.00	0.00	3.35	2.34	3.35	2.34	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.89	2.08
J12D	9.81	0.0000	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00	12.70	8.89	12.70	8.89	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.64	5.72
J12E	2.88	0.0105	0.08	0.00	0.94	0.03	0.01	0.01	0.03	0.08	3.15	2.20	3.18	2.22	#DIV/0!	UNDER-UTILISED	LOW	0.83	1.85
J12F	4.50	0.0000	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	10.30	6.18	10.30	6.18	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.50	3.09

GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

J12G	4.47	0.0066	0.04	0.00	0.86	0.03	0.00	0.00	0.03	0.04	9.67	5.80	9.70	5.82	#DIV/0!	UNDER-UTILISED	LOW	0.45	2.65
J12H	4.29	0.0000	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.00	10.90	7.63	10.90	7.63	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.67	5.09
J12J	2.92	0.0000	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	5.16	3.62	1.15	-0.40	0.90	UNDER-UTILISED	NEGLIGABLE	0.40	1.45
J12K	1.58	0.0000	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	4.34	2.61	4.34	2.61	#DIV/0!	UNDER-UTILISED	NEGLIGABLE	0.20	0.52
J12L	7.07	0.0126	0.12	0.00	1.44	0.09	0.01	0.01	0.09	0.12	9.63	6.74	7.17	4.26	2.67	UNDER-UTILISED	LOW	0.53	3.58
J12M	3.50	0.0087	0.06	0.00	0.79	0.03	0.00	0.00	0.03	0.06	9.52	6.66	3.30	0.43	1.07	UNDER-UTILISED	LOW	0.30	2.00
J13A	3.92	0.0078	0.06	0.00	1.05	0.03	0.00	0.00	0.03	0.06	9.93	6.95	1.57	-1.42	0.83	UNDER-UTILISED	LOW	0.33	2.33
J13B	3.41	0.0087	0.07	0.00	1.02	0.03	0.00	0.00	0.03	0.07	7.36	5.15	7.39	5.17	#DIV/0!	UNDER-UTILISED	LOW	0.33	1.72
J13C	5.68	0.0105	0.14	0.00	2.05	0.06	0.00	0.00	0.06	0.14	12.78	7.67	12.84	7.70	#DIV/0!	UNDER-UTILISED	LOW	0.27	2.10
J21A	14.81	0.0021	0.04	0.00	1.99	0.03	0.01	0.01	0.03	0.04	6.06	4.24	3.83	2.00	1.89	MODERATELY-UTILISED	LOW	0.86	3.67
J21B	5.05	0.0000	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	2.08	1.45	1.93	1.30	9.58	UNDER-UTILISED	NEGLIGABLE	0.72	1.04
J21C	4.42	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58	0.95	1.45	0.82	7.37	UNDER-UTILISED	NEGLIGABLE	0.96	0.91
J21D	4.49	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95	0.98	1.56	0.58	2.47	MODERATELY-UTILISED	NEGLIGABLE	0.89	0.86
J21E	3.30	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.76	1.33	0.57	4.11	UNDER-UTILISED	NEGLIGABLE	0.68	0.51
J22A	10.36	0.0000	0.00	0.00	1.29	0.00	0.00	0.00	0.00	0.00	3.42	1.71	3.41	1.70	338.87	UNDER-UTILISED	NEGLIGABLE	0.67	1.14
J22B	5.41	0.0000	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	2.42	1.45	2.38	1.41	35.45	UNDER-UTILISED	NEGLIGABLE	0.96	1.39
J22C	5.48	0.0000	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	2.65	1.59	2.64	1.58	155.85	UNDER-UTILISED	NEGLIGABLE	0.77	1.23
J22D	5.83	0.0000	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	3.59	2.15	3.44	2.00	14.43	UNDER-UTILISED	NEGLIGABLE	0.79	1.69
J22E	6.76	0.0000	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	4.32	2.59	4.13	2.41	13.82	UNDER-UTILISED	NEGLIGABLE	0.83	2.15
J22F	32.00	0.0000	0.00	0.00	3.81	0.00	0.00	0.00	0.00	0.00	0.89	0.53	0.51	0.15	1.40	UNDER-UTILISED	NEGLIGABLE	0.71	0.38
J22G	8.76	0.0000	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	4.42	3.09	4.41	3.08	327.27	UNDER-UTILISED	NEGLIGABLE	0.58	1.80
J22H	13.99	0.0021	0.04	0.00	1.94	0.03	0.01	0.01	0.03	0.04	5.33	3.20	5.33	3.19	137.15	UNDER-UTILISED	LOW	0.81	2.59
J22J	4.43	0.0000	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	2.04	1.23	1.97	1.15	16.36	UNDER-UTILISED	NEGLIGABLE	0.91	1.12
J22K	3.07	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69	1.18	-0.98	-1.49	0.44	OVER-UTILISED	NEGLIGABLE	0.82	0.97
J23A	2.75	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.29	1.60	-2.63	-3.32	0.33	OVER-UTILISED	NEGLIGABLE	0.81	1.30
J23B	4.45	0.0000	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	2.35	1.64	1.53	0.82	2.00	MODERATELY-UTILISED	NEGLIGABLE	0.85	1.40
J23C	1.20	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54	1.08	1.53	1.07	149.51	UNDER-UTILISED	NEGLIGABLE	0.85	0.91
J23D	1.45	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.76	1.38	2.75	1.37	138.54	UNDER-UTILISED	NEGLIGABLE	0.88	1.22
J23E	7.36	0.0408	1.33	4.10	9.20	0.30	0.04	0.04	0.30	1.33	8.04	5.63	5.11	2.60	1.80	MODERATELY-UTILISED	LOW	0.40	2.34
J23F	4.36	0.0000	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	6.99	4.20	4.09	1.29	1.44	HEAVILY-UTILISED	NEGLIGABLE	0.86	3.62
J23G	0.26	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.29	0.72	0.29	85.54	UNDER-UTILISED	NEGLIGABLE	1.00	0.29
J23H	2.59	0.0000	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	3.76	2.25	3.08	1.58	3.32	UNDER-UTILISED	NEGLIGABLE	0.50	1.13
J23J	6.61	0.0408	1.18	3.40	8.14	0.27	0.04	0.04	0.27	1.18	6.87	4.12	6.40	3.54	5.78	UNDER-UTILISED	LOW	0.70	3.00

GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

J24A	16.34	0.0000	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00	7.25	4.35	7.25	4.35	579.85	UNDER-UTILISED	NEGLIGABLE	0.78	3.42
J24B	6.82	0.0000	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	3.58	2.15	3.55	2.12	88.36	UNDER-UTILISED	NEGLIGABLE	0.92	1.97
J24C	3.87	0.0000	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	3.22	1.93	3.22	1.93	281.32	UNDER-UTILISED	NEGLIGABLE	0.95	1.85
J24D	2.71	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.78	2.27	3.77	2.26	395.39	UNDER-UTILISED	NEGLIGABLE	0.95	2.16
J24E	2.93	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.21	1.93	3.21	1.93	716.16	UNDER-UTILISED	NEGLIGABLE	0.89	1.71
J24F	0.81	0.0000	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	2.87	1.44	2.09	0.65	1.84	MODERATELY-UTILISED	NEGLIGABLE	0.40	0.57
J25A	8.69	0.0414	1.02	2.90	7.04	0.36	0.03	0.03	0.36	1.02	12.99	6.50	11.08	4.40	2.93	UNDER-UTILISED	LOW	0.95	6.34
J25B	13.56	0.0465	1.59	4.00	10.35	0.63	0.05	0.05	0.63	1.59	12.81	8.97	13.44	9.41	#DIV/0!	UNDER-UTILISED	LOW	1.00	9.41
J25C	1.08	0.0000	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	7.28	5.09	7.22	5.04	94.65	UNDER-UTILISED	NEGLIGABLE	0.85	4.33
J25D	9.58	0.0438	2.00	5.30	13.35	0.42	0.06	0.06	0.42	2.00	6.54	2.61	6.25	2.08	3.94	UNDER-UTILISED	LOW	0.85	2.37
J25E	1.02	0.0000	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	11.52	8.07	11.49	8.04	269.64	UNDER-UTILISED	NEGLIGABLE	0.70	5.65
J31A	9.55	0.0408	0.87	2.50	6.92	0.39	0.02	0.02	0.39	0.87	20.18	14.12	20.27	14.10	49.08	UNDER-UTILISED	LOW	0.50	7.20
J31B	2.31	0.0519	0.60	1.60	3.50	0.12	0.02	0.02	0.12	0.60	7.76	4.66	7.88	4.73	#DIV/0!	UNDER-UTILISED	LOW	0.40	1.89
J31C	2.04	0.0441	0.54	1.70	3.61	0.09	0.01	0.01	0.09	0.54	6.93	4.16	6.58	3.78	9.67	UNDER-UTILISED	LOW	0.70	2.95
J31D	2.00	0.0600	0.39	1.10	2.06	0.12	0.02	0.02	0.12	0.39	5.34	3.20	4.95	2.76	6.37	MODERATELY-UTILISED	LOW	0.10	0.33
J32A	0.58	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.62	1.24	0.62	352.77	UNDER-UTILISED	NEGLIGABLE	0.84	0.52
J32B	1.03	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.18	1.53	2.02	1.37	9.59	UNDER-UTILISED	NEGLIGABLE	0.75	1.15
J32C	0.67	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20	1.32	2.05	1.17	8.87	UNDER-UTILISED	NEGLIGABLE	0.93	1.23
J32D	0.48	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.27	0.81	0.18	2.91	HEAVILY-UTILISED	NEGLIGABLE	0.20	0.05
J32E	5.08	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.59	5.80	11.13	5.33	12.47	UNDER-UTILISED	NEGLIGABLE	0.67	3.86
J33A	5.11	0.0588	0.67	1.90	4.01	0.30	0.02	0.02	0.30	0.67	18.19	10.91	17.29	9.89	9.25	UNDER-UTILISED	LOW	0.40	4.44
J33B	9.16	0.0558	0.86	2.40	5.51	0.51	0.02	0.02	0.51	0.86	23.52	16.46	20.95	13.74	5.46	HEAVILY-UTILISED	LOW	0.40	6.73
J33C	2.56	0.0000	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	10.62	7.43	9.27	6.09	5.52	HEAVILY-UTILISED	NEGLIGABLE	0.40	2.97
J33D	12.38	0.0411	1.96	5.90	14.25	0.51	0.07	0.07	0.51	1.96	6.77	2.71	6.62	2.26	4.46	HEAVILY-UTILISED	LOW	0.70	2.04
J33E	24.59	0.0414	3.09	8.60	23.04	1.02	0.08	0.08	1.02	3.09	11.85	8.30	8.88	5.01	2.26	OVER-UTILISED	LOW	1.00	9.01
J33F	11.74	0.0666	2.14	4.50	10.90	0.78	0.05	0.05	0.78	2.14	14.27	9.99	14.80	10.29	42.33	UNDER-UTILISED	LOW	0.95	9.98
J34A	5.59	0.0429	0.95	2.90	7.25	0.24	0.02	0.02	0.24	0.95	14.57	7.28	14.79	7.38	373.14	UNDER-UTILISED	LOW	1.00	7.40
J34B	12.94	0.0417	1.58	4.80	12.30	0.54	0.03	0.03	0.54	1.58	15.96	7.98	16.43	8.18	112.75	UNDER-UTILISED	LOW	1.00	8.25
J34C	21.27	0.0423	2.82	7.50	21.66	0.90	0.05	0.05	0.90	2.82	18.87	11.32	19.77	11.86	#DIV/0!	UNDER-UTILISED	LOW	0.70	8.31
J34D	7.75	0.0582	1.27	2.80	7.74	0.45	0.03	0.03	0.45	1.27	15.06	9.04	15.51	9.31	#DIV/0!	UNDER-UTILISED	LOW	1.00	9.31
J34E	4.30	0.0699	1.17	2.30	5.98	0.30	0.03	0.03	0.30	1.17	9.89	5.94	10.20	6.12	#DIV/0!	UNDER-UTILISED	LOW	0.40	2.45
J34F	4.67	0.0642	0.94	2.20	5.42	0.30	0.03	0.03	0.30	0.94	11.64	8.15	11.61	8.03	25.26	UNDER-UTILISED	LOW	0.40	3.34
J35A	22.73	0.0714	3.79	7.40	17.78	1.62	0.12	0.12	1.62	3.79	11.83	8.28	12.56	8.52	10.56	UNDER-UTILISED	LOW	1.00	9.41

GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

J35B	9.36	0.0672	0.97	2.10	5.29	0.63	0.02	0.02	0.63	0.97	24.72	17.31	24.86	17.26	36.35	UNDER-UTILISED	LOW	0.60	10.65
J35C	2.85	0.0738	0.79	1.70	3.98	0.21	0.02	0.02	0.21	0.79	11.45	8.01	11.60	8.11	149.70	UNDER-UTILISED	LOW	0.70	5.71
J35D	25.29	0.0711	3.55	6.90	17.04	1.80	0.12	0.12	1.80	3.55	12.75	8.92	14.31	9.95	43.74	UNDER-UTILISED	LOW	0.74	7.55
J35E	4.28	0.0492	0.98	2.40	5.83	0.21	0.03	0.03	0.21	0.98	7.72	4.63	7.82	4.65	45.45	UNDER-UTILISED	LOW	0.40	1.90
J35F	18.33	0.0507	1.86	4.50	11.62	0.93	0.05	0.05	0.93	1.86	17.59	10.56	18.29	10.88	47.76	UNDER-UTILISED	LOW	0.50	5.56
J40A	31.94	0.0441	3.10	8.50	22.44	1.41	0.10	0.10	1.41	3.10	12.18	6.09	13.58	6.79	#DIV/0!	UNDER-UTILISED	LOW	0.40	2.72
J40B	17.24	0.0486	3.77	8.80	24.99	0.84	0.07	0.07	0.84	3.77	11.23	6.74	12.07	7.24	#DIV/0!	UNDER-UTILISED	LOW	0.95	6.88
J40C	39.07	0.0675	6.05	11.30	34.05	2.64	0.17	0.17	2.64	6.05	12.85	9.00	15.48	10.83	785.66	UNDER-UTILISED	LOW	0.33	3.61
J40D	25.50	0.0540	2.10	4.40	13.92	1.38	0.15	0.15	1.38	2.10	7.59	3.80	8.85	4.36	37.07	UNDER-UTILISED	LOW	0.58	2.62
J40E	20.79	0.0534	2.00	4.30	13.39	1.11	0.06	0.06	1.11	2.00	18.88	11.33	19.98	11.99	1332.69	UNDER-UTILISED	LOW	0.56	6.75
K10A	6.08	0.0690	2.36	4.40	12.95	0.42	0.13	0.13	0.42	2.36	2.92	2.04	3.33	2.33	#DIV/0!	UNDER-UTILISED	LOW	0.17	0.39
K10B	5.70	0.0684	2.28	4.40	12.32	0.39	0.14	0.14	0.39	2.28	2.47	1.48	2.86	1.72	#DIV/0!	UNDER-UTILISED	LOW	0.86	1.47
K10C	11.09	0.1029	7.18	10.50	27.46	1.14	0.12	0.12	1.14	7.18	8.13	4.07	9.27	4.64	#DIV/0!	UNDER-UTILISED	LOW	0.85	3.94
K10D	5.75	0.0678	2.38	4.40	12.87	0.39	0.10	0.10	0.39	2.38	3.49	1.75	3.88	1.94	#DIV/0!	UNDER-UTILISED	LOW	0.40	0.78
K10E	31.07	0.1815	42.40	49.00	114.07	5.64	0.73	0.73	5.64	42.40	2.12	1.06	7.76	3.88	#DIV/0!	UNDER-UTILISED	MODERATE	0.70	2.72
K10F	4.89	0.0735	3.39	10.80	17.03	0.36	0.14	0.14	0.36	3.39	2.13	1.28	2.49	1.49	#DIV/0!	UNDER-UTILISED	LOW	0.40	0.60
K20A	39.52	0.2505	58.93	53.70	125.35	9.90	1.16	1.00	8.55	50.91	0.00	0.00	8.55	5.13	#DIV/0!	UNDER-UTILISED	HIGH	0.40	2.05
K30A	51.99	0.2538	67.32	57.20	142.28	13.20	1.19	1.00	11.11	56.68	0.00	0.00	11.11	4.44	#DIV/0!	UNDER-UTILISED	HIGH	0.40	1.78
K30B	41.74	0.2586	77.65	61.10	159.24	10.79	1.79	1.00	6.04	43.44	0.00	0.00	6.04	3.02	#DIV/0!	UNDER-UTILISED	HIGH	0.40	1.21
K30C	53.56	0.2508	70.70	63.40	150.68	13.43	1.31	1.00	10.23	53.86	0.00	0.00	10.23	4.09	#DIV/0!	UNDER-UTILISED	HIGH	0.40	1.64
K30D	37.07	0.2427	50.54	53.90	110.61	9.00	0.87	0.87	9.00	50.54	1.29	0.64	10.29	5.14	#DIV/0!	UNDER-UTILISED	HIGH	0.50	2.57
K40A	17.45	0.3060	61.38	51.70	116.32	5.34	0.66	0.66	5.34	61.38	2.79	1.40	8.13	4.07	#DIV/0!	UNDER-UTILISED	MODERATE	0.85	3.46
K40B	25.96	0.2796	64.81	68.50	128.42	7.26	0.90	0.90	7.26	64.81	0.79	0.31	8.05	3.22	#DIV/0!	UNDER-UTILISED	HIGH	0.70	2.25
K40C	35.42	0.3177	112.53	79.50	191.11	11.25	1.82	1.00	6.19	61.94	0.00	0.00	6.19	3.10	#DIV/0!	UNDER-UTILISED	HIGH	0.50	1.55
K40D	33.86	0.3198	83.30	57.60	140.85	10.83	2.62	1.00	4.14	31.81	0.00	0.00	4.14	2.48	#DIV/0!	UNDER-UTILISED	HIGH	0.40	0.99
K40E	54.19	0.2247	45.43	70.70	95.52	12.18	0.52	0.52	12.18	45.43	11.21	7.85	23.39	16.37	#DIV/0!	UNDER-UTILISED	MODERATE	0.85	13.92
K50A	50.85	0.2436	52.71	68.90	120.38	12.39	0.51	0.51	12.39	52.71	12.00	4.80	24.38	9.75	#DIV/0!	UNDER-UTILISED	MODERATE	0.95	9.27
K50B	53.54	0.2409	63.54	73.00	125.64	12.90	0.61	0.61	12.90	63.54	8.35	3.34	21.25	8.50	#DIV/0!	UNDER-UTILISED	MODERATE	0.95	8.08
K60A	13.95	0.1785	15.47	15.50	42.03	2.49	0.21	0.21	2.49	15.47	9.38	5.63	11.79	7.04	81.89	UNDER-UTILISED	LOW	0.95	6.77
K60B	17.40	0.2499	30.41	29.90	66.24	4.35	0.36	0.36	4.35	30.41	7.89	4.73	12.23	7.34	1359.91	UNDER-UTILISED	MODERATE	1.00	7.34
K60C	19.78	0.2577	31.66	29.60	69.94	5.10	0.30	0.30	5.10	31.66	11.82	7.09	16.92	10.15	#DIV/0!	UNDER-UTILISED	MODERATE	1.00	10.15
K60D	44.40	0.2643	40.19	32.00	84.86	11.73	0.40	0.40	11.73	40.19	17.61	10.57	29.35	17.61	#DIV/0!	UNDER-UTILISED	MODERATE	0.85	14.97
K60E	9.46	0.2982	28.21	30.60	59.46	2.82	0.36	0.36	2.82	28.21	4.93	1.97	7.75	3.10	#DIV/0!	UNDER-UTILISED	MODERATE	0.85	2.64

GROUNDWATER CONTRIBUTION TO BASEFLOW PER QUATERNARY CATCHMENT

K60F	21.42	0.2802	24.80	31.80	56.55	6.00	0.29	0.29	6.00	24.80	14.75	8.85	20.75	12.45	#DIV/0!	UNDER-UTILISED	LOW	0.85	10.58
K60G	19.53	0.2781	32.52	33.50	66.44	5.43	0.39	0.39	5.43	32.52	8.65	5.19	13.24	7.61	10.06	UNDER-UTILISED	MODERATE	0.85	7.18
K70A	24.69	0.2334	33.90	35.50	82.30	5.76	0.30	0.30	5.76	33.90	13.15	6.57	18.78	9.32	71.64	UNDER-UTILISED	MODERATE	0.85	8.04
K70B	40.92	0.2733	105.50	97.70	210.73	11.18	0.94	0.94	11.18	105.50	0.74	0.37	11.92	5.96	#DIV/0!	UNDER-UTILISED	HIGH	0.85	5.07
	1678.53	9.17	1507.13	1501.10	3542.25	249.41	24.29	20.37	225.88	1333.12	939.18	563.85	1100.81	613.93	#DIV/0!	0.00	0.00	87.63	454.82

GOURITZ WATER MANAGEMENT AREA
APPENDIX G5 - WATER QUALITY INFORMATION

Quatenary	Station No	Mean (mg/l)	Maximum (mg/l)	Mean colour	Maximum colour	Overall colour
H80A	NO					
H80B	NO					
H80C	NO					
H80D	NO					
H80E	NO					
H80F	NO					
H90A	H9H004Q01	57.3	87.0	Blue	Blue	Blue
H90B	H9R001Q01	68.4	106.0	Blue	Blue	Blue
H90C	H9H005Q01	570.0	2342.0	Green	Red	Yellow
H90D	NO					
H90E	NO					
J11A	J1R003Q01	705.0	2831.0	Yellow	Red	Red
J11B	J1R003Q01	705.0	2831.0	Yellow	Red	Red
J11C	J1R003Q01	705.0	2831.0	Yellow	Red	Red
J11D	J1R003Q01	705.0	2831.0	Yellow	Red	Red
J11E	J1R003Q01	705.0	2831.0	Yellow	Red	Red
J11F	J1R003Q01	705.0	2831.0	Yellow	Red	Red
J11G	J1R003Q01	705.0	2831.0	Yellow	Red	Red
J11H	NO					
J11J	NO					
J11K	NO					
J12A	J1H015Q01	22.3	35.0	Blue	Blue	Blue
J12B	NO					
J12C	NO					
J12D	NO					
J12E	NO					
J12F	NO					
J12G	J1H022Q01	355.0	525.0	Green	Green	Green
J12H	J1H022Q01	355.0	525.0	Green	Green	Green
J12J	J1R002Q01	3855.6	17022.0	Purple	Purple	Purple
J12K	J1R002Q01	3855.6	17022.0	Purple	Purple	Purple
J12L	NO					
J12M	J1R004Q01	1061.7	1767.0	Yellow	Yellow	Yellow
J13A	J1H019Q01	4332.5	7129.0	Purple	Purple	Purple
J13B	J1H019Q01	4332.5	7129.0	Purple	Purple	Purple
J13C	NO					
J21A	J2R004Q01	225.3	313.0	Blue	Green	Green
J21B	NO					
J21C	NO					
J21D	NO					
J21E	NO					
J22A	NO					
J22B	NO					
J22C	NO					
J22D	NO					

Quaternary	Station No	Mean (mg/l)	Maximum (mg/l)	Mean colour	Maximum colour	Overall colour
J22E	NO					
J22F	NO					
J22G	NO					
J22H	J2R002Q01	252.2	420.0	Blue	Green	Green
J22J	J2R002Q01	252.2	420.0	Blue	Green	Green
J22K	J2R002Q01	252.2	420.0	Blue	Green	Green
J23A	NO					
J23B	NO					
J23C	NO					
J23D	NO					
J23E	J2R003Q01	224.0	356.0	Blue	Green	Green
J23F	NO					
J23G	NO					
J23H	NO					
J23J	NO					
J24A	NO					
J24B	NO					
J24C	NO					
J24D	NO					
J24E	NO					
J24F	NO					
J25A	J2H010Q01	586.5	999.0	Green	Yellow	Yellow
J25B	J2H005Q01	965.0	1318.0	Yellow	Yellow	Yellow
J25C	NO					
J25D	J2R001Q01	182.0	235.0	Blue	Blue	Blue
J25E	NO					
J31A	NO					
J31B	NO					
J31C	NO					
J31D	NO					
J32A	NO					
J32B	NO					
J32C	NO					
J32D	NO					
J32E	NO					
J33A	J3H016Q01	296.8	466.0	Green	Green	Green
J33B	J3R002Q01	578.9	888.0	Green	Yellow	Yellow
J33C	J3H012Q01	249.1	347.0	Blue	Green	Green
J33D	J3H012Q01	249.1	347.0	Blue	Green	Green
J33E	NO					
J33F	NO					
J34A	J3R001Q01	258.5	405.0	Blue	Green	Green
J34B	J3R001Q01	258.5	405.0	Blue	Green	Green
J34C	J3R001Q01	258.5	405.0	Blue	Green	Green
J34D	J3R001Q01	258.5	405.0	Blue	Green	Green
J34E	J3R001Q01	258.5	405.0	Blue	Green	Green
J34F	J3R001Q01	258.5	405.0	Blue	Green	Green
J35A	J3H015Q01	68.8	189.0	Blue	Blue	Blue

Quatenary	Station No	Mean (mg/l)	Maximum (mg/l)	Mean colour	Maximum colour	Overall colour
J35B	J3H017Q01	729.0	1680.1	Yellow	Yellow	Yellow
J35C	J3H011Q01	13602.1	20371.0	Purple	Purple	Purple
J35D	J3H020Q01	232.9	631.0	Blue	Yellow	Green
J35E	J3H011Q01	13602.1	20371.0	Purple	Purple	Purple
J35F	J3H011Q01	13602.1	20371.0	Purple	Purple	Purple
J40A	J4H002Q01	2882.0	6031.0	Red	Purple	Purple
J40B	J4H002Q01	2882.0	6031.0	Red	Purple	Purple
J40C	J4H003Q01	105.3	376.0	Blue	Green	Green
J40D	NO					
J40E	NO					
K10A	NO					
K10B	K1R001Q01	661.4	1020.0	Yellow	Yellow	Yellow
K10C	K1H004Q01	160.5	235.0	Blue	Blue	Blue
K10D	K1H004Q01	160.5	235.0	Blue	Blue	Blue
K10E	K1H005Q01	182.2	257.0	Blue	Blue	Blue
K10F	K1H005Q01	182.2	257.0	Blue	Blue	Blue
K20A	K2H002Q01	336.4	1158.8	Green	Yellow	Yellow
K30A	K3H003Q01	320.0	719.0	Green	Yellow	Yellow
K30B	K3H007Q01	228.5	332.0	Blue	Green	Green
K30C	K3R002Q01	88.6	247.0	Blue	Blue	Blue
K30D	K3H005Q01	82.9	103.0	Blue	Blue	Blue
K40A	K4H003Q01	111.9	138.0	Blue	Blue	Blue
K40B	K4H001Q01	190.4	1974.0	Blue	Red	Yellow
K40C	K4H002Q01	76.3	133.0	Blue	Blue	Blue
K40D	NO					
K40E	NO					
K50A	K5H002Q01	70.3	84.0	Blue	Blue	Blue
K50B	NO					
K60A	K6H001Q01	206.4	262.0	Blue	Green	Green
K60B	K6H002Q01	73.5	123.0	Blue	Blue	Blue
K60C	K6H002Q01	73.5	123.0	Blue	Blue	Blue
K60D	K6H002Q01	73.5	123.0	Blue	Blue	Blue
K60E	K6H002Q01	73.5	123.0	Blue	Blue	Blue
K60F	NO					
K60G	NO					

APPENDIX H

WATER RESOURCES

APPENDIX H.1	**Data sources.**
APPENDIX H.2	**Data default values used in WRSA report.**

GOURITZ WATER MANAGEMENT AREA

APPENDIX H.1

DATA SOURCES

PARAMETER	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

GOURITZ WATER MANAGEMENT AREA

APPENDIX H.2

DATA DEFAULT VALUES USED IN THE WRSA REPORT

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

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

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)*
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

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)*
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

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)*
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**

LIST OF FIGURES

2.1.1 The study area
2.1.2 Topography and river catchments
2.1.3 Hydrological sub-catchments
2.2.1 Mean annual precipitation
2.2.2 Mean annual Symons Pan evaporation
2.3.1 Geology
2.4.1 Soils
2.5.2.1 Natural vegetation
2.6.3.1 Default ecological management classes
2.6.3.2 Present ecological status class and ecologically sensitive sites
2.6.3.3 Suggested future ecological management class
3.2.4.1 Population distribution
3.4.9.1 District Councils and magisterial districts
3.4.9.2 Institutional boundaries related to water supply
3.5.1.1 Land use
3.5.4.1 Livestock and game numbers
3.5.6.1 Alien vegetation infestation
4.1.1 Water related infrastructure
5.1.1 Total equivalent water requirements 1995
5.1.2 Water requirements at 1:50 year assurance per user sector 1995
5.2.1.1 Desktop Reserve parameter regions
5.2.4.1 Water requirements for ecological component of the Reserve
5.3.1.1 Urban and rural domestic water requirements in 1995
5.6.2.1 Irrigation water requirements in 1995
5.9.1 Water use by afforestation in 1995
5.11.1 Water use by alien vegetation
5.14.1 Water transfer schemes
6.1.1 1:50 year yield of the total water resource as developed in 1995
6.1.2 1:50 year yield of the total water resources if developed to full potential
6.2.1 Groundwater harvest potential
6.2.2 Groundwater exploitation potential
6.2.3 Contribution of groundwater to surface water base flow
6.2.4 Groundwater use in 1995
6.2.5 Remaining groundwater exploitation potential in 1995
6.3.1 Mean annual naturalised surface runoff
6.3.2 Undeveloped potential 1:50 year surface water yield
6.4.1.1 Mineralogical surface water quality
6.4.2.1 Mineralogical groundwater quality
6.4.2.2 Percentage of potable groundwater
6.4.3.1 Potential surface faecal contamination
6.4.3.2 Risk of faecal contamination of groundwater
6.5.1 Potential for sediment accumulation in reservoirs
7.2.1 Yield balance overview 1995

LEGEND

		GIS COV
	WMA Boundaries	Watermas
	Provincial Boundaries	Prov0807
	Towns	Imp (Amended)
	Rivers	Wr1500
	Dams	Ndams
	Quaternary Catchment	Drgnquat
E24D	Quaternary Number	Drgnquat
	Secondary Catchment	Drgnsd
J2	Secondary Catchment Number	Drgnsd
	Nature Reserve Boundaries	Conagen
	Catchments of Key Points	Wsa_key_pts

PREPARED BY

NINHAM SHAND CONSULTING ENGINEERS

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE 1:1 500 000

20 0 20 40 Km

N

TITLE:

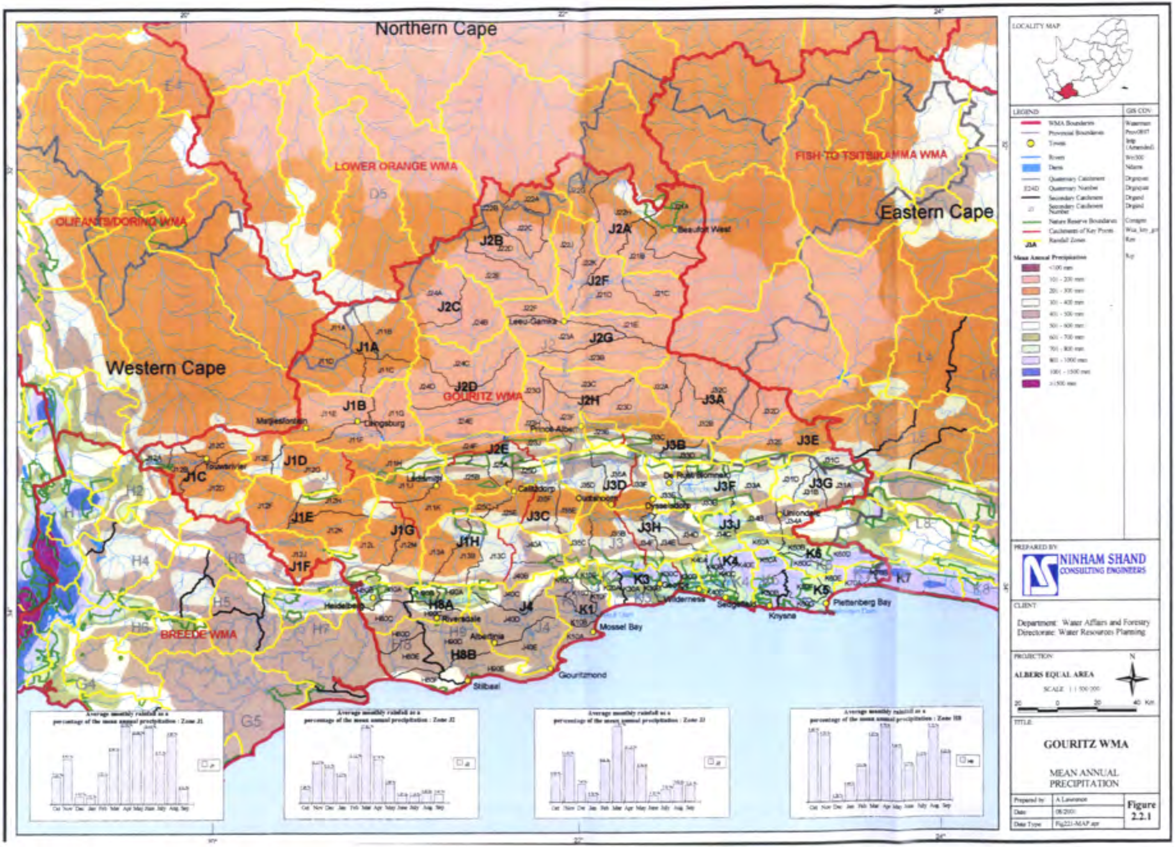
GOURITZ WMA

STUDY AREA

Prepared by	A Lawrence	**Figure 2.1.1**
Date	06/2001	
Data Type	Fig211-Study apr	

Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
OLIFANTS/DORING WMA
Western Cape
GOURITZ WMA
BREEDE WMA
E4
E2
L2
L3
L4
L5
L6
L8
J1
J2
J3
J4
H1
H2
H3
H4
H5
H6
H7
H8
H9
G4
G5
K1
K3
K4
K5
K6
K7
K8
Beaufort West
Leeu-Gamka
Laingsburg
Matjiesfontein
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust/Blomnek
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Heidelberg
Riversdale
Albertinia
Mossel Bay
Gouritzmond
Stilbaai
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Endemic Areas
Local
Global
Elevation
0 - 400
401 - 800
801 - 1200
1201 - 1600
1601 - 2000
2001 - 2400
2401 - 2800
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
SCALE 1:1 500 000
N
20 0 20 40 Km
TITLE
GOURITZ WMA
TOPOGRAPHY AND RIVER CATCHMENTS
Prepared by A Lawrence
Date 08/2001
Figure 2.1.2

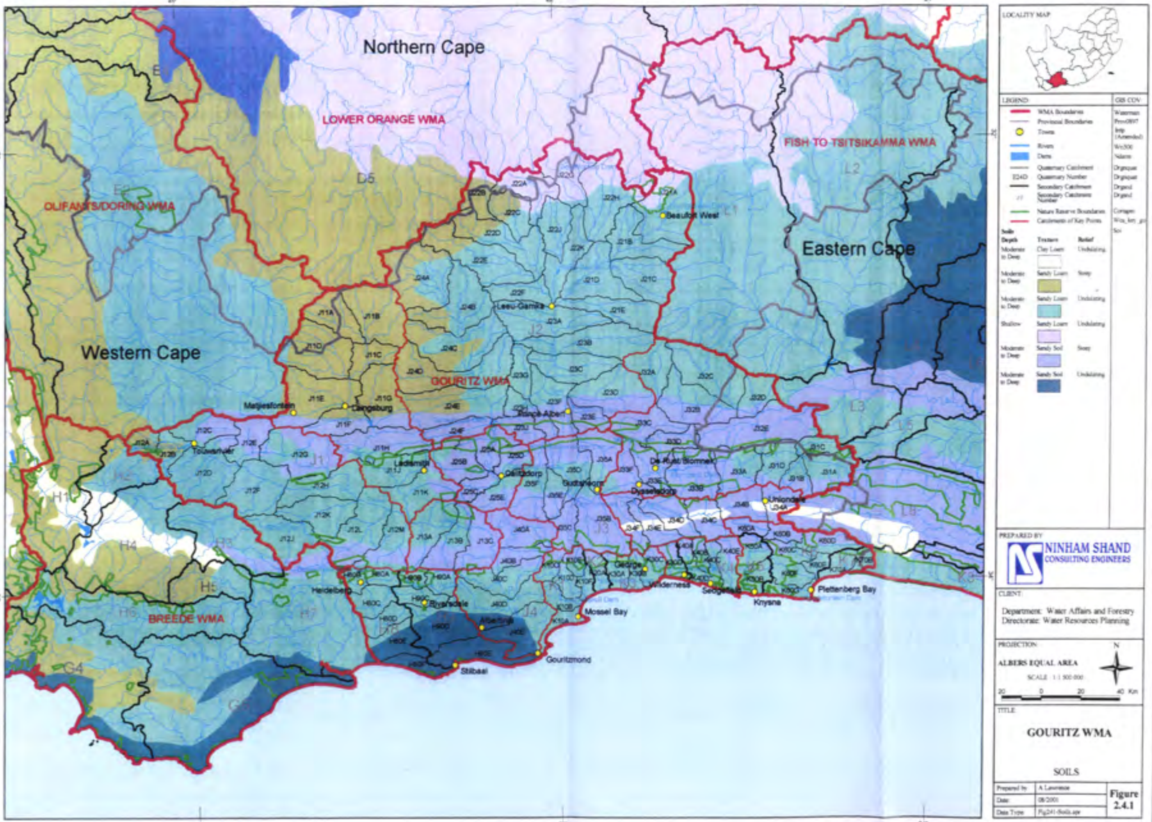

Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Matjiesfontein
Laingsburg
Ladismith
De Rust
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Albertinia
Gouritzmond
Riversdale
Heidelberg
Stilbaai
LOCALITY MAP
LEGEND
PREPARED BY:
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
HYDROLOGICAL
SUB-CATCHMENTS
Figure
2.1.3

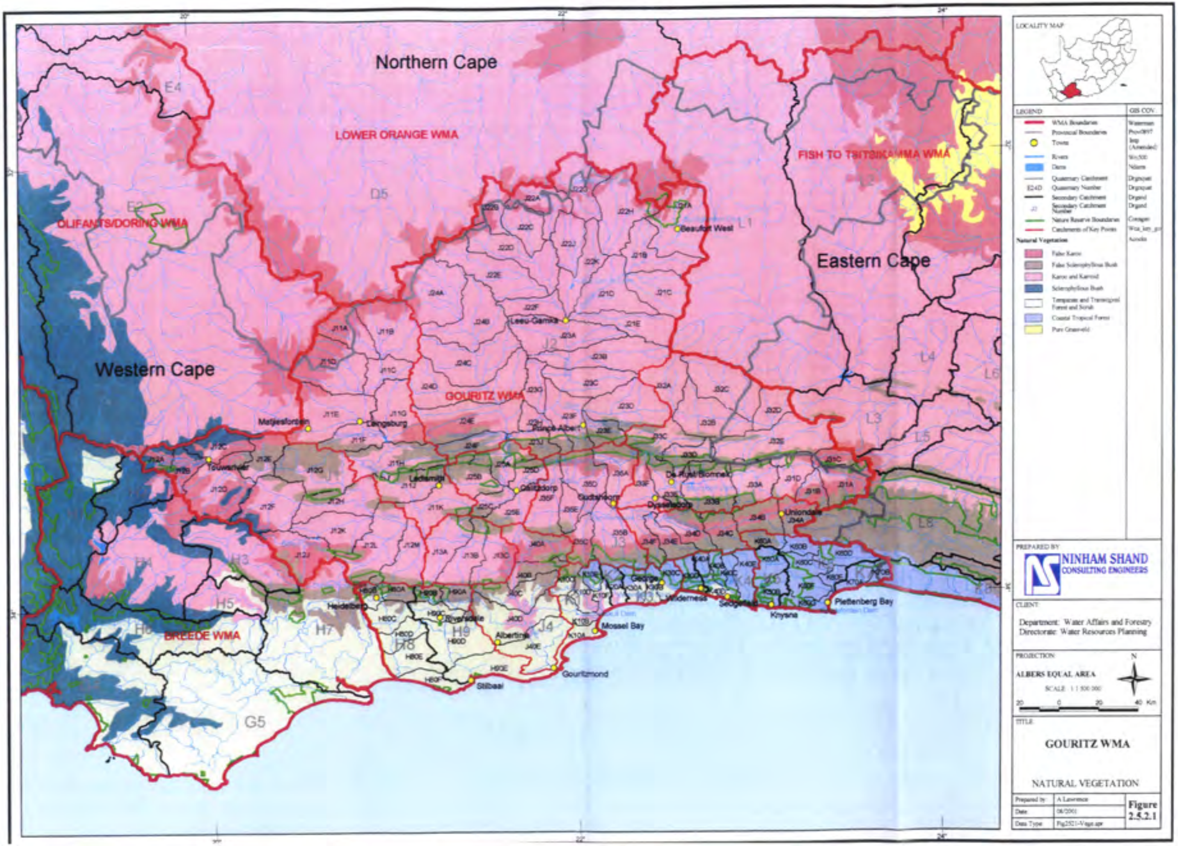


Northern Cape
LOWER ORANGE WMA
FISH-TO-TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
J1A
J1B
J1C
J1D
J1E
J1F
J1G
J1H
J2A
J2B
J2C
J2D
J2E
J2F
J2G
J2H
J3A
J3B
J3C
J3D
J3E
J3F
J3G
J3H
J3J
J4
H8A
H8B
K1
K3
K4
K5
K6
K7
Beaufort West
Leeu-Gamka
Laingsburg
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Heidelberg
Riversdale
Albertinia
Gouritzmond
Stilbaai
Average monthly rainfall as a percentage of the mean annual precipitation : Zone J1
Average monthly rainfall as a percentage of the mean annual precipitation : Zone J2
Average monthly rainfall as a percentage of the mean annual precipitation : Zone J3
Average monthly rainfall as a percentage of the mean annual precipitation : Zone H8
LOCALITY MAP
LEGEND
Mean Annual Precipitation
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
MEAN ANNUAL PRECIPITATION
Figure 2.2.1

Northern Cape
LOWER ORANGE WMA
OLIFANTS/DORING WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
24A
24B
24C
23E
Beaufort West
Leeu-Gamka
Prince Albert
Matjiesfontein
Laingsburg
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Mossel Bay
Gouritzmond
Stilbaai
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Monthly evaporation as a percentage of the mean annual evaporation
Oct Nov Dec Jan Feb Mar Apr May June July Aug Sep
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Evaporation Zones
Mean Annual Evaporation (S-Pan)
< 1200 mm
1200-1300 mm
1300-1400 mm
1400-1500 mm
1500-1600 mm
1600-1700 mm
1700-1800 mm
1800-2000 mm
2000-2200 mm
2200-2600 mm
> 2600 mm
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
SCALE 1:1 500 000
N
TITLE
GOURITZ WMA
MEAN ANNUAL SYMONS PAN EVAPORATION
Prepared by: A Lawrance
Date: 08/2001
Data Type: Fig222-MAE.apr
Figure 2.2.2

Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Matjiesfontein
Laingsburg
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Gouritzmond
Stilbaai
LOCALITY MAP
LEGEND
GIS COV.
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Geology
Acid, intermediate or alkaline intrusives
Compact arenaceous and argillaceous strata
Compact sedimentary strata
Compact, dominantly arenaceous strata
Compact, dominantly argillaceous strata
Consolidated porous to compact sedimentary strata
Mainly compact tillite, shale and sandstone (Dwyka formation and Ecca Group)
Porous unconsolidated to semi-consolidated sediment
Mines in Production
Mineral Pigment
Fuller's Earth
Silcrete
Kaolin
Bentonite
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
SCALE 1:1 300 000
N
TITLE
GOURITZ WMA
GEOLOGY
Prepared by
A Lawrence
Date
08/2001
Figure 2.3.1


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Matjiesfontein
Laingsburg
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust/Blommes
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Heidelberg
Riversdale
Albertinia
Gouritzmond
Stilbaai
LOCALITY MAP
LEGEND
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
GOURITZ WMA
SOILS
Figure
2.4.1



Northern Cape
LOWER ORANGE WMA
OLIFANTS/DORING WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Matjiesfontein
Laingsburg
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritzmond
LOCALITY MAP
LEGEND
GIS COV.
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Natural Vegetation
False Karoo
False Sclerophyllous Bush
Karoo and Karroid
Sclerophyllous Bush
Temperate and Transitional Forest and Scrub
Coastal Tropical Forest
Pure Grassveld
PREPARED BY
NINHAM SHAND CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
NATURAL VEGETATION
Figure 2.5.2.1


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Matjiesfontein
Laingsburg
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mosselbaai
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritzmond
LOCALITY MAP
LEGEND
Default Ecological Management Classes
Class A: Unmodified, Natural
Class B: Largely Natural
Class C: Moderately Modified
Not Assessed
Note:
The ecological management class that is shown only applies to the river reach at the outlet of the quaternary catchment
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
SCALE 1:1 500 000
20 0 20 40 Km
TITLE
GOURITZ WMA
DEFAULT ECOLOGICAL MANAGEMENT CLASSES
Prepared by A Lawrence
Date 08/2001
Figure 2.6.3.1


Northern Cape
LOWER ORANGE WMA
OLIFANTS/DORING WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
E4
E2
D5
L1
L2
L3
L4
L5
L6
L8
K8
H1
H2
H3
H4
H5
H6
H7
H8
G4
G5
J1
J2
Gamka
Springfontein Dam
Beaufort West
Beaufort West Bird Sanctuary
Leeu-Gamka
Buffels
Grobbelaars
Klues
Millwood Creek
Nels
Olifants
Swart
Wynands
Oshoekagang Vlei
Matjiesfontein
Laingsburg
Floriskraal
Doring
Gamkapoort
Prince Albert
Oukloof
Groot
Koos Raubenheimer
Waterkloof
Duiwenshoeks
Ladismith
Calitzdorp
Touwsrivier
Prinsrivier
Kango
Stompdrift
Oudtshoorn
Dysel
Kammanassie
Moeras
Uniondale
Keurbooms
Swartvlei
Touws
Kaaimans
Bellair
Miertjieskraal
Korentepoort
Duiwenhoksrivier
Heidelberg
Longtou
Riversdale
Soetmelks
Weyers
Groot Brak
Klein Brak River
Hartenbos
Hartbeeskuil
Blinde Gorge
Albertinia
Voëlvlei
Gericke
Se Sloot
Gouritzmond
Gourikwa
Duiwenhoks
Stilbaai
Mossel Bay
Sewage Farm
Wilderness-Rondevlei
George
Skaapkop
Gwaing
Maalgate
Klein Brak
Meul
Klein Brak
Kaaimans
Touws
Wilderness-Serpentine
Wilderness-Langvlei
Wilderness-Rondevlei
Wilderness-Eilandvlei
Ruigtevlei
Groenvlei
Goukamma
Sedgefield
Knysna
Knysna Lagoon
Homtini
Crooks
Grootelland
Kranshoek
Bitou Rivier
Keurbooms
Piesang
Plettenberg Bay
Sout
Matjies
Bietou R
Rietvlei
Helpmekaars
Groot (Wes)
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Present Ecological Status Class
Class B: Largely Natural
Class C: Moderately Modified
Class D: Largely Modified
Not Assessed
Ecologically Sensitive Cultural and Heritage Sites
Lacustrine
Estuarine
Riverine
Palustrine
Heritage Sites and Protected Areas
RAMSAR Sites
Note:
The ecological status class that is shown only applies to the river reach at the outlet of the quaternary catchment
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
SCALE 1:1 500 000
20 0 20 40 Km
N
TITLE
GOURITZ WMA
PRESENT ECOLOGICAL STATUS CLASS AND ECOLOGICALLY SENSITIVE SITES
Prepared by A Lawrence
Date 08/2001
Figure 2.6.3.2

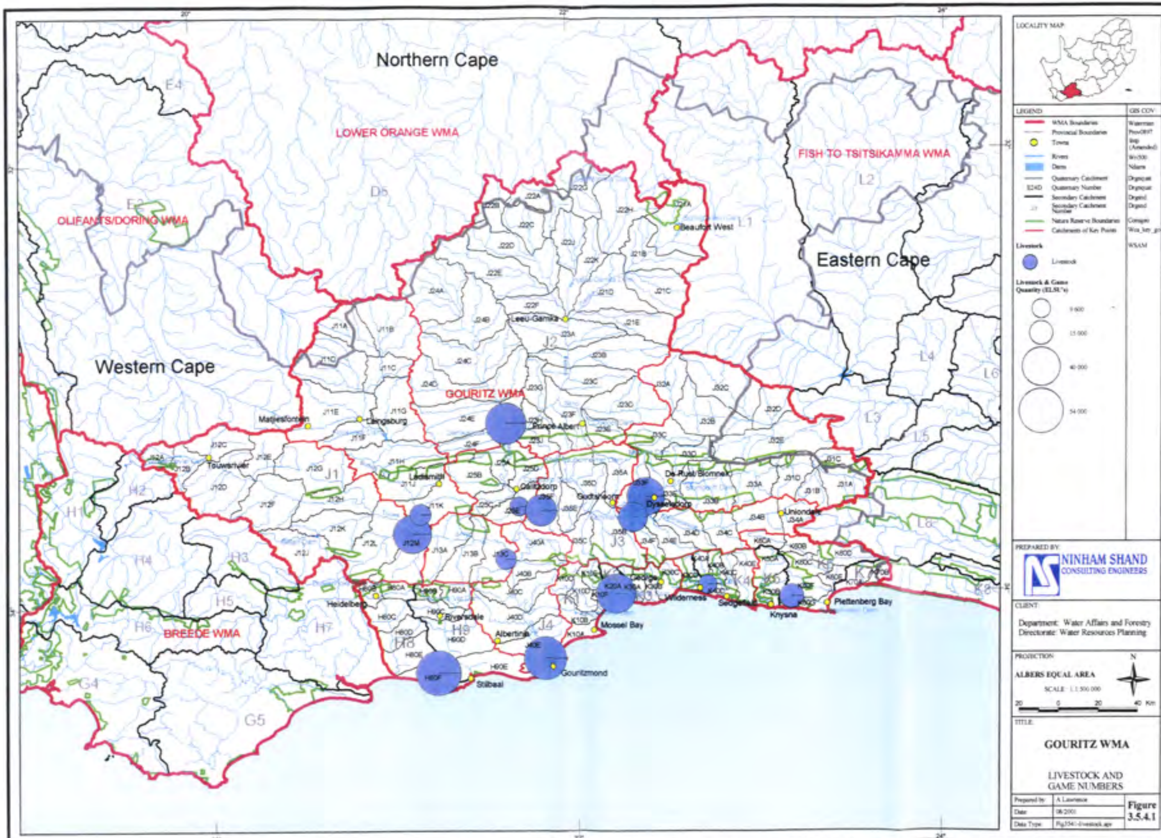
Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Laingsburg
Matjiesfontein
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritzmond
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Suggested Future Ecological Management Class
Class B: Largely Natural
Class C: Moderately Modified
Class D: Largely Modified
Not Assessed
PREPARED BY:
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
20 0 20 40 Km
TITLE
GOURITZ WMA
SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASS
Prepared by: A Lawrence
Figure 2.6.3.3

Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Laingsburg
Matjiesfontein
Touwsrivier
Prince Albert
Ladismith
Calitzdorp
Oudtshoorn
De Rust/Blomnek
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mosse! Bay
Heidelberg
Riversdale
Albertinia
Gouritzmond
Stilbaai
LOCALITY MAP
LEGEND
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
POPULATION DISTRIBUTION
Figure 3.2.4.1

Northern Cape
HANTAM
BO KAROO
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
WEST COAST
CENTRAL KAROO
Eastern Cape
WESTERN REGION
Western Cape
BREEDE RIVER
GOURITZ WMA
KLEIN KAROO
SOUTHERN CAPE
WINE-LANDS
BREEDE WMA
OVERBERG
Beaufort West
Leeu-Gamka
Laingsburg
Matjiesfontein
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
De Rust/Blomnek
Oudtshoorn
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Heidelberg
Riversdale
Albertinia
Mossel Bay
Gouritzmond
Stilbaai
LOCALITY MAP
LEGEND
District Councils
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
DISTRICT COUNCILS AND MAGISTERIAL DISTRICTS
Prepared by
A Lawrence
Figure 3.4.9.1

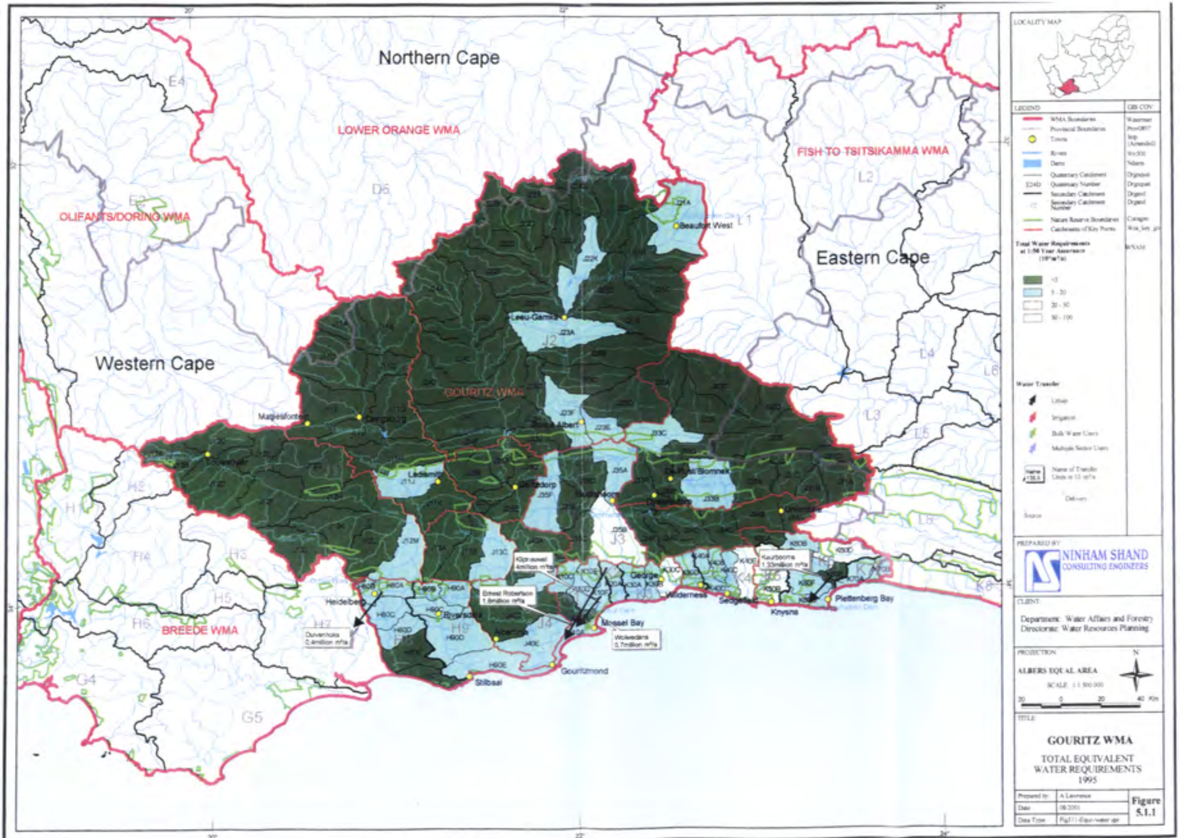

Northern Cape
LOWER ORANGE WMA
OLIFANTS/DORING WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Overberg
BEAUFORT-WEST
Beaufort West
Leeu-Gamka
LEEU-GAMKA
PRINCE ALBERT
Prince Albert
Matjiesfontein
Laingsburg
LAINGSBURG
Touwsrivier
TOUWSRIVIER
LADISMITH
Ladismith
CALITZDORP
Calitzdorp
DE RUST/BLOMNEK
De Rust/Blomnek
OUDTSHOORN
Oudtshoorn
Dysselsdorp
UNIONDALE
Uniondale
ZOAR
VANWYKSDORP
BARRYDALE
FRIEMERSHEIM
GROOT BRAKRIVIER
GEORGE
George
WILDERNESS
Wilderness
KNYSNA
Knysna
SEDGEFIELD
Sedgefield
Plettenberg Bay
PLETTENBERG BAY
Heidelberg
HEIDELBERG
SLANGRIVIER
Riversdale
RIVERSDALE
ALBERTINIA
Albertinia
Mossel Bay
MOSSEL BAY
Gourtizmond
GOURITZMOND
Stilbaai
STILBAAI
INFANTA
LOCALITY MAP
LEGEND
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
INSTITUTIONAL BOUNDARIES RELATED TO WATER SUPPLY
Prepared by: A Lawrence
Figure 3.4.9.2

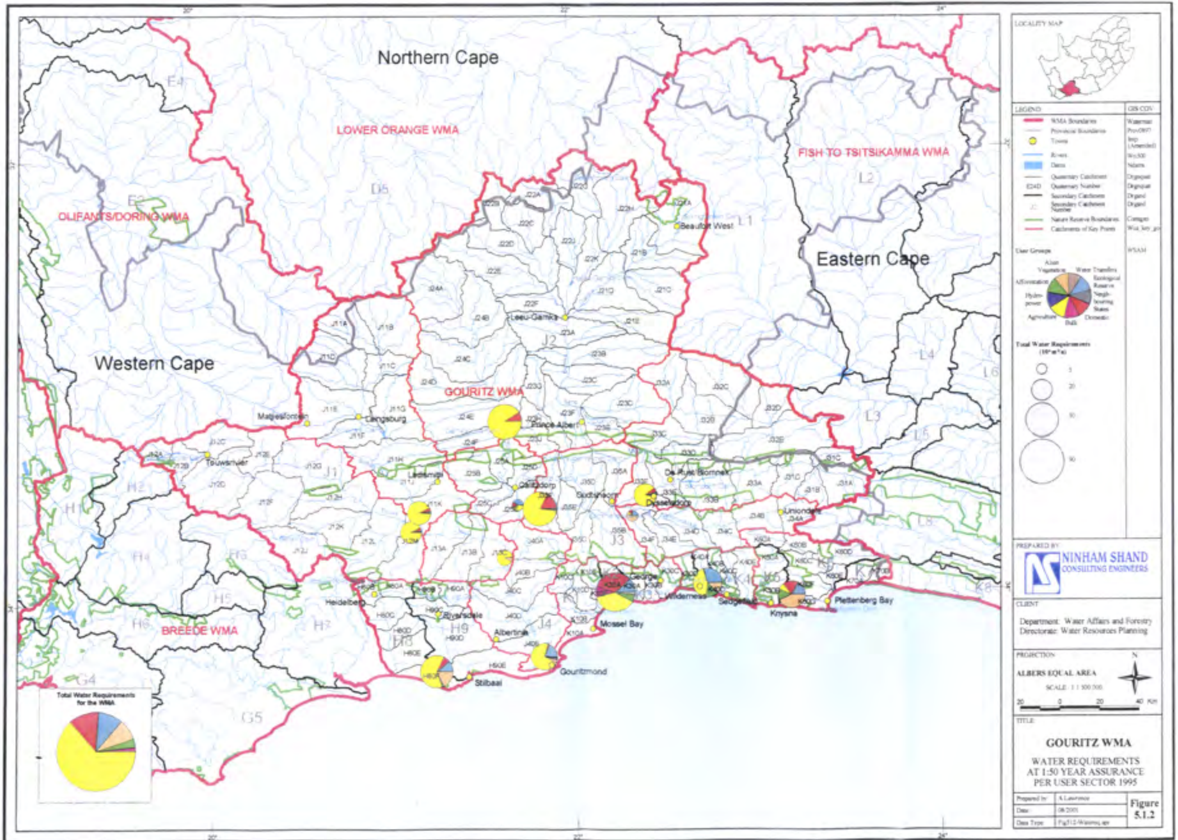

Northern Cape
LOWER ORANGE WMA
OLIFANTS/DORING WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Matjiesfontein
Laingsburg
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Heidelberg
Riversdale
Albertinia
Gouritzmond
Stilbaai
LOCALITY MAP
LEGEND
Land Use
Dryland
Afforestation
Irrigation
Total Land Use (km²)
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
GOURITZ WMA
LAND USE
Prepared by: A Lawrence
Date: 08/2001
Figure 3.5.1.1


Northern Cape
LOWER ORANGE WMA
OLIFANTS/DORING WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Matjiesfontein
Laingsburg
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mosselbaai
Mossel Bay
Gouritzmond
Albertinia
Riversdale
Heidelberg
Stilbaai
LOCALITY MAP
LEGEND
Livestock
Livestock & Game Quantity (ELSU's)
9 600
15 000
40 000
54 000
PREPARED BY:
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
SCALE 1:1 500 000
N
TITLE:
GOURITZ WMA
LIVESTOCK AND GAME NUMBERS
Prepared by
A Lawrence
Date
08/2001
Figure 3.5.4.1


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Matjiesfontein
Laingsburg
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust/Blomnek
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Heidelberg
Riversdale
Albertinia
Gouritzmond
Stilbaai
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
E24D Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Condensed Area Of Alien Vegetation (km²)
2
10
21
44
WSAM
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
SCALE : 1:1 500 000
20 0 20 40 Km
N
TITLE
GOURITZ WMA
ALIEN VEGETATION INFESTATION
Prepared by A Lawrence
Date 08/2001
Figure 3.5.6.1

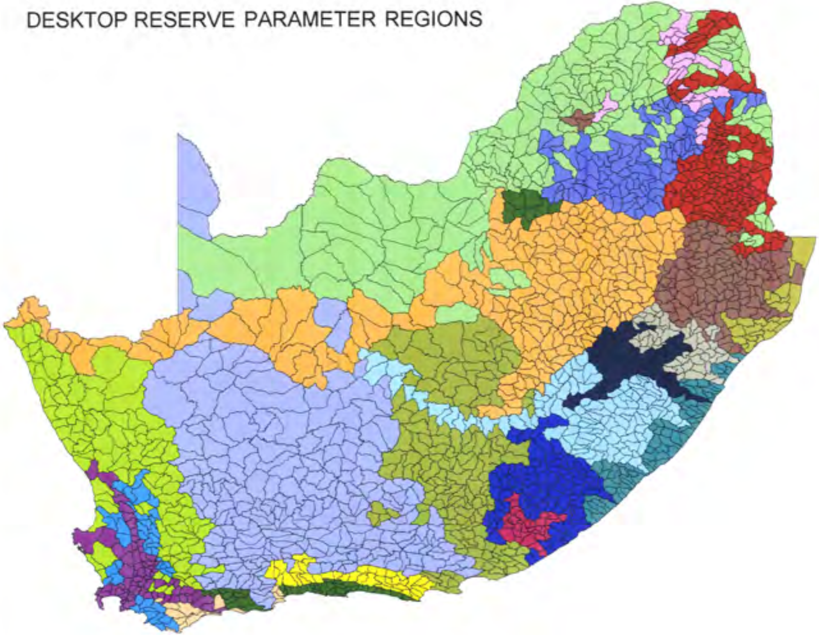
Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Matjiesfontein
Laingsburg
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Mossel Bay
Gouritzmond
Stilbaai
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
PREPARED BY:
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE:
GOURITZ WMA
WATER RELATED INFRASTRUCTURE
Figure 4.1.1


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Ladismith
Oudtshoorn
Uniondale
Heidelberg
Riversdal
Albertinia
Mossel Bay
Gouritsmond
Stilbaai
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Klipheuwel 4million m³/a
Ernest Robertson 1.6million m³/a
Duivenhoks 0.4million m³/a
Wolwedans 5.7million m³/a
Keurbooms 1.33million m³/a
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Total Water Requirements at 1:50 Year Assurance
Water Transfer
Urban
Irrigation
Bulk Water Users
Multiple Sector Users
PREPARED BY
NINHAM SHAND CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
GOURITZ WMA
TOTAL EQUIVALENT WATER REQUIREMENTS 1995
Figure 5.1.1



Northern Cape
LOWER ORANGE WMA
OLIFANTS/DORING WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Laingsburg
Matjiesfontein
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mosse Bay
Gouritzmond
Albertinia
Riversdale
Heidelberg
Stilbaai
Total Water Requirements for the WMA
LOCALITY MAP
LEGEND
User Groups
Total Water Requirements
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
GOURITZ 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: Amatole
- 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

PREPARED BY:

NINHAM SHAND
CONSULTING ENGINEERS

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

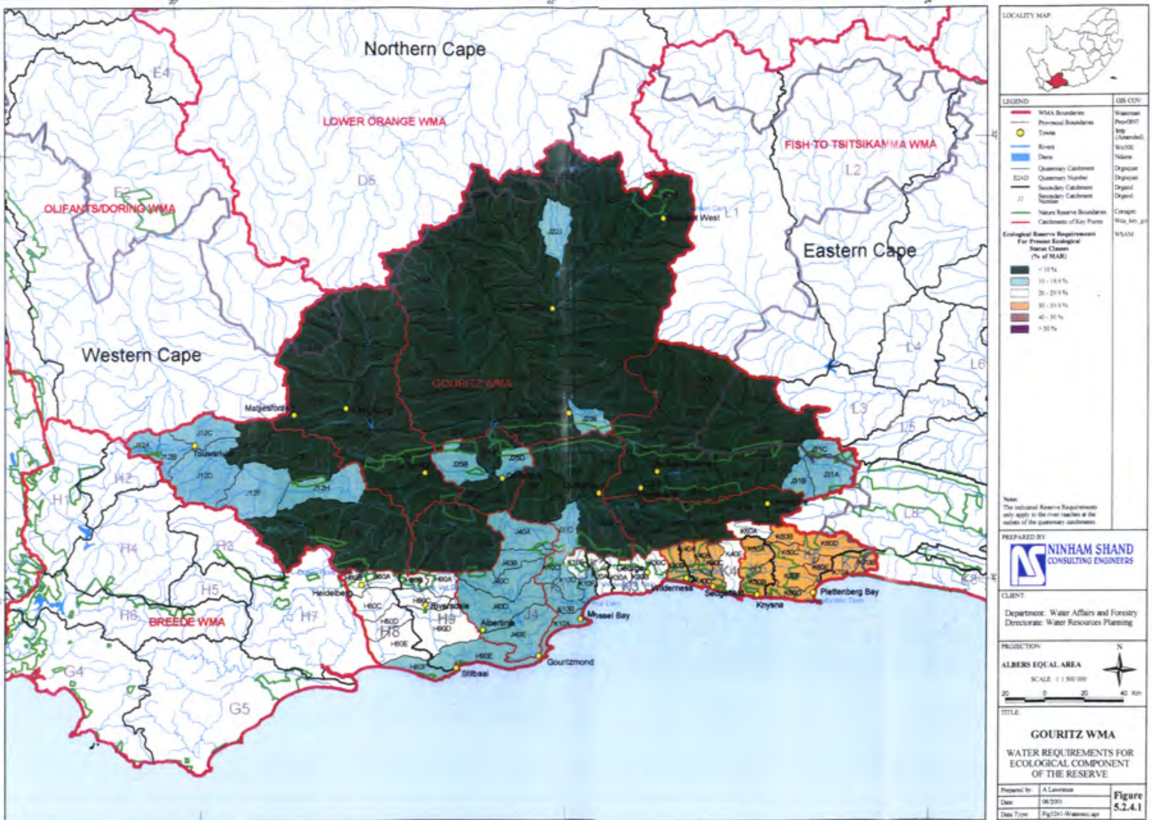
SCALE: N.T.S

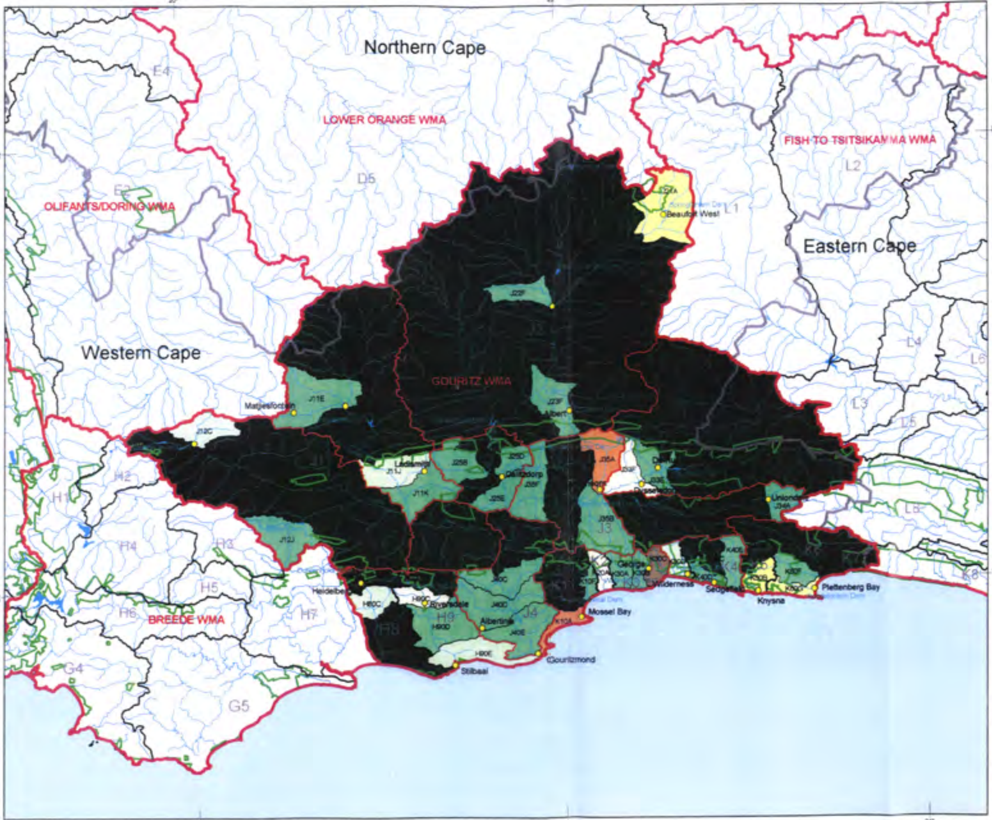
TITLE:

GOURITZ WMA

DESKTOP RESERVE
PARAMETER REGIONS

Prepared by	A Lawrence	**Figure 5.2.1.1**
Date	08/2003	
Data Type	Fig5211-Model.apr	


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
E4
D5
L1
L2
L3
L4
L5
L6
L8
K8
H1
H2
H4
H5
H6
H7
H8
H9
G4
G5
J4
K4
K5
K7
Matjiesfontein
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritzmond
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
E24D Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Ecological Reserve Requirements For Present Ecological Status Classes (% of MAR)
< 10 %
10 - 19.9 %
20 - 29.9 %
30 - 39.9 %
40 - 50 %
> 50 %
WSAM
Note:
The indicated Reserve Requirements only apply to the river reaches at the outlets of the quaternary catchments.
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
SCALE : 1:1 500 000
N
20 0 20 40 Km
TITLE
GOURITZ WMA
WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE
Prepared by A Lawrence
Date 08/2001
Data Type
Figure 5.2.4.1



LOCALITY MAP

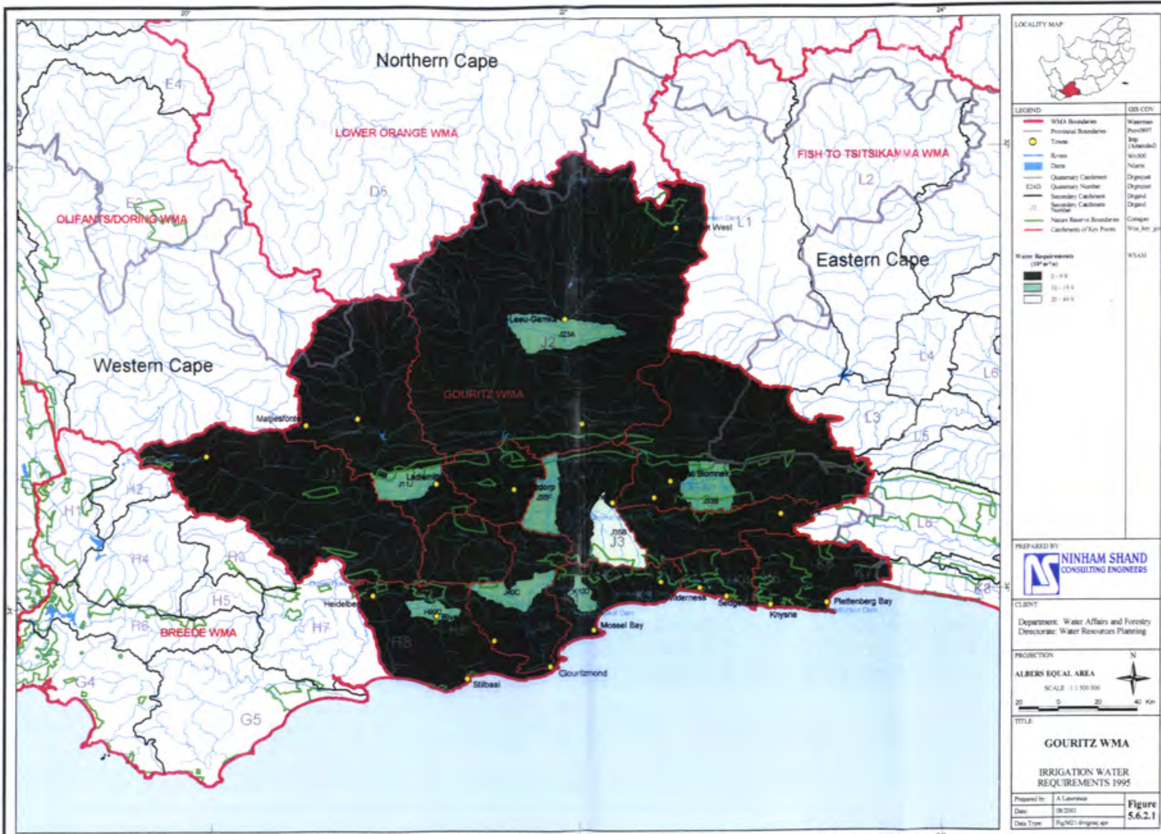
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS

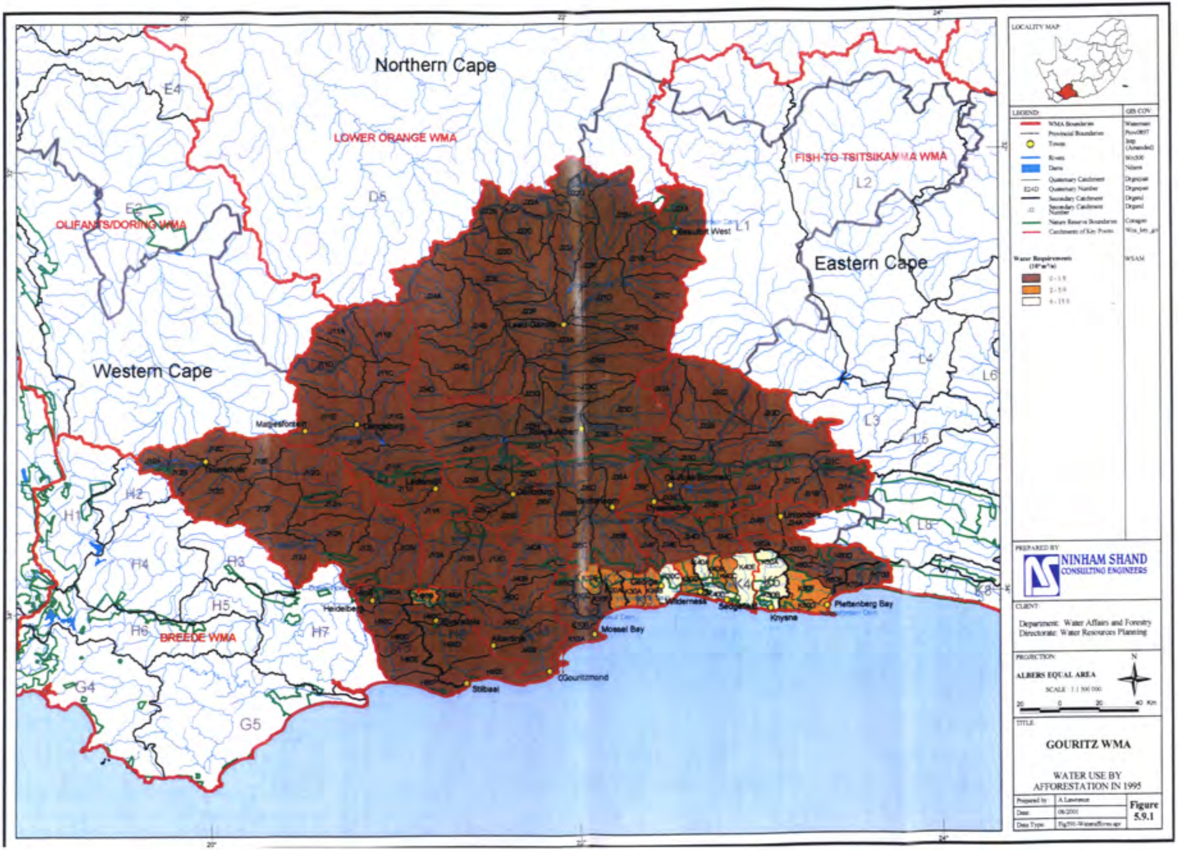
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning

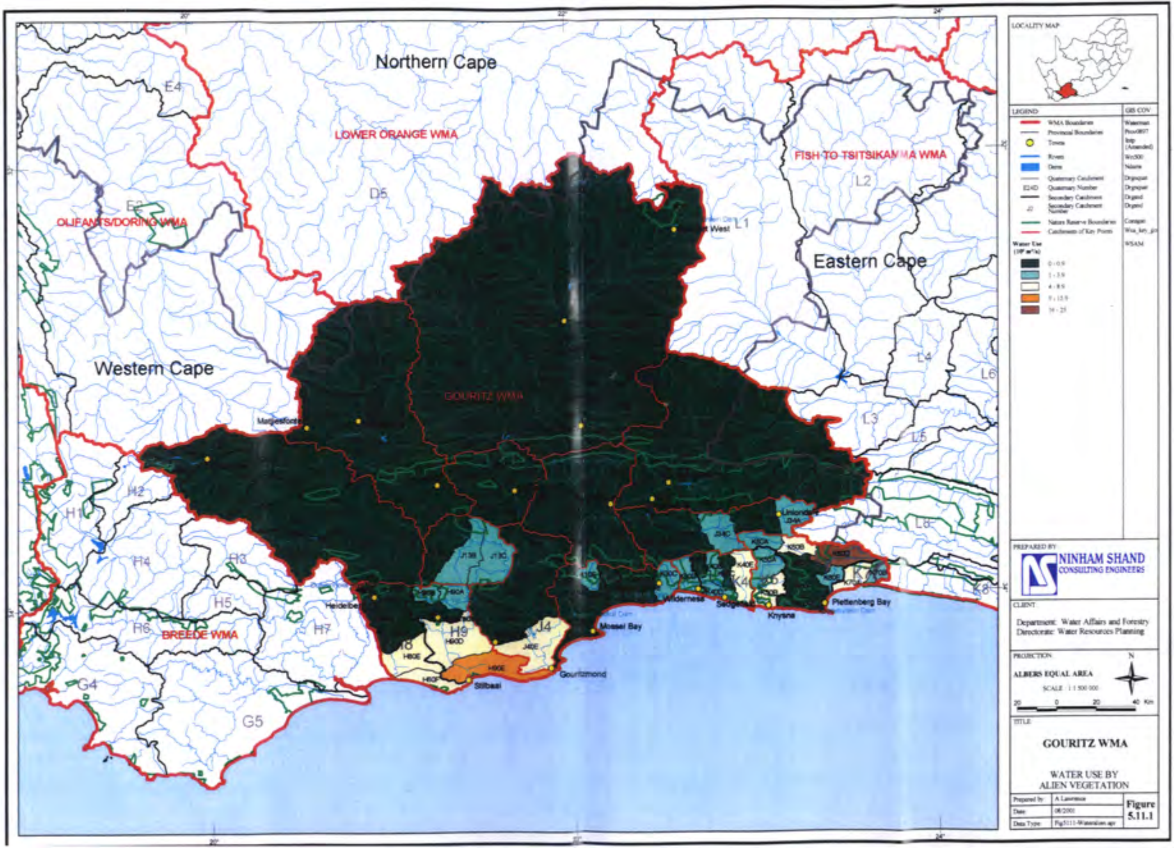
PROJECTION
ALBERS EQUAL AREA

TITLE
GOURITZ WMA
URBAN & RURAL DOMESTIC WATER REQUIREMENTS IN 1995

Figure 5.3.1.1


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Leeu-Gamka
Ladismith
Mossel Bay
Gouritzmond
Stilbaai
Heidelberg
Knysna
Plettenberg Bay
Wilderness
Matjiesfontein
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
GIS COV
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
IRRIGATION WATER
REQUIREMENTS 1995
Figure
5.6.2.1

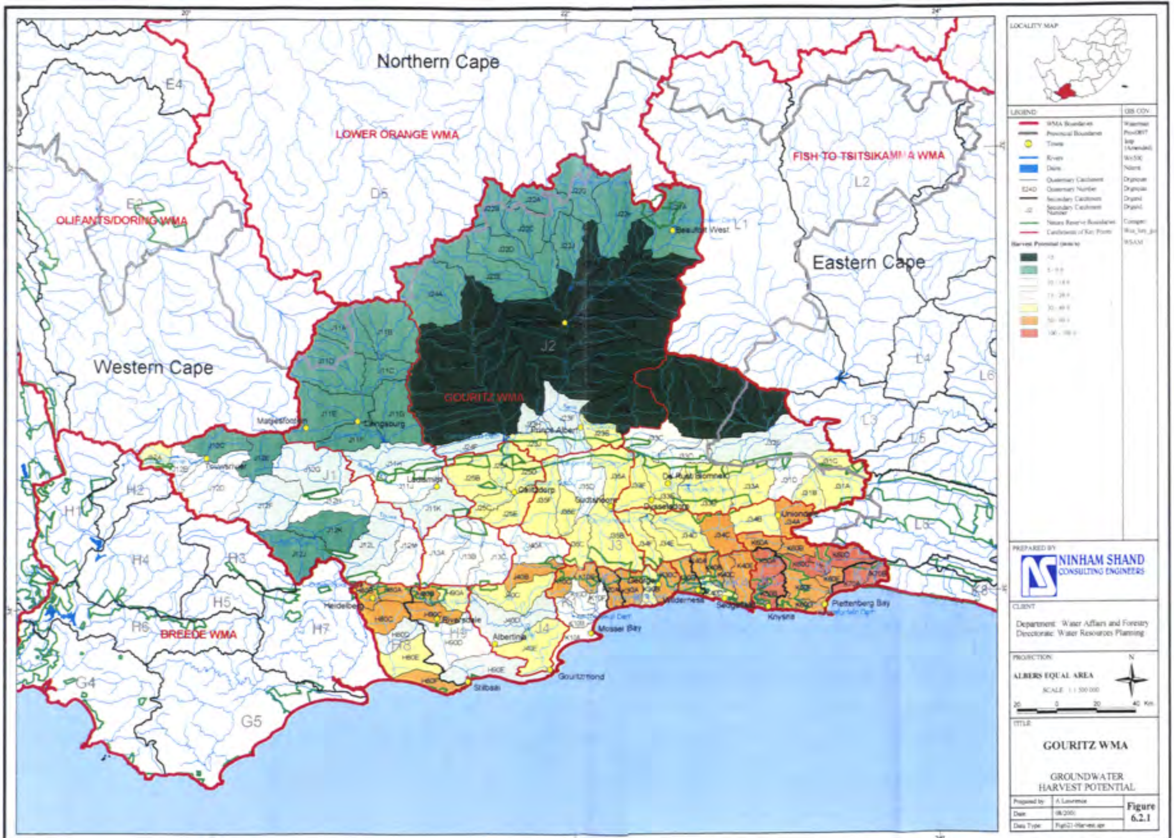

Northern Cape
LOWER ORANGE WMA
FISH-TO-TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
BREEDE WMA
Beaufort West
Matjiesfontein
Heidelberg
Mossel Bay
Gouritzmond
Stilbaai
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
GIS COV
Water Requirements
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
GOURITZ WMA
WATER USE BY
AFFORESTATION IN 1995
Figure
5.9.1

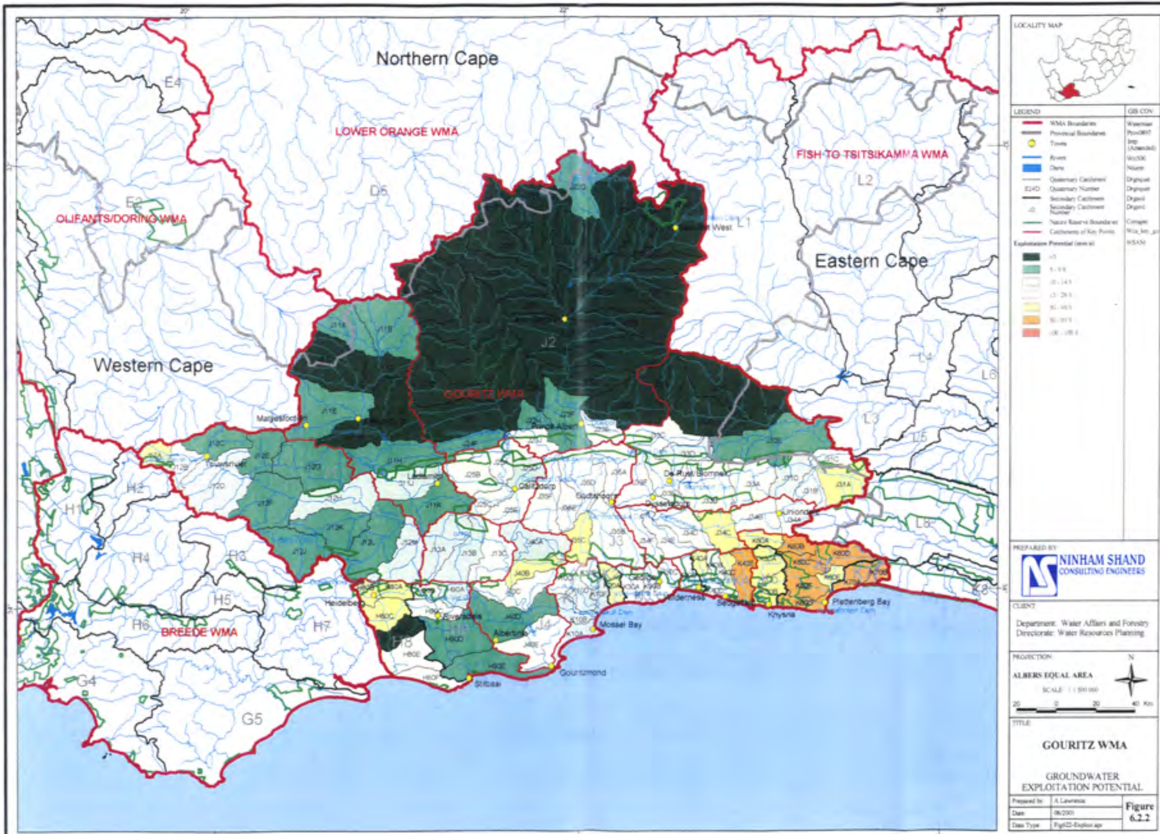

Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
OLIFANTS/DORING WMA
Western Cape
GOURITZ WMA
BREEDE WMA
E4
D5
L1
L2
L3
L4
L5
L6
L8
K8
H1
H2
H3
H4
H5
H6
H7
H8
H9
J4
K4
G4
G5
Matjiesfontein
Heidelberg
Mossel Bay
Gouritzmond
Stilbaai
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Uniondale
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Water Use
0 - 0.9
1 - 3.9
4 - 8.9
9 - 13.9
14 - 25
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
20 0 20 40 Km
TITLE
GOURITZ WMA
WATER USE BY
ALIEN VEGETATION
Prepared by A Lawrence
Date 08/2001
Figure 5.11.1


Northern Cape
LOWER ORANGE WMA
FISH-TO-TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Laingsburg
Matjiesfontein
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust/Blomnek
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritzmond
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Ernest Robertson 1.8million m³/a
Duiwenhoks 0.4million m³/a
Wolwedans 5.7million m³/a
Keurbooms 1.33million m³/a
LOCALITY MAP
LEGEND
Irrigation
Urban
Multiple Sector Users
Delivery
Source
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
20 0 20 40 Km
TITLE
GOURITZ WMA
WATER TRANSFER SCHEMES
Prepared by A Lawrence
Date 08/2001
Figure 5.14.1

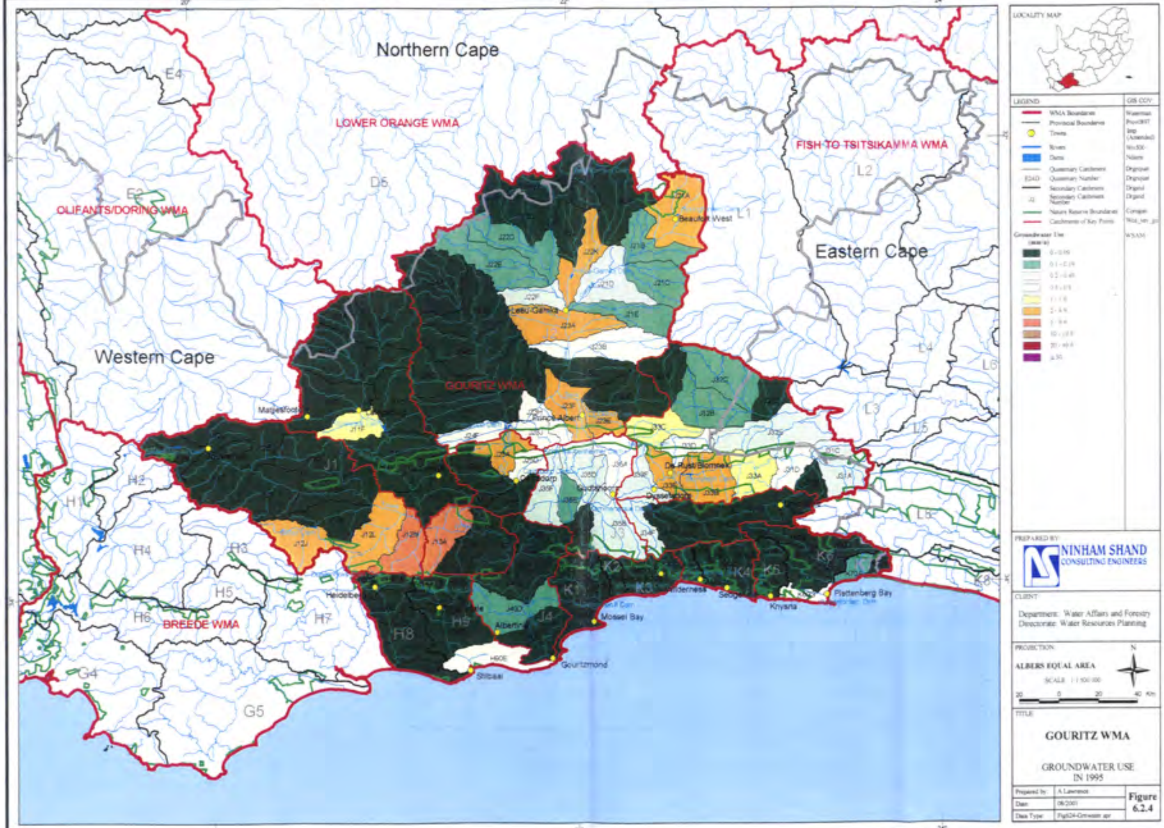
Northern Cape
LOWER ORANGE WMA
FISH-TO-TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
E4
E2
D5
L1
L2
L3
L4
L5
L6
L8
J1
J2
J3
J4
K1
K4
K5
K6
K8
H1
H2
H3
H4
H5
H6
H7
H8
H9
G4
G5
Beaufort West
Leeu-Gamka
Matjiesfontein
Laingsburg
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Mossel Bay
Gouritzmond
Stilbaai
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
Total Water Resource
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
1:50 YEAR YIELD OF
THE TOTAL WATER RESOURCE
AS DEVELOPED IN 1995
Prepared by
A Lawrence
Date
08/2001
Figure
6.1.1


LOCALITY MAP
LEGEND
Total Water Resource
Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Matjiesfontein
Laingsburg
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Uniondale
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritzmond
Mossel Bay
Wilderness
Sedgefield
Knysna
Plettenberg Bay
J1
J2
J3
J4
H9
K4
L1
L2
L3
L4
L5
L6
L8
D5
E4
H1
H2
H3
H4
H5
H6
H7
H8
G4
G5
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
20 0 20 40 Km
TITLE
GOURITZ WMA
1:50 YEAR YIELD OF
THE TOTAL WATER RESOURCE IF
DEVELOPED TO FULL POTENTIAL
Prepared by
A Lawrence
Date
08/2001
Figure
6.1.2

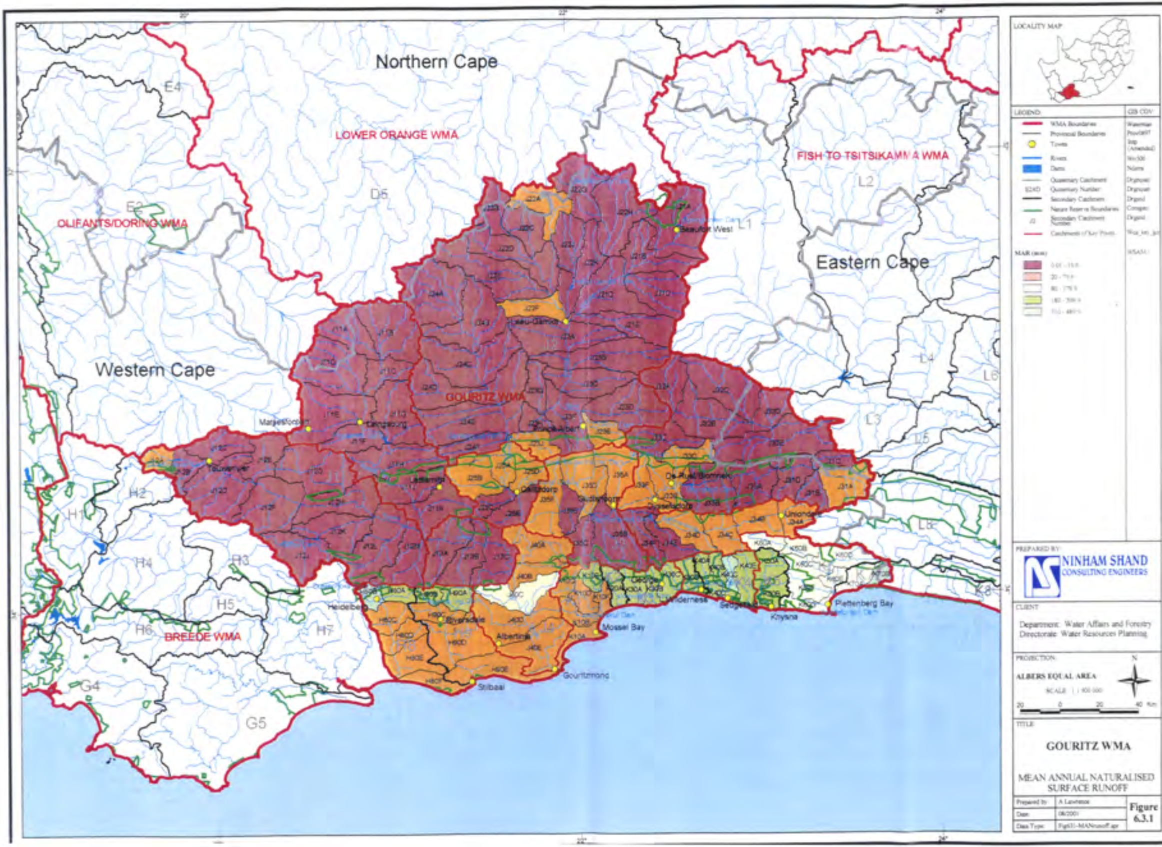

Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
J2
J1
J3
J4
Beaufort West
Matjiesfontein
Laingsburg
Prince Albert
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Gouritzmond
Albertinia
Riversdale
Heidelberg
Stilbaai
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
GROUNDWATER
HARVEST POTENTIAL
Prepared by
A Lawrence
Date
Data Type
Figure 6.2.1


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
J2
J3
L2
L3
L4
L5
L6
L8
D5
E4
H1
H2
H3
H4
H5
H6
H7
H8
G4
G5
Matjiesfontein
Prince Albert
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Stilbaai
Gouritzmond
LOCALITY MAP
LEGEND
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
GROUNDWATER
EXPLOITATION POTENTIAL
Figure
6.2.2


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
E4
D5
E2
L1
L2
L3
L4
L5
L6
L8
K8
J1
J2
J3
H1
H2
H3
H4
H5
H6
H7
H8
G4
G5
Majesfontein
Heidelberg
Albertinia
Stilbaai
Gouritzmond
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Contribution of Groundwater to Surface Water Base Flow (% of base flow)
PREPARED BY:
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
20 0 20 40 Km
TITLE:
GOURITZ WMA
CONTRIBUTION OF GROUNDWATER TO SURFACE WATER BASE FLOW
Prepared by: A Lawrence
Date: 08/2001
Figure 6.2.3

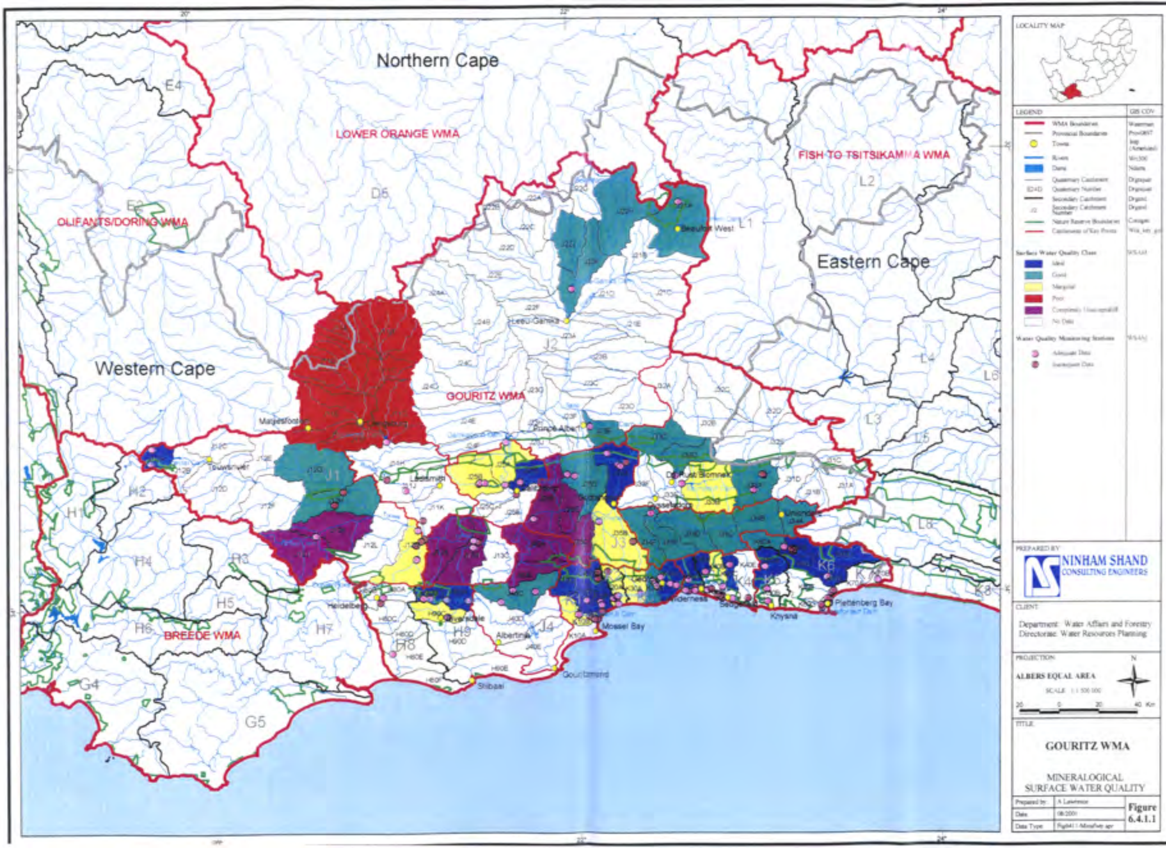

Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Oudtshoorn
Heidelberg
Albertinia
Mossel Bay
Gourtizmond
Stilbaai
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
PREPARED BY:
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
TITLE:
GOURITZ WMA
GROUNDWATER USE IN 1995
Prepared by: A Lawrence
Date: 08/2001
Figure 6.2.4

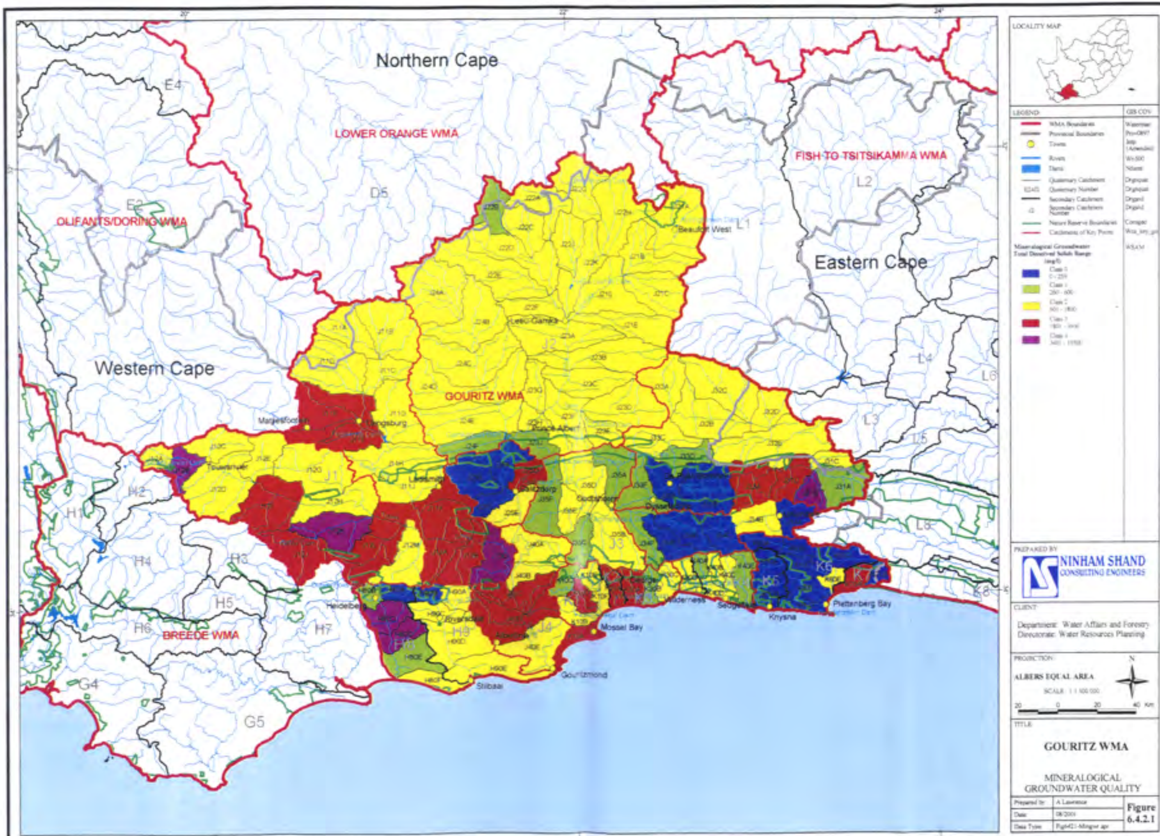

Northern Cape
LOWER ORANGE WMA
FISH-TO-TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
J2
J1
J3
J4
D5
E2
E4
L2
L3
L4
L5
L6
L8
K8
H1
H2
H3
H4
H5
H6
H7
H8
H9
G4
G5
Beaufort West
Matjiesfontein
Laingsburg
Prince Albert
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritsmond
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
GIS COV.
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
REMAINING GROUNDWATER EXPLOITATION POTENTIAL IN 1995
Prepared by
A Lawrence
Date
Figure 6.2.5

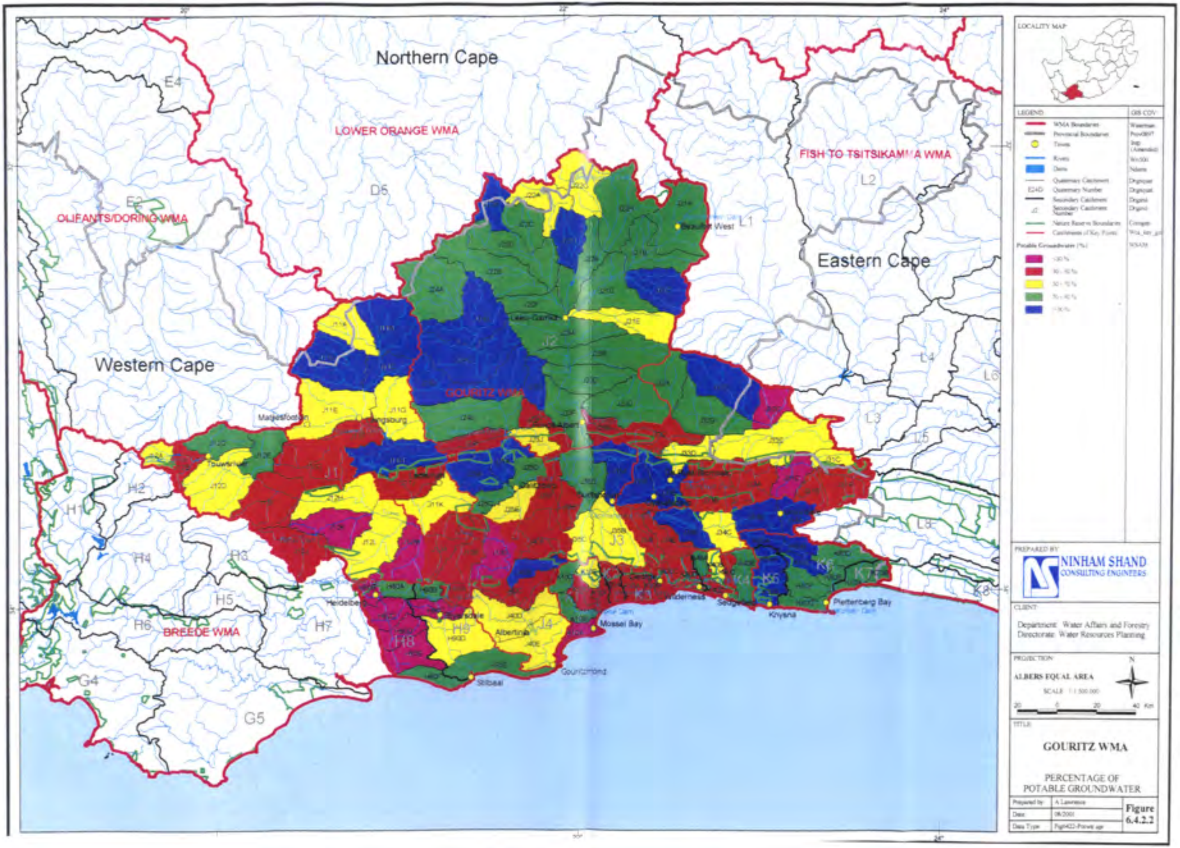


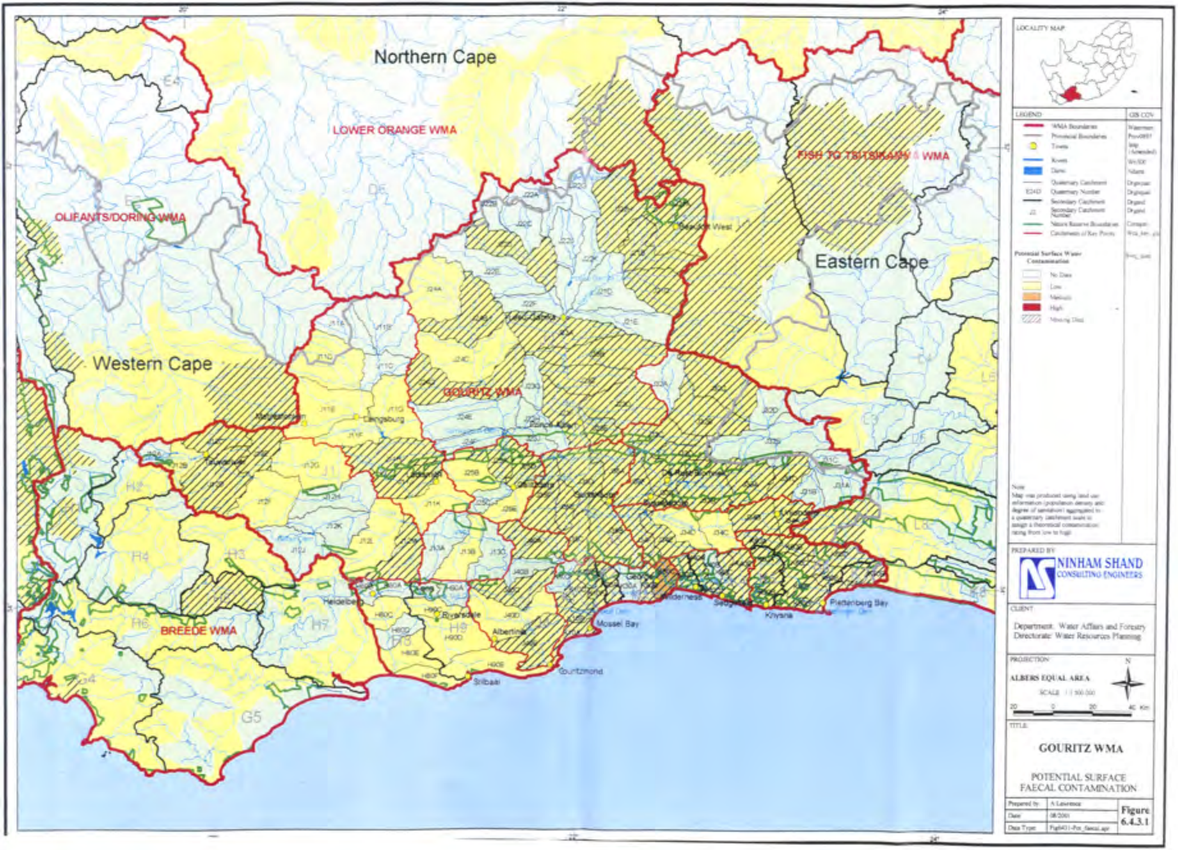
Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Laingsburg
Matjiesfontein
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritzmond
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
Secondary Catchment Number
MAR (mm)
PREPARED BY:
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
20 0 20 40 Km
TITLE
GOURITZ WMA
MEAN ANNUAL NATURALISED SURFACE RUNOFF
Prepared by: A Lawrence
Date: 08/2001
Figure 6.3.1


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Laingsburg
Matjiesfontein
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Mossel Bay
Gouritsmond
Stilbaai
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
GOURITZ WMA
UNDEVELOPED
POTENTIAL 1:50 YEAR
SURFACE WATER YIELD
Figure
6.3.2


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Laingsburg
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Albertinia
Riversdale
Heidelberg
Gouritsmond
Stilbaai
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Surface Water Quality Class
Ideal
Good
Marginal
Poor
No Data
Water Quality Monitoring Stations
Adequate Data
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
20 0 20 40 Km
TITLE
GOURITZ WMA
MINERALOGICAL
SURFACE WATER QUALITY
Prepared by
Date
Data Type
Figure
6.4.1.1


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Matjiesfontein
Laingsburg
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
Heidelberg
Riversdale
Albertinia
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Gouritzmond
Stilbaai
LOCALITY MAP
LEGEND
GIS COV
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchments of Key Points
Mineralogical Groundwater Total Dissolved Solids Range (mg/l)
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
20 0 20 40 Km
TITLE
GOURITZ WMA
MINERALOGICAL GROUNDWATER QUALITY
Prepared by: A Lawrence
Date
Data Type
Figure 6.4.2.1


Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Matjiesfontein
Laingsburg
Touwsrivier
Heidelberg
Riversdale
Albertinia
Mossel Bay
Gouritzmond
Stilbaai
Wilderness
Sedgefield
Knysna
Plettenberg Bay
E4
E2
D5
L1
L2
L3
L4
L5
L6
L8
K8
H1
H2
H3
H4
H5
H6
H7
H8
H9
G4
G5
J1
J2
J3
J4
K1
K2
K4
K5
K6
K7
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
Potable Groundwater (%)
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
PERCENTAGE OF
POTABLE GROUNDWATER
Prepared by
A Lawrence
Date
Figure
6.4.2.2



Northern Cape
LOWER ORANGE WMA
OLIFANTS/DORING WMA
FISH TO TSITSIKAMMA WMA
Eastern Cape
Western Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Ladismith
Oudtshoorn
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Mossel Bay
Heidelberg
Riversdale
Albertinia
Gouritzmond
Stilbaai
LOCALITY MAP
LEGEND
Potential Surface Water Contamination
No Data
Low
Medium
High
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
GOURITZ WMA
POTENTIAL SURFACE
FAECAL CONTAMINATION
Prepared by
A Lawrence
Date
08/2001
Figure
6.4.3.1

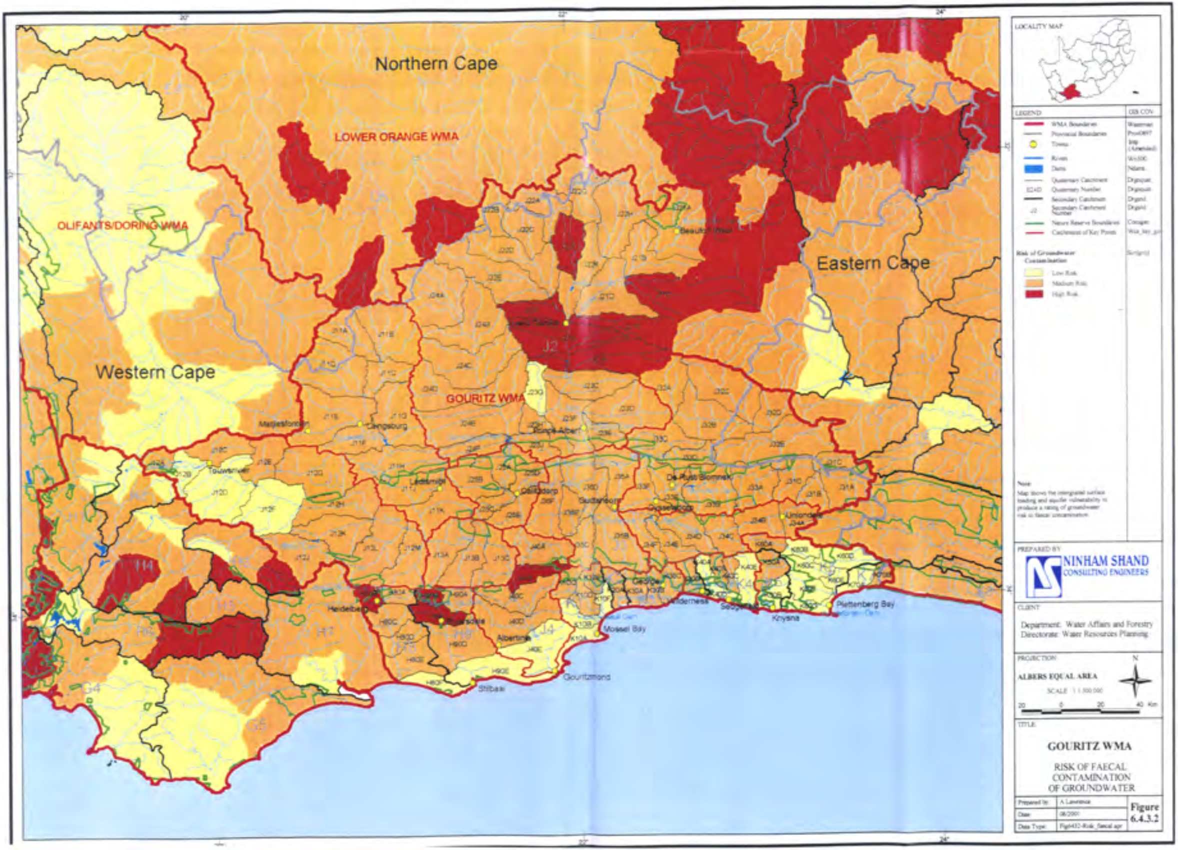

Northern Cape
LOWER ORANGE WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
J2
Beaufort West
Prince Albert
Laingsburg
Matjiesfontein
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritzmond
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
LOCALITY MAP
LEGEND
GIS COV.
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
Catchment of Key Points
Risk of Groundwater Contamination
Low Risk
Medium Risk
High Risk
Note:
Map shows the intergrated surface loading and aquifer vulnerability to produce a rating of groundwater risk to faecal contamination
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
N
TITLE
GOURITZ WMA
RISK OF FAECAL CONTAMINATION OF GROUNDWATER
Prepared by
A Lawrence
Date
08/2001
Figure 6.4.3.2

FIGURE 6.4.4.1: WATER QUALITY ISSUES

THIS FIGURE IS NOT ACCESSIBLE IN ELECTRONIC FORMAT.
IT IS AVAILABLE IN HARD COPY FROM:

DEPARTMENT OF WATER AFFAIRS AND FORESTRY
DIRECTORATE: WATER RESOURCES PLANNING

Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Prince Albert
Laingsburg
Matjiesfontein
Touwsrivier
Ladismith
Calitzdorp
Oudtshoorn
De Rust/Blomnek
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Stilbaai
Gouritzmond
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
E4
E2
D5
L1
L2
L3
L4
L5
L6
L8
K8
H1
H2
H3
H4
H5
H6
H7
G4
G5
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Secondary Catchment Number
Nature Reserve Boundaries
PREPARED BY:
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
TITLE:
GOURITZ WMA
POTENTIAL FOR SEDIMENT ACCUMULATION IN RESERVOIRS
Prepared by: A Lawrence
Figure 6.5.1

Northern Cape
LOWER ORANGE WMA
FISH TO TSITSIKAMMA WMA
OLIFANTS/DORING WMA
Western Cape
Eastern Cape
GOURITZ WMA
BREEDE WMA
Beaufort West
Leeu-Gamka
Matjiesfontein
Laingsburg
Touwsrivier
Prince Albert
Ladismith
Calitzdorp
Oudtshoorn
De Rust/Blommek
Dysselsdorp
Uniondale
Heidelberg
Riversdale
Albertinia
Mossel Bay
George
Wilderness
Sedgefield
Knysna
Plettenberg Bay
Stilbaai
Gouritzmond
Total Yield Balance for the WMA
406
365
LOCALITY MAP
LEGEND
WMA Boundaries
Provincial Boundaries
Towns
Rivers
Dams
Water Categories
Water Surplus
Water Shortfall
PREPARED BY
NINHAM SHAND
CONSULTING ENGINEERS
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
GEOGRAPHIC PROJECTION
TITLE
GOURITZ WMA
YIELD BALANCE OVERVIEW
Figure 7.2.1