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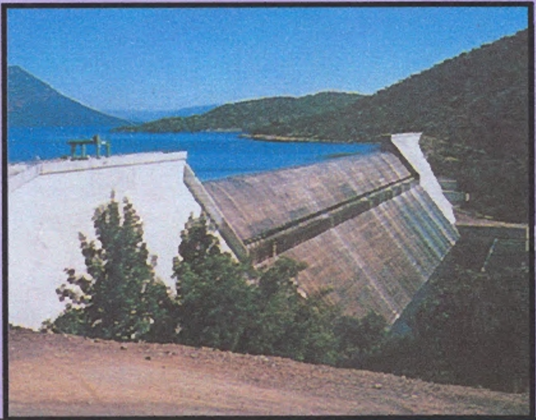
DEPARTMENT: WATER AFFAIRS AND FORESTRY

Directorate: Water Resources Planning

OLIFANTS WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

MAIN REPORT
JULY 2003



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OLIFANTS 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 Olifants Water Management Area, which occupies a portion of the Northern Province. The report does not address the water requirements beyond 1995 but does provide estimates of the utilisable potential of the water resources after so-called full development of these resources, as this can be envisaged at present. A separate national study has been conducted to consider future scenarios of land use and water requirements and the effects of water conservation and demand measures on these requirements and to identify alternative water resource developments and water transfers that will reconcile these requirements with the supplies.

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

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

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

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

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

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

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

The main objective of this water resources situation assessment has been to determine the water requirements of all the user sectors (including those of the riverine and estuarine ecosystems) and the ability of the available water resources to supply these requirements. However, other aspects such as water quality, legal and institutional aspects, macro-economics, existing infrastructure and international requirements 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.

CONTENTS

CHAPTER 1: INTRODUCTION

1.1 PURPOSE OF THE STUDY 1-1

1.2 APPROACH TO THE STUDY 1-1

1.3 REPORT LAYOUT AND CONTENT 1-2

CHAPTER 2: PHYSICAL FEATURES

2.1 THE STUDY AREA 2-1

2.2 CLIMATE 2-3

2.2.1 Temperature 2-3
2.2.2 Precipitation 2-4
2.2.3 Evaporation 2-4

2.3 GEOLOGY 2-4

2.3.1 Introduction 2-4
2.3.2 Basement Gneisses 2-5
2.3.3 Murchison Sequence 2-5
2.3.4 Rooiwater Igneous Complex 2-5
2.3.5 Basement Granites 2-5
2.3.6 Transvaal Sequence 2-6
2.3.7 The Bushveld Complex 2-6
2.3.8 Other Mafic intrusions 2-6
2.3.9 Karoo Sequence 2-7
2.3.10 Quaternary Deposits 2-7

2.4 SOILS 2-7

2.5 NATURAL VEGETATION 2-7

2.5.1 General 2-7
2.5.2 Natural vegetation types 2-9

2.6 ECOLOGICALLY SENSITIVE SITES 2-10

2.6.1 Definition of Sensitive Ecosystem 2-10
2.6.2 River Classification 2-12
....
2.6.3 Aquatic Ecosystems of Concern to the Study 2-17
2.6.4 National Heritage Sites, Game and Nature Reserves, Wilderness Areas ... 2-18

2.7 CULTURAL AND HISTORICAL SITES 2-19

CHAPTER 3: DEVELOPMENT STATUS

3.1 HISTORICAL DEVELOPMENT OF WATER RELATED INFRASTRUCTURE 3-1

3.2 DEMOGRAPHY 3-3

3.2.1 Introduction 3-3
3.2.2 Methodology 3-4
3.2.3 Historical Population Growth Rate 3-5
3.2.4 Population Size and Distribution in 1995 3-5

3.3 MACRO-ECONOMIC INFLUENCES 3-8

3.3.1 Introduction 3-8
3.3.2 Data Sources 3-8
3.3.3 Methodology 3-9
3.3.4 Status of Economic Development 3-10
3.3.5 Comparative Advantages 3-12

3.4. LEGAL ASPECTS AND INSTITUTIONAL ARRANGEMENT FOR WATER SUPPLY 3-14

3.4.1 Background 3-14
3.4.2 National Water Act 3-14
3.4.3 Strategies 3-15
3.4.4 Environmental Protection 3-15
3.4.5 Recognition of Entitlements 3-15
3.4.6 Licensing 3-16
3.4.7 Other Legislation 3-17
3.4.8 Institutions Created Under the National Water Act 3-19
3.4.9 Institutional Arrangements 3-19

3.5 LAND USE 3-25

3.5.1 Introduction 3-25
3.5.2 Irrigation 3-28
3.5.3 Dryland Agriculture 3-28
3.5.4 Livestock and Game Farming 3-32
3.5.5 Afforestation and Indigenous Forest 3-32
3.5.6 Alien Vegetation 3-35
3.5.7 Urban Areas 3-36

3.6 MAJOR INDUSTRIES AND POWER STATIONS 3-38

3.7 MINES 3-39

3.7.1 Introduction 3-39
3.7.2 The Upper Olifants Area 3-39
3.7.3 The Middle Olifants Area 3-40
3.7.4 The Steelpoort Area 3-40
3.7.5 The Lower Olifants Area 3-40

CHAPTER 4: WATER RELATED INFRASTRUCTURE

4.1 OVERVIEW 4-1

4.2 REGIONAL WATER SUPPLY SCHEMES........ 4-2

4.2.1 Premier Dam to Premier Mine Water Transfer Scheme 4-2
4.2.2 Olifants-Sand Transfer Scheme 4-2
4.2.3 The Komati River Government Water Scheme 4-2
4.2.4 Usutu-Olifants Transfer Scheme 4-5
4.2.5 Usutu-Vaal Transfer Scheme 4-7
4.2.6 Importation from Ebenezer Dam to a fish farm in the Olifants River catchment........ 4-9
4.2.7 Importation from Mogoboya Ramadika Dam to Naphuno 1 District, Lebowa 4-9
4.2.8 Importation from the Groot Letaba River to Consolidated Murchison Gold Mine........ 4-10
4.2.9 Rand Water Board supplies to Eloff and Sundra, Kinross, Leandra, Trichardt and Devon 4-10
4.2.10 Water transfer between Olifants River-Loskop reach and Elands River catchment........ 4-10
4.2.11 Water transfer between Steelpoort and Blyde River catchments 4-11
4.2.12 Water transfer between the Blyde River and Lower Olifants catchment.... 4-11

4.3 WATER RELATED INFRASTRUCTURE........ 4-11

4.3.1 The Upper Olifants River Catchment 4-11
4.3.2 The Wilge River Catchment........ 4-14
4.3.3 The Elands River Catchment........ 4-15
4.3.4 The Olifants River Catchment between the confluences with the Wilge and Elands River 4-16
4.3.5 The Steelpoort River Catchment........ 4-16
4.3.6 The Middle Olifants River Catchment........ 4-17
4.3.7 The Blyde River Catchment 4-17
4.3.8 The Lower Olifants River Catchment........ 4-18

4.4 HYDRO-POWER AND PUMPED STORAGE........ 4-18

CHAPTER 5: WATER REQUIREMENTS

5.1. WATER USE SUMMARY 5-1

5.2 ECOLOGICAL COMPONENT OF THE RESERVE........ 5-2

5.2.1 Introduction 5-2
5.2.2 Quantifying the Water Requirements........ 5-3
5.2.3 Comments on the Results........ 5-5
5.2.4 Presentation of Results........ 5-5
5.2.5 Discussion and Conclusions........ 5-5

5.3 URBAN AND RURAL 5-7

5.3.1 Introduction 5-7
5.3.2 Urban 5-7
5.3.3 Rural 5-13

5.4 BULK WATER USE 5-16

5.4.1 Introduction 5-16
5.4.2 Strategic 5-16
5.4.3 Mining 5-18
5.4.4 Other Bulk Users 5-18

5.5 NEIGHBOURING STATES 5-18

5.6 IRRIGATION 5-20

5.6.1 General 5-20
5.6.2 Water User Patterns 5-20
5.6.3 Water Losses 5-22
5.6.4 Return Flows 5-22

5.7 DRYLAND 5-22

5.8 WATER LOSSES FROM RIVERS, WETLANDS AND DAMS 5-23

5.9 AFFORESTATION 5-23

5.10 HYDROPOWER AND PUMPED STORAGE 5-25

5.11 ALIEN VEGETATION 5-25

5.12 WATER CONSERVATION AND DEMAND MANAGEMENT 5-28

5.12.1 Introduction 5-28
5.12.2 Background 5-29
5.12.3 Legal and Regulatory Framework 5-30
5.12.4 The Role of Water Conservation and Demand Management 5-31
5.12.5 Planning Considerations 5-32
5.12.6 Water Conservation and Demand Management Measures 5-32
5.12.7 Objectives of the national Water Conservation and Demand Management Strategy 5-33
5.12.8 Water Conservation in South Africa 5-33
5.12.9 Water Conservation in the Olifants Water Management Area 5-35

5.13 WATER ALLOCATIONS 5-35

5.13.1 Introduction 5-35
5.13.2 Allocations and Permits Issued Under the Old Water Act 5-35
5.13.3 Water Control Areas in the Water Management Area 5-36
5.13.4 Permits and Other Allocations 5-37
5.13.5 Allocations in Relation to Water Requirements and Availability 5-38

5.14 EXISTING WATER TRANSFERS 5-39

5.14.1 Introduction 5-39
5.14.2 Transfers to and from Neighbouring States 5-39
5.14.3 Inter-WMA Transfers 5-39
5.14.4 Transfers within the WMA 5-40

5.15 SUMMARY OF WATER LOSSES AND RETURN FLOWS 5-41

CHAPTER 6: WATER RESOURCES

6.1 EXTENT OF THE WATER RESOURCES 6-1

6.2 GROUNDWATER 6-3

6.3 SURFACE WATER RESOURCES 6-6

6.3.1 Stream Flow Data 6-6
6.3.2 Yield Analysis 6-7

6.4. WATER QUALITY 6-11

6.4.1 Mineralogical Surface Water Quality 6-11
6.4.2 Mineralogical Groundwater Quality 6-13
6.4.3 Microbiological (or microbial) Water Quality 6-13
6.4.4 Water Quality Issues 6-15

6.5 SEDIMENTATION 6-16

CHAPTER 7: WATER BALANCE

7.1 METHODOLOGY 7-1

7.1.1 Water Situation Assessment Model 7-1
7.1.2 Estimating the Water Balance 7-1
7.1.3 Estimating the Water Requirement 7-1
7.1.4 Estimating the Water Resources 7-3

7.2 OVERVIEW 7-6

7.3 THE UPPER OLIFANTS AREA 7-9

7.4 THE MIDDLE OLIFANTS AREA 7-9

7.5 THE STEELPOORT AREA 7-9

7.6 THE LOWER OLIFANTS AREA 7-9

CHAPTER 8: COSTS OF WATER RESOURCES DEVELOPMENT

8.1 METHODOLOGY 8-1

8.1.1 Capital cost of dams 8-1
8.1.2 Capital cost of wellfields 8-1

8.2 THE UPPER OLIFANTS AREA 8-1

8.3 THE MIDDLE OLIFANTS AREA 8-1

8.4 THE STEELPOORT AREA 8-3

8.5 THE LOWER OLIFANTS AREA 8-3

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 AVAILABLE DATA 9-1

9.2 THE UPPER OLIFANTS AREA 9-2

9.3 THE MIDDLE OLIFANTS AREA 9-2

9.4 THE STEELPOORT AREA 9-2

9.5 THE LOWER OLIFANTS AREA 9-3

LIST OF REFERENCES

APPENDICES

LIST OF TABLES

TABLE 2.1.1: DESCRIPTION OF KEY POINTS 2-2

TABLE 2.2.1: TEMPERATURE DETAILS FOR THE WMA 2-3

TABLE 2.5.1: A LIST OF THE DETAILED AND SIMPLIFIED ACOCKS VELD TYPES 2-8

TABLE 2.6.4.1: PROTECTED NATURAL AREAS AND NATURAL HERITAGE SITES 2-19

TABLE 3.2.4.1: POPULATION SIZE AND DISTRIBUTION IN 1995 3-7

TABLE 3.4.9.1: TASKS AND RESPONSIBILITIES OF EXISTING STRUCTURES 3-21

TABLE 3.4.2: FORUMS AND STRUCTURES (Provincial and local levels) 3-22

TABLE 3.5.1.1: LAND USE BY DRAINAGE AREAS IN KM^2 3-26

TABLE 3.5.1.2:	LAND USE BY PROVINCE AND DISTRICT COUNCIL AREA .	3-27
TABLE 3.5.2.2:	ASSURANCE CATEGORIES FOR IRRIGATED CROPS	3-28
TABLE 3.5.2.1:	IRRIGATION LAND USE	3-30
TABLE 3.5.3.1:	AREAS OF DRYLAND CROPS	3-31
TABLE 3.5.4.1:	LIVESTOCK AND GAME	3-33
TABLE 3.5.5.1:	AREAS OF AFFORESTATION AND INDIGENOUS FOREST ...	3-34
TABLE 3.5.6.1:	INFESTATION BY ALIEN VEGETATION	3-37
TABLE 3.6.1:	POWER STATIONS IN THE OLIFANTS WMA...........................	3-38
TABLE 4.1.1:	COMBINED CAPACITIES OF INDIVIDUAL TOWN AND REGIONAL, POTABLE WATER SUPPLY SCHEMES BY KEY AREAS	4-3
TABLE 4.2.3.1:	ESTIMATES OF WATER REQUIREMENTS FROM ESKOM POWER STATIONS (1990)	4-5
TABLE 4.2.4.1:	ESTIMATES OF WATER REQUIREMENTS FOR ESKOM POWER STATIONS (1990)	4-7
TABLE 4.2.8:	ESTIMATED FUTURE WATER DEMAND FOR TOWNS IN THE OLIFANTS RIVER BASIN THAT USE RWB WATER	4-10
TABLE 4.3.1:	MAIN DAMS IN THE OLIFANTS WMA	4-19
TABLE 4.3.2:	RAW WATER AND SEWAGE/EFFLUENT TREATMENT WORKS..	4-21
TABLE 4.3.3:	SEWAGE/EFFLUENT TREATMENT WORKS IN THE OLIFANTS WMA	4-22
TABLE 4.3.4:	CONTROLLED IRRIGATION SCHEMES....................................	4-23
TABLE 5.1.1:	WATER REQUIREMENTS PER USER GROUP IN 1995............	5-1
TABLE 5.1.2:	WATER REQUIREMENT PER PROVINCE IN 1995 AT 1:50 YEAR ASSURANCE	5-2
TABLE 5.2.4.1:	WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE	5-6
TABLE 5.3.1.1:	URBAN AND RURAL DOMESTIC WATER REQUIREMENTS IN 1995..	5-8
TABLE 5.3.2.1.1:	DIRECT WATER USE: CATEGORIES AND ESTIMATED UNIT WATER USE	5-9

TABLE 5.3.2.1.2: CLASSIFICATION OF URBAN CENTRES RELATED TO INDIRECT WATER USE 5-10

TABLE 5.3.2.1.3: INDIRECT WATER USE AS A COMPONENT OF TOTAL DIRECT WATER USE 5-10

TABLE 5.3.2.1.4: URBAN WATER REQUIREMENTS BY DRAINAGE AREA IN 1995 5-11

TABLE 5.3.3.1.1: PER CAPITA WATER REQUIREMENTS IN RURAL AREAS IN 1995 5-13

TABLE 5.3.3.1.2: RURAL DOMESTIC WATER REQUIREMENTS BY DRAINAGE AREA IN 1995 5-14

TABLE 5.4.2.1: STRATEGIC WATER REQUIREMENTS 5-16

TABLE 5.4.3.1: WATER REQUIREMENTS OF MINES 5-18

TABLE 5.6.2.1: IRRIGATION WATER REQUIREMENTS 5-20

TABLE 5.8.1: WATER LOSSES FROM RIVERS, WETLANDS AND DAMS 5-23

TABLE 5.9.1: WATER USE BY AFFORESTATION IN 1995 5-25

TABLE 5.11.1: WATER USE BY ALIEN VEGETATION IN 1995 5-26

TABLE 5.13.3.1: ARTICLE 62 – SCHEDULING AND QUOTAS IN GOVERNMENT WATER CONTROL AREAS 5-36

TABLE 5.13.3.2: ARTICLE 63 – SCHEDULING AND QUOTAS FROM GOVERNMENT WATER WORKS 5-36

TABLE 5.13.3.3: ARTICLE 56(3) – ALLOCATIONS FROM GOVERNMENT WATER SCHEMES 5-37

TABLE 5.14.3.1: INTER-WMA TRANSFERS UNDER 1995 DEVELOPMENT CONDITIONS 5-39

TABLE 5.14.4.1: AVERAGE TRANSFERS WITHIN WMA’S IN 1995 5-40

TABLE 5.15.1: SUMMARY OF WATER REQUIREMENTS, LOSSES AND RETURN FLOWS AT 1:50 YEAR ASSURANCE 5-40

TABLE 5.15.2: SUMMARY OF MAIN INTER-CATCHMENT TRANSFERS OF RETURN FLOWS 5-40

TABLE 6.1.1: WATER RESOURCES 6-2

TABLE 6.2.1: GROUNDWATER RESOURCES AT 1:50 YEAR ASSURANCE OF SUPPLY 6-5

TABLE 6.3.1: SURFACE WATER RESOURCES 6-9

TABLE 6.4.1.1: CLASSIFICATION SYSTEM FOR MINERALOGICAL WATER QUALITY.. 6-16

TABLE 6.4.1.2: OVERALL CLASSIFICATION 6-11

TABLE 6.4.1.3: SUMMARY OF MINERALOGICAL SURFACE WATER QUALITY OF THE OLIFANTS WATER MANAGEMENT AREA.. 6-11

TABLE 6.5.1: RECORDED RESERVOIR SEDIMENTATION RATES FOR RESERVOIRS IN THE VICINITY OF THE OLIFANTS WMA 6-16

TABLE 7.2.1: KEY POINTS FOR YIELD DETERMINATION 7-6

TABLE 7.2.2: WATER REQUIREMENTS BY DRAINAGE AREA IN 1995....... 7-7

TABLE 7.2.3: WATER REQUIREMENTS AND AVAILABILITY 7-8

TABLE 8.1.1: COSTS OF WATER RESOURCE DEVELOPMENT 8-4

TABLE 8.3.1: COSTS OF FUTURE WATER RESOURCE DEVELOPMENT IN THE MIDDLE OLIFANTS AREA... 8-3

TABLE 8.4.1: COSTS OF FUTURE WATER RESOURCE DEVELOPMENT IN THE STEELPOORT AREA 8-3

LIST OF FIGURES

FIGURE 2.1.1: THE OLIFANTS RIVER WATERCOURSE

FIGURE 2.1.2: THE STUDY AREA

FIGURE 2.1.3: TOPOGRAPHY AND RIVER CATCHMENTS

FIGURE 2.1.4: HYDROLOGICAL SUB-CATCHMENTS

FIGURE 2.2.1: MEAN ANNUAL PRECIPITATION

FIGURE 2.2.2: MEAN ANNUAL EVAPORATION

FIGURE 2.3.1: GEOLOGY

FIGURE 2.4.1: SOILS

FIGURE 2.5.2.1: NATURAL VEGETATION

FIGURE 2.6.3.1: DEFAULT ECOLOGICAL MANAGEMENT CLASSES

FIGURE 2.6.3.2: PRESENT ECOLOGICAL STATUS CLASS AND ECOLOGICALLY SENSITIVE SITES

FIGURE 2.6.3.3: SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASS

FIGURE 3.2.4.1: POPULATION DISTRIBUTION

FIGURE 3.4.2.1: DISTRICT COUNCILS AND MAGISTERIAL DISTRICTS

FIGURE 3.4.2.2: INSTITUTIONAL BOUNDARIES RELATED TO WATER SUPPLY

FIGURE 3.5.1.1: LAND USE

FIGURE 3.5.4.1: LIVESTOCK AND GAME NUMBERS

FIGURE 3.5.1.1: AFFORESTATION

FIGURE 3.5.6.1: ALIEN VEGETATION INFESTATION

FIGURE 3.7.1: MINES

FIGURE 4.1.1: WATER RELATED INFRASTRUCTURE

FIGURE 5.1.1: TOTAL EQUIVALENT WATER REQUIREMENTS 1995

FIGURE 5.1.2: WATER REQUIREMENTS AT 1:50 YEAR ASSURANCE PER USER SECTOR 1995

FIGURE 5.1.4.1: WATER TRANSFER SCHEMES

FIGURE 5.2.4.1: WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE

FIGURE 5.3.1.1: URBAN AND RURAL DOMESTIC WATER REQUIREMENTS IN 1995

FIGURE 5.6.2.1: IRRIGATION WATER REQUIREMENTS IN 1995

FIGURE 5.9.1: WATER USE BY AFFORESTATION IN 1995

FIGURE 5.11.1: WATER USE BY ALIEN VEGETATION

FIGURE 6.1.1: NET 1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE AS DEVELOPED IN 1995
FIGURE 6.1.2: NET 1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE IF DEVELOPED TO FULL POTENTIAL
FIGURE 6.2.1: GROUNDWATER HARVEST POTENTIAL
FIGURE 6.2.2: GROUNDWATER EXPLOITATION POTENTIAL
FIGURE 6.2.3: GROUNDWATER USE IN 1995
FIGURE 6.2.4: REMAINING GROUNDWATER EXPLOITATION POTENTIAL IN 1995
FIGURE 6.3.1: MEAN ANNUAL NATURALISED SURFACE RUNOFF
FIGURE 6.3.2: WATER RESOURCE DEVELOPMENT
FIGURE 6.4.2.1: MINERALOGICAL GROUNDWATER QUALITY
FIGURE 6.4.3.1: POTENTIAL FAECAL CONTAMINATION OF GROUNDWATER
FIGURE 6.4.3.2: RISK OF FAECAL CONTAMINATION OF GROUNDWATER
FIGURE 6.5.1: SEDIMENT YIELD VARIATION
FIGURE 7.2.1: WATER BALANCE OVERVIEW IN 1995

LIST OF DIAGRAMS

DIAGRAM 2.6.2.1: PROCEDURE FOLLOWED TO DETERMINE THE RIVER CLASSIFICATIONS
DIAGRAM 2.6.2.2: DESCRIPTIONS OF EISC, DEMC DESC, PESC AND AEMC.

DIAGRAM 3.3.1: CONTRIBUTION BY SECTOR TO ECONOMY OF OLIFANTS WMA, 1988 AND 1977 (%)
DIAGRAM 3.3.2: AVERAGE ANNUAL ECONOMIC GROWTH BY SECTOR OF OLIFANTS WATER MANAGEMENT AREA AND SOUTH AFRICA, 1988 – 1997
DIAGRAM 3.3.3: OLIFANTS GROSS GEOGRAPHIC PRODUCT LOCATION QUOTIENT BY SECTOR, 1997

DIAGRAM 5.15.1: CATEGORY LOSS AS A PORTION OF THE TOTAL LOSSES IN THE OLIFANTS WMA
DIAGRAM 5.15.2: CATEGORY RETURN FLOW AS A PORTION OF THE TOTAL RETURN FLOW IN THE OLIFANTS WMA.

DIAGRAM 6.3.1: DAM STORAGE LIMITS

DIAGRAM 7.1.1: WATER BALANCE MODEL CONCEPTUAL LAYOUT
DIAGRAM 7.1.2: WATER BALANCE MODEL YIELD BALANCE ALGORITHM

DIAGRAM 8.1.1: CAPITAL COST OF DAMS
DIAGRAM 8.1.2: GROUNDWATER DEVELOPMENT COST

ACRONYMS

AEMC	Suggested future ecological management class
AR	Area Rating
ARDC	Agriculture and Rural Development Corporation
CB	Consultburo (now BKS)
CCWR	Centre for Computing Water Research
CMA	Catchment Management Agency
CMIP	Consolidated Municipal Infrastructure Programme
CSIR	Council for Scientific and Industrial Research
CWSS	DWAF: Sub-directorate: Community Water Supply and Sanitation
DBSA	Development Bank of Southern Africa
DCD	Department of Constitutional Development
DEMC	Default ecological management class
DESC	Default Ecological Status Class
DOC	Dissolved Organic Carbon
DRASTIC	Software used in microbiological water quality assessment, where 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
DWAF	Department: Water Affairs and Forestry
DWAF:WS	Department: Water Affairs and Forestry: Directorate Water Services
EA	Enumerator Area
EC	Electrical conductivity
EISC	Ecological importance and sensitivity class
ELSU	Equivalent live stock unit.
ESCOM	Electricity Supply Commision
EVT	Evapotranspiration (A-pan equivalent in mm/m)
FFC	Financial and Fiscal Commission
GGP	Gross Geographic Product
GIS	Geographic Information System
GWS	Government Water Scheme

HIS	Hydrological Information Services (of DWAF)
HKS	Hill Kaplan Scott (Now Gibb Africa)
IFR	Instream flow requirement
IRP	Integrated Resource Planning
IWQS	Institute for Water Quality Studies
KNP	The Kruger National Park
LDC	Consortium Comprising Consultant Buro (now BKS), HRS and Loubscher Smith
LSU	Live Stock Unit
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MD	Magisterial District
MSL	Mean sea level
NGO	Non-Governmental Organisation
NMMP	National Microbiological Monitoring Programme
NPLGA	The Northern Province Local Government Association
NSTT	The National Sanitation Task Team
NWA	National Water Act
NWRS	National Water Resources Strategy
NWSR	National Water Supply Regulation
OD	Outside Diameter
PESC	Present ecological status class
PGRWS	The Pietersburg Governmental Regional Water Supply Scheme
RDP	Reconstruction and Development Programme.
RI	Relative Index
RWS	Regional Water Scheme
SABS	South African Buro of Standards
SALGA	South African Local Government Association
SAR	Sodium Adsorption Ratio
SRK	Steffen Robertson Kirsten
TDS	Total Dissolved Solids
THM	Trihalomethane
TLC	Transitional Local Council

TOR	Terms of Reference
TRC	Transitional Rural Council
VAT	Value Added Tax
VIP	Ventilated pit-latrine
WMA	Water Management Area
WR 90	Refer to References, Midgley (1994)
WRC	Water Research Commission
WRM	Water Resource Management
WRSA	Water Resources Situation Assessments
WS	Water Scheme
WSAM	Water Situation Assessment Model
WTW	Water Treatment Works
WUA	Water User Association

SYMBOLS

AIR	Irrigation Area (km^2)
BFI	Base Flow
CLI	Irrigaton conveyance loss
CRC	Crop factor
CV	Coefficient of variation
ECA	Total catchment area (minus) catchment area of next major dam upstream
fBML	Mining Losses (factor)
fBOL	Other industrial losses (factor)
fBSL	Strategic losses (factor)
fIHC	Irrigaton conveyance losses – High category irrigation
fILC	Irrigaton conveyance losses – Low category irrigation
fIMC	Irrigaton conveyance losses – Medium category irrigation
fIPH	Irrigation efficiency – High category irrigation
fIPL	Irrigation efficiency – Low category irrigation
fIPM	Irrigation efficiency – Medium category irrigation
IRC	Irrigation efficiency
IRR	Irrigation water requirements ($10^6 m^3/m^2$)
LER	Leaching factor
LU	Land use rating per settlement
LUn	Land use rating for n settlements, per quaternary
oRTL	Rural losses (factor)
PD	Population Density rating
REF	Effective rainfall (mm/m)
SA	No/poor Sanitation Rating
TLU	Total land use rating for area
TLU	Total land use rating per quaternary catchment
TWU	Total water use rating for area
V_T	Sediment volume at end of period
V_{50}	Estimated sediment volume after fifty years at the same average yeild
$10^6 m^3/a$	Million cubic metres per annum
mg/ℓ	Milligram per litre
Mℓ/day	megalitre per day
t/km^2.a	Ton per square kilometre per annum

GLOSSARY OF TERMS

ANASTOMOSED	A river made up of multiple channels with stable islands, usually with a bedrock substrate.
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.
CAIRN	Mound of rough stones packed as a monument or landmark.
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.
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.
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 (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 Class A (highly sensitive, no risks allowed) to Class D (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.

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.

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.

EDAPHIC — Pertaining to the influence of soil on organisms.

or

Resulting from or influenced by factors inherent in soil rather than by climatic factors.

ENDANGERED SPECIES — Species in danger of extinction and whose survival is unlikely if the causal factors bringing about its endangered status continue operating. Included are species whose numbers have been reduced to a critically low level or whose habitat has been so drastically diminished and/or degraded that they are deemed to be in immediate danger of extinction.

ENDEMIC — Occurring within a specified locality; not introduced.

ENDOREIC	Portion of a hydrological catchment that does not contribute towards river flow in its own catchment (local) or to river flow in downstream catchments (global). In such catchments the water generally drains to pans where much of the water is lost through evaporation.
ENVIRONMENTALLY SENSITIVE AREA	A fragile ecosystem which will be maintained only by conscious attempts to protect it.
EPHEMERAL RIVERS	Rivers where no flow occurs for long periods of time.
FORMAL IRRIGATION SCHEME	The term applies to a scheme where water for irrigation purposes is stored in a dam controlled by DWAF or an Irrigation Board and supplied in predetermined quotas to irrigators registered under the scheme.
GIS	A computer system which enables data to be stored, manipulated and presented visually, in a geographically located or spatially distributed format.
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	Flowing water.
MANAGEMENT CLASS	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).

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.
PETROGLYPH	A carving or inscription on a rock.
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 Class A (largely natural) to Class F (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.
RAMSAR SITE	Wetland of international importance, especially was waterfaul habitat, that is proclaimed in terms of the Ramsar Convention, to which South Africa is a signatory.

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	Two kinds if water resources are recognised, namely surface water and groundwater, however these are often interdependent.

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 interconnected by man-made transfer schemes.
SCHEDULED LAND	Irrigable land to which a water quota has been allocated.
SETTLEMENT	smaller Centre of population, industry and services but still deemed to be of importance.
SPATIO - TEMPORALLY ROBUST	Does not change significantly with time in relation to spatial distribution.
STROMATOLITE	A rocky cushion-like growth formed by the growth of lime-secreting blue-green algae, thought to be abundant 200 million years ago, when blue-green algae were the most advanced form of life on earth.
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	A class of water resource indicating the suggested
SWALE	A small earth wall guiding surface runoff away from the stream back onto fields.

TAXON	A taxonomic group referring to the systematic ordering and naming of plants and animals according to their presumed natural relationships. For example, the taxa *Simuliidae, Diptera, Insecta* and *Arthropoda* are examples of a family, order, class and phylum respectively.
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 overexploitation, 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 quantity of water available from a dam under specified conditions of catchment development and dam operation at a specific assurance level.

CHAPTER 1: INTRODUCTION

1.1 PURPOSE OF THIS 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 water 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 one each water management area. This report is in respect of the Olifants Water Management Area, which occupies portions of the Northern Province, Mpumalanga Province, and the Gauteng Province. A provincial water resources situation assessment can be derived by assembling the provincial data from each of those reports that describe the water management areas that occupy the province.

1.2 APPROACH TO THE STUDY

The study was carried out as a desktop investigation using data from reports and electronic databases, or supplied by associated studies, local authorities and DWAF. The study considered conditions as they were in the year 1995 and did not make projections of future conditions. Data at reconnaissance level of detail was collected on land-use, water requirements, water use, water related infrastructure, water resources and previous investigations of water supply development possibilities.

Relevant data was used in a computerized water balance model, developed in a separate study (DWAF, February 2000) 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. (DWAF, 2001).

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 analyzed 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 Olifants Water Management Area by the national demographic study (DWAF, March 2000), 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. (Appendix B).
- Legal aspects of water resource management. (Section 3.4).
- Institutional arrangements for water supply. (Section 3.4).
- Effects of alien vegetation on runoff. (DWAF, 1998).
- Groundwater resources. (Appendix G).
- Bacteriological contamination of water resources. (Appendix E).
- Water requirements for irrigation
- Ecological classification of rivers
- Water requirements for ecological component of reserve. (Hughes, 1999).
- Effects of afforestation on runoff. (DWAF, 1998).
- Storage-yield characteristics of rivers. (Section 6.3.2).

Information from all the above studies, that is relevant to the Olifants 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 Olifants 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

Chapter 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 Olifants Water Management Area is located on the north eastern part of the Republic of South Africa and includes portions of the following provinces: the eastern part of Gauteng, the northern part of Mpumalanga Province and the south eastern part of the Northern Province. The large urban centers in the WMA are Witbank and Middelburg, while towns of significance include Bronkhorstspruit, Groblersdal, Lydenburg, Belfast, Phalaborwa and Lebowakgomo. The Olifants WMA is shown in Figure 2.1.2. The Olifants River catchment area constitutes the WMA.

The main stem of the Olifants River originates in the far southern, Highveld region of the WMA. In this Upper Region (secondary catchment area B10) the altitude in the south is in the order of 1 700 m and in the vicinity of Middelburg 1 500 m. (See Figure 2.1.3).

The Middle Olifants River section is taken from the Elands River confluence to the Olifants River at Bewaarkloof (see Table 2.1.1), where the river flows north east between the Springbokvlakte and the Nebo Plateau (around Jane Furse).

The altitude in the catchment is 1 000 m in the Springbokvlakte and east of the river, about 1 500 m on the plateau.

The major portion of the Springbokvlakte is a local endoreic area, as shown in Figure 2.1.3. The endoreic area boundaries were taken from Midgley *et al* (1994). However, all the figures show rivers draining this area. The GIS river coverage used in the figures was obtained from DWAF but inspection of 1:250 000 maps does not show continuous rivers draining quaternary catchments B31J, B51E and part of B31E. The river coverage should be improved in these catchments.

The Olifants River flows generally eastwards from Lebowakgoma, in deep valleys west of the Escarpment and exiting onto the Lowveld at quaternary catchment boundary B71G/H. In the Lowveld region the altitude is at about 400 m (to 250 m in the Kruger National Park).

The major rivers contributing to the Olifants River are the following:

- The Rietspruit, the Steenkoolspruit and the Viskuile that confluences to form the main stem of the Olifants River south of Witbank. The Klein Olifants River is to the east of the tributaries above, and joins the river north west of Middelburg.
- The Wilge and Koffiespruit Rivers drains the area to the west of the main stem and join the Olifants River north of Witbank.
- The Moses and Elands Rivers drain the western part of the region south of the endoreic Springbokvlakte and the Elands River confluences with the Olifants River upstream of Arabie Dam.
- The Steelpoort River, and its tributaries the Dwars and Spekboom Rivers, drains a large area in the east, rising near Belfast and Lydenburg.
- The Blyde and Klaserie Rivers originates east of the Steelpoort River on the western mountainous area of the Escarpment. The Blyde River has its confluence with the Olifants River in the Lowveld region.

- The Ga-Selati River flows north of the main stream, in the Lowveld region, and originates on the eastern face of the Escarpment.
- The last tributary, and by far the largest, is the Letaba River which joins the Olifants River virtually on the Mozambican border.

The basic unit of area used in the assessment is the quaternary catchments. The quaternary catchments used were defined by Midgley *et al* (1994). The drainage regions throughout the country are divided into secondary, tertiary and quaternary catchments. The quaternary catchments have been selected to have similar runoffs. By definition, the greater the runoff volume the smaller the catchment area and *vice versa*.

This explains the large size of quaternary catchment B51E in the endoreic area. This catchment is about 3 000 km², while the average for the other catchments is in the order of 500 km². Being about six times larger than the other areas, some of the physical attributes of this catchment, when shown graphically as absolute values in the figures, seem distorted.

The Olifants River is within primary drainage Region B. The Water Management Area includes a total of 114 quaternary catchments. Figure 2.1.4 shows the numbered quaternary sub-catchments, as well as the hydrological sub-catchments grouped into so-called Key points, as indicated by shading.

The data in this study are given for the key points. Key points of interest were generally selected at existing large dams, possible future dam sites and at the confluences of important rivers. Table 2.1.1 lists the quaternary catchments per key point.

TABLE 2.1.1: DESCRIPTION OF KEY POINTS

LOCATION OF KEYPOINT				DESCRIPTION
PRIMARY CATCHMENT		SECONDARY CATCHMENT NO.	QUARTERNARY CATCHMENT NO.'S	
NO.	NAME			
B	Olifants River	B1 Upper Olifants	B11C,D,E	Rietspruit at Olifants
			B11A,B	Olifants at Rietspruit
			B11F,G	Witbank Dam
			B11H,J	Olifants at Klein Olifants
			B11K,L	Olifants at Wilge
			B12A,B,C	Middelburg Dam
			B12D,E	Klein Olifants at Olifants
		B2 Wilge	B20A,B,C	Bronkhorstpruit Dam
			B20D,E,F,G,H,J	Wilge at Olifants
		B3 Olifant-Loskop Reach	B31A,B,C	Rust de Winter Dam
			B31D,E,F	Renosterkop Dam
			B31G,H,J	Elands at Olifants
			B32A	Loskop Dam
			B32B,C,D	Olifants at Bloed
			B32E,F	Bloed at Olifants
			B32G,H,J	Olifants at Elands
		B4 Steelpoort	B41A,B	Steelpoort at Klip
			B41C,D	Steynsdrift Dam Proposal
			B41E,F,G,H,J	Steelpoort at Spekboom
			B41K	Steelpoort at Olifants
			B42A,B,C,D,E,F,G,H	Spekboom at Steelpoort
		B5 Middle Olifants	B51A,B	Arabie Dam
			B51C,E,F,G,H;B52A	Olifants at Lepelane

LOCATION OF KEYPOINT				DESCRIPTION
PRIMARY CATCHMENT		SECONDARY CATCHMENT NO.	QUARTERNARY CATCHMENT NO.'S	
NO.	NAME			
			B52B,C,D,E,F,G,H,J	Olifants at Bewaarkloof
		B6 Blyde	B60A,B,C,D	Blyde at Blyde Dam
			B60E,F,G,H	Orighstad River
			B60J	Blyde at Olifants
		B7 Lower Olifants	B71A,B	Rooipoort Dam Proposal
			B71C,D,E,F,G	Strijdom Tunnel Proposal
			B71H,J	Olifants at Blyde
			B72A,B,C,D	Olifants at Selati
			B72E,F,G,H,J,K	Selati at Olifants
			B73A,B,C,D,E,F,G,H	Olifants at Letaba
			B73J	Olifants at Mozambique

2.2 CLIMATE

The climatic conditions vary significantly within the Olifants Water Management Area.

2.2.1 Temperature

The mean annual temperature ranges between 14°C in the southwest to more than 22°C in the northeast with an average of 16°C for the catchment as a whole. Maximum temperatures are usually experienced in January and minimum temperatures occur on average in July. The following Table 2.2.1 summarizes temperature data for the Olifants management area for these two months (Schulze, 1997).

TABLE 2.2.1 TEMPERATURE DETAILS FOR THE WMA

Month	Temperature	Average (°C)
January	Mean Temperature	30,3
	Maximum Temperature	34,1
	Minimum Temperature	18,3
	Diurnal Range	±12
July	Mean Temperature	22,2
	Maximum Temperature	26,0
	Minimum Temperature	5,5
	Diurnal Range	±16

Frost usually occurs over the period between early July to August with the average number of frost days per year ranging from none in the northeastern area to 90 days in the southwestern area.

2.2.2 Precipitation

The rainfall occurs mainly in summer, (i.e. October to March). The peak rainfall months are January and February and rainfall occurs generally as thunderstorms.

The highest mean annual precipitation (MAP) occurs on the Escarpment (see Figure 2.2.1) and ranges between 800 and 1 500 mm.

However, on the remainder of the study area the rainfall varies between 800 to 500 mm. The higher rainfall occurs on the higher laying eastern portions of the Highveld area (Belfast to Lydenburg).

The MAP decreases from 800 mm on the Highveld region to 500 mm in the northern parts of the WMA. In the Lowveld area, east of the Escarpment, the rainfall is between 500 to 600 mm.

2.2.3 Evaporation

The mean annual gross evaporation (as measured by Symons pan) ranges from 1 300 mm to 2 000 mm over the whole Olifants WMA.

In the region of the Escarpment the MAE are at its lowest namely 1 300 mm. To the east and west of the Escarpment the evaporation changes and become higher. Over the Springbokvlakte the evaporation is as high as 2 000 mm.

Three evaporation zones are defined in the WR90 and are shown on Figure 2.2.2. The histograms shows the monthly evaporation as a percentage of the MAE per zone. The lowest evaporation in the WMA is in June and the highest varies per zone from October to January.

2.3 GEOLOGY

2.3.1 Introduction

The Olifants River Catchment is made up of a wide variety of lithologies. The main stratigraphic units from oldest to youngest are:

(i) Basement Gneisses or the Makhutsi and Houtrivier Gneisses.
(ii) Archean Greenschists or Murchison Sequence.
(iii) Archean ultra-mafic intrusions or the Rooiwater Complex.
(iv) Basement Granites.
(v) The Transvaal Sequence.
(vi) The Bushveld Igneous Complex.
(vii) Other mafic intrusions.
(viii) Karoo Sequence.
(ix) Quaternary Deposits.

2.3.2 Basement Gneisses

This formation is in the eastern quadrant of the study area and forms the Lowveld valley plains between the Wolkberg Mountains in the west and the Lebombo Mountain range in the east.

The gneisses have been described as two types:

- The Goudplaats Gneiss- grey biotite gneiss and migmatite. The Goudplaats gneiss occurs to the north of the Murchison range.

- Makhutsi gneiss are very similar to the Goudplaats gneiss in composition and age and have been distinguished from each other on the basis of structure on opposite sides of the Murchison lineament.

2.3.3 Murchison Sequence

This formation occurs as a linear east-north-east trending greenstone belt situated at the north eastern part of the catchment area. It is made up of Gravelotte Group, which consists of ultra-mafic to acidic volcano-sedimentary sequence of rocks that have been infolded into the basement gneiss and metamorphosed to green schist facies metamorphism.

2.3.4 Rooiwater Igneous Complex

This Complex is a layered ultra-mafic intrusive which has been thrusted against the Gravelotte group rocks. It is a typical layered intrusive consisting of gabbro norites, magnetite seams and diorite.

2.3.5 Basement Granites

This formation comprises of numerous younger granite suites that have intruded into the basement gneisses.

They are, from oldest to youngest:

- The Nelspruit Suite which consists of a white to pale brown porphyritic biotite granite and a quartz plagioclase migmatite gneiss.

- The Vorster Granite Suite consisting of the Lekkersmaak Granite and Willie Granite.

- The Moshimole Suite consisting of the Mararanda Granite, Harmony Granite and Cunning Moor Tonalite.

2.3.6 Transvaal Sequence

This sequence is a thick volcano-sedimentary package which forms the escarpment face between the Lowveld and the Highveld plateau. The Transvaal Sequence is divided into the following groups:

- The Wolkberg group consists of a thick sequence of quartzites, andositic lavas and shales;
- The Chuniespoort group consists of alternating layers of dolomitic-banded iron formations and cherts.
- The Pretoria group consists of a thick sequence of interlayered shales, lavas and quartzites.
- The Rooiberg group consists of rhyolites, quartzites and conglomerates.

2.3.7 The Bushveld Complex

This formation is a massive layered igneous pluton of which the eastern lobe is situated in the centre of the study area. The igneous complex is intrusive into the Transvaal sequence.

It is made up of a ultra-mafic component known as the Rustenburg Layered Suite and capped by an acidic component known as the Lebowa Granite Suite.

- The Rustenburg Layered Suite can be subdivided into the following horizons:
  - Lower zone - melanonorite, pyroxenite and chromite.
  - Critical zone - pyroxenite, anorthosite and leuconorite.
  - Main zone - gabbro, norite and anorthosite.
  - Upper zone - ferrogabbro, troctolite, anorthosite and magnetite.
- The Lebowa Granite Suite consists of the following:
  - Rashoop Granophyre suite - granophyre and quartz porphery.
  - The Nebo granites - a coarse grained red K-feldspar granite;

2.3.8 Other Mafic intrusions

These intrusives occur in the study area of slightly younger age to the Bushveld Complex. These are:

- The Timbavati Gabbro, a medium to coarse grained gabbro.
- The Palaborwa Complex, an alkaline complex consisting of pyroxenite, dunite, foskorite, carbonotite and syenite.
- The Spitshoop Complex, including pyroxenite, ijolite, foyaite and carbonatite.

2.3.9 Karoo Sequence

This formation is an intrusive sedimentary sequence capped by basaltic lava. It is preserved in the Springbok flats basin to the west and south of the study area. It is made up of the following lithological horizons:

- Dwyka formation - glacial tillite.
- Ecca formation - coal bearing shales and sandstones.
- Irrigasie formation – sandstones, shales and mudstones.
- Clarens formation - sandstone, grit and mudstone.
- Letaba formation - basalt.

2.3.10 Quaternary Deposits

These deposits are found in the larger drainages of the catchment area that have associated unconsolidated alluvial deposits.

2.4 SOILS

The soils in the Olifants WMA are shown in Figure 2.4.1, which has been taken from the WR90 study (Midgley *et al*, 1994). This map is a simplified version of a more complete soil zone map developed by the University of Natal and reproduced in the South African Atlas of Agrohydrology and – Climatology (Schulze *et al*, 1997). The soil zones had been delimited by the Institute for Soil, Climate and Water, based on soil texture (i.e. clay, sand, silt, etc.), soil forms and series (i.e. Hu 18 for a Hutten soil form and 18 for the Balmoral series) and soil depth. In total, 84 zones had been identified in a coarse scale, regional zonation, originally mapped at 1:2 500 000 scale. Each of the 84 zones still displays a wide range of soil properties.

In the WR90 study, the soil types were further analysed according to features most likely to influence hydrological response, viz. depth of soil, soil texture and slope. Some 16 broad groupings were obtained, of which eight occur in the WMA.

The soil texture in the WMA varies from clayey (undulating) in the extreme south (Highveld), to clayey loam (undulating) in the majority of the Loskop Dam catchment area. North of Loskop Dam, sandy loam (flat to steep) dominates, except for the Springbokvlakte where clayey soil (flat) occurs. In the east, on the Lebombo Mountain range, clayey soil (steep) occurs.

2.5 NATURAL VEGETATION

2.5.1 General

Some 20 000 different plant species occur throughout South Africa. These are however not randomly distributed but are organized into distinct communities, largely dependent on the prevailing climate (especially rainfall) and edaphic (soil) conditions.

For the purpose of identifying and managing the heterogenous range of vegetation within South Africa, it has been decided to recognize relative homogenous vegetation groups or types. Furthermore for the recognized 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". Some 70 veld types were identified in South Africa including 75 variations. These 70 veld types fall into 11 broad categories, ranging from various forest types to sclerophyllous (Fynbos) types as indicated in Table 2.5.1.

TABLE 2.5.1: 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

Detailed Veld Types	No.	Simplified Veld Type
False Upper Karoo False Karroid Broken Veld False Central Lower Karoo False Succulent Karoo False Orange River Broken Karoo Pan Turf Veld invaded by Karoo Karroid Merxmuellera Mountain Veld replaced by Mountain Renosterveld	36 37 38 39 40 41 42 43	
Highveld Sourveld and Dohne Sourveld Natal Mist Belt 'Ngongoni Veld Coastal Renosterveld Coastal Fynbos	44 45 46 47	Temperate and Transitional Forest
Cymbopogon – Themeda Veld Transitional Cymbopogon – Themeda Veld Dry Cymbopogon – Themeda Veld Pan Turf Veld Themeda Veld or Turf Highveld Patchy Highveld to Cymbopogon – Themeda Turf Highveld to Highland Sourveld Transition Bakenveld to Turf Highveld Transition Highland Sourveld to Cymbopogon – Themeda	48 49 50 51 52 53 54 55 56	Pure Grassveld
North-eastern Sandy Highveld Themeda – Festuca Alpine Veld Stormberg Plateau Sweetveld Karroid Merxmuellera Mountain veld	57 58 59 60	
Bankenveld	61	False Grassveld
Bankenveld to Sour Sandveld Transition	62	
Piet Retief Sourveld	63	
Northern Tall Grassveld Southern Tall Grassveld	64 65	
Natal Sour Sandveld Pietersburg Plateau False Grassveld Eastern Province Grassveld	66 67 68	
Fynbos	69	Sclerophyllous Bush
False Fynbos	70	False Sclerophyllous Bush

2.5.2 Natural vegetation types within the Olifants WMA

The Olifants WMA is dominated by Tropical Bush and Savanna, with smaller areas of False and Pure Grassveld. Small areas of Inland Tropical Forest occur in the Blyde River catchment and close to the central northern boundary. Figure 2.5.2.1 shows the simplified veld types and they are described as follows:

Tropical Bush and Savanna

This veld type dominates the central eastern and north western regions of Olifants WMA, occupying about 65% of its area. Tropical trees and shrubs are common and the dominant grass is a tall form of Themeda Triandra that enjoys rainfall between 500 – 750 mm per annum, falling mainly in summer. The tropical bush and savanna generally occurs at altitudes between 1 500 m and 1 600 m above mean sea level.

False Grassveld

The Upper Olifants and Wilge River catchments are dominated by the False Grassveld, which occurs at altitudes ranging from 1 500 – 1 700 m above sea level and rainfall from 600 – 800 mm per annum. Under these conditions combined with regular burning the veld is a particularly sour wiry grassveld.

Pure Grassveld

Small patches occur on the southern boundaries of this WMA. The dominant grass is tall and creeping grasses tend to become common with over grazing. Shrubs and bushy plants are plentiful within this veld type.

Inland Tropical Forest

Occurs predominantly on the Escarpment. This vegetation dominates the mountain ranges where high rainfall is experienced ranging on average from 800 mm to over 1 500 mm per annum.

2.6. ECOLOGICALLY SENSITIVE SITES

2.6.1 Definition of Sensitive Ecosystem

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 utilization of species and 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. Table 2.6.4.1 contains a list of protected areas within the Olifants WMA.

South Africa also recognizes the importance of its wetlands as sensitive ecosystems which require conservation, and accordingly has become a signatory to the international 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.

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 No 36 of 1998) the water resources requirements of aquatic ecosystems are recognized and protected by the introduction of the concept of an ecological reserve, i.e. the water required to protect the aquatic ecosystem of the water resources. The Reserve refers to both quantity and quality of the resource. Accordingly, development must take cognisance not only on the sensitivity of the receiving ecosystem but also of the resource requirements or ecological reserve of the aquatic communities it supports.

2.6.2 River Classification

The water resources 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.

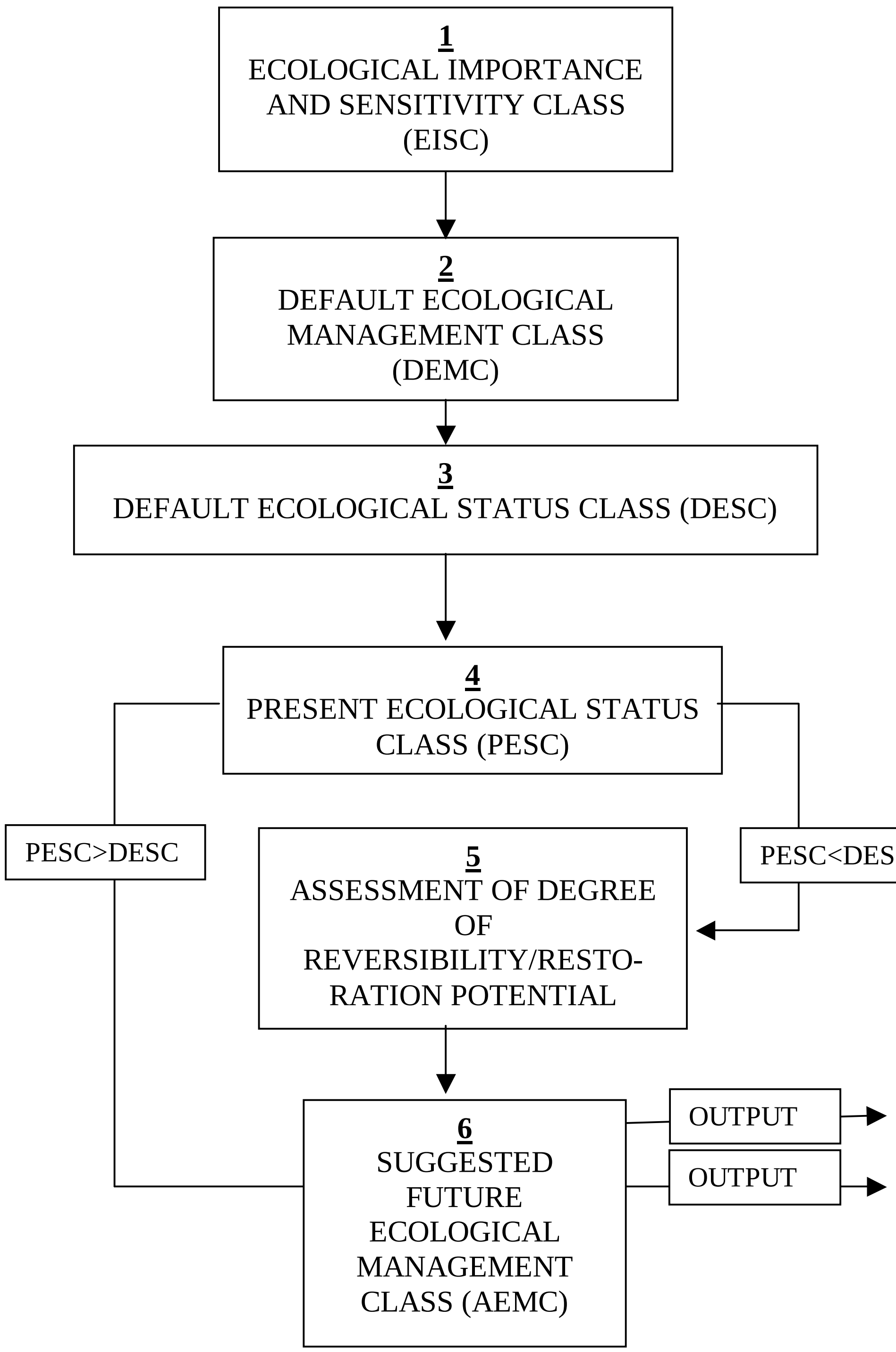
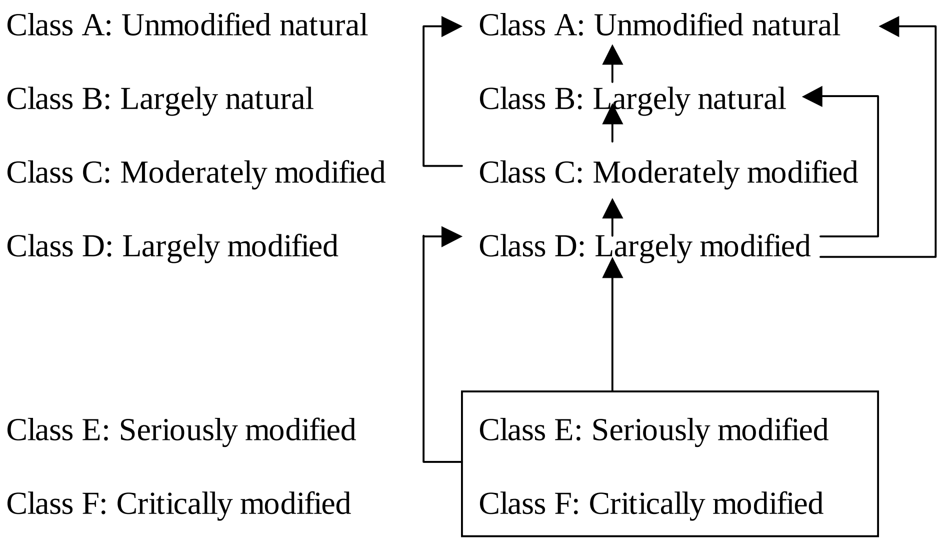


Diagram 2.6.2.1: Procedure followed to determine the river classifications

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:



→ : indicates relationship.
⟶ : indicates possible direction of desirable change.

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

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 assessed during meetings or 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.

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 was 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 species diversity was 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.

Each of the above attributes that were used to estimate the present ecological status were 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

The ecological sensitivity of aquatic systems other than rivers, including lakes, wetlands and groundwater systems, has to date not been assessed within the Olifants WMA. Similarly, the estuarine systems are generally not well studied, but could be ecologically important and sensitive to reduced flows and changes in water quality, especially salinity. It is considered to be of national importance from a vegetation and piscifaunal perspective, and of international importance from an avifaunal perspective.

The ecological significance of the river systems falling within the Olifants WMA, as exemplified by their Ecological Importance and Sensitvity Classes (EISC), are summarized in Figures 2.6.3.1 to 2.6.3.3. These show, respectively for each quaternary catchment, the default ecological management class, the present ecological status class, and the suggested future ecological management class. As outlined in section 2.6.2 the EISC of a river is an expression of its importance to the maintenance of ecological diversity and functioning on a local and wider scale, as well as the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred.

The Olifants River has several major tributaries including the Elands River, Klein Olifants River, Wilge River, Steelpoort and Blyde River. The river traverses highveld areas, mountainous areas and lowveld areas before flowing into the large Massingir Dam in Mozambique. The various river reaches of the Olifants River are considered important from a conservation perspective, for the following reasons:

- The Upper Olifants River, upstream of Loskop Dam, contains the gorge area which has scenic qualities and numerous fish populations.
- The Bronkhorstspruit has a moderate conservation status and the small scale yellow fish occurs along this river reach.
- Downstream of Loskop Dam, numerous flow dependent species occur in the river.
- Downstream of Arabie Dam the habitat is degraded until the confluence of the Mohlapitse River.
- The Olifants River in the vicinity of the Mohlapitse River is of considerable importance in view of the numerous cool mountain streams which join the river. The mix of hot and cold waters provides habitats with high diversity and numerous red data and indemic fish populations occur in such environments. Of particular importance is the aplocheilichthys katangal which occurs in the river. Ghost frogs are also found in the Mohlapitse River. The Mohlapitse River area also has several wetland areas.

- The Steelpoort River, although having a high sediment load, has several flow dependent fish species and contributes considerably to the flow in the gorge which occurs in the Drakensberg.
- The Blyde River has several flow dependent species, however their habitat is considerably disturbed by the pulse flows which occur in the river as a result of the release pattern from Blyde Dam for irrigation. The Upper Selati River is undeveloped and red data fish species occur in this river.
- The upper reaches of the Klaserie River has several red data species particularly in the steep mountainous sections. Mormyiad Churchill and bulldog fish occur in high populations.
- The Lower Olifants River upstream of Massingir Dam has been found to have tiger fish. The Massingir Dam is however a major obstacle to migration of fish into the Olifants River System from further downstream in Mozambique.

2.6.4 National Heritage Sites, Game and Nature Reserves, Wilderness Areas

General

As previously alluded to, the sensitive ecosystems outlined above only include those relevant to aquatic ecosystems. However, in addition to these ecosystems the Olifants WMA contains other protected areas, which may be impacted directly or indirectly upon by developments activities associated with water resources. These protected areas include Natural Heritage Sites as well as Scientific and Wilderness Areas, National Parks and Equivalent Reserves, Natural Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas, Protected Land, Seascapes.

Game and Nature Reserves

The Kruger National Park is the largest nature reserve occupying approximately 10% of this Water Management Area along the Eastern boundary. The park contains a great variety of wildlife and is said to have a greater diversity than any other African game reserve. The Kruger National Park is particularly noted for its high elephant populations and also for some of the rarer antelope such as sable, roan, tsessebe, nyala and eland.

There are a number of other conservation areas and nature reserves in the central, northern and eastern regions of the WMA. The Klaserie, Umbabat, Timbavati, and Thorny Bush are privately owned Game Reserves located adjacent to the Kruger National Park. Other smaller reserves situated in the northern and central regions are named in Table 2.6.4.1

Natural Heritage Sites

A number of natural heritage sites are situated along the eastern boundary of the WMA. Mokobulaan, In-de-Diepte, Driekop Caves and London Nature Reserve are the large proclaimed heritage sites within the catchment.

Table 2.6.4.1 contains a list of protected areas within the Olifants WMA. All water resource developments 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.

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

TABLE 2.6.4.1: PROTECTED NATURAL AREAS AND NATURAL HERITAGE SITES

Area Name	Category
Kruger National Park	National Park and Equivalent Reserves
Klaserie	Habitat & Wildlife Management Area
Umbabat	Habitat & Wildlife Management Area
Timbavati	Habitat & Wildlife Management Area
Thorny Bush	Habitat & Wildlife Management Area
Blyderivierspoort	Habitat & Wildlife Management Area
Hebron	Habitat & Wildlife Management Area
Welgevonden	Habitat & Wildlife Management Area
Burgersfort	Habitat & Wildlife Management Area
Lydenburg	Habitat & Wildlife Management Area
Loskop Dam	Habitat & Wildlife Management Area
Enkeldoornspoort	Habitat & Wildlife Management Area
Scuinsdraal	Habitat & Wildlife Management Area
Bewaarkloof	Habitat & Wildlife Management Area
Serala	Habitat & Wildlife Management Area
Lekgalameetse	Habitat & Wildlife Management Area
Mokobulaan	Natural Heritage Site
In-de-Diepte Reserve	Natural Heritage Site
Mount Sheba	Natural Heritage Site
Driekop Caves	Natural Heritage Site
London Nature Reserve	Natural Heritage Site
Doornkop	Natural Heritage Site

Note: This list should only be viewed as a guide to the protected areas, since as the status of protected areas is constantly changing and new areas are receiving protection, the list cannot be comprehensive. It is the developer's responsibility to ascertain the location of any protected area adjacent to the development and to ensure that activities do not impact on the areas.

2.7 CULTURAL AND HISTORICAL SITES

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

The National Monuments Act (No.28 of 1969) provides for the protection and conservation of cultural resources including all archaeological sites. In addition, the Environment Conservation Act (No. 73 of 1989) provides for the integration of cultural resources into environmental management processes.

Early iron age sites occur in the Lydenburg area. Many artifacts from this age can be found at the Lydenburg Heads. These sites are not influenced by dams.

The area from Strydpoort Mountains to Middelburg, Steelpoort River and Spekboom River was a baPedi settlement region and sites of interest are being developed in the Mapachsgronde area near Roossenekal. Remnants of Voortrekker occupation occur in the areas around Lydenburg, Steelpoort and Ohrigstad (Basin Study, 1991).

It is the responsibility of any developer to liaise with the National Monuments Council and South African Museum to establish whether they are aware of any sites of cultural, historical or archaeological interest within any area earmarked for development.

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 Monuments Act and any other relevant legislation (e.g. National Monuments Act and any other relevant legislation (e.g. National Parks Act (No. 57 of 1975)), and should consult with the National Monument Council on discovering sites or artefacts of palaeontological, archaeological or historical significance. Also, developers should take cognisance of the fact that the National Heritage Act is likely to supercede the National Monuments Act in April 2000, and should undertake to familiarize themselves with the contents of the new Act.

CHAPTER 3: DEVELOPMENT STATUS

3.1 HISTORICAL DEVELOPMENT OF WATER RELATED INFRASTRUCTURE

Water resources development and the development of related water supply infrastructure in the Olifants WMA were driven by the following factors:

- Domestic water supply was driven by spatial and temporal demographic patterns. The area encompasses areas of traditional land mainly parts of the former Lebowa area and also smaller parts of Bophutatswana, KwaNdebele and Gazankulu and areas where population growth was stimulated by agricultural, industrial or mining activities.

- Irrigation water supply was driven by the development of large irrigation schemes, notably Loskop Irrigation scheme which was developed in the 1930's to accommodate persons affected by the 1930's economic depression.

- Mining and industrial water supply was driven by the discovery and exploitation of coal, (which stimulated industrial development in the existing towns of Witbank and Middelburg) minerals, such as ferro-chrome (at Lydenburg and Roossenekal), phosphate, copper and associated deposits (new town of Phalaborwa was established), platinum and chrome (in the Steelpoort River catchment area).

- Strategic water supply, driven by the establishment of large coal-fired power stations in the Upper Olifants and Wilge River catchment areas, which necessitated major inter-basin water transfer schemes.

Major dams are classified as dams with a dam wall higher than 12 m, a minor dam is registered at the Dam Safety Office, with wall height less than 12 m and more than 5 m, and small dams are not registered at this office.

Major dams in the Secondary Catchment areas are listed in tables below. Regarding the purpose of the dam, municipal water supply is defined as water used for domestic and industrial purposes, where the industries are generally within municipal boundaries and supplied by the local authority. Strategic water supply is mainly linked with a water transfer scheme, developed for power generation and domestic water.

The **Upper Olifants River catchment** in the southern part of the WMA has five major dams and these are listed below. This key point has a high population concentration in the urban areas and therefore a high need for domestic water supply.

The major dams in this sub-catchment are:

Dam Name	Capacity (10^6 m^3)	Purpose
Trichardtsfontein Dam	15,20	Strategic
Rietspruit Dam	4,50	Domestic Water Supply
Witbank Dam	104,14	Strategic and Municipal
Doornpoort Dam	9,18	Domestic Water Supply
Middelburg Dam	47,90	Municipal

The **Wilge River catchment**, also has a high urban population and domestic and mining water supply are needed.

The major dams in this sub-catchment are:

Dam Name	Capacity (10^6 m^3)	Purpose
Bronkhorstspruit Dam	58,90	Domestic Water Supply
Premier Mine Dam	1,69	Mining Domestic Water Supply

The **Elands River catchment**, in the western part of the WMA has a high rural population that exceeds the urban population, since most of the former Kwandebele Homeland is situated in the catchment.

Major dams in this sub-catchment are:

Dam Name	Capacity (10^6 m^3)	Purpose
Rhenosterkop Dam	204,62	Domestic Water Supply
Rust de Winter Dam	27,21	Irrigation

The **Olifants-Loskop Reach** contains the Loskop Dam that was constructed for irrigation purposes. The sub-catchment upstream of Loskop Dam falls in the Control Area where construction of dams in certain rivers is prohibited and limited on others.

Major dams in this sub-catchment are:

Dam Name	Capacity (10^6 m^3)	Purpose
Rooikraal Dam	2,12	Irrigation
Loskop Dam	348,10	Irrigation Domestic Water Supply

The **Steelpoort River catchment** to the east of the main stream has various Government control areas and therefore limited potential for agricultural development.

Major dams in this sub-catchment include:

Dam Name	Capacity (10^6 m^3)	Purpose
Belfast Dam	4,39	Domestic Water Supply
Buffelskloof Dam	5,27	Irrigation

The **Middle Olifants River catchment**, between the Springbokvlakte and Nebo plateau has a large rural population as a part of the former Lebowa Homeland are in this catchment.

Major dams in this sub-catchment are:

Dam Name	Capacity (10^6 m^3)	Purpose
Arabie Dam	104,00	Irrigation *
Piet Gouws Dam	4,35	Irrigation
Chuniespoort Dam	3,1	Irrigation
Mogoto Dam	2,9	Irrigation
Lola Montes Dam	1,48	Irrigation
Nkadimeng Dam	2,10	Irrigation

* Domestic and Industrial water supply planned.

The **Blyde River catchment**, is located to the east of the Steelpoort River catchment, is the catchment. Irrigation and commercial forestry are the main land-use activities. The Ohrigstad and Blyde Rivers, as well as many of their tributaries, are perennial. Since storage is not needed to ensure successful irrigation, the water infrastructure in this catchment lacks sophistication and only two major dams have been built. (Note that since 1995, water from the Blyde River Dam is increasingly used for domestic water supply and bulk pipe distribution systems have been installed) and it includes the Blyde River and its major tributary, the Ohrigstad River.

The major dams in this sub-catchment are:

Dam Name	Capacity (10^6 m^3)	Purpose
Blyderivierspoort Dam	54,64	Municipal Water Supply
Ohrigstad Dam	13,24	Irrigation

The **Lower Olifants River catchment** in the north eastern part of the WMA, has a limited available water as the development occurred upstream of this catchment. The rural population are high as the Lebowa Homeland are mainly in this catchment.

Dam Name	Capacity (10^6 m^3)	Purpose
Jan Wassenaar (Klaserie) Dam	5,76	Irrigation
Phalaborwa Barrage	5,65	Municipal Water Supply
Tours Dam	5,50	Irrigation

3.2 DEMOGRAPHY

3.2.1 Introduction

A national study (DWAF, 2001) to develop water use projections to the year 2025 was undertaken for the Department of Water Affairs and Forestry 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 categorized 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 (for RSA) 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

The population in the Olifants WMA comprises residents in several urban centres and developing rural communities who are concentrated in the former Lebowa, KwaNdebele, Boputhatswana and Gazankulu homeland areas. A major part of the household economy in the rural areas is on survivalist level with some 70% of the population living in poverty (DWAF: WS Planning, 1999).

Unemployment, which is in the order of 45% in the Olifants WMA, is a major driver of **migration out** of the rural areas of the WMA to larger industrial centres and urban areas outside the WMA, including Johannesburg/Pretoria and within the WMA, including Middelburg/Witbank. Assessments of the absenteeism of potentially economically active males in the WMA during the late 1980's found that some 24% of males may be considered to be migrant workers (DWAF: WS Planning, 1999). This situation is aggravated by the formal sectors of the provincial economy displaying a generally declining rate of labour absorption/employment creation relative to output and is also associated with increasing mechanisation.

Indications are that some 45% of the population does not have access to water that meets RDP Standards. Health services are also poor and the literacy rate is about 54% (DWAF: WS Planning, 1999). Population movement to areas having improved services has been experienced, but no statistics are available in this regard.

Illegal immigrants, who have migrated to South Africa from neighbouring countries, have occurred for the past several decades. Statistics from the Department of Interior for the late 1980's and early 1990's show a rising trend in the number of illegal aliens with some 2 000 repatriations occurring per week at that time (DBSA, 1993). It is almost impossible to obtain an estimate of the size of the influx of these people in view of the endeavours of such people to remain unidentified.

The historical population growth rate in the WMA is a function of the population growth rate of communities in the former homeland areas, as well as the growth rate in the larger urban centres.

The former Lebowa areas, which are located in the central and northern parts of the WMA, experienced a moderate to high population growth rate increasing from 1,1% per annum and 7,8% per annum for the period 1960 to 1991 (DBSA, 1993).
The average population growth rate for the Northern Province for the period 1985 to 1994 was about 3,9% per annum (DBSA, 1998). Mpumalanga experienced a growth rate of 3,03% during 1988 to 1993.

3.2.4 Population Size and Distribution in 1995

Table 3.2.4.1 shows the population size of the Olifants WMA in 1995 according to SWAF (2001).

The total population of the **Upper Olifants River catchment** amounts to about 358 100 and comprises 281 200 urban residents and 76 900 rural residents. A large portion of the population is concentrated in the Witbank and Middelburg areas.

The **Wilge River catchment** has a total population of about 394 100 and comprises 355 200 urban residents and 38 900 rural residents.

The total population of the **Elands River catchment** amounts to about 549 600 and comprises 161 300 urban residents and 388 200 rural residents.

The total population of the **Steelpoort River catchment** amounts to about 185 000 and comprises 25 900 urban residents and 159 000 rural residents. The population is concentrated in the northern part of the catchment in the former homeland area.

The total population of the **Middle Olifants River catchment** amounts to about 681 800 and comprises 43 700 urban residents and 638 200 rural residents. The rural population is widely distributed in the former homeland areas.

The **Blyde River catchment** has a total population of about 37 300 and comprises 750 urban residents and 36 500 rural residents.

The Lower Olifants River catchment (downstream of the confluence of the Olifants and Steelpoort Rivers) has a total population of about 334 100 and comprises about 65 000 urban residents and 269 100 rural residents. The population is concentrated mainly in the western and northern parts of the catchment in line with the boundaries of the previous homeland boundaries.

A detailed breakdown of the population is given in **Appendix A**. Figure 3.2.4.1 shows the population distribution for 1995.

TABLE 3.2.4.1: POPULATION SIZE AND DISTRIBUTION IN 1995

CATCHMENT						POPULATION		
Primary		Secondary		Tertiary				
No	Description	No	Description	No	Description	Urban	Rural	Total
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	12 000	17 712	29 710
					Olifants at Rietspruit	3 450	15 819	19 260
					Witbank Dam	0	14 126	14 130
					Olifants at Klein Olifants	167 700	5 104	172 803
					Olifants at Wilge	0	4 331	4 331
				B12	Middelburg Dam	13 500	13 331	26 830
					Klein Olifants at Olifants	84 550	6 497	91 047
			Sub total			**281 200**	**76 920**	**358 120**
		B2	Wilge	B20	Bronkhorstspruit Dam	253 800	15 001	268 800
					Wilge at Olifants	101 400	23 944	125 350
			Sub total			**355 200**	**38 945**	**394 145**
		B3	Elands	B31	Rust de Winter Dam	0	21 376	21 370
					Renosterkop Dam	15 450	73 860	89 310
					Elands at Olifants	122 850	61 466	184 370
			Olifants - Loskop Reach	B32	Loskop Dam	0	4 229	4 229
					Olifants at Bloed	3 150	6 580	9 729
					Bloed at Olifants	7 000	24 443	31 450
					Olifants at Elands	12 850	196 279	209 150
			Sub total			**161 300**	**388 233**	**549 608**
		B4	Steelpoort	B41	Steelpoort at Klip	9 450	6 713	16 163
					Steynsdrift Dam Proposal	0	9 600	9 600
					Steelpoort at Spekboom	0	90 819	90 820
					Steelpoort at Olifants	0	41 800	41 800
				B42	Spekboom at Steelpoort	16 500	10 073	26 570
			Sub total			**25 950**	**159 005**	**184 953**
		B5	Middle Olifants	B51	Arabie Dam	7 200	70 270	77 470
					Olifants at Lepelane	1 700	288 000	289 700
				B52	Olifants at Bewaarkloof	34 750	279 907	314 650
			Sub total			**43 650**	**638 177**	**681 820**
		B6	Blyde	B60	Blyde at Blyde Dam	0	16 630	16 630
					Ohrigstad River	0	16 430	16 430
					Blyde at Olifants	750	3 483	4 233
			Sub total			**750**	**36 543**	**37 293**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0	8 598	8 598
					Strijdom Tunnel Proposal	1 400	99 661	89 450
					Olifants at Blyde	0	18 837	30 460
				B72	Olifants at Selati	0	54 234	54 230
					Selati at Olifants	5 650	86 490	92 150
				B73	Olifants at Letaba	57 950	1 213	59 163
					Olifants at Mozambique	0	18	18
			Sub total			**65 000**	**269 051**	**334 069**
Total in Gauteng						**132 965**	**39 660**	**172 625**
Total in Mpumalanga						**660 709**	**537 160**	**1 197 869**
Total in Northern Province						**139 376**	**1 030 054**	**1 169 430**
Total WMA						**933 050**	**1 606 874**	**2 539 924**

3.3 MACRO-ECONOMIC INFLUENCES

3.3.1 Introduction

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

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

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

3.3.2 Data Sources

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

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

The **labour** distribution provides information on the sectoral distribution of formal economic activities, as do the GGP figures, but in addition, information is provided on the extent of informal activities, as well as dependency. Dependency may be assessed from unemployment figures, as well as by determining the proportion of the total population that is economically active. *Total economically active* population consists of those employed in the formal and informal sectors, and the unemployed. *Formally employed* includes employers, employees and self-employed who are registered taxpayers. *Unemployment figures* include people who are actively looking for work, but are not in any type of paid employment, either formal or informal. *Active in informal sector* includes people who are employers, employees or self-employed in unregistered economic activities, i.e. businesses not registered as such. The labour data was obtained directly from the Development Bank of Southern Africa (DBSA). The DBSA has utilised the 1980 and 1991 population censuses as the basis but has also updated the figures utilising the 1995 October Household Surveys of Statistics South Africa (CSS statistical release P0317 for South Africa as a whole and P3017.1 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 WMA's 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 that 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 that should be allocated to each segment of a MD, so that theses figures could be totaled up within the WMA boundaries.

- **Other Sectors**

  Historical factors such as the relocation of certain segments of the population to non-productive areas, and the immigration of mainly Mozambicans, especially to Mpumalanga and the Northern Province, had to be taken into account when allocating the GGP figure to the WMAs. Subsequently, for all the sectors apart from those discussed above, only the Caucasian population was used to perform the calculations as described above. Economic activities in these sectors are less dependent on population *per se*, but are dependent on the same factors that 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 Olifants WMA was R28,7 bn in 1997. The most important magisterial districts in terms of contribution to GGP in this WMA are shown below:

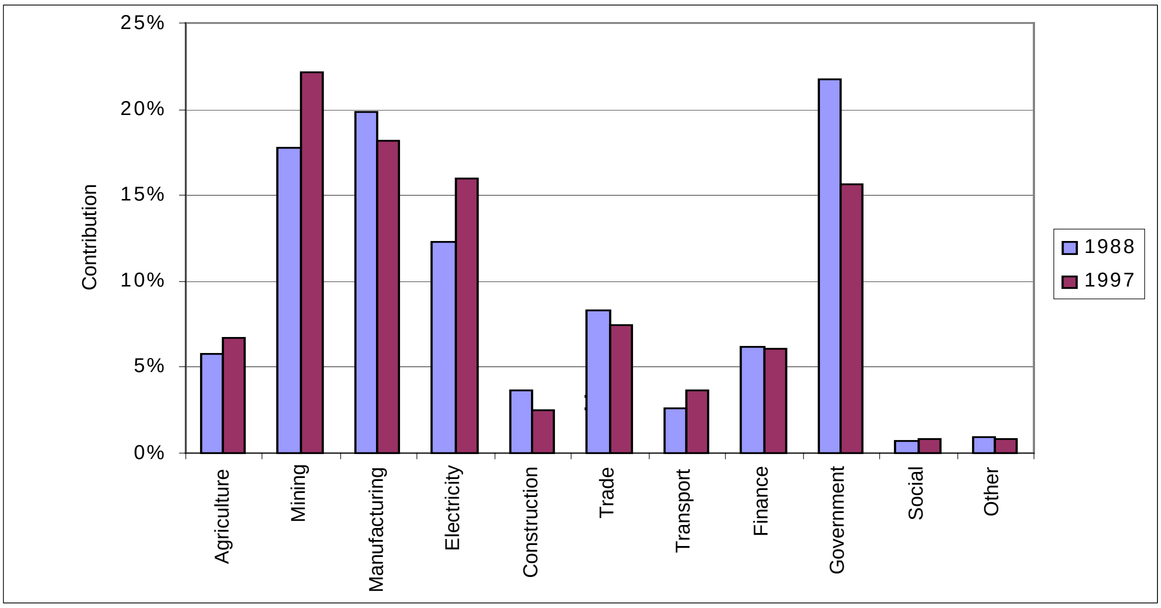
- Middelburg 25,7%
- Witbank 20,6%
- Moretele 2 14,5%
- Highveld Ridge 7,5%
- Phalaborwa 5,3%
- Other 26,4%

♦ **Economic Profile**

The composition of the Olifants WMA economy is shown in Figure 3.3.1. The most important sectors in terms of contribution to GGP are shown below:

Mining	22,1%
Manufacturing	18,2%
Electricity	15,9%
Government	15,6%
Other	28,2%

DIAGRAM 3.3.1: CONNTRIBUTION BY SECTOR TO ECONOMY OF OLIFANTS WATER MANAGEMENT AREA, 1988 AND 1997 (%)



There are a large number of mining activities in the Olifants WMA. Mining activities are dominated by coal mining, but include copper, phosphate and diamond mining. In the Highveld Region in Mpumalanga, extensive coal mining takes place. Other mining activities in this area include the mining and processing of flint clay in the Middelburg and Belfast areas. Minerals, such as ferro-chrome, are mined at Lydenburg and Roossenekal in the Steelpoort River Catchment Area. The mining industry of the Lowveld sub-region in the Northern province is dominated by the Phalaborwa Mining Company (PMC) (copper) and Foscor (phosphates), both of which are located on the Phalaborwa Mineral Complex in the northeastern corner of the WMA. In the Cullinan/Rayton area, which falls partly in the Crocodile West and Marico WMA and partly in the Olifants WMA, mining activities are concentrated in diamonds and silica.

The significance of the electricity sector can be attributed to the vast supply of coal in this area, which is used to fire power stations, especially in the Highveld Region of Mpumalanga.

The success of the manufacturing sector can be attributed to cheap supply of electricity and coal. The steel manufacturing activities taking place in Witbank (Highveld Steel) and Middelburg (Columbus Steel) are based on this advantage. Some industries in the Ekangala area (Ekandustria) near Bronkhorstspruit derived their advantage from the decentralisation incentives offered by the previous government. Some of these industries, but not all, are still thriving today.

During the period March 1996 to May 1997, approximately R4,9 million of industrial development took place in Witbank. Other industrial areas include Springs and Nigel. Activities taking place in these areas include basic metal industries, machinery and equipment.

The Highveld area has a reasonably high rainfall, making it suitable for dryland crops, such as maize and sunflowers. There are important fisher hatcheries at Lydenburg. The area has a number of trout farms that also attract tourists. Another tourist attraction is the Kruger National Park, which falls partly in this WMA. There are also a number of other nature reserves, and private game farms. Timbavati Game Reserve is famous for its lion breeding and the Blyde River Canyon Nature Reserve is famous for its scenery and hiking trails.

♦ **Economic Growth**

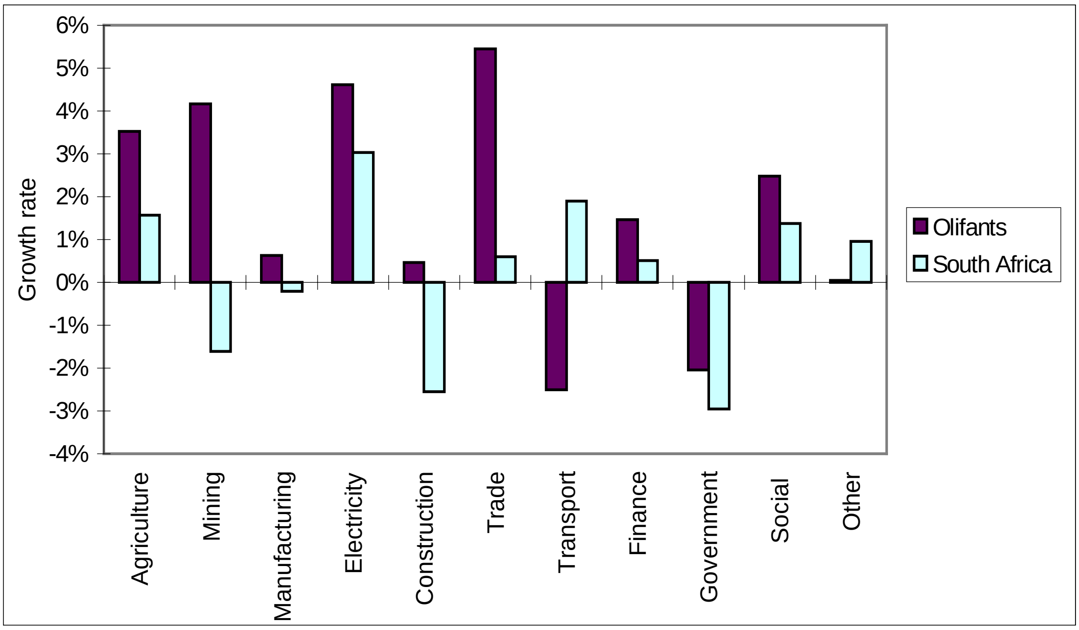
The average annual economic growth by sector is shown in Figure 3.3.2. Between 1987 and 1997, the highest average growth rates were recorded in the following sectors:

- Trade : 5,5%
- Electricity : 4,6%
- Mining : 4,2%
- Agriculture : 3,5%

The growth in the agricultural sector can be ascribed to a number of reasons. The Northern Province and Mpumalanga have a number of important irrigation areas that contributes to agricultural growth. The diversity of the agricultural sector also contributes to growth by making it less vulnerable to seasonal fluctuations.

Mining growth could be ascribed to the large number mining projects taking place in this WMA, for example the production of ferrochrome in Lydenburg with 240 000 tons produced annually and which is 100% export orientated. R100 million was invested in this project and approximately 100 new jobs have been created in the process. The demand for coal for electricity generation also contributed to growth in the mining sector.

DIAGRAM 3.3.2: AVERAGE ANNUAL ECONOMIC GROWTH BY SECTOR OF OLIFANTS WATER MANAGEMENT AREA AND SOUTH AFRICA, 1988 - 1997



The importance of the manufacturing sector and its demand for electricity and water contributed to growth in the electricity sector. Trade sector growth was stimulated by the development of new shopping centres. During 1997, approximately R17 million worth of commercial development took place in Witbank.

♦ **Labour**

Of the total labour force of 847 000 in 1994, 45% were unemployed, which is higher than the national average of 29,3%. Forty three percent (43,4%) were active in the formal economy. Forty eight percent (48,3%) of the formally employed labour force worked in the government sector, while 21,3% were involved in the mining sector and 19,1% in the agricultural sector.

During the period 1980 to 1994 employment growth was recorded in the mining sector (2,7% per annum); manufacturing sector (3,6% per annum); the financial service sector (5,1% per annum); and government sector (3,8% per annum).

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 tend to become relatively more concentrated in the region that 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.

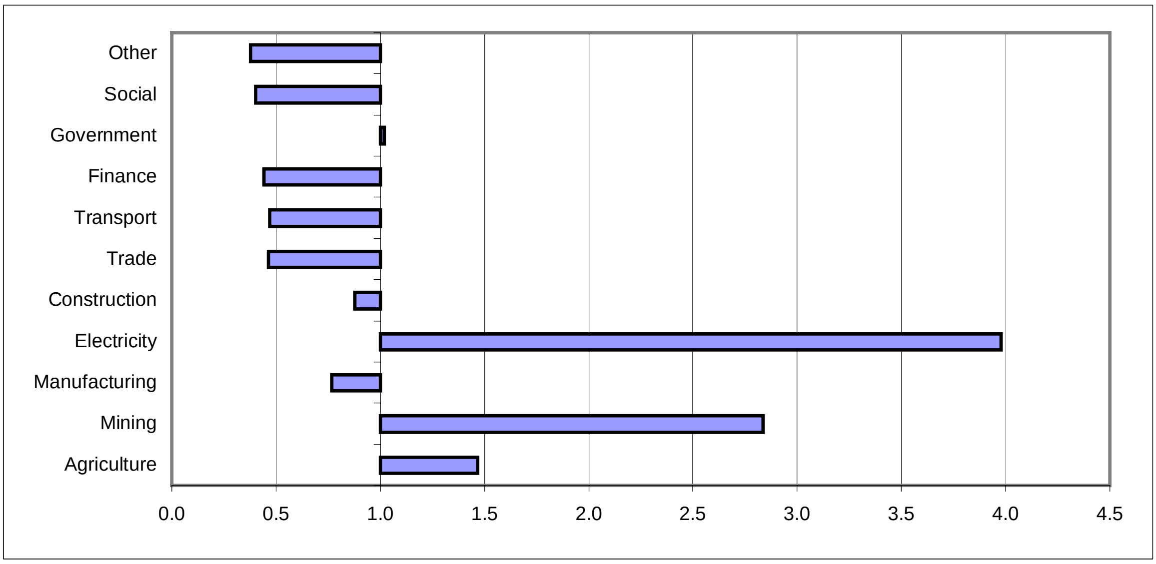
Diagram 3.3.3 shows the location quotients for Olifants WMA. The Diagram shows that, based on the location quotients for 1997, the Olifants WMA economy is relatively more competitive than the remainder of South Africa in the following economic activities:

- Electricity : 4,0
- Mining : 2,7
- Agriculture : 1,5.

The comparative advantage of the electricity sector can be attributed to the numerous power stations in especially the Highveld Region of Mpumalanga and the demand for electricity and water by the manufacturing sector.

The mining sector has a comparative advantage as a result of the nature and extent of minerals encountered in this WMA, for example coal and diamonds. Coal mining is especially important in this WMA and linkages exist with local power stations as well as with the industrial sector in Gauteng Province.

DIAGRAM 3.3.3: OLIFANTS GROSS GEOGRAPHIC PRODUCT LOCATION QUOTIENT BY SECTOR, 1997



The agricultural sector is characterised by a wide variety of products, supplying local and regional communities, as well as the export market.

3.4 LEGAL ASPECTS AND INSTITUTIONAL ARRANGEMENTS FOR WATER SUPPLY

3.4.1 Background

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 colonizing 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 whom 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 license.

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 and recharging of an aquifer are examples of activities that are already controlled activities.

All water use requires a license 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 license 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 license can be increased at each review period but not for more than the review period. This is known as the "revolving license".

If a person who has an existing lawful use applies for a license under section 43 of the NWA (compulsory licensing), and the application has been refused or has been granted for a lesser amount that 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 license 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 license;
- If a license is issued under other acts that meet the purpose of the NWA, the responsible authority can dispense with the issuing of a license 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 that 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.) is 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 WUA's 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 CMA's 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 Institutional Arrangements

A distinction is made between those institutions that are directly involved, and those that are indirectly involved. A third category is also listed and includes all those forums and committees established to facilitate and co-ordinate the execution of certain initiatives or programmes. These forums and committees do not have any official administrative task or line function and have been established to fulfill a particular task. Similarly, such forums and committees may be disbanded upon completion of such task. Apart from these line departments, there are also political structures that play a vital role.

Institutional structures directly involved. The following structures are considered to be directly involved in the provision of water and sanitation services in the Northern Province (in order of hierarchy):

National level:
- Department of Water Affairs and Forestry (DWAF);
- Department of Constitutional Development (DCD);

- Department of Finance;
- Department of Health; and

Provincial level:
- Department of Housing and Water Affairs;
- Department of Local Government and Traditional Affairs;
- Department of Public Works;
- Department of Health and Welfare;
- Office of the Premier;
- Department of Agriculture, Land and Environment;
- Agriculture and Rural Development Corporation (ARDC).

Local level:
- Northern District Council;
- Bushveld District Council;
- Highveld District Council;
- Eastvaal District Council;
- Lowveld and Escarpment District Council;
- Eastern Gauteng Services Council;
- Lepelle Northern Water Board;
- Magalies Water Board;
- The various Irrigation Boards.

Institutions indirectly involved. The following are considered to be indirectly involved in the provision of water and sanitation services in the Northern Province (in hierarchical order):

National level:
- Development Bank of Southern Africa (DBSA);

Provincial level:
- Department of Education and Training.

Forums and committees. The following forums and structures have been established to perform specific tasks relating to the provision of water and sanitation in the Northern Province (in hierarchical order):

National level:
- National Water Advisory Council;
- Advisory Committee of Safety of Dams;
- National Community Water and Sanitation Training Institution;
- Financial and Fiscal Commission (FFC); and
- The National Sanitation Task Team (NSTT).

Provincial level:
- Provincial Planning Forum;
- Provincial Liaison Committee;
- Northern Province Development Management Committee, and
- The Inter-departmental Water and Sanitation Planning Forum.

Local level:

- Northern Area Planning Forum;
- Western and Central Area Planning Forum.

Political structures. The following structures are predominantly political in their nature and are also involved in the provision of water and sanitation services, albeit indirectly: (in hierarchical order):

National level:

- National Council of Provinces; and
- South African Local Government Association (SALGA).

Provincial level:

- Northern Province Legislature (with portfolio committees);
- Northern Province Cabinet;
- EXECO: Infrastructure; and
- The Northern Province Local Government Association (NPLGA).

Local level:

- The various Transitional Local Councils (particularly their "Water Desks").

Tasks and responsibilities. This sub-paragraph presents some perspective on the tasks and responsibilities of those structures that are directly involved. This perspective is presented as follows:

Table 3.4.9.1: Existing structures.
Table 3.4.9.2: Existing forums and committees (only those on provincial and local levels).

Figures included are:
Figure 3.4.9.1: District councils and magisterial districts.
Figure 3.4.9.2: Institutional boundaries related to water supply.

TABLE 3.4.9.1: TASKS AND RESPONSIBILITIES OF EXISTING STRUCTURES

Name	Tasks
National level	
DWAF (national and provincial)	Custodian of national water resources.
Department of Constitutional Development (DCD)	Financier of CMIP and BCIG.
Department of Health	Set national standards and priorities (also policy framework).
Department of Finance	Lead and facilitate Financial and Fiscal Commission (FFC) in its work concerning inter-governmental transfers.
Development Bank of Southern Africa (DBSA)	A possible source to finance bulk and reticulation projects.
Provincial level	
Department of Local Government and Traditional Affairs	Administers the CMIP.
Department of Housing and Water Affairs	Administers the BCIG.
Department of Agriculture, Land and Environment	Planning of agricultural projects and schemes, such as intensive irrigation schemes. Conservation of the natural resource base.
Agriculture and Rural Development Corporation (ARDC)	Detail design, implementation and operation of agricultural projects and schemes (i.e. the ARDC can be considered the "implementation arm" of the Department of Agriculture, Land and Environment in the Northern Province).

Name	Tasks
Office of the Premier	Coordinator of all programmes.
Department of Health and Welfare	Procure the provision of water and sanitation services to health facilities. Implement the VIP toilet construction programme.
Department of Public Works	Project manager of the Public Works Programme, School Building Programme and the Clinic Building Programme.
Local level	
Water Boards: ▪ Lepelle Northern Water Board ▪ Magalies Water Board	Plan, implement, operate and maintain bulk water schemes. In extraordinary cases, a water board may also act as a water services authority.
District Councils: ▪ Northern District Council ▪ Bushveld District Council ▪ Highveld District Council	In accordance with the provision of the Provincial Gazette Extraordinary, 31 July 1995 (No. 73), a district council is considered a local government in terms of the Local Government Ordinance (1939) and a TLC in terms of section 16 of the Local government Transition Act (No. 209 of 1993). As such, the district council has to provide services to a TLC falling in its area of jurisdiction until such time that a TLC has demonstrated that it has sufficient capacity to provide such services itself.
Mvula Trust	Finance and implement certain of the water and sanitation projects
The irrigation boards	In terms of the provisions of Section 89 of the Water Act (No 54 of 1956), the Minister may assign a number of functions, powers and duties to an irrigation board. (The existing irrigation boards will have to restructure themselves into water services authorities by drafting and adopting a Constitution, which has to be proved by the Minister).

TABLE 3.4.9.2: FORUMS AND STRUCTURES (Provincial and local levels)

Name	Composition	Function
Provincial level		
Provincial Planning Forum	▪ DWAF ▪ Relevant line departments of provincial government ▪ Consultants	To report progress on and discuss all matter relating to CWSS.
Northern Province Development Management Committee	All line departments of provincial government	To coordinate all development projects planned by government, parastatal organizations and community based organizations (also refer to paragraph 1.5.4 of the CWSS Strategic Study Report – p. 34).
Inter-department Development Management Committee	▪ DWAF ▪ All line departments of provincial government ▪ Consultants involved in the CWSS ▪ NGO's and parastatal water services institutions	To coordinate all development projects planned by government, parastatal organizations and community based organizations (also refer paragraph 1.5.4 of the CWSS Strategic Study Report - p. 34).
Provincial Liaison Committee	All line departments of provincial government	To discuss all matter relating to water supply and sanitation. For this purpose, the structure comprise three sub-committees namely: ▪ Water quality planning forum; ▪ Agriculture action committee; and ▪ Disaster committee. (Refer to paragraph 1.5.4 of the CWSS Strategic Study Report – p. 35).

Name	Composition	Function
Local level		
Area Planning Form: ▪ Central, Western and Bushveld Districts ▪ Northern District	▪ TLC's ▪ Consultants ▪ Community representatives ▪ Other (e.g. Mvula, Metsico, etc)	To discuss progress made with CWSS and to assess needs and requirements relating to water and sanitation.
Water Committee(s)	Depends on local circumstances and project(s).	Act as discussion forum for particular project(s).
Reservoir Committees (where they have been established)	Depends on local circumstances.	To act as platform for the communities served by a particular reservoir and other role-players such as the TLC.

Local Government structures include:

Transitional Local Councils:
Breyten
Kriel
Hendrina
Witbank
Middelburg
Delmas
KwaMhlanga
Mkobola
Moutse 3
Mdutjana
Mathanjana
Moutse 1
Belfast
Lydenburg
Steelpoort
Greater Phalaborwa

Transitional Regional Councils:
Highveld Ridge
Bethal
Delmas
Witbank
Middelburg
Belfast
Groblersdal
Hlogotlou/Lepelle
Lydenburg
Pilgrim's Rest
Ngwaritsi/Makhudu-Thamaga
Eastern Tubatse/Ohrigstad
Hoedspruit/Makhutswi
Letsitele/Gravelotte
Noko-Tlou/Fetakgomo
Dilokong
Greater Lebowakgomo
Zebediela
Mankweng
Maraba-Mashashane/Maja
Naboomspruit/Roedtan-Thusang

Middle Lepelle
Nebo North

Following are lists of irrigation districts, government water control areas and government water schemes in the Olifants WMA. It should be noted that, in terms of the National Water Act, No. 36 of 1998, irrigation boards will be superseded by water user associations.

Irrigation Districts	Gouwsberg	–	Wilge River
	Selons River	–	Selons River
	Hereford	–	Olifants River
	Olifants River	–	Olifants River
	Bloempoort	–	Moses River
	Trans-Elands	–	Elands River
	Laersdrift	–	Laersdriftspruit
	Dwars River	–	Groot Dwars River
	Central Steelpoort	–	Steelpoort River
	Spekboom	–	Spekboom River
	Lower Spekboom	–	Spekboom River
	Ohrigstad	–	Ohrigstad River
	Kaspersnek	–	Vyehoek River
	Blyde	–	Blyde River
	Klaserie	–	Klaserie River
	Waterval	–	Waterval River
	Selati	–	Selati River

Government Water Control Areas	Blyde River
	Klaserie River
	Loskop
	Loskop Dam Catchment
	Mapochs
	Ohrigstad River
	Olifants River (Lowveld)
	Olifants River (Phalaborwa)
	Rooikraal
	Rust de Winter
	Sekhukhuneland (Olifants River)
	Vyehoeksloop
	Waterval River
Government Water Schemes	Loskop
	Rooikraal
	Rust de Winter
	Mapochs
	Waterval River
	Ohrigstad
	Klaserie
	Blyde River
Water Boards	Magalies Water
	Lepelle Northern Water

3.5 LAND USE

3.5.1 Introduction

The limited extent of the water resources has given rise to intense competition between the ever growing water use sectors and thus land use sectors, such as agricultural, industry, domestic and nature. Figure 3.5.1.1 and Table 3.5.1.1 shows the extent and total area of land use in the Olifants WMA.

Agriculture is a major land use sector in the WMA with irrigation land covering some 800 km^2 and dryland about 8 160 km^2. (Table 3.5.3.1). Large parts of the WMA are being used for game and stock farming. The whole area was fully stocked or over stocked but as a result of the drought in recent years numbers have decreased.

There are a few forestry plantations covering about 400 km^2 and the indigenous forests cover only about 140 km^2.

The Lower Olifants River catchment contains a section of the Kruger National Park. Timbavati Game Reserve is famous for its lion breeding and the Blyde River Canyon Nature Reserve is famous for its scenery and hiking trails. Several “Habitat and Wildlife Management Areas” also exist through the WMA.

Major industries are mainly situated within the urban areas. A variety of minerals and non-metallic deposits are mined in the Olifants WMA, with a concentration of mining activities in the Upper Olifants River catchment.

Alien vegetation covers a area of about 2 000 km^2 in the WMA. The reduction of these areas can increase the runoff available to the catchment.

TABLE 3.5.1.1 : LAND USE BY DRAINAGE AREAS IN km^2

Catchment						Irrigation	Dryland sugar cane	Other dryland crops	Afforestation	Nature reserves*	Urban	Other **
Primary		Secondary		Tertiary								
No	Description	No	Description	No	Description							
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	17.4	0.0	545.5	0.0	0	12.9	827.2
					Olifants at Rietspruit	3.6	0.0	592.3	0.0	0	6.3	777.8
					Witbank Dam	2.1	0.0	226.2	0.0	0	20.2	547.5
					Olifants at Klein Olifants	12.0	0.0	104.8	1,27	0	17.5	379.5
					Olifants at Wilge	7.2	0.0	70.4	0.0	0	26.1	516.3
				B12	Middelburg Dam	10.9	0.0	662.5	11,05	0	10.6	897.9
					Klein Olifants at Olifants	3.6	0.0	257.0	26,83	27	30.0	453.3
			Sub total			**56.9**	**0.0**	**2458.7**	**39,15**	**27**	**123.7**	**4399.3**
		B2	Wilge	B20	Bronkhorstspruit Dam	7.9	0.0	635.5	0.0	14	7.6	594.9
					Wilge at Olifants	40.0	0.0	1101.1	0,17	0	33.7	1921.0
			Sub total			**47.9**	**0.0**	**1736.6**	**0,17**	**14**	**41.3**	**2515.9**
		B3	Elands	B31	Rust de Winter Dam	8.7	0.0	162.2	0.0	15	9.4	950.2
					Renosterkop Dam	88.9	0.0	800.4	0.0	154	130.1	1404.4
					Elands at Olifants	9.8	0.0	497.2	0.0	7	100.9	1810.6
			Olifants - Loskop Reach	B32	Loskop Dam	16.9	0.0	114.9	0.0	122	0.5	546.4
					Olifants at Bloed	70.1	0.0	169.2	5,85	11	3.0	1178.9
					Bloed at Olifants	11.2	0.0	19.8	0.0	85	11.9	741.9
					Olifants at Elands	120.4	0.0	81.0	0.0	15	119.4	1649.5
			Sub total			**325.9**	**0.0**	**1844.7**	**5.9**	**408**	**375.1**	**8282.0**
		B4	Steelpoort	B41	Steelpoort Klip	8.3	0.0	333.7	48,52	44	6.9	1102.0
					Steynsdrift Dam Proposal	22.0	0.0	79.5	0.0	0	5.7	597.8
					Steelpoort at Spekboom	31.3	0.0	39.1	0,43	40	30.2	2019.3
					Steelpoort at Olifants	1.4	0.0	0.0	0.0	121	15.5	496.8
				B42	Spekboom at Steelpoort	31.4	0.0	153.3	25,59	219	14.4	1649.6
			Sub total			**94.3**	**0.0**	**605.6**	**74,5**	**423**	**72.8**	**5865.4**
		B5	Middle Olifants	B51	Arabie Dam	5.9	0.0	5.0	0.0	74	47.2	769.6
					Olifants at Lepelane	98.7	0.0	1443.8	0.0	106	157.6	4027.7
				B52	Olifats at Bewaarskloof	6.9	0.0	14.3	13,07	171	112.8	2673.5
			Sub total			**111.5**	**0.0**	**1463.1**	**13,07**	**352**	**317.6**	**7470.7**
		B6	Blyde	B60	Blyde at Blyde Dam	3.2	0.0	10.9	201,4	319	7.4	308.6
					Ohrigstad River	35.7	0.0	23.7	19,96	104	1.6	1131.5
					Blyde at Olifants	24.2	0.0	4.8	0.0	86	0.5	561.0
			Sub total			**63.0**	**0.0**	**39.4**	**221,36**	**508**	**9.5**	**2001.1**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	8.8	0.0	0.0	2,96	117	1.1	441.8
					Strijdom Tunnel Proposal	10.9	0.0	0.0	11,16	214	8.8	1813.6
					Olifants at Blyde	13.1	0.0	0.0	0.0	8	0.0	386.9
				B72	Olifants at Selati	8.4	0.0	0.0	0.0	614	1.5	1500.1
					Selati at Olifants	35.3	0.0	8.0	0.0	118	47.4	2130.8
				B73	Olifants at Letaba	7.1	0.0	0.0	26,79	3931	36.9	395.5
					Olifants at Mozambique	0.0	0.0	0.0	0.0	255	0.0	0.0
			Sub total			**83.6**	**0.0**	**8.0**	**40,9**	**5257**	**95.7**	**6668.8**
Total in Gauteng						**36.5**	**0.0**	**868.8**	**0.1**	**32**	**39.1**	**1770.9**
Total in Mpumalanga						**463.8**	**0.0**	**5254.1**	**347.8**	**2712**	**479.7**	**18411.4**
Total in Northern Province						**282.8**	**0.0**	**2033.1**	**47.1**	**4246**	**516.9**	**17021.0**
Total WMA						**783.0**	**0.0**	**8156.1**	**395.0**	**6990**	**1035.7**	**37203.2**

* Includes National Parks, wilderness areas, etc.

** Includes all other areas. Thus the total area in the table should equal the total drainage area.

TABLE 3.5.1.2: LAND USE BY PROVINCE AND DISTRICT COUNCIL AREA

Type of land use	Areas in Northern Province			Areas in Gauteng		Areas in Mpumalanga				Total Area (km^2)
	Northern District Council (km^2)	Bushveld District Council (km^2)	Total area (km^2)	Eastern Gauteng Services Council (km^2)	Total Area (km^2)	Eastvaal District Council (km^2)	Highveld District Council (km^2)	Lowveld and Escarpment District Council (km^2)	Total Area (km^2)	
Irrigation	192,6	91,7	284,3	33,3	33,3	32,0	341,0	92,6	465,6	783,0
Dryland sugar cane	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other dryland crops	842,2	1 212,9	2 055,1	870,1	870,1	1 552,4	3 458,1	220,5	5 231,0	8 156,1
Afforestation	46,6	0,0	46,6	0,1	0,1	0,7	92,9	254,7	348,3	395,0
Nature reserves*	4 139,8	136,1	4 275,9	26,8	26,8	9,4	383,3	2 294,5	2 687,2	6 989,9
Urban areas	354,0	168,6	522,6	34,2	34,2	27,9	393,2	57,8	478,9	1 035,7
Other**	13 786,2	3 307,6	17 093,8	1 779,7	1 779,7	2 070,5	11 729,0	4 530,2	18 329,7	37 203,2
TOTAL	19 361,4	4 916,9	24 278,3	2 744,2	2 744,2	3 692,9	16 397,5	7 450,3	27 540,7	54 563

* Includes National Parks, wilderness areas, etc.
** Includes all other areas. Thus the total area in the table equals the total drainage areas.

3.5.2 Irrigation

The total irrigated crop areas for each sub-catchment are shown in Table 3.5.2.1. The total irrigated crop areas include the perennial crop area (eg. Citrus orchards, banana plantations) and fields which are planted more than once a year. Therefore the total irrigation area is more than the area identified as irrigated land, shown in tables 3.5.1.1 and 3.5.1.2. The extent of the existing irrigation is shown in Figure 3.5.1.1. The irrigated area has been accepted as the maximum of the mid-summer crop area and the mid-winter crop area. Considering the given full range of crops being irrigated, mid-summer has been defined as January/February while mid-winter was defined as July/August. This will account for double cropping, where appropriate.

The available information on irrigation methods only stipulates the dominant irrigation method per sub-catchment. The irrigation methods used for a specific crop type however do not vary significantly between different catchments. The most common methods used are flood irrigation, sprinkler systems, centre pivot systems, micro systems and drip systems (DWAF, 1991).

It is generally recognized that future growth in irrigation will be severely limited by the availability of water. 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 generalized, it is suggested that only three income categories of irrigated crops be used for the purpose of this study. These 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 3.5.2.2: ASSURANCE CATEGORIES FOR IRRIGATED CROPS

Category	Crop Examples
Low	Maize, wheat, dry bean, groundnut, lucerne and pasture (small stock). Includes double cropping.
Medium	Vegetables, potatoes, tobacco, cotton, lucerne and pasture for dairying and ostrich. Includes double cropping.
High	Citrus, deciduous fruit and nuts, dates and speciality vegetables.

The above categories include for double cropping of the different crop types where appropriate.

The information on crop areas and methods was obtained mainly from the DWAF, 1991 Basin study.

3.5.3 Dryland Agriculture

Dryland cultivation of sugar cane is considered by DWAF to be a potential streamflow reduction activity. With the exception of afforestation, other forms of dryland farming are not considered to significantly reduce streamflow.

Except for sugarcane, the water use of all the other dry land crops produced in South Africa are considered to be adequately accounted for in the surface water runoff used to estimate the water resources. Because of the considerable annual variation in dry land cultivation (due to climatic conditions) reliable dry land data are also not always readily available. According to preliminary investigation, dry land sugarcane is the most significant dry land crop affecting runoff, and therefore it was included in this study. For completeness, total areas of dry land cultivation were obtained from the CSIR Landcover Spacemaps (CSIR, 1999) and the areas of dry land sugarcane were subtracted from these to obtain the areas of other dry land crops shown in Table 3.5.3.1. These values serve only to give an indication of the total areas of dry land cultivation and are not necessarily accurate.

No significant dry land sugarcane is being produced in the WMA. Other dryland crops are cultivated on significant areas in the following catchments (CSIR, 1999):

- Upper Olifants River Catchment
- Wilge River Catchment
- Steelpoort River Catchment
- The northwestern part of the Elands River Catchment
- The southwestern part and southeastern part of the Middle Olifants River Catchment.

TABLE 3.5.2.1 : IRRIGATION LAND USE

Catchment						Irrigation area by crop category (km^2)				
Primary		Secondary		Tertiary						
No	Description	No	Description	No	Description	Perennial	Summer	Winter	Undifferentiated	Total
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	2,65	2,42	1,63	12,35	17,42
					Olifants at Rietspruit	2,52	0,53	0,08	0,68	3,73
					Witbank Dam	0,69	0,36	0,16	1,33	2,38
					Olifants at Klein Olifants	3,00	2,25	0,75	9,00	14,25
					Olifants at Wilge	1,80	1,35	0,45	5,40	8,55
				B12	Middelburg Dam	6,41	1,26	0,37	4,17	11,84
					Klein Olifants at Olifants	2,14	0,41	0,21	1,24	3,79
			Sub total			**19,21**	**8,58**	**3,65**	**34,17**	**61,96**
		B2	Wilge	B20	Bronkhorstspruit Dam	0,37	1,95	0,47	5,03	7,35
					Wilge at Olifants	4,86	22,05	0,95	20,21	47,12
			Sub total			**5,23**	**24,00**	**1,42**	**25,24**	**54,47**
		B3	Elands	B31	Rust de Winter Dam	2,28	3,88	4,99	1,52	8,79
					Renosterkop Dam	25,87	23,71	2,74	59,85	109,43
					Elands at Olifants	0,00	0,00	0,00	0,00	0
			Olifants - Loskop Reach	B32	Loskop Dam	5,16	15,54	2,81	6,48	27,18
					Olifants at Bloed	27,34	15,14	12,34	75,04	117,52
					Bloed at Olifants	1,08	5,69	0,27	8,45	15,22
					Olifants at Elands	48,99	38,57	15,65	97,24	184,8
			Sub total			**110,72**	**102,53**	**38,80**	**248,58**	**462,94**
		B4	Steelpoort	B41	Steelpoort tot Klip	0,55	5,27	1,92	3,17	8,99
					Steynsdrift Dam Proposal	1,11	9,88	3,83	12,43	23,42
					Steelpoort at Spekboom	3,37	11,95	8,61	20,45	35,77
					Steelpoort at Olifants	0,19	0,48	0,44	0,94	1,61
				B42	Spekboom at Steelpoort	4,94	6,42	4,73	30,38	41,74
			Sub total			**10,16**	**34,00**	**19,53**	**67,37**	**111,53**
		B5	Middle Olifants	B51	Arabie Dam	2,87	2,13	0,00	1,67	6,67
					Olifants at Lepelane	31,36	56,62	26,65	26,09	114,07
				B52	Olifants at Bewaarkloof	0,08	0,08	1,90	9,06	11,04
			Sub total			**34,31**	**58,83**	**28,55**	**36,82**	**131,78**
		B6	Blyde	B60	Blyde at Blydedam	2,26	2,33	0,14	0,92	5,51
					Ohrigstad River	8,62	14,49	6,77	18,54	41,65
					Blyde at Olifants	3,02	4,36	4,70	16,78	24,5
			Sub total			**13,90**	**21,18**	**11,61**	**36,24**	**71,66**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,06	0,58	4,04	4,66	8,76
					Strijdom Tunnel Proposal	0,06	0,74	3,84	7,03	10,93
					Olifants at Blyde	0,07	0,89	4,61	8,44	13,12
				B72	Olifants at Selati	2,69	3,78	0,00	1,93	8,4
					Selati at Olifants	8,36	6,56	9,57	15,02	32,95
				B73	Olifants at Letaba	2,48	2,67	1,15	3,05	8,2
					Olifants at Mozambique	0,00	0,00	0,00	0,00	0
			Sub total			**13,72**	**15,22**	**23,21**	**40,13**	**82,36**
Total in Gauteng						**7,18**	**15,39**	**4,16**	**19,23**	**42,5**
Total in Mpumalanga						**132,73**	**151,95**	**60,59**	**333,74**	**618,8**
Total in Northern Province						**67,34**	**97,00**	**62,02**	**135,58**	**315,4**
Total in WMA						**207,25**	**264,34**	**126,77**	**488,55**	**976,70**

TABLE 3.5.3.1: AREAS OF DRYLAND CROPS

Catchment						Dryland crops (km²)
Primary		Secondary		Tertiary		
No	Description	No	Description	No	Description	
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	545,5
					Olifants at Rietspruit	592,3
					Witbank Dam	226,2
					Olifants at Klein Olifants	104,8
					Olifants at Wilge	70,4
				B12	Middelburg Dam	662,5
					Klein Olifants at Olifants	257,0
			Sub total			**2 458,7**
		B2	Wilge	B20	Bronkhorstspruit Dam	635,5
					Wilge at Olifants	1 101,1
			Sub total			**1 736,6**
		B3	Elands	B31	Rust de Winter Dam	162,2
					Renosterkop Dam	800,4
					Elands at Olifants	497,2
			Olifants - Loskop Reach	B32	Loskop Dam	114,9
					Olifants at Bloed	169,2
					Bloed at Olifants	19,8
					Olifants at Elands	81,0
			Sub total			**1 844,7**
		B4	Steelpoort	B41	Steelpoort at Klip	333,7
					Steynsdrift Dam Proposal	79,5
					Steelpoort at Spekboom	39,1
					Steelpoort at Olifants	0,0
				B42	Spekboom at Steelpoort	153,3
			Sub total			**605,6**
		B5	Middle Olifants	B51	Arabie Dam	5,0
					Olifants at Lepelane	1 443,8
				B52	Olifants at Bewaarkloof	14,3
			Sub total			**1 463,1**
		B6	Blyde	B60	Blyde at Blyde Dam	10,9
					Ohrigstad River	23,7
					Blyde at Olifants	4,8
			Sub total			**39,4**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,0
					Strijdom Tunnel Proposal	0,0
					Olifants at Blyde	0,0
				B72	Olifants at Selati	0,0
					Selati at Olifants	8,0
				B73	Olifants at Letaba	0,0
					Olifants at Mozambique	0,0
			Sub total			**8,0**
Total in Gauteng						**868,8**
Total in Mpumalanga						**5 254,1**
Total in Northern Province						**2 033,1**
Total WMA						**8 156,1**

3.5.4 Livestock and Game Farming

Cattle are the most popular form of livestock in the Olifants WMA and are mainly reared for meat. Five commercial feedlots are located in the Upper Olifants River catchment and Wilge River catchment (DWAF, 1997). Sheep are also kept in considerable numbers, especially in the Upper Olifants catchment and the Steelpoort River catchment (DWAF, 1991). Goats are kept in relatively small numbers and the largest numbers are kept in the Elands River catchment.

Game is farmed for hunting and meat production and this type of farming has gained popularity in recent years. The main game types are Impala, Kudu, Water Buck, Gemsbok and Rhino. The eastern catchments are more popular for game farming, as they are drier and less suitable for cattle. The Klaserie, Umbabat, Timbavati, and Thorny Bush are privately owned Game Reserves located adjacent to the Kruger National Park.

Table 3.5.4.1 gives the numbers ELSU per tertiary catchment. A map depicting the extent of the existing livestock and game is shown in Figure 3.5.4.1.

3.5.5 Afforestation and Indigenous Forest

The largest commercial forestry plantations in the Olifants WMA can be found in the Blyde River catchment, covering an area of about 221,40 km². Other catchments with significant areas of afforestation are:

- Steelpoort River - 74,5 km²
- Lower Olifants River - 40,9 km²
- Upper Olifants River - 39,2 km²

The remaining catchments contain a total of approximately 6 km² exotic forest and no further development is expected in any of these areas.

The main types of trees are pine and eucalyptus, with eucalyptus the dominant species in the Upper Olifants Area and the rest of the Olifants WMA having afforested areas of mainly pine trees.

There is a total area of about 1 399 km² indigenous forest in the Blyde River catchment and the Lower Olifants River catchment. The largest area (about 912 km²) is found in the Lower Olifants River catchment. No significant indigenous forest occurs in the rest of the Olifants WMA. It should be noted that the effect of indigenous forest on runoff is regarded as natural.

Table 3.5.5.1 gives areas of afforestation and indigenous forest per tertiary catchment. A map depicting the extent of these areas are shown in Figure 3.5.1.1.

TABLE 3.5.4.1: LIVESTOCK AND GAME

Catchment						No of ELSU
Primary		Secondary		Tertiary		
No	Description	No	Description	No	Description	
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	2 781
					Olifants at Rietspruit	13 670
					Witbank Dam	3 751
					Olifants at Klein Olifants	10 940
					Olifants at Wilge	158
				B12	Middelburg Dam	48 850
					Klein Olifants at Olifants	21 710
			Sub total			**101 860**
		B2	Wilge	B20	Bronkhorstspruit Dam	27 050
					Wilge at Olifants	40 640
			Sub total			**67 690**
		B3	Elands	B31	Rust de Winter Dam	12 250
					Renosterkop Dam	4 375
					Elands at Olifants	1 555
			Olifants - Loskop Reach	B32	Loskop Dam	10 940
					Olifants at Bloed	31 040
					Bloed at Olifants	12 950
					Olifants at Elands	6 856
			Sub total			**79 966**
		B4	Steelpoort	B41	Steelpoort at Klip	18 090
					Steynsdrift Dam Proposal	7 237
					Steelpoort at Spekboom	8 494
					Steelpoort at Olifants	0
				B42	Spekboom at Steelpoort	20 380
			Sub total			**54 201**
		B5	Middle Olifants	B51	Arabie Dam	0
					Olifants at Lepelane	0
				B52	Olifants at Bewaarkloof	0
			Sub total			**0**
		B6	Blyde	B60	Blyde at Blyde Dam	0
					Ohrigstad River	4 034
					Blyde at Olifants	2 268
			Sub total			**6 302**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	965
					Strijdom Tunnel Proposal	1 654
					Olifants at Blyde	5 440
				B72	Olifants at Selati	5 751
					Selati at Olifants	8 263
				B73	Olifants at Letaba	4 914
					Olifants at Mozambique	0
			Sub total			**26 987**
Total in Gauteng						**34 320**
Total in Mpumalanga						**265 911**
Total in Northern Province						**36 775**
Total WMA						**337 006**

* Game numbers could not be obtained and stock number in former homeland areas not readily available for all areas.

TABLE 3.5.5.1: AREAS OF AFFORESTATION AND INDIGENOUS FOREST

Catchment						Areas of afforestation				Areas of indigenous forest (km^2)
Primary		Secondary		Tertiary		Eucalyptus (km^2)	Pine (km^2)	Wattle (km^2)	Total (km^2)	
No	Description	No	Description	No	Description					
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	0,0	0,0	0,0	0,0	0,0
					Olifants at Rietspruit	0,0	0,0	0,0	0,0	0,0
					Witbank Dam	0,0	0,0	0,0	0,0	0,0
					Olifants at Klein Olifants	1,3	0,0	0,0	1,3	0,0
					Olifants at Wilge	0,0	0,0	0,0	0,0	0,0
				B12	Middelburg Dam	9,6	1,5	0,0	11,1	0,0
					Klein Olifants at Olifants	20,1	5,3	1,3	26,8	0,0
			Sub total			**31,0**	**6,8**	**1,3**	**39,2**	**0,0**
		B2	Wilge	B20	Bronkhorstspruit Dam	0,0	0,0	0,0	0,0	0,0
					Wilge at Olifants	0,2	0,0	0,0	0,2	0,0
			Sub total			**0,2**	**0,0**	**0,0**	**0,2**	**0,0**
		B3	Elands	B31	Rust de Winter Dam	0,0	0,0	0,0	0,0	0,0
					Renosterkop Dam	0,0	0,0	0,0	0,0	0,0
					Elands at Olifants	0,0	0,0	0,0	0,0	0,0
			Olifants - Loskop Reach	B32	Loskop Dam	0,0	0,0	0,0	0,0	0,0
					Olifants at Bloed	5,7	0,2	0,0	5,8	0,0
					Bloed at Olifants	0,0	0,0	0,0	0,0	0,0
					Olifants at Elands	0,0	0,0	0,0	0,0	0,0
			Sub total			**5,7**	**0,2**	**0,0**	**5,8**	**0,0**
		B4	Steelpoort	B41	Steelpoort at Klip	2,2	46,3	0,0	48,5	0,0
					Steynsdrift Dam Proposal	0,0	0,0	0,0	0,0	0,0
					Steelpoort at Spekboom	0,0	0,4	0,0	0,4	0,0
					Steelpoort at Olifants	0,0	0,0	0,0	0,0	0,0
				B42	Spekboom at Steelpoort	0,7	24,9	0,0	25,6	0,0
			Sub total			**3,0**	**71,6**	**0,0**	**74,5**	**0,0**
		B5	Middle Olifants	B51	Arabie Dam	0,0	0,0	0,0	0,0	0,0
					Olifants at Lepelane	0,0	0,0	0,0	0,0	0,0
				B52	Olifants at Bewaarkloof	0,5	12,6	0,0	13,1	0,0
			Sub total			**0,5**	**12,6**	**0,0**	**13,1**	**0,0**
		B6	Blyde	B60	Blyde at Blyde Dam	1,5	199,9	0,0	201,4	31,9
					Ohrigstad River	0,8	19,2	0,0	20,0	6,3
					Blyde at Olifants	0,0	0,0	0,0	0,0	10,5
			Sub total			**2,3**	**219,1**	**0,0**	**221,4**	**48,8**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,0	3,0	0,0	3,0	0,0
					Strijdom Tunnel Proposal	0,0	11,2	0,0	11,2	13,7
					Olifants at Blyde	0,0	0,0	0,0	0,0	10,0
				B72	Olifants at Selati	0,0	0,0	0,0	0,0	21,3
					Selati at Olifants	0,0	0,0	0,0	0,0	13,7
				B73	Olifants at Letaba	4,7	22,1	0,0	26,8	32,5
					Olifants at Mozambique	0,0	0,0	0,0	0,0	0,0
			Sub total			**4,7**	**36,2**	**0,0**	**40,9**	**91,2**
Total in Gauteng						**0,1**	**0,0**	**0,0**	**0,1**	**0,0**
Total in Mpumalanga						**43,6**	**302,9**	**1,3**	**347,8**	**50,1**
Total in Northern Province						**3,6**	**43,5**	**0,0**	**47,2**	**89,8**
Total WMA						**47,4**	**346,4**	**1,3**	**395,1**	**139,9**

3.5.6 Alien Vegetation

The impacts of the widespread infestations by alien plants in South Africa are increasingly recognized. The total incremental water use of invading alien plants was estimated at 3 300 million m^3/a by Le Matre et al. (1999) but this estimate is not widely recognized 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 Matre et al. (1999) estimate that the impact will increase significantly in the next five to ten years, resulting in the loss of much, or possibly even all, of the available water in certain catchment areas. Again, this is a debatable point requiring more research to verify these statements.

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

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

Alien vegetation infestations across South Africa were mapped under supervision of a CSIR (Environmentek) team using a “best expert knowledge” approach, supplemented by existing detailed localized 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 standardize the approach and terminology and to ensure consistency and comparability in the inputs made by the wide range of people involved.

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

The following shortcomings and limitations of the CSIR database on alien vegetation infestation have been highlighted by DWAF (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 20 m.

- 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.

Areas of infestation by alien vegetation are shown in Table 3.5.6.1.

3.5.7 Urban Areas

Urban areas are located throughout the study area and include residents in major and small towns as well as settlements and villages. The extent of the urban areas is shown in Figure 3.5.1.1. Major urban areas include Witbank, Middelburg, Lydenburg, Belfast and Phalaborwa. Quasi-urban concentrations are also found near mines.

Large numbers of people are settled in the rural areas of the WMA, especially in the former Lebowa homeland area.

TABLE 3.5.6.1: INFESTATION BY ALIEN VEGETATION

Catchment						Condensed area (km²)
Primary		Secondary		Tertiary		
No	Description	No	Description	No	Description	
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	0,0
					Olifants at Rietspruit	0,0
					Witbank Dam	0,0
					Olifants at Klein Olifants	0,6
					Olifants at Wilge	0,3
				B12	Middelburg Dam	0,4
					Klein Olifants at Olifants	0,5
			Sub total			**1,8**
		B2	Wilge	B20	Bronkhorstspruit Dam	6,4
					Wilge at Olifants	16,8
			Sub total			**23,2**
		B3	Elands	B31	Rust de Winter Dam	4,0
					Renosterkop Dam	73,5
					Elands at Olifants	178,2
			Olifants - Loskop Reach	B32	Loskop Dam	0,4
					Olifants at Bloed	1,2
					Bloed at Olifants	8,9
					Olifants at Elands	3,9
			Sub total			**270,1**
		B4	Steelpoort	B41	Steelpoort at Klip	1,4
					Steynsdrift Dam Proposal	4,1
					Steelpoort at Spekboom	57,4
					Steelpoort at Olifants	78,0
				B42	Spekboom at Steelpoort	153,0
			Sub total			**293,8**
		B5	Middle Olifants	B51	Arabie Dam	21,3
					Olifants at Lepelane	656,8
				B52	Olifants at Bewaarkloof	193,8
			Sub total			**871,9**
		B6	Blyde	B60	Blyde at Blyde Dam	125,8
					Ohrigstad River	174,8
					Blyde at Olifants	8,7
			Sub total			**309,3**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	29,2
					Strijdom Tunnel Proposal	133,0
					Olifants at Blyde	21,4
				B72	Olifants at Selati	0,7
					Selati at Olifants	5,0
				B73	Olifants at Letaba	29,0
					Olifants at Mozambique	0,0
			Sub total			**218,2**
Total in Gauteng						**20,6**
Total in Mpumalanga						**694,3**
Total in Northern Province						**1273,4**
Total WMA						**1988,3**

3.6 MAJOR INDUSTRIES AND POWER STATIONS

The main industrial activities in the Olifants WMA are concentrated in the Upper Olifants River catchment. Witbank, Middelburg, Bronkhorstspruit and Ekandustria contain the fastest developing industrial areas (BKS et al, 1997). Phalaborwa in the Lower Olifants River catchment is also a major industrial centre with industries like Fedmis.

Industries in Witbank include:

- Polifin
- Samcor Ferrometals
- Landau
- Transalloys
- Vantra
- Highveld Steel and Vanadium
- Witbank Abattoir

Industries in Middelburg include:

- Colombus Steel
- Middelburg Ferrochrome
- Kanhym Feedlot

Delmas has an I & J which is supplied with water from boreholes.

Some industries in the Ekangala area (Ekandustria) near Bronkhorstspruit derived their advantage from the decentralisation incentives offered by the previous government.

The power stations and Highveld Steel as an industry are shown in Figure 3.5.1.1. The GIS coverage do not show the other industries. There are seven power stations in the Olifants WMA. Table 3.6.1 gives more detail on the power stations.

TABLE 3.6.1: POWER STATIONS IN THE OLIFANTS WMA

Quaternary catchment	Name	Type	Generating capacity (MW)	Owner
B12C	Arnot	Coal	1980	Eskom
B11G	Duvha	Coal	3450	Eskom
B12A	Hendrina	Coal	1900	Eskom
B20E	Kendal	Coal	3840	Eskom
B11E	Kriel	Coal	2850	Eskom
B11D	Matla	Coal	3450	Eskom
B11B	Komati *	Coal	891	Eskom
B20C	Wilge **			Eskom

* Power station has been mothballed
** Power station has been decommissioned and is used for training only

Hydro power stations are described in greater detail in Section 4.4.

3.7 MINES

3.7.1 Introduction

Mining operations in South Africa encompass a wide range of activities, which include the dressing, and benefaction of naturally occurring minerals, whether in solid, liquid or gaseous form to render the material marketable or to enhance the market value of the material mining operation include underground and surface mines, quarries and the operation of oil and gas wells.

Products of the mining industry in the Olifants Water Management Area (WMA) include coal, fluorspar, lime, sand, clay, brick, stone, granite, magnesite, mica, copper, emeralds, phosphate, andalusite, tin, gold, iron ore, felsite, asbestos, chrome, vanadium and platinum. Mines that have an impact on the hydrology and water quality of the river systems and mines that impact significantly on the economy of a region or town are shown in Figure 3.7.1. In Appendix D a list of mines, obtained from the Council of Geoscience, is shown.

For summarising mining impacts the Olifants WMA has been divided into four areas of interest.

The areas of interest are:

- Upper Olifants Area (including the Upper Olifants catchment, Wilge River catchment and the Loskop Dam)
- Middle Olifants Area (downstream of Loskop Dam, including the Elands River catchment, down to the confluence of the Olifants and Steelpoort rivers)
- Steelpoort Area (the Steelpoort River catchment down to its confluence with the Olifants River)
- Lower Olifants Area (downstream of the confluence of the Olifants and Steelpoort Rivers, including the Blyde River catchment)

The impact of mining activities on hydrology, water quality and on the economy is described in general terms for the WMA within the areas of interest listed. Quantitative information is given in Chapter 5.

3.7.2 Upper Olifants Area

Extensive coal mining takes place in this area. The coal mines provide essential fuel to the local power stations as well as to the domestic and international markets. The Komati, Usutu and Usutu-Vaal Government Water Schemes supply a substantial portion of the water required, with the rest of the water abstracted from within the catchment.

The Premier Mine is situated outside the Olifants River Basin, but receives water from the Wilge River.

Large areas that previously contributed to natural runoff are isolated from the catchment by opencast mining. Decanting, seepage and dewatering from mines increase the flow in some natural streams. Water quality is generally affected negatively by mining activities.

3.7.3 Middle Olifants Area

Mining activity is very limited in the southern and central part of this area, with Vergenoeg Fluorspar Mine (B31B) being the only significant mine.

The northeastern part of this area contains more concentrated mining activities – about 27 mines occur in this area. Some of the mines use subterranean water, while others abstract water from the Olifants River. Mining products include andalusite, platinum, asbestos and chrome.

3.7.4 Steelpoort Area

Eight mines operate in this area and products include chrome, vanadium, platinum, granite and coal. The existing mines use mainly public and borehole water and a small amount of sub-terranean water. Vast expansion of mining activity is expected in this area.

3.7.5 Lower Olifants Area

Significant mining activities occur in this area. The Phalaborwa Mining Company and Foskor, which receive water from the Phalaborwa Water Board, are the major water users among the mines. Pegmin Mine abstracts water from the Olifants River. Products in this area include copper, emeralds, asbestos, magnetite, phosphate, clay, feldspar, slate, fertilizer, gold, mica, crushed stone, platinum, andalusite and chrome.

CHAPTER 4: WATER RELATED INFRASTRUCTURE

4.1 OVERVIEW

This chapter describes the bulk water and hydro-power infrastructure in the Olifants WMA.

Regional water supply schemes that supply water from outside the Olifants WMA include the following (see figure 4.1.1):

- Premier Dam to Premier Mine Water Transfer Scheme.
- Olifants-Sand Transfer Scheme.
- The Komati River Government Water Scheme.
- The Usutu-Olifants Transfer Scheme.
- Usutu-Vaal Transfer Scheme.
- Importation from Ebenezer Dam to a fish farm in the Olifants River catchment.
- Importation from Mogoboya Ramedike Dam to Naphuno 1 District, Lebowa.
- Importation from Groot Letaba River to Consolidated Murchison Gold Mine.
- Rand Water supplies water to several towns in the south of the Olifants WMA from the Upper Vaal WMA.

Most towns have developed bulk surface water supply schemes and these include Witbank, Middelburg, Bronkhorstspruit, Groblersdal, Lydenburg and Phalaborwa.

Several villages obtain water supplies from boreholes. Groundwater is also used to meet irrigation water needs in certain areas particularly in the Elands River sub-catchment. Groundwater is extensively used in areas of limited surface water for domestic supply to remote villages.

The Olifants WMA contains 30 major dams. More than 200 minor dams and over 2 000 small dams have been constructed to improve assurance of irrigation water supplies and for stock and game watering, as well as for supply and as holding dams for industries and mines.

Future developments in terms of major dams include the raising of Flag Boshielo Dam Dam, the possible construction of the Rooipoort Dam in the Olifants River and the De Hoop Dam in the Steelpoort River.

Presently, hydro-electric or pumped storage power stations exist in the Olifants WMA. A pump-storage scheme is being investigated in the Steelpoort catchment for development between 2012 and 2014.

Information regarding the bulk water infrastructure and the yield of the developed water sources was obtained from the Olifants Basin Study Report (1991), Dam Feasibility Studies, Design Reports, DWAF Water Services Strategic Study and personal communication with local consultants. Table 4.1.1 gives a summary of individual town and regional potable water supply schemes by key area.

4.2 REGIONAL WATER SUPPLY SCHEMES

This section describes major schemes, according to the Olifants River Basin Study, that cross boundaries of the Olifants WMA (i.e. inter-basin transfer schemes) and regional schemes within the Olifants WMA that cross the boundaries of the key areas.

4.2.1 Premier Dam to Premier Mine Water Transfer Scheme

This is the only water scheme that transfer water out of the Olifants WMA. The scheme transfers a total of 3,9 x 10^6 m^3/annum bulk water from the Premier Mine Dam (Wilge River Dam) to the Premier Diamond Mine and the town of Cullinan.

The pipeline is 36,5 km long, with 18 km of 533 mm diameter steel and the remainder, 510 mm diameter steel pipe. The pipeline discharges into a 45 000 m^3 reservoir at the mine.

4.2.2 Olifants-Sand Transfer Scheme

Raw water is drawn from a weir at Olifantspoort on the Olifants River and treated at a works adjacent to the river, with a capacity of 33 Mℓ/day. From the treatment works the water is pumped to end users in the Limpopo WMA. It is first pumped to Lebowakgomo via a 28 km, 800 mm diameter pipeline, from Lebowakgomo to Seshego via a 60 km, 700 mm diameter pipeline and from Seshego to Perskebult via a 5,6 km, 400 mm diameter pipeline. The total supply capacity of the scheme is 27 Mℓ/day. The scheme came into operation in 1997.

4.2.3 The Komati River Government Water Scheme

The Komati River Government Water Scheme consists of the Nooitgedacht and Vygeboom Dams in the Komati River, weirs at Gemsbokhoek and Gladdespruit and pumping stations at the Bosloop and Wintershoek Reservoirs, as well as at the two dams as shown on Figure 4.2.3.1. (Note that the weir at Gladdespruit is not shown).

The Nooitgedacht Dam and Vygeboom Dam provide water to four Eskom power stations, namely Komati, Arnot, Hendrina and Duvha. Duvha power station is supplied mainly from the Komati System, the balance being supplied from the Grootdraai Dam in the Vaal River via Witbank Dam.

Water is diverted into Vygeboom Dam from the Gladdespruit via a canal and pipeline. Water is pumped from Vygeboom Dam and Gemsbokhoek weir to the Bosloop reservoir. From Bosloop it is pumped to Wintershoek reservoir and pumping station. Nooitgedacht Dam also feeds the Wintershoek reservoir, from where water is pumped to Hendrina and Arnot power stations. From Hendrina reservoir water gravitates to Duvha power station.

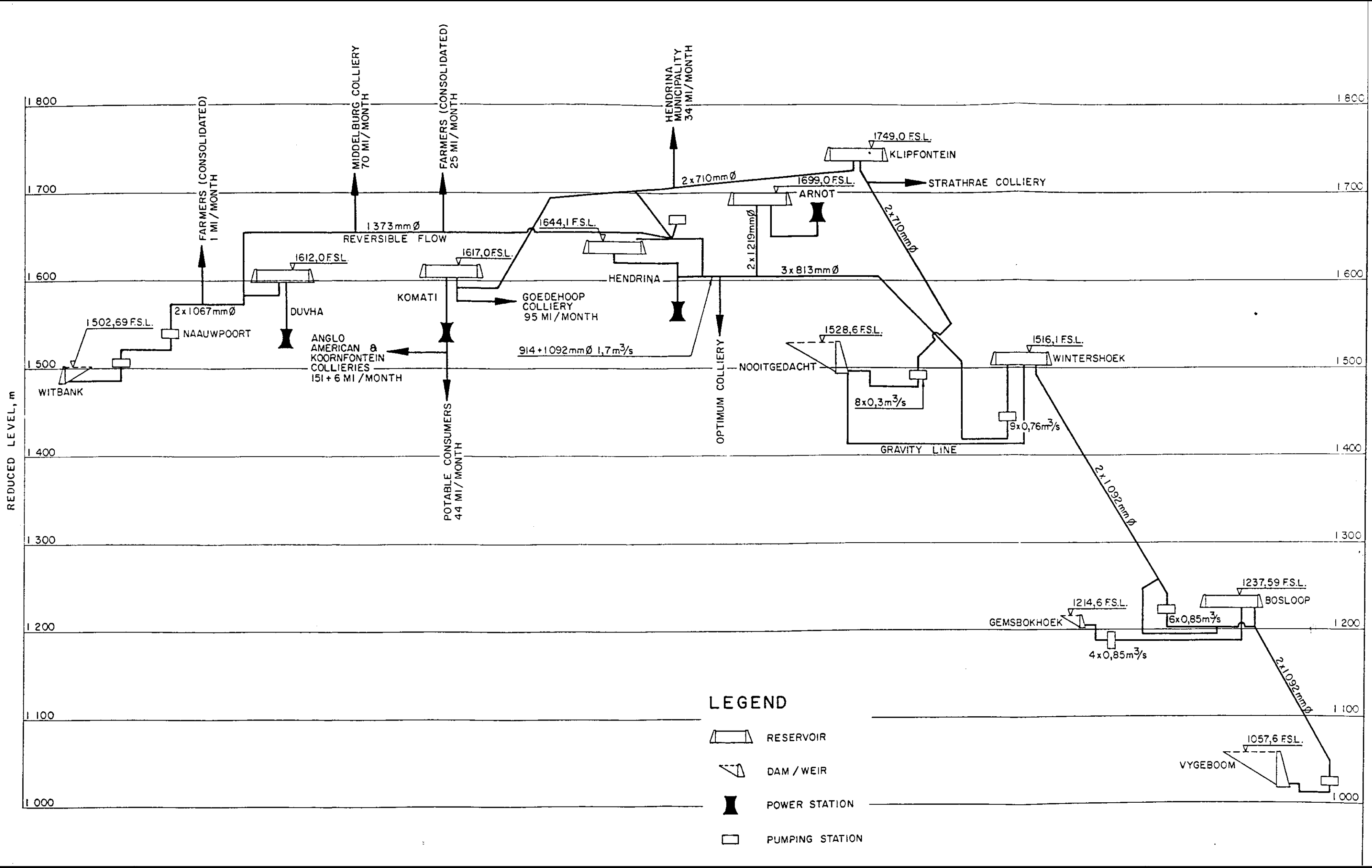
Water is pumped from Nooitgedacht Dam to Klipfontein reservoir from where it gravitates to Komati power station.

There are several links between the Komati-Olifants and other systems to provide backup sources of supply in case of an emergency. Additional water to Duvha power station can be supplied from the Usutu-Vaal I scheme with water abstracted at Naauwpoort pump station. There are however reservations about using water from the Grootdraai Dam via the Witbank Dam as sole supply because the water quality is not acceptable for use at Duvha power station. All four power stations can in fact be supplied from the Grootdraai Dam in an emergency.

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

Catchment						Area (km²)	Population	Town and Regional water supply schemes	
Primary		Secondary		Tertiary +				Capacity	
No	Description	No	Description	No	Description			(10^6 m^3/a)	(ℓ/c/d)
A (Part)	Olifants	B1	Upper Olifant	B11	Olifants	1 403	29 710	-	
					Olifants at Rietspruit	1 380	19 260	-	
					Witbank Dam	796	14 130	24 090	
					Olifants at Klein Olifants	515	172 803	-	
					Olifants at Wilge	620	4 331	-	
				B12	Middelburg Dam	1 593	26 830	19 564	
					Klein Olifants at Olifants	798	91 047	-	
			Sub Total			**7 105**	**328 401**	**43 654**	
		B2	Wilge	B20	Bronkhorstspruit Dam	1 260	268 800	14 673	
					Wilge at Olifants	3 096	125 350		
			Sub Total			**4 356**	**349 150**	**14 673**	
		B3	Elands	B31	Rust de Winter Dam	1 145	21 370		
					Renosterkop Dam	2 578	89 310		
					Elands at Olifants	2 425	184 370	1 314	
			Olifants – Loskop Reach	B32	Loskop Dam	801	4 229		
					Olifants at Bloed	1 438	9 729	3 814	
					Bloed at Olifants	870	31 450		
					Olifants at Elands	1 985	209 150		
			Sub Total			**11 242**	**549 608**	**14 253**	
		B4	Steelpoort	B41	Steelpoort at Klip	1 543	16 163	13 505	
					Steynsdrift Dam Proposal	705	9 600	-	
					Steelpoort at Spekboom	2 160	90 820	-	
					Steelpoort at Olifants	635	41 800	-	
				B42	Spekboom at Steelpoort	2 093	26 570	2 774	
			Sub Total			**7 136**	**184 953**	**16 279**	
		B5	Middle Olifants	B51	Arabie Dam	906	77 470		
					Olifants at Lepelane	5 834	289 700		
				B52	Olifants at Bewaarkloof	2 992	314 650		
			Sub Total			**9 728**	**681 820**	**183**	
		B6	Blyde	B60	Blyde at Blyde Dam	850	16 630	-	
					Ohrigstad River	1 316	16 430	2 920	
					Blyde at Olifants	676	4 233	-	
			Sub Total			**2 842**	**37 293**	**2 920**	
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	572	8 598	-	
					Strijdom Tunnel Proposal	1 813	89 450	-	
					Olifants at Blyde	653	30 460	-	
				B72	Olifants at Selati	2 124	54 230	-	
					Selati at Olifants	2 340	92 150	-	
				B73	Olifants at Letaba	4 397	59 163	-	
					Olifants at Mozambique	255	18	-	
			Sub Total			**12 154**	**33 069**	**-**	
Total in Gauteng						**2 747**	**205 630**	**-**	
Total in Mpumalanga						**27 669**	**1 195 867**	**-**	
Total in Northern Province						**24 147**	**1 108 797**	**-**	
Total WMA						**54 563**	**2 510 294**	**91 962**	

*** NOTE: Borehole schemes are not included**



WSM	**Schematic Layout of the Komati – River Government Water Scheme**	**Figure 4.2.3.1**

Internal links between the different lines in the Komati-Olifants system ensure continuous water supplies to any of the power stations: In the event of a break in the supply to Arnot and Hendrina power stations from Wintershoek reservoir, the pipeline from Hendrina to Duvha power stations is used in reverse to pump water from Naauwpoort to Hendrina and Duvha. Komati power-station can also be supplied via Hendrina from the Witbank Dam in case of a break in the Klipfontein-Komati line. Similarly, Hendrina, Duvha and Arnot can be supplied from the Klipfontein-Komati line through the same link, in the event of a break in the Wintershoek-Hendrina pipeline.

The estimated water demands to be supplied to power stations by the Komati and Vaal Systems, are listed in Table 4.2.3.1. These figures are based on those obtained from Eskom. (1990).

TABLE 4.2.3.1: ESTIMATES OF WATER REQUIREMENTS FROM ESKOM POWER STATIONS (1990)

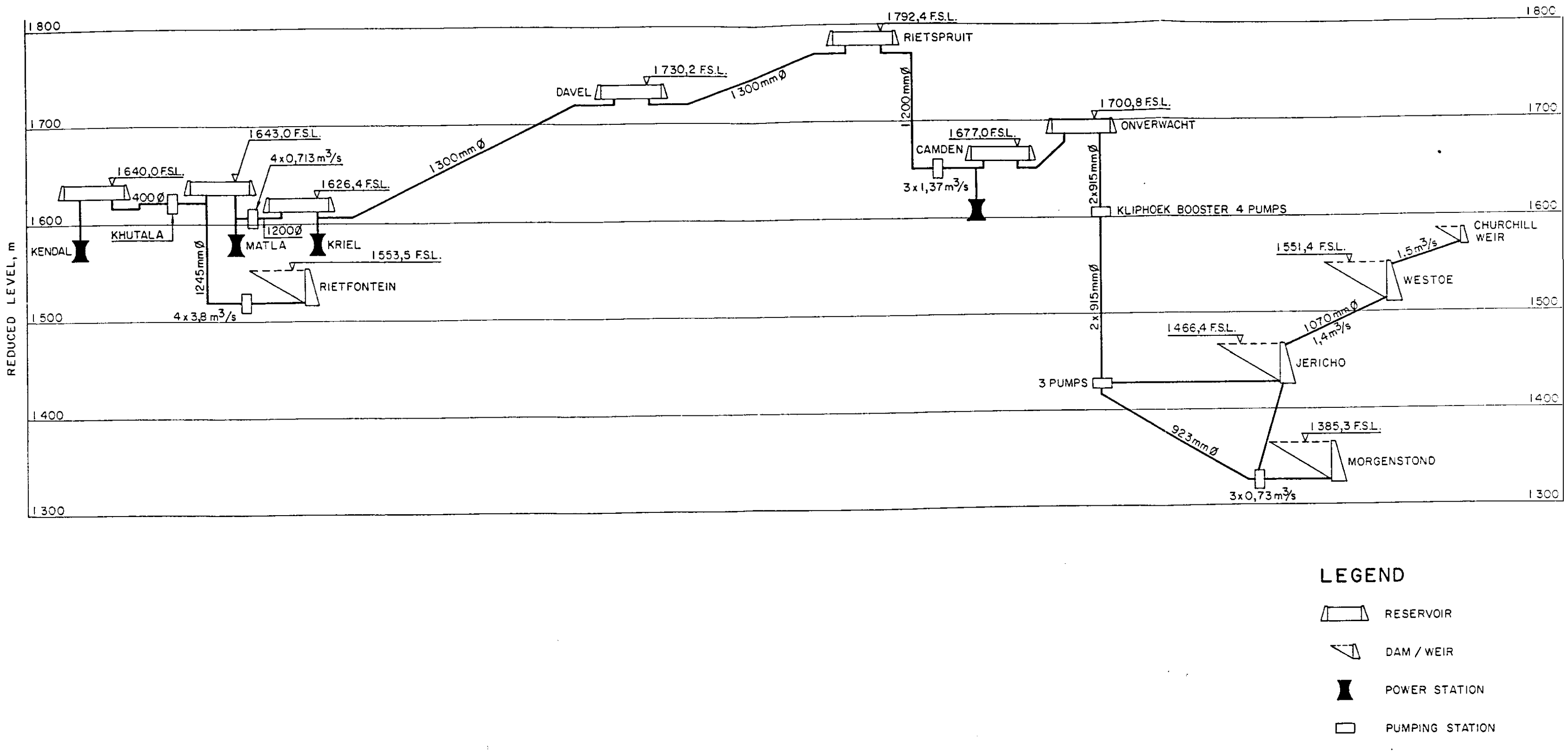
USER	m^3/day	Requirements million m^3/year
Power Stations		
Komati	27 000	9,9
Arnot	68 000	24,7
Hendrina	72 000	26,2
Duvha	115 000	42,0
Other users	11 000	4,2
Total	**293 000**	**107,0**
Supplied from Vaal River	8 000	3,0
Supplied from Komati River	285 000	104,00

Other users that are supplied with water from the Komati pipeline are Hendrina municipality, collieries in the Witbank area and farmers estimated to use 4,2 million m^3 per annum in total.

4.2.4 Usutu-Olifants Transfer Scheme

Three of the four existing dams in the Usutu River catchment, namely Westoe, Jericho and Morgenstond Dams are linked to form the Usutu River system and supply water to four power stations in the Vaal and Olifants River catchments. Water from the fourth dam, Heyshope, is transferred via the Usutu-Vaal II scheme to the Vaal River catchment to be abstracted at Grootdraai Dam, partly to supply the upper Olifants River basin via Trichardsfontein Dam, shown diagrammatically in Figure 4.2.4.1.

The Usutu River system, comprising Westoe, Jericho and Morgenstond Dams is linked to Heyshope Dam, but this link between the Heyshope canal near the watershed and Morgenstond Dam, is an emergency measure for Eskom and does not influence normal operations. In future an additional indirect link will be possible if the proposed Merriekloof Dam is built downstream of Jericho and Morgenstond Dams and is linked to Heyshope Dam.



WSM	**Schematic Layout of the Usutu – Olifants Transfer Scheme**	**Figure 4.2.4.1**

Water is imported from the Usutu River System to four Eskom power stations and some smaller users along the pipeline route in the Olifants River catchment (see Figure 4.2.4.1). The water gravitates from the Westoe Dam and is pumped from the Morgenstond Dam to the Jericho Dam, from where it is pumped to the Onverwach reservoir which serves the Camden power station by gravity. At Camden water is pumped to the Rietspruit reservoir from where it gravitates to Kriel via a break pressure tank at Davel. Water for Matla and Kendal power stations is pumped from Kriel and Khutala pump stations respectively.

Three power stations, namely Camden, Kriel and Kendal are fully supplied from the Usutu system while Matla receives part of its supply from this source. The balance of the requirements at Matla is supplied from Grootdraai Dam via Rietfontein Weir. In case of an emergency the full requirements of Matla, Kriel and Kendal power stations can be supplied from Grootdraai Dam, subject to water quality constraints at Kriel. The Heyshope-Morgenstond link reduces the problem of ensuring the supply of good quality water to the Kriel power station.

The quantity of water imported from the Usutu and Usutu-Vaal River systems to the Olifants River catchment is summarized in Table 4.2.4.1. The figures are based on estimates from Eskom. (1990).

TABLE 4.2.4.1: ESTIMATES OF THE WATER REQUIREMENTS FOR ESKOM POWER STATIONS (1990)

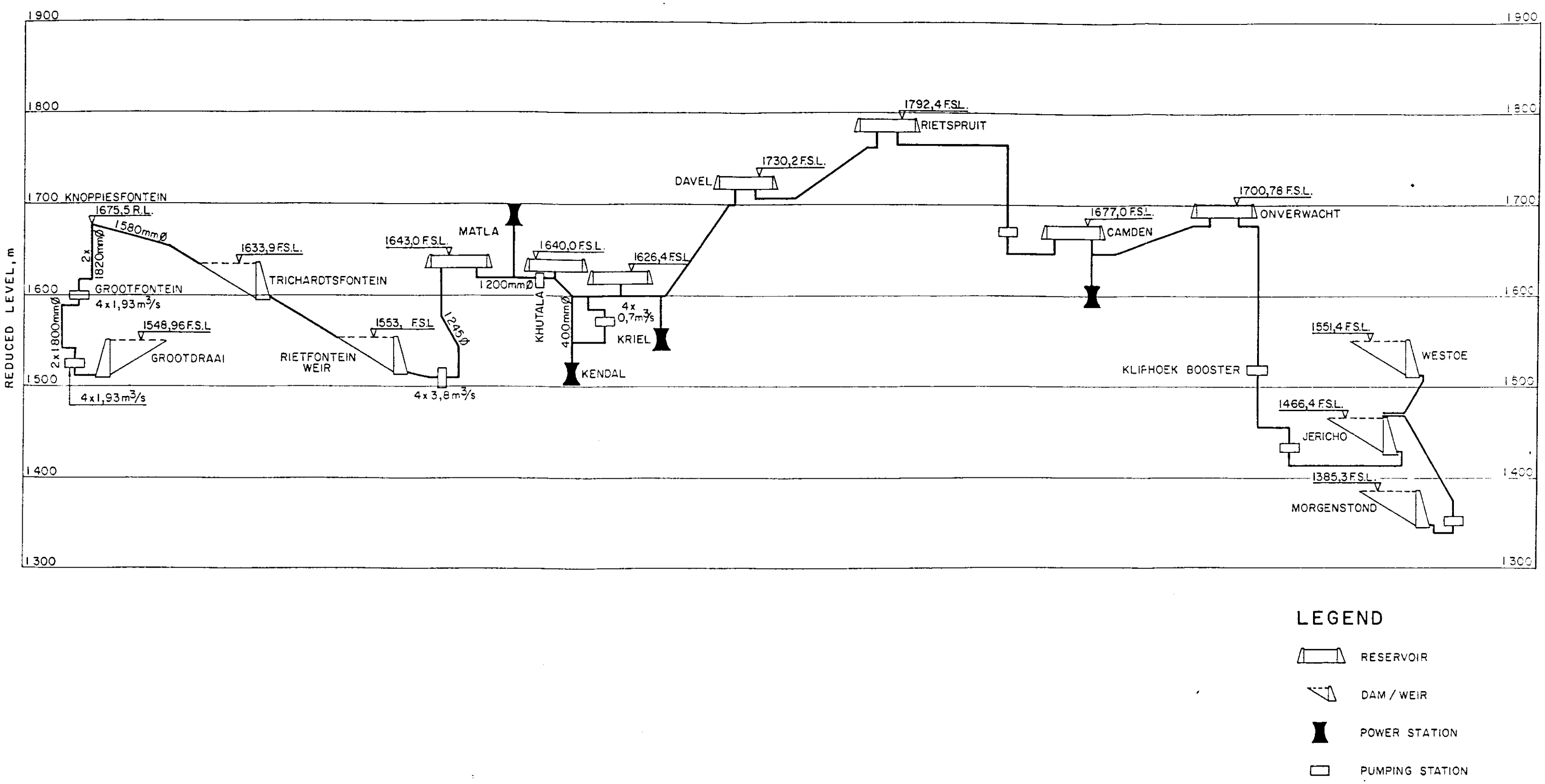
	TOTAL REQUIREMENTS	
USER	**m³/ per day**	**million m³ per year**
Camden	20 000	7,4
Kriel	92 000	33,5
Matla *	113 000	41,2
Kendal	5 000	2,0
Other users	5 000	1,7
TOTAL	**235 000**	**85,8**
Supplied from Grootdraai Dam	60 000	21,8
Supplied from the Usutu River	175 000	64,0

* Matla receives water from both systems.

It has to be borne in mind that since both the Komati and Usutu River systems supply water almost exclusively to the Eskom power station – the demands of other users being insignificant in comparison – these systems do not affect the rest of the Olifants River basin to any appreciable extent.

4.2.5 Usutu-Vaal Transfer Scheme

The role of the Usutu-Vaal scheme's first phase plays in the Olifants River catchment, is predominantly to augment water supplies from the Komati and Usutu systems, especially in the event of failure of a system, to Eskom power stations in the area.



Schematic Layout of the Usutu – Vaal Transfer Scheme | **Figure 4.2.5.1**

Water is pumped from the Grootdraai Dam in the Vaal river above Standerton to Vlakfontein pressure relief tank at the head of a canal which discharges into the forebay of the Grootfontein pump station for pumping to Knoppiesfontein. (See Figure 4.2.5.1). At Knoppiesfontein water is fed by gravity pipeline to Bossiesspruit Dam (not shown in Figure 4.2.5.1), for use by Sasol works and coalmines at Secunda, and to Trichardtsfontein balancing dam on the watershed of the Olifants River catchment.

From Trichardtsfontein Dam water is released down the Trichardtspruit to Rietfontein weir for pumping augment supplies to Matla and Kendal Power Stations. In case of an emergency, Kriel Power Station can also be supplied with water from Rietfontein, because this pump station is designed to supply the full demand of Matla, Kendal and Kriel power stations.

Emergency water supplies for the Duvha power station can also be released from Rietfontein weir to Witbank Dam and from there via Naauwpoort pump station, which is designed to supply the full demand of the Duvha and Hendrina power station if the line from the Komati System is interrupted. Water from this source to Duvha and Kriel power stations is reserved for exceptional cases, because the quality of the Usutu-Vaal I system water is not acceptable for continuous use at these stations. The spare capacity from the Witbank Dam will be available until such time as Witbank Town’s own demand exceeds the capacity of the dam whereupon this demand will have to be met by Grootdraai Dam.

Inflow to Trichardsfontein Dam has varied between about 3 and 4 million m³ per month with an annual total of 40 million m³ in 1987/88. It is expected that the quantity of water imported via Trichardtsfontein Dam will gradually increase to about 113 million m³ per year. A 10-day supply for all of Eskom’s power stations in the Olifants River catchment, at 1990 consumption levels, is stored in Trichardtsfontein Dam.

Trichardtsfontein Dam and Rietfontein Weir are therefore important links in the emergency supply of water to a large number of power stations.

4.2.6 Importation from Ebenezer Dam to a fish farm in the Olifants River catchment

A fish farm located on George’s Valley between Ebenezer Dam and Tzaneen on the watershed between the Groot Letaba and Olifants Rivers, draws water from the Groot Letaba River. The water feeds two dams and is consumptively mainly used in the form of evaporation.

Spillage from the dams is mainly returned to the Groot Letaba River, but some 0,04 million m³ water per annum is estimated to spill to the Olifants catchment.

4.2.7 Importation from Mogoboya Ramedika Dam to Naphuno 1 District, Lebowa

The Thabina bulk water supply scheme in the Letaba River catchment comprises the Mogoboya Ramedike Dam and a loop distribution main.

The two legs of the loop main are known as the Mogoboya pipeline and the Maake pipeline.

A portion of the water conveyed in the Maake pipeline is transported to Sedan, which is partly located in the Selati river catchment of the Olifants River basin, and to the Shiluwane Hospital in the same catchment area. It is estimated that about 0,16 million m³ per annum is imported into the study area by this scheme. Return flow of this water to the Olifants River system is negligible.

4.2.8 Importation from the Groot Letaba River to Consolidated Murchison Gold Mine

Water for the Consolidated Murchiso Gold Mine located in the Selati River catchment is pumped directly from the Groot Letaba River at Deeside and is conveyed over a distance of some 35 km to the mine. The 1990 usage is 0,96 million m³ per annum, approximately evenly distributed throughout the year. The mine has a permit to abstract about 1,75 million m³ water per annum from the Letaba River. Projections are that the mine will be using the full amount approximately by the year 2010.

4.2.9 Rand Water Board supplies to Eloff and Sundra, Kinross, Leandra, Trichardt and Devon

The Rand Water Board's area of supply covers approximately 17 000 km² and extends from Mabopane, north of Pretoria, and Rustenburg in the northwest, to Sasolburg in the south and from Bethal in the east to Carletonville in the west.

Apart from a small percentage from the boreholes at Zuurbekom, all the water is abstracted from the Vaal Dam and the Vaal Barrage.

Purified water is transferred for domestic and industrial use from the Vaal River catchment to users in the Crocodile and Olifants River catchments. Part of the water transferred is discharged as effluent into tributaries of these rivers.

Table 4.2.8 summarises estimated water needs for large towns in the Olifants River basin that receive water from the Rand Water Board. (Basin Study, 1991).

TABLE 4.2.8: ESTIMATED FUTURE WATER DEMAND FOR TOWNS IN THE OLIFANTS RIVER BASIN THAT USE RWB WATER (10^6 m³ /a)

	REQUIREMENTS AT FUTURE DATE		
USER	**1985**	**2000**	**2010**
Eloff and Sundra	0,36	0,64	0,73
Kinross	0,27	0,48	0,63
Leandra	0,46	1,17	1,90
Tricardt	0,25	0,39	0,47
Devon	0,15	0,21	0,24
Total	1,49	2,89	3,97

4.2.10 Water transfer between Olifants River-Loskop reach and Elands River catchment

Water from Loskop Dam is supplied via the left bank irrigation canals to the Mtombo balancing dam, from where it is piped to Weltevreden weir and purification works. The capacity of the pipeline is 222 ℓ/s. The total amount of water that can be transported from Loskop Dam to Weltevreden weir with the existing system is about 7,0 million m³ per annum. However the amount transferred depends on the ability of Rhenosterkop Dam to supply in the requirement.

The Weltevreden purification works which form part of the Kwandebele Regional Water Scheme have a capacity of 60 000 m³ per day which can readily be increased to 120 000 m³ per day. From the purification works the water is pumped via Walkraal and Zoetmelksfontein to Kwaggafontein and gravitates from there into the distribution system for supply as far as Kwamhlanga.

4.2.11 Water transfer between Steelpoort and Blyde River catchments

This scheme transfers from Spekboom River to the farm Doornhoek on the Ohrighstad River. The Spekboom Irrigation Board operates an 11 km long main canal with two branches, one 5,5 km long to the Ohrighstad River sub-catchment, and the second serves irrigators along the right bank of the Spekboom River over a distance of 7 km. The two branch canals have a capacity of 283 ℓ/s each. It is estimated that about 10 percent of the water transferred from the Spekboom River to the Ohrighstad River Subcatchment, appears as return flow in the Ohrighstad River.

4.2.12 Water transfer between the Blyde River and Lower Olifants catchments

Hoedspruit Air Force Base and Hoedspruit town annually abstract about 2,3 million m³ water from the Blyde River. While Hoedspruit is located on the ridge between the two catchments on the Blyde River side, the Air Force Base falls in the Lower Olifants catchment area.

4.3. WATER RELATED INFRASTRUCTURE

4.3.1 The Upper Olifants River Catchment

The population in the Upper Olifants River catchment is 328 401. There are five major dams in the catchment with a combined capacity of 177 million m^3 and a firm yield of 159 million m^3/a. Details of all major the dams in the Olifants WMA are shown in Table 4.3.1. The combined capacity of small and minor dams in the catchment is 64,3 million m^3.

Eighteen raw water treatment works operate in the catchment with capacities ranging from 1,6 to 66 Mℓ/day. There are also eighteen sewage/effluent treatment works in the catchment with capacities ranging from 1 to 30 Mℓ/day. Details of all water and sewage/effluent treatment works in the Olifants WMA are shown in Tables 4.3.2 and 4.3.3.

Water schemes in the catchment not already discussed in section 4.2, are as follow:

- Hendrina and Kwazamokuhle

  Hendrina receives imported water from the Nooitgedacht Dam via the Komati pipeline. The water is pumped to Hendrina from the pipeline and is purified by the municipality at a treatment plan and stored in a 1 Mℓ reservoir. The pipeline consists of a 200 mm diameter uPVC pipe and is 17,5 km long.

- Middelburg and Mhluzi

The town's main water source is the Middelburg Dam. Occasionally small amounts of water are drawn from the Pienaar and Athlone Dams. Figure 4.3.2.1 shows the extent of the scheme. A gravity line comprising a 250º mm diameter reinforced concrete pipeline about 1 300 m long, runs from the Middelburg Dam to the old pump station that pump the water through a 450 mm diameter steel pipe to a sump some 1,6 km away.

The Rondebosch pump station, downstream of the Middelburg Dam, pumps water from the dam to the sump through a 700 mm diameter steel pipe some 2,8 km away.

From the sump a 400 mm diameter fibre-cement line gravitates to the RMB raw water reservoir which has a capacity of 11,3 Mℓ.

Two 150 mm diameter pipelines supply Kanhym and Middelburg Steel and Alloys from the RMB reservoir. Raw water gravitates from the RMB reservoir to Vaalbank purification works along a 3 km, 500 mm diameter fibre-cement pipeline.

A concrete contingency gravity line, with a diameter of 450 mm runs from the RMB reservoir to Pienaars Dam, from which water can be gravitated to Vaalbank purification works via a 700 mm diameter 7 km long reinforced concrete pipeline. Raw water can be gravitated 5,8 km from Vaalbank works to Kruger Dam purification works via Athlone and Kruger Dams.

From Vaalbank purification works potable water is pumped to the 9,1 Mℓ Nasaret service reservoir via a 400 mm diameter 3 km long fibre-cement pipeline. Potable water is also pumped from Vaalbank works to Skietbaan reservoir via three fibre-cement pipelines, two with diameters of 375 mm and the other 500 mm. Skietbaan reservoir has a capacity of 13,5 Mℓ.

From Skietbaan reservoir water is gravitated to the 9,1 Mℓ concrete Graspan reservoir via a 450 mm diameter 7,6 km long fibre-cement pipeline.

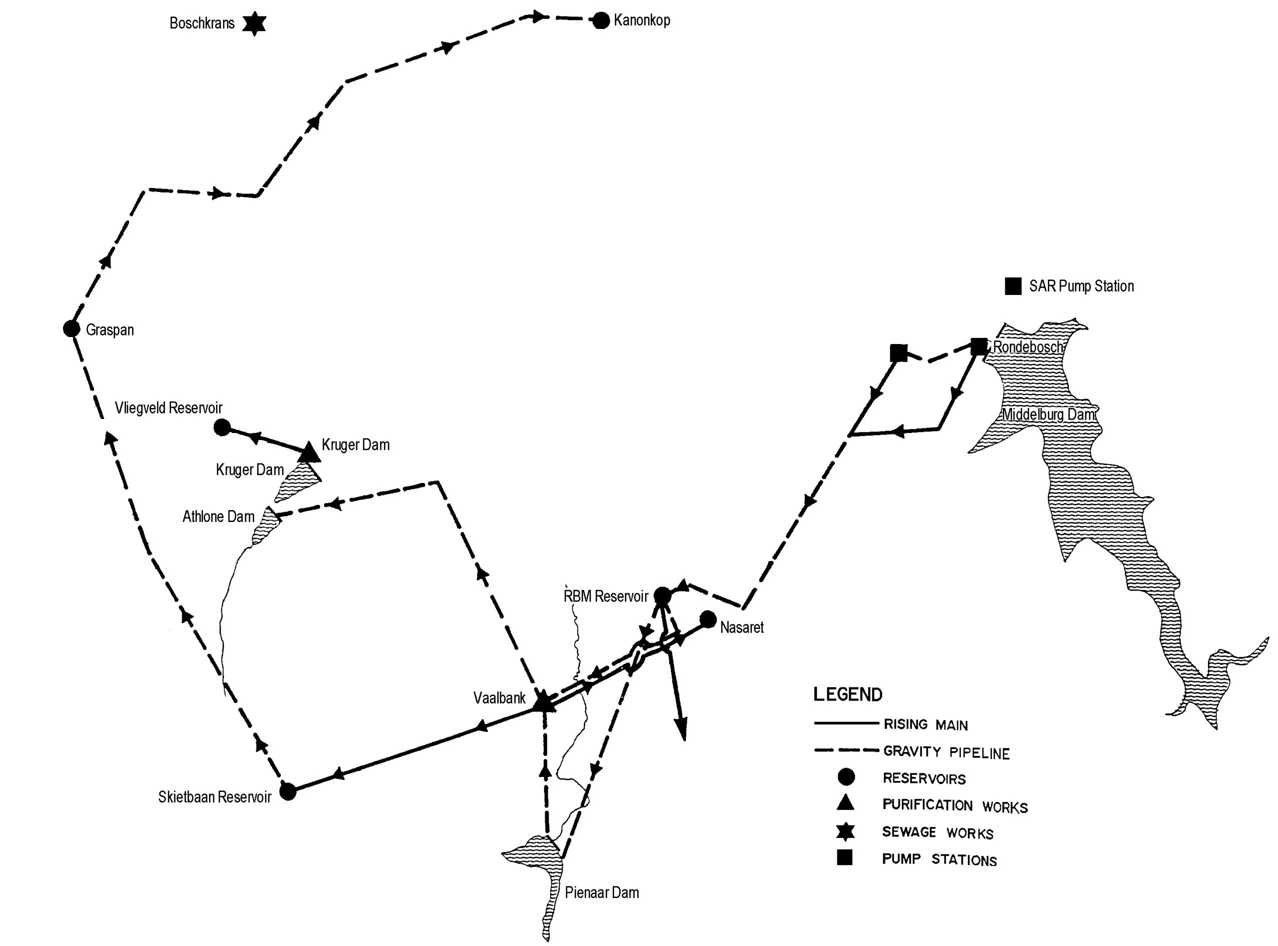
A 9,7 km long 450 mm diameter fibre-cement gravity line supplies Kanonkop reservoir with water from Graspan reservoir. Kanonkop reservoir is a concrete structure with a capacity of 414,5 Mℓ. The northern suburbs of Middelburg are supplied from Kanonkop.

From Kruger Dam purification works potable water is pumped 1,2 km to Vliegveld reservoir, a concrete structure with a capacity of 9,1 Mℓ. Water is distributed to the town from this reservoir.

- Witbank and Kwa Guqa

A pump station situated just downstream of the Witbank Dam wall has an average daily output of 100 Mℓ. Water is pumped to a 25 Mℓ raw water reservoir located in the town via three pipelines which are approximately 5 km long. Two of the lines are reinforced concrete with diameters of 450 mm and 600 mm. The third is a steel pipeline with a diameter of 900 mm.

The town has four concrete reservoirs say A, B, C and D. A diagrammatic layout of the system is not readily available.



Schematic Layout of Middelburg Bulk Water Supply | **Figure 4.3.2.1**

From the raw water reservoir at B water gravitates 1,5 km to D via 5 pipelines of varying sizes. An 11 Mℓ potable water reservoir and 66 Mℓ water purification works are situated at D.

Potable water is pumped 850 m via a 500 mm diameter concrete pipeline to a 46 Mℓ concrete service reservoir at A. Water is distributed to the town from a water tower at point A. Potable water is pumped from D to 31,3 Mℓ reservoirs at B. An additional 20 Mℓ capacity is being planned. Water is distributed to the town for a water tower at B and is also pumped 3,5 km to a 64,5 Mℓ reservoir at point C via two reinforced concrete pipelines of 350 and 200 mm diameter. A water tower at C serves part of the town reticulation system.

A 450 mm reinforced concrete 18 km gravity line supplies Highveld Steel and Vanadium from the raw water reservoir at point B. A 250 mm diameter reinforced concrete line about 5,5 km long supplies Spoornet from the same reservoir.

4.3.2 The Wilge River Catchment

The population in the Wilge River Catchment is 394 150. There are two major dams in the catchment with a combined capacity of 64 million m^3 and a firm yield of 24,7 million m^3/a. Details of all major the dams in the Olifants WMA are shown in Table 4.3.1. The combined capacity of small and minor dams in the catchment is 32,5 million m^3.

Two raw water treatment works operate in the catchment with capacities of 16,2 and 24 Mℓ/day respectively. There are also six sewage/effluent treatment works in the catchment with capacities ranging from <1 to 5 Mℓ/day. Details of all water and sewage/effluent treatment works in the Olifants WMA are shown in Tables 4.3.2 and 4.3.3.

The Gouwsberg Irrigation District is the only controlled irrigation scheme in the catchment, with a scheduled irrigation area of 1 267 ha. In 1995, 1 200 ha was irrigated with an average water demand of 5,8 million m^3/a. The whole catchment falls within the Loskop GWCA. Details of all the controlled irrigation schemes in the Olifants WMA are shown in Table 4.3.4.

Water schemes in the catchment not already discussed in section 4.2 are as follow:

- Bronkhortspruit and Zithobeni

  The municipality has a pump station at flow gauging weir B2M01 at the confluence of the Honde River and Bronkhorspruit. The pump station delivers raw water via a 700 mm diameter steel pipeline to the purification works situated 260 m from the pump station.

  A pump station at the works is being used to deliver potable water to reservoirs at Bronkhorspruit and Ekangala via a 3 km long 700 mm diameter steel pipeline.

  Bronkhorstspruit has two service reservoirs with capacities of 1,6 Mℓ and 30 Mℓ.

Water is supplied to Ekangala and Ekandustria from these reservoirs via a 6,2 km long 600 mm steel pipeline. Ekangala has two reservoirs with a total capacity of 25 Mℓ.

- Ogies and Phola

  Ogies receive raw water from the Wilge Power Station which in turn obtains its water from the Bronkhortspruit Dam.

  A 150 mm diameter fibre-cement pipeline is installed between the power station and the water purification works with a maximum delivery of 15,8 ℓ/s.

  When the raw water from Wilge is insufficient, the supply is supplemented from Prinsloo Dam.

  All the treated water gravitates to a 0,35 Mℓ potable water reservoir, from where the water gravitates to high lift pumps which feed the East and West reservoirs with a capacity of 0,6 Mℓ and 1,1 Mℓ respectively.

- Leandra

  Potable water is supplied to Leandra by the Rand Water Board via a 200 mm diameter fibre-cement pipeline and is delivered to the towns three reservoirs with a total capacity of 30,75 Mℓ.

4.3.3 The Elands River Catchment

The population in the Elands River Catchment is 295 050. There are two major dams in the catchment with a combined capacity of 233 million m^3 and a firm yield of 16,4 million m^3/a. Details of all major the dams in the Olifants WMA are shown in Table 4.3.1. The combined capacity of small and minor dams in the catchment is 24,3 million m^3.

Two raw water treatment works operate in the catchment with capacities of 3,6 and 25 Mℓ/day respectively. There are also four sewage/effluent treatment works in the catchment with capacities ranging from <1 to 2,7 Mℓ/day. Details of all water and sewage/effluent treatment works in the Olifants WMA are shown in Tables 4.3.2 and 4.3.3.

There are three controlled irrigation schemes in the catchment, with a combined scheduled irrigation area of 7 454 ha. In 1995, 5 550 ha was irrigated with an average water demand of 26,2 million m^3/a. Infrastructure other than main dams includes 36,47 km canal systems, three balancing dams with a combined capacity of 0,105 million m^3 and two storage weirs with a combined capacity of 0,7 million m^3. Details of all the controlled irrigation schemes in the Olifants WMA are shown in Table 4.3.4.

Water schemes in the catchment not already discussed in section 4.2 are as follow:

- Marble Hall

  Marble Hall receives water from the Loskop scheme via a canal. A borehole is used as a standby for emergencies.

  The water is treated and stored in two reservoirs with a total capacity of 2,8 Mℓ.

4.3.4 The Olifants River Catchment between the confluences with the Wilge and Elands Rivers

The population in the Olifants River Catchment between the confluence with the Wilge and Elands Rivers is about 254 600. There are two major dams in the catchment with a combined capacity of 350 million m^3 and a firm yield of 145,8 million m^3/a. Details of all major the dams in the Olifants WMA are shown in Table 4.3.1. The combined capacity of small and minor dams in the catchment is 43,3 million m^3.

One raw water treatment plant operates in the catchment with a capacity of 10,45 Mℓ/day. There is also only one sewage/effluent treatment works in the catchment. Details of all water and sewage/effluent treatment works in the Olifants WMA are shown in Tables 4.3.2 and 4.3.3.

There are six controlled irrigation schemes in the catchment, with a combined scheduled irrigation area of 21 604 ha. In 1995 an area of 37 380 ha was irrigated with an average water demand of 335,65 million m^3/a. Infrastructure other than main dams include 198 km canal systems, three balancing dams with a combined capacity of 0,23 million m^3 and five storage weirs/minor dams. Details of all the controlled irrigation schemes in the Olifants WMA are shown in Table 4.3.4.

Water schemes in the catchment not already discussed in section 4.2 are as follow:

- Groblersdal

  Water is obtained from the Loskop Dam irrigation scheme and is pumped from the Olifants River by three submersible pumps.

  The water is pumped to the water works and stored after treatment in the main reservoir at Groblersdal and the reservoir at Tafelkop each with a capacity of 4,2 Mℓ.

4.3.5 The Steelpoort River catchment

The population in the Steelpoort River catchment is 185 000. There are three major dams in the catchment with a combined capacity of 17 million m^3 and a firm yield of 18,7 million m^3/a. Details of all major the dams in the Olifants WMA are shown in Table 4.3.1. The combined capacity of small and minor dams in the catchment is 20,4 million m^3.

Three raw water treatment works operate in the catchment with capacities ranging from 0,5 to 7,6 Mℓ/day. There are also three sewage/effluent treatment works in the catchment with capacities ranging from 0,75 to 2,1 Mℓ/day.

Details of all water and sewage/effluent treatment works in the Olifants WMA are shown in Tables 4.3.2 and 4.3.3.

There are seven controlled irrigation schemes in the catchment, with a combined scheduled irrigation area of 8 621 ha. In 1995 7 438 ha was irrigated with an average water demand of 50,21 million m^3/a. Infrastructure other than main dams include 118,08 km canal systems and 5,9 km pipelines. Details of all the controlled irrigation schemes in the Olifants WMA are shown in Table 4.3.4.

Burgersfort is supplied with water for domestic use from boreholes.

Water schemes in the catchment not already discussed in section 4.2 are as follow:

- Belfast and Siyathuthuka

  Belfast abstracts water from the Lakenvlei Dam and pumps it to the Belfast Dam. From here it goes to the Railway Dam and purification plant. The only reservoir storage is at the water works, from here the water is pumped to 3 elevated tanks.

- Lydenburg and Mashishing

  Lydenburg and Mashishing abstracted water from the Lydenburg Dam in the Sterkspruit. The water is processed at the water works and stored in a reservoir with a capacity of 4,78 Mℓ.

4.3.6 The Middle Olifants River catchment

The population in the Middle Olifants catchment is 681 820. There are six listed and five not listed major dams in the catchment with a combined capacity of 143 million m^3 and a firm yield of 69,5 million m^3/a. Details of six major the dams in the Olifants WMA are shown in Table 4.3.1. The combined capacity of small and minor dams in the catchment is 3,4 million m^3.

One raw water treatment plant operates in the catchment with a capacity of 0,5 Mℓ/day. There is also one sewage/effluent treatment works in the catchment with a capacity of <1 Mℓ/day. Details of all water and sewage/effluent treatment works in the Olifants WMA are shown in Tables 4.3.2 and 4.3.3.

4.3.7 The Blyde River catchment

The population in the Blyde River catchment is 37 300. There are two major dams in the catchment with a combined capacity of 68 million m^3 and a firm yield of 152,5 million m^3/a. Details of all major the dams in the Olifants WMA are shown in Table 4.3.1. The combined capacity of small and minor dams in the catchment is 7,4 million m^3.

Two raw water treatment works operate in the catchment with capacities of 0,5 and 7,5 Mℓ/day respectively. There are also four sewage/effluent treatment works in the catchment with capacities ranging from 0,5 to 1 Mℓ/day. Details of all water and sewage/effluent treatment works in the Olifants WMA are shown in Tables 4.3.2 and 4.3.3.

There are three controlled irrigation schemes in the catchment, with a combined scheduled irrigation area of 11 903 ha. In 1995 12 740 ha was irrigated with an average water demand of 58,98 million m^3/a. Infrastructure other than main dams includes 238,25 km canal systems. Details of all the controlled irrigation schemes in the Olifants WMA are shown in Table 4.3.4.

4.3.8 The Lower Olifants River catchment

The population in the Lower Olifants catchment is 334 069. There are three major dams in the catchment with a combined capacity of 15,7 million m^3 and a firm yield of 41,1 million m^3/a. Details of all major the dams in the Olifants WMA are shown in Table 4.3.1. The combined capacity of small and minor dams in the catchment is 19,3 million m^3.

One raw water treatment plant operates in the catchment with a capacity of 25 $M\ell$/day. There are also five sewage/effluent treatment works in the catchment with capacities ranging from <1 to 20 $M\ell$/day. Details of all water and sewage/effluent treatment works in the Olifants WMA are shown in Tables 4.3.2 and 4.3.3.

There are two controlled irrigation schemes in the catchment, with a combined scheduled irrigation area of 2 145 ha. In 1995 an area of 5 125 ha was irrigated with an average water demand of 21,52 million m^3/a. Details of all the controlled irrigation schemes in the Olifants WMA are shown in Table 4.3.4.

Water schemes in the catchment not already discussed in section 4.2 are as follow:

- Phalaborwa

  Phalaborwa receives water from the Olifants River via the Phalaborwa Water Board which has water treatment works with a design capacity greater than 25 000 m^3/day.

4.4 HYDRO-POWER AND PUMPED STORAGE

There are no existing hydropower stations in the Olifants WMA. A future pumped storage scheme is being investigated by Eskom in the Steelpoort River in the region of Roossenekal. Depending on the approval of other schemes the Steelpoort scheme could be developed between 2012 and 2014 (Lowinger F, Eskom, pers. comm.).

TABLE 4.3.1: MAIN DAMS IN THE OLIFANTS WMA

NAME	** LIVE STORAGE CAPACITY (10^6 m^3)	FIRM YIELD (10^6 m^3/a)	OWNER
Upper Olifants River Catchment			
Doornpoort	5.22	minimal	Private
Middelburg	47.90	12.90	Municipality
Rietspruit	4.50	2.40	Private
Trichardtsfontein	15.20	# 112,70	DWAF
Witbank	104.14	30.70	Municipality
Wilge River Catchment			
Bronkhorstspruit	58.90	19.00	DWAF
Wilge River (Premier Mine Dam)	5.04	5.70	Private
Elands River Catchment			
Rhenosterkop	204.62	8.90	DWAF
Rust de Winter	28.09	7.50	DWAF
Olifants River Catchment between confluences with Wilge and Elands Rivers			
Loskop	348.10	145.20	DWAF
Rooikraal	2.12	0.64	DWAF
Steelpoort River Catchment			
Belfast	4.39	2.04	Municipality
Buffelskloof	5.27	8.80	DWAF
Der Brochen	7.29	7.90	Irrigation Board
Middle Olifants River Catchment			
Arabie	104.00	53.80	DWAF
Chuniespoort	3.10	1.40	DWAF
Lepellane	3.30	2.30	DWAF
Lola Montes	1.48	0.80	DWAF
Lower Gompies	9.12	2.30	Private
Makotswane	3.37	1.00	DWAF
Mogoto	2.90	0.50	Private
Molepo	4.52	2.36	DWAF
Nkadimeng	2.10	0.62	DWAF
Piet Gouws	6.51	3.20	DWAF
Upper Gompies	2.27	1.20	Private
Blyde River Catchment			
Blyderivierspoort	54.64	143.80	DWAF
Origstad	13.24	8.70	DWAF
Lower Olifants River Catchment			
Klaserie (Jan Wassenaar)	5.76	7.00	Irrigation Board
Phalaborwa	4.48	30.30	Private
Tours	5.50	3.80	DWAF
(continued on next page)			

TABLE 4.3.1: MAIN DAMS IN THE OLIFANTS WMA (continued)

NAME	** LIVE STORAGE CAPACITY (10^6 m^3)	"FIRM" YIELD (10^6 m^3/a)	OWNER
Small and Minor Dams			
Upper Olifants River Catchment	64.30		
Wilge River Catchment	32.50		
Elands River Catchment	24.30		
Olifants River Catchment between confluences with Wilge and Elands Rivers	43.30		
Steelpoort River Catchment	20.36		
Middle Olifants River Catchment	3.40		
Blyde River Catchment	7.40		
Lower Olifants River Catchment	19.29		

** Storage volume above lowest drawdown level.
# Includes transfers.

TABLE 4.3.2: RAW WATER TREATMENT WORKS IN THE OLIFANTS WMA

NAME	RAW WATER SOURCE	CAPACITY
Upper Olifants River Catchment		
Hendrina	Nooitgedacht Dam via Komati pipeline	1,6 Mℓ /day
Middelburg	Middelburg Dam	52 Mℓ /day
Witbank	Witbank Dam	66 Mℓ /day
Highveld Steel and Vanadium	Witbank Dam	7,5 Mℓ /day
Tavistock - Tavistock Collieries		7,5 Mℓ /day
- Middelburg mine Services		7,5 Mℓ /day
Boschmans - Duiker Exp Tweefontein		7,5 Mℓ /day
Village - Duiker Exp Tweefontein		7,5 Mℓ /day
Douglas - Rand mines		7,5 Mℓ /day
Van Dyksdrift - Rand mines		2,5 Mℓ /day
Wolwekrans - Rand mines		7,5 Mℓ /day
Main - Duiker Exp Witbank		2,5 Mℓ /day
Phoenix - Tavistock Coll Ltd		7,5 Mℓ /day
Goedehoop - Anglo Americam Corporation		7,5 Mℓ /day
Springbok - Anglo Americam Corporation		7,5 Mℓ /day
Middelburg - Rand mines Ltd		7,5 Mℓ /day
Derwent - SA Transport Services		25 Mℓ /day
New Largo - Anglo Americam Corporation		7,5 Mℓ /day
Wilge River Catchment		
Bronkhorstspruit	Bronkhorstspruit Dam	24 Mℓ /day
Ogies	Bronkhorstspruit Dam supplemented by Prinsloo Dam	16,2 ℓ /s
Elands River Catchment		
Marble Hall	Loskop Dam	3,6 Mℓ /day
Ndebele		< 25 Mℓ /day
Olifants River Catchment between confluences with Wilge and Elands Rivers		
Groblerdal	Loskop Dam	10,45 Mℓ /day
Steelpoort River Catchment		
Belfast	Lakenvlei Dam via Belfast & Railway Railway Dams	37 Mℓ /month
Burgersfort	B/H	0,5 Mℓ /day
Lydenburg	PTC du Plessis Dam	7,6 Mℓ /day
Middle Olifants River Catchment		
Settlers Agricultural High School		0,5 Mℓ /day
Blyde River Catchment		
Sybrand van Niekerk	Blyde River	7,5 Mℓ /day
Overvaal Resorts	Blyde River	0,5 Mℓ /day
Lower Olifants River Catchment		
Consolidated Murchison Ltd		25 Mℓ /day

TABLE 4.3.3: SEWAGE/EFFLUENT TREATMENT WORKS IN THE OLIFANTS WMA

Name	Receiving river	Capacity
Upper Olifants River Catchment		
Hendrina	0,7 Mℓ/day Klein Olifants	1 Mℓ/day
Kinross	Trib Vaalbankspruit	18 Mℓ/day
Boskranz (Middelburg)	9 Mℓ/day Klein Olifants	30 Mℓ/day
Trichardt	Trichardtspruit	20,8 m^3/h
River view (Witbank)	Olifants River	4,6 Mℓ/day
Ferrobank (Witbank)	Brugspruit (trib Klipspruit)	18 Mℓ/day
Naauwpoort (Witbank)	Spruit to Witbank Dam	4,2 Mℓ/day
Kriel P/S	Steenkoolspruit	5 Mℓ/day
Matla P/S	Steenkoolspruit	5 Mℓ/day
Duvha P/S	Olifants River	< 1 Mℓ/day
Komati P/S	Olifants River	5 Mℓ/day
Arnot P/S	Klein Olifants	5 Mℓ/day
Hendrina P/S	Klein Olifants	5 Mℓ/day
Consol Coll old mine		5 Mℓ/day
Consol Coll new mine		20 Mℓ/day
Blinkpan Village (Blinkpan Collieries)		5 Mℓ/day
Khutala (Rand mines Ltd)		5 Mℓ/day
Rietspruit (Rand mines Ltd)		5 Mℓ/day
Wilge River Catchment		
Delmas	Bronkhorstspruit Dam	2,25 Mℓ/day
Bronkhorstspruit	Bronkhorstspruit	2 Mℓ/day
Zithobeni	Bronkhorstspruit	< 1 Mℓ/day
Leslie	Trib Wilge River	3 Mℓ/day
Ekandustria	Mosokololo Stream (B310)	oxidation ponds
Kendal P/S	Wilge River	5 Mℓ/day
Elands River Catchment		
Rayton	Elands River	0,6 Mℓ/day
Refilwe	Elands River	< 1 Mℓ/day
Siyabuswa	Elands River	< 2,7 Mℓ/day
Kwamhlanga	Elands River	stabilisation ponds
Olifants River Catchment between confulences with Wilge and Elands Rivers		
Groblerdal	Olifants River	ctivated sludge plan
Steelpoort River Catchment		
Belfast	Belfast Dam	2,1 Mℓ/day
Lydenburg	Dorps River	1,7 Mℓ/day
Mashishing		0,75 Mℓ/day
Middle Olifants River Catchment		
Settlers Agricultural High School		< 1 Mℓ/day
Blyde River Catchment		
Pelgrim's Rest	Irrigation	< 1 Mℓ/day
Sybrand van Niekerk	Blyde River	< 1 Mℓ/day
Bourke's Luck Military Base	Blyde River	0,5 Mℓ/day
Overvaal Resorts	Blyde River	< 1 Mℓ/day
Lower Olifants River Catchment		
Lelekani	Ga-Selati River via Jebene River	2,2 Mℓ/day
Namakgale	Selati River	< 1 Mℓ/day
Phalaborwa	< 1 Mℓ/day Ga-Selati River	4 Mℓ/day
Fosfaat-ontginningskorp Bpk		20 Mℓ/day
Fedmis Phalaborwa		5 Mℓ/day

TABLE 4.3.4: CONTROLLED IRRIGATION SCHEMES

Scheme name	Scheduled area (ha)	Irrigated area (ha)	Produce	Supply source	Present average annual use (1) (10^6 m^3/a)
Wilge River Catchment					
Gouwsberg ID	1267	1200	Pasture/fodder/Vegetables	Wilge River	5,8
Elands River Catchment					
Rust de Winter GWS	4750	5550	Maize/Cotton/Wheat	Rust de Winter Dam	13,1
Trans-Elands ID	832	1470	Cotton/Wheat	Eland River	6,6
Rust de Winter GWCA	1872	1150	Vegetables/Pasture/Fodder	Elands & tributaries, small dams	6,5
Olifants River Catchment between confluences with Wilge and Elands Rivers					
Loskop Irrigation Scheme	16289	25000	Tabacco/Wheat/Cotton/Maize/ Groundnuts/Vegetables	Loskop Dam	125
Bloempoort ID (Loskop GWCA)	340	1910	Cotton/Maize/Wheat	Loskop Dam & Moses River	9,17
Hereford ID (Loskop GWCA)	2840	5600	Cotton/Wheat	Miessner Weir & Loskop Dam	30,61
Olifants River ID (Loskop GWCA)	1732	3170	Citrus/Cotton	Olifants River	135,72
Selons River ID	188	1200	Wheat/Tobacco/Citrus	Selons & Kruis Rivers & Roodepoort Dam	5,15
Rooikraal GWCA	215	500	Wheat/Maize/Lucerne	Rooikraal Dam	30
Steelpoort River Catchment					
Mapochsgronde GWCA	302	120	Maize/Beans/Lucerne/Wheat	Tonteldoos & Vlugkraal Dams	0,6
Spekboom ID	1125	968	Wheat/Maize/Lucerne	Spekboom River	6,56
Lower Spekboom ID	1513	1310	Maize/Cotton	Lower Spekboom River	8,88
Waterval River GWCA	2275	2000	Wheat/Maize/Lucerne	Waterval River & Buffelskloof Dam	13,56
Laersdrift ID	499	440	Maize/Cotton	Steelpoort River	2,98
Groot Dwars river ID	1222	1100	Cotton/Maize/Wheat	Groot Dwars River	7,46
Central Steelpoort river ID	1685	1500	Maize/Cotton/Wheat	Steelpoort River	10,17
Blyde River Catchment					
Ohrigstad Gov Irr Area	3100	5500	Wheat/Vegetables	Ohrigstad Dam & GW	28,54
Kaspersnek/Vyehoek river ID	614	850	Wheat/Vegetables	Rivers	4,86
Blyde River GWCA & ID	8189	6390	Vegetables/Maize	Blyde River	25,58
Lower Olifants River Catchment					
Selati ID	998	3945	Subtropical fruits	Ga-Selati River	16,16
Klaserie ID	1047	1180	Citrus/Subtropical fruits	Klaserie River & Klaserie Dam	5,36

(1) Quantities include conveyance losses.

CHAPTER 5: WATER REQUIREMENTS

5.1 WATER USE SUMMARY

Development and population have brought increasing pressure to bear on the resources of the Olifants WMA, particularly water resources.

The limited extent of the water resources has given rise to intensive competition between the ever-growing water use sectors. The groups each have their own needs, norms and expectations and have for the most part, followed a course of independent and ad hoc water resource development.

Agriculture (45%) is by far the largest water use sector in the Olifants WMA, followed by the bulk (25%) and domestic (12%) water sector. The water requirements per user group and per province are shown in Tables 5.1.1 and 5.1.2 respectively. Distribution losses and conveyance losses are included in the values given for requirements, including water transfers, but return flows have not been subtracted. The water requirement for the ecological reserve is the requirement at the outlet of the WMA. The different water user groups require water at different assurance of supply levels. The water use / requirements are therefore also shown at a 1:50 assurance level.

Figure 5.1.1 shows the total equivalent 1:50 year water requirements for 1995, including water transfers to and from the WMA. The water transfer schemes are shown schematically in Figure 5.1.4.1. Water requirements at a 1: 50 year assurance per user sector are indicated on Figure 5.1.2.

TABLE 5.1.1: WATER REQUIREMENTS PER USER GROUP IN 1995

User Group	Estimated Water Requirement (10^6 m^3/a)	Requirement/Use At 1:50 Year Assurance (10^6 m^3/ a)
Ecological reserve (1)	480,3	162,4
Domestic (2)	123,83	128,99
Bulk water use (3)	257,78	271,95
Neighbouring States	0,0	0,0
Agriculture (4)	599,64	492,06
Afforestation	54,2	3,38
Alien vegetation	122,1	31,61
Water transfers (5)	5,0	5,0
Hydropower	0,0	0,0
TOTAL		**1 095,39**

(1) At outlet of WMA..
(2) Includes urban and rural domestic requirements and commercial, institutional and municipal requirements.
(3) Includes thermal power stations, major industries and mines.
(4) Includes requirements for irrigation, dryland sugar cane, livestock and game.
(5) Only transfers out of the WMA are included.

TABLE 5.1.2: WATER REQUIREMENT IN THE OLIFANTS WMA PER PROVINCE IN 1995 AT 1:50 YEAR ASSURANCE

User Group	Requirement in Gauteng (10^6 m^3/a)	Requirement in Mpumalanga (10^6 m^3/a)	Requirement in Northern Province (10^6 m^3/a)	Total Requirement (10^6 m^3/a)
Domestic	10,0	81,5	37,5	129,0
Bulk water use	7,42	206,13	58,4	271,95
Agriculture	15,77	291,81	184,48	492,06
Afforestation	0	3,22	0,16	3,38
Alien vegetation	0,59	9,92	21,10	31,61
Water transfers *	5,0	0	0	5,0
Hydropower	0	0	0	0
TOTALS	**38,78**	**592,58**	**301,64**	**933,00**

* Assigned to province where transfer intake is situated.

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 2.6.2. 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 water required for the ecological component of the Reserve, which is suitable for use in this water resources situation assessment.

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

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

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

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

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

- The extrapolations from past IFR workshops are based on a very limited data set, which does not cover the whole of the country. While some development work has been completed to try and extend the extrapolations and has improved the high flow estimations for dry and variable rivers, this has been quite 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 this Olifants Water Management Area fall within the so-called regions 17,18,19 and 21.

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

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

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

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

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

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

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

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

5.2.3 Comments on the Results

Generally the Ecological Component of the Reserve is higher the closer an area is to natural or unmodified conditions. In view of the low confidence attached to the estimated water requirements for the ecological component of the Reserve, these values should be re-evaluated as more ecological data becomes available.

5.2.4 Presentation of Results

The water requirement for the Ecological Component of the reserve is shown in Table 5.2.4.1 and Figure 5.2.4.1. The key points considered coincide with catchment or sub-catchment outlets. These areas are listed in Chapter 7. There can be intra-quaternary catchment variation in class and state, so there may be intra-tertiary or intra-key point variations. Appendix F of this report contains the quaternary information.

5.2.5 Discussion and Conclusions

The estimated water requirement for the ecological component of the Reserve indicated in Table 5.2.4.1 gives the impact on the 1:50 year yield. The total value for the Olifants WMA is about 25% of the developed yield for surface water resources, which seems a large portion. It would be necessary for future planning to critically and individually evaluate the different sections of sub-catchments and to adapt the ecological component of the Reserve to a viable value for each area.

Primary		Secondary		Tertiary		Ecological Status Class	% Virgin MAR	*10^6 m^3/a	Impact on 1:50 yr yield (10^6 m^3/a)
No	**Description**	**No**	**Description**	**No**	**Description**				
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	D	17.0	2.2	1.4
					Olifants at Rietspruit	D	10.6	5.6	0.7
					Witbank Dam	D	10.4	13.0	3.1
					Olifants at Klein Olifants	D	11.3	16.6	1.8
					Olifants at Wilge	C	20.3	52.2	0.3
				B12	Middelburg Dam	C	18.7	8.4	2.4
					Klein Olifants at Olifants	C	21.0	17.1	1.0
			Sub total					**17.1**	**10.8**
		B2	Wilge	B20	Bronkhorstspruit Dam	C	19.9	9.4	4.7
					Wilge at Olifants	C	22.8	38.1	5.9
			Sub total					**38.1**	**10.6**
		B3	Elands	B31	Rust de Winter Dam	C	15.5	4.9	1.3
					Renosterkop Dam	D	9.8	5.6	2.1
					Elands at Olifants	D	9.2	7.7	-0.1
			Olifants - Loskop Reach	B32	Loskop Dam	C	22.4	104.3	34.7
					Olifants at Bloed	D	15.9	82.6	0.3
					Bloed at Olifants	D	8.3	2.2	0.6
					Olifants at Elands	D	15.7	92.5	-0.1
			Sub total					**92.5**	**38.8**
		B4	Steelpoort	B41	Steelpoort at Klip	C	21.8	21.0	2.8
					Steynsdrift Dam Proposal	B	31.3	40.9	1.0
					Steelpoort at Spekboom	C	21.0	45.0	1.7
					Steelpoort at Olifants	D	16.7	66.2	2.3
				B42	Spekboom at Steelpoort	C	25.3	41.7	9.0
			Sub total					**66.2**	**17.0**
		B5	Middle Olifants	B51	Arabie Dam	E	15.0	102.9	19.0
					Olifants at Lepelane	D	14.3	105.7	-4.2
				B52	Olifants at Bewaarkloof	D	13.7	108.8	-4.2
			Sub total					**108.8**	**10.5**
		B6	Blyde	B60	Blyde at Blyde Dam	B	42.3	141.2	31.6
					Ohrigstad River	D	38.7	168.5	-4.4
					Blyde at Olifants	B	38.7	168.5	8.1
			Sub total					**168.5**	**35.3**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	D	13.5	110.0	-0.7
					Strijdom Tunnel Proposal	D	15.2	143.9	7.3
					Olifants at Blyde	C	22.7	316.0	-2.8
				B72	Olifants at Selati	C	24.6	463.7	31.3
					Selati at Olifants	D	10.5	8.4	0.1
				B73	Olifants at Letaba	C	24.1	491.6	-1.4
					Olifants at Mozambique	C	24.0	628.1	5.6
			Sub total					****628,1**	**39.5**
Total in Gauteng									**5.1**
Total in Mpumalanga									**104.5**
Total in Northern Province									**52.8**
Total WMA								**628.1**	**162.4**

* Accumulative values.

** This includes the component of the Luvuvhu/Letaba WMA

5.3 URBAN AND RURAL

5.3.1 Introduction

Domestic water users can be grouped into several categories, with the main categories being urban and rural communities.

The urban population all have fully reticulated water supply systems with water borne sewage facilities and have a relatively high per capita water use. This group uses a significant percentage of the water for gardening purposes. Commercial and industrial activity is high in centres having first world residents.

The rural community, which comprises about 63% of the population, generally have rudimentary water supply systems and have a relatively low per capita water use. Water is, in most cases used only for basic needs. This population group is mostly residents in densely populated areas and has high population growth rates, in most cases, have a high impact on the water resources in terms of use and water quality.

The urban and rural domestic water requirements in 1995 are shown in Table 5.3.1.1. The extent is shown in Figure 5.3.1.1. The Human reserve is included in the other water requirements shown in the table. The Human reserve can be defined as the water requirement for the basic needs of people in both urban and rural communities in a specific catchment.

The total urban water requirement for the Olifants WMA (including losses) is estimated at 80 million m^3 per annum. In view of the high per capita use (about 200 ℓ/c/day on average) it should be possible to curtail water use under 1:50 year drought conditions. The 1:50 year domestic flow requirements were determined and shown in Tables 5.3.1.1, 5.3.2.1.4 and 5.3.3.1.2. It is less than the 1995 use in most instances.

5.3.2 Urban

Water Requirements

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.

TABLE 5.3.1.1: URBAN AND RURAL DOMESTIC WATER REQUIREMENTS IN 1995

Catchment						Urban requirements $(10^6 m^3/a)$	Rural domestic water requirements $(10^6 m^3/a)$	Combined urban and rural domestic requirements $(10^6 m^3/a)$	Requirement at 1:50 year assurance $(10^6 m^3/a)$
Primary		Secondary		Tertiary					
No	Description	No	Description	No	Description				
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	1,90	0,24	2,14	2,12
					Olifants at Rietspruit	0,30	0,25	0,55	0,57
					Witbank Dam	0,00	0,30	0,30	0,32
					Olifants at Klein Olifants	26,60	0,25	26,85	26,47
					Olifants at Wilge	0,00	0,17	0,17	0,18
				B12	Middelburg Dam	0,90	0,62	1,52	1,57
					Klein Olifants at Olifants	11,40	0,25	11,65	11,48
			Sub total			**41,10**	**2,07**	**43,17**	**42,74**
		B2	Wilge	B20	Bronkhorstspruit Dam	9,10	0,28	9,38	9,70
					Wilge at Olifants	10,90	0,94	11,84	11,95
			Sub total			**20,00**	**1,21**	**21,21**	**21,66**
		B3	Elands	B31	Rust de Winter Dam	0,00	1,25	1,25	1,35
					Renosterkop Dam	0,90	3,10	4,00	4,32
					Elands at Olifants	7,20	2,07	9,27	9,79
			Olifants - Loskop Reach	B32	Loskop Dam	0,00	0,27	0,27	0,29
					Olifants at Bloed	0,50	0,47	0,97	0,99
					Bloed at Olifants	0,30	1,43	1,73	1,86
					Olifants at Elands	0,80	8,33	9,13	9,82
			Sub total			**9,70**	**16,91**	**26,61**	**28,45**
		B4	Steelpoort	B41	Steelpoort at Klip	0,80	0,34	1,14	1,17
					Steynsdrift Dam Proposal	0,00	0,57	0,57	0,61
					Steelpoort at Spekboom	0,00	1,77	1,77	1,89
					Steelpoort at Olifants	0,00	2,38	2,38	2,54
				B42	Spekboom at Steelpoort	1,50	0,29	1,79	1,80
			Sub total			**2,30**	**5,35**	**7,65**	**8,04**
		B5	Middle Olifants	B51	Arabie Dam	0,30	2,00	2,30	2,49
					Olifants at Lepelane	0,00	6,78	6,78	7,38
				B52	Olifants at Bewaarkloof	2,00	9,17	11,17	12,08
			Sub total			**2,30**	17,95	20,25	**21,95**
		B6	Blyde	B60	Blyde at Blyde Dam	0,00	0,28	0,28	0,29
					Ohrigstad River	0,00	0,32	0,32	0,35
					Blyde at Olifants	0,10	0,06	0,16	0,16
			Sub total			**0,10**	**0,66**	**0,76**	**0,80**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,00	0,25	0,25	0,27
					Strijdom Tunnel Proposl	0,10	2,52	2,62	2,85
					Olifants at Blyde	0,00	0,99	0,99	1,06
				B72	Olifants at Selati	0,00	2,72	2,72	2,88
					Selati at Olifants	0,20	3,05	3,25	3,50
				B73	Olifants at Letaba	4,20	0,05	4,25	4,24
					Olifants at Mozambique	0,00	0,00	0,00	0,00
			Sub total			**4,50**	**9,57**	**14,07**	**14,81**
Total WMA						**80,00**	**53,72**	**133,72**	**138,44**

Note: The values in this table include water losses as shown in Table 5.3.2.1.4 and 5.3.3.1.2.

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 5.3.2.1.1.

TABLE 5.3.2.1.1: DIRECT WATER USE: CATEGORIES AND ESTIMATED UNIT WATER USE

Category		Water Use ℓ/c/day
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 5.3.2.1.2.

TABLE 5.3.2.1.2: 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 Table 5.3.2.1.3.

TABLE 5.3.2.1.3: INDIRECT WATER USE AS A COMPONENT OF TOTAL DIRECT WATER USE

<table>
<tr><th rowspan="2">Urban Centre Classification</th><th colspan="4"></th></tr>
<tr><th>Commercial</th><th>Industrial</th><th>Institutional</th><th>Municipal</th></tr>
<tr><td>Metropolitan Cities</td><td rowspan="3">0,2</td><td rowspan="3">0,3</td><td rowspan="3">0,15</td><td rowspan="3">0,08</td></tr>
<tr><td>Towns Industrial</td></tr>
<tr><td>Towns Isolated</td></tr>
<tr><td>Towns Special</td><td>0,30</td><td>0,15</td><td>0,08</td><td>0,03</td></tr>
<tr><td>Towns Country</td><td>0,10</td><td>0,15</td><td>0,03</td><td>0,10</td></tr>
<tr><td>New Centres</td><td>0,15</td><td>0,08</td><td>0,08</td><td>0,08</td></tr>
</table>

Where detailed data was not available, table 5.3.2.1.3 was used as a basis for estimating the indirect water use.

Table 5.3.2.1.4 contains urban water requirements and return flows.

TABLE 5.3.2.1.4: URBAN WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

Catchment						Urban water requirements ($10^6m^3/a$)							Total at 1:50 yr assurance ($10^6m^3/a$)	Return flows (10^6 m^3/a)			
Primary		Secondary		Tertiary		Direct	Indirect	Bulk conveyance losses		Distribution losses		Total		Effluent	Impervious urban area	Total return flow	Return flow 1:50 year assurance
No	Description	No	Description	No	Description			$10^6m^3/a$	%	$10^6m^3/a$	%						
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	1.1	0.4	0.07	5	0.29	20	1.9	1.9	1.44	0.00	1.44	1.43
					Olifants at Rietspruit	0.2	0.1	0.01	5	0.05	20	0.3	0.3	0.12	0.00	0.12	0.12
					Witbank Dam	0.0	0.0	0.00	5	0.00	20	0.0	0.0	2.15	0.00	2.15	2.15
					Olifants at Klein Olifants	13.1	9.5	1.13	5	2.26	10	26.6	26.5	4.11	2.00	6.11	6.05
					Olifants at Wilge	0.0	0.0	0.00	5	0.00	20	0.0	0.0	7.40	0.00	7.40	7.40
				B12	Middelburg Dam	0.5	0.2	0.04	5	0.15	20	0.9	0.9	0.44	0.00	0.44	0.43
					Klein Olifants at Olifants	7.5	2.8	0.52	5	1.03	10	11.4	11.4	6.18	1.57	7.75	7.69
			Sub total			**22.3**	**13.0**	**1.77**		**3.77**		**41.1**	**41.0**	**21.84**	**3.57**	**25.41**	**25.27**
		B2	Wilge	B20	Bronkhorstspruit Dam	4.7	2.4	0.36	5	1.44	20	9.1	9.4	3.16	0.00	3.16	3.20
					Wilge at Olifants	5.2	2.9	0.41	5	1.64	20	10.9	11.0	4.48	0.00	4.48	4.48
			Sub total			**10.0**	**5.4**	**0.77**		**3.07**		**20.0**	**20.3**	**7.65**	**0.00**	**7.65**	**7.68**
		B3	Elands	B31	Rust de Winter Dam	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
					Renosterkop Dam	0.5	0.2	0.03	5	0.13	20	0.9	0.9	0.28	0.00	0.28	0.29
					Elands at Olifants	3.9	1.5	0.27	5	1.09	20	7.2	7.5	2.19	0.00	2.19	2.23
			Olifants - Loskop Reach	B32	Loskop Dam	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
					Olifants at Bloed	0.3	0.1	0.02	5	0.04	10	0.5	0.5	0.25	0.00	0.25	0.25
					Bloed at Olifants	0.2	0.1	0.01	5	0.05	20	0.3	0.3	0.10	0.00	0.10	0.10
					Olifants at Elands	0.4	0.2	0.03	5	0.12	20	0.8	0.8	0.28	0.00	0.28	0.28
			Sub total			**5.3**	**2.0**	**0.37**		**1.42**		**9.7**	**10.0**	**3.10**	**0.00**	**3.10**	**3.15**
		B4	Steelpoort	B41	Steelpoort at Klip	0.5	0.2	0.03	5	0.12	20	0.8	0.8	0.34	0.00	0.34	0.34
					Steynsdrift Dam Prop	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
					Steelpoort at Spekboom	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
					Steelpoort at Olifants	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
				B42	Spekboom at Steelpoort	0.9	0.4	0.06	5	0.13	10	1.5	1.5	0.68	0.00	0.68	0.68
			Sub total			**1.4**	**0.5**	**0.10**		**0.25**		**2.3**	**2.4**	**1.01**	**0.00**	**1.01**	**1.01**
		B5	Middle Olifants	B51	Arabie Dam	0.2	0.1	0.01	5	0.04	20	0.3	0.3	0.09	0.00	0.09	0.09
					Olifants at Lepelane	0	0	0.00	5	0.00	20	0	0	0.01	0	0.01	0.01
				B52	Olifants at Bewaarkloof	1.1	0.4	0.08	5	0.30	20	2.0	2.0	0.77	0.00	0.77	0.77
			Sub total			**1.2**	**0.5**	**0.09**		**0.35**		**2.3**	**2.3**	**0.87**	**0.00**	**0.87**	**0.87**
		B6	Blyde	B60	Blyde at Blyde Dam	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
					Ohrigstad River	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
					Blyde at Olifants	0.0	0.0	0.00	5	0.01	20	0.1	0.1	0.02	0.00	0.02	0.02
			Sub total			**0.0**	**0.0**	**0.00**		**0.01**		**0.1**	**0.1**	**0.02**	**0.00**	**0.02**	**0.02**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
					Strijdom Tunnel Proposal	0.0	0.0	0.00	5	0.01	20	0.1	0.1	0.02	0.00	0.02	0.02
					Olifants at Blyde	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
				B72	Olifants at Selati	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
					Selati at Olifants	0.1	0.0	0.01	5	0.03	20	0.2	0.2	0.07	0.00	0.07	0.07
				B73	Olifants at Letaba	2.3	0.9	0.16	5	0.63	20	4.2	4.2	1.76	0.00	1.76	1.75
					Olifants at Mozambique	0.0	0.0	0.00	5	0.00	20	0.0	0.0	0.00	0.00	0.00	0.00
			Sub total			**2.4**	**0.9**	**0.17**		**0.67**		**4.5**	**4.5**	**1.85**	**0.00**	**1.85**	**1.84**
Total in Gauteng						**3.9**	**2.1**	**0.30**		**1.20**		**7.8**	**7.9**	**2.99**	**0.00**	**3.00**	**3.01**
Total in Mpumalanga						**34.2**	**18.6**	**2.64**		**7.10**		**63.8**	**64.2**	**30.33**	**3.57**	**33.89**	**33.80**
Total in Northern Province						**4.5**	**1.7**	**0.31**		**1.25**		**8.4**	**8.5**	**3.02**	**0.00**	**3.01**	**3.03**
Total WMA						**42.6**	**22.4**	**3.25**		**9.55**		**80.0**	**80.6**	**36.34**	**3.57**	**39.90**	**39.84**

Water Losses

Water losses in urban areas can be broken down into two components:

Losses in the bulk supply system
Losses in the bulk supply system to an urban area typically range from 3% to 7% of the urban water use, and include losses at purification works due to backwashing of sand filters. The portion of urban water use lost in the bulk supply system is 0,05% of the urban water use within the WMA, which implies a total loss of 3,25 million m^3/a for the WMA.

Losses in the water distribution system
Distribution losses include losses due to leaking pipes and reservoirs. Distribution losses can range from 10% of the urban water use to as high as 30% of the urban water use in places where proper maintenance is not done. Total losses in the distribution systems in the WMA are 9,55 million m^3/a.

Other losses
Unauthorised connections and unmetered water supply can also be considered to be losses. It is difficult to estimate these losses because they would differ depending on each urban area. These losses are not included in the tables.

Return flows

Return flows from urban areas can be broken down into two categories:

Effluent from residential and industrial areas
Effluent generated from residential and industrial areas is directly proportional to the water used. The water use is further dependent on the standard of living and type of industries. All these factors have been taken into consideration when estimating the return flow. The total return flow has been estimated as 39,9 million m^3 /a.

Return flow due to impervious urban areas
Additional rainfall run off is created due to impervious areas created in urban areas. On average one eighth of the urban areas in the WMA are effectively paved and it is assumed that 84% of rain falling on these areas runs off into the river system. The impervious areas in the WMA total 129,5 km^2 and thus the return flow generated from these areas is 3,57 million m^3/a.

5.3.3 Rural

Water Requirements

Rural water users include domestic, subsistence farming, commercial farming and livestock and game users. The rural domestic users generally have rudimentary water supply systems and have a relatively low per capita water use.

Domestic water users are located throughout the area and include the domestic uses of villages, settlements, farming communities and mines. As the assurance of supply of the users differs, the 1:50 year assurances are also shown in the tables.

The water requirement per capita is shown in Table 5.3.3.1.1 and Table 5.3.3.1.2 shows the rural domestic water requirements by drainage area in 1995.

TABLE 5.3.3.1.1: PER CAPITA WATER REQUIREMENTS IN RURAL AREAS IN 1995

User Category	Unit Water Requirements			
	Direct use (ℓ/c/day)	Distribution losses		Total (ℓ/c/day)
		(ℓ/c/day)	(%)	
Rural	30	4	15	34
Advanced rural	75	11	15	86
Developing urban	150	22	15	172
Commercial farming	175	26	15	201

Regarding livestock and game, water requirements corresponding to the distribution of large stock units (livestock and game) and are described in Section 3.5.4. The unit water requirement is 45 ℓ/LSU/day. A table showing the relationship between various livestock and game species and LSU is contained in Appendix F (water requirements).

While livestock farming is a significant activity within the WMA it is an activity that derives its water mainly from groundwater, run of river and from small farm dams.

The available livestock data provided overall numbers for cattle (beef/milk), sheep, goats, horses, donkeys and mules on a primary catchment basis for magisterial districts. Game data was also provided per magisterial district according to species type.

The disaggregation of livestock and game from Magisterial District (MD) resolution to quaternary catchment resolution was based on the uniform spatial distribution of livestock and game within a MD. The actual disaggregation was carried out pro-rata to the area of the quaternary catchments within the MDs. Judgement was, however, exercised where there was additional information.

The LSU for each species was then combined per quaternary. The livestock and game requirement forms part of the rural consumption. The average water use by LSU was taken at 45 ℓ/LSU/day. Water consumption by livestock and game per quaternary is obtained by multiplying the LSUs by 45 ℓ/LSU/day.

It was assumed that livestock data for 1990 can be used to represent 1995 figures as the general consensus is that agriculture has reached a threshold and numbers are unlikely to change much at present. Furthermore the 1990 data represents both mature and immature livestock and game numbers, therefore these numbers can be used to represent the mature livestock and game numbers for 1995.

Another source of data was provided by the Central Statistical Services. They produced a "Census of Agriculture, 1988" on a magisterial district basis and is similar to that provided by "Glen". Data on pigs, horses etc are defined. The main disadvantages of this data are that unlike the "Glen" data it is not presented per primary catchment and game is not broken down into species.

TABLE 5.3.3.1.2: RURAL DOMESTIC WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

Catchment						Rural water requirements (10^6 m^3/a)							Return flow	
Primary		Secondary		Tertiary		Domestic (10^6 m^3 /a)	Subsistence farming [(1)] (10^6 m^3 /a)	Livestock & game [(1)] (10^6 m^3 /a)	Losses		Total (10^6 m^3 /a)	Total at 1:50 yr assurance (10^6 m^3 /a)	Normal (10^6 m^3 /a)	Total at 1:50 yr assurance (10^6 m^3 /a)
No	Description	No	Description	No	Description				10^6 m^3/a	%				
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	0,19	0,00	0,04	0,05	20	0,28	0,26	0,00	0,00
					Olifants at Rietspruit	0,17	0,00	0,20	0,07	20	0,45	0,43	0,00	0,00
					Witbank Dam	0,24	0,00	0,05	0,06	20	0,35	0,32	0,00	0,00
					Olifants at Klein Olifants	0,18	0,00	0,16	0,07	20	0,41	0,39	0,00	0,00
					Olifants at Wilge	0,14	0,00	0,00	0,03	20	0,17	0,16	0,00	0,00
				B12	Middelburg Dam	0,40	0,00	0,71	0,22	20	1,33	1,29	0,00	0,00
					Klein Olifants at Olifants	0,15	0,00	0,32	0,10	20	0,57	0,55	0,00	0,00
			Sub total			**1,48**	**0,00**	**1,48**	**0,59**		**3,55**	**3,40**	**0,00**	**0,00**
		B2	Wilge	B20	Bronkhorstspruit Dam	0,16	0,00	0,39	0,11	20	0,67	0,66	0,00	0,00
					Wilge at Olifants	0,68	0,00	0,59	0,25	20	1,53	1,46	0,00	0,00
			Sub total			**0,85**	**0,00**	**0,98**	**0,37**		**2,20**	**2,12**	**0,00**	**0,00**
		B3	Elands	B31	Rust de Winter Dam	1,01	0,00	0,18	0,24	20	1,43	1,31	0,00	0,00
					Renosterkop Dam	2,57	0,00	0,06	0,53	20	3,16	2,86	0,00	0,00
					Elands at Olifants	1,72	0,00	0,02	0,35	20	2,09	1,89	0,00	0,00
			Olifants Loskop Reach	B32	Loskop Dam	0,20	0,00	0,16	0,07	20	0,43	0,41	0,00	0,00
					Olifants at Bloed	0,31	0,00	0,45	0,15	20	0,92	0,89	0,00	0,00
					Bloed at Olifants	1,16	0,00	0,19	0,27	20	1,62	1,48	0,00	0,00
					Olifants at Elands	6,93	0,00	0,10	1,41	20	8,43	7,60	0,00	0,00
			Sub total			**13,90**	**0,00**	**1,17**	**3,01**		**18,09**	**16,43**	**0,00**	**0,00**
		B4	Steelpoort	B41	Steelpoort at Klip	0,24	0,00	0,26	0,10	20	0,60	0,57	0,00	0,00
					Steynsdrift Dam Proposal	0,46	0,00	0,11	0,11	20	0,68	0,61	0,00	0,00
					Steelpoort at Spekboom	1,45	0,00	0,12	0,31	20	1,89	1,70	0,00	0,00
					Steelpoort at Olifants	1,98	0,00	0,00	0,40	20	2,38	2,12	0,00	0,00
				B42	Spekboom at Steelpoort	0,19	0,00	0,30	0,10	20	0,59	0,56	0,00	0,00
			Sub total			**4,32**	**0,00**	**0,80**	**1,02**		**6,15**	**5,57**	**0,00**	**0,00**
		B5	Middle Olifants	B51	Arabie Dam	1,67	0,00	0,00	0,33	20	2,00	1,81	0,00	0,00
					Olifants at Lepelane	5,65	0,00	0,00	1,13	20	6,78	6,12	0,00	0,00
				B52	Olifants at Blyde Dam	7,64	0,00	0,00	1,53	20	9,17	8,36	0,00	0,00
			Sub total			**14,96**	**0,00**	**0,00**	**2,99**		**17,95**	**16,29**	**0,00**	**0,00**
		B6	Blyde	B60	Blyde at Blyde dam	0,23	0,00	0,00	0,05	20	0,28	0,25	0,00	0,00
					Ohrigstad River	0,26	0,00	0,06	0,06	20	0,38	0,35	0,00	0,00
					Blyde at Olifants	0,04	0,00	0,03	0,01	20	0,09	0,08	0,00	0,00
			Sub total			**0,53**	**0,00**	**0,09**	**0,12**		**0,75**	**0,67**	0,00	0,00
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,20	0,00	0,01	0,04	20	0,26	0,24	0,00	0,00
					Strijdom Tunnel Proposal	2,09	0,00	0,02	0,42	20	2,54	2,34	0,00	0,00
					Olifants at Blyde	0,81	0,00	0,08	0,18	20	1,07	0,97	0,00	0,00
				B72	Olifants at Selati	2,25	0,00	0,08	0,47	20	2,80	2,47	0,00	0,00
					Selati at Olifants	2,52	0,00	0,12	0,53	20	3,17	2,82	0,00	0,00
				B73	Olifants at Letaba	0,03	0,00	0,07	0,02	20	0,12	0,12	0,00	0,00
					Olifants at Mozambique	0,00	0,00	0,00	0,00	20	0,00	0,00	0,00	0,00
			Sub total			**7,91**	**0,00**	**0,39**	**1,66**		**9,96**	**8,96**	**0,00**	**0,00**
Total in Gauteng						**1,36**	**0,00**	**0,50**	**0,37**		**2,23**	**2,07**	**0,00**	**0,00**
Total in Mpumalanga						**15,47**	**0,00**	**3,89**	**3,87**		**23,23**	**21,38**	**0,00**	**0,00**
Total in Northern Province						**27,12**	**0,00**	**0,53**	**5,53**		**33,18**	**29,98**	**0,00**	**0,00**
Total WMA						**43,95**	**0,00**	**4,92**	**9,77**		**58,64**	**53,43**	**0,00**	**0,00**

(1) Direct use excluding losses.

Water losses

Bulk supply and distribution losses
The losses in the rural supply systems vary from 10% of the rural water use to 30% of the rural water use. The total losses in the bulk supply to the rural consumers and the losses in the distribution system are 9,91 million m^3/a for the WMA.

Return Flows

The return flow generated by rural consumers is minimal due to their low water use and can in most cases be taken as zero. The return flow for the WMA is estimated to be zero.

5.4 BULK WATER USE

5.4.1 Introduction

This section deals with industries, mines and thermal power stations having individual bulk raw water supplies, or direct supplies from water boards, or DWAF, as well as mines that receive water from local authorities or water boards. Industries and power stations supplied with potable water by municipalities are included in urban water requirements. Users in the bulk water use category are divided into "Strategic", "Mining" and "Other".

5.4.2 Strategic

Water Requirements

Only the requirements of thermal power stations are considered to be strategic water use. The Olifants WMA contains seven power stations (of which six are operative) with a water demand of 167,56 million m^3/a. The strategic water requirements of the Olifants WMA are shown in Table 5.4.2.1.

Witbank Dam supplies a part of the water required by Duvha power station. The rest of the power stations use imported water from the Komati River Government Water Scheme, the Usutu-Olifants and Usutu-Vaal transfer schemes.

Water Losses

These losses include transmission and purification losses in privately owned bulk supply systems and losses by bulk suppliers of bulk users. Losses are similar to those in urban bulk supply systems. The bulk losses in this WMA are about 7,98 million m^3/a. Losses are included in Table 5.4.2.1.

Return flows

Return flows generated by the power station are zero. Return flows are included in Table 5.4.2.1.

TABLE 5.4.2.1: STRATEGIC WATER REQUIREMENTS

Catchment						On-site strategic use ($10^6 m^3/a$)	Conveyance losses		Total water requirement ($10^6 m^3/a$)	Total water requirement at 1:50 yr assurance ($10^6 m^3/a$)	Normal return flow ($10^6 m^3/a$)	Return flow at 1:50 yr assurance ($10^6 m^3/a$)
Primary		Secondary		Tertiary			$10^6 m^3/a$	%				
No	Description	No	Description	No	Description							
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	78,3	3,91	5	82,2	87,35	0,0	0,0
					Olifants at Rietspruit	0,0	0,00	0	0,00	0,00	0,0	0,0
					Witbank Dam	38,0	1,90	5	39,88	42,39	0,0	0,0
					Olifants at Klein Olifants	0,0	0,00	0	0,00	0,00	0,0	0,0
					Olifants at Wilge	0,0	0,00	0	0,00	0,00	0,0	0,0
				B12	Middelburg Dam	39,6	1,98	5	41,55	44,17	0,0	0,0
					Klein Olifants at Olifants	0,0	0,00	0	0,00	0,00	0,0	0,0
			Sub total			**155,81**	**7,79**		**163,60**	**173,91**	**0,0**	**0,0**
		B2	Wilge	B20	Bronkhorstspruit Dam	0,0	0,00	0	0,00	0,00	0,0	0,0
					Wilge at Olifants	3,8	0,19	5	3,96	4,22	0,0	0,0
			Sub total			**3,77**	**0,19**		**3,96**	**4,22**	**0,0**	**0,0**
		B3	Elands	B31	Rust de Winter Dam	0,0	0,00	0	0,00	0,00	0,0	0,0
					Renosterkop Dam	0,0	0,00	0	0,00	0,00	0,0	0,0
					Elands at Olifants	0,0	0,00	0	0,00	0,00	0,0	0,0
			Olifants - Loskop Reach	B32	Loskop Dam	0,0	0,00	0	0,00	0,00	0,0	0,0
					Olifants at Bloed	0,0	0,00	0	0,00	0,00	0,0	0,0
					Bloed at Olifants	0,0	0,00	0	0,00	0,00	0,0	0,0
					Olifants at Elands	0,0	0,00	0	0,00	0,00	0,0	0,0
			Sub total			**0,00**	**0,00**		**0,00**	**0,00**	**0,0**	**0,0**
		B4	Steelpoort	B41	Steelpoort at Klip	0,0	0,00	0	0,00	0,00	0,0	0,0
					Steynsdrift Dam Proposal	0,0	0,00	0	0,00	0,00	0,0	0,0
					Steelpoort at Spekboom	0,0	0,00	0	0,00	0,00	0,0	0,0
					Steelpoort at Olifants	0,0	0,00	0	0,00	0,00	0,0	0,0
				B42	Spekboom at Steelpoort	0,0	0,00	0	0,00	0,00	0,0	0,0
			Sub total			**0,00**	**0,00**		**0,00**	**0,00**	**0,0**	**0,0**
		B5	Middle Olifants	B51	Arabie Dam	0,0	0,00	0	0,00	0,00	0,0	0,0
					Olifants at Lepelane	0,0	0,00	0	0,00	0,00	0,0	0,0
				B52	Olifants at Bewaarkloof	0,0	0,00	0	0,00	0,00	0,0	0,0
			Sub total			**0,00**	**0,00**		**0,00**	**0,00**	**0,0**	**0,0**
		B6	Blyde	B60	Blyde at Blydedam	0,0	0,00	0	0,00	0,00	0,0	0,0
					Ohrigstad River	0,0	0,00	0	0,00	0,00	0,0	0,0
					Blyde at Olifants	0,0	0,00	0	0,00	0,00	0,0	0,0
			Sub total			**0,00**	**0,00**		**0,00**	**0,00**	**0,0**	**0,0**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,0	0,00	0	0,00	0,00	0,0	0,0
					Strijdom Tunnel Proposal	0,0	0,00	0	0,00	0,00	0,0	0,0
					Olifants at Blyde	0,0	0,00	0	0,00	0,00	0,0	0,0
				B72	Olifants at Selati	0,0	0,00	0	0,00	0,00	0,0	0,0
					Selati at Olifants	0,0	0,00	0	0,00	0,00	0,0	0,0
				B73	Olifants at Letaba	0,0	0,00	0	0,00	0,00	0,0	0,0
					Olifants at Mozambique	0,0	0,00	0	0,00	0,00	0,0	0,0
			Sub total			**0,00**	**0,00**		**0,00**	**0,00**	**0,0**	**0,0**
Total in Gauteng						**1,60**	**0,08**		**1,63**	**1,73**	**0,00**	**0,00**
Total in Mpumalanga						**158,00**	**7,90**		**165,93**	**176,39**	**0,00**	**0,00**
Total in Northern Province						**0,00**	**0,00**		**0,00**	**0,00**	**0,00**	**0,00**
Total WMA						**159,60**	**7,98**		**167,56**	**178,12**	**0,00**	**0,00**

5.4.3 Mining

Water Requirements

Mining activity requires a level of assurance better than 90%. This catchment contains close to two hundred active mines. The Premier Mine, which is situated outside the Olifants basin, receives water from the Wilge River. Appendix D lists all operating mines and highlights the important mines. Water requirements of mines are shown in Table 5.4.3.1.

During 1995 mines used in the order of 90 x 10^6 million m^3 water in the Olifants WMA, of which two-thirds from surface water and the rest from imported and underground water.

Water Losses

These losses include transmission and purification losses in privately owned bulk supply systems and losses by bulk suppliers of bulk users. Losses are similar to those in urban bulk supply systems. The proportion bulk losses in this WMA are about 8,2 million m^3/a. Losses are included in Table 5.4.3.1.

Return Flows

During 1995, return flows from mining operations amounted to about 16,4 million m^3. The return flows impact significantly on both the hydrology and water quality of the Olifants WMA. The impact in terms of quality is generally negative for downstream users. Return flows are included in Table 5.4.3.1.

5.4.4 Other Bulk Users

There are no other non-strategic bulk users in the Olifants WMA.

5.5 NEIGHBOURING STATES

The Olifants River catchment falls within RSA boundaries down to the boundary with Mozambique. No agreement exists between the Republic of South Africa and Mozambique about the required amount of water to be released from the Olifants catchment upstream of the boundary with Mozambique.

The Minister of Water Affairs and Forestry would have to establish a body in consultation with the Cabinet to conclude and implement an international agreement.

TABLE 5.4.3.1: WATER REQUIREMENTS OF MINES

Catchment						Mines with individual bulk supplies*				Total water requirement (10^6 m^3/a)		Return flow (10^6 m^3/a)			
Primary		Secondary		Tertiary		No	On-site bulk use (10^6m^3/a)	Conveyance losses							
No	Description	No	Description	No	Description			(10^6m^3/a)	%	Normal	At 1:50 yr assurance	Surface returns	Ground-water decanting	Total	Total at 1:50 yr assurance
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants		2.6	0.3	10.0	2.9	3.0			0.5	0.54
					Olifants at Rietspruit		1.3	0.1	10.0	1.4	1.5			0.3	0.27
					Witbank Dam		3.5	0.3	10.0	3.8	4.0			0.7	0.72
					Olifants at Klein Olifants		1.7	0.2	10.0	1.9	2.0			0.3	0.36
					Olifants at Wilge		0.9	0.1	10.0	1.0	1.0			0.2	0.18
				B12	Middelburg Dam		1.3	0.1	10.0	1.4	1.5			0.3	0.27
					Klein Olifants at Olifants		0.9	0.1	10.0	1.0	1.0			0.2	0.18
			Sub total				**12.2**	**1.2**		**13.4**	**13.9**	**0.0**	**0.0**	**2.4**	**2.53**
		B2	Wilge	B20	Bronkhorstspruit Dam		1.3	0.1	10.0	1.4	1.4			0.3	0.26
					Wilge at Olifants		4.4	0.4	10.0	4.8	5.0			0.9	0.91
			Sub total				**5.6**	**0.6**		**6.2**	**6.5**	**0.0**	**0.0**	**1.1**	**1.17**
		B3	Elands	B31	Rust de Winter Dam		0.4	0.0	10.0	0.4	0.5			0.1	0.08
					Renosterkop Dam		0.2	0.0	10.0	0.2	0.2			0.0	0.04
					Elands at Olifants		0.2	0.0	10.0	0.2	0.2			0.0	0.04
			Olifants - Loskop Reach	B32	Loskop Dam		0.0	0.0	0.0	0.0	0.0			0.0	0.00
					Olifants at Bloed		0.0	0.0	0.0	0.0	0.0			0.0	0.00
					Bloed at Olifants		0.0	0.0	0.0	0.0	0.0			0.0	0.00
					Olifants at Elands		0.0	0.0	10.0	0.0	0.0			0.0	0.00
			Sub total				**0.8**	**0.1**		**0.9**	**0.9**	**0.0**	**0.0**	**0.2**	**0.17**
		B4	Steelpoort	B41	Steelpoort at Klip		6.6	0.7	10.0	7.2	7.5			1.3	1.36
					Steynsdrift Dam Proposal		0.7	0.1	10.0	0.8	0.8			0.1	0.15
					Steelpoort at Spekboom		6.6	0.7	10.0	7.2	7.5			1.3	1.36
					Steelpoort at Olifants		0.0	0.0	0.0	0.0	0.0			0.0	0.00
				B42	Spekboom at Steelpoort		0.7	0.1	10.0	0.8	0.8			0.1	0.15
			Sub total				**14.6**	**1.5**		**16.1**	**16.7**	**0.0**	**0.0**	**2.9**	**3.03**
		B5	Middle Olifants	B51	Arabie Dam		0.0	0.0	0.0	0.0	0.0			0.0	0.00
					Olifants at Lepelane		1.2	0.1	10.0	1.3	1.3			0.2	0.24
				B52	Olifants at Bewaarkloof		0.3	0.0	10.0	0.3	0.3			0.1	0.06
			Sub total				**1.5**	**0.1**		**1.6**	**1.7**	**0.0**	**0.0**	**0.3**	**0.30**
		B6	Blyde	B60	Blyde at Blyde Dam		0.4	0.0	10.0	0.4	0.4			0.1	0.08
					Ohrigstad River		0.0	0.0	0.0	0.0	0.0			0.0	0.00
					Blyde at Olifants		0.0	0.0	0.0	0.0	0.0			0.0	0.00
			Sub total				**0.4**	**0.0**		**0.4**	**0.4**	**0.0**	**0.0**	**0.1**	**0.08**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal		0.0	0.0	0.0	0.0	0.0			0.0	0.00
					Strijdom Tunnel Proposal		9.4	0.9	10.0	10.3	10.7			1.9	1.95
					Olifants at Blyde		0.0	0.0	0.0	0.0	0.0			0.0	0.00
				B72	Olifants at Selati		9.4	0.9	10.0	10.3	10.7			1.9	1.94
					Selati at Olifants		28.1	2.8	10.0	31.0	32.3			5.6	5.88
				B73	Olifants at Letaba		0.0	0.0	0.0	0.0	0.0			0.0	0.00
					Olifants at Mozambique		0.0	0.0	0.0	0.0	0.0			0.0	0.00
			Sub total				**46.9**	**4.7**		**51.6**	**53.7**	**0.0**	**0.0**	**9.4**	**9.77**
Total in Gauteng							**2.51**	**0.25**		**2.76**	**2.87**	**0.00**	**0.00**	**0.50**	**0.52**
Total in Mpumalanga							**29.31**	**2.93**		**32.25**	**33.45**	**0.00**	**0.00**	**5.86**	**6.08**
Total in Northern Province							**50.20**	**5.02**		**55.21**	**57.50**	**0.00**	**0.00**	**10.04**	**10.46**
Total WMA							**82.02**	**8.20**		**90.22**	**93.82**	**0.00**	**0.00**	**16.40**	**17.06**

* Includes mines supplied individually by Water Boards or DWAF

Note: There are no mines that are supplied by municipalities in the Olifants WMA.

5.6 IRRIGATION

5.6.1 General

Comprehensive detailed observed data on water use is not available at this stage, therefore irrigation water requirements were estimated from available information on irrigated areas, typical quotas and assurances of supply.

The water requirement for irrigation was calculated by means of the irrigation pre-processor of the National Water Balance Model and was based on the following well-known equation.

$$IRR\ (1 - CLI) = AIR * (EVT * CRC - REF) * 0.001 * LER/IRC$$

Where:
IRR: Irrigation water requirement (10^6 m^3/m)
AIR: Irrigation area (km^2)
EVT: Evapotranspiration (A-Pan equivalent in mm/m)
CRC: Crop factor
REF: Effective rainfall (mm/m)
LER: Leaching factor
IRC: Irrigation efficiency
CLI: Irrigation conveyance loss (Proportion of IRR)

The processor calculates the irrigation water requirement for every crop separately for each of the 12 months, using the appropriate quaternary mean monthly data obtained from the CCWR. This seemingly detailed methodology is essential to eliminate considerable errors that can be made by combining crop factors. The final annual water requirements are then obtained by simple summation of the various crop water requirements.

5.6.2 Water User Patterns

The Olifants WMA generally has a moderate Mean Annual Precipitation (MAP) (except the Blyde River catchment area) and a high mean annual evaporation. An additional water source is thus important for successful crop farming. There are various irrigation schemes (government and private) throughout the WMA and farmers make use of drip, micro, sprinkler, center pivots and flood irrigation to irrigate their crops. Water is pumped from large dams, smaller farm dams, weirs, canals, rivers and the groundwater aquifer for the necessary crop demand.

Irrigation water requirements in 1995 are shown in Table 5.6.2.1 and Figure 5.6.2.1. The irrigation areas are normally concentrated around the main rivers.

TABLE 5.6.2.1: IRRIGATION WATER REQUIREMENTS

Catchment						Field edge water requirement ($10^6m^3/a$)	Total conveyance losses		Total water requirements		Return flows ($10^6m^3/a$)				
Primary		Secondary		Tertiary							Leaching beyond root zone	Add return flow from lands	From convey -ance losses	Total return flow	
No	Description	No	Description	No	Description		$10^6m^3/a$	%	($10^6m^3/a$)	1:50 yr assurance (10^6 m^3 /a)				Normal	At 1:50 yr assu-rance
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	8.7	0.0	0.0	8.7	7.2	1.02	0.11	0.00	1.1	0.7
					Olifants at Rietspruit	1.8	0.0	2.0	1.8	1.5	0.21	0.02	0.02	0.0	0.2
					Witbank Dam	1.0	0.0	0.0	1.0	0.9	0.12	0.01	0.00	0.1	0.1
					Olifants at Klein Olifants	6.0	0.0	0.0	6.0	5.0	0.70	0.08	0.00	0.8	0.5
					Olifants at Wilge	3.6	0.0	0.0	3.6	3.0	0.41	0.04	0.00	0.5	0.3
				B12	Middelburg Dam	5.5	0.0	0.0	5.5	4.5	0.64	0.07	0.00	0.7	0.5
					Klein Olifants at Olifants	1.8	0.0	0.0	1.8	1.5	0.21	0.02	0.00	0.2	0.1
			Sub total			**28.4**	**0.0**		**28.4**	**23.6**	**3.31**	**0.35**	**0.02**	**3.7**	**2.4**
		B2	Wilge	B20	Bronkhorstspruit Dam	4.0	0.0	0.0	4.0	3.3	0.43	0.05	0.00	0.5	0.3
					Wilge at Olifants	20.0	0.0	0.0	20.0	16.6	2.14	0.23	0.01	2.4	1.7
			Sub total			**23.9**	**0.0**		**23.9**	**19.8**	**2.57**	**0.28**	**0.01**	**2.9**	**2.0**
		B3	Elands	B31	Rust de Winter Dam	6.1	1.0	15.0	7.0	5.7	0.56	0.06	0.52	1.1	0.6
					Renosterkop Dam	61.9	10.7	15.0	71.1	57.7	6.90	0.74	5.33	13.0	5.8
					Elands at Olifants	6.8	1.2	15.0	7.8	6.4	0.79	0.08	0.59	1.5	0.6
			Olifants - Loskop Reach	B32	Loskop Dam	7.7	0.8	10.0	8.4	7.0	0.71	0.08	0.42	1.2	0.7
					Olifants at Bloed	48.7	8.4	15.0	56.1	45.4	4.50	0.48	4.20	9.2	4.5
					Bloed at Olifants	7.8	1.3	15.0	8.9	7.2	0.67	0.07	0.67	1.4	0.7
					Olifants at Elands	83.8	14.4	15.0	96.3	78.1	7.61	0.81	7.22	15.6	7.8
			Sub total			**222.7**	**37.9**		**255.7**	**207.4**	**21.74**	**2.32**	**18.95**	**43.0**	**20.7**
		B4	Steelpoort	B41	Steelpoort at Klip	5.9	0.6	10.0	6.5	5.2	0.55	0.06	0.32	0.9	0.5
					Steynsdrift Dam Proposal	16.0	1.3	7.0	17.2	13.9	1.49	0.16	0.63	2.3	1.4
					Steelpoort at Spekboom	22.5	2.0	8.0	24.4	19.8	2.10	0.23	1.01	3.3	2.0
					Steelpoort at Olifants	1.0	0.1	5.0	1.1	0.9	0.09	0.01	0.03	0.1	0.1
				B42	Spekboom at Steelpoort	22.3	2.4	1.0	24.5	19.8	2.07	0.22	1.21	3.5	2.0
			Sub total			**67.6**	**6.4**		**73.5**	**59.6**	**6.30**	**0.68**	**3.20**	**10.2**	**6.0**
		B5	Middle Olifants	B51	Arabie Dam	4.1	0.7	15.0	4.7	3.8	0.39	0.04	0.36	0.8	0.4
					Olifants at Lepelane	68.6	11.8	15.0	78.9	64.0	7.27	0.78	5.92	14.0	6.4
				B52	Olifants at Bewaarkloof	4.8	0.8	15.0	5.5	4.7	0.45	0.05	0.41	0.9	0.5
			Sub total			**77.5**	**13.4**		**89.2**	**72.5**	**8.11**	**0.87**	**6.69**	**15.7**	**7.3**
		B6	Blyde	B60	Blyde at Blyde Dam	2.3	0.4	15.0	2.7	2.2	0.26	0.03	0.20	0.5	0.2
					Ohrigstad River	26.4	4.5	15.0	30.3	24.6	2.53	0.27	2.27	5.1	2.5
					Blyde at Olifants	17.9	3.1	15.0	20.5	18.0	1.90	0.20	1.54	3.6	1.8
			Sub total			**46.6**	**8.0**		**53.5**	**44.7**	**4.69**	**0.50**	**4.01**	**9.2**	**4.5**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	6.1	1.1	15.0	7.0	5.7	0.57	0.06	0.53	1.2	0.6
					Strijdom Tunnel Proposal	7.6	1.3	15.0	8.7	7.1	0.71	0.08	0.66	1.5	0.7
					Olifants at Blyde	9.1	1.6	15.0	10.5	8.5	0.85	0.09	0.79	1.7	0.9
				B72	Olifants at Selati	6.2	1.1	15.0	7.1	6.2	0.58	0.06	0.54	1.2	0.6
					Selati at Olifants	26.1	4.5	15.0	30.0	26.3	2.39	0.26	2.25	4.9	2.6
				B73	Olifants at Letaba	5.2	0.9	15.0	6.0	5.2	0.49	0.05	0.45	1.0	0.5
					Olifants at Mozambique	0.0	0.0	0.0	0.0	0.0			0.00	0.0	
			Sub total			**60.4**	**10.4**		**69.4**	**59.0**	**5.6**	**0.6**	**5.2**	**11.4**	**5.9**
Total in Gauteng						**21.60**	**2.08**		**23.42**	**19.15**	**2.30**	**0.20**	**1.0**	**3.6**	**1.9**
Total in Mpumalanga						**305.28**	**40.19**		**340.55**	**277.23**	**29.80**	**3.20**	**20.1**	**52.8**	**27.7**
Total in Northern Province						**200.23**	**33.94**		**229.77**	**190.30**	**20.20**	**2.20**	**17.0**	**39.4**	**19.0**
Total WMA						**527.11**	**76.21**		**593.74**	**486.68**	**52.30**	**5.60**	**38.1**	**95.8**	**48.7**

** River and communal canal losses where water is released from dams.

5.6.3 Water Losses

All the water losses associated with irrigation methods are included in the field edge water requirement. Irrigation methods that are used in the WMA include, drip, micro, centre pivot, overhead sprinkler and flood irrigation.

Assumed canal or river losses include losses due to leaking of canals and normal losses from rivers for the bulk supply of water to farmers. Distribution losses can be very high in places where proper maintenance is not done. These losses can be as high as 30%. On farm conveyance losses include conveyance losses from river, farm dam or communal canal to the field edge. The total conveyance losses as shown in Table 5.6.2.1 is not divided into canal and on farm losses and can be as high as 15%.

5.6.4 Return Flows

Return flows as a result of irrigation can be broken down into two components:

Return flow due to leaching beyond the root zone
Irrigation water not used by the plant is returned to the groundwater or streams due to leaching and is largely dependent on the soil characteristics and water quality. The total return flow due to leaching is unknown for the WMA.

Additional return flow
The return flow from irrigation can further increase due to the increased rainfall runoff due to the higher level of soil moisture when compared with the natural state. This increased return flow can be calculated for a seasonal or yearly crop. No figure is available at this time for additional return flow generated in the Olifants WMA.

5.7 DRYLAND

Sugarcane
No sugarcane is grown in the WMA and therefore no streamflow reduction occurs in this regard.

5.8 WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

Rivers and wetlands

The losses in all the major wetlands and river channels given in WR90 were used unless more accurate data have come available. Losses due to aquifers are not considered to be a loss unless these occur where the surface water storage capacity is low. In this instance the aquifer recharge could impact on the total utilizable water resource at a specific point in time. Losses in rivers traversing arid areas are substantial especially if they are used to convey water to downstream users. These channel losses have been estimated separately if the losses given in WR90 were considered to be too low, by multiplying the net class A pan evaporation with the area of the riverine strip.

Dams

Evaporation losses from the reservoir surface depend on net evaporation rates and the surface area exposed. The critical evaporation losses occur during the critical drought, which establishes the yield of the system. The total net evaporation losses during this period for the 30 major dams in the WMA have been estimated to be 130,9 million m^3/a.

Water losses from rivers, wetlands and dams are shown in Table 5.8.1.

5.9 AFFORESTATION

The water use by commercial afforestation is based on the so-called CSIR curves (CSIR, 1995), which have replaced the so-called Van der Zel curves that were used for the preparation of WR90 (Midgley, et al., 1994). The Van der Zel curves were considered to be too simplistic compared to the CSIR curves, which now take the species, age and site conditions into account in estimating the stream flow reductions. A study was undertaken (Ninham Shand, 1999) to provide adjusted naturalised flow sequences for the Water Situation Assessment Model (WSAM) (Department of Water Affairs and Forestry, 2000) 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).

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.

TABLE 5.8.1: WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

Catchment						Losses from rivers and wetlands	Evaporation losses from dams	Total
Primary		Secondary		Tertiary				
No	Description	No	Description	No	Description	($10^6m^3/a$)	($10^6m^3/a$)	($10^6m^3/a$)
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	0,0	6,6	6,6
					Olifants at Rietspruit	0,0	0,7	0,7
					Witbank Dam	0,0	7,8	7,8
					Olifants at Klein Olifants	0,0	2,2	2,2
					Olifants at Wilge	0,0	0,2	0,2
				B12	Middelburg Dam	0,0	3,7	3,7
					Klein Olifants at Olifants	0,0	5,0	5,0
			Sub total			**0,0**	**26,3**	**26,3**
		B2	Wilge	B20	Bronkhorstspruit Dam	0,0	7,4	7,4
					Wilge at Olifants	0,0	6,7	6,7
			Sub total			**0,0**	**14,1**	**14,1**
		B3	Elands	B31	Rust de Winter Dam	0,0	3,8	3,8
					Renosterkop Dam	0,0	30,2	30,2
					Elands at Olifants	0,0	1,6	1,6
			Olifants - Loskop Reach	B32	Loskop Dam	0,0	17,2	17,2
					Olifants at Bloed	0,0	2,1	2,1
					Bloed at Olifants	0,0	0,1	0,1
					Olifants at Elands	0,0	7,2	7,2
			Sub total			**0,0**	**62,1**	**62,1**
		B4	Steelpoort	B41	Steeloort at Klip	0,0	1,0	1,0
					Steynsdrift Dam Proposal	0,0	0,2	0,2
					Steelpoort at Spekboom	0,0	2,4	2,4
					Steelpoort at Olifants	0,0	0,0	0,0
				B42	Spekboom at Steelpoort	0,0	0,4	0,4
			Sub total			**0,0**	**4,0**	**4,0**
		B5	Middle Olifants	B51	Arabie Dam	0,0	10,2	10,2
					Olifants at Lepelane	0,0	3,3	3,3
				B52	Olifants at Bewaarkloof	0,0	1,1	1,1
			Sub total			**0,0**	**14,6**	**14,6**
		B6	Blyde	B60	Blyde at Blyde Dam	0,0	0,0	0,0
					Ohrigstad River	0,0	2,4	2,4
					Blyde at Olifants	0,0	0,5	0,5
			Sub total			**0,0**	**3,0**	**3,0**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,0	0,0	0,0
					Strijdom Tunnel Proposal	0,0	0,0	0,0
					Olifants at Blyde	0,0	0,9	0,9
				B72	Olifants at Selati	0,0	1,5	1,5
					Selati at Olifants	0,0	2,5	2,5
				B73	Olifants at Letaba	0,0	2,0	2,0
					Olifants at Mozambique	0,0	0,0	0,0
			Sub total			**0,0**	**6,9**	**6,9**
Total in Gauteng						**0,0**	**11,2**	**11,2**
Total in Mpumalanga						**0,0**	**84,3**	**84,3**
Total in Northern Province						**0,0**	**35,4**	**35,4**
Total WMA						**0,0**	**130,9**	**130,9**

The average annual water use by afforestation in the Olifants WMA is estimated at 54,2 million m^3, causing a reduction of 3,38 million m^3 in the 1:50 year system yield. Afforestation is concentrated largely in the Blyde River catchment, which uses about 80% of the abovementioned value. Table 3.5.1.1 contains areas of afforestation per key point area and Figure 3.5.1.1 depicts the land use categories.

Table 5.9.1 gives water use by afforestation at the selected keypoints.

5.10 HYDROPOWER AND PUMPED STORAGE

There are no hydropower or pumped storage schemes in the Olifants WMA and therefore the associated water requirements are zero. The development of the Steelpoort pumped storage is expected between 2012 and 2014.

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.

The extent of water use by Alien Vegetation is shown in Figure 5.11.1 and their reducing effects of the normal run-off are shown in Table 5.11.1.

TABLE 5.9.1: WATER USE BY AFFORESTATION IN 1995

Catchment						Average water use		Reduction in system 1:50 yr yield	
Primary		Secondary		Tertiary		($10^6m^3/a$)	(mm/a)	($10^6m^3/a$)	(mm/a)
No	Description	No	Description	No	Description				
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	0,0	0,0	0,00	0,00
					Olifants at Rietspruit	0,0	0,0	0,00	0,00
					Witbank Dam	0,0	0,0	0,00	0,00
					Olifants at Klein Olifants	0,0	0,0	0,01	0,02
					Olifants at Wilge	0,0	0,0	0,00	0,00
				B12	Middelburg Dam	0,3	0,2	0,18	0,11
					Klein Olifants at Olifants	0,7	0,9	0,36	0,45
			Sub total			**1,0**	**1,1**	**0,55**	**0,58**
		B2	Wilge	B20	Bronkhorstspruit Dam	0,0	0,0	0,00	0,00
					Wilge at Olifants	0,0	0,0	0,00	0,00
			Sub total			**0,0**	**0,0**	**0,00**	**0,00**
		B3	Elands	B31	Rust de Winter Dam	0,0	0,0	0,00	0,00
					Renosterkop Dam	0,0	0,0	0,00	0,00
					Elands at Olifants	0,0	0,0	0,00	0,00
			Olifants - Loskop Reach	B32	Loskop Dam	0,0	0,0	0,00	0,00
					Olifants at Bloed	0,3	0,2	0,12	0,09
					Bloed at Olifants	0,0	0,0	0,00	0,00
					Olifants at Elands	0,0	0,0	0,00	0,00
			Sub total			**0,3**	**0,2**	**0,12**	**0,09**
		B4	Steelpoort	B41	Steelpoort at Klip	2,3	1,5	0,53	0,34
					Steynsdrift Dam Proposal	0,0	0,0	0,00	0,00
					Steelpoort at Spekboom	0,0	0,0	0,01	0,01
					Steelpoort at Olifants	0,0	0,0	0,00	0,00
				B42	Spekboom at Steelpoort	2,8	1,3	0,76	0,36
			Sub total			**5,1**	**2,8**	**1,30**	**0,71**
		B5	Middle Olifants	B51	Arabie Dam	0,0	0,0	0,00	0,00
					Olifants at Lelelane	0,0	0,0	0,00	0,00
				B52	Olifants at Bewaarkloof	0,5	0,2	0,16	0,05
			Sub total			**0,5**	**0,2**	**0,16**	**0,05**
		B6	Blyde	B60	Blyde at Blyde Dam	41,2	48,4	0,00	0,00
					Ohrigstad River	2,2	1,7	1,24	0,94
					Blyde at Olifants	0,0	0,0	0,00	0,00
			Sub total			**43,3**	**50,1**	**1,24**	**0,94**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,1	0,2	0,00	0,00
					Strijdom Tunnel Proposal	1,1	0,6	0,00	0,00
					Olifants at Blyde	0,0	0,0	0,00	0,00
				B72	Olifants at Selati	0,0	0,0	0,00	0,00
					Selati at Olifants	0,0	0,0	0,00	0,00
				B73	Olifants at Letaba	2,7	0,6	0,00	0,00
					Olifants at Mozambique	0,0	0,0	0,00	0,00
			Sub total			**4,0**	**1,5**	**0,00**	**0,00**
Total in Gauteng						**0,0**	**0,0**	**0,00**	**0,00**
Total in Mpumalanga						**50,4**	**54,2**	**3,05**	**2,19**
Total in Northern Province						**3,8**	**1,6**	**0,33**	**0,18**

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					
No	Description	No	Description	No	Description	($10^6m^3/a$)	(mm/a)	($10^6m^3/a$)	(mm/a)
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	0,0	0,0	0,00	0,00
					Olifants at Rietspruit	0,0	0,0	0,00	0,00
					Witbank Dam	0,0	0,0	0,00	0,01
					Olifants at Klein Olifants	0,0	0,1	0,02	0,05
					Olifants at Wilge	0,0	0,0	0,00	0,00
				B12	Middelburg Dam	0,0	0,0	0,02	0,01
					Klein Olifants at Olifants	0,0	0,0	0,02	0,02
			Sub total			**0,1**	**0,2**	**0,06**	**0,09**
		B2	Wilge	B20	Bronkhorstspruit Dam	0,5	0,4	0,35	0,28
					Wilge at Olifants	1,3	0,4	0,57	0,19
			Sub total			**1,8**	**0,8**	**0,92**	**0,47**
		B3	Elands	B31	Rust de Winter Dam	0,3	0,3	0,19	0,17
					Renosterkop Dam	1,3	0,5	1,55	0,60
					Elands at Olifants	4,3	1,8	1,39	0,58
			Olifants - Loskop Reach	B32	Loskop Dam	0,0	0,0	0,04	0,05
					Olifants at Bloed	0,1	0,0	0,03	0,02
					Bloed at Olifants	0,6	0,7	0,07	0,08
					Olifants at Elands	0,2	0,1	0,11	0,06
			Sub total			**6,8**	**3,5**	**3,39**	**1,56**
		B4	Steelpoort	B41	Steelpoort at Klip	0,1	0,1	0,03	0,02
					Steynsdrift Dam Proposal	0,3	0,5	0,05	0,07
					Steelpoort at Spekboom	1,9	0,9	1,00	0,46
					Steelpoort at Olifants	2,6	4,1	0,00	0,00
				B42	Spekboom at Steelpoort	19,4	9,3	5,37	2,57
			Sub total			**24,3**	**14,8**	**6,45**	**3,12**
		B5	Middle Olifants	B51	Arabie Dam	0,5	0,6	0,66	0,73
					Olifants at Lepelane	20,0	3,4	9,99	1,71
				B52	Olifants at Bewaarkloof	5,2	1,7	1,76	0,59
			Sub total			**25,7**	**5,8**	**12,41**	**3,03**
		B6	Blyde	B60	Blyde at Blyde Dam	33,6	39,5	0,00	0,00
					Ohrigstad River	12,8	9,7	7,30	5,55
					Blyde at Olifants	0,6	0,9	0,31	1,03
			Sub total			**47,0**	**50,1**	**7,61**	**6,58**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	1,4	2,4	0,00	0,00
					Strijdom Tunnel Proposal	9,2	5,1	0,00	0,00
					Olifants at Blyde	2,9	4,4	0,67	1,03
				B72	Olifants at Selati	0,0	0,0	0,00	0,00
					Selati at Olifants	0,4	0,2	0,09	0,04
				B73	Olifants at Letaba	2,3	0,5	0,00	0,00
					Olifants at Mozambique	0,0	0,0	0,00	0,00
			Sub total			**16,2**	**12,6**	**0,77**	**1,07**
Total in Gauteng						**1,1**	**0,5**	**0,66**	**0,35**
Total in Mpumalanga						**73,2**	**62,7**	**15,22**	**9,29**
Total in Northern Province						**47,8**	**24,5**	**15,73**	**6,28**
Total WMA						**122,1**	**87,8**	**31,61**	**15,92**

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 emphasized, 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 unrecognized by many water users. South Africa is a developing country that is water stressed and requires improved management of its limited water resources.

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

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

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

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

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

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

This section describes the National Water Conservation and Demand Management Objectives that will lead to the development of action plans to be implemented by the various water institutions. The needs and opportunities for the implementation of water conservation are described, as are some of the important principles on water conservation and demand management. This section also describes the platform on which the National Water Conservation and Demand Management Strategy will be based. This National Strategy Framework will also be used to develop the functions of the Directorate: Water Conservation within the Department of Water Affairs and Forestry and the functions of other departments and other water institutions. It is also intended that those principles will assist the water industry to comprehensively implement water conservation and demand management.

5.12.2 Background

Water resources and supply

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

Environment

Environmental degradation and the prevention thereof are 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

Of the total quantity of water that are supplied to many of the urban areas it is estimated that up to 50% is not accounted for. This unaccounted for water consists of a combination of reticulation system leaks, unauthorized 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 water use in the Olifants Water Management Area. Irrigation losses are often quite significant and it is estimated that often no more than 80% 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 0,38% of total water use in the Olifants WMA. 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 minimize 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 Management Strategy is to fulfill the requirements made through the legislation and to utilize the opportunities created through the legislation to develop comprehensive policies and to identify and develop regulations.

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

Water Services Act

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

National Water Act

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

Codes of Practice

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

5.12.4 The Role of Water Conservation and Demand Management

Security of supply

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

With the current growth of water requirements it is estimated that unless water conservation and sustainable development policies are implemented, South Africa will utilize 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-utilization 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, which 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.
- Minimizing 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 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 hosepipe 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-1980's 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 Olifants 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.

5.13 WATER ALLOCATIONS

5.13.1 Introduction

As described in Section 3.4 of the report, numerous allocations of water rights have been made in the past. In Section 5.2.2.9 of the ToR, "existing water allocations and compensation releases" are listed as water requirements. However, for the purpose of this study distinction should be made between Allocations and Compensation Releases. The latter have been included as a demand in yield calculations (where applicable), whereas allocations are legal entitlements which do not necessarily reflect actual usage.

5.13.2 Allocations and Permits Issued Under the Old Water Act (Act 54 of 1956)

The following types of permits and allocations are considered:

- Government Water Works:
  Section 63. Determination of areas to be irrigated from Government water works.
  In terms of sub-section 63 (2)(a) and (b), the extent of the land which may be irrigated and the quantity of water which may be supplied, are determined.

- Allocations from Government water works:
  A Government water works is established in terms of section 56. In sub-section 56(3), the Minister may supply or distribute water to any person, including departments of State, SA Transport Services and any provincial administration.

- Allocations in Government Water Control Areas (GWCA):
  A GWCA is declared in terms of section 59 and the control and use of public water in a GWCA is set out in section 62. In terms of sub-section (2F), the Minister shall publish in the Gazette a list of all the pieces of land in respect of which an allocation was made, stating the area which is permitted to be irrigated and the quantity of water which may be used.

- Allocations in Subterranean Government Water Control Areas (SGWCA):
  A SGWCA is declared in terms of section 28. In terms of section 32A, the Minister shall publish in the Gazette a list of all the pieces of land in respect of which permission to use water is granted, or (in terms of section 32B) a list of allocations made.

- Use of water for industrial purposes: Section 12
  No person shall use more than 150 m³/day without a permit, issued in terms of the regulations published under section 26.

- Water care works: Section 12A
  No person shall erect or enlarge a water care works without a permit, issued in terms of the regulations published under section 26.

- Purification and disposal of water used for industrial purposes and effluent: Section 21
  Any person shall purify or treat water used, in accordance with the Minister's requirements as prescribed by notice in the Gazette from time to time. The treated effluent shall be discharged as required by regulations published under section 26.

  The allocation made and permits issued, which could be obtained for the Olifants WMA are shown in the tables below.

5.13.3 Water Control Areas in the Water Management Area

Scheduling and quotas for Government Water Control Areas are shown in Table 5.13.3.1. It should be noted that the Gazetting of the allocations in GWCA's had been achieved for only a relatively small number of the proclaimed control areas.

The GWCA's in the WMA area listed below:

Blyde River
Klaserie River
Loskop
Loskop Dam Catchment
Mapochs
Ohrigstad River
Olifants River (Lowveld)
Olifants River (Phalaborwa)
Rooikraal
Rust de Winter
Sekhukhuneland (Olifants River)
Vyehoeksloop
Waterval River

There is no Subterranean Government Water Control Area in the WMA.

Scheduling and permits for Government water works are shown in Table 5.13.3.2. Allocations from Government water works are given in Table 5.13.3.3.

5.13.4 Permits and Other Allocations

Details of industrial, mining and effluent permits in terms of Articles 12, 12B and 21 are available from an old, existing database at DWAF, that may not be complete, since older and more recent permits were probably not entered into the electronic database.

However,data for all catchments except primary catchments A and B (including the Olifants River catchment area), are available in this database and therefore no information are given in this report.

TABLE 5.13.3.1: ARTICLE 62 – SCHEDULING AND QUOTAS IN GOVERNMENT WATER CONTROL AREAS

Water Control Area	Quaternary * Catchments	Scheduling ** (Ha)	Quota (m^3/ha/a)	Allocation ($10^6 m^3$/a) **
Rooikraal GWCA	B32E	Unknown	Unknown	Unknown
Loskop Dam Catchment GWCA	B11A-L,B12A-E, B20A-J,B32A	Unknown	6 100	Unknown
Rust de Winter GWCA	B31C,D	Unknown	Unknown	Unknown
Ohrigstad GWCA	B60E,F,G,H	4 091	7 000	28,6
(Upper) Blyde River GWCA	B60A,B,C,D	2 374	4 510	10,1
Blyde River GWCA (Blyde River Irrigation District)	B60J	7 889		

* All quaternaries that the area covers.
** Totals for the whole area only.

TABLE 5.13.3.2: ARTICLE 63 - SCHEDULING AND QUOTAS FROM GOVERNMENT WATER WORKS

Scheme	Quaternary * Catchments	Scheduling ** (ha)	Quota (m^3/ha/a)	Allocation (10^6 m^3/a) **
Loskop GWS	B31H,J B32A,D,H,J B51B,C,E	16 289	7 700	125,4
Rust de Winter GWS	B31C,D	1 871 #	7 000	13,1
Klaserie GWS	B73A,B	1 047	4 017	10,362

* All quaternaries in which the scheme lies.
** Totals for the whole scheme only.
# Area calculated from allocation and quota.

TABLE 5.13.3.3: ARTICLE 56(3) - ALLOCATIONS FROM GOVERNMENT WATER SCHEMES

Scheme	Allocation (10^6 m^3/a)**					
	Household & Stock Watering	**Municipalities & Water Boards**	**Bulk Strategic**	**Bulk Mining**	**Irrigation**	**Total**
Loskop Dam Catchment (Bronkhorstspruit Dam)	0,23	44,85	3,0	0,01	0,65	48,74
Olifants River (Loskop Dam)	6,7	28,1	-	-	1,2	36,0
Olifants River (Lowveld – beyond confluence of Blyde River)	-	0,2	-	-		0,2
Watervals River (Buffelskloof Dam)	-	-	-	-	17,5	17,5
Blyde River (Blyderivierspoort Dam)	3,66	66,25	-	-	-	69,92
Mapochsgronde (Vlugkraal Dam)	-	-	-	-	0,015	0,015

* All quaternaries in which the scheme lies.
** Totals for the whole scheme only.

5.13.5 Allocations in Relation to Water Requirements and Availability

When evaluating the incomplete information about the existing allocations from water resources in the Olifants WMA, and comparing allocations to the 1:50 year yield as listed in Table 6.1.1, the following observations are made:

- The Rust de Winter Dam has a higher yield than the allocations from it.
- The allocations made from Bronkhorstspruit Dam by far exceed its firm yield.
- Almost the full yield of the Loskop Dam is allocated with Article 63 and Article 56(3) allocations.
- The Article 56(3) allocations from Buffelskloof Dam seem to exceed the available yield in that subcatchment.
- The Blyderivierspoort Dam has enough yield for both allocations for irrigation and water released for use by the Phalaborwa Water Board.
- The allocations in the Klaserie GWS compares well with the 1:50 year yield of the Klaserie (Jan Wassenaar) Dam, with some of the yield still available.

The irrigation requirements (Table 5.6.2.1) compared to the irrigation permits show the following:

- A large irrigation requirement exists in the secondary catchment B3 (the Elands River subcatchment and the "Loskop Reach" of the Olifants River). Permits for this area amount to about 84% of the estimated1:50 year irrigation requirement.
- Permits from the Buffelskloof Dam in the Steelpoort sub-catchment are close the 1:50 year irrigation requirement.
- The permits from Blyderivierspoort Dam and Ohrigstad Dam exceed the estimated irrigation requirement.
- The irrigation requirement at the Klaserie Dam seems to be less than the permits allocated.

5.14 EXISTING WATER TRANSFERS

5.14.1 Introduction

Water transfers out of a quaternary catchment are a water requirement from the catchment, while water transfers into a catchment represent a resource or source of supply for the catchment. Water transfers to augment the supply of water for urban, industrial and agricultural use are categorized as follows:

- Transfers to and from neighbouring states.
- Transfers between Water Management Areas (e.g. Usutu-Olifants transfer).
- Transfers within WMAs are transfers between and within quaternary catchments within a WMA.

The Olifants WMA receives water from the following WMAs:

- Inkomati
- Upper Vaal
- Usutu to Mhlatuze
- Levuvhu/Letaba

The Olifants WMA transfers water to the Crocodile West and Marico WMA (i.e. 5 million m^3/a) and in the Olifants-Sand Transfer Scheme (established only in 1997) water is transferred into the Limpopo WMA.

Inter-WMA transfers are listed in Table 5.14.3.1. The significant within WMA transfers are listed in Table 5.14.4.1. A full list of all transfers is given in Appendix E.

5.14.2 Transfers to and from Neighbouring States

There are no transfers to and from neighbouring states.

5.14.3 Inter-WMA Transfers

The major schemes have been previously briefly described in section 4.2 and all transfers for 1995 are listed in Table 5.14.3.1.

During 1995 approximately 370 million m^3 of water was imported from various WMAs to augment the water resources of the Olifants WMA. The most significant imports were to power stations in the Upper Olifants catchment from the following schemes:

- Komati River Government Water Scheme
- Usutu-Olifants transfer scheme
- Usutu-Vaal transfer scheme

During 1995 approximately 5 million m^3 of water was exported from the Olifants WMA to the Crocodile and West Marico WMA.

The transfer from the Olifants-Sand Scheme is excluded from the total value because it only came into operation in 1997.

TABLE 5.14.3.1: INTER-WMA TRANSFERS UNDER 1995 DEVELOPMENT CONDITIONS

Description of Transfer	Source WMA and quaternary	Receiving WMA and quaternary	Transfer Quantity Receiving WMA ($10^6m^3/a$)	Transfer Quantity Source WMA ($10^6m^3/a$)		
				Transfer	Losses	Total
Inter-WMA transfers into WMA:						
Komati-Olifants Transfer Scheme	Inkomati	Olifants B12B,B11B, B11H	106 (-)	106	16	122
Usutu-Olifants Transfer Scheme	Usutu to Mhlatuze	Olifants B11D	81 (-)	81	12	93
Usutu-Vaal Transfer Scheme	Upper Vaal	Olifants B11D	40 (-)	40	6	46
Ebenezer Dam	Levuvhu/Letaba	Olifants B71C	0,17 (-)	0,17	0,03	0,20
Mogoboya Ramedike Dam	Levuvhu/Letaba	Olifants B72A	0,16 (-)	0,16	0,02	0,18
Groot Letaba River to Consolidated Murchison Gold Mine	Levuvhu/Letaba	Olifants B72K	0,96 (-) (1,75 permitted)	0,96	0,14	1,10
Rand Water	Upper Vaal	Olifants B11D,B20E	2,32 (-)	2,32	0,35	2,67
Inter-WMA transfers out of WMA:						
Olifants-Sand Transfer Scheme *	Olifants	Limpopo	7,665	(7,665) *	0	(7,665) *
Premier Mine Dam (Wilge River Dam) to Premier Mine	Olifants B20D	Crocodile West and Marico	5,0	5,0 (-)	0	5,0 (-)
Total water imports in 1995:				**230,6**		
Total water exports in 1995:				**5,0**		

(-) The supply of a requirement in the receiver quaternary
(+) A surplus for the receiver quaternary that is routed through the system
* This scheme only came into operation in 1997 and the value is excluded for 1995

5.14.4 Transfers within the WMA

Within the Olifants WMA there are a few in-basin transfers that include transfers between quaternaries. Significant transfers by urban users [including water boards], bulk users [industry & mines] and agriculture [for irrigation] have been listed in Table 5.14.4.1.

The most significant urban transfer is from the Loskop Dam to the KwaNdebele Regional Water Scheme.

TABLE 5.14.4.1: AVERAGE TRANSFERS WITHIN WMA'S IN 1995

Description Of Transfer	Source & Quaternary	Destination & Quaternary	Quantity [$10^6 m^3$ a]
Urban users:			
Olifants-Loskop Reach to Elands River Catchment	Loskop Dam B32A	Weltevreden Purification Works (KwaNdebele Regional Water Scheme) B31H	temporarily 7,0
Blyde River to Lower Olifants River Catchment	Blyde River B60J	Hoedspruit Air Force Base and Hoedspruit Town B72D	2,3
Agriculture:			
Steelpoort to Blyde River Catchment	Spekboom River B42	Doornhoek Farm B60	2,7

5.15 SUMMARY OF WATER LOSSES AND RETURN FLOWS

A summary of the water requirements, losses and return flows are shown in Table 5.15.1. Table 5.15.2 summarises the main inter-catchment transfers of return flows. Diagram 5.15.1 shows the portion of total losses contributed by each of the five categories considered. Diagram 5.15.2 shows the portion of total return flow contributed by each of the six categories considered.

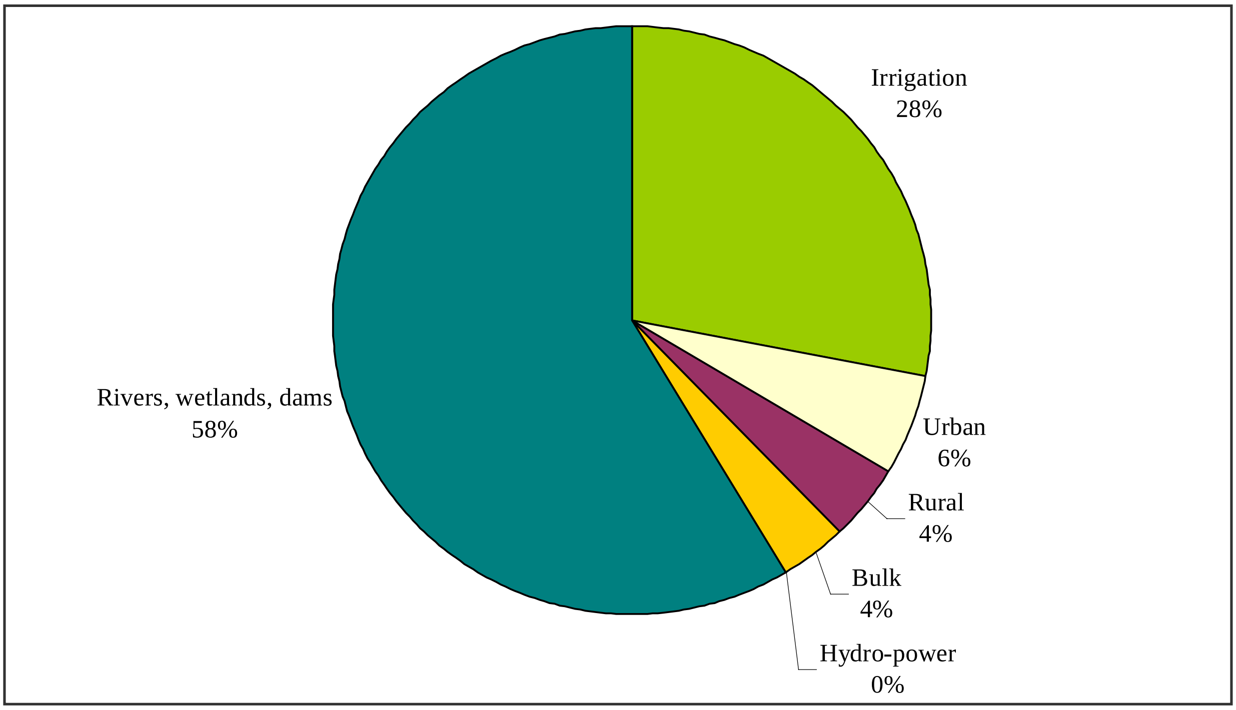
TABLE 5.15.1: SUMMARY OF WATER REQUIREMENTS, LOSSES AND RETURN FLOWS AT 1:50 YEAR ASSURANCE

Category		On-Site Water Requirements ($10^6 m^3/a$)	Losses		Return Flow ($10^6 m^3/a$)
			($10^6 m^3/a$)	(%)	
Irrigation		486,68	76,21	15,7	48,7
Urban		80,60	12,9	20	39,84
Rural		53,43	8,9	20	0
Bulk	a) Strategic	178,13	8,5	5	0
	b) Mining	93,82	8,5	10	17,06
	c) Other	0	0	0	0
Hydro-power		0	0	0	0
Rivers, wetlands, dams		130,9	130,9	100	0
TOTAL		1 023,56	232,18	22,7	105,6

TABLE 5.15.2: SUMMARY OF MAIN INTER-CATCHMENT TRANSFERS OF RETURN FLOWS

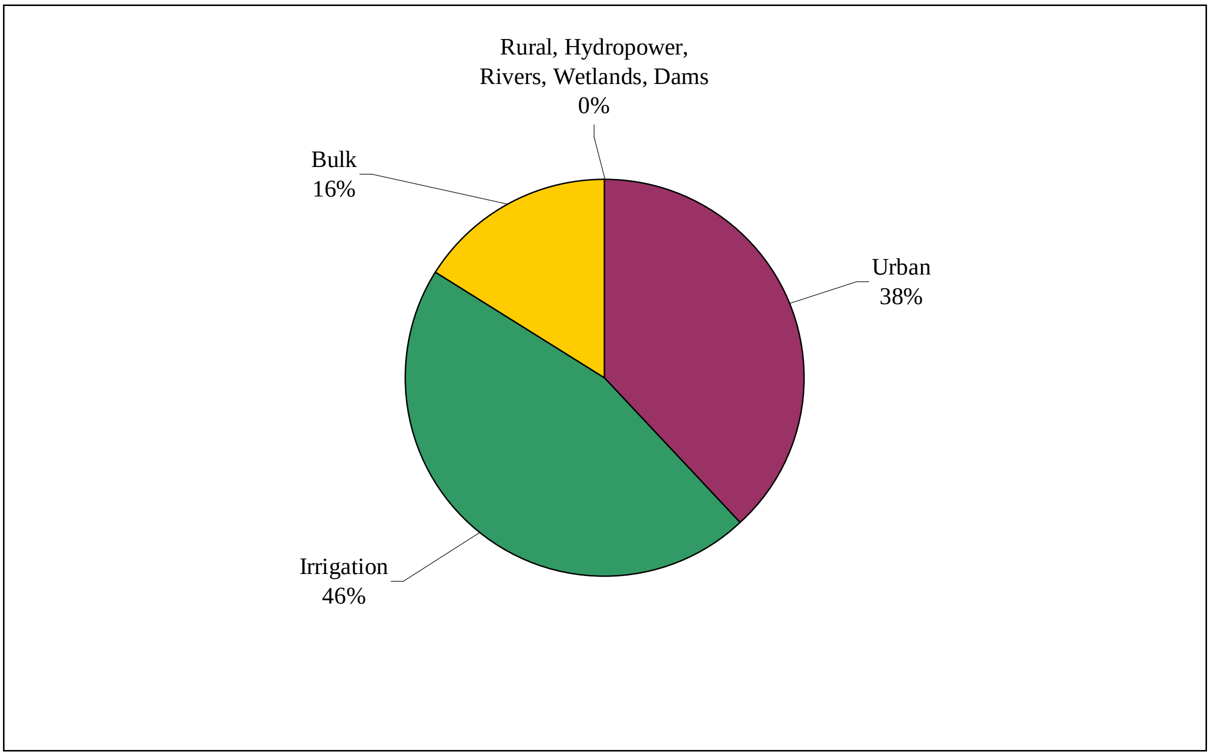
Description	Source *Catchment*	Receiving Catchment	Quantity ($m^3 \times 10^6/a$)
Ebenezer Dam to Fish Farm	Levuvhu/Letaba	Olifants	0,04

Note: These quantities are included in Table 5.15.1.



NOTE : "Bulk" is bulk industrial, mining and thermal power stations.

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



NOTE : "Bulk" is bulk industrial, mining and thermal power stations.

Diagram 5.15.2: Category return flow as a portion of the total return flow in the OlifantsWMA.

CHAPTER 6: WATER RESOURCES

6.1 EXTENT OF WATER RESOURCES

As described in Chapter 2 and shown in Figure 2.2.1, the MAP generally increases southwards and the highest precipitation occurs along the Escarpment. The western edge of the Great Escarpment between Lydenburg in the south and Acornhoek in the north experiences the highest MAP of up to 1 500 mm. The surface runoff per unit area is therefore highest in this region as shown in Figure 6.3.1. The naturalised mean annual surface runoff is approximately 2 042 million m^3. This is augmented by the net import of water into the catchment of 230 million m^3/a. The imported water is mainly to supply power stations and major industries in the south (the Kriel, Witbank, Middelburg area), where the potential for surface water development is relatively low.

The developed yield from groundwater in 1995 is 100,6 million m^3/a. The potential ground water yield is estimated at 287 million m^3/a. This leaves an exploitable yield of about 180 million m^3/a. To develop this potential is a short term solution with low capital cost relative to the building of a dam. The Steelpoort River catchment's exploitable groundwater yield are nearly fully developed. The Blyde River catchment's exploitable groundwater yield are over developed.

The developed yield from surface water in 1995 as shown in Figure 6.1.1, is 630,0 million m^3/a. This is about 49% of the potential yield from surface water which estimated as 1 288 million m^3/a.

Taking into account the relationship between groundwater and surface water, the total developed yield is 730,5 million m^3. The total potential exploitable yield is estimated at 845,2 million m^3/a.

Table 6.1.1 shows the water resources of the Olifants WMA. It should be noted that the ecological reserve has not been deducted from the surface water yields. All yields are at 1:50-year level of assurance of supply and the total potential yield is illustrated in Figure 6.1.2.

The method used to determine the full potential yield is described in paragraph 6.3.2. It should be noted that the value obtained with this method has to be refined by doing feasibility studies for specific projects in the different sub-catchments.

TABLE 6.1.1 : WATER RESOURCES

Catchment						Surface water resources $(10^6 m^3/a)$			Sustainable groundwater exploitation potential not linked to surface water $(10^6 m^3/a)$		Total water resources $(10^6 m^3/a)$	
Primary		Secondary		Tertiary								
No	Description	No	Description	No	Description	Nat - MAR	1:50 yr Developed yield in 1995	1:50 yr Total potential yield	Developed in 1995	Total potential	1:50 yr Developed in 1995	1:50 yr Total potential
B	Olifants	B1	Upper Olifants	B11	Rietspruit at Olifants	44,4	7,1	29,3	0,0	8,3	7,2	37,6
					Olifants at Rietspruit	52,5	4,1	34,7	0,1	10,1	4,2	44,8
					Witbank Dam	27,9	77,2	18,4	0,0	5,1	77,2	23,5
					Olifants at Klein Olifants	22,0	0,1	13,2	0,1	1,4	0,1	14,6
					Olifants at Wilge	29,0	4,2	16,2	0,0	-2,1	4,2	14,1
				B12	Middelburg Dam	44,9	64,2	29,6	1,1	9,2	65,3	38,8
					Klein Olifants at Olifants	36,4	0,0	21,8	0,1	2,7	0,1	24,5
			Sub total			**257,1**	**157,0**	**163,2**	**1,4**	**34,6**	**158,4**	**197,8**
		B2	Wilge	B20	Bronkhorstspruit Dam	47,4	30,6	26,6	1,6	12,7	32,2	39,3
					Wilge at Olifants	119,5	24,0	66,9	1,2	3,8	25,2	70,7
			Sub total			**166,9**	**54,6**	**93,5**	**2,8**	**16,6**	**57,4**	**110,1**
		B3	Elands	B31	Rust de Winter Dam	31,3	17,3	20,7	8,7	7,7	26,0	28,4
					Renosterkop Dam	26,0	17,0	14,9	18,2	28,3	35,2	43,2
					Elands at Olifants	26,0	5,2	15,9	8,1	24,3	13,3	40,2
			Olifants - Loskop Reach	B32	Loskop Dam	41,4	109,3	23,2	0,1	-3,1	109,3	20,1
					Olifants at Bloed	54,2	0,0	31,5	0,4	7,3	0,4	38,8
					Bloed at Olifants	26,3	2,0	17,4	0,2	9,1	2,2	26,5
					Olifants at Elands	43,5	53,4	28,7	0,1	20,3	53,4	49,0
			Sub total			**248,6**	**204,2**	**152,3**	**35,8**	**94,0**	**239,9**	**246,3**
		B4	Steelpoort	B41	Steelpoort at Klip	96,4	8,8	54,0	0,4	0,8	9,2	54,8
					Steynsdrift Dam Proposal	34,3	12,4	19,2	2,8	-0,1	15,2	19,1
					Steelpoort at Spekboom	83,7	24,1	49,5	6,4	6,5	30,5	56,0
					Steelpoort at Olifants	17,0	4,8	11,2	1,1	5,5	5,9	16,7
				B42	Spekboom at Steelpoort	164,9	5,8	95,7	3,6	0,9	9,3	96,6
			Sub total			**396,3**	**55,9**	**229,6**	**14,2**	**13,6**	**70,1**	**243,2**
		B5	Middle Olifants	B51	Arabie Dam	13,2	19,9	8,7	0,3	4,9	20,2	13,6
					Olifants at Lepelane	53,1	0,0	32,1	22,6	45,8	22,6	77,9
				B52	Olifants at Bewaarkloof	54,8	15,1	28,4	2,1	20,3	17,2	48,7
			Sub total			**121,2**	**35,0**	**69,2**	**25,0**	**71,0**	**60,0**	**140,2**
		B6	Blyde	B60	Blyde at Blyde Dam	333,9	16,4	276,7	0,2	-7,6	16,6	269,1
					Ohrigstad River	67,7	13,0	42,9	3,6	5,0	16,6	47,9
					Blyde at Olifants	33,7	0,0	18,9	0,0	1,7	0,0	20,6
			Sub total			**435,2**	**29,4**	**338,5**	**3,8**	**-0,9**	**33,2**	**337,6**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	21,0	0,0	9,5	2,6	6,3	2,6	15,8
					Strijdom Tunnel Proposal	131,9	9,0	101,3	6,2	-5,6	15,2	95,7
					Olifants at Blyde	48,5	15,1	7,0	1,3	3,3	16,3	10,3
				B72	Olifants at Selati	57,6	23,4	35,7	2,3	10,8	25,7	46,5
					Selati at Olifants	79,9	29,8	47,5	4,5	13,4	34,3	60,9
				B73	Olifants at Letaba	75,3	16,7	40,1	0,6	29,2	17,2	69,3
					Olifants at Mozambique	2,0	0,0	1,0	0,0	1,1	0,0	2,1
			Sub total			**416,1**	**93,9**	**242,1**	**17,5**	**58,5**	**111,4**	**300,6**
Total in Gauteng						**88,7**	**33,9**	**51,7**	**10,9**	**9,7**	**42,4**	**66,0**
Total in Mpumalanga						**1340,3**	**448,7**	**878,2**	**29,6**	**122,9**	**483,8**	**1001,2**
Total in Northern Province						**612,6**	**147,4**	**358,5**	**60,0**	**154,8**	**204,3**	**508,5**
Total WMA						**2041,6**	**630,0**	**1288,4**	**100,6**	**287,4**	**730,5**	**1575,7**

6.2 GROUNDWATER

Groundwater is an important part of the total water resources of South Africa and must be seen as part of the total hydrological cycle. The information provided here gives an overview of the groundwater resources, it's interaction with surface water, the present use, (1995) and it's 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 Ground Water Harvest Potential (Seward and Seymour, 1996) was used as the basis for the evaluation. The Harvest Potential is defined as the maximum volume of groundwater that is available for abstraction without depleting the aquifer systems, and takes into account recharge, storage and drought periods (see Figure 6.2.1).

The Harvest Potential was then reduced by an exploitation factor, determined from borehole yield data, to obtain an exploitation potential i.e. the portion of the Harvest Potential which can practically be exploited (see Table 6.2.1 and Figure 6.2.2).

Groundwater, surface water interaction was determined by evaluating the base flow or more specifically the contribution of Harvest Potential to the base flow. This contribution can be seen as water that can either be abstracted as groundwater or surface water. From this, the extent to which groundwater abstraction will impact on surface water has been qualitatively evaluated (see Figure 6.2.3) i.e. where the contribution is 0 the impact will be negligible where the contribution is ≤ 30% of the base flow the impact will be low where the contribution is 30% - 80% of the base flow, the impact will be moderate and a high impact has been evaluated where the contribution to base flow is > 80%.

The existing groundwater use was determined by Baron and Seward 2000. The information was then verified at a workshop held in the WMA by the Water Resources Situation Assessment team. This provided local input to the groundwater use numbers provided by Baron and Seward, which were then adjusted accordingly (see Table 6.2.1 and Figure 6.2.4).

The groundwater balance then compares existing groundwater use to Harvest and Exploitation Potential to determine the extent to which the groundwater resources are utilized (see Figure 6.2.5) i.e., if total use was greater then the Harvest Potential, the catchment was considered over-utilized, if the total use was greater than the exploitation potential but less than the Harvest Potential, the catchment was considered heavily utilized, if the total use was more than 2/3 of the Exploitation Potential the catchment was considered moderately-utilized and if the total use was less than 2/3 of the exploitation potential the catchment was considered under-utilized.

The following figures are included:

- Figure 6.2.1 Groundwater Harvest Potential and
- Figure 6.2.2 Groundwater Exploitation Potential;
- Figure 6.2.3 Groundwater Use in 1995 and
- Figure 6.2.4 Remaining Groundwater Exploitation Potential in 1995
- Figure 6.2.5 Estimated Extend of Groundwater Utilisation.

Table 6.2.1 indicates groundwater resources at 1 in 50 year assurance of supply. This table shows that there is exploitable groundwater potential in most of the key areas, totalling about 287 million m³ per annum. In a few key areas the groundwater is over-exploited.

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

Catchment						Groundwater Exploitation Potential	Total Groundwater Use (1995)	Unused Groundwater Exploitation Potential	Groundwater Contribution to Base Flow	Exploitable Groundwater Potential not contributing to Base Flow
Primary		Secondary		Tertiary						
No	Description	No	Description	No	Description	($10^6m^3/a$)	($10^6m^3/a$)	($10^6m^3/a$)	($10^6m^3/a$)	($10^6m^3/a$)
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	13,07	0,04	13,04	4,80	8,28
					Olifants at Rietspruit	15,42	0,10	14,94	4,98	10,44
					Witbank Dam	7,74	0,02	7,72	2,67	5,07
					Olifants at Klein Olifants	5,49	0,05	5,44	4,05	1,44
					Olifants at Wilge	5,09	0,00	5,09	7,23	-2,14
				B12	Middelburg Dam	15,77	1,09	14,67	6,57	9,20
					Klein Olifants at Olifants	9,48	0,11	9,37	6,78	2,69
			Sub total			**71,68**	**1,42**	**70,27**	**37,08**	**34,98**
		B2	Wilge	B20	Bronkhorstspruit Dam	21,55	1,59	19,96	8,82	12,73
					Wilge at Olifants	30,81	1,25	29,56	26,97	3,84
			Sub total			**52,36**	**2,84**	**49,52**	**35,79**	**16,57**
		B3	Elands	B31	Rust de Winter Dam	11,48	8,70	2,78	3,81	7,67
					Renosterkop Dam	30,09	18,21	11,88	1,74	28,35
					Elands at Olifants	27,54	8,12	19,42	3,21	24,33
			Olifants - Loskop Reach	B32	Loskop Dam	5,98	0,06	5,92	9,06	-3,07
					Olifants at Bloed	15,91	0,41	15,50	8,64	7,27
					Bloed at Olifants	9,68	0,21	9,46	0,54	9,14
					Olifants at Elands	26,84	0,05	26,79	6,54	20,30
			Sub total			**127,52**	**35,77**	**91,76**	**33,54**	**93,99**
		B4	Steelpoort	B41	Steelpoort at Klip	12,91	0,41	12,49	12,09	0,82
					Steynsdrift Dam Proposal	5,00	2,78	2,22	5,13	-0,13
					Steelpoort at Spekboom	14,63	6,38	8,25	8,18	6,45
					Steelpoort at Olifants	5,54	1,11	4,42	0,00	5,54
				B42	Spekboom at Steelpoort	13,45	3,56	9,89	12,57	0,88
			Sub total			**51,53**	**14,24**	**37,28**	**37,97**	**13,56**
		B5	Middle Olifants	B51	Arabie Dam	4,88	0,29	4,60	0,00	4,88
					Olifants at Lepelane	45,80	22,62	23,18	0,00	45,80
				B52	Olifants at Bewaarkloof	20,30	2,09	18,21	0,00	20,30
			Sub total			**70,99**	**25,00**	**45,99**	**0,00**	**70,99**
		B6	Blyde	B60	Blyde at Blyde Dam	12,90	0,18	12,72	20,47	-7,57
					Ohrigstad River	11,55	3,59	7,96	6,57	4,98
					Blyde at Olifants	6,51	0,02	6,48	4,77	1,74
			Sub total			**30,96**	**3,79**	**27,17**	**31,81**	**-0,85**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	6,31	2,65	3,66	0,00	6,31
					Strijdom Tunnel Proposal	18,14	6,22	11,91	23,71	-5,58
					Olifants at Blyde	3,29	1,28	2,01	0,00	3,29
				B72	Olifants at Selati	16,55	2,30	14,25	5,80	10,76
					Selati at Olifants	18,26	4,46	13,81	4,87	13,40
				B73	Olifants at Letaba	31,97	0,58	31,39	2,78	29,19
					Olifants at Mozambique	1,14	0,00	1,14	0,00	1,14
			Sub total			**95,65**	**17,49**	**78,16**	**37,15**	**58,50**
Total in Gauteng						**26,37**	**10,92**	**15,44**	**16,66**	**9,71**
Total in Mpumalanga						**277,48**	**29,63**	**247,85**	**154,58**	**122,90**
Total in Northern Province						**196,85**	**60,00**	**136,85**	**42,10**	**154,75**
Total WMA						**500,70**	**100,55**	**400,15**	**213,34**	**287,36**

6.3 SURFACE WATER RESOURCES

6.3.1 Streamflow Data

The basis for the analysis of surface water resources for all WMAs 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 naturalised 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%.

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 be done in order to determine whether these limitations have a significant effect on the results.

Existing flow gauging stations are considered inadequate and should be upgraded, especially to include strategically important points in the WMA.

6.3.2 Yield Analysis

In order to estimate the total potential yield available from the catchments within the Water Management Area, future storage dams of a particular maximum net storage capacity have been postulated. The net incremental storage capacities that have been adopted within the Water Management Area are given in Appendix G3 for each group of quaternary catchments that falls within the same hydrological zone, as defined in WR90 (Midgley, *et al.*, 1994). These range from 28% of the MAR in the higher rainfall quaternary catchments to 1,8% of the MAR in the drier quaternary catchments within the Olifants Water Management Area.

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 size have been derived for the entire South Africa and which will provide consistent results throughout the country. The water balance model 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%, 150%, 200%, 250%, or 300% of the MAR as appropriate. The following assumptions were made for the calculations of potential dam yield namely:

- Dams with low variability yield thus 100% of MAR.
- Dams with medium variability yield thus 15%, and 200% of MAR.
- Dams with high variability yield thus 250 and 300% of MAR.

This maximum potential yields are shown in Table 6.3.1.

Figure 6.3.1 shows the mean annual naturalised runoff for the different quaternaries. Figure 6.3.2 shows water resource development potential according to drainage areas.

Table 6.3.1 gives values of the presently developed surface water resources in the Olifants WMA, as well as the total potential developable yield per key area as determined by the methodology described above. The values in the last column therefore do not reflect existing development. For the whole of the WMA, the difference between the potential and 1995 developed yield, indicates the probable scope for further development.

From Table 6.3.1 it can be seen that the surface water yield seems to be over-developed in same key areas of the Upper Olifants sub-catchment and at Loskop Dam. On the other hand there is considerable exploitable surface water yield available in the Steelpoort, Middle Olifants, Blyde and Lower Olifants sub-catchments. However, the availability of suitable dam sites, and distance from the regions where water is required, inhibits the development of these sources.

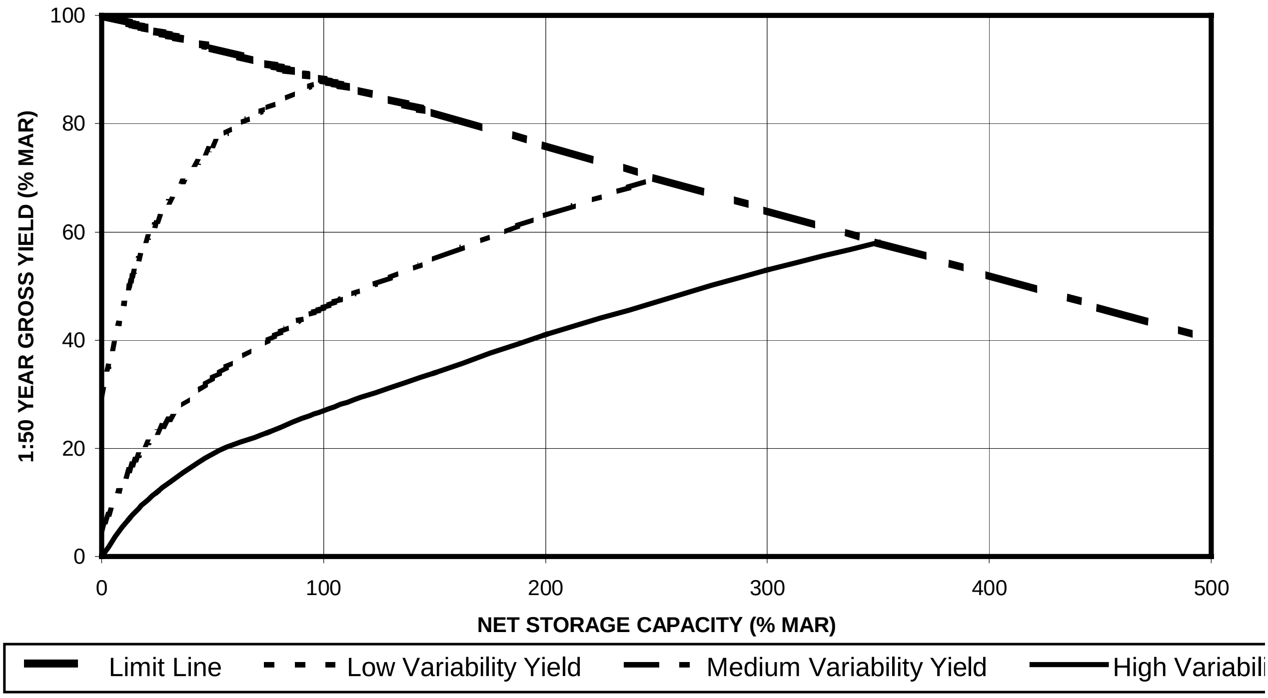


DIAGRAM 6.3.1: DAM STORAGE LIMITS

TABLE : 6.3.1 : SURFACE WATER RESOURCES

Catchment						Catchment area	Mean annual precipitation	Mean annual evaporation	Naturalised MAR		Yield (1:50 yr)[1]	
Primary		Secondary		Tertiary					Incremental	Cumulative	Developed in 1995	Total potential
No	Description	No	Description	No	Description	(km^2)	(mm/a)	(mm/a)[2]	($10^6m^3/a$)	($10^6m^3/a$)	($10^6m^3/a$)	($10^6m^3/a$)
B	Olifants	B1	Upper Olifants	B11	Rietspruit at Olifants	1,403.00	675.20	1,599.00	44.40	44.40	7.15	37.60
					Olifants at Rietspruit	1,380.00	695.20	1,550.00	52.54	52.54	4.11	44.80
					Witbank Dam	796.00	692.50	1,600.00	27.87	124.80	77.22	23.50
					Olifants at Klein Olifants	515.00	688.20	1,637.00	22.03	146.80	0.05	14.60
					Olifants at Wilge	620.00	687.10	1,700.00	28.97	257.10	4.21	14.10
				B12	Middelburg Dam	1,593.00	694.00	1,549.00	44.88	44.88	64.24	38.80
					Klein Olifants at Olifants	798.00	699.70	1,600.00	36.43	81.31	0.00	24.50
			Sub total			**7,105.00**			**257.12**	**257.10**	**156.96**	**197.90**
		B2	Wilge	B20	Bronkhorstspruit Dam	1,260.00	666.60	1,693.00	47.42	47.42	30.61	39.30
					Wilge at Olifants	3,096.00	671.40	1,676.00	119.50	166.90	24.00	70.70
			Sub total			**4,356.00**			**166.92**	**166.90**	**54.60**	**110.00**
		B3	Elands	B31	Rust de Winter Dam	1,145.00	641.80	1,796.00	31.33	31.33	17.25	28.40
					Renosterkop Dam	2,578.00	585.40	1,847.00	25.98	57.31	17.02	43.20
					Elands at Olifants	2,425.00	567.10	1,900.00	26.00	83.31	5.22	40.20
			Olifants - Loskop Reach	B32	Loskop Dam	801.00	691.00	1,700.00	41.41	465.50	109.29	20.10
					Olifants at Bloed	1,438.00	664.70	1,634.00	54.15	519.60	0.00	38.80
					Bloed at Olifants	870.00	661.10	1,750.00	26.29	26.29	2.02	26.50
					Olifants at Elands	1,985.00	620.70	1,900.00	43.48	589.40	53.37	49.00
			Sub total			**11,242.00**			**248.64**	**672.70**	**204.17**	**246.20**
		B4	Steelpoort	B41	Steelpoort at Klip	1,543.00	709.50	1,500.00	96.40	96.40	8.79	54.80
					Steynsdrift Dam Proposal	705.00	670.00	1,534.00	34.32	130.70	12.41	19.10
					Steelpoort at Spekboom	2,160.00	628.70	1,529.00	83.70	214.40	24.11	56.00
					Steelpoort at Olifants	635.00	626.00	1,500.00	17.01	396.30	4.79	16.70
				B42	Spekboom at Steelpoort	2,093.00	727.40	1,438.00	164.90	164.90	5.75	96.60
			Sub total			**7,136.00**			**396.33**	**396.33**	**55.86**	**243.20**
		B5	Middle Olifants	B51	Arabie Dam	902.00	591.10	1,900.00	13.23	685.90	19.90	13.60
					Olifants at Lepelane	5,834.00	538.00	1,872.00	53.14	739.10	0.00	77.90
				B52	Olifants at Bewaarkloof	2,992.00	562.20	1,782.00	54.83	793.90	15.10	48.70
			Sub total			**9,728.00**			**121.20**	**793.90**	**35.00**	**140.20**
		B6	Blyde	B60	Blyde at Blyde Dam	850.00	1,097.00	1,400.00	333.90	333.90	16.41	269.10
					Ohrigstad River	1,316.00	757.00	1,447.00	67.65	401.55	13.03	47.90
					Blyde at Olifants	676.00	607.00	1,482.00	33.69	435.24	0.00	20.60
			Sub total			**2,842.00**			**435.24**	**435.24**	**29.44**	**337.60**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	572.00	627.50	1,650.00	21.00	814.90	0.00	15.80
					Strijdom Tunnel Proposal	1,813.00	704.00	1,557.00	131.90	1,343.10	8.99	95.70
					Olifants at Blyde	653.00	682.70	1,450.00	48.53	1,391.60	15.07	10.30
				B72	Olifants at Selati	2,124.00	539.20	1,600.00	57.60	1,885.00	23.38	46.50
					Selati at Olifants	2,340.00	593.00	1,582.00	79.86	79.86	29.80	60.90
				B73	Olifants at Letaba	4,397.00	541.10	1,697.00	75.27	2,040.00	16.66	69.30
					Olifants at Mozambique	255.00	333.80	1,900.00	1.95	2,041.95	0.00	2.10
			Sub total			**12,154.00**			**416.11**	**2,041.95**	**93.90**	**300.60**
Luvuvhu/ Letaba WMA *									**575.05**	**2,617.00**		
Total in Gauteng						**2,747.00**			**88.70**		**33.92**	**66.00**
Total in Mpumalanga						**27,669.00**			**1,340.30**		**448.70**	**1,001.20**
Total in Northern Province						**24,147.00**			**612.60**		**147.35**	**508.50**
Total WMA						**54,563.00**			**2,041.60**	**2,617.00**	**629.97**	**1,575.70**

1. The Ecological Reserve has not yet been deducted from the yields shown.
2. Class A Pan.

* This is the contribution of the incomming Luvuvhu/Letaba WMA

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 Olifants Water Management Area.

The mineralogical water quality of the surface water bodies is only 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. The data sets were filtered to monthly data, and various techniques were used to fill in missing values where possible. Only those data sets that spanned at least two years and contained at least 24 data points were eventually selected for analysis. These were used to derive the mean and maximum TDS concentrations.

Details of the TDS and electrical conductivity (EC) 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 Purple
Green	Green Yellow Red Purple	Green Yellow Yellow Purple
Yellow	Yellow Red Purple	Yellow Red Purple
Red	Red Purple	Red Purple
Purple	Purple	Purple

The mineralogical surface water quality of the Olifants 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 OLIFANTS WATER MANAGEMENT AREA

Secondary Catchment	No of Quaternary Catchments	No of Quaternary Catchments in Class					
		Blue	Green	Yellow	Red	Purple	No Data
B1	16	6	10	0	0	0	0
B2	9	6	3	0	0	0	0
B31	9	4	1	4	0	0	0
B32	9	1	5	3	0	0	0
B4	18	12	4	2	0	0	0
B5	16	0	5	11	0	0	0
B6	9	3	5	1	0	0	0
B7	28	0	5	23	0	0	0

The mineralogical surface water quality is generally good in the Upper Olifants and Wilge River catchments. It deteriorates slightly in the Elands River catchment and in the Olifants River downstream of Loskop Dam. The Middle Olifants River catchment mineralogical surface water quality falls mainly in the "marginal" category, while it is mostly "ideal" and "good" in the Steelpoort and Blyde River catchments. In the Lower Olifants River catchment it is mostly marginal.

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

In catchments where no information was available estimates of the portion potable were made using Vegters 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 potable water per quaternary catchment.

Estimated overall groundwater quality class and areas with high fluoride or nitrate concentrations are shown in Figure 6.4.2.1.

The southern Olifants WMA has a low quantity of TDS as the highest are shown as 600 mg/ℓ.

The Elands and Middel Olifants River catchments as well as the lower Olifants River catchment shows a 600 – 1 800 mg/ℓ mean TDS.

Quaternary catchment B52E is the only quat that shows a high (1 800 – 3 400 mg/ℓ) mean TDS. This quaternary catchment is situated in the former Lebowa Homeland.

A new northern quaternary catchment also shows a mean TDS of 260 – 600 mg/ℓ.

6.4.3 Microbiological (or microbial) 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 E 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.

The upper Olifants River catchment shows a low potential for contamination, in spite of all the power stations situated in the catchments as well as some of the main industries. The reason can be that there are no or very little run-off from the powerstations that can contaminate the surface water.

The Elands River catchment and the Middle Olifants River have a high potential for contamination as the former Lebowa homeland are in this area. Phalaborwa area also shows a high potential due to the mining activities in the area.

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 Olifants WMA is given in Figure 6.4.3.1.

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 resources

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 Olifants WMA is given in Figure 6.4.3.2. This map shows the degree of potential faecal contamination in groundwater using a rating scale that ranges from low to medium to high.

Conclusions and recommendations

A limitation of the study was the inability to validate results due to the limited information on groundwater contamination resulting from human wastes.

Once sufficient microbial data becomes available, the numerical methods and associated assumptions should be validated and the maps replotted. Monitoring data from selected areas should also be collected to assess the validity of the vulnerability assessment presented in this report.

6.4.4 Water Quality Issues

Water quality is important in terms of suitability for different uses. One example of water of a high quality required is that used by the Highveld power stations. All of the water for the six operating power stations in the Olifants WMA has to be imported because salinity of the upper Olifants River exceed the design requirements of the power stations.

Water quality concerns in the Olifants and Klein Olifants River catchments are high concentrations of dissolved solids (TDS) and sulphate, low pH, and at times high concentrations of iron, manganese and aluminium as a result of mining activities (DWAF, 1998). It was found that TDS and sulphate concentrations increased where streams pass through mining areas. In the Klipspruit catchment, major concerns have been expressed about pH, TDS, sulphate, aluminium and manganese (DWAF, 1998). The Wilge River catchment was largely unpolluted, with low TDS and sulphate concentrations, and no water quality concerns were noted (DWAF, 1998). In the Olifants River between Witbank Dam and Loskop Dam, concerns were noted about low pH, high EC and high sulphate concentrations in the Spookspruit, but Loskop Dam appeared to meet guidelines values (DWAF, 1998), probably as a result of the Wilge River improving the inflowing water quality into Loskop Dam.

In the middle Olifants River, concerns have been expressed about high salinities at the downstream ends of the Moses River and Elands River, especially during the low flow periods (Venter & Maimane, 1999). These increases were mostly due to irrigation return flows from irrigation projects. Sodium and chloride were identified as the main quality variables of concern during the low flow periods. Water quality in the middle Olifants catchment is also regarded as poor as a result of high TDS concentrations with high sodium and chloride being the constituents of concern. The high salinities are also ascribed to irrigation activities at the Loskop Irrigation Scheme.

Historically the Olifants River used to be a turbid system. Most of the suspended sediment from the upper Olifants River is now trapped in Loskop Dam and water with a low turbidity is released from the dam. However, due to high erodibility potential and poor land-use practises in the downstream half of the Middle Olifants study area, high suspended sediment concentrations occur during the summer rainfall months (Moolman, Quibell & Hohls, 1999).

In the lower Olifants River, concerns have been expressed about heavy metal pollution from chrome and vanadium mining activities in the Wapadskloof area and Groot Dwars River area of the Steelpoort River catchment. High chloride concentrations in the Ohrigstad River, (which are potentially detrimental to tobacco farming) as well as the effects of old gold mining activities in the Pilgrim's Rest area (Venter & Maimane, 1999) are of concern. Water quality in the lower Olifants River improves moderately downstream of the confluences with the Steelpoort River and the Blyde River. Water quality in the upper Selati River is generally regarded as good but effluents from mining activities at Phalaborwa increase salinity to very high concentrations, with the main constituents of concern being sodium, chloride and fluoride. High suspended sediment concentrations, emanating from the old Lebowa homeland during the summer rainfall months, are also a concern in the lower Olifants River.

6.5 SEDIMENTATION

Sedimentation has a significant impact on water resources development as well as riverine ecology.

The sediment yield in the Olifants WMA is generally low in the Upper Olifants Area and fairly high in the central to lower parts of the catchment.

The sediment yield in a dam can be affected by the creation of additional storage in the catchment. In the case of large dams a new dam built upstream of an existing dam can create a problem.

Table 6.5.1 shows observed sedimentation rates and total decreases in capacity of existing reservoirs within the Olifants WMA.

The sedimentation per quaternary catchment and the 25-year sediment volume is tabulated in Appendix G of this report. Figure 6.5.1 shows the variation in sediment yield per quaternary catchment.

TABLE 6.5.1: RECORDED RESERVOIR SEDIMENTATION RATES FOR RESERVOIRS IN THE VICINITY OF THE OLIFANTS WMA

Quaternary Catchment No.	River	Dam Name	ECA (km^2)	Period	V_T (10^6 m^3)	V_{50} (10^6 m^3)	Sediment Yield ($t/km^2.a$)
B20C	Bronkhorstspruit	Bronkhorstspruit	1 263	1948-1983	1,954	2,257	48
B42F	Waterval	Buffelskloof	278	1972-1987	0,111	0,203	20
B32A	Olifants	Loskop	5 820	1939-1977	11,238	12,533	58
B31C	Elands	Rust-de-Winter	1 147	1934-1977	1,303	1,382	33
B73A	Klaserie	Jan Wassenaar	165	1960-1979	0,470	0,739	121

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

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 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 modeled correctly.

The approach taken to determine the water balance was therefore to remove the above questionable components out of the WSAM modeling 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.

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 worksheet were structured so a to present most of the information contained in the tables of this report. This is not only limited to water requirements but also lists land uses such as irrigated areas, afforested areas, etc.

The data was 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 Appendices 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 and 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 WSAM does not report directly on the available water resource, as required for this WRSA report. This was therefore calculated external to the model as follows:

- The water balance produced by the WSAM, as described in paragraph 7.1.2 above, was mostly deemed to be correct. A few adjustments were made to the model to allow for the following:
  - Runoff into minor dams
    It appears as if the WSAM assumes that the runoff into minor dams is equal to the entire incremental flow generated within a quaternary catchment. Considering the definition of a minor dam, i.e. a dam that is not situated on the main stream of the catchment, this is not possible. An assumption was made that only 50% of the runoff of a catchment flows into minor dams and this assumption was applied throughout the WMA.
  - Impact of afforestation and alien vegetation on catchment yield
    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. The impacts on the yield of the catchments were then accounted for external to the model when determining the water balance.

- The available water resource was then assumed to be the difference between the water balance and the water requirements that are supplied from the catchment.
- In some cases, there are negative balances within the quaternary catchments making up a key area. These negative balances are not routed through the system, and it was therefore necessary to sum these negative balances and subtract them from the water resource.
- In some cases the WSAM did not model the yield of major dams correctly and the yield curves were adjusted to approximate the yield as obtained from more detailed studies.

DIAGRAM 7.1.1: WATER BALANCE MODEL CONCEPTUAL LAYOUT

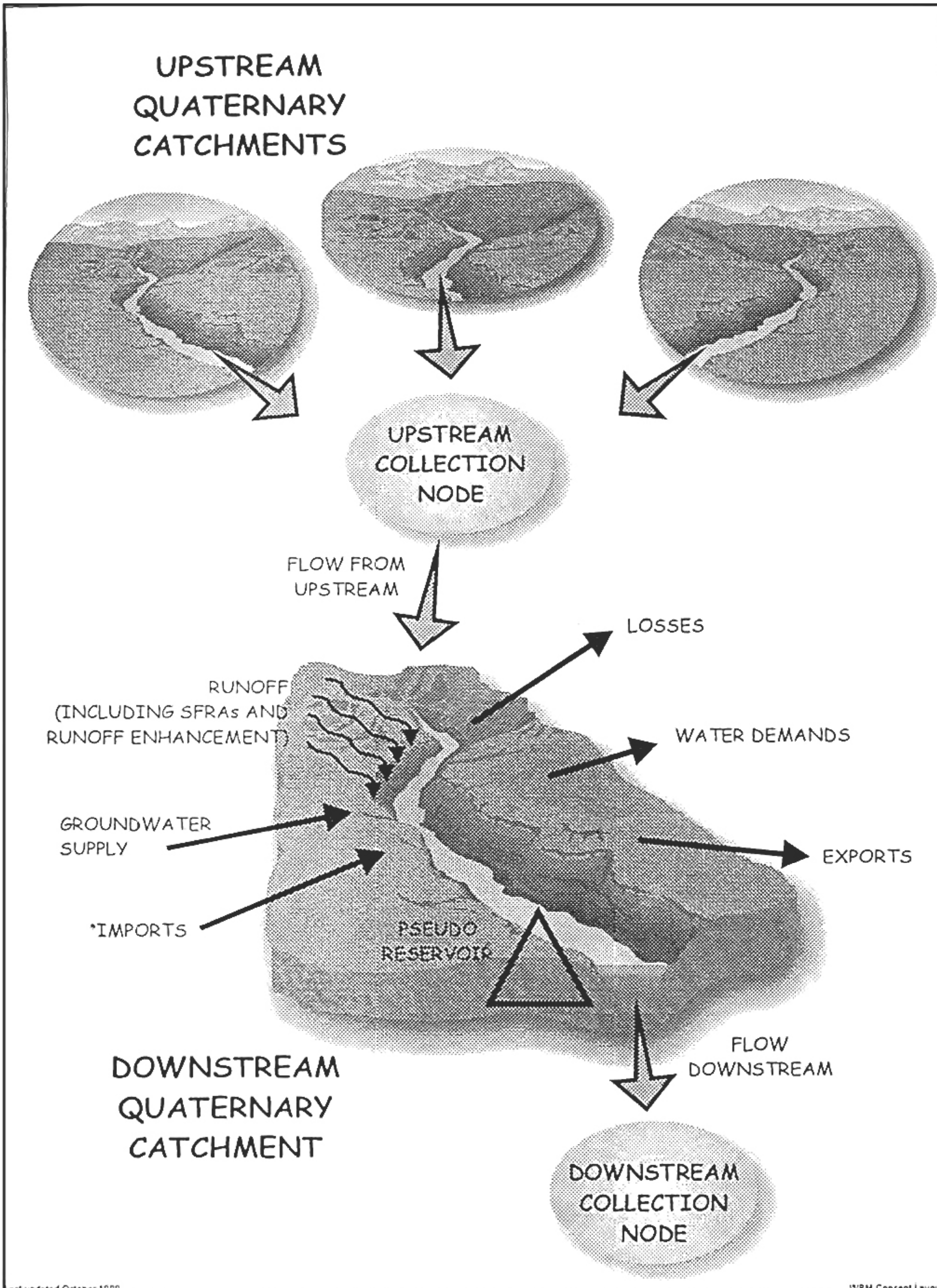
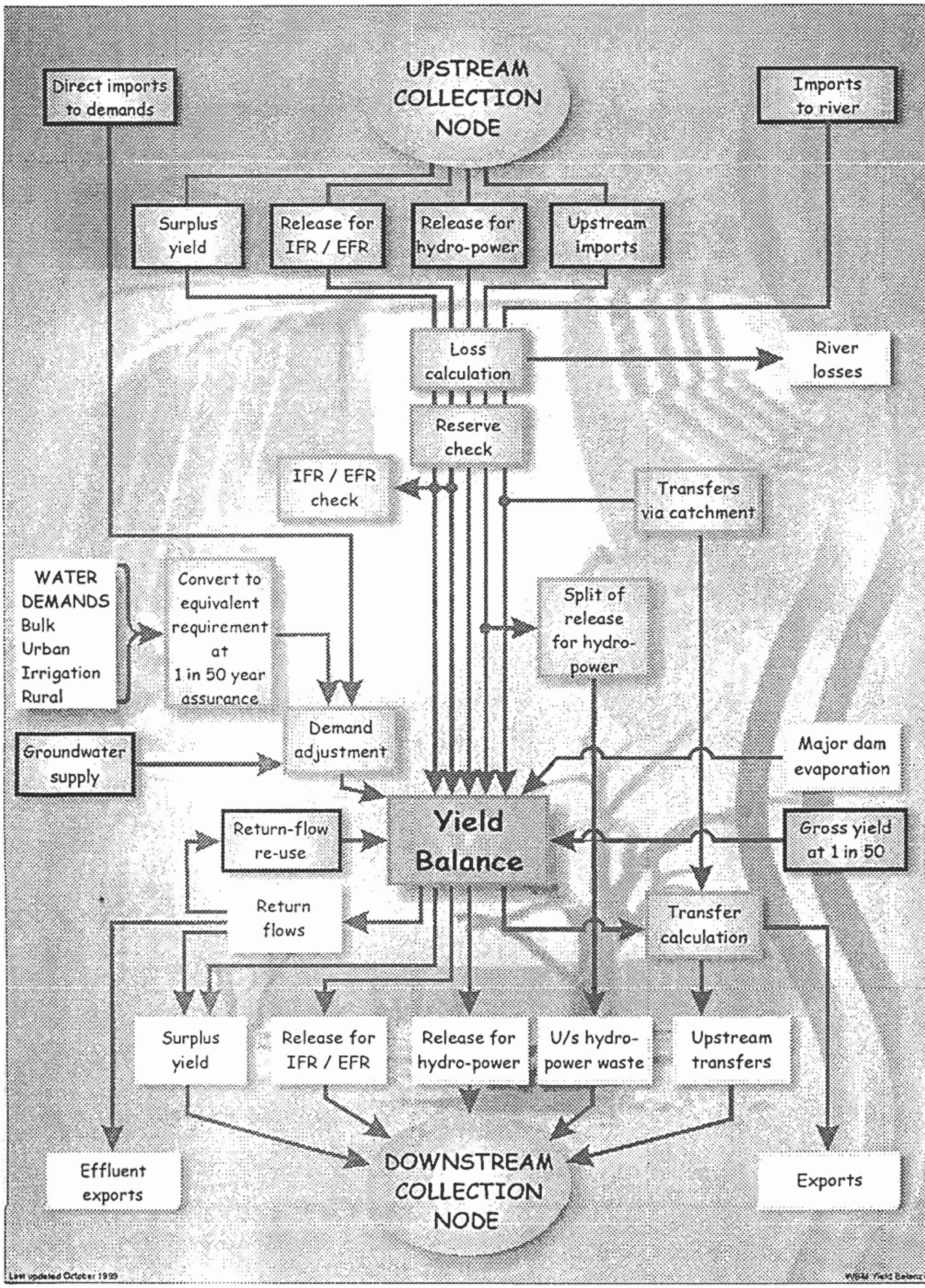


DIAGRAM 7.1.2: WATER BALANCE MODEL YIELD BALANCE ALGORITHM



7.2 OVERVIEW

Key points of interest were generally selected at existing large dams, possible future dam sites and at the confluences of important rivers. Table 7.2.1 gives the quaternary catchments included in each keypoint.

TABLE 7.2.1: KEY POINTS FOR YIELD DETERMINATION

LOCATION OF KEY POINT				DESCRIPTION
PRIMARY CATCHMENT		SECONDARY CATCHMENT NO.	QUARTERNARY CATCHMENT NO.'S	
NO.	NAME			
B	Olifants River	B1	B11C,D,E	Rietspruit at Olifants
			B11A,B	Olifants at Rietspruit
			B11F,G	Witbank Dam
			B11H,J	Olifants at Klein Olifants
			B11K,L	Olifants at Wilge
			B12A,B,C	Middelburg Dam
			B12D,E	Klein Olifants at Olifants
		B2	B20A,B,C	Bronkhorstpruit Dam
			B20D,E,F,G,H,J	Wilge at Olifants
		B3	B31A,B,C	Rust de Winter Dam
			B31D,E,F	Renosterkop Dam
			B31G,H,J	Elands at Olifants
			B32A	Loskop Dam
			B32B,C,D	Olifants at Bloed
			B32E,F	Bloed at Olifants
			B32G,H,J	Olifants at Elands
		B4	B41A,B	Steelpoort at Klip
			B41C,D	Steynsdrift Dam Proposal
			B41E,F,G,H,J	Steelpoort at Spekboom
			B41K	Steelpoort at Olifants
			B42A,B,C,D,E,F,G,H	Spekboom at Steelpoort
		B5	B51A,B	Arabie Dam
			B51C,E,F,G,H;B52A	Olifants at Lepelane
			B52B,C,D,E,F,G,H,J	Olifants at Bewaarkloof
		B6	B60A,B,C,D	Blyde at Blyde Dam
			B60E,F,G,H	Ohrigstad River
			B60J	Blyde at Olifants
		B7	B71A,B	Rooipoort Dam Proposal
			B71C,D,E,F,G	Strijdom Tunnel Proposal
			B71H,J	Olifants at Blyde
			B72A,B,C,D	Olifants at Selati
			B72E,F,G,H,J,K	Selati at Olifants
			B73A,B,C,D,E,F,G,H	Olifants at Letaba
			B73J	Olifants at Mozambique

Table 7.2.2 indicates the water requirements in 1995 at the different keypoints. Table 7.2.3 compares the water requirements and availability per key area. Figure 7.2.1 gives a water balance overview.

TABLE 7.2.2: WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

Catchment						Streamflow Reduction Activities ($10^6m^3/a$)		Water Use ($10^6m^3/a$)		Water Requirement ($10^6m^3/a$)						Ecological Reserve ($10^6m^3/a$)	TOTAL ($10^6m^3/a$)
Primary		Secondary		Tertiary													
No	Description	No	Description	No	Description	Afforestation	Dryland Sugar Cane	Alien Vegetation	River Losses[5]	Bulk[1]	Irrigation[2]	Rural[3]	Urban[4]	Hydro-power	Water Transfers out of WMA		
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	0,00	0,0	0,00	6,6	90,3	7,2	0,26	1,9	0,0	0,0	1,4	107,77
					Olifants at Rietspruit	0,00	0,0	0,00	0,7	1,5	1,5	0,43	0,3	0,0	0,0	0,7	5,17
					Witbank Dam	0,00	0,0	0,00	7,8	46,4	0,9	0,32	0,0	0,0	0,0	3,1	58,46
					Olifants at Klein Olifants	0,01	0,0	0,02	2,2	2,0	5,0	0,39	26,5	0,0	0,0	1,8	37,97
					Olifants at Wilge	0,00	0,0	0,00	0,2	1,0	3,0	0,16	0,0	0,0	0,0	0,3	4,60
				B12	Middelburg Dam	0,18	0,0	0,02	3,7	45,7	4,5	1,29	0,9	0,0	0,0	2,4	58,72
					Klein Olifants at Olifants	0,36	0,0	0,02	5,0	1,0	1,5	0,55	11,4	0,0	0,0	1,0	20,79
			Sub total			**0,55**	**0,00**	**0,06**	**26,3**	**187,8**	**23,6**	**3,40**	**41,0**	**0,0**	**0,0**	**10,8**	**293,48**
		B2	Wilge	B20	Bronkhorstspruit Dam	0,00	0,0	0,35	7,4	1,4	3,3	0,66	9,4	0,0	0,0	4,7	27,23
					Wilge at Olifants	0,00	0,0	0,57	6,7	9,2	16,6	1,46	11,0	0,0	5,0	5,9	56,34
			Sub total			**0,00**	**0,00**	**0,92**	**14,1**	**10,7**	**19,8**	**2,12**	**20,3**	**0,0**	**5,0**	**10,6**	**83,57**
		B3	Elands	B31	Rust de Winter Dam	0,00	0,0	0,19	3,8	0,5	5,7	1,31	0,0	0,0	0,0	1,3	12,76
					Renosterkop Dam	0,00	0,0	1,55	30,2	0,2	57,7	2,86	0,9	0,0	0,0	2,1	95,51
					Elands at Olifants	0,00	0,0	1,39	1,6	0,2	6,4	1,89	7,5	0,0	0,0	-0,1	18,86
			Olifants - Loskop Reach	B32	Loskop Dam	0,00	0,0	0,04	17,2	0,0	7,0	0,41	0,0	0,0	0,0	34,7	59,34
					Olifants at Bloed	0,12	0,0	0,03	2,1	0,0	45,4	0,89	0,5	0,0	0,0	0,3	49,34
					Bloed at Olifants	0,00	0,0	0,07	0,1	0,0	7,2	1,48	0,3	0,0	0,0	0,6	9,76
					Olifants at Elands	0,00	0,0	0,11	7,2	0,0	78,1	7,60	0,8	0,0	0,0	-0,1	93,71
			Sub total			**0,12**	**0,00**	**3,39**	**62,1**	**0,9**	**207,4**	**16,43**	**10,0**	**0,0**	**0,0**	**38,8**	**339,28**
		B4	Steelpoort	B41	Steelpoort at Klip	0,53	0,0	0,03	1,0	7,5	5,2	0,57	0,8	0,0	0,0	2,8	18,50
					Steynsdrift Dam Proposal	0,00	0,0	0,05	0,2	0,8	13,9	0,61	0,0	0,0	0,0	1,0	16,63
					Steelpoort at Spekboom	0,01	0,0	1,00	2,4	7,5	19,8	1,70	0,0	0,0	0,0	1,7	34,16
					Steelpoort at Olifants	0,00	0,0	0,00	0,0	0,0	0,9	2,12	0,0	0,0	0,0	2,3	5,29
				B42	Spekboom at Steelpoort	0,76	0,0	5,37	0,4	0,8	19,8	0,56	1,5	0,0	0,0	9,0	38,26
			Sub total			**1,30**	**0,00**	**6,45**	**4,0**	**16,7**	**59,6**	**5,57**	**2,4**	**0,0**	**0,0**	**17,0**	**112,85**
		B5	Middle Olifants	B51	Arabie Dam	0,00	0,0	0,66	10,2	0,0	3,8	1,81	0,3	0,0	0,0	19,0	35,84
					Olifants at Lepelane	0,00	0,0	9,99	3,3	1,3	64,0	6,12	0	0,0	0,0	-4,2	80,46
				B52	Olifants at Bewaarkloof	0,16	0,0	1,76	1,1	0,3	4,7	8,36	2,0	0,0	0,0	-4,2	14,21
			Sub total			**0,16**	**0,00**	**12,41**	**14,6**	**1,7**	**72,5**	**16,29**	**2,3**	**0,0**	**0,0**	**10,5**	**130,51**
		B6	Blyde	B60	Blyde at Blyde Dam	0,00	0,0	0,00	0,0	0,4	2,2	0,25	0,0	0,0	0,0	31,6	34,51
					Ohrigstad River	1,24	0,0	7,30	2,4	0,0	24,6	0,35	0,0	0,0	0,0	-4,4	31,49
					Blyde at Olifants	0,00	0,0	0,31	0,5	0,0	18,0	0,08	0,1	0,0	0,0	8,1	27,01
			Sub total			**1,24**	**0,00**	**7,61**	**3,0**	**0,4**	**44,7**	**0,67**	**0,1**	**0,0**	**0,0**	**35,3**	**93,00**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,00	0,0	0,00	0,0	0,0	5,7	0,24	0,0	0,0	0,0	-0,7	5,20
					Strijdom Tunnel Proposal	0,00	0,0	0,00	0,0	10,7	7,1	2,34	0,1	0,0	0,0	7,3	27,53
					Olifants at Blyde	0,00	0,0	0,67	0,9	0,0	8,5	0,97	0,0	0,0	0,0	-2,8	8,26
				B72	Olifants at Selati	0,00	0,0	0,00	1,5	10,7	6,2	2,47	0,0	0,0	0,0	31,3	52,18
					Selati at Olifants	0,00	0,0	0,09	2,5	32,3	26,3	2,82	0,2	0,0	0,0	0,1	64,32
				B73	Olifants at Letaba	0,00	0,0	0,00	2,0	0,0	5,2	0,12	4,2	0,0	0,0	-1,4	10,23
					Olifants at Mozambique	0,00	0,0	0,00	0,0	0,0	0,0	0,00	0,0	0,0	0,0	5,6	5,64
			Sub total			**0,00**	**0,00**	**0,77**	**6,9**	**53,7**	**59,0**	**8,96**	**4,5**	**0,0**	**0,0**	**39,5**	**173,36**
Total in Gauteng						**0,00**	**0,00**	**0,66**	**11,25**	**4,61**	**19,15**	**2,07**	**7,93**	**0,00**	**5,00**	**5,10**	**52,66**
Total in Mpumalanga						**3,05**	**0,00**	**15,22**	**84,34**	**209,84**	**277,23**	**21,38**	**64,24**	**0,00**	**0,00**	**104,53**	**779,55**
Total in Nortern Province						**0,33**	**0,00**	**15,73**	**35,35**	**57,50**	**190,30**	**29,98**	**8,47**	**0,00**	**0,00**	**52,80**	**393,83**
Total WMA						**3,38**	**0,00**	**31,61**	**130,94**	**271,95**	**486,68**	**53,43**	**80,64**	**0,00**	**5,00**	**162,43**	**1226,05**

(1) Requirements of wet industries, mines, thermal power stations and 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) Includes evaporation losses from dams.

TABLE 7.2.3: WATER REQUIREMENTS AND AVAILABILITY

Catchment						Available 1:50 year yield in 1995 ($10^6m^3/a$)			Water Transfers at 1:50 years assurance ($10^6m^3/a$)		Return flows at 1:50 years assurance ($10^6m^3/a$)	Water Requirements at 1:50 year assurance(1) ($10^6m^3/a$)	Water Balance at 1:50 year assurance(2) ($10^6m^3/a$)
Primary		Secondary		Tertiary		Surface Water	Groundwater not linked to Surface Water	Total	Imports	Exports	Re-usable		
No	Description	No	Description	No	Description								
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	7,1	0,0	7,2	118,32	0,0	2,7	107,8	20,4
					Olifants at Rietspruit	4,1	0,1	4,2	0,00	0,0	0,5	5,2	-0,4
					Witbank Dam	77,2	0,0	77,2	42,00	0,0	3,0	58,5	63,7
					Olifants at Klein Olifants	0,1	0,1	0,1	0,00	0,0	6,9	38,0	-31,0
					Olifants at Wilge	4,2	0,0	4,2	0,00	0,0	7,9	4,6	7,5
				B12	Middelburg Dam	64,2	1,1	65,3	64,00	0,0	1,2	58,7	71,8
					Klein Olifants at Olifants	0,0	0,1	0,1	0,00	0,0	8,0	20,8	-12,7
			Sub total			**157,0**	**1,4**	**158,4**	**224,32**	**0,0**	**30,2**	**293,5**	**119,4**
		B2	Wilge	B20	Bronkhorstspruit Dam	30,6	1,6	32,2	0,00	0,0	3,8	27,2	8,8
					Wilge at Olifants	24,0	1,2	25,2	5,00	5,0	7,1	51,3	-19,0
			Sub total			**54,6**	**2,8**	**57,4**	**5,00**	**5,0**	**10,8**	**78,6**	**-10,3**
		B3	Elands	B31	Rust de Winter Dam	17,3	8,7	26,0	0,00	0,0	0,7	12,8	13,8
					Renosterkop Dam	17,0	18,2	35,2	0,00	0,0	6,1	95,5	-54,2
					Elands at Olifants	5,2	8,1	13,3	0,00	0,0	2,9	18,9	-2,6
			Olifants - Loskop Reach	B32	Loskop Dam	109,3	0,1	109,3	0,00	0,0	0,7	59,3	50,7
					Olifants at Bloed	0,0	0,4	0,4	0,00	0,0	4,8	49,3	-44,1
					Bloed at Olifants	2,0	0,2	2,2	0,00	0,0	0,8	9,8	-6,7
					Olifants at Elands	53,4	0,1	53,4	0,00	0,0	8,1	93,7	-32,2
			Sub total			**204,2**	**35,8**	**239,9**	**0,00**	**0,0**	**24,1**	**339,3**	**-75,3**
		B4	Steelpoort	B41	Steelport at Klip	8,8	0,4	9,2	0,00	0,0	2,2	18,5	-7,1
					Steynsdrift Dam Proposal	12,4	2,8	15,2	0,00	0,0	1,5	16,6	0,1
					Steelpoort at Spekboom	24,1	6,4	30,5	0,00	0,0	3,3	34,2	-0,3
					Steelpoort at Olifants	4,8	1,1	5,9	0,00	0,0	0,1	5,3	0,7
				B42	Spekboom at Steelpoort	5,8	3,6	9,3	0,00	0,0	2,8	38,3	-26,1
			Sub total			**55,9**	**14,2**	**70,1**	**0,00**	**0,0**	**10,0**	**112,8**	**-32,7**
		B5	Middle Olifants	B51	Arabie Dam	19,9	0,3	20,2	0,00	0,0	0,5	35,8	-15,2
					Olifants at Lepelane	0,0	22,6	22,6	0,00	0,0	6,7	80,5	-51,2
				B52	Olifants at Bewaarkloof	15,1	2,1	17,2	0,00	0,0	1,3	14,2	4,3
			Sub total			**35,0**	**25,0**	**60,0**	**0,00**	**0,0**	**8,4**	**130,5**	**-62,1**
		B6	Blyde	B60	Blyde at Blyde Dam	16,4	0,2	16,6	0,00	0,0	0,3	34,5	-17,6
					Ohrigstad River	13,0	3,6	16,6	0,00	0,0	2,5	31,5	-12,4
					Blyde at Olifants	0,0	0,0	0,0	0,00	0,0	1,8	27,0	-25,2
			Sub total			**29,4**	**3,8**	**33,2**	**0,00**	**0,0**	**4,6**	**93,0**	**-55,2**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	0,0	2,6	2,6	0,00	0,0	0,6	5,2	-2,0
					Strijdom Tunnel Proposal	9,0	6,2	15,2	0,17	0,0	2,7	27,5	-9,5
					Olifants at Blyde	15,1	1,3	16,3	0,00	0,0	0,9	8,3	8,9
				B72	Olifants at Selati	23,4	2,3	25,7	0,16	0,0	2,6	52,2	-23,8
					Selati at Olifants	29,8	4,5	34,3	0,96	0,0	8,6	64,3	-20,5
				B73	Olifants at Letaba	16,7	0,6	17,2	0,00	0,0	2,3	10,2	9,3
					Olifants at Mozambique	0,0	0,0	0,0	0,00	0,0	0,0	5,6	-5,6
			Sub total			**93,9**	**17,5**	**111,4**	**1,3**	**0,0**	**17,5**	**173,4**	**-43,2**
Total in Gauteng						**33,9**	**10,9**	**44,8**	**2,1**	**5,0**	**5,4**	**50,8**	**-2,9**
Total in Mpumalanga						**448,7**	**29,6**	**478,3**	**227,3**	**0,0**	**67,6**	**779,8**	**-4,1**
Total in Nortern Province						**147,4**	**60,0**	**207,3**	**1,3**	**0,0**	**32,5**	**390,5**	**-152,4**
Total WMA						**630,0**	**100,6**	**730,5**	**230,7**	**5,0**	**105,6**	**1221,0**	**-159,4**

(1) Surpluses indicated by a + and deficits by a -.

The overall water balance for the Olifants WMA is approximately minus 160 million m^3/a.

7.3 THE UPPER OLIFANTS AREA

The Upper Olifants Area includes the Upper Olifants River catchment, Wilge River catchment and the Loskop Dam quaternary catchment area B32A.

This area is characterized by a high level of mining activities. The largest water requirement is for the six operating thermal power stations, which receive mainly imported water. The Upper Olifants River catchment has a water balance of 20,4 million m^3/a. The Wilge River catchment exports water to the Premier Mine and has a negative water balance of 10,3 million m^3/a. The Loskop Dam has a positive water balance of 50,7 million m^3/a.

The combined water balance for this area is 60,8 million m^3/a. It should be noted that this positive balance includes the yield of Loskop Dam and that the water released for irrigation downstream is not taken into account. This also explains why the downstream quaternary catchment shows a large negative balance in the Table 7.2.3.

7.4 THE MIDDLE OLIFANTS AREA

The Middle Olifants Area includes the area downstream of Loskop Dam, the Elands River catchment, and all other catchments down to the Olifants River at Bewaarkloof.

The former homelands form a major part of this area and relatively large rural water requirements have to be met. The runoff in this area is influenced by the largely endoreic Springbokvlakte. A large component of the water requirement is for irrigation downstream of Loskop Dam. This explains the combined water balance for this area which is minus 188,1 million m^3/a.

7.5 THE STEELPOORT AREA

The Steelpoort Area includes the Steelpoort River catchment down to its confluence with the Olifants River.

Irrigation and mining activities form the largest category of water use in this area. The Steelpoort Area has a negative water balance of 32,7 million m^3/a.

7.6 THE LOWER OLIFANTS AREA

The Lower Olifants Area includes the area downstream of the Olifants River at Bewaarkloof, including the Blyde River catchment.

A large percentage of the water requirement is for irrigation. The Blyde River catchment has a negative water balance of 55,2 million m^3/a. The combined water balance for the Lower Olifants Area is minus 98,4 million m^3/a. It should be noted that this balance does not include any contribution from the Letaba River catchment and is therefore effectively taken at the exit of quaternary catchment B73H.

CHAPTER 8: COSTS OF WATER RESOURCE DEVELOPMENT

8.1 METHODOLOGY

The methodology used to estimate the cost of harnessing the potential maximum yield of the water resources in the Olifants WMA is described below.

Table 8.1.1 indicates the costs of water resource development in the Olifants WMA. It only summarises the theoretically possible water resource development per key point, as calculated in Appendix G, but does not take into account the feasibility of individual projects.

8.1.1 Capital Cost of Dams

Figure 8.1.1 shows a proposed relationship between the gross storage capacity of a dam (at full supply level) and the capital cost at year 2000 prices including 14% VAT. The cost is not in a direct linear relationship with the storage capacity. Separate costs were therefore derived for the creation of theoretical shortfall dam storages in each key point area. To allow for large existing dams where, per key point, the dam is over-large, a negative construction cost was determined. Given the approximate approach used in determining the potential yield given in Table 6.1.1, this method of dealing with the large existing dams is deemed acceptable. In deriving the capital cost requirements in Table 8.1.1, it should be noted that the existing storage in a catchment area has generally been underestimated, because the existing volumes of small dams were not incorporated. The storage volumes to be supplied are therefore a conservative estimate and the capital cost requirement may be over-estimated by 10%.

The total estimated cost of dam development of R7 925 million, would increase the yield by about 658 million m^3/a (see Table 6.1.1.). The unit cost of about R 12 /m^3 is high, probably because a large number of relatively small storages were considered, thereby losing the economy of scale effect. A description of actual schemes considered in the past, is given in Sections 8.2 to 8.5 below.

8.1.2 Capital Cost of Wellfields

The cost to develop groundwater has been estimated and is given as Rands to develop 1kℓ/annum.

The costs include all evaluations, borehole siting, drilling, test pumping and equipping of the boreholes with positive displacement pumps and electrically driven motors.

The cost will however vary from area to area depending mainly on the following factors, viz.:

- Availability of existing information
- Borehole yield obtainable
- Drilling depth
- Drilling success rate
- Drilling conditions

The biggest influence on the cost was however found to be the borehole yield.

Figure 8.1.2 gives the estimated development cost for different borehole yields with an upper and lower range. The costs are at 2000 prices. The estimated development cost shown on Figure 8.1.2 is in Rand per kℓ/annum of water produced.

The estimated costs to fully exploit the groundwater potential is shown in Table 8.1.1. The average unit cost would be in the order of R 13 /m^3, which is very high. The most economical well field development schemes (compared to surface water development) would have to be identified, bearing in mind that in some instances groundwater is the only possible source.

8.2 THE UPPER OLIFANTS AREA

The Upper Olifants Area includes the Upper Olifants catchment, Wilge River catchment and the Loskop Dam. Potential dams according to maximum dam size for each catchment are shown in Appendix G.

The surface water resource of the region upstream of Loskop Dam is considered to be fully exploited. No new dams have been investigated for this area, although the approximate methodology followed in this study showed that storage could be developed in the upper catchment areas. Such development would however, impact on the yield at Loskop Dam.

8.3 THE MIDDLE OLIFANTS AREA

The Middle Olifants Area includes the area downstream of Loskop Dam, including the Elands River catchment, down to the confluence of the Olifants and Steelpoort rivers.

Two projects that are considered in combination are the raising of Arabie Dam (now Flag Boshielo Dam) and the construction of the Rooipoort Dam. These projects had been investigated by Ninham Shand.

If the **Arabie Dam** wall is raised by 5 m, the incremental yield will be 16,1 million m^3. The estimated total cost (in 2000) is R129 million, broken down as follows:
- construction: R 67,1m
- compensation: R 61,9m (of which R24,6m is for historic compensation).

The likely option for the **Rooipoort Dam** will be a dam volume of 265 million m^3 of which 75 million m^3 is a silt allowance. The estimated costs (in 2000) are:
- construction: R 207,5m
- relocation of roads: R 90,6m
- compensation: R 30,2m

The yield will be 59,9 million m^3 and the total estimated cost is R328,3 million.

The potential dams according to the postulated maximum dam size for each catchment, are shown in Appendix G.

TABLE 8.3.1: COSTS OF FUTURE SURFACE WATER RESOURCE DEVELOPMENT IN THE MIDDLE OLIFANTS AREA (2000)

Catchment No.	Scheme No.	Storage Volume (10^6m^3)	Incremental Surface Water Yield ($10^6m^3/a$)	Costs	
				Dams (R x 10^6)	Totals (R x 10^6)
B51B	Arabie Dam	increase of 84	16,1	129	129
B71B	Rooipoort Dam	190	59,9	328,3	328,3
TOTALS		**274**	**76**	**457,3**	**457,3**

8.4 THE STEELPOORT AREA

The Steelpoort Area includes the Steelpoort River catchment down to its confluence with the Olifants River. Potential dams according to maximum dam size for each catchment are shown in Appendix G.

Several dam options were investigated at a pre-feasibility level. The most probable option considered for further study is the De Hoop Dam. Table 8.4.1 gives details for a dam capacity of 1,0 x MAR.

Another option considered is the Steynsdrift Dam. This could be developed in a joint project with Eskom, with the development of the hydro-power scheme envisaged in the Steelpoort. If the dam is to be developed without Eskom, it is not considered a viable option. The details for a 1,0 x MAR dam at Steynsdrift are included in Table 8.4.1.

TABLE 8.4.1: COSTS OF FUTURE SURFACE WATER RESOURCE DEVELOPMENT IN THE STEELPOORT AREA (January 1999)

Catchment No.	Scheme No.	Storage Volume (10^6m^3)	Incremental Surface Water Yield ($10^6m^3/a$)	Costs	
				Dams (R x 10^6)	Totals (R x 10^6)
B41E	De Hoop Dam	161	87	100	100
B41D	Steynsdrift *	106	58	289	289
TOTALS		**267**	**145**	**389**	**389**

* Only an option if jointly developed with Eskom.

8.5 THE LOWER OLIFANTS AREA

The Lower Olifants Area includes the area downstream of the confluence of the Olifants and Steelpoort Rivers, including the Blyde River catchment. Potential dams according to maximum dam size for each catchment are shown in Appendix G3.

The 1991 Basin Study identified the Fountain Gorge Dam and Strijdom Tunnel Dam viable options for further investigation, the latter in conjunction with a hydropower scheme. No current feasibility studies are available for these proposed dams.

TABLE 8.1.1: COSTS OF WATER RESOURCE DEVELOPMENT

Catchment						Net Storage Volume to be Supplied	Estimated Cost	Wellfield yield to be developed	Estimated Cost	Total Cost
Primary		Secondary		Tertiary						
No	Description	No	Description	No	Description	(10^6m^3)*	(R x 10^6)	($10^6m^3/a$)	(R x 10^6)	(R x 10^6)
B	Olifants (part)	B1	Upper Olifants	B11	Rietspruit at Olifants	68,66	284,07	8,24	140,08	424,15
					Olifants at Rietspruit	105,30	345,50	9,96	263,94	609,44
					Witbank Dam	-48,54	-240,88	5,05	133,83	-107,05
					Olifants at Klein Olifants	32,26	199,11	1,39	18,77	217,88
					Olifants at Wilge	43,51	228,75	-2,14	0,00	228,75
				B12	Middelburg Dam	41,80	224,79	8,11	194,64	419,43
					Klein Olifants at Olifants	62,17	268,98	2,59	25,64	294,62
			Sub total			**305,16**	**1 310,32**	**33,20**	**776,90**	**2 087,22**
		B2	Wilge	B20	Bronkhorstspruit Dam	12,44	126,54	11,14	64,06	190,60
					Wilge at Olifants	174,23	437,53	2,59	33,41	470,94
			Sub total			**186,67**	**564,07**	**13,73**	**97,47**	**661,54**
		B3	Elands	B31	Rust de Winter Dam	34,69	205,57	-1,02	0,00	205,57
					Renosterkop Dam	-144,63	-391,99	10,14	130,81	-261,18
					Elands at Olifants	43,80	266,15	16,21	154,00	420,15
			Olifants - Loskop Reach	B32	Loskop Dam	-285,62	-551,45	-3,13	0,00	-551,45
					Olifants at Bloed	87,30	316,59	6,86	65,17	381,76
					Bloed at Olifants	50,37	245,28	8,92	49,06	294,34
					Olifants at Elands	87,14	316,27	20,25	12,15	328,42
			Sub total			**-126,95**	**406,42**	**58,23**	**411,19**	**817,61**
		B4	Steelpoort	B41	Steelpoort at Klip	142,55	395,31	0,40	5,80	401,11
					Steynsdrift Dam Proposal	51,51	230,55	-2,91	0,00	230,55
					Steelpoort at Spekboom	132,34	393,61	0,01	0,08	393,69
					Steelpoort at Olifants	34,29	204,04	4,42	39,78	243,82
				B42	Spekboom at Steelpoort	258,60	526,44	-2,68	0,00	526,44
			Sub total			**619,29**	**1 749,95**	**-0,76**	**45,66**	**1 795,61**
		B5	Middle Olifants	B51	Arabie Dam	-79,54	-302,44	4,60	110,40	-192,04
					Olifants at Lepelane	56,46	340,62	23,80	223,72	564,34
				B52	Olifants at Bewaarkloof	115,92	360,73	18,21	178,46	539,19
			Sub total			**92,84**	**398,91**	**46,61**	**512,58**	**911,49**
		B6	Blyde	B60	Blyde at Blyde Dam	328,46	569,32	-7,75	0,00	569,32
					Ohrigstad River	57,78	357,95	1,39	13,21	371,16
					Blyde at Olifants	50,70	245,45	1,71	16,25	261,70
			Sub total			**436,94**	**1 172,72**	**-4,65**	**29,46**	**1 202,18**
		B7	Lower Olifants	B71	Rooipoort Dam Proposal	52,77	249,87	3,66	34,77	284,64
					Strijdom Tunnel Proposal	325,88	585,43	-11,80	0,00	585,43
					Olifants at Blyde	40,90	223,56	2,01	34,17	257,73
				B72	Olifants at Selati	126,61	382,45	8,45	84,50	466,95
					Selati at Olifants	188,41	449,54	8,94	134,10	583,64
				B73	Olifants at Letaba	172,30	431,79	28,61	271,80	703,59
					Olifants at Mozambique	5,89	0,00	1,14	19,95	19,95
			Sub total			**912,76**	**2 322,64**	**41,01**	**579,29**	**2 901,93**
Total in Gauteng						**82,26**	**311,30**	**5,84**	**51,69**	**363,00**
Total in Mpumalanga						**1 307,08**	**4 457,20**	**87,79**	**1 275,70**	**5 732,90**
Total in Northern Province						**1 037,10**	**3 156,50**	**93,74**	**1 125,16**	**4 281,70**
Total WMA						**2 426,44**	**7 925,00**	**187,37**	**2 452,55**	**10 377,60**

* A negative value implies that surface water resources in the key point area have been developed past the level accepted for this evaluation.

DIAGRAM 8.1.1: CAPITAL COST OF DAMS

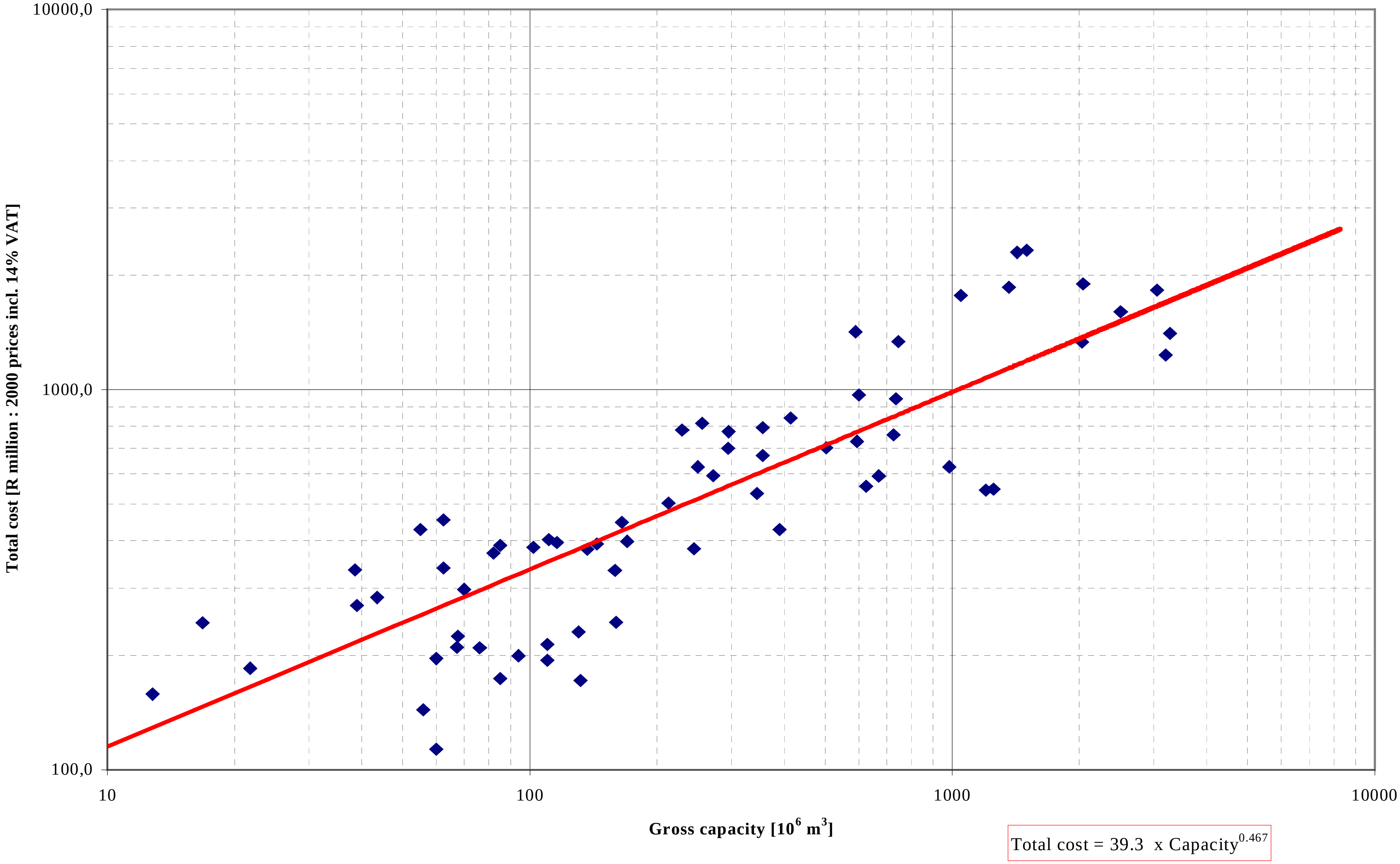
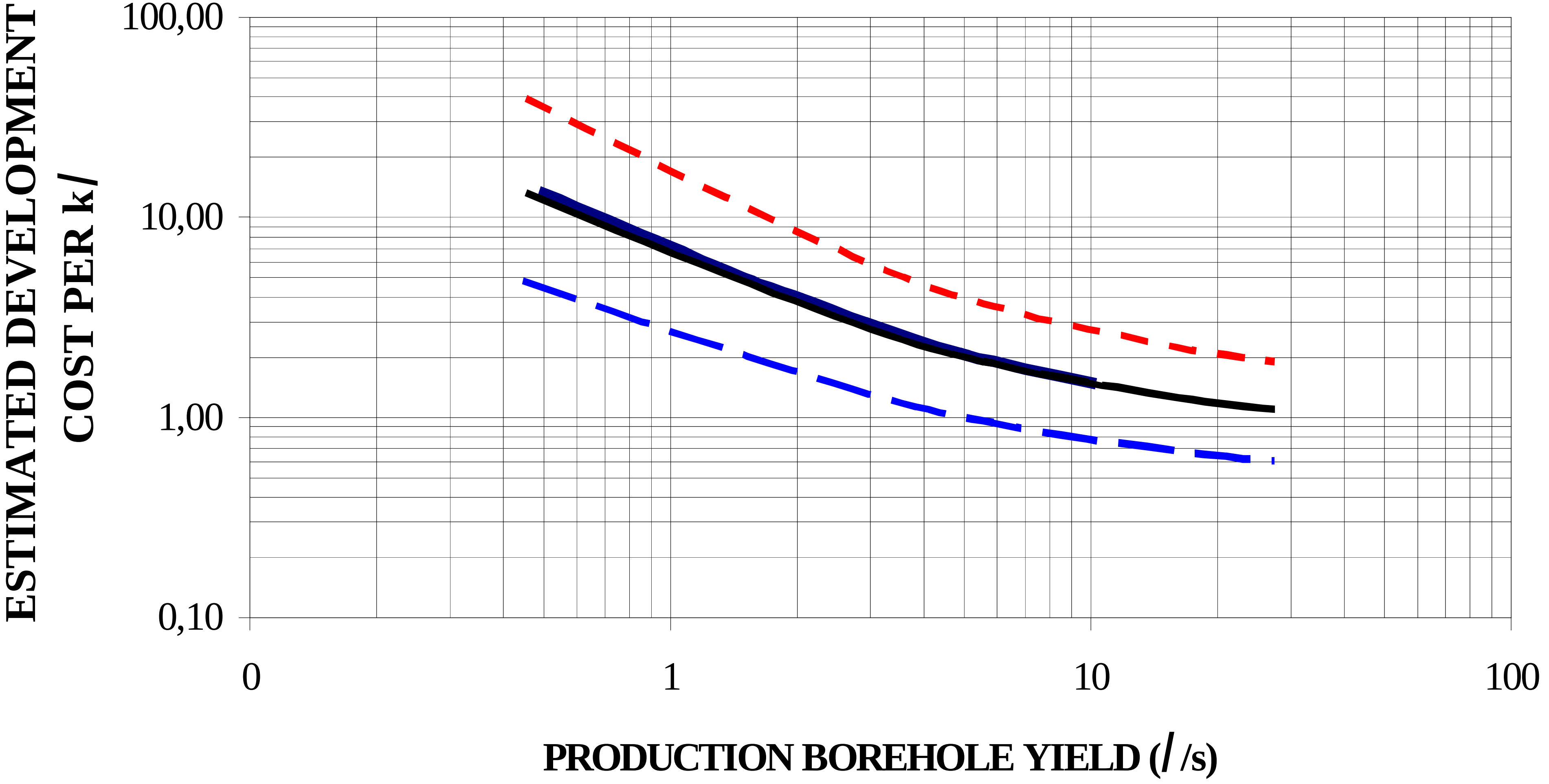


DIAGRAM 8.1.2: GROUNDWATER DEVELOPMENT COST



CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 AVAILABLE DATA

Data that should be collected for the purpose of proper management of the Olifants WMA include:

- Monitoring of **large water abstractions** from both surface and ground water resources and the recording of these in a database. The agricultural sector is the largest water user in the Olifants WMA, yet largely incomplete information exists about the water use on individual farms. Although the water use registration process will collect data on from use, the data may not reflect annual, actual usage.

- The quantity and quality of **effluent discharge** streams from towns, industries and other sources should be monitored and the information kept in a database.

- Information on **silt loads** should be collected. Overgrazing should be discouraged to improve the erosion of such areas.

- Estimates of domestic **water requirements** were based on population data and associated unit water usage, for the different levels of development. In many instances there are no, or unreliable, measurements of actual usage. The annual data to be submitted by Water Supply Authorities to DWAF in terms of the Water Services Act, should be linked to the Planning Data Base. An initiative should be launched to encourage proper measurements and reporting of domestic and industrial water usages, for all levels of development.

- The **river flow gauging network** should be improved with new gauges at strategically important points in the basin. Existing gauges should be checked for accuracy and reliability.

- Information on **infiltration and seepage losses** from rivers and canal distribution systems is unavailable and is required for the optimising of water supply systems.

- A sensitivity analysis should be done on the influence of **afforested areas** on stream flows. This would show how significant the effect is on the results.

- The **rainfall station network** should be augmented with a number of new gauges in the rain shadow areas west of the Escarpment.

- **Water quality** should be investigated and monitored especially in the Steelpoort River, Selati River and the Middle Olifants River (secondary catchment B5). Water quality monitoring stations are insufficient.

- For the purpose of estimating surface water resources, it is recommended (see section 6.3.1) that **catchments** affected by afforestation should be **re-calibrated** in the process of calculating the MAR from naturalised flows.

- Information regarding **groundwater contamination** resulting from human wastes should be collected. Once sufficient microbial data becomes available, the numerical methods and associated assumptions discussed in section 6.4.3 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.

- The yield for the Blyderivierspoort Dam in Table 6.1.1 is very low compared to the Basin Study value. The yields of dams in the WMA should be re-assessed where required so that further planning can be done on a sound basis.

9.2 THE UPPER OLIFANTS AREA

Although this area falls within the Loskop Dam Catchment Government Water Control Area, no official information regarding the extent of irrigation exists. Satellite image data taken on several points in time might enable the composition of better information on irrigation. A survey on the impact of irrigation where it is a major consumer of water will provide further information.

Augmentation of water resources in this area with transfers from other basins is required and the expectation is that these transfers will have to increase substantially in future.

9.3 THE MIDDLE OLIFANTS AREA

Augmentation of water supplies to the former KwaNdebele and stabilisation of runoff for irrigation should be investigated. The rising water demand of the former Lebowa should be planned for timeously, in view of the high population growth rate. The introduction of more ecologically sound agricultural practices and stocking rates are required to halt the current degradation of the vegetation and thus improve runoff, control erosion and improve water quality.

The water resource needs to be classified and the estimates of the ecological component of the Reserve must be improved in order that a better assessment can be made of the utilizable water resources.

9.4 THE STEELPOORT AREA

It is recommended that the proposed De Hoop Dam is further investigated in a feasibility study to regulate the flow in the Steelpoort River in order to increase the availability of reliable supplies and improve the quality of runoff to the Lower Olifants River.

The impact of increased mining activities on the quality and quantity of water available should be investigated.

Irrigation is still the largest category of water user category. Priority should be given to the monitoring of irrigation water needs to ensure that the values used are representative of the reality.

9.5 THE LOWER OLIFANTS AREA

Irrigation development in the Selati River catchment is affected by water shortages. The allocation of water from the Tours Dam and the possibility of a new dam in the catchment should be investigated.

Users in the lower Olifants River are at a disadvantage as far as their water requirements are concerned. The needs of upstream and downstream users should be balanced. The Kruger National Park needs to take proactive stance to clarify what its water needs are to ensure that these needs are acknowledged by other water users and decision makers. It must also ensure that sufficient funding is made available to permit implementation of the development required to meet its needs.

It may be considered to have a body established by the Minister of Water Affairs and Forestry to conclude and implement an international agreement with Mozambique on the required flow in the Olifants River downstream of the South African boundary with Mozambique.

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APPENDICES

APPENDIX A:	**DEMOGRAPHIC DATA**
APPENDIX B:	**MACRO-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

APPENDIX A

DEMOGRAPHIC DATA

APPENDIX A

WMA 4: OLIFANTS Version 2: June 2001 Quaternary Catchment	Urban Population	Rural Population
B11A	3,250	5,599
B11B	200	10,220
B11C	0	3,386
B11D	12,000	4,396
B11E	0	9,930
B11F	0	7,596
B11G	0	6,530
B11H	0	3,576
B11J	167,700	1,528
B11K	0	3,121
B11L	0	1,210
B12A	13,500	2,652
B12B	0	6,794
B12C	0	3,885
B12D	84,550	3,324
B12E	0	3,173
B20A	159,900	7,257
B20B	93,900	4,644
B20C	0	3,100
B20D	19,950	3,630
B20E	27,400	5,675
B20F	0	4,384
B20G	23,450	3,394
B20H	30,600	1,921
B20J	0	4,940
B31A	0	3,660
B31B	0	17,290
B31C	0	426
B31D	4,450	33,310
B31E	0	12,880
B31F	11,000	27,670
B31G	0	27,800
B31H	120,400	26,680
B31J	2,450	6,986
B32A	0	4,229
B32B	0	3,232
B32C	0	959
B32D	3,150	2,388
B32E	0	563
B32F	7,000	23,880
B32G	4,700	159,400
B32H	0	5,529
B32J	8,150	31,350
B41A	9,450	2,769
B41B	0	3,944
B41C	0	1,700
B41D	0	7,900
B41E	0	21,000
B41F	0	1,069
B41G	0	750
B41H	0	31,550
B41J	0	36,450
B41K	0	41,800
B42A	0	1,715
B42B	15,200	419
B42C	0	350
B42D	0	284
B42E	0	612
B42F	0	775
B42G	0	755
B42H	1,300	5,164

WMA 4: OLIFANTS Version 2: June 2001 Quaternary Catchment	Urban Population	Rural Population
B51A	7,200	28,870
B51B	0	41,400
B51C	0	40,420
B51E	0	29,450
B51F	0	1,125
B51G	0	87,730
B51H	1,700	85,980
B52A	0	43,290
B52B	6,150	89,970
B52C	0	14,710
B52D	28,600	36,890
B52E	0	30,940
B52F	0	8,132
B52G	0	20,200
B52H	0	59,320
B52J	0	19,750
B60A	0	1,200
B60B	0	1,655
B60C	0	275
B60D	0	13,500
B60E	0	201
B60F	0	1,029
B60G	0	2,730
B60H	0	12,470
B60J	750	3,483
B60J*	0	0
B71A	0	2,616
B71B	0	5,982
B71C	0	2,164
B71D	0	9,064
B71E	0	71,980
B71F	1,400	4,833
B71G	0	11,620
B71H	0	18,240
B71J	0	597
B72A	0	48,680
B72B	0	164
B72C	0	4,427
B72D	0	963
B72E	0	40,180
B72F	0	193
B72G	0	1,299
B72H	400	150
B72J	200	2,709
B72K	5,050	41,960
B73A	0	49
B73B	0	489
B73C	57,950	392
B73D	0	125
B73E	0	52
B73F	0	31
B73G	0	54
B73H	0	22
B73J	0	18
TOTAL	933,050	1,606,874

APPENDIX B

MACRO-ECONOMIC DATA

APPENDICES

SUPPLEMENTARY ECONOMIC INFORMATION

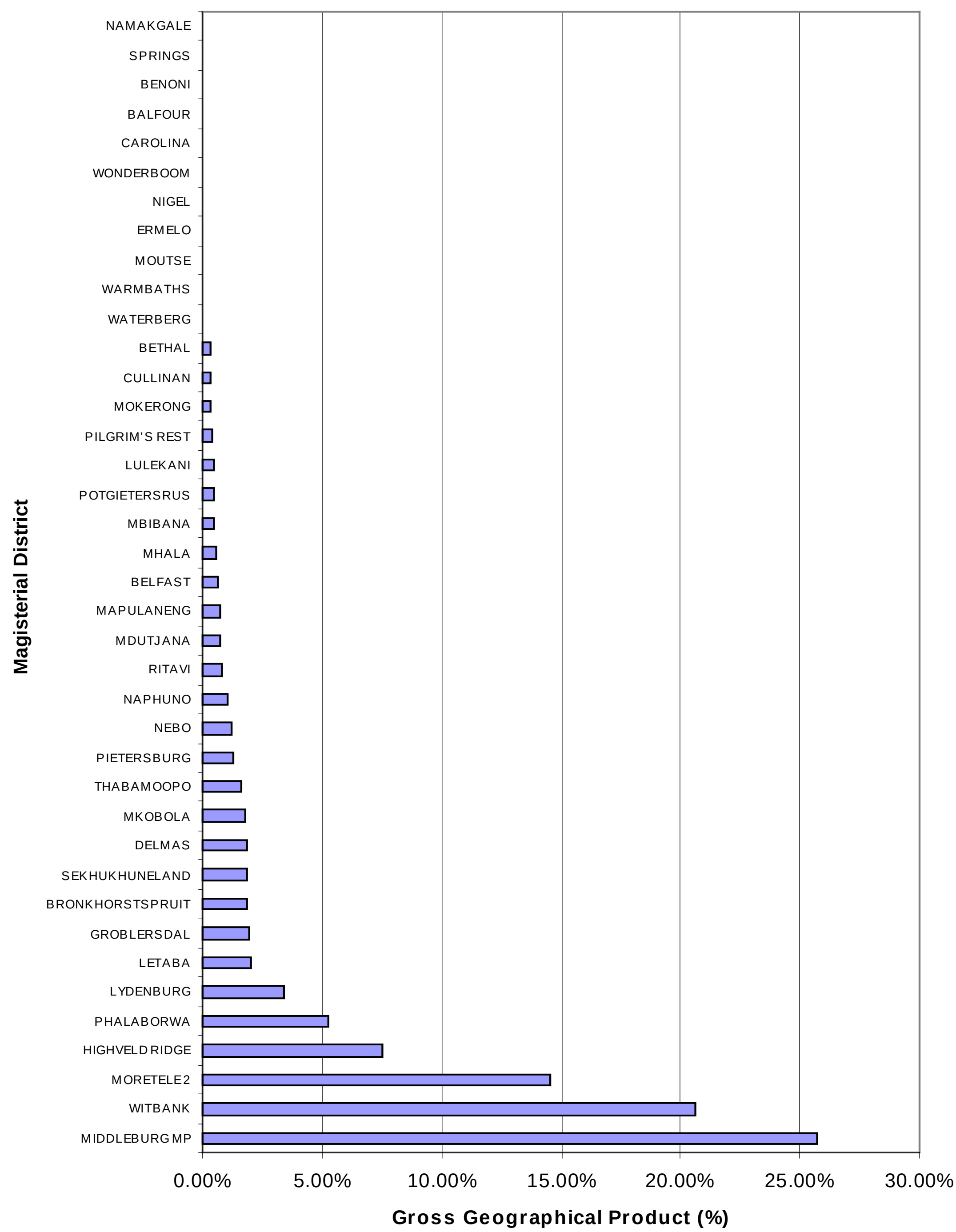
APPENDIX B.1

GRAPHS: GROSS GEOGRAPHIC PRODUCT, LABOUR AND SHIFT-SHARE

APPENDIX B.1
DESCRIPTION OF GRAPHS

Diagram No	Graphic Illustration	Description
	• **Gross Geographic Product**:	
B.1	➩ Contribution by Magisterial District to Berg 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 Berg 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 Berg Employment, 1980 and 1994 (%)	Shows the sectoral composition of the formal WMA labour force.
B.5	➩ Contribution by Sectors of Berg 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 Berg 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 Olifants economy, 1997 (%)



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

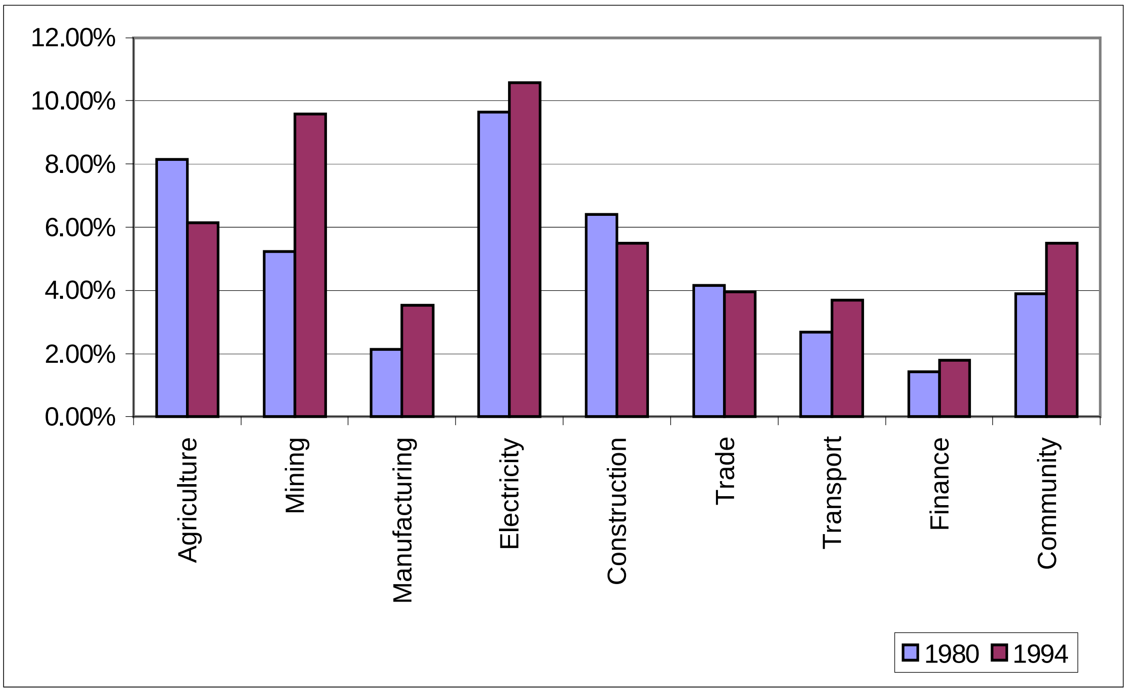


Figure B.3: Composition of Olifants Labour Force, 1994 (%)

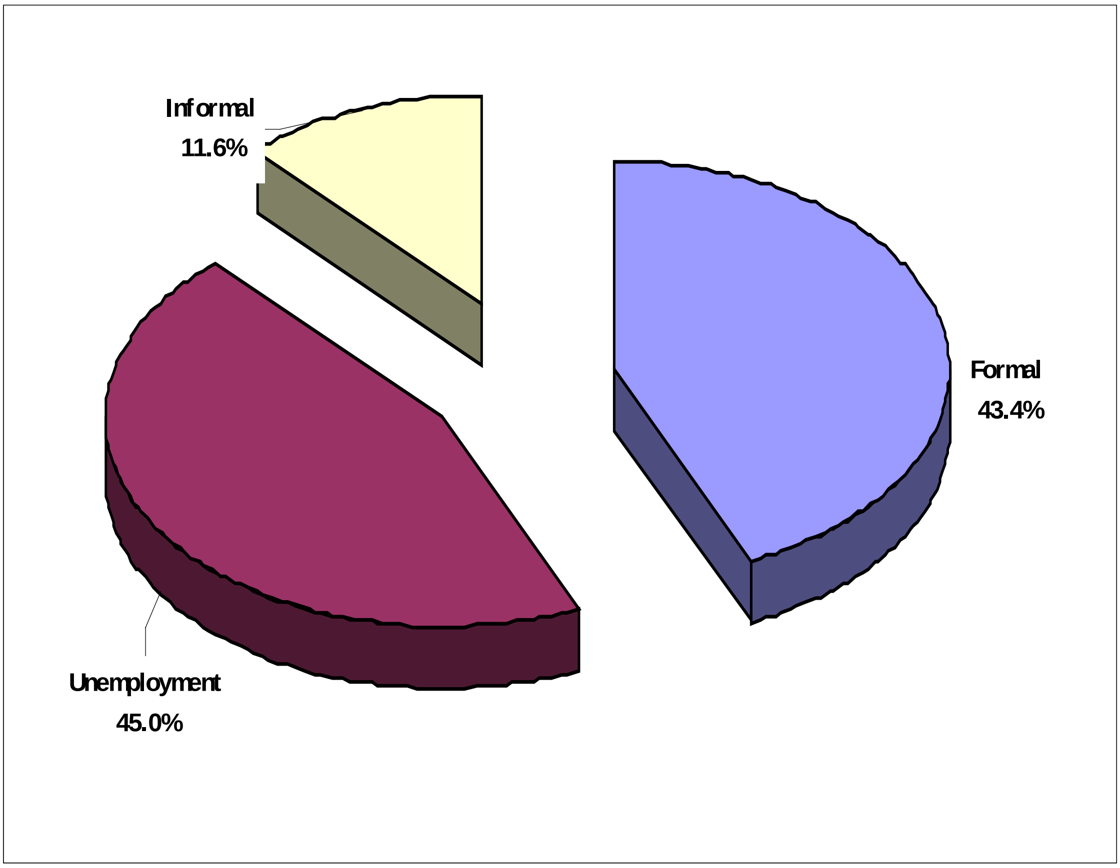


Figure B.4: Contribution by Sector to Olifants Employment, 1980 and 1994(%)

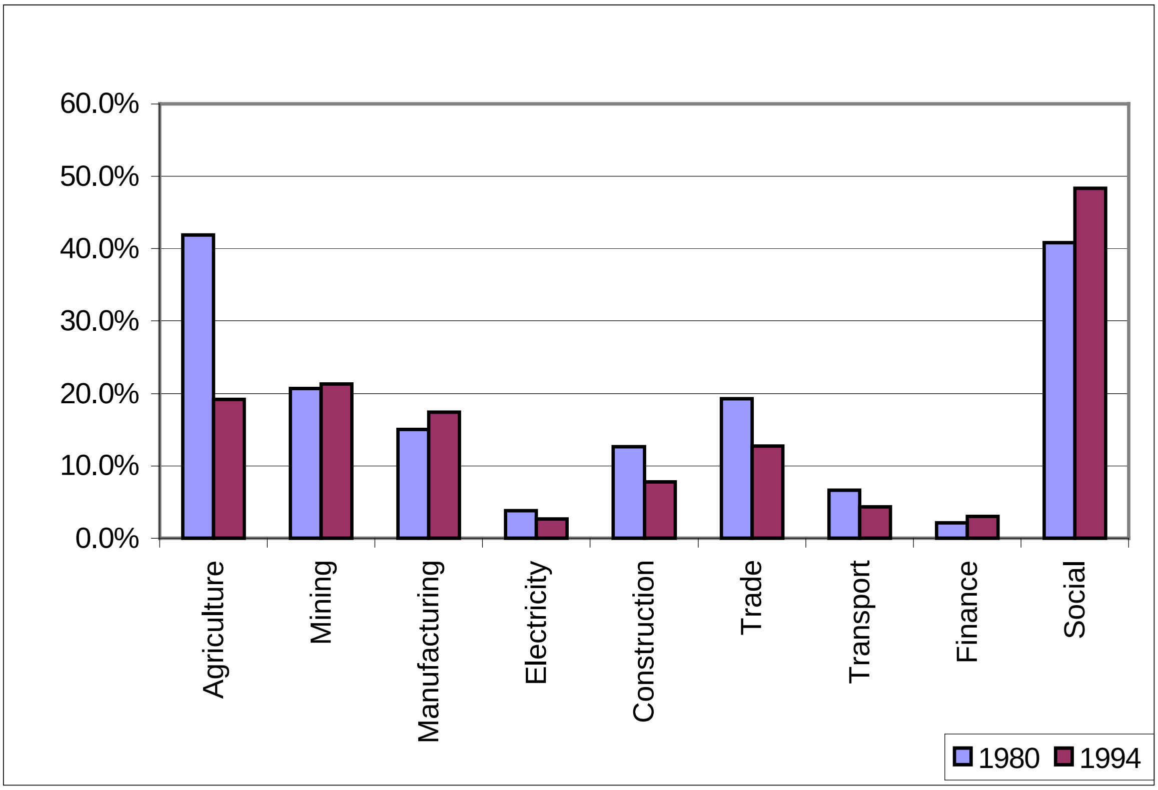


Figure B.5: Contribution by Sectors of Olifants Employment to National Sectoral Employment, 1980 and 1994 (%)

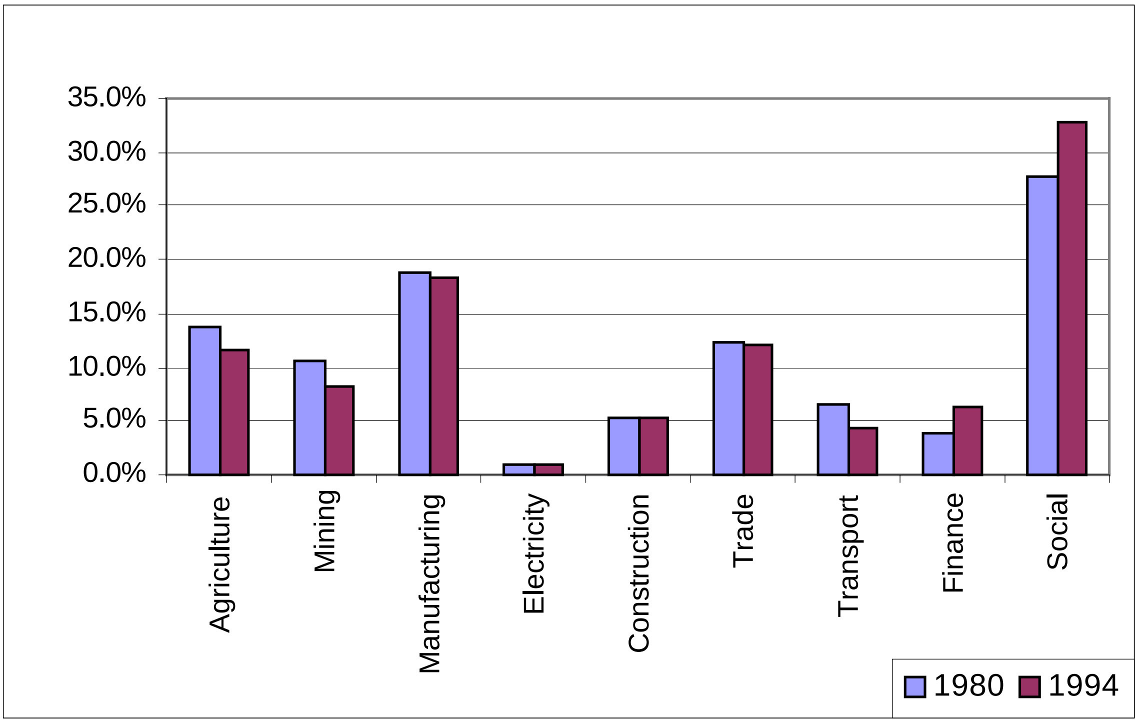


Figure B.6: Average Annual Employment Growth by Sector of Olifants versus South Africa, 1980 to 1994 (%)

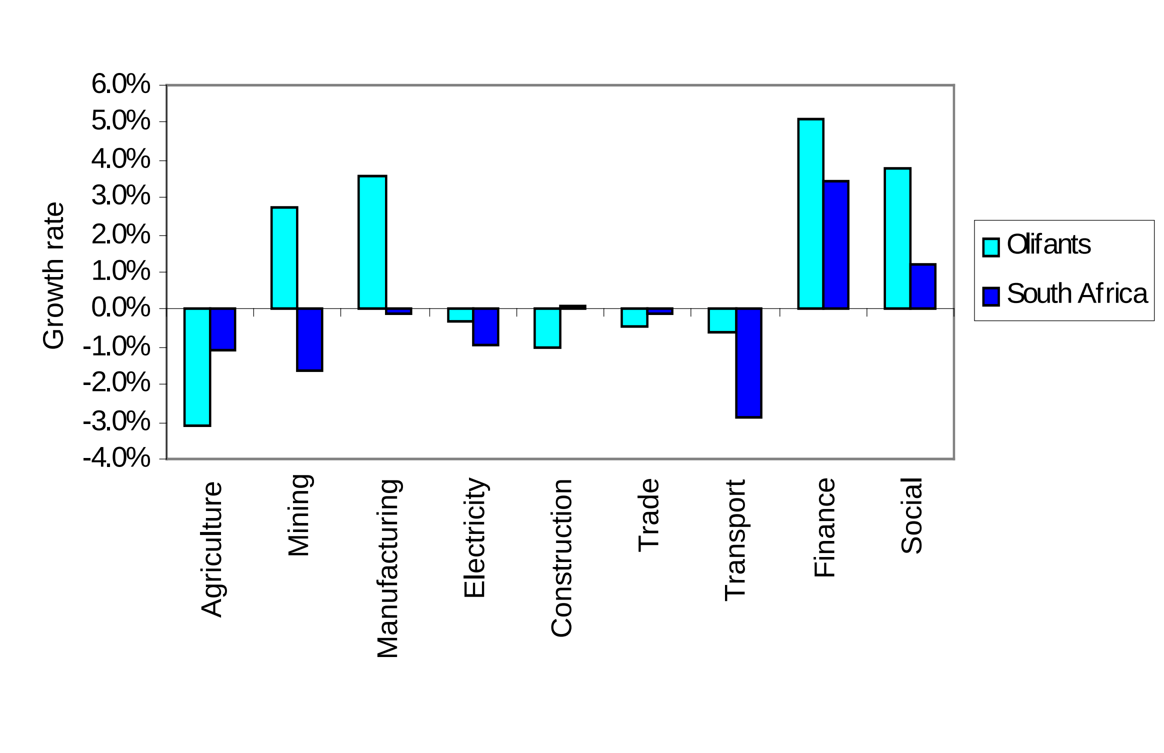
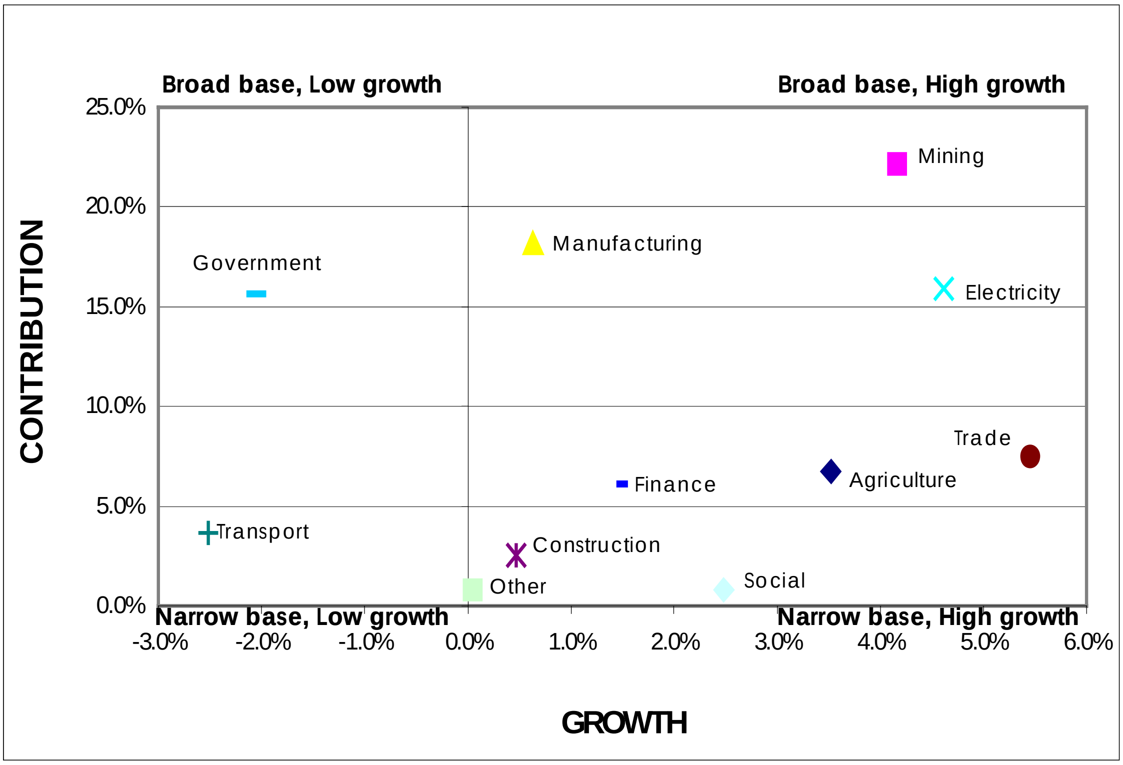


Figure B.7: Shift-Share Analysis, 1997



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

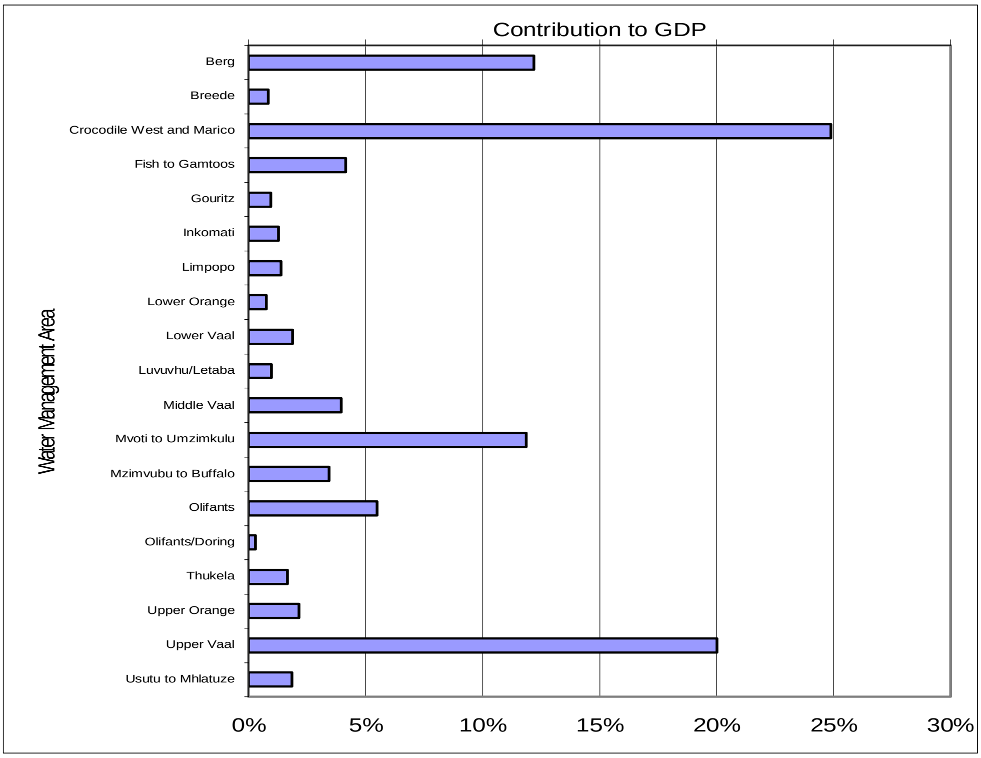
- The largest contribution to the national economy is made by the Crocodile West and Marico WMA which contributes (19.1%) to GDP. This WMA comprises, inter alia, magistrates districts of Pretoria, Johannesburg, Germiston, Kempton Park, Benoni, Thabazimbi and Lichtenburg.

- 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.

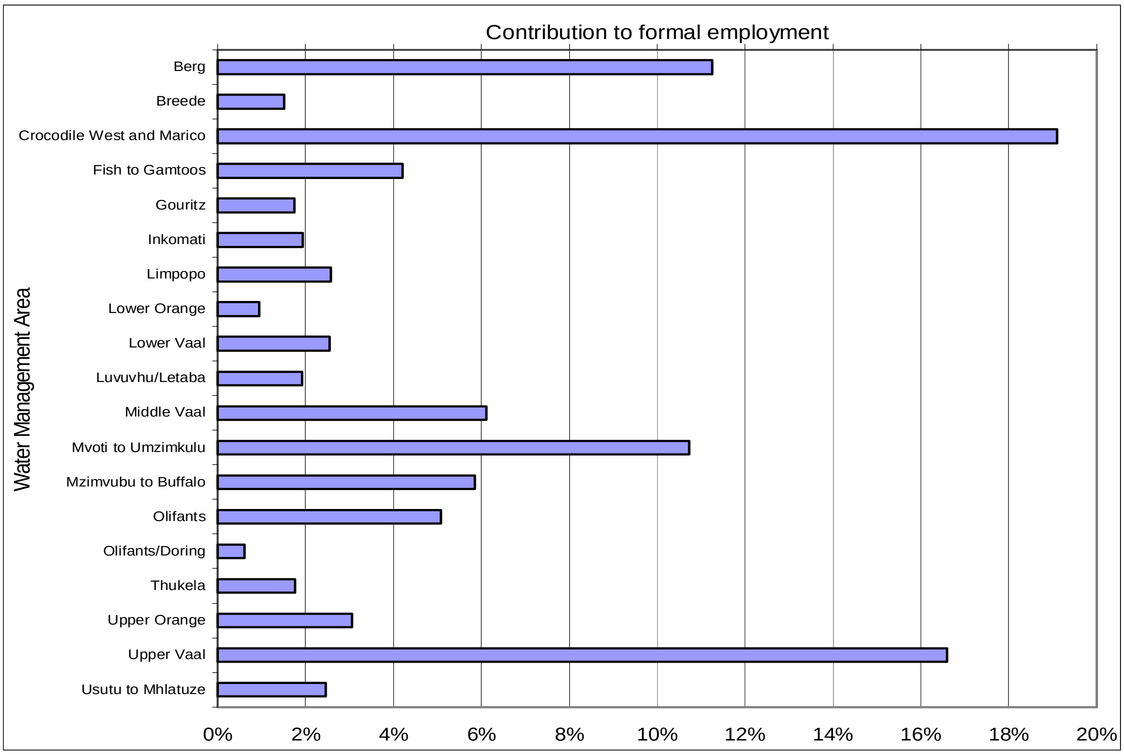
Figure B.1: Total GGP by Water Management Area (% of Country)



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.

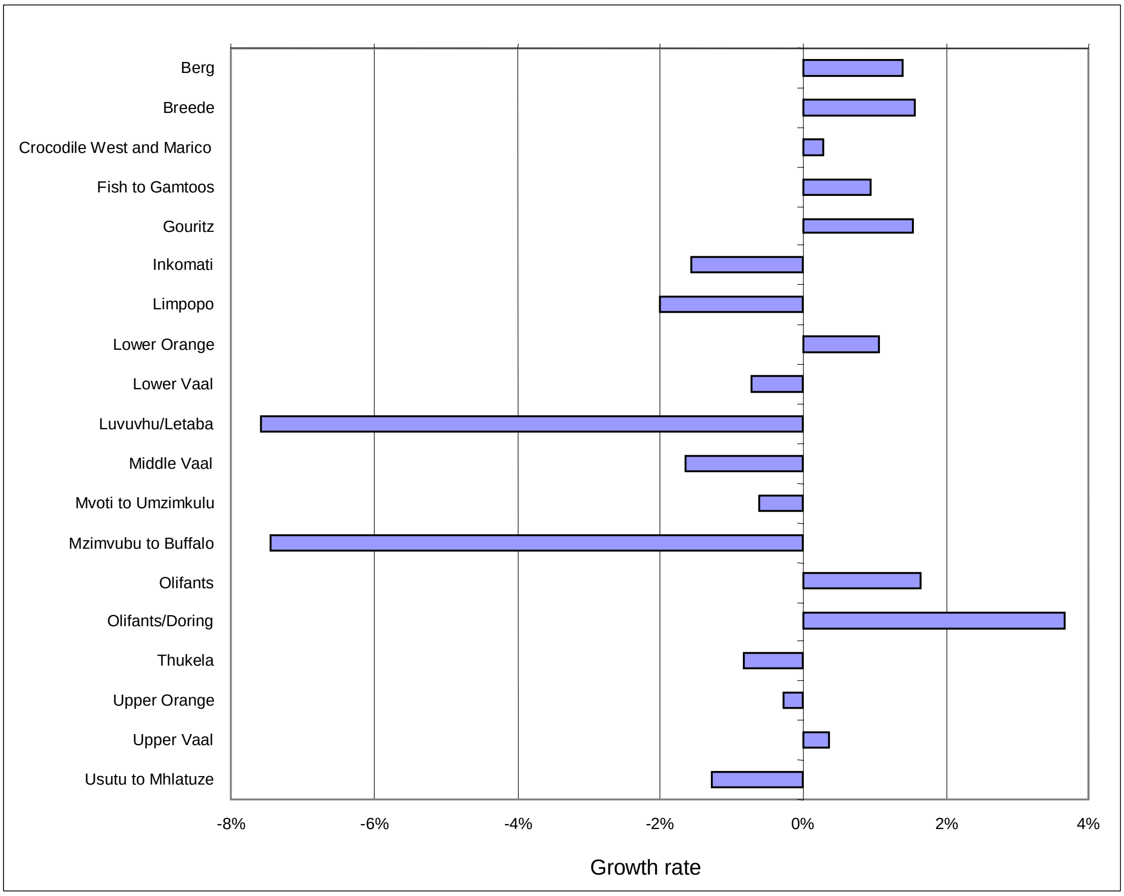
Figure B.2: Formal Employment by Water Management Area (% of country)



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.

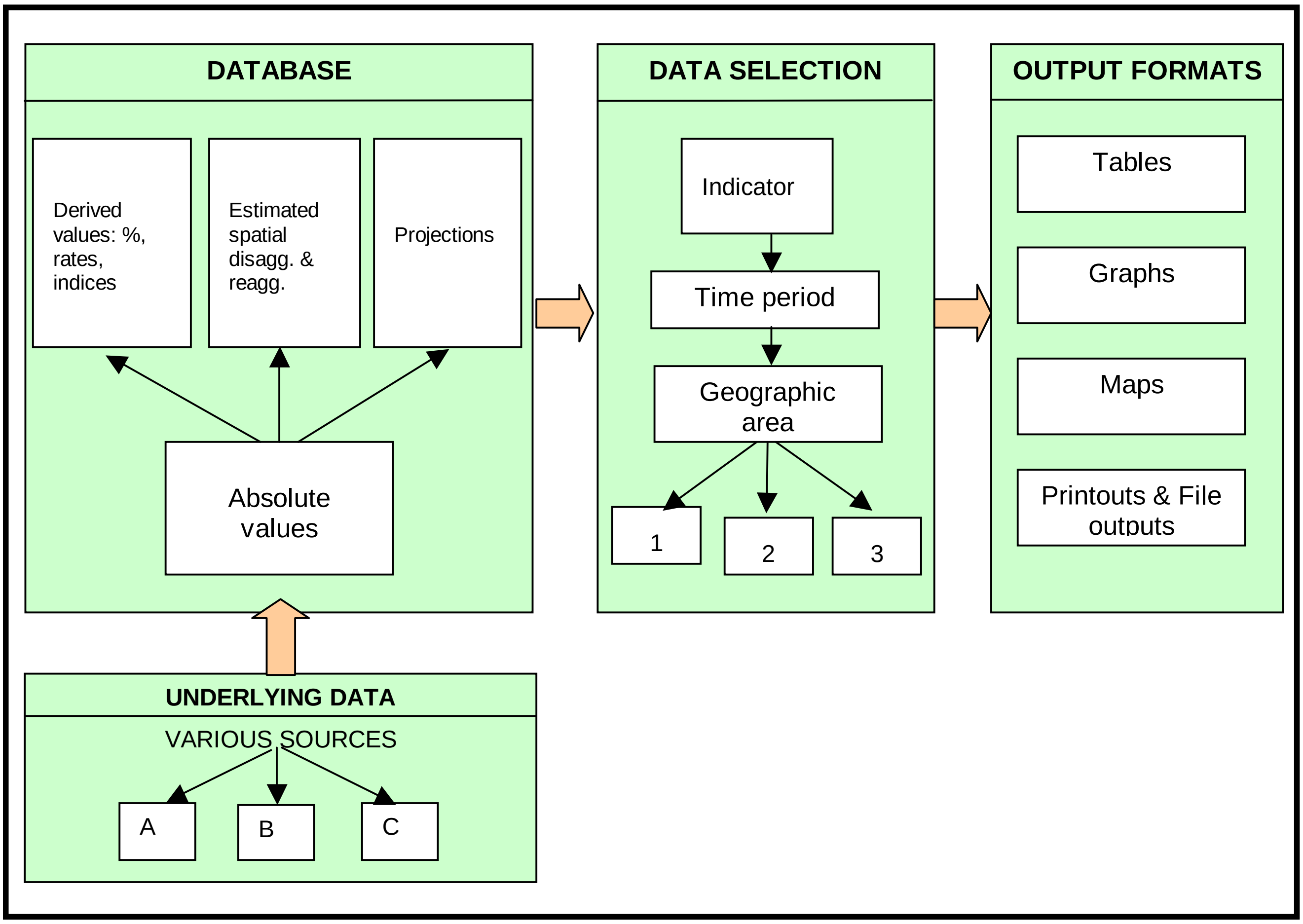
Indicator	Categories	Timespan	Geographic detail
Gross geographic product	Major sectors	1972-1997	Magisterial districts
Labour distribution	Employment/un-employment Major sectors	1980, 1991, 1994	Magisterial districts
Electricity consumption	Economic sectors, domestic	1988-1997	Local authority area, service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

APPENDIX D

LAND-USE DATA

Source of data:									
COUNCIL OF GEOSCIENCE (previously Geological Survey)									
Private Bag X112; Pretoria; RSA									
Mr CJ Vorster;		**Tel: (012) 841-11**	**Fax: (012) 841-1140**						
(Samindaba database)		***e-mail: cvorster@geoscience.org.za***							
MINERALS BUREAU (coal mining data)									
Johannesburg									
Mr Xavier Prevost		**Tel: (012) 317-9573**							
		Fax: (012) 320-4268							
(Mineral Economist)		*e-mail: xavier@mejhb.pwv.gov.za*							
LONGITUDE	**LATITUDE**	**Quaternary**	**MINE_NAME**	**Primary Commodity Mined**	**PROVINCE**	**FARM_NAME**	**FARM_NO**	**SAMINDABA No.**	**Minerals Bureau**
Dec. degree	**Dec. degree**	**Catchment**						**Council of Geoscience**	**No.**
29.56666	-26.28333	B11A	FORZANDO COLLIERY	COAL (ANGLOVAAL)	MPUMALANGA	BANKPAN	225 IS		2996
29.43333	-26.11667	B11B	GOEDEHOOP COLLIERY	COAL (AMCOAL)	MPUMALANGA	GOEDEHOOP	46 IS		1439
29.46667	-26.08333	B11B	KOORNFONTEIN MINES - BLINKPAN	COAL (INGWE)	MPUMALANGA	BROODSNEYERSPLAATS	25 IS		0048
29.20000	-26.26667	B11D	KRIEL COLLIERY	COAL (AMCOAL)	MPUMALANGA	DRIEFONTEIN	69 IS		0014
29.13333	-26.36667	B11D	SYFERFONTEIN COLLIERY	COAL (SASOL)	MPUMALANGA	TWEEDRAAI	139 IS		2543
29.23333	-26.45000	B11D	TWEEDRAAI COLLIERY	COAL	MPUMALANGA	TWEEDRAAI	139 IS		2991
29.20972	-26.43694	B11D	QUARRY (NAME UNKNOWN)	STONE AGGREGATE, GRAVEL	MPUMALANGA	TWEEDRAAI	139	1148359	
29.21667	-26.11667	B11E	ARTHUR TAYLOR COLLIERY & OPENCAST MINE	COAL (JCI)	MPUMALANGA	BLESBOKFONEIN / KROMFONTEIN	31 IS, 30 IS - PTN 3		1272 /
29.21667	-26.15000	B11E	RIETSPRUIT MINE	COAL (INGWE)	MPUMALANGA	HARTEBEESTFONTEIN	39 IS		0817
29.23333	-26.01667	B11F	KLEINKOPJE COLLIERY	COAL (AMCOAL)	MPUMALANGA	KLEINKOPJE	15 IS		4059
29.26667	-25.98333	B11F	DOUGLAS COLLIERY	COAL (INGWE)	MPUMALANGA	WOLVEKRANS	17 IS		0947
29.03333	-26.11667	B11F	KHITALA MINING	COAL (INGWE)	MPUMALANGA	HEUVELFONTEIN	215 JR		1691
29.21667	-26.06667	B11F	PHOENIX COLLIERY	COAL (JCI)	MPUMALANGA	BLESBOKFONTEIN	31 IS		0503
29.15000	-26.15000	B11F	SOUTH WITBANK COLLIERY	COAL (JCI)	MPUMALANGA	BLESBOKFONTEIN	38 IS & 31 IS		0598
29.20000	-26.13333	B11F	TAVISTOCK COLLIERY	COAL (JCI)	MPUMALANGA	BLESBOKFONTEIN	31 & 38 IS		0633
29.16667	-26.03333	B11F	TWEEFONTEIN COLLIERY	COAL	MPUMALANGA	TWEEFONTEIN	13 IS		0164
29.16667	-25.96667	B11G	GREENSIDE COLLIERY & NEW CLYDESDALE	COAL (GOLDFIELDS)	MPUMALANGA	GROENFONTEIN	331 JS		0906
29.45000	-25.96667	B11H	BANK 2 COLLIERY	COAL (AMCOAL)	MPUMALANGA	BANKFONTEIN	340 JS		0115
29.46667	-26.01667	B11H	BANK 5 COLLIERY	COAL (AMCOAL)	MPUMALANGA	WELVERDIEND	23 IS		0045
29.41667	-25.96667	B11H	MIDDELBURG MINE	COAL (INGWE)	MPUMALANGA	HARTBEESFONTEIN	339 JS		0793
29.24556	-25.88528	B11J	WITBANK CRUSHERY MINE	STONE AGGREGATE, GRAVEL	MPUMALANGA	WITBANK		1052737	
29.16667	-25.75000	B11K	BLESBOKLAAGTE COLLIERY	COAL	MPUMALANGA	BLESBOKLAAGTE	296 JS		3165
29.13333	-25.83333	B11K	KLIPFONTEIN COLLIERY	COAL	MPUMALANGA	SCHOONGEZICHT	308 JS, PTN 44 & 43		2345
29.76667	-25.93333	B12B	ARNOT COLLIERY	COAL (AMCOAL)	MPUMALANGA	BLESBOKFONTEIN	487 JS		0013
29.61667	-26.00000	B12B	OPTIMUM COLLIERY	COAL (INGWE)	MPUMALANGA	PULLENSHOPE	155 IS		0474
29.75667	-26.00306	B12B	CRUSHER & CIVIL FELSITE QUARRY	STONE AGGREGATE, GRAVEL	MPUMALANGA	AMSTERDAM	489	1148377	
29.43333	-25.73333	B12D	BLACK WATTLE COLLIERY	COAL	MPUMALANGA	MIDDELBURG TOWN & TOWNLANDS	287 JS		3046
29.53417	-25.77889	B12D	MIDDELBURG CRUSHERY MINE	STONE AGGREGATE, GRAVEL	MPUMALANGA	RONDEBOSCH	403	1052736	
28.67833	-26.08028	B20A	STERLING SLATE QUARRY	SHALE/SLATE/JASPILITE/SCHIST (DIMENSION STONE)	MPUMALANGA	LEEUWPOORT	205	1148597	
28.77972	-26.15333	B20A	DELMAS SILICA MINE	SILICON	MPUMALANGA	MOABSVELDEN	248	1165233	
28.75306	-25.99361	B20C	QUARRY (NAME UNKNOWN)	SILICA (GENERAL)	MPUMALANGA	GROENFONTEIN	206	1041403	
28.72361	-26.00389	B20C	QUARRY (NAME UNKNOWN)	VEIN QUARTZ (SILICA)	MPUMALANGA	GROENFONTEIN	206	1164394	
28.67472	-25.87333	B20D	BRONX & MOWKOP SILICA MINES	FOUNDRY SAND (SILICA)	GAUTENG	VLAKFONTEIN	523	1041473 / 1041394	
28.62139	-25.84139	B20D	NOEL LANCASTER SANDS QUARRY	GLASS SAND (SILICA)	GAUTENG	WITFONTEIN	521	1041393	
28.59361	-25.82861	B20D	PUNTLYF SANDS QUARRY	GLASS SAND (SILICA)	GAUTENG	PUNTLYF	520	1041268	
28.71139	-25.77611	B20D	B & E QUARRIES	STONE AGGREGATE, GRAVEL	GAUTENG	HONDSRIVIER	508	1041440	
28.83333	-26.26667	B20E	DELMAS COLLIERY	COAL (INGWE)	MPUMALANGA	HAWERKLIP	265 IR		0150
28.83333	-26.25000	B20E	IKHWEZI COLLIERY	COAL	MPUMALANGA	MAYERGLEN	269 IR		3166
28.95000	-26.13333	B20E	LEEUWFONTEIN COLLIERY	COAL (METOREX)	MPUMALANGA	LEEUWFONTEIN	219 IR		4218
28.93333	-26.11667	B20E	LAKESIDE COLLIERY	COAL	MPUMALANGA	LEEUWFONTEIN	219 IR		2559
28.92722	-25.86639	B20F	SPITZKOP SILICA QUARRY	SILICA (GENERAL)	GAUTENG	SPITZKOP	533	1041450	
29.06667	-25.78333	B20G	LANDAU COLLIERY	COAL (AMCOAL)	MPUMALANGA	KROMDRAAI	279 JS		2928
29.11667	-25.93333	B20G	ELANDSFONTEIN COLLIERY	COAL (METOREX)	MPUMALANGA	ELANDSFONTEIN	309 JS, PTN 14		2994
29.06667	-25.88333	B20G	RONDEBULT COLLIERY	COAL	MPUMALANGA	RONDEBULT	303 JS		3071
28.72528	-25.63972	B20H	NDEBELE MINING KAOLIN PLANT	KAOLIN (CLAY)	MPUMALANGA	LEEUWFONTEIN	466	1041272	

LONGITUDE	LATITUDE	Quaternary	MINE_NAME	Primary Commodity Mined	PROVINCE	FARM_NAME	FARM_NO	SAMINDABA No.	Minerals Bureau
Dec. degree	Dec. degree	Catchment						Council of Geoscience	No.
28.80417	-25.58972	B20H	CULLINAN CLAY QUARRIES PIT 3	REFRACTORY CLAY (FLINT)	MPUMALANGA	BLESBOKFONTEIN	459	1041330	
28.78194	-25.56139	B31B	NOOITGEDACHT CLAY QUARRY	REFRACTORY CLAY (FLINT)	MPUMALANGA	NOOITGEDACHT	436	1044993	
28.71694	-25.63611	B31B	RIETFONTEIN MINE	REFRACTORY CLAY (FLINT)	MPUMALANGA	RIETFONTEIN	470	1044976	
28.57944	-25.25694	B31D	VERGENOEG FLUORSPAR MINE	FLUORSPAR	GAUTENG	KROMDRAAI	209	1044508	
29.30444	-24.96194	B31J	MARBLE HALL MINE	LIMESTONE	MPUMALANGA	LOSKOP NOORD	12	1128588	
28.79389	-25.50306	B32G	ROODEPOORT MINE 1	REFRACTORY CLAY (FLINT)	MPUMALANGA	ROODEPOORT	439	1041312	
29.30639	-25.15333	B32H	FRIK GEYSER MINE	STONE AGGREGATE, GRAVEL	MPUMALANGA	LOSKOP NOORD	12	1052743	
29.86667	-25.58333	B41A	WAPADSKLOOF MINE	VANADIUM	GAUTENG	LEEUKLIP	363	1167369	
30.00000	-25.70000	B41A	GLISA COLLIERY	COAL (INGWE)	MPUMALANGA	PAARDEPLAATS	380 JT, PTNS 1-5 & 24		6272
29.91722	-25.68722	B41A	MARLIN / BOSCHPOORT GRANITE QUARRIES	GABBRO/DOLERITE/NORITE (DIMENSION STONE)	MPUMALANGA	BOSCHPOORT	388	1052484 / 1052749	
29.92028	-25.61583	B41A	COLORADO GRANITE QUARRY	GABBRO/DOLERITE/NORITE (DIMENSION STONE)	MPUMALANGA	SPITZKOP	383	1052748	
29.92111	-25.6125	B41A	IMPALA GRANITE QUARRY	GABBRO/DOLERITE/NORITE (DIMENSION STONE)	MPUMALANGA	SPITZKOP	383	1052742	
29.92389	-25.62694	B41A	KUDU / IMPALA / COLORADI GRANITE QUARRIES	GABBRO/DOLERITE/NORITE (DIMENSION STONE)	MPUMALANGA	SPITZKOP	383	1052741/1052742/1052748	
29.93694	-25.58585	B41B	BASIL READ / BELFAST GRANITE QUARRIES	GABBRO/DOLERITE/NORITE (DIMENSION STONE)	MPUMALANGA	DE SUIKERBOSCHKOP / KWAGGASKOP	361 / 359	1052346/1052739/1052740	
29.93139	-25.58083	B41B	ROWHILL BLACK GRANITE QUARRY	GABBRO/DOLERITE/NORITE (DIMENSION STONE)	MPUMALANGA	KWAGGASKOP	359	1052750	
29.93	-25.50889	B41B	NYALA GRANITE	GABBRO/DOLERITE/NORITE (DIMENSION STONE)	MPUMALANGA	DOORNKOP	356	1052754	
29.91806	-25.16111	B41C	MAPOCHS MINE	VANADIUM	MPUMALANGA	MAPOCHSGRONDE	500	1073078	
30.01667	-25.03333	B41F	TSELENTIS COAL	COAL	MPUMALANGA	BOTHASRUST	211 IS		1087
30.125	-24.97222	B41G	THORNCLIFFE MINE	CHROME	MPUMALANGA	THORNCLIFFE	374	1167995	
30.1225	-24.89361	B41H	TWEEFONTEIN CHROME MINE	CHROME	MPUMALANGA	TWEEFONTEIN	360	1163855	
30.17444	-24.76972	B41J	LANNEX CHROME MINE	CHROME	MPUMALANGA	GROOTBOOM	336	1163851	
30.15056	-24.62889	B41J	MONTROSE CHROME MINE	CHROME	MPUMALANGA	HENDRIKSPLAATS	281	1163832	
30.18528	-24.67194	B41J	WINTERVELD CHROME MINE	CHROME	MPUMALANGA	DOORNBOSCH	294	1163833	
30.1075	-24.82667	B41J	VANTECH MINE	VANADIUM	MPUMALANGA	KENNEDY'S VALE	361	1163515	
30.14194	-24.55194	B41J	DILOKONG MINE	CHROME	NORTHERN PROVINCE	MOOIHOEK	255	1163842	
30.20278	-24.74722	B41J	TUBATSE MINING	SILICA (GENERAL)	NORTHERN PROVINCE	GOUDMYN	337	1163896	
30.43806	-24.93917	B42E	KRUGERS POST MINE	ANDALUSITE	MPUMALANGA	KLIPFONTEIN	400	1164148	
29.25222	-24.51417	B51E	QUARRY (NAME UNKNOWN)	ATTAPULGITE/SEPIOLITE (CLAY)	NORTHERN PROVINCE	CALAIS	563	1128523	
29.18972	-24.26806	B51E	ZEBEDIELA DIAMOND MINE	DIAMOND (IN KIMBERLITE)	NORTHERN PROVINCE	RUSLAND	93	1155303	
29.28167	-24.52917	B51E	KERKAW LIME MINE	DOLOMITIC LIMESTONE	NORTHERN PROVINCE	ANTWERPEN	564	1128524	
29.29472	-24.53417	B51E	KERKAW LIME MINE	DOLOMITIC LIMESTONE	NORTHERN PROVINCE	SINGAPORE	585	1128529	
29.87389	-24.28806	B52J	ATOK MINE	PLATINUM	NORTHERN PROVINCE	MIDDELPUNT	420	1128209	
30.72722	-24.87222	B60A	MORGENZON MINE	GOLD	MPUMALANGA	MORGENZON	525	1163491	
30.09361	-24.56528	B71E	ATTA CLAY MINE	ATTAPULGITE/SEPIOLITE (CLAY)	NORTHERN PROVINCE	MAANDAGSHOEK	254	1163808	
30.25722	-24.39972	B71F	ANNESLEY MINE	ANDALUSITE	NORTHERN PROVINCE	ANNESLEY	109	1164152	
30.18944	-24.31806	B71F	HAVERCROFT ANDALUSITE	ANDALUSITE	NORTHERN PROVINCE	HAVERCROFT	99	1164137	
31.01833	-24.05056	B72D	FREDDIES MINE	FELDSPAR	NORTHERN PROVINCE	MORELAG	5	1163909	
30.83333	-24.16111	B72D	UNION PEGMATITE MINE	FELDSPAR / MICA / SILICA (GENERAL)	NORTHERN PROVINCE	INYOKU	159	1150004/1163952/1167355	
30.84722	-24.14722	B72D	KETELBY & GELLETICH MICA MINE	SILICA (GENERAL)	NORTHERN PROVINCE	INYOKU	159	1165641	
30.68083	-23.89722	B72J	ATHENS MINE	ANTIMONY	NORTHERN PROVINCE	CLAIMLAND	780	1068384	
30.605	-23.94111	B72J	GRAVELOTTE & APPHA MINES	ANTIMONY	NORTHERN PROVINCE	FARRELL	781	1068383 / 1068711	
30.71611	-23.88556	B72J	MONARCH MINE	ANTIMONY	NORTHERN PROVINCE	JOSEPHINE	777	1068431	
30.75444	-23.85	B72J	LETABA ZINC MINE	ZINC	NORTHERN PROVINCE	BEGIN	765	1068401	
31.12889	-23.99139	B72K	PALABORA MINE	COPPER & VERMICULITE	NORTHERN PROVINCE	LOOLE	31	1068490 / 1068491	
31.0125	-23.83	B72K	MINE (NAME UNKNOWN)	FELDSPAR	NORTHERN PROVINCE	LEEUWSPRUIT	18	1068759	
30.64306	-23.96861	B72K	DISCOVERY & BLUE JACKET MINES	GOLD	NORTHERN PROVINCE	FARRELL	781	1068469 / 1068474	
31.09556	-23.99472	B72K	THABAZIMBI IRON ORE MINE	IRON + BUILDING SAND	NORTHERN PROVINCE	WEGSTEEK	30	1068334 / 1068726	
31.12778	-23.96417	B72K	PALABORA V.O.D. MINE	PHOSPHATE	NORTHERN PROVINCE	WEGSTEEK	30	1068492	

APPENDIX E

WATER RELATED INFRASTRUCTURE

APPENDIX F

WATER REQUIREMENTS

F1. ECOLOGICAL CLASSES PER QUATERNARY CATCHMENT FOR THE OLIFANTS WMA

ECOLOGICAL CLASSES PER QUATERNERY CATCHMENT FOR THE OLIFANTS WMA

QUARTERNARY	DEMC	PESC	AEMC
B11A	C	C	B
B11B	C	D	C
B11C	D	C	B
B11D	D	D	C
B11E	C	D	C
B11F	D	D	C
B11G	D	D	C
B11H	C	C	C
B11J	B	D	C
B11K	C	D	C
B11L	B	C	B
B12A	C	C	B
B12B	C	D	C
B12C	C	C	C
B12D	C	D	D
B12E	C	C	C
B20A	C	C	B
B20B	C	C	C
B20C	D	C	C
B20D	C	C	C
B20E	C	D	C
B20F	C	C	C
B20G	C	D	C
B20H	B	C	C
B20J	B	C	C
B31A	C	C	B
B31B	C	C	B
B31C	C	C	B
B31D	C	D	D
B31E	D	C	B
B31F	D	D	D
B31G	D	D	D
B31H	C	D	D
B31J	C	D	D
B32A	B	C	D
B32B	C	D	D
B32C	C	C	C
B32D	B	D	C
B32E	D	B	B
B32F	D	D	D
B32G	C	C	B
B32H	C	C	B
B32J	C	D	C
B41A	C	C	B
B41B	C	C	B
B41C	C	C	B
B41D	C	B	B
B41E	C	C	C
B41F	A	B	B
B41G	B	B	B
B41H	C	C	C
B41J	B	C	C
B41K	B	D	C
B42A	C	C	B
B42B	C	D	C
B42C	C	C	C
B42D	C	B	B

QUARTERNARY	DEMC	PESC	AEMC
B42E	B	B	B
B42F	C	C	B
B42G	B	C	B
B42H	B	C	B
B51A	C	C	C
B51B	C	D	D
B51C	C	D	D
B51E	D	D	D
B51F	D	D	C
B51G	C	D	D
B51H	D	D	C
B52A	C	D	D
B52B	D	D	C
B52C	D	D	C
B52D	D	D	C
B52E	C	D	D
B52F	D	D	C
B52G	C	D	D
B52H	D	D	C
B52J	C	D	D
B60A	A	C	B
B60B	C	C	B
B60C	A	A	A
B60D	B	B	A
B60E	B	B	A
B60F	C	D	D
B60G	C	D	D
B60H	B	D	D
B60J	B	B	B
B71A	C	D	D
B71B	C	D	D
B71C	A	A	A
B71D	C	C	C
B71E	D	C	B
B71F	C	D	D
B71G	C	D	D
B71H	C	D	D
B71J	C	C	C
B72A	B	C	C
B72B	D	D	D
B72C	B	C	C
B72D	B	C	C
B72E	B	C	C
B72F	A	A	A
B72G	B	C	C
B72H	D	D	D
B72J	D	D	D
B72K	C	D	D
B73A	C	C	C
B73B	B	D	D
B73C	B	C	C
B73D	C	C	B
B73E	C	C	B
B73F	C	C	B
B73G	B	C	C
B73H	B	C	C
B73J	B	C	B

F2. RELATIONSHIP BETWEEN LIVESTOCK AND GAME SPECIES AND ELSU

CONVERSION OF MATURE LIVESTOCK AND GAME POPULATIONS TO EQUIVALENT LARGE STOCK

Units (ELSU)

Species	Group *	Number per Elsu
Livestock:		
Cattle	L	0,85
Sheep	S	6,5
Goats	S	5,8
Horses	L	1
Donkeys / mules	S	1,1
Pigs	S	4
Game:		
Black Wildebeeste	LA	3,3
Blesbuck	SA	5,1
Blou Wildebeeste	LA	2,4
Buffalo	BG	1
Eland	BG	1
Elephant	BG	0,3
Gemsbok	LA	2,2
Giraffe	BG	0,7
Hippopotamus	BG	0,4
Impala	SA	7
Kudu	LA	2,2
Nyala	SA	3,3
Ostrich	-	2,7
Red Hartebeest	LA	2,8
Roan Antelope	LA	2
Sable Antelope	LA	2
Southern Reedbuck	SA	7,7
Springbok	SA	10,3
Tsessebe	LA	2,8
Warthog	O	5
Waterbuck	LA	2,4
Rhinoceros	BG	0,4
Zebra	O	1,6

Groups (in terms of water consumption) : L = cattle and horses; S = small livestock; LA = large antelope; SA = small antelope; BG = big game; O = other game,

The livestock and game figures per category are not shown per quaternary due to a lack of information.

F3. PERMITS AND OTHER ALLOCATIONS

APPENDIX G

WATER RESOURCES

G1. DETAILED INFORMATION ON GROUNDWATER

GROUND WATER 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 scenario's 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 GROUND WATER 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 ie 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.

G2. POTENTIAL VULNERABILITY OF SURFACE WATER & GROUNDWATER TO MICROBIAL CONTAMINATION

WATER RESOURCES SITUATION ASSESSMENTS

DEPARTMENT: WATER AFFAIRS & FORESTRY
DIRECTORATE: WATER RESOURCE PLANNING

POTENTIAL VULNERABILITY OF SURFACE WATER & GROUNDWATER TO MICROBIAL CONTAMINATION

AUGUST 2001

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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	10
4.	CONCLUSIONS & RECOMMENDATIONS	14
5.	REFERENCES	15

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 of Groundwater Resources
- Section Four: Conclusions and Recommendations
- Section Five: References

2. MAPPING SURFACE WATER RESOURCES

2.1 Background

The water resources of South Africa have come under increasing influence from faecal contamination as a result of increased urban development and lack of appropriate sanitation. Due to increased use of contaminated water for domestic consumption, people are at serious risk of contracting water-borne disease (e.g. gastroenteritis, salmonellosis, dysentery, cholera, typhoid fever and hepatitis). The Department of Water Affairs and Forestry (DWAF) is the custodian of the national water resources and should ensure *fitness for use* of the water resources. Thus, the Department has developed a monitoring system to provide the necessary management information to assess and control the health hazard in selected areas. This project is called the National Microbiological Monitoring Programme (NMMP).

As part of the NMMP, a screening exercise was carried out to determine the number of catchments that experience faecal contamination. A short-list of tertiary catchment areas was compiled. Data from the database of the Directorate: Water Services Planning of DWAF was used to prioritize catchments to assess the overall health hazard (see Figure 1).

Ratings for land use activity were assigned using the method developed by Goodmin & Wright (1991), IWQS (1996), and Murray (1999). Ratings for land and water use were combined to establish an overall rating. Water use was considered to have a higher effect than the land use so that a 60:40 weighting was used (see Equation 1).

$$OR = 0.4\ TLU + 0.6\ TWU \qquad \text{........ (1)}$$

Where OR = Area Rating (no units)
TLU = Total land use rating for area (no units)
TWU = Total water use rating for area (no units)

Each area was assigned a rating to indicate low (1), medium (2) or high (3) potential risk to users in the catchment area. The following values were used to designate each class:

Low	OR = 0 to 1000	
Medium	OR = 1001 to100 000	
High	OR > 100 000	.... (2)

Figure 1 shows the surface faecal contamination map for priority rated catchments in South Africa.

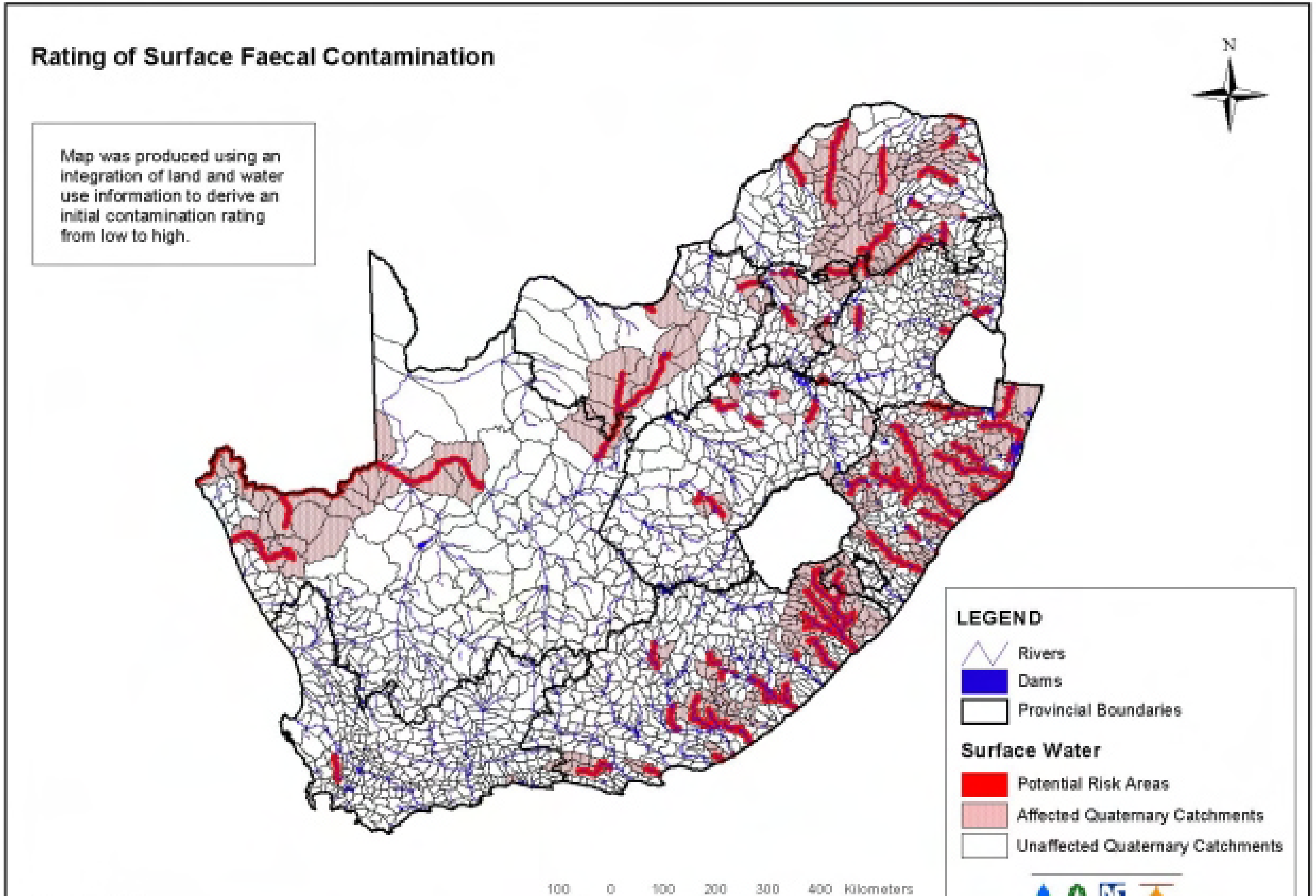

Rating of Surface Faecal Contamination
Map was produced using an integration of land and water use information to derive an initial contamination rating from low to high.
N
LEGEND
Rivers
Dams
Provincial Boundaries
Surface Water
Potential Risk Areas
Affected Quaternary Catchments
Unaffected Quaternary Catchments
100 0 100 200 300 400 Kilometers

FIGURE 1

2.2 Surface faecal contamination

Figure 2 shows the potential surface faecal contamination map, developed using average population density (for a quaternary) and degree of sanitation (Venter, 1998). The land use rating is given by:

$$LU = SA + PD \qquad \text{........ (3)}$$

Where LU = Land use rating per settlement (no units)
SA = No/poor sanitation rating (no units)
PD = Population Density rating (no units)

Land use rankings for quaternary catchments were determined by calculating the total ratings of all settlements within a particular quaternary catchment, given by:

$$TLU = (LU_n) \qquad \text{........ (4)}$$

Where TLU = Total land use rating per quaternary catchment
LU_n = Land use rating for n settlements, per quaternary

Each quaternary catchment was allocated a low (1), medium (2) and high (3) priority rating used to map the information using GIS. Classes were designated by the following values:

Low	=	$TLU < 1000$	
Medium	=	$1000 < TLU < 3000$	
High	=	$TLU > 3000$	.... (5)

2.3 Results: GIS Surface Water Mapping

Figure 1 was plotted on GIS by firstly assembling the national coverages for the quaternary catchments, rivers and dams. The data described above were processed using the following method:

The quaternary catchments were shaded according to whether they were considered potential risk areas or not (refer to Equations 1 & 2).

Within the quaternaries at risk, the rivers were buffered and shaded red to indicate the risk to potential surface water users.

Figure 2, the potential surface faecal contamination map, was produced as follows:

The ratings (TLU) were distributed into intervals (refer to Equations 5 and 6).

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.

Potential Surface Faecal Contamination

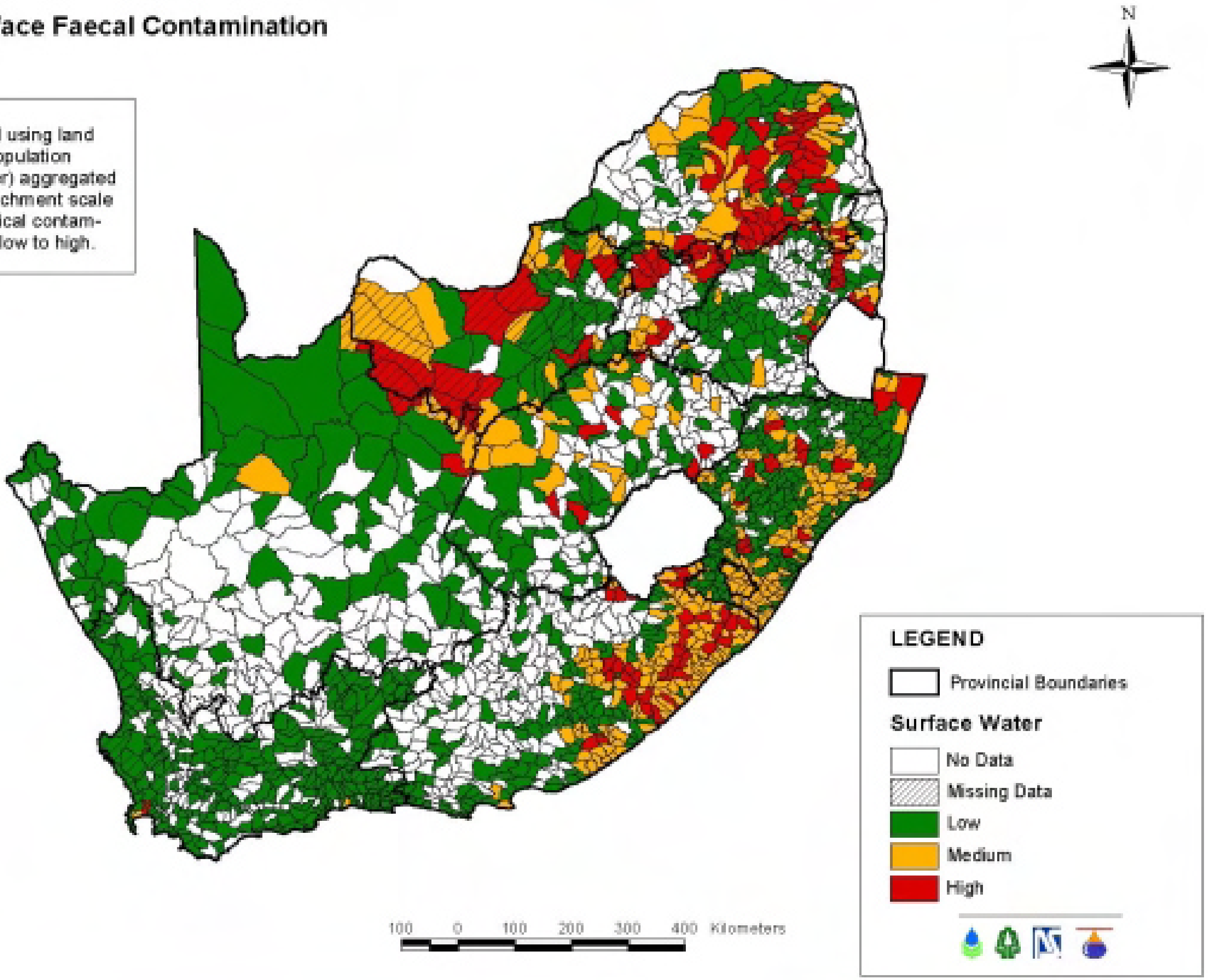


FIGURE 2

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.

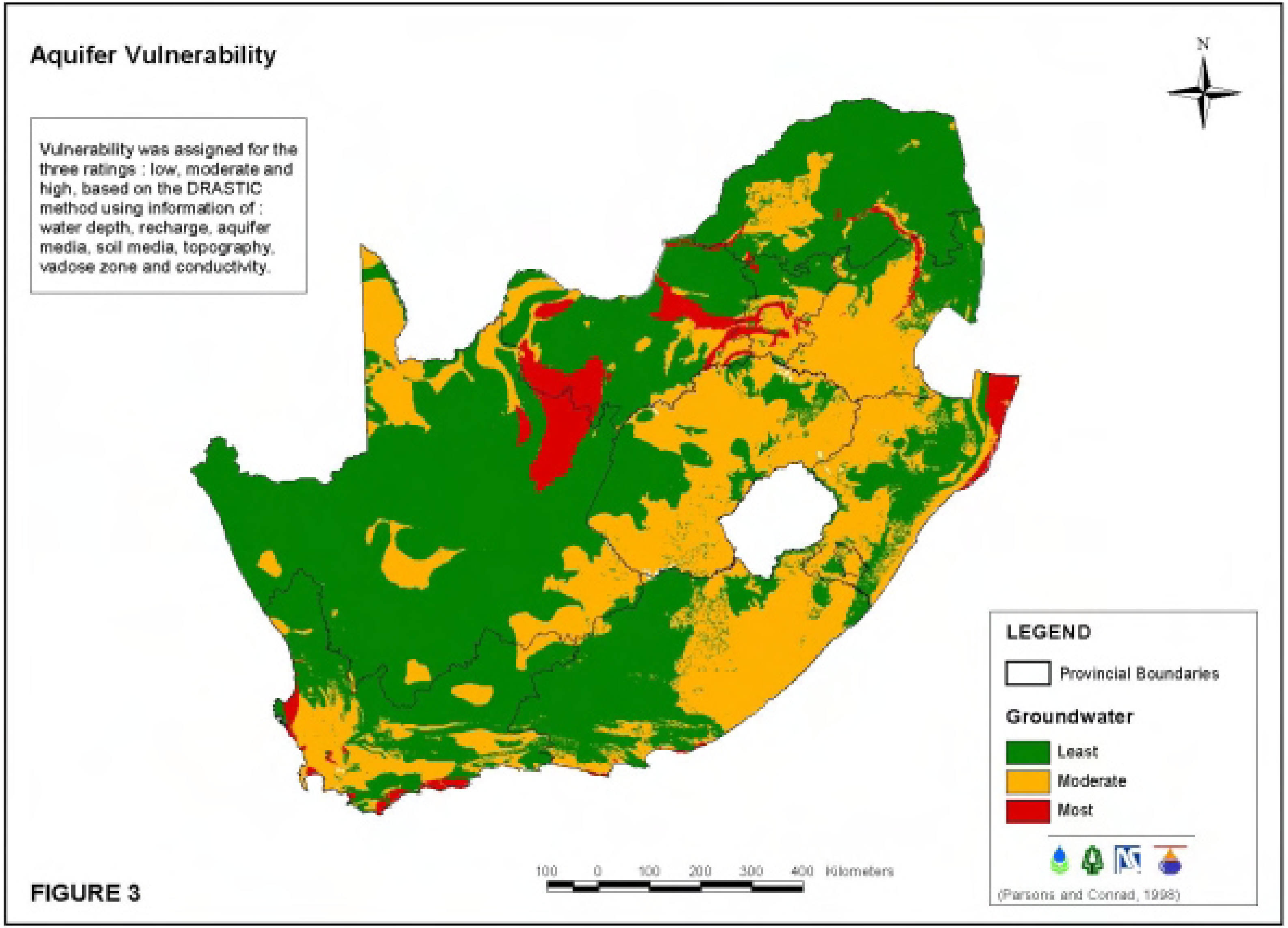

Aquifer Vulnerability
Vulnerability was assigned for the three ratings : low, moderate and high, based on the DRASTIC method using information of : water depth, recharge, aquifer media, soil media, topography, vadose zone and conductivity.
N
LEGEND
Provincial Boundaries
Groundwater
Least
Moderate
Most
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:

$$I = D_R D_W + R_R R_W + A_R A_W + S_R S_W + T_R T_W + I_R I_W + C_R C_W \qquad ...... (7)$$

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]

[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.

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,

$$\text{Index} = 5\ D_R + 5\ S_R + 4\ I_R \qquad \text{.........} (8)$$

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.

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

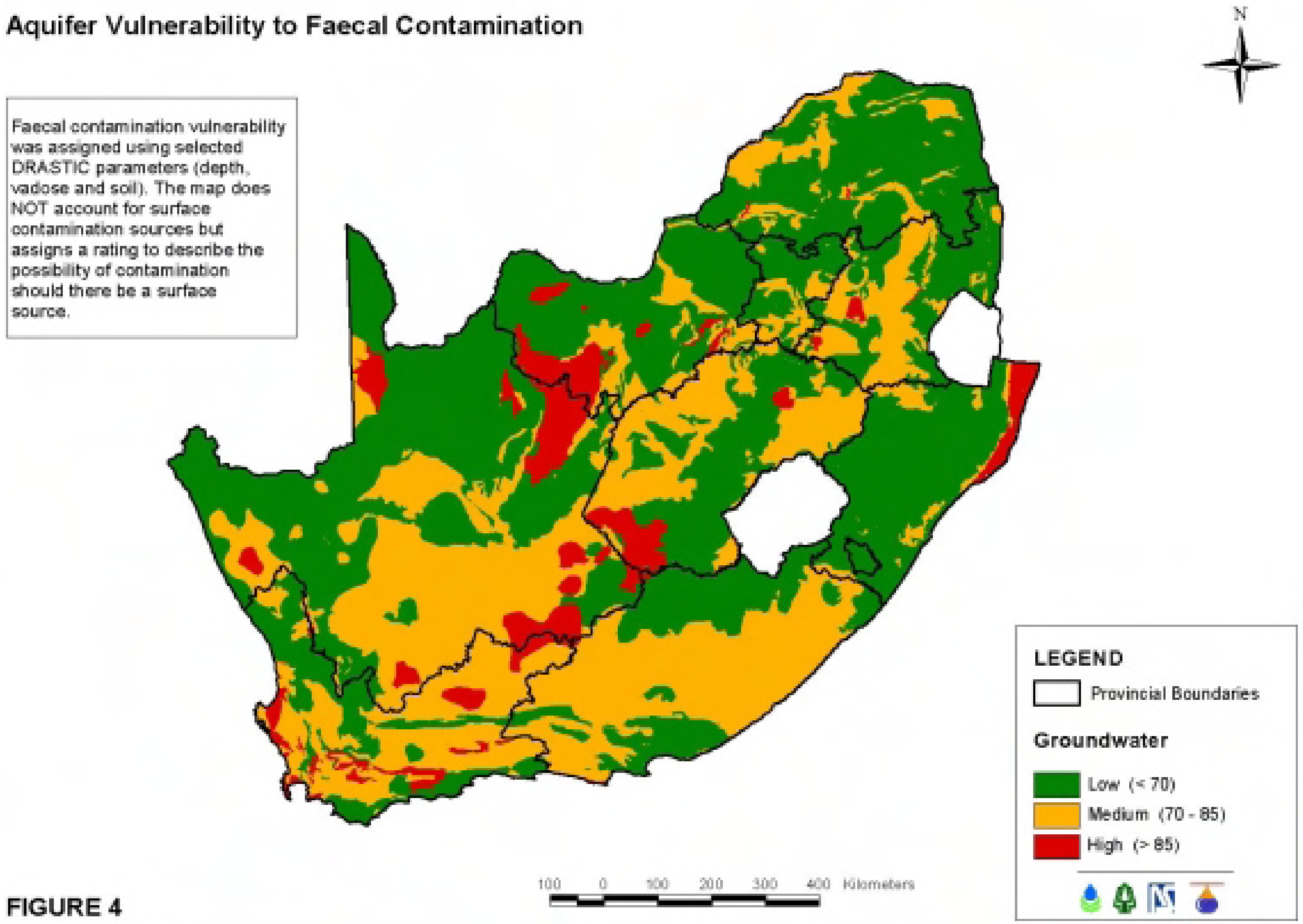


FIGURE 4

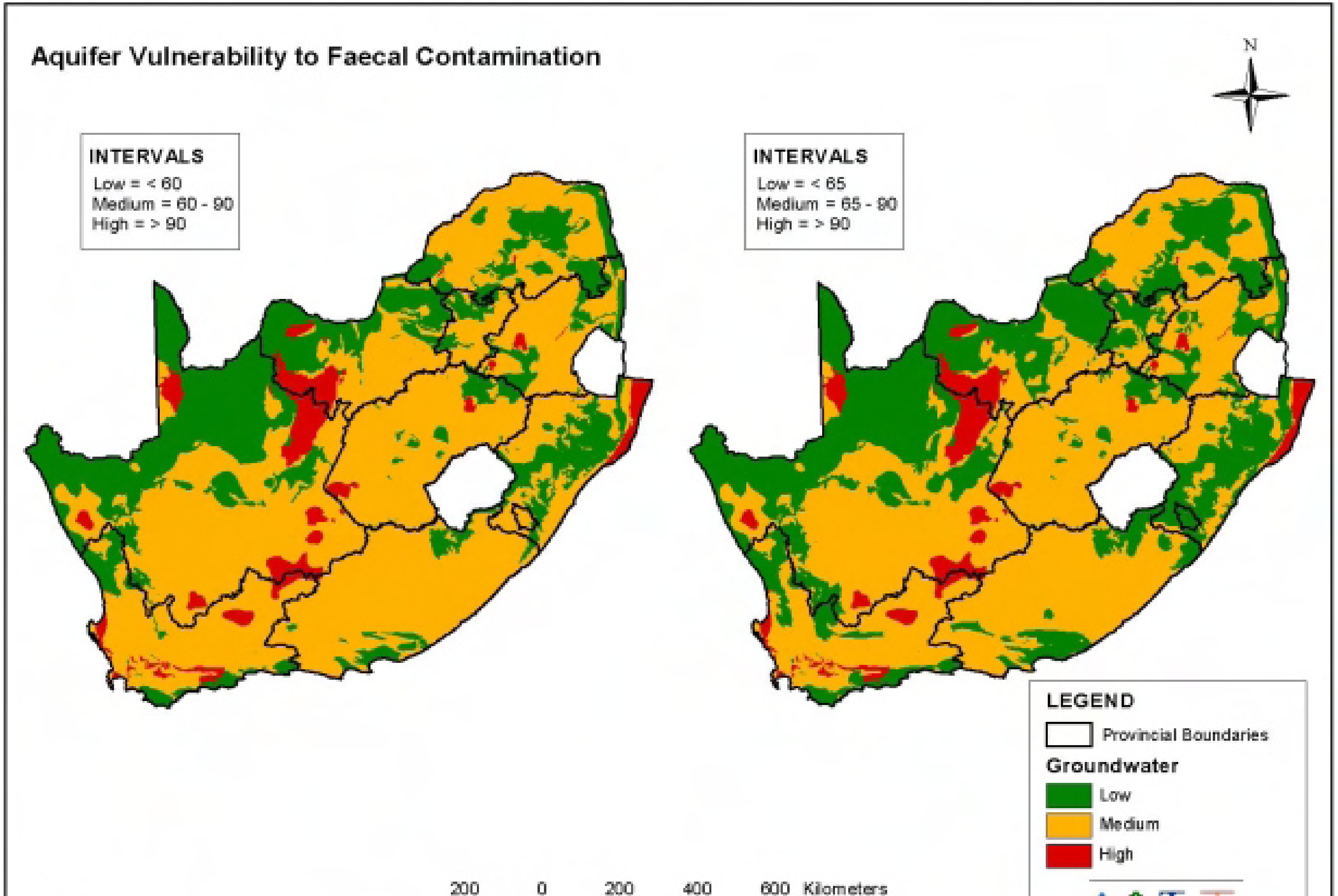
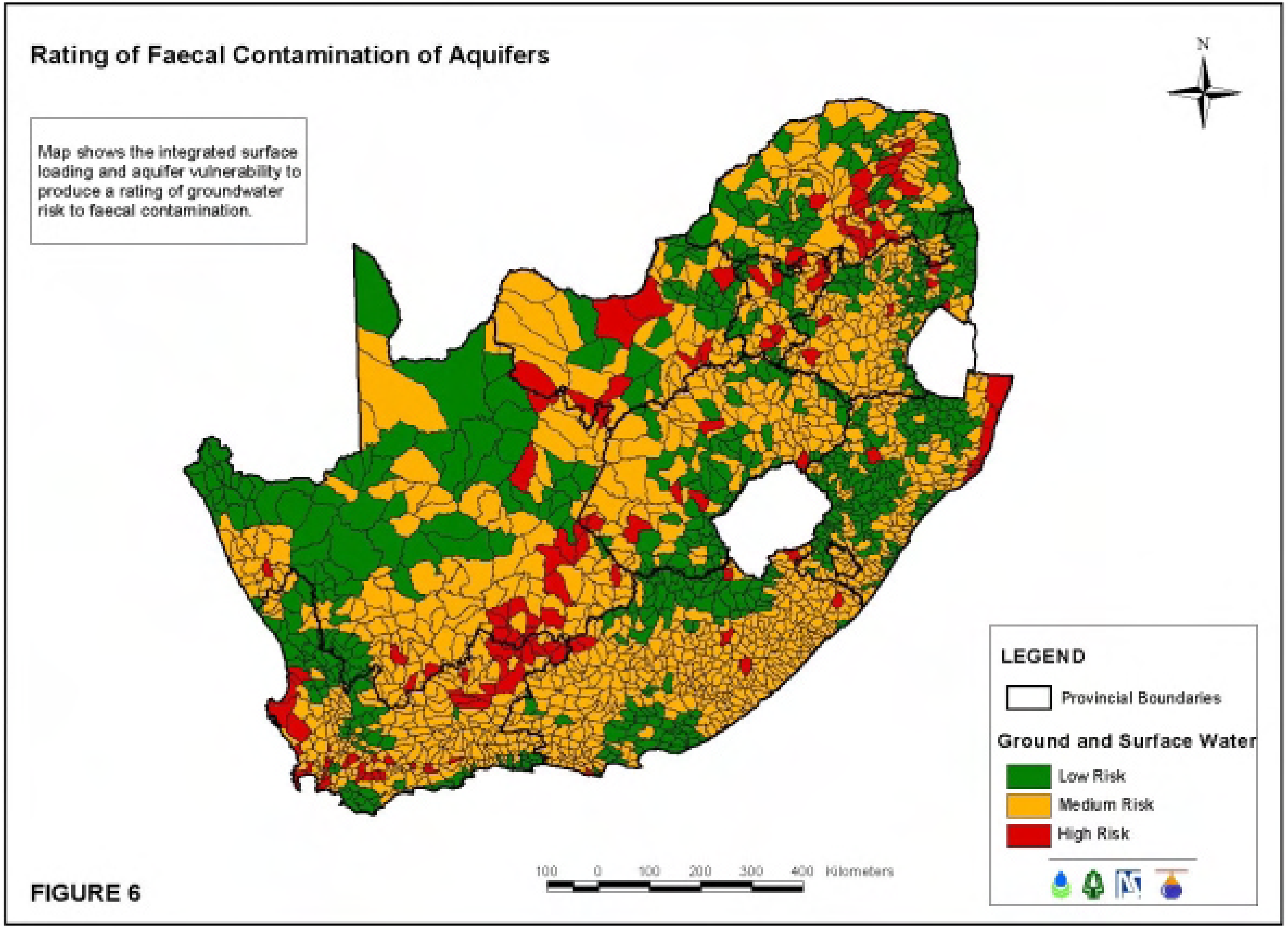

Aquifer Vulnerability to Faecal Contamination
N
INTERVALS
Low = < 60
Medium = 60 - 90
High = > 90
INTERVALS
Low = < 65
Medium = 65 - 90
High = > 90
LEGEND
Provincial Boundaries
Groundwater
Low
Medium
High
200 0 200 400 600 Kilometers

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.

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G3. POTENTIAL DAMS

OLIFANTS

Note: Dam volumes and yields in million cubic metre and dam cost in million R

Quat	Zone	Volume I		Max Dam Size per Quat	*Major Dams* KEY POINTS	Max Dam Size per Keypoint	Existing Dam Storage	Potential Dams	Gross Yield	Combined yield	Capital Cost estimate
		1*	2*								
B11C	L	195	200	25.54	*Trichardtsfontein Dam &*				8.43		
B11D	L	195	200	33.16	*Rietspruit Dam*				10.94		
B11E	L	195	200	30.1	Rietspruit at Olifants	88.80	19.70	69.10	9.93	29.30	284.07
B11A	L	195	200	73.58					24.28		
B11B	L	195	200	31.5	Olifants at Rietspruit	105.08	0.00	105.08	10.40	34.68	345.50
B11F	L	195	200	29.36	*Witbank Dam*				9.69		
B11G	L	195	200	26.38	Witbank Dam	55.74	104.14	-48.40	8.71	18.39	-240.56
B11H	L	195	200	17.84	*Doornpoort Dam*				5.89		
B11J	J	168	150	19.665	Olifants at Klein Olifants	37.51	5.22	32.29	7.34	13.23	199.11
B11K	J	168	150	26.085					9.74		
B11L	J	168	150	17.37	Olifants at Wilge	43.46	0.00	43.46	6.48	16.22	228.75
B12A	L	195	200	21.26	*Middelburg Dam*				7.02		
B12B	L	195	200	36.92					12.18		
B12C	L	195	200	31.58	Middelburg Dam	89.76	47.90	41.86	10.42	29.62	224.79
B12D	L	195	200	27.32					9.02		
B12E	J	168	150	34.155	Klein Olifants at Olifants	61.48	0.00	61.48	12.75	21.77	268.98
B20A	J	168	150	32.61	*Bronkhorstspruit Dam*				12.17		
B20B	J	168	150	17.64					6.59		
B20C	J	168	150	20.88	Bronkhorstspruit Dam	71.13	58.90	12.23	7.80	26.56	126.54
B20D	J	168	150	25.98	*Premier Mine Dam*				9.70		
B20E	J	168	150	31.5					11.76		
B20F	J	168	150	25.185					9.40		
B20G	J	168	150	34.515					12.89		
B20H	J	168	150	35.055					13.09		
B20J	J	168	150	27.045	Wilge at Olifants	179.28	5.04	174.24	10.10	66.93	437.53
B31A	L	195	200	27.26	*Rust de Winter Dam*				9.00		
B31B	L	195	200	19.88					6.56		
B31C	L	195	200	15.52	Rust de Winter Dam	62.66	28.09	34.57	5.12	20.68	205.57
B31D	L	195	200	22.04	*Renosterkop Dam*				7.27		
B31E	V	280	300	32.13					5.46		
B31F	V	280	300	12.75	Renosterkop Dam	66.92	204.62	-137.70	2.17	14.90	-391.99
B31G	L	195	200	17.24					5.69		
B31H	L	195	200	18.56					6.12		
B31J	V	280	300	24.3	Elands at Olifants	60.10	0.00	60.10	4.13	15.95	266.15
B32A	J	168	150	62.115	Loskop Dam	62.12	348.10	-285.99	23.19	23.19	-551.45
B32B	J	168	150	46.92					17.52		
B32C	J	168	150	16.53					6.17		
B32D	M	202	200	23.7	Olifants at Bloed	87.15	0.00	87.15	7.82	31.51	316.59
B32E	M	202	200	13.7	*Rooikraal Dam*				4.52		
B32F	M	202	200	38.88	Bloed at Olifants	52.58	2.12	50.46	12.83	17.35	245.28
B32G	L	195	200	49.88					16.46		
B32H	L	195	200	28.08					9.27		
B32J	T	208	200	9	Olifants at Elands	86.96	0.00	86.96	2.97	28.70	316.27
B41A	G	149	150	72.45	*Belfast Dam*				27.05		
B41B	G	149	150	72.15	Steelpoort at Klip	144.60	4.39	140.21	26.94	53.98	395.31
B41C	G	149	150	26.625	*Mapochs Dam*				9.94		
B41D	G	149	150	24.855	Steynsdrift Dam	51.48	7.29	44.19	9.28	19.22	230.55
B41E	T	208	200	8.3					2.74		
B41F	G	149	150	41.925					15.65		
B41G	G	149	150	43.5					16.24		
B41H	T	208	200	14.9					4.92		
B41J	T	208	200	30.3	Steelpoort at Spekboom	138.93	0.00	138.93	10.00	49.55	393.61
B41K	T	208	200	34.02	Steelpoort at Olifants	34.02	0.00	34.02	11.23	11.23	204.04
B42A	E	163	150	52.245	*Buffelskloof Dam*				19.50		
B42B	E	163	150	50.28					18.77		
B42C	M	202	200	16.36					5.40		
B42D	E	163	150	51.87					19.36		
B42E	M	202	200	11.68					3.85		
B42F	E	163	150	42.27					15.78		
B42G	M	202	200	21.16					6.98		
B42H	M	202	200	18.34	Spekboom at Steelpoort	264.21	5.27	258.94	6.05	95.71	526.44
B51A	T	208	200	10.64	*Arabie & Lola Montes Dam*				3.51		
B51B	T	208	200	15.82	Arabie Dam	26.46	105.48	-79.02	5.22	8.73	-302.44
B51C	T	208	200	12.38	*Makotswane Dam &*				4.09		
B51E	V	280	300	59.46	*Piet Gouws Dam &*				10.11		
B51F	T	208	200	12.7	*Mogoto & Nkumpi Dam*				4.19		
B51G	T	208	200	14.18					4.68		
B51H	T	208	200	18.28					6.03		
B52A	T	208	200	9.1	Olifants at Lepelane	126.10	24.17	101.93	3.00	32.10	340.62

Quat	Zone	Volume I		Max Dam Size per Quat	*Major Dams* KEY POINTS	Max Dam Size per Keypoint	Existing Dam Storage	Potential Dams	Gross Yield	Combined yield	Capital Cost estimate
		1*	2*								
B52B	T	208	200	17.72	*Lepelane Dam &*				5.85		
B52C	U	247	250	7.95	*Nkadimeng Dam &*				1.43		
B52D	T	208	200	6.46	*Chuniespoort Dam &*				2.13		
B52E	T	208	200	11.04	*Molepo Dam*				3.64		
B52F	U	247	250	5.275					0.95		
B52G	U	247	250	9.95					1.79		
B52H	U	247	250	50.475					9.09		
B52J	U	247	250	19.4	Olifants at Bewaarkloof	128.27	13.02	115.25	3.49	28.37	360.73
B60A	B	111	100	110.4	*Ohrigstad River*				97.15		
B60B	B	111	100	115.6					101.73		
B60C	B	111	100	54.24					47.73		
B60D	E	163	150	80.595	Blyde at Blydedam	360.84	54.64	306.20	30.09	276.70	569.32
B60E	E	163	150	26.1	*Ohrigstad River*				9.74		
B60F	M	202	200	36.56					12.06		
B60G	M	202	200	26.66					8.80		
B60H	M	202	200	37.28	Ohrigstad River	126.60	13.24	113.36	12.30	42.91	357.95
B60J	E	163	150	50.535	Blyde at Olifants	50.54	0.00	50.54	18.87	18.87	245.45
B71A	U	247	250	34.275					6.17		
B71B	U	247	250	18.225	Rooipoort Dam Proposal	52.50	0.00	52.50	3.28	9.45	249.87
B71C	E	163	150	59.025					22.04		
B71D	H	213	200	30.02					9.91		
B71E	U	247	250	56.95					10.25		
B71F	H	213	200	109.58					36.16		
B71G	H	213	200	69.48	Strijdom Tunnel Dam Propos	325.06	0.00	325.06	22.93	101.28	585.43
B71H	X	296	300	39.09					6.65		
B71J	X	296	300	2.28	Olifants at Blyde	41.37	0.00	41.37	0.39	7.03	223.56
B72A	H	213	200	84.36					27.84		
B72B	X	296	300	15.57					2.65		
B72C	X	296	300	12.87					2.19		
B72D	X	296	300	17.82	Olifants at Selati	130.62	0.00	130.62	3.03	35.70	382.45
B72E	H	213	200	62.7	*Tours Dam &*				20.69		
B72F	H	213	200	27.22	*Phalaborwa Barrage*				8.98		
B72G	X	296	300	6.12					1.04		
B72H	X	296	300	40.83					6.94		
B72J	X	296	300	34.17					5.81		
B72K	X	296	300	23.58	Selati at Olifants	194.62	9.98	184.64	4.01	47.47	449.54
B73A	E	163	150	50.67	*Klaserie Dam*				18.92		
B73B	X	296	300	14.64					2.49		
B73C	X	296	300	21.54					3.66		
B73D	X	296	300	15.51					2.64		
B73E	X	296	300	27.87					4.74		
B73F	X	296	300	19.38					3.29		
B73G	X	296	300	20.88					3.55		
B73H	X	296	300	4.65	Olifants at Letaba	175.14	5.76	169.38	0.79	40.08	431.79
B73J	X	296	300	5.85	Olifants at Mozambique	5.85	0.00	5.85	0.99	0.99	
TOTAL								**2520.83**		**1288.35**	**7925.34**

G4. SEDIMENT YIELD

Quaternary	Tonnes / annum ($x10^6$)	25 Year Sediment Volume ($x10^6$)
B11A	43	1178.2
B11B	20	548
B11C	18	493.2
B11D	25	685
B11E	21	575.4
B11F	19	520.6
B11G	17	465.8
B11H	11	301.4
B11J	12	328.8
B11K	17	465.8
B11L	11	301.4
B12A	18	493.2
B12B	30	822
B12C	24	657.6
B12D	16	438.4
B12E	20	548
B20A	26	712.4
B20B	14	383.6
B20C	16	438.4
B20D	22	602.8
B20E	28	767.2
B20F	23	630.2
B20G	24	657.6
B20H	26	712.4
B20J	19	520.6
B31A	18	493.2
B31B	18	493.2
B31C	18	493.2
B31D	27	739.8
B31E	69	1890.6
B31F	31	849.4
B31G	21	575.4
B31H	46	1260.4
B31J	94	2575.6
B32A	38	1041.2
B32B	29	794.6
B32C	16	438.4
B32D	49	1342.6
B32E	12	328.8
B32F	67	1835.8
B32G	45	1233
B32H	60	1644
B32J	35	959
B41A	43	1178.2
B41B	51	1397.4
B41C	25	685
B41D	40	1096
B41E	26	712.4
B41F	28	767.2
B41G	41	1123.4
B41H	45	1233
B41J	75	2055

Quaternary	Tonnes / annum ($x10^6$)	25 Year Sediment Volume ($x10^6$)
B41K	57	1561.8
B42A	17	465.8
B42B	10	274
B42C	10	274
B42D	8	219.2
B42E	22	602.8
B42F	14	383.6
B42G	30	822
B42H	43	1178.2
B51A	34	931.6
B51B	60	1644
B51C	70	1918
B51E	153	4192.2
B51F	39	1068.6
B51G	51	1397.4
B51H	78	2137.2
B52A	60	1644
B52B	69	1890.6
B52C	22	602.8
B52D	32	876.8
B52E	49	1342.6
B52F	12	328.8
B52G	18	493.2
B52H	57	1561.8
B52J	26	712.4
B60A	10	274
B60B	15	411
B60C	5	137
B60D	12	328.8
B60E	4	109.6
B60F	20	548
B60G	28	767.2
B60H	20	548
B60J	33	904.2
B71A	15	411
B71B	14	383.6
B71C	17	465.8
B71D	11	301.4
B71E	82	2246.8
B71F	27	739.8
B71G	12	328.8
B71H	16	438.4
B71J	4	109.6
B72A	26	712.4
B72B	16	438.4
B72C	16	438.4
B72D	45	1233
B72E	22	602.8
B72F	4	109.6
B72G	2	54.8
B72H	19	520.6
B72J	26	712.4

Quaternary	Tonnes / annum ($x10^6$)	25 Year Sediment Volume ($x10^6$)
B72K	47	1287.8
B73A	8	219.2
B73B	34	931.6
B73C	43	1178.2
B73D	34	931.6
B73E	21	575.4
B73F	0	0
B73G	0	0
B73H	0	0
B73J	0	0

Quaternary	Tonnes / annum ($x10^6$)	25 Year Sediment Volume ($x10^6$)
B41K	57	1561.8
B42A	17	465.8
B42B	10	274
B42C	10	274
B42D	8	219.2
B42E	22	602.8

APPENDIX H

WATER BALANCE

H1. DATA SOURCES

DATA SOURCES

Data type	Responsible organization
Afforestation	CSIR
Alien vegetation	CSIR
Industrial, urban and strategic water use	WRSA consultants
Ground water	WSM Civil 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	WRSA consultant
▪ Efficiency and losses	WRSA consultant
▪ Evapotranspiration and crop factors	WRP
Storage-draft-frequency curves	WRP

H2. DATA DEFAULT VALUES USED IN THE WRSA REPORT

DATA DEFAULT VALUES USED IN THE WRSA REPORT

Parameter	Description	Default value
fBMLi	Mining losses (factor)	0,1
fBOLi	Other industrial losses (factor)	0,1
fBSLi	Strategic losses (factor)	0,05
fIHCi	Irrigation conveyance losses – High category irrigation (factor)	0,1
fIMCi	Irrigation conveyance losses – Medium category irrigation (factor)	0,1
fILCi	Irrigation conveyance losses – Low category irrigation (factor)	0,1
fIPLi	Irrigation efficiency – Low category irrigation (factor)	0,75
fiIPMi	Irrigation efficiency – Medium category irrigation (factor)	0,75
fiIPHi	Irrigation efficiency – High category irrigation (factor)	0,75
oRTLi	Rural losses (factor)	0,2

THE DATA AT QUATERNARY CATCHMENT RESOLUTION

For the record – not part of appendix

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D11A	278	278	7	10	203	56434	0.0565	0.0426	255	71024	0.0712	0.0536
D11B	236	236	7	10	203	47908	0.0480	0.0589	255	60294	0.0604	0.0741
D11C	292	292	7	10	203	59276	0.0594	0.0549	255	74601	0.0748	0.0691
D11D	319	319	7	10	203	64757	0.0649	0.0774	255	81499	0.0817	0.0975
D11E	322	322	7	10	203	65366	0.0655	0.1018	255	82266	0.0824	0.1281
D11F	413	413	7	10	203	83839	0.0840	0.0749	255	105514	0.1057	0.0943
D11G	320	320	7	10	203	64960	0.0651	0.1368	255	81755	0.0819	0.1722
D11H	359	359	7	10	203	72877	0.0730	0.1420	255	91718	0.0919	0.1787
D11J	440	440	7	10	203	89320	0.0895	0.1485	255	112412	0.1126	0.1869
D11K	381	381	7	10	203	77343	0.0775	0.1565	255	97339	0.0975	0.1970
0	**3360**	**3360**				**682080**	**0.6834**	**0.0863**		**858423**	**0.8601**	**0.1087**
D12A	369	369	6	13	335	123615	0.1239	0.2878	422	155574	0.1559	0.3622
D12B	385	385	6	13	335	128975	0.1292	0.1969	422	162320	0.1626	0.2478
D12C	343	343	6	13	335	114905	0.1151	0.5597	422	144612	0.1449	0.7044
D12D	355	355	6	12	335	118925	0.1192	0.6649	422	149671	0.1500	0.8368
D12E	712	712	6	12	335	238520	0.2390	0.7200	422	300186	0.3008	0.9062
D12F	803	803	6	13	335	269005	0.2695	0.9797	422	338553	0.3392	1.2330
0	**2967**	**2967**				**993945**	**0.9959**	**0.4791**		**1250916**	**1.2534**	**0.6030**
D13A	475	475	6	13	335	159125	0.1594	0.2239	422	200265	0.2007	0.2817
D13B	533	533	6	13	335	178555	0.1789	0.2420	422	224718	0.2252	0.3046
D13C	517	517	6	13	335	173195	0.1735	0.3160	422	217972	0.2184	0.3977
D13D	635	635	6	13	335	212725	0.2132	0.3679	422	267722	0.2683	0.4630
D13E	1031	1031	6	13	335	345385	0.3461	0.2673	422	434680	0.4355	0.3364
D13F	970	970	6	13	335	324950	0.3256	0.3358	422	408961	0.4098	0.4226
D13G	1125	1125	6	13	335	376875	0.3776	0.7118	422	474311	0.4753	0.8958
D13H	1144	1144	6	13	335	383240	0.3840	1.2843	422	482322	0.4833	1.6163
D13J	1167	1167	6	13	335	390945	0.3917	1.1828	422	492019	0.4930	1.4886

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D13K	397	397	6	13	335	132995	0.1333	0.2641	422	167379	0.1677	0.3324
D13L	682	682	6	13	335	228470	0.2289	0.9037	422	287538	0.2881	1.1373
D13M	678	678	6	13	335	227130	0.2276	1.0546	422	285851	0.2864	1.3272
0	**9354**	**9354**				**3133590**	**3.1399**	**0.4499**		**3943737.7**	**3.9516**	**0.5662**
D14A	764	764	6	12	335	255940	0.2565	1.0205	422	322110	0.3228	1.2843
D14B	324	324	6	13	335	108540	0.1088	1.3492	422	136602	0.1369	1.6981
D14C	722	722	6	13	335	241870	0.2424	1.3106	422	304402	0.3050	1.6494
D14D	680	680	6	13	335	227800	0.2283	1.9450	422	286695	0.2873	2.4479
D14E	663	663	6	13	335	222105	0.2225	2.1580	422	279527	0.2801	2.7159
D14F	541	541	6	13	335	181235	0.1816	1.2767	422	228091	0.2285	1.6067
D14G	605	605	6	13	335	202675	0.2031	1.0383	422	255074	0.2556	1.3068
D14H	697	697	6	13	335	233495	0.2340	1.5790	422	293862	0.2944	1.9872
D14J	515	515	6	13	335	172525	0.1729	1.5681	422	217129	0.2176	1.9735
D14K	634	634	6	13	335	212390	0.2128	1.6937	422	267301	0.2678	2.1316
0	**6145**	**6145**				**2058575**	**2.0627**	**1.4136**		**2590792**	**2.5960**	**1.7790**
D15A	437	437	7	10	203	88711	0.0889	0.0749	255	111646	0.1119	0.0942
D15B	393	393	7	10	203	79779	0.0799	0.0773	255	100405	0.1006	0.0973
D15C	276	276	7	10	203	56028	0.0561	0.1036	255	70513	0.0707	0.1304
D15D	437	437	7	12	203	88711	0.0889	0.0842	255	111646	0.1119	0.1060
D15E	619	619	7	12	203	125657	0.1259	0.1097	255	158144	0.1585	0.1380
D15F	352	352	7	12	203	71456	0.0716	0.2366	255	89930	0.0901	0.2978
D15G	485	485	7	12	203	98455	0.0987	0.3474	255	123909	0.1242	0.4372
D15H	361	361	7	12	203	73283	0.0734	0.4943	255	92229	0.0924	0.6221
0	**3360**	**3360**				**682080**	**0.6834**	**0.1199**		**858422.63**	**0.8601**	**0.1509**
D16A	159	159	7	10	203	32277	0.0323	0.0762	255	40622	0.0407	0.0960
D16B	249	249	7	10	203	50547	0.0506	0.0925	255	63615	0.0637	0.1164
D16C	438	438	7	10	203	88914	0.0891	0.2732	255	111902	0.1121	0.3438
D16D	339	339	7	10	203	68817	0.0690	0.1114	255	86609	0.0868	0.1402
D16E	434	434	7	10	203	88102	0.0883	0.1763	255	110880	0.1111	0.2219
D16F	277	277	7	10	203	56231	0.0563	0.1105	255	70769	0.0709	0.1391
D16G	290	290	7	10	203	58870	0.0590	0.1269	255	74090	0.0742	0.1597
D16H	345	345	7	10	203	70035	0.0702	0.2191	255	88142	0.0883	0.2758

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D16J	374	374	7	10	203	75922	0.0761	0.1584	255	95551	0.0957	0.1993
D16K	329	329	7	10	203	66787	0.0669	0.1116	255	84054	0.0842	0.1404
D16L	533	533	7	10	203	108199	0.1084	0.1819	255	136172	0.1364	0.2290
D16M	753	753	7	10	203	152859	0.1532	0.1152	255	192379	0.1928	0.1450
0	**4520**	**4520**				**917560**	**0.9194**	**0.1369**		**1154782.8**	**1.1571**	**0.1722**
D17A	638	638	7	10	203	129514	0.1298	0.0629	255	162998	0.1633	0.0791
D17B	442	442	7	10	203	89726	0.0899	0.0710	255	112923	0.1131	0.0894
D17C	525	525	7	10	203	106575	0.1068	0.1379	255	134129	0.1344	0.1735
D17D	748	748	7	10	203	151844	0.1521	0.1356	255	191101	0.1915	0.1707
D17E	605	605	7	10	203	122815	0.1231	0.1276	255	154567	0.1549	0.1606
D17F	582	582	7	10	203	118146	0.1184	0.2451	255	148691	0.1490	0.3084
D17G	849	849	7	10	203	172347	0.1727	0.1584	255	216905	0.2173	0.1994
D17H	852	852	7	10	203	172956	0.1733	0.1701	255	217671	0.2181	0.2140
D17J	437	437	7	10	203	88711	0.0889	0.0890	255	111646	0.1119	0.1120
D17K	383	383	7	10	203	77749	0.0779	0.1533	255	97850	0.0980	0.1929
D17L	590	590	7	10	203	119770	0.1200	0.1611	255	150735	0.1510	0.2027
D17M	528	528	7	10	203	107184	0.1074	0.1475	255	134895	0.1352	0.1857
0	**7179**	**7179**				**1457337**	**1.4603**	**0.1241**		**1834111.9**	**1.8378**	**0.1562**
D18A	599	599	7	10	203	121597	0.1218	0.1259	255	153034	0.1533	0.1584
D18B	327	327	7	10	203	66381	0.0665	0.1668	255	83543	0.0837	0.2100
D18C	466	466	7	12	203	94598	0.0948	0.1972	255	119055	0.1193	0.2482
D18D	766	766	7	10	203	155498	0.1558	0.1393	255	195700	0.1961	0.1753
D18E	376	376	7	10	203	76328	0.0765	0.1376	255	96062	0.0963	0.1731
D18F	446	446	7	12	203	90538	0.0907	0.2071	255	113945	0.1142	0.2607
D18G	492	492	7	13	203	99876	0.1001	0.1160	255	125698	0.1259	0.1460
D18H	384	384	7	13	203	77952	0.0781	0.1551	255	98105	0.0983	0.1952
D18J	859	859	7	12	203	174377	0.1747	0.1561	255	219460	0.2199	0.1964
D18K	935	935	7	13	203	189805	0.1902	0.1290	255	238877	0.2394	0.1623
D18L	610	610	7	12	203	123830	0.1241	0.1919	255	155845	0.1562	0.2415
0	**6260**	**6260**				**1270780**	**1.2733**	**0.1486**		**1599323.1**	**1.6025**	**0.1871**
D21A	309	309	6	10	335	103515	0.1037	0.1688	422	130277	0.1305	0.2124
D21B	394	394	6	10	335	131990	0.1323	0.1495	422	166114	0.1664	0.1882

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**
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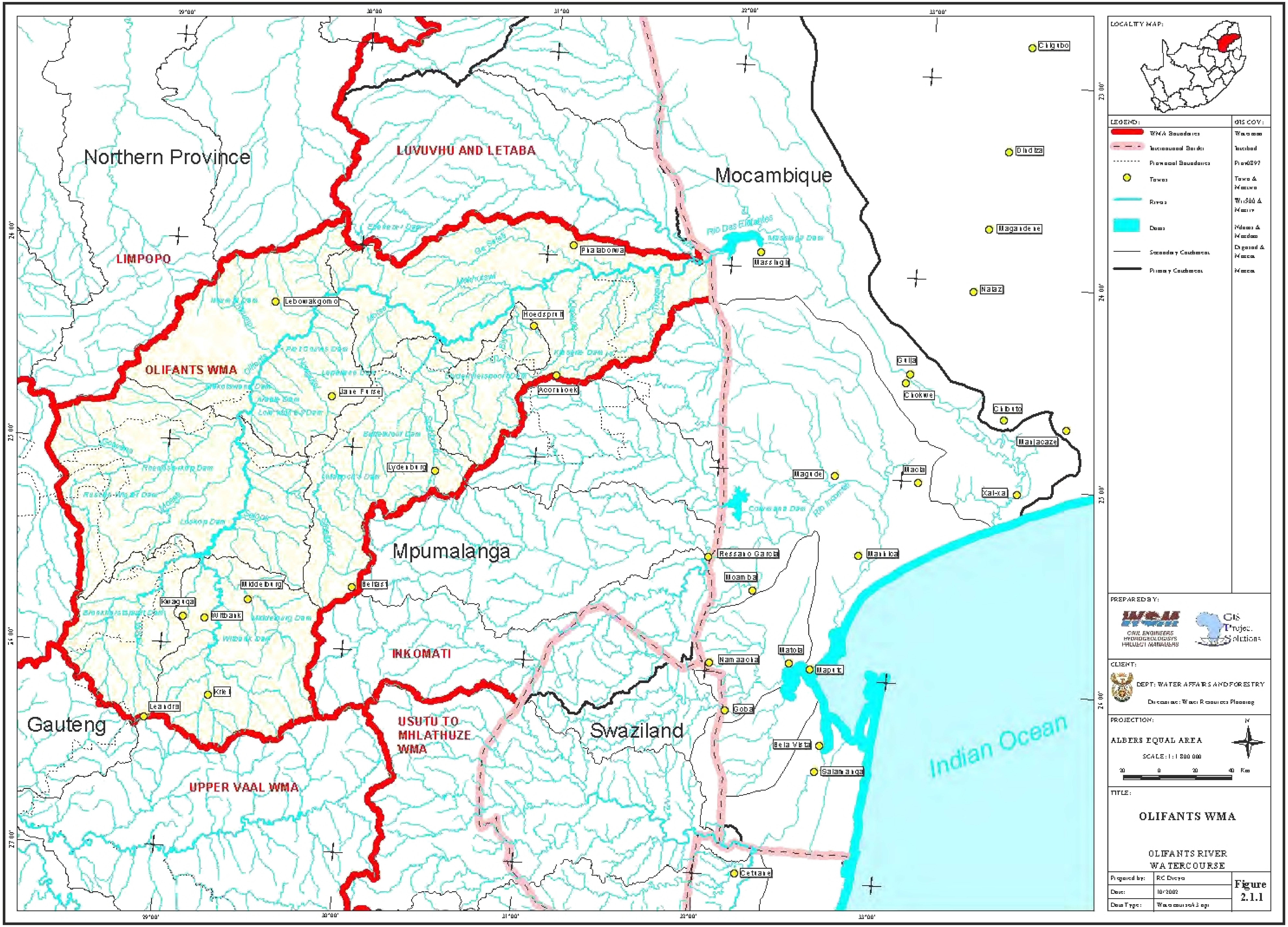
FIGURES


Northern Province
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LUVUVHU AND LETABA
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INKOMATI
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Gauteng
Swaziland
Indian Ocean
Phalaborwa
Lebowakgomo
Hoedspruit
Acornhoek
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Leandra
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Massingir
Ressano Garcia
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Namaacha
Matola
Maputo
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Dindiza
Chigubo
Rio Das Elefantes
Massingir Dam
Corumana Dam
Rio Incomati
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Witbank Dam
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Flag Boshielo Dam
Rhenosterkop Dam
Blyde River Poort Dam
Ebenezer Dam
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Secondary Catchment
Primary Catchment
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
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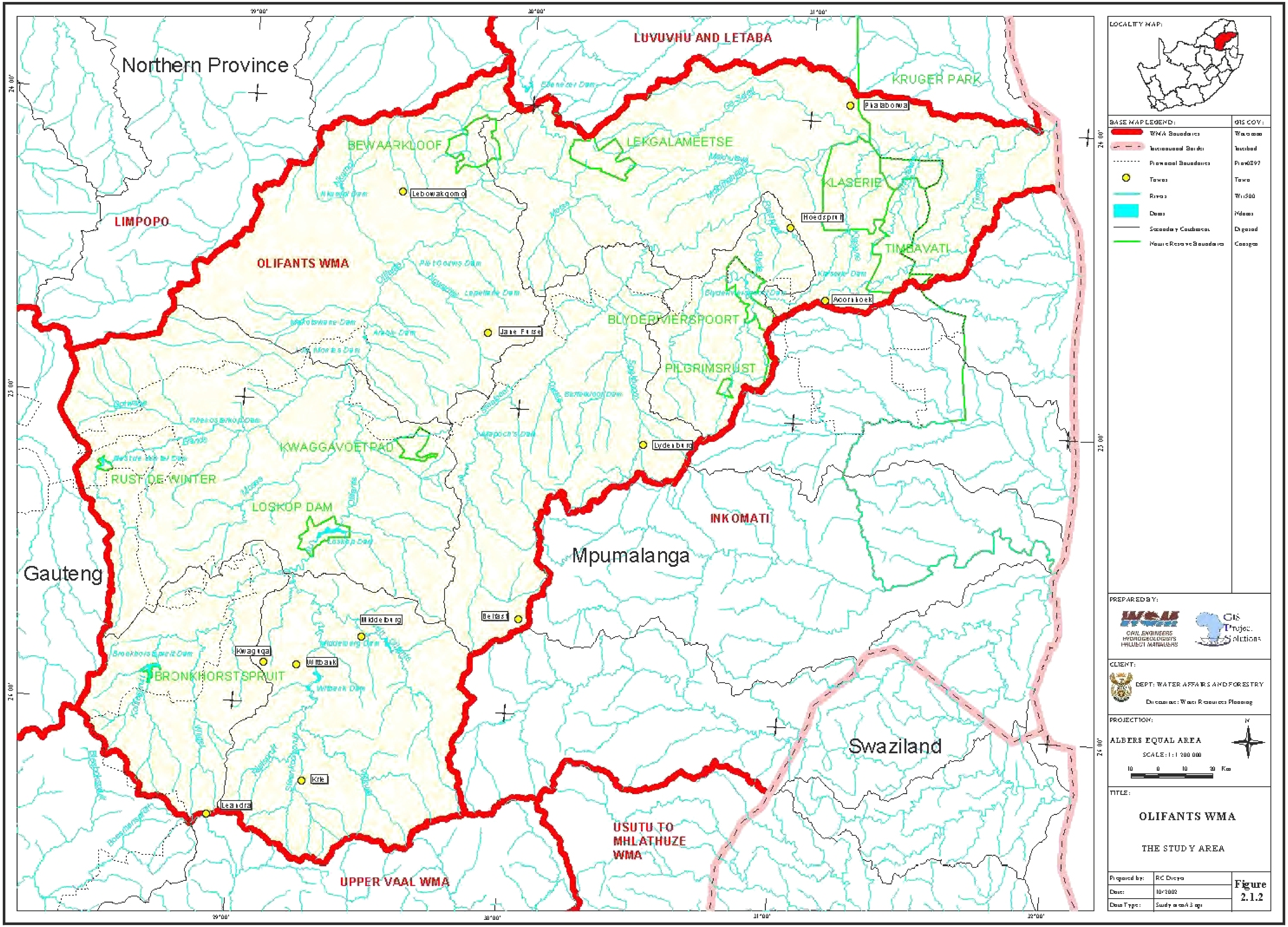
Prepared by:
Date:
Data Type:
Figure 2.1.1


LUVUVHU AND LETABA
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Phalaborwa
BEWAARKLOOF
LEKGALAMEETSE
Lebowakgomo
KLASERIE
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LIMPOPO
TIMBAVATI
OLIFANTS WMA
Acornhoek
BLYDERIVIERSPOORT
Jane Furse
PILGRIMSRUST
Lydenburg
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
INKOMATI
Mpumalanga
Gauteng
Belfast
Middelburg
Kwaggafontein
Witbank
BRONKHORSTSPRUIT
Swaziland
Kriel
Leandra
USUTU TO
MHLATHUZE
WMA
UPPER VAAL WMA
LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
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International Border
Provincial Boundaries
Towns
Rivers
Dams
Secondary Catchments
Nature Reserve Boundaries
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CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
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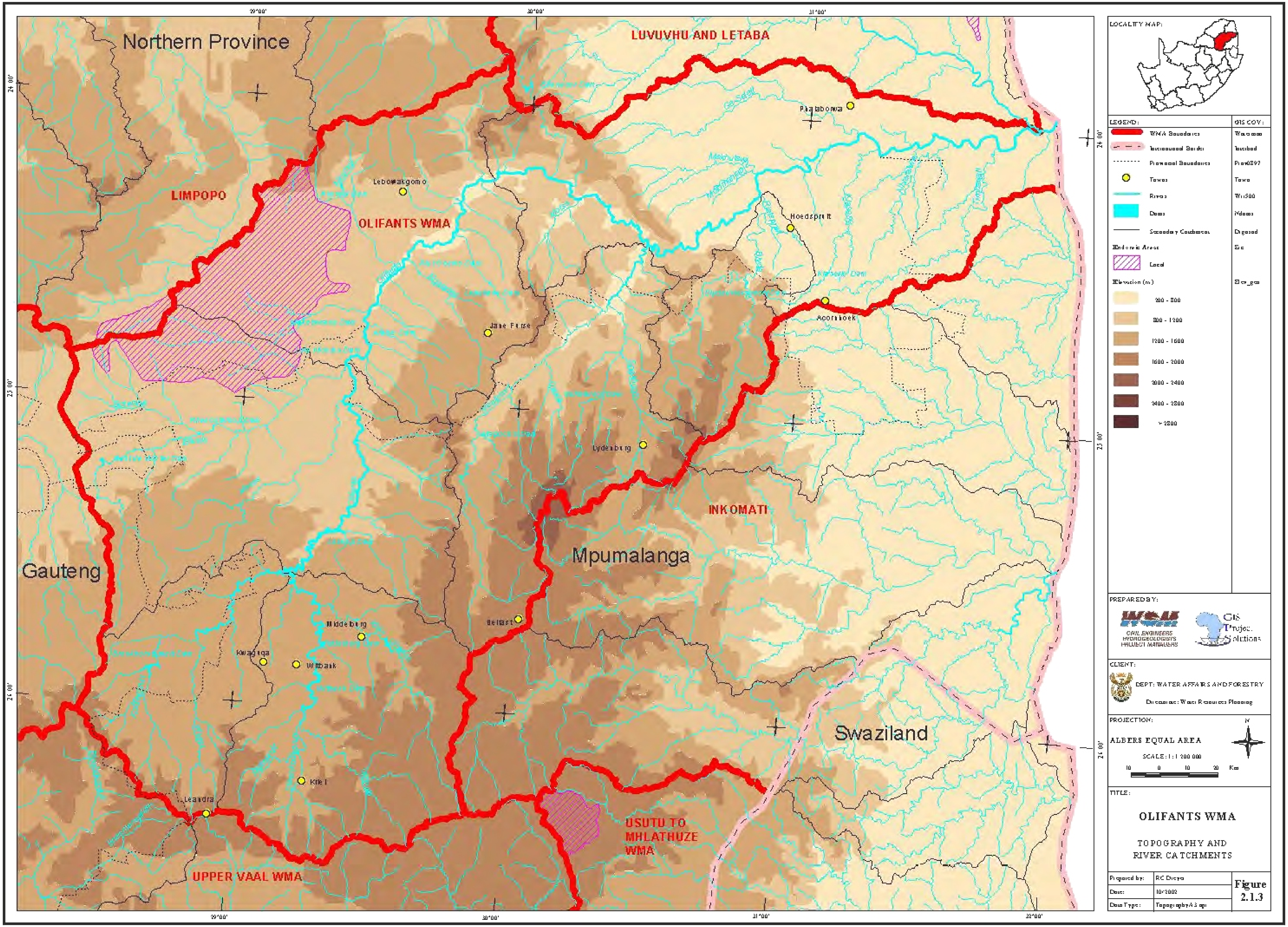

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LUVUVHU AND LETABA
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Phalaborwa
Hoedspruit
Acornhoek
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Lydenburg
INKOMATI
Mpumalanga
Gauteng
Middelburg
Belfast
Kwaguqa
Witbank
Kriel
Leandra
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
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DEPT: WATER AFFAIRS AND FORESTRY
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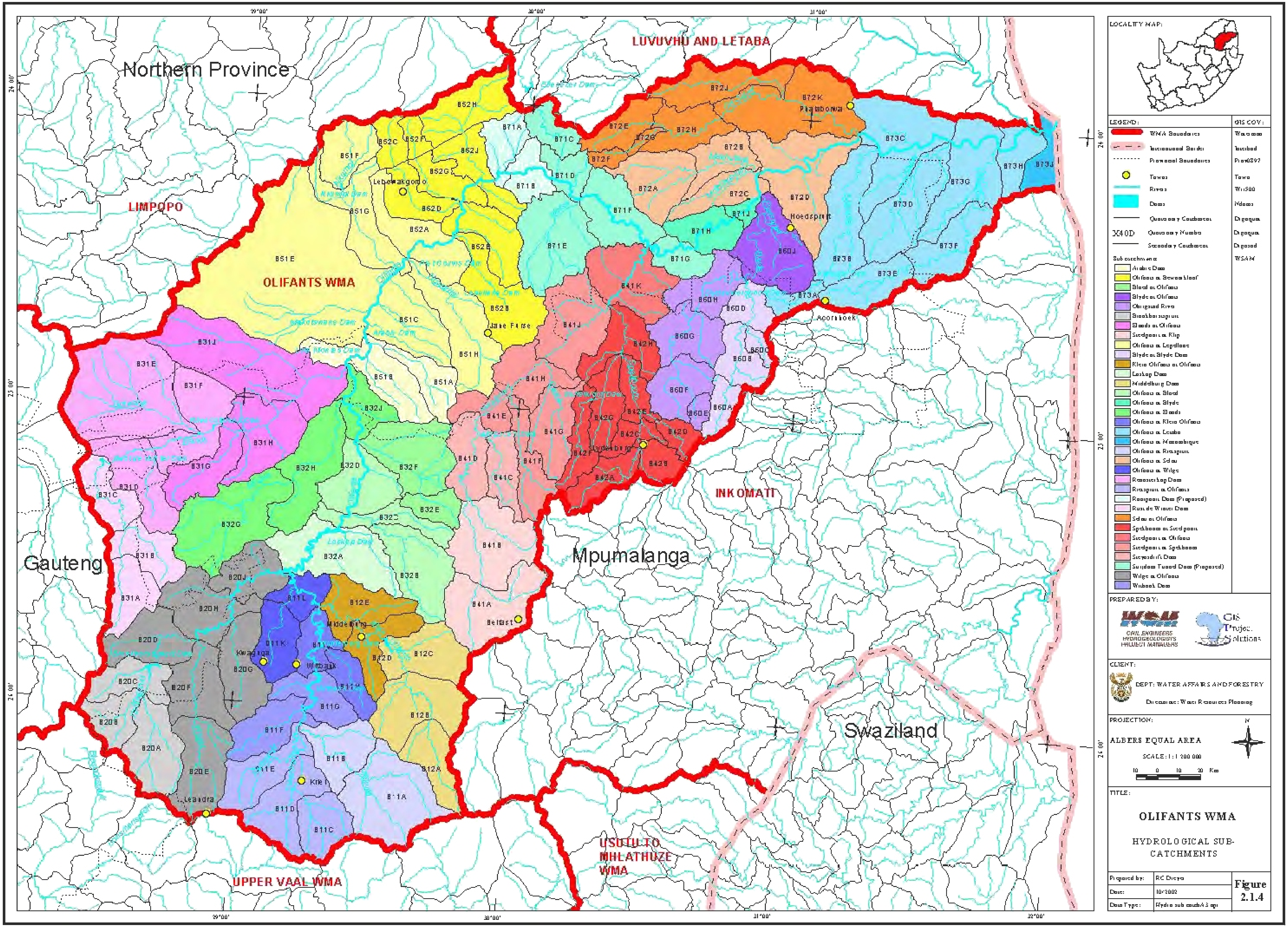
TOPOGRAPHY AND RIVER CATCHMENTS
Figure 2.1.3


Northern Province
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Swaziland
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LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
X40D
Subcatchments
PREPARED BY:
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DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
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SCALE: 1 : 1 200 000
TITLE:
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Prepared by:
Date:
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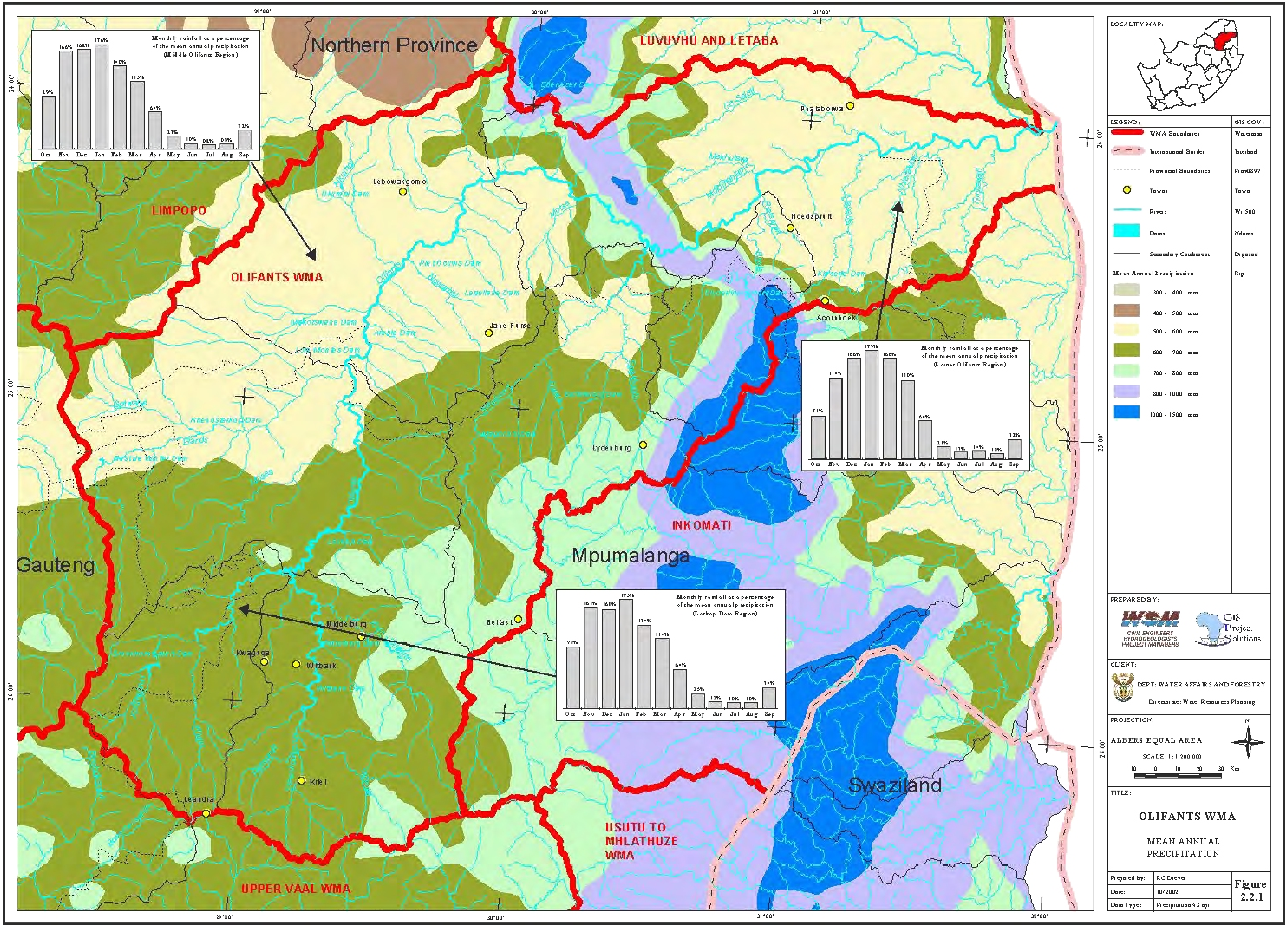
Northern Province
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Mpumalanga
Gauteng
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Lebowakgomo
Phalaborwa
Hoedspruit
Acornhoek
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
LOCALITY MAP:
LEGEND:
GIS COV:
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600 - 700 mm
700 - 800 mm
800 - 1000 mm
1000 - 1500 mm
PREPARED BY:
CIVIL ENGINEERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
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SCALE: 1:1 200 000
TITLE:
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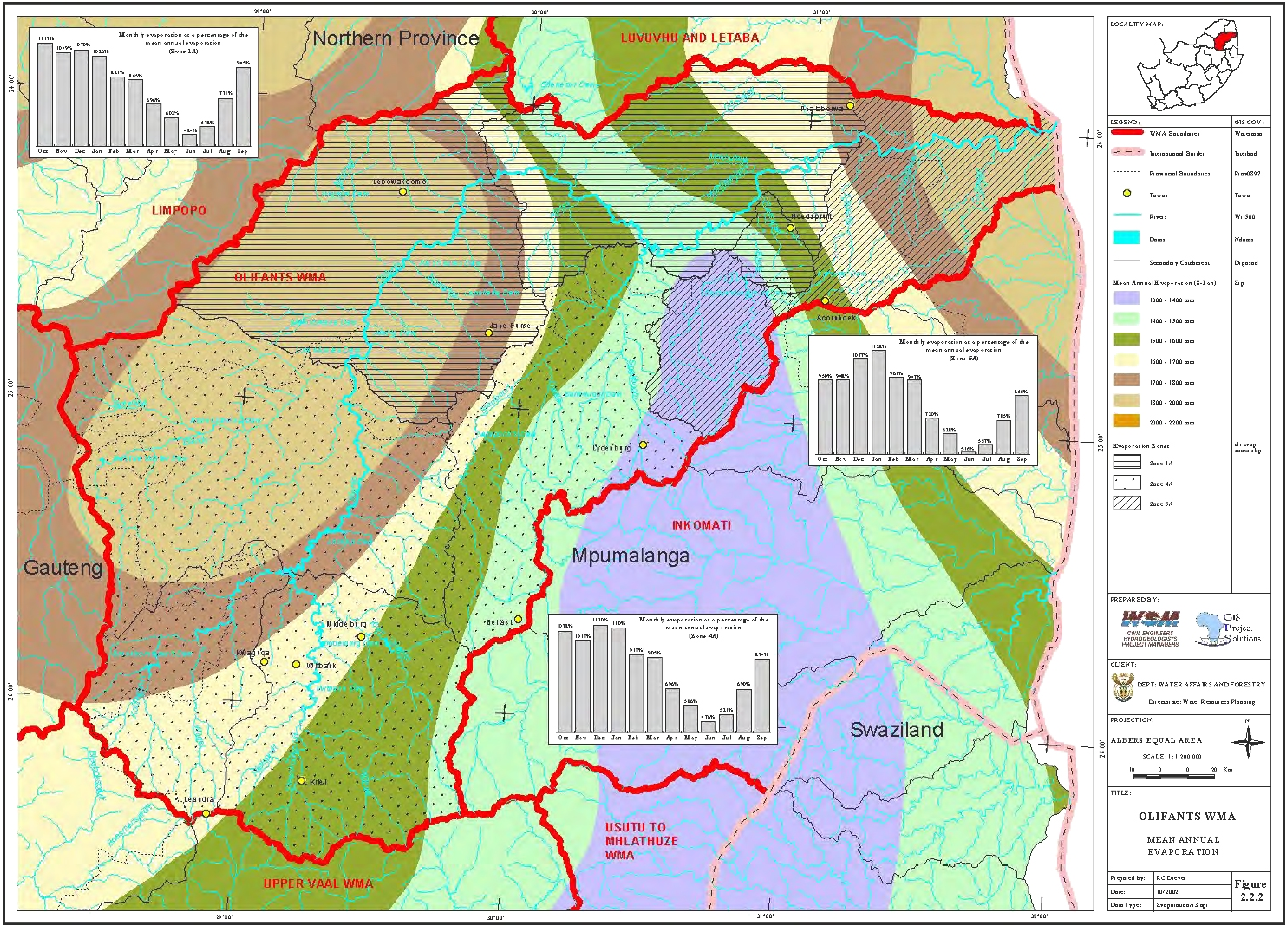
MEAN ANNUAL PRECIPITATION
Figure 2.2.1


Northern Province
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Gauteng
Mpumalanga
INKOMATI
Swaziland
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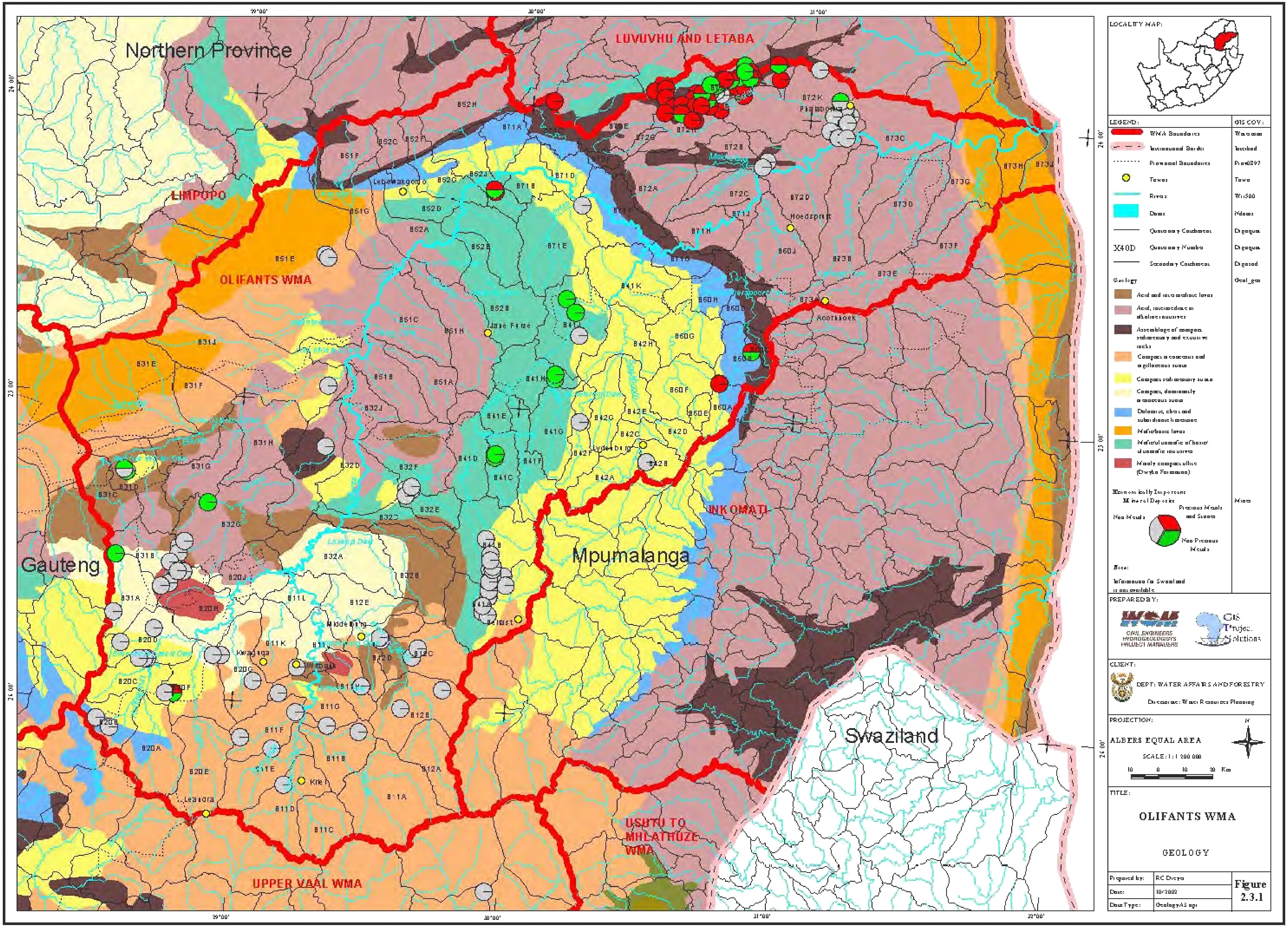
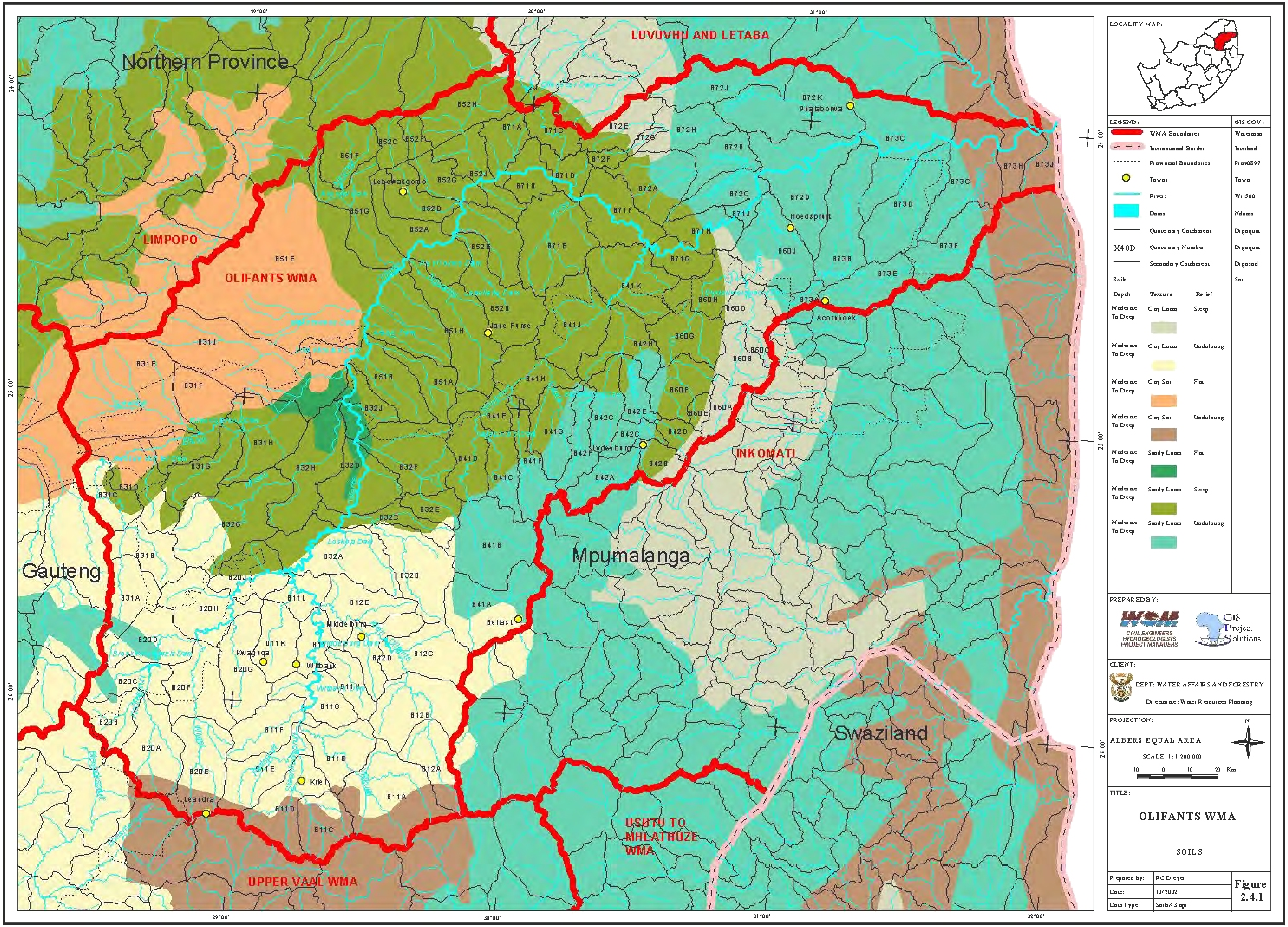
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kriel
Leandra
Monthly evaporation as a percentage of the mean annual evaporation (Zone 1A)
Monthly evaporation as a percentage of the mean annual evaporation (Zone 5A)
Monthly evaporation as a percentage of the mean annual evaporation (Zone 4A)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Secondary Catchments
Mean Annual Evaporation (S-Pan)
1300 - 1400 mm
1400 - 1500 mm
1500 - 1600 mm
1600 - 1700 mm
1700 - 1800 mm
1800 - 2000 mm
2000 - 2200 mm
Evaporation Zones
Zone 1A
Zone 4A
Zone 5A
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
TITLE:
OLIFANTS WMA
MEAN ANNUAL EVAPORATION
Prepared by:
Date:
Data Type:
Figure 2.2.2



OLIFANTS WMA

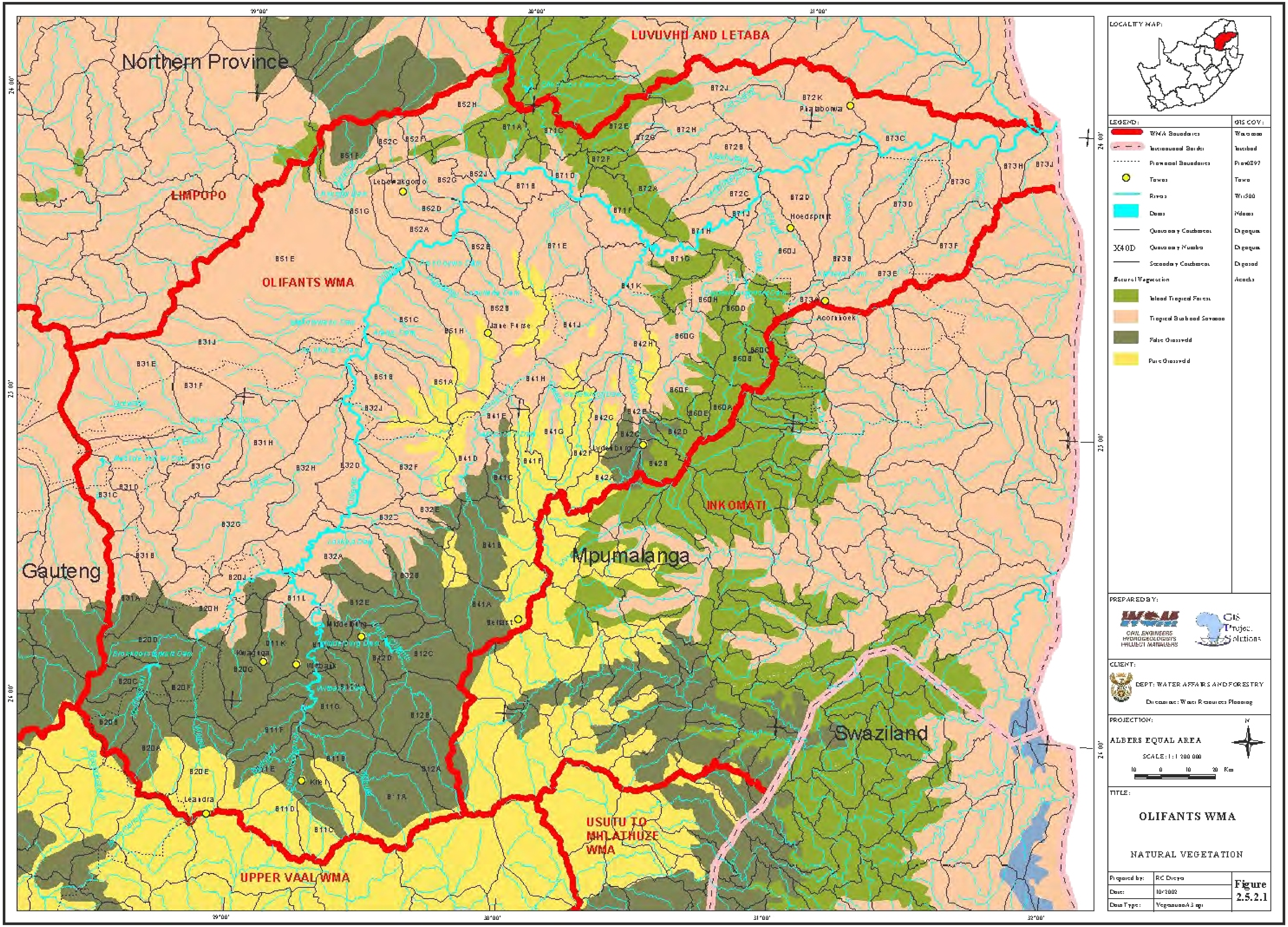
GEOLOGY

Figure 2.3.1

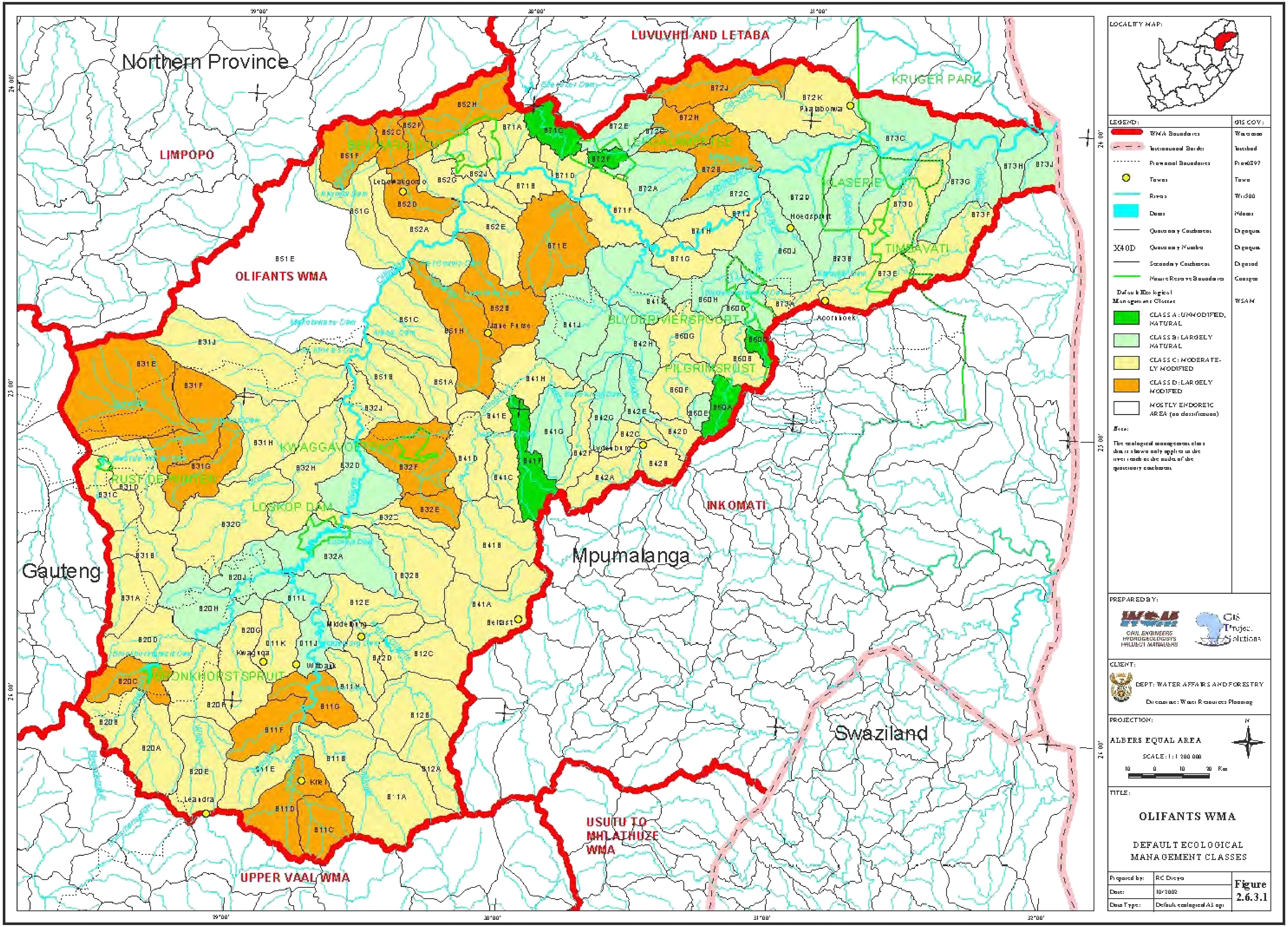


Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
INKOMATI
Mpumalanga
Gauteng
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
Loskop Dam
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Soils
Depth
Texture
Relief
Moderate To Deep
Clay Loam
Steep
Undulating
Clay Soil
Flat
Sandy Loam
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
TITLE:
OLIFANTS WMA
SOILS
Prepared by:
RC Dreyer
Date:
10/2002

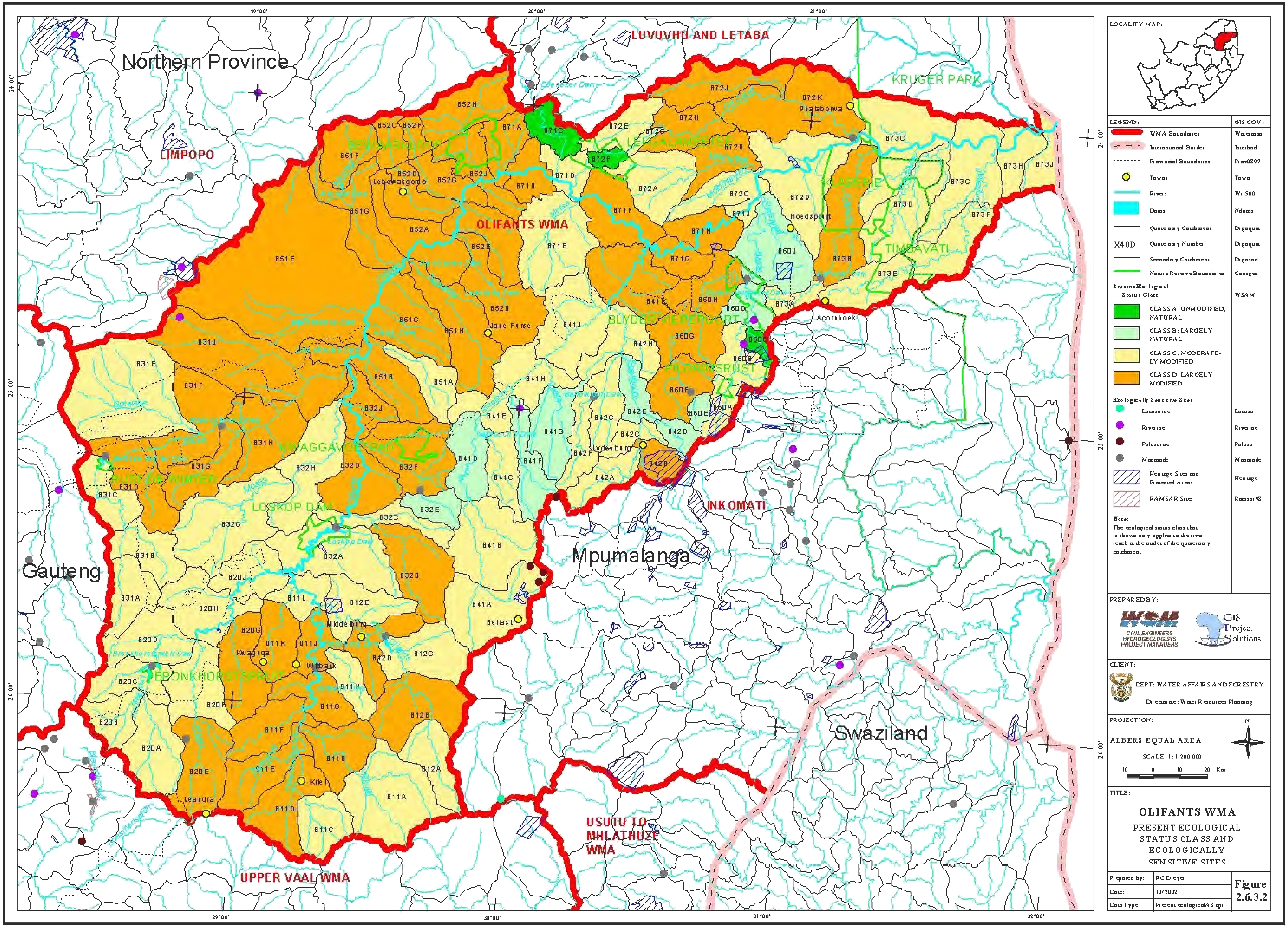
Figure 2.4.1

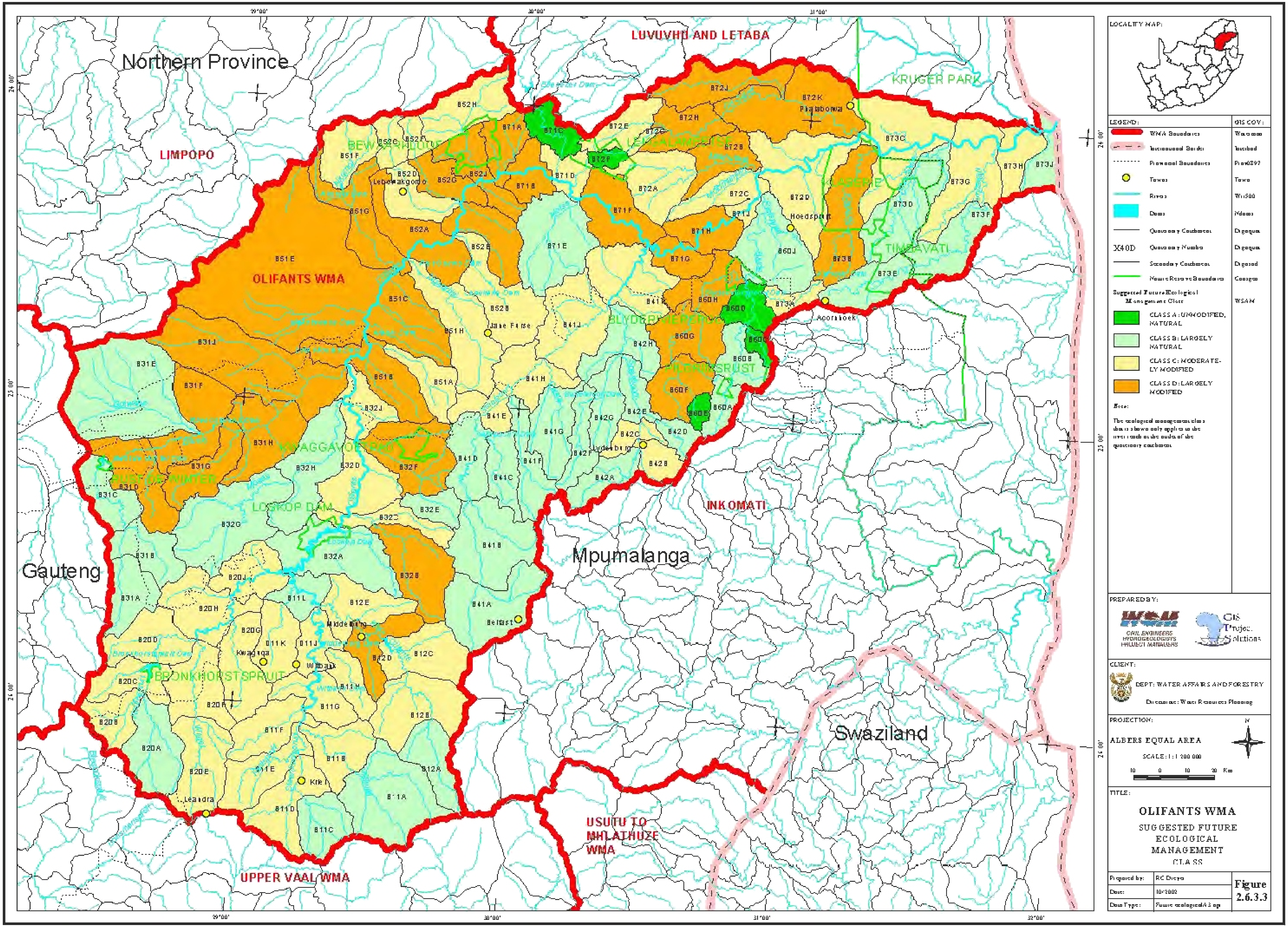


LUVUVHU AND LETABA
Northern Province
LIMPOPO
OLIFANTS WMA
INKOMATI
Mpumalanga
Gauteng
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Lebowakgomo
Hoedspruit
Acornhoek
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Natural Vegetation
Inland Tropical Forest
Tropical Bushveld Savanna
False Grassveld
Pure Grassveld
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
10 0 10 20 Km
TITLE:
OLIFANTS WMA
NATURAL VEGETATION
Prepared by:
Date:
10/2002
Data Type:
Figure 2.5.2.1

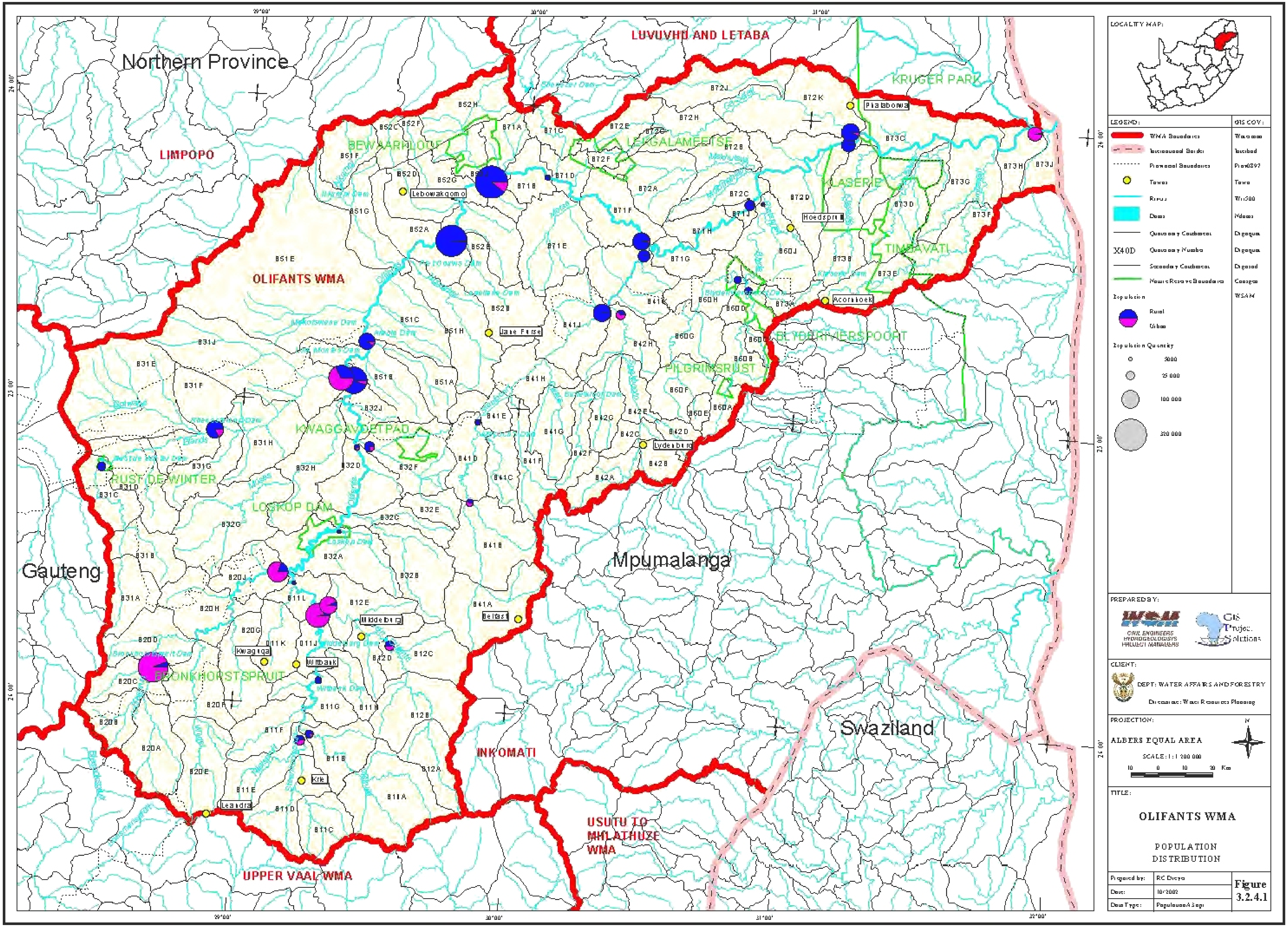


Northern Province
LIMPOPO
OLIFANTS WMA
LUVUVHU AND LETABA
KRUGER PARK
KLASERIE
TIMBAVATI
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
BRONKHORSTSPRUIT
INKOMATI
Mpumalanga
Gauteng
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
Towns
Rivers
Dams
X40D
Default Ecological Management Classes
WSAM
CLASS A: UNMODIFIED, NATURAL
CLASS B: LARGELY NATURAL
CLASS C: MODERATELY MODIFIED
CLASS D: LARGELY MODIFIED
MOSTLY ENDOREIC AREA (no classification)
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
TITLE:
OLIFANTS WMA
DEFAULT ECOLOGICAL MANAGEMENT CLASSES
Prepared by:
RC Dreyer
Date:
10/2002
Figure 2.6.3.1


Northern Province
LIMPOPO
LUVUVHU AND LETABA
KRUGER PARK
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
LOSKOP DAM
BRONKHORSTSPRUIT
TIMBAVATI
KLASERIE
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Lydenburg
Belfast
Middelburg
Witbank
Kwaggafontein
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
CLASS A: UNMODIFIED, NATURAL
CLASS B: LARGELY NATURAL
CLASS C: MODERATELY MODIFIED
CLASS D: LARGELY MODIFIED
RAMSAR Sites
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
10 0 10 20 Km
TITLE:
OLIFANTS WMA
PRESENT ECOLOGICAL STATUS CLASS AND ECOLOGICALLY SENSITIVE SITES
RC Dreyer
10/2002
Figure 2.6.3.2



LUVUVHU AND LETABA
Northern Province
LIMPOPO
KRUGER PARK
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
LOSKOP DAM
BRONKHORSTSPRUIT
Lebowakgomo
Phalaborwa
Hoedspruit
Acornhoek
Lydenburg
Belfast
Middelburg
Witbank
Kwaggufontein
Kriel
Leandra
LOCALITY MAP:
LEGEND:
CLASS A: UNMODIFIED, NATURAL
CLASS B: LARGELY NATURAL
CLASS C: MODERATELY MODIFIED
CLASS D: LARGELY MODIFIED
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
TITLE:
OLIFANTS WMA
SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASS
Figure 2.6.3.3



Northern Province
LIMPOPO
LUVUVHU AND LETABA
KRUGER PARK
OLIFANTS WMA
Mpumalanga
Gauteng
Swaziland
INKOMATI
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
BEWAARKLOOF
LEGALAMEETSE
KLASERIE
TIMBAVATI
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
BRONKHORSTSPRUIT
Phalaborwa
Lebowakgomo
Hoedspruit
Acornhoek
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaggafontein
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
Population
Rural
Urban
Population Quantity
5000
25 000
100 000
320 000
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
POPULATION DISTRIBUTION
Prepared by:
Date: 10/2002
Data Type:
Figure 3.2.4.1

FIGURE 3.4.2.1: DISTRICT COUNCILS AND MAGISTERIAL DISTRICTS

THIS FIGURE IS NOT ACCESSIBLE IN ELECTRONIC FORMAT.

IT IS AVAILABLE IN HARD COPY FROM:

DEPARTMENT: WATER AFFAIRS & FORESTRY
DIRECTORATE: WATER RESOURCES PLANNING

FIGURE 3.4.2.2: INSTITUTIONAL BOUNDARIES RELATED TO WATER SUPPLY

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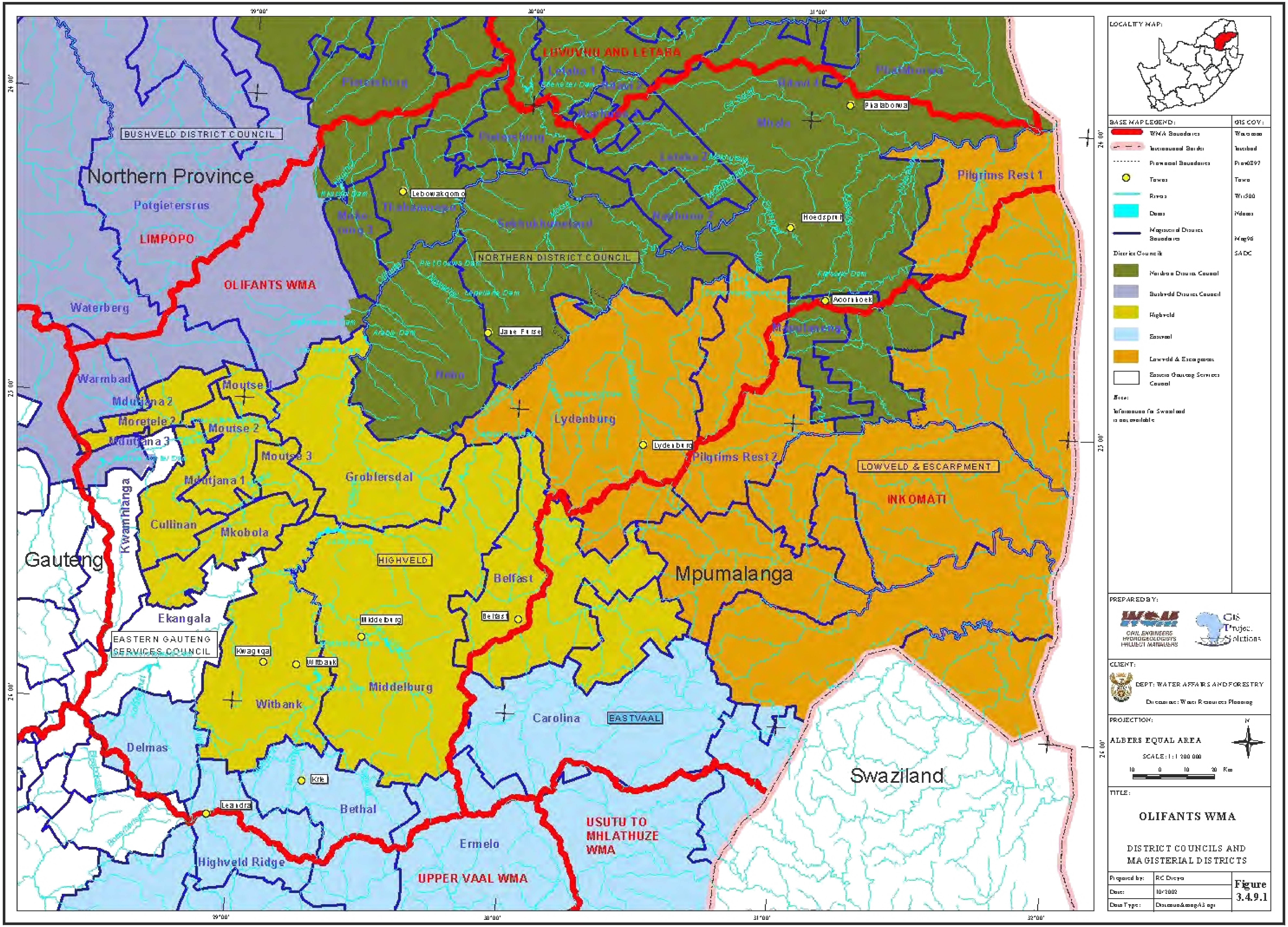
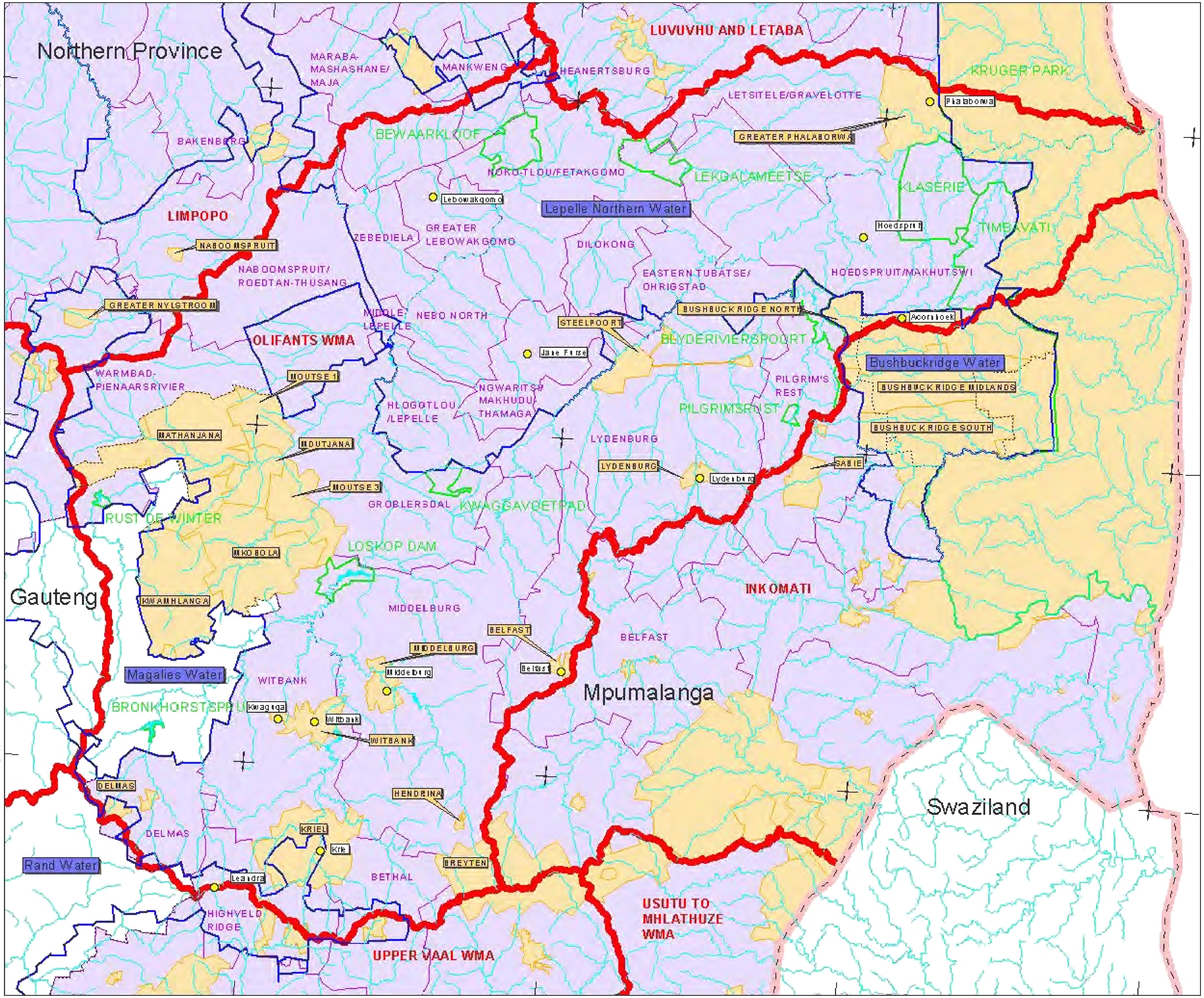
IT IS AVAILABLE IN HARD COPY FROM:

DEPARTMENT: WATER AFFAIRS & FORESTRY
DIRECTORATE: WATER RESOURCES PLANNING


LUVUVHU AND LETABA
Letaba 1
Phalaborwa
Pietersburg
BUSHVELD DISTRICT COUNCIL
Northern Province
Potgietersrus
LIMPOPO
OLIFANTS WMA
Waterberg
Pilgrims Rest 1
Lebowakgomo
Sekhukhuneland
NORTHERN DISTRICT COUNCIL
Hoedspruit
Acornhoek
Jane Furse
Warmbad
Mdutjana 2
Moutse 1
Moretele 2
Moutse 2
Mdutjana 3
Moutse 3
Groblersdal
Lydenburg
Pilgrims Rest 2
LOWVELD & ESCARPMENT
INKOMATI
Mdutjana 1
Cullinan
Mkobola
Kwamhlanga
Gauteng
HIGHVELD
Belfast
Mpumalanga
Ekangala
EASTERN GAUTENG SERVICES COUNCIL
Middelburg
Kwaguqa
Witbank
Carolina
EASTVAAL
Delmas
Kriel
Swaziland
Leandra
Bethal
USUTU TO MHLATHUZE WMA
Ermelo
Highveld Ridge
UPPER VAAL WMA
LOCALITY MAP:
BASE MAP LEGEND:
WMA Boundaries
Towns
Rivers
Dams
District Councils
Highveld
Eastvaal
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
TITLE:
OLIFANTS WMA
DISTRICT COUNCILS AND MAGISTERIAL DISTRICTS
Figure 3.4.9.1



LOCALITY MAP:

BASE MAP LEGEND:

GIS COV:

WMA Boundaries

Towns

Rivers

Dams

Local/Regional Council

Transitional Local Council

Transitional Regional Council

PREPARED BY:

CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS

GIS Project Solutions

CLIENT:

DEPT: WATER AFFAIRS AND FORESTRY

PROJECTION:

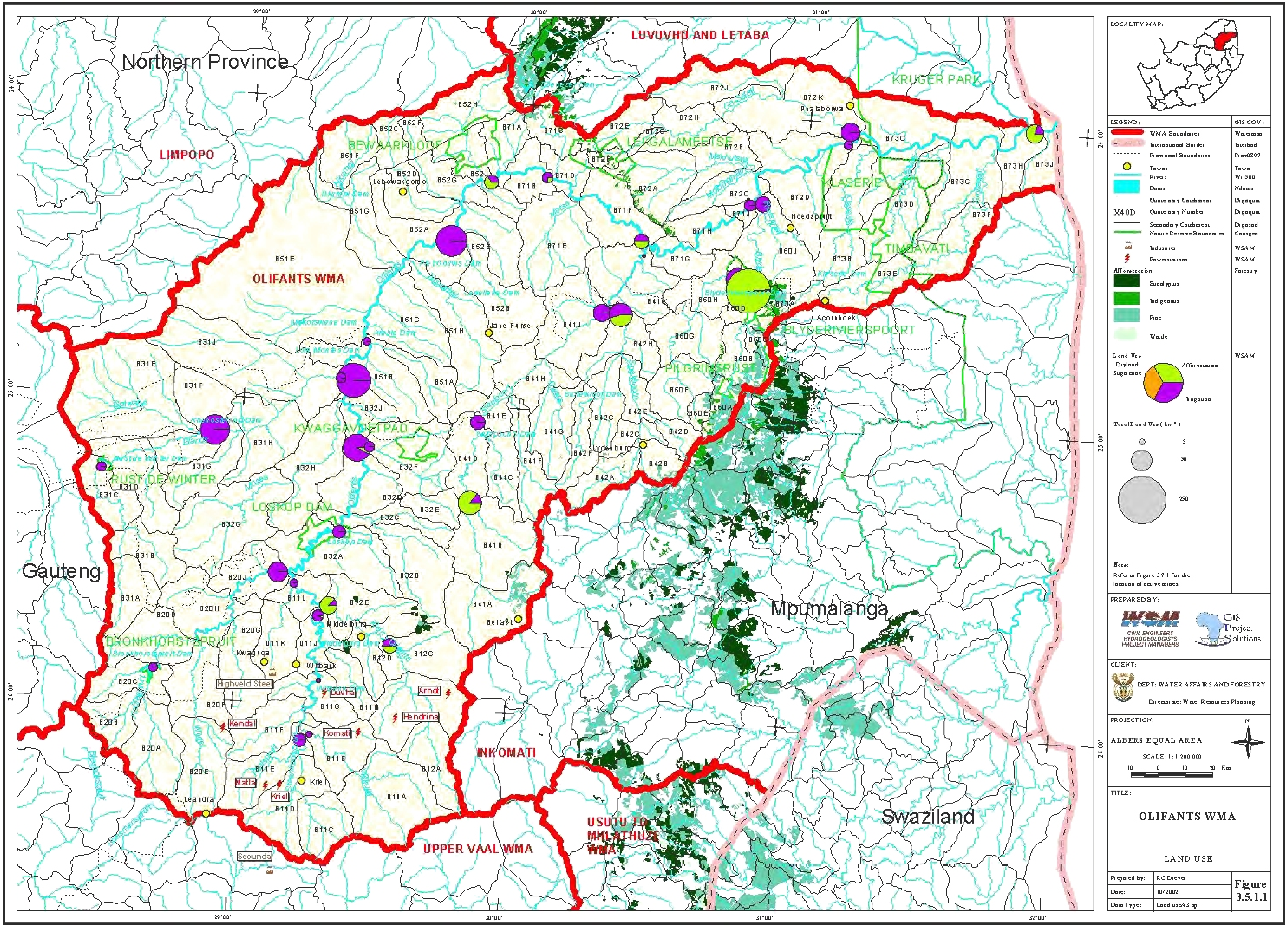
ALBERS EQUAL AREA

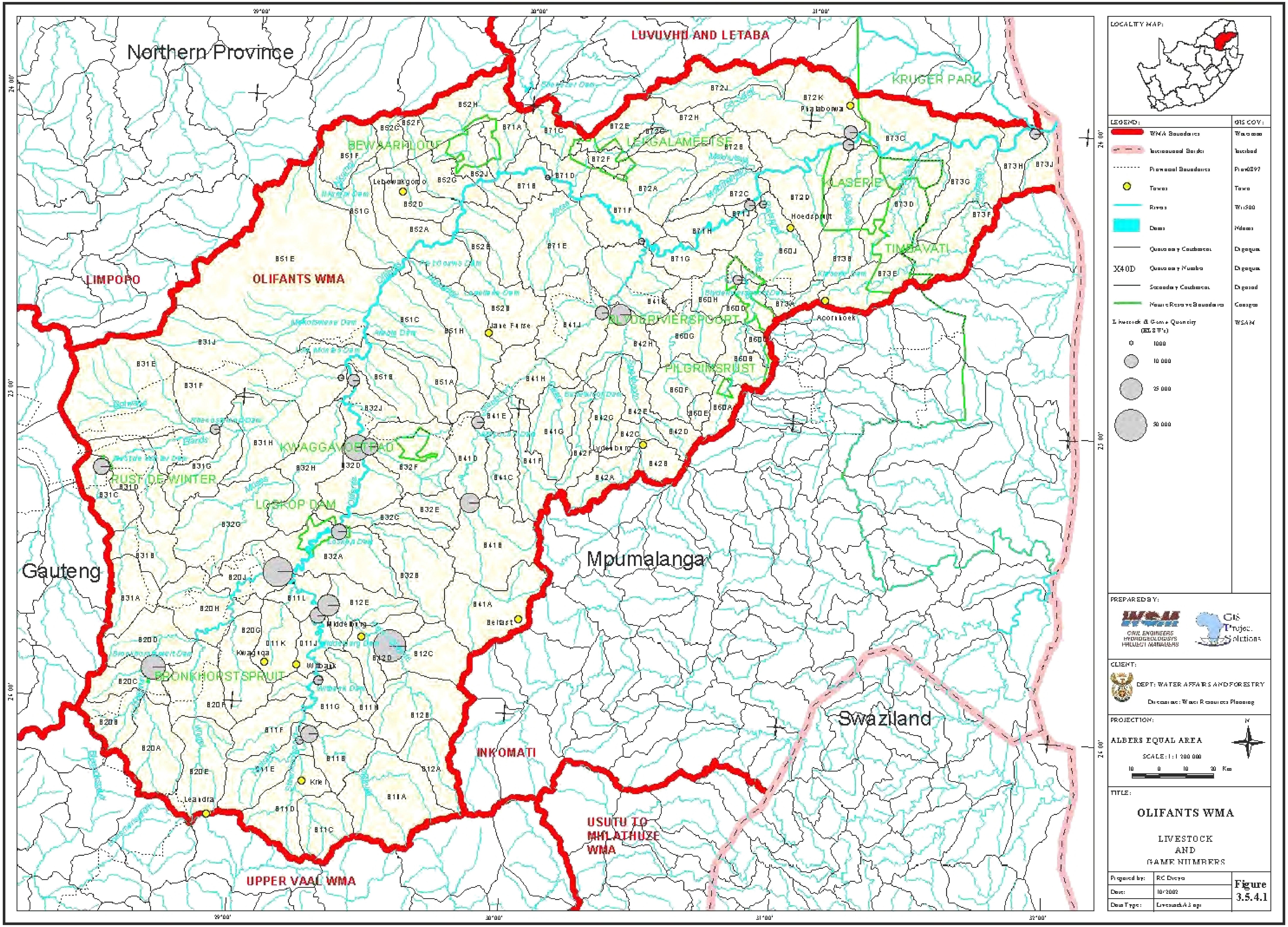
TITLE:

OLIFANTS WMA

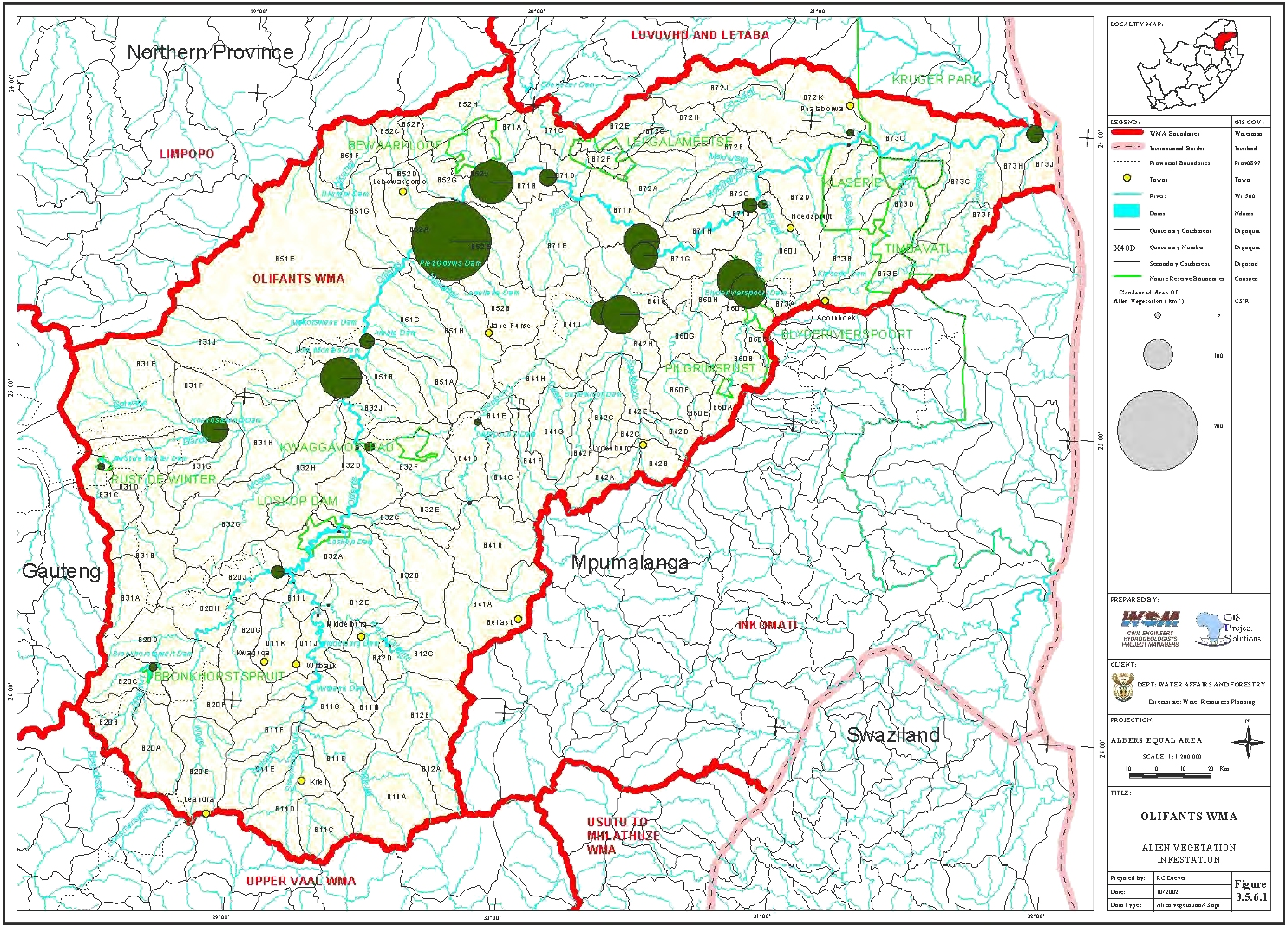
INSTITUTIONAL BOUNDARIES RELATED TO WATER SUPPLY

Figure 3.4.9.2


Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
BEWAARKLOOF
LEPGALAMEETSE
KLASERIE
TIMBAVATI
OLIFANTS WMA
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
Gauteng
BRONKHORSTSPRUIT
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Lebowakgomo
Hoedspruit
Acornhoek
Jane Furse
Lydenburg
Middelburg
Belfast
Witbank
Kwaguqa
Kriel
Leandra
Secunda
Highveld Steel
Duvha
Arnot
Hendrina
Kendal
Komati
Matla
Kriel
LOCALITY MAP:
LEGEND:
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
TITLE:
OLIFANTS WMA
LAND USE
Prepared by:
RC Dreyer
Date:
10/2002
Figure 3.5.1.1

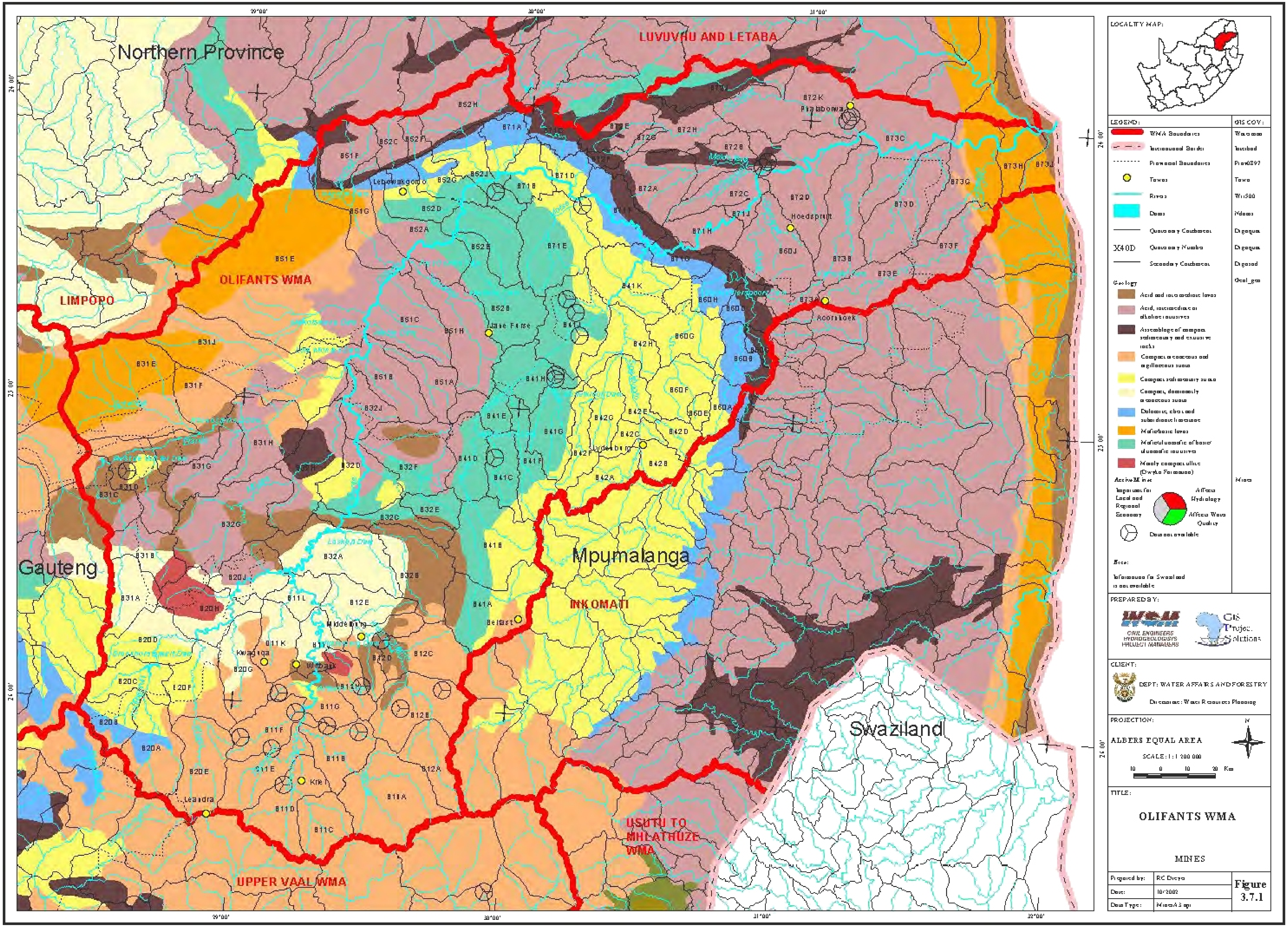


Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
BEWAARKLOOF
LEGALAMEETSE
KLASERIE
TIMBAVATI
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
BRONKHORSTSPRUIT
Gauteng
Mpumalanga
Swaziland
INKOMATI
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Lebowakgomo
Hoedspruit
Acornhoek
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
Livestock & Game Quantity (ELSU's)
1000
10 000
25 000
50 000
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
LIVESTOCK AND GAME NUMBERS
Prepared by:
Date:
10/2002
Data Type:
Figure 3.5.4.1

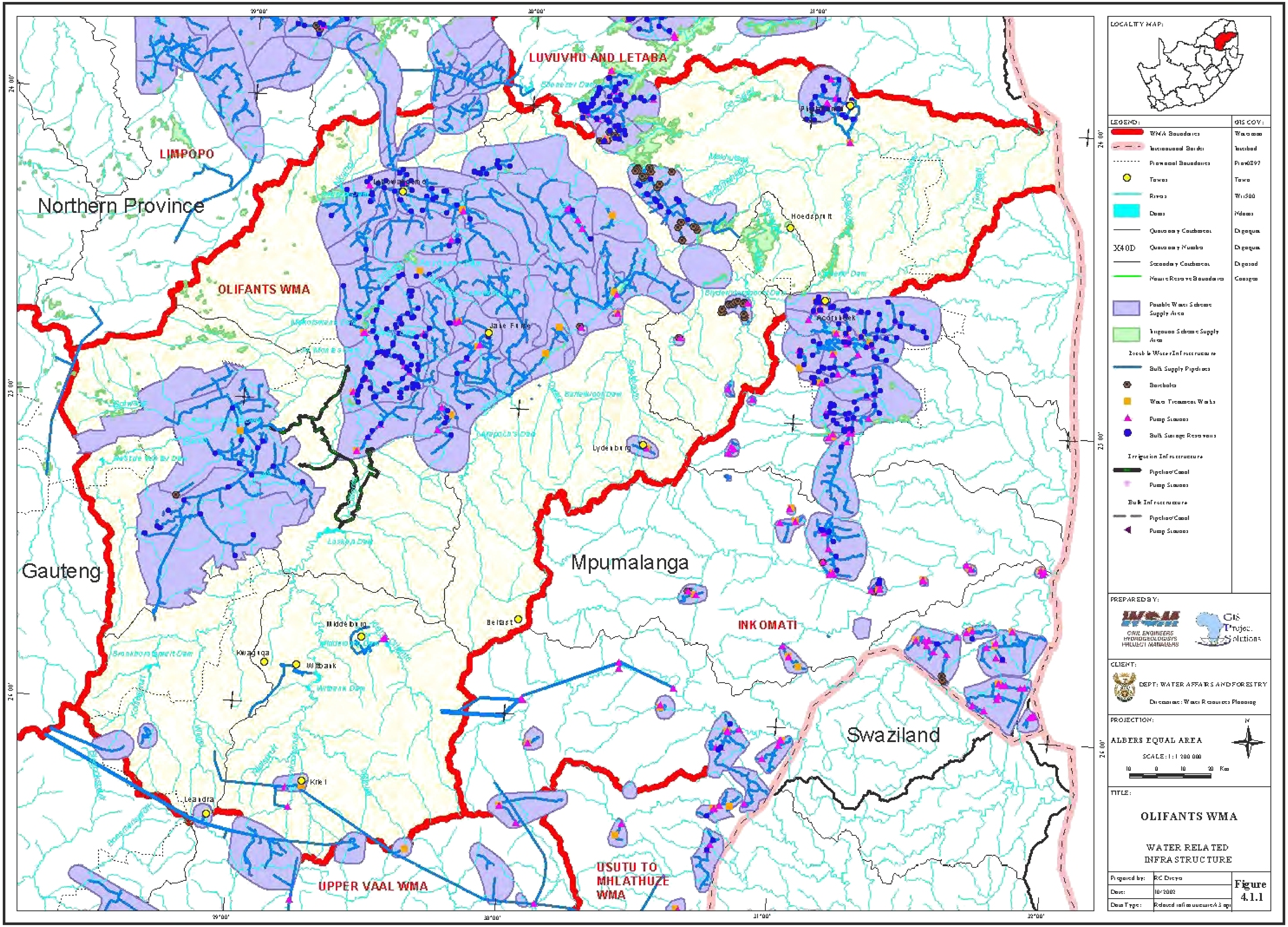


Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
BEWAARKLOOF
LEGALAMEETSE
KLASERIE
TIMBAVATI
OLIFANTS WMA
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOEDRAD
RUST DE WINTER
LOSKOP DAM
Gauteng
Mpumalanga
INKOMATI
Swaziland
BRONKHORSTSPRUIT
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Lebowakgomo
Hoedspruit
Acornhoek
Jane Furse
Lydenburg
Belfast
Middelburg
Kwaguqa
Witbank
Kriel
Leandra
Piet Gouws Dam
Loskop Dam
Witbank Dam
Middelburg Dam
Blyderivierspoort Dam
Bronkhorstspruit Dam
LOCALITY MAP:
LEGEND:
GIS COV:
Condensed Area Of Alien Vegetation (km²)
5
100
200
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
ALIEN VEGETATION INFESTATION
Prepared by:
Date:
Data Type:

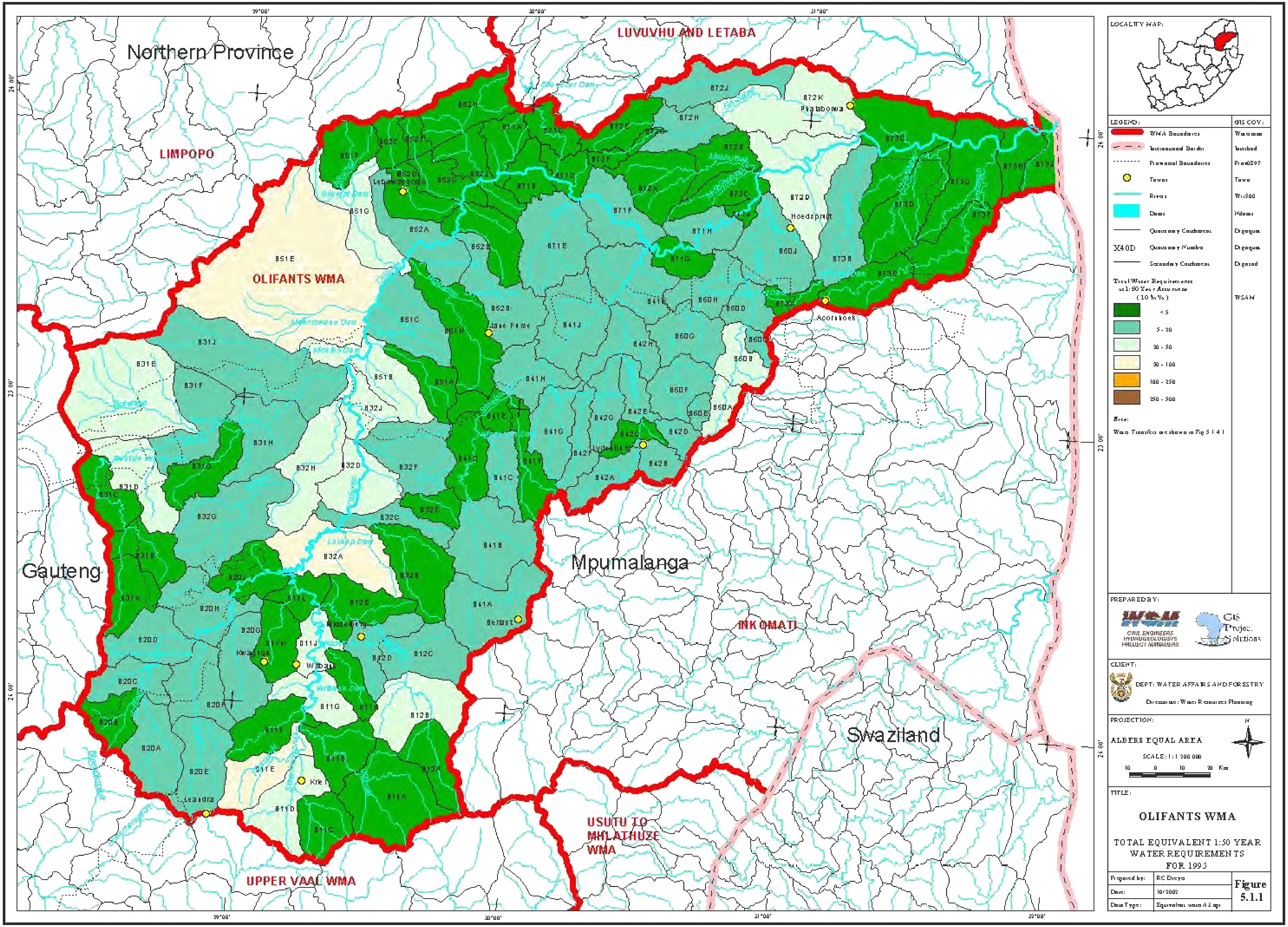
Figure 3.5.6.1

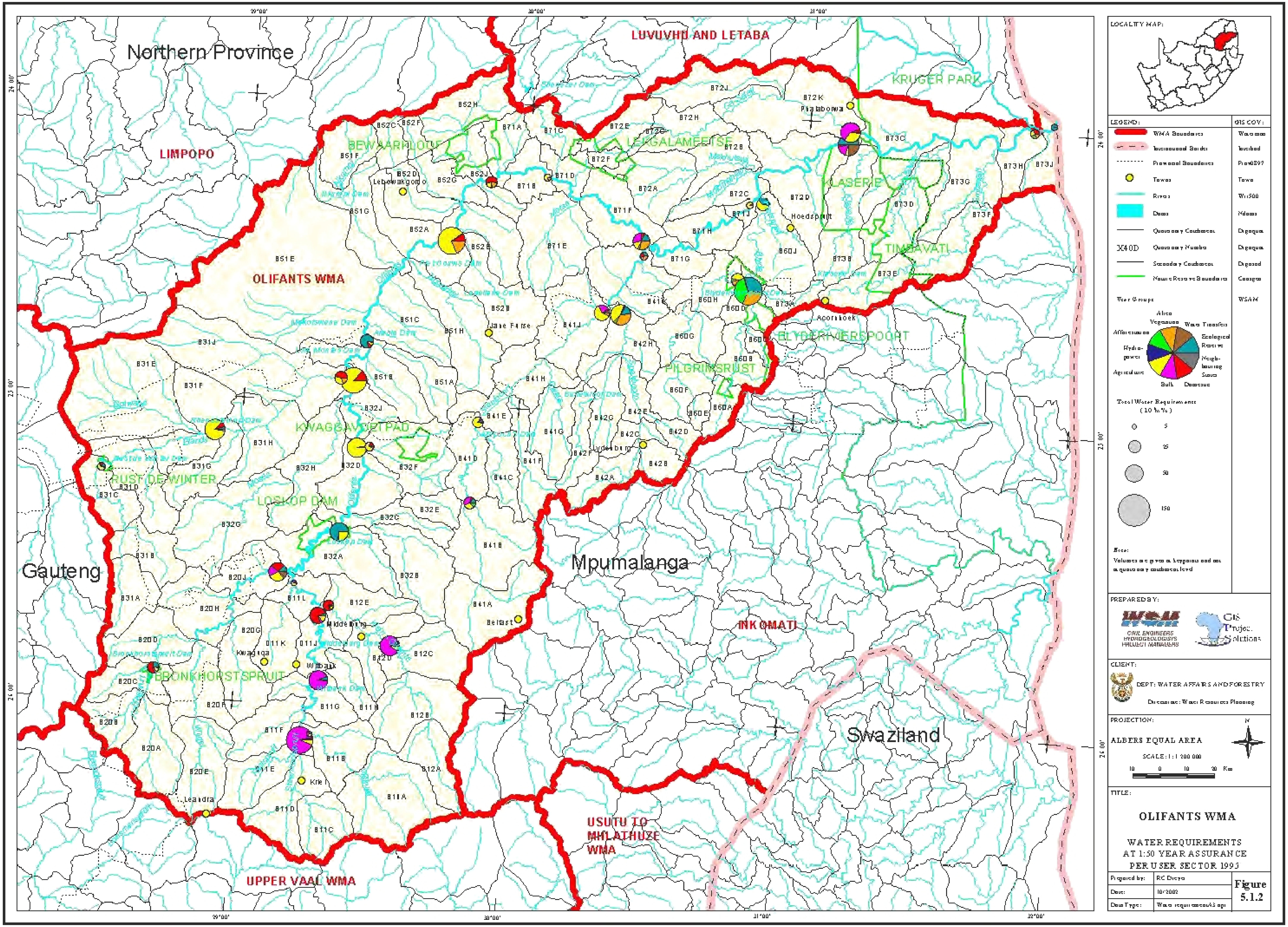


Northern Province
LUVUVHU AND LETABA
OLIFANTS WMA
LIMPOPO
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Lebowakgomo
Phalaborwa
Hoedspruit
Acornhoek
Jane Furse
Lydenburg
Belfast
Middelburg
Kwaguqa
Witbank
Kriel
Leandra
LOCALITY MAP:
LEGEND:
WMA Boundaries
Towns
Rivers
Dams
X40D
Geology
Active Mines
Dams not available
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
TITLE:
OLIFANTS WMA
MINES
Figure 3.7.1



LUVUVHU AND LETABA
LIMPOPO
Northern Province
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
UPPER VAAL WMA
USUTU TO MHLATHUZE WMA
Hoedspruit
Jane Furse
Lydenburg
Acornhoek
Belfast
Middelburg
Kwaguqa
Witbank
Kriel
Leandra
Witbank Dam
Middelburg Dam
Bronkhorstspruit Dam
Loskop Dam
Arabie's Dam
Blyderivierspoort Dam
Ebenezer Dam
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
N
TITLE:
OLIFANTS WMA
WATER RELATED INFRASTRUCTURE
Figure 4.1.1


Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
Loskop Dam
Witbank Dam
LOCALITY MAP:
LEGEND:
GIS COV:
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
TITLE:
OLIFANTS WMA
TOTAL EQUIVALENT 1:50 YEAR WATER REQUIREMENTS FOR 1995
Figure 5.1.1



Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
BEWAARKLOOF
LEGALAMEETSE
KLASERIE
TIMBAVATI
OLIFANTS WMA
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
Gauteng
Mpumalanga
INKOMATI
Swaziland
BRONKHORSTSPRUIT
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Lebowakgomo
Hoedspruit
Acornhoek
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
User Groups
Water Transfers
Ecological Reserve
Afforestation
Hydro-power
Agriculture
Domestic
Total Water Requirements
5
25
50
150
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
10 0 10 20 Km
N
TITLE:
OLIFANTS WMA
WATER REQUIREMENTS
AT 1:50 YEAR ASSURANCE
PER USER SECTOR 1995
Prepared by:
Date:
10/2002
Data Type:
Figure 5.1.2

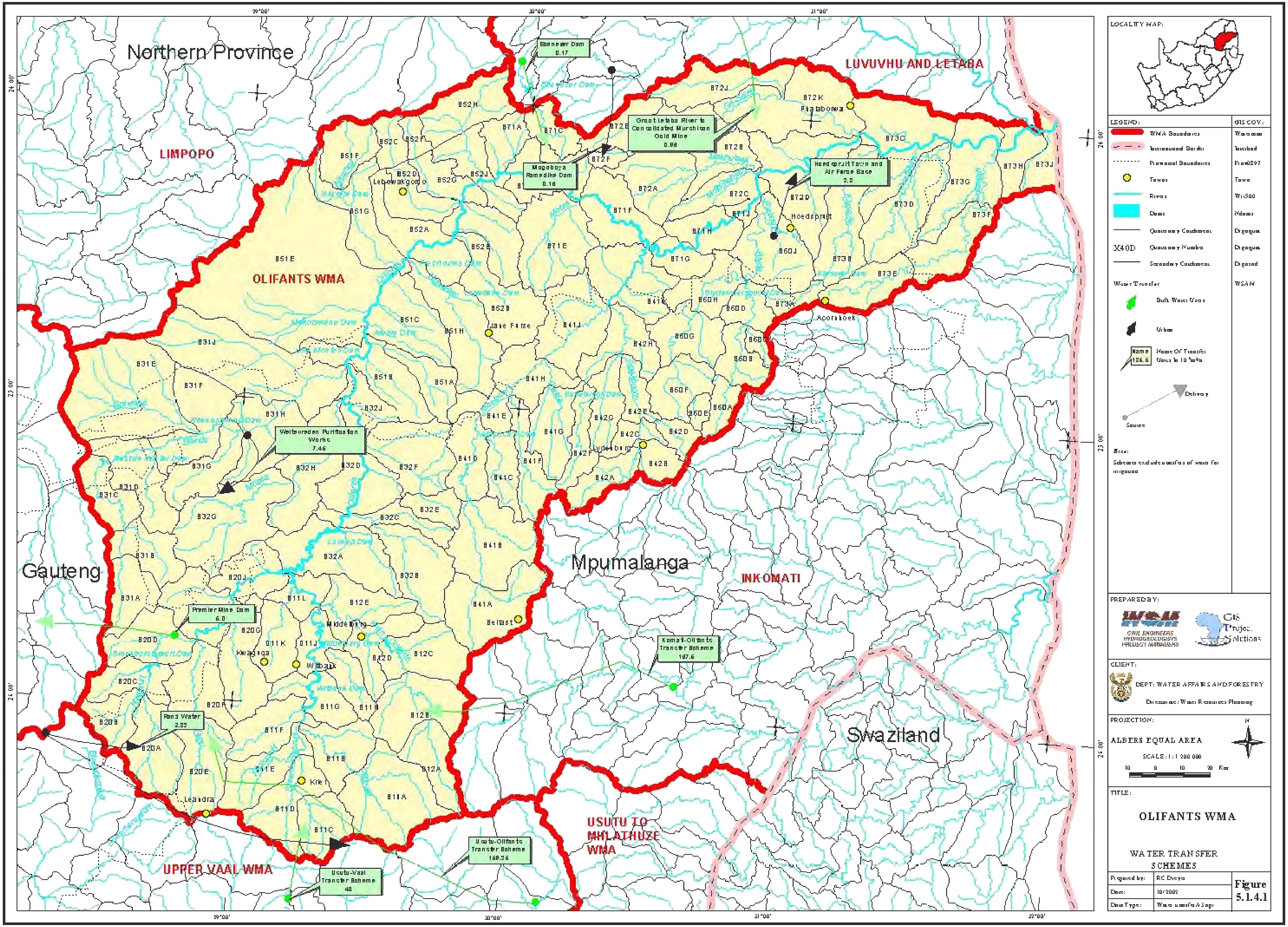
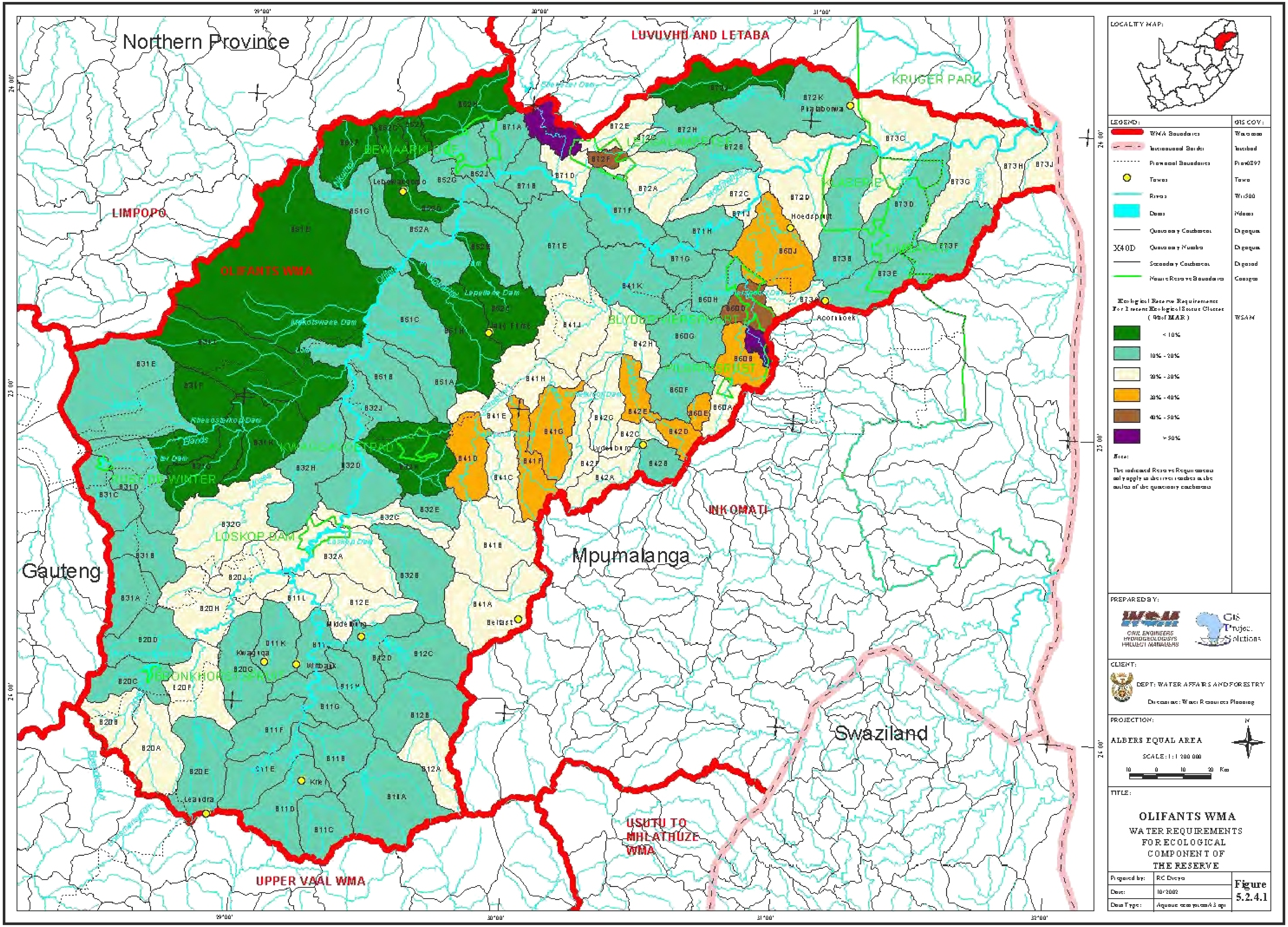
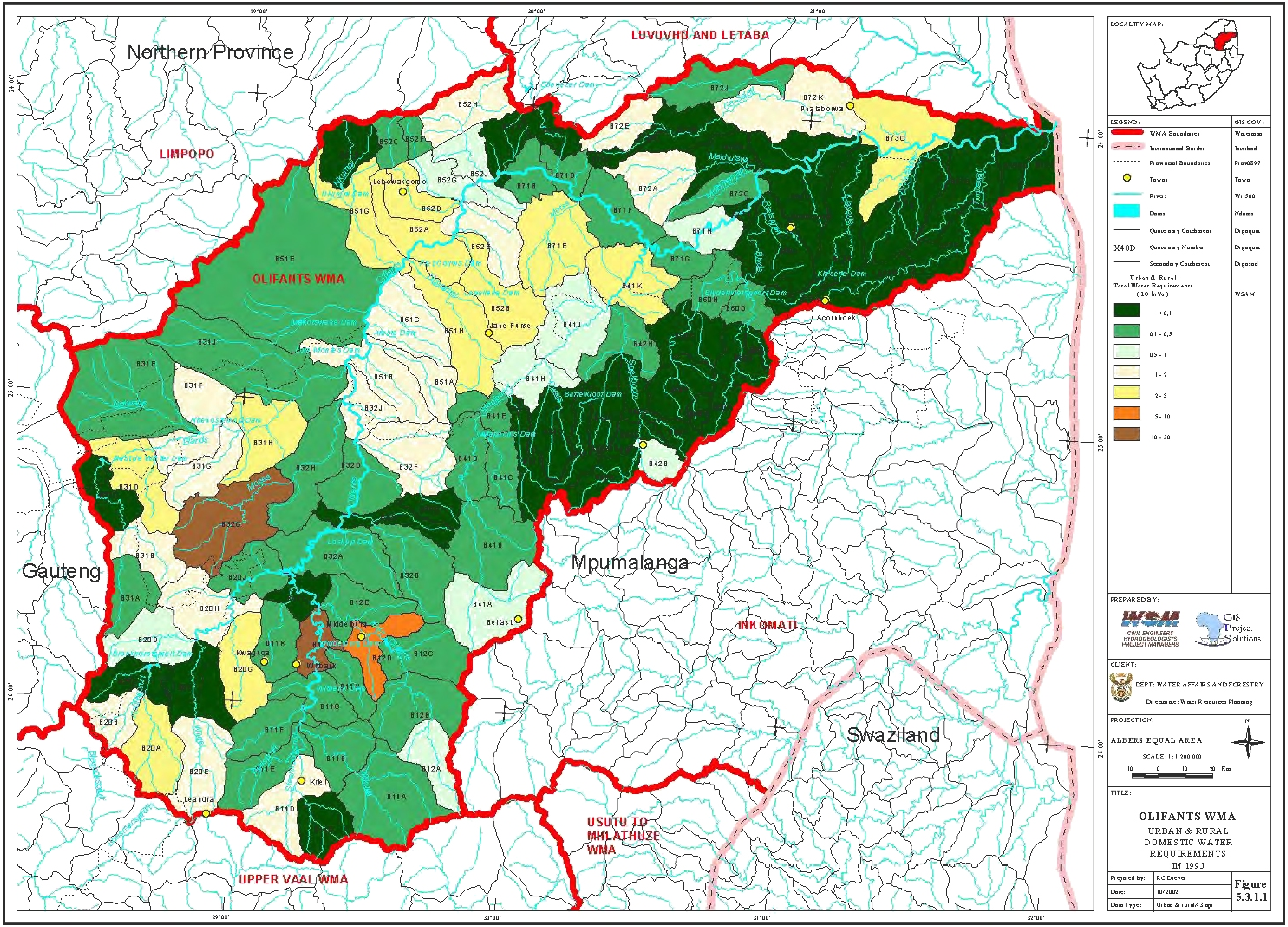
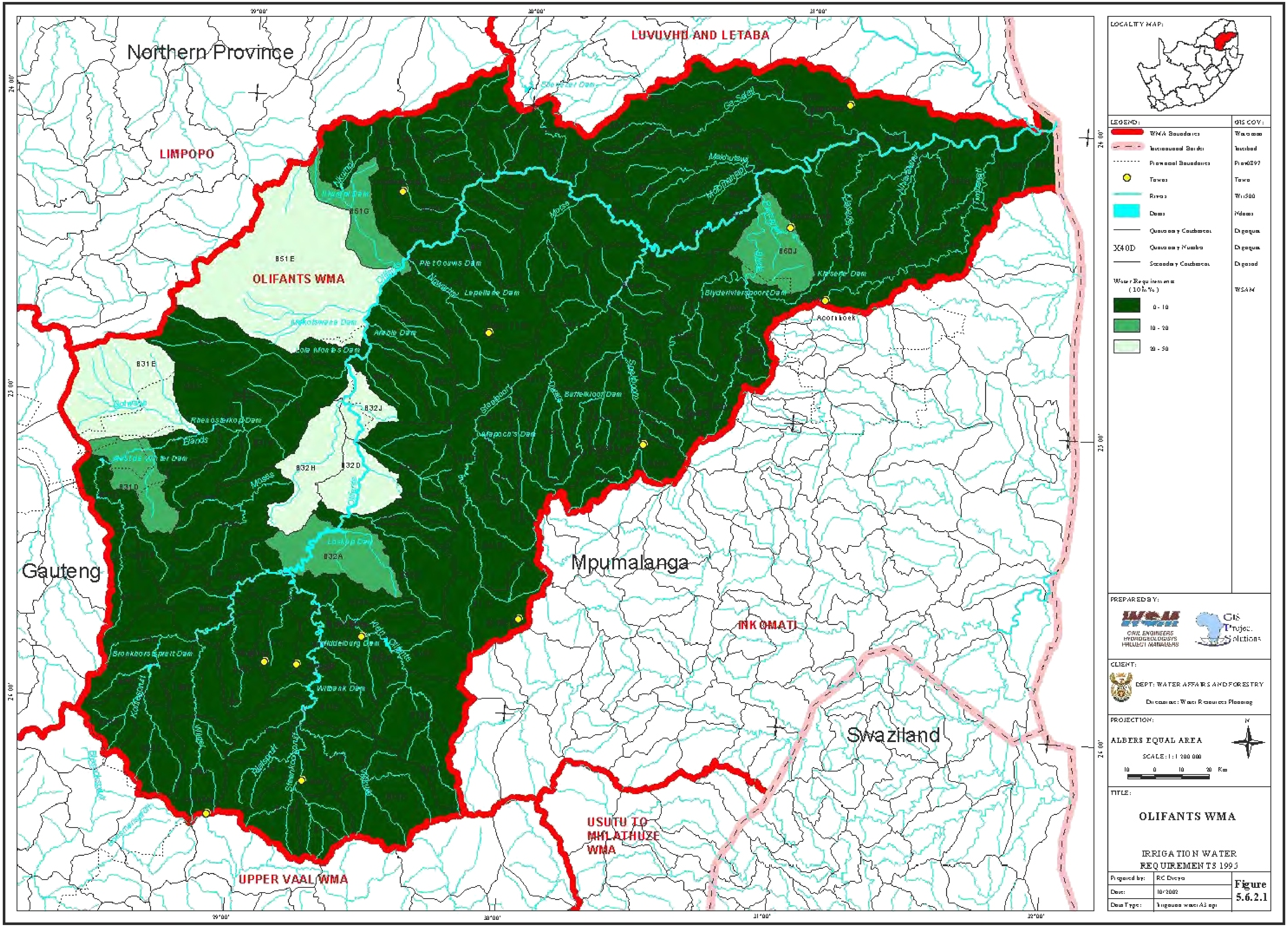

Northern Province
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Ebenezer Dam 0.17
Groot Letaba River to Consolidated Murchison Gold Mine 0.98
Mogoboya Ramodike Dam 0.18
Hoedspruit Town and Air Force Base 2.3
Weltevreden Purification Works 7.46
Premier Mine Dam 6.0
Komati-Olifants Transfer Scheme 187.6
Rand Water 2.82
Usutu-Olifants Transfer Scheme 169.26
Usutu-Vaal Transfer Scheme 40
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D Quaternary Number
Secondary Catchment
Water Transfer
Bulk Water Users
Urban
Name Of Transfer
Delivery
Source
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
WATER TRANSFER SCHEMES
Date: 10/2002

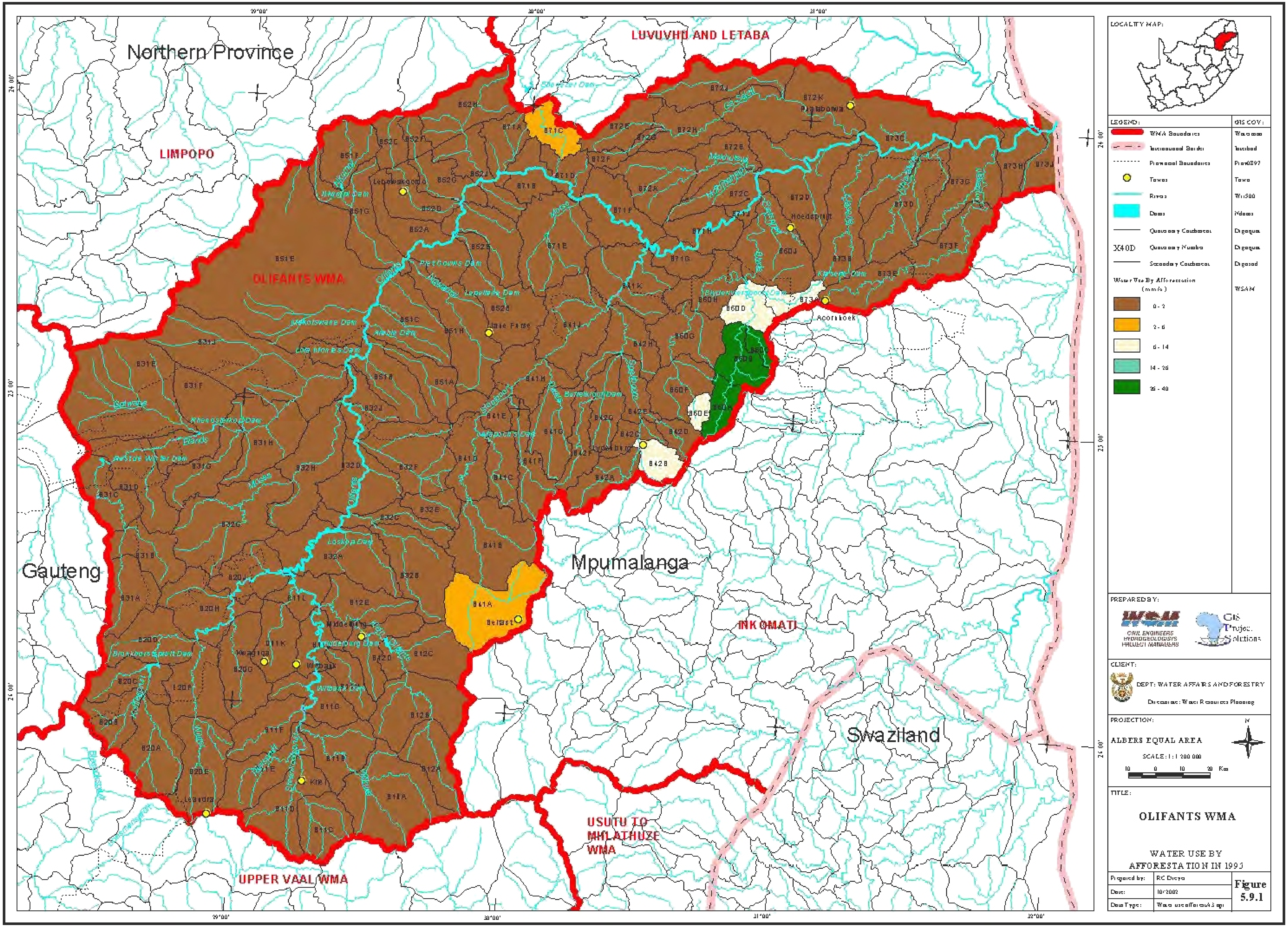
Figure 5.1.4.1


Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
LOSKOP DAM
BEWAARKLOOF
BLYDERIVIERSPOORT
RUST DE WINTER
BRONKHORSTSPRUIT
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Towns
Rivers
Dams
X40D
WSAM
< 10%
10% - 20%
20% - 30%
30% - 40%
40% - 50%
> 50%
PREPARED BY:
CIVIL ENGINEERS
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
N
TITLE:
OLIFANTS WMA
WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE
Prepared by:
Date:
Figure 5.2.4.1


LOCALITY MAP:
LEGEND:
GIS COV:
X40D
Urban & Rural
Total Water Requirement
(10 M/a)
< 0,1
0,1 - 0,5
0,5 - 1
1 - 2
2 - 5
5 - 10
10 - 30
WSAM
Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Lebowakgomo
Jane Furse
Acornhoek
Belfast
Middelburg
Witbank
Kwaggafontein
Kriel
Leandra
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
URBAN & RURAL
DOMESTIC WATER
REQUIREMENTS
IN 1995
Date:
10/2002
Figure
5.3.1.1

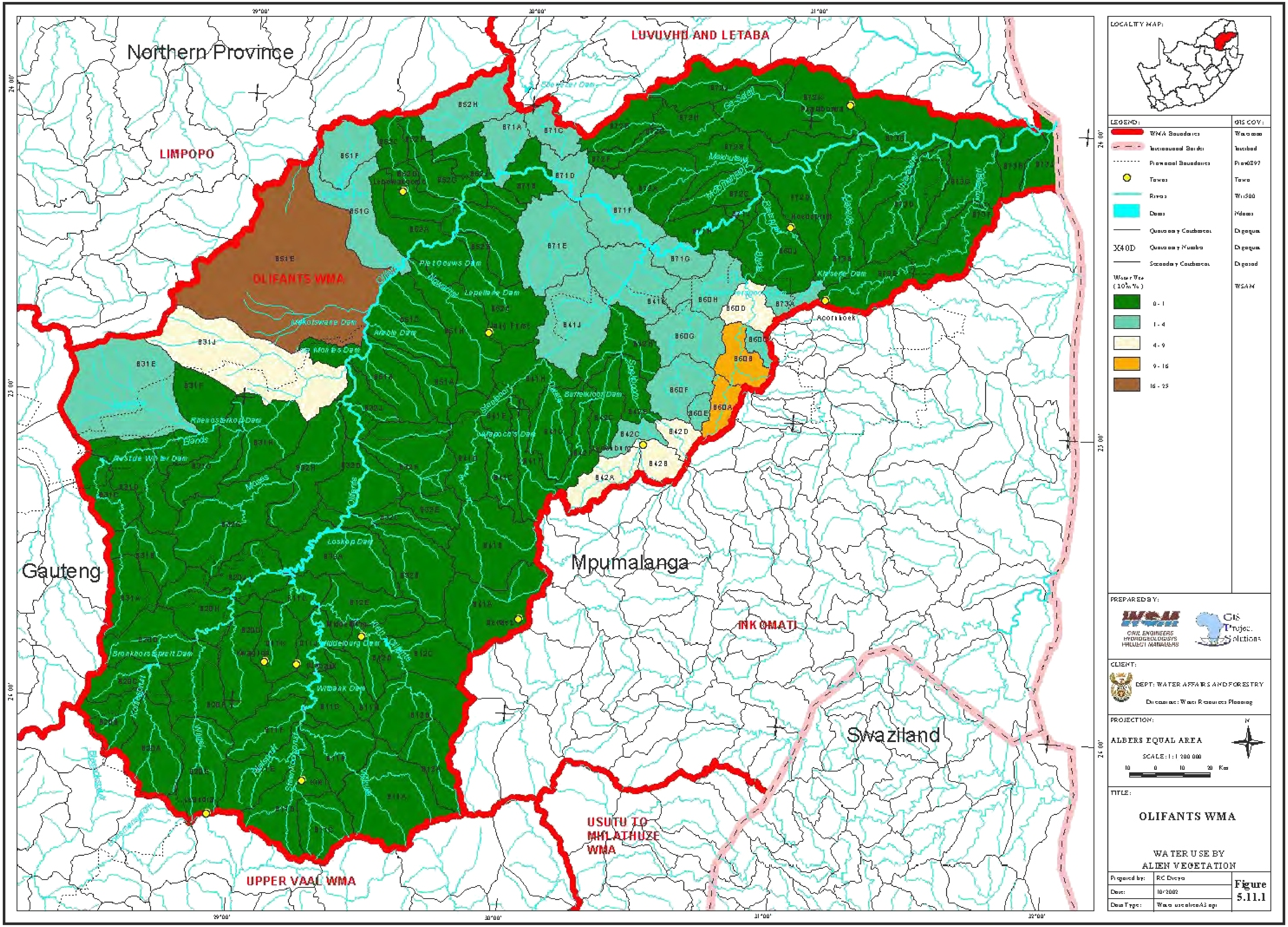


Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
B51E
B51G
B60J
B31E
B32J
B32H
B32D
B31D
B32A
Piet Gouws Dam
Lepellane Dam
Arabie Dam
Blydevierspoort Dam
Buffelskloof Dam
Rhenosterkop Dam
Loskop Dam
Middelburg Dam
Witbank Dam
Bronkhorstspruit Dam
Acornhoek
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
0 - 10
10 - 20
WSAM
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
N
TITLE:
OLIFANTS WMA
IRRIGATION WATER
REQUIREMENTS 1995
Prepared by:
RC Dreyer
Date:
Data Type:
Figure
5.6.2.1

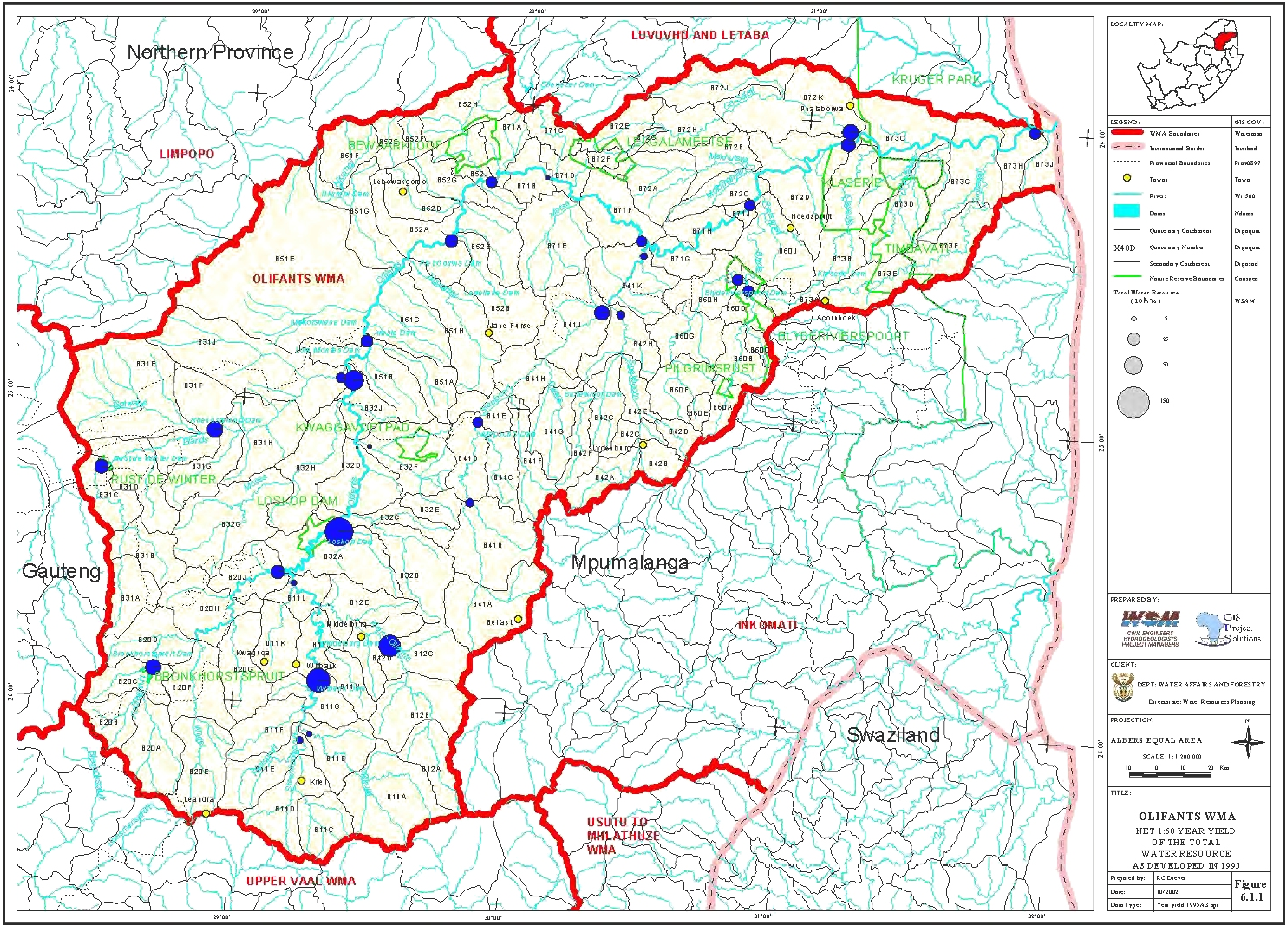


Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Lydenburg
Belfast
Middelburg
Witbank
Kriel
Leandra
Loskop Dam
Flag Boshielo Dam
Witbank Dam
Middelburg Dam
Blydepoortspruit Dam
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
0 - 2
2 - 6
6 - 14
14 - 26
26 - 40
WSAM
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
WATER USE BY AFFORESTATION IN 1995
Prepared by:
Date:
10/2002
Data Type:

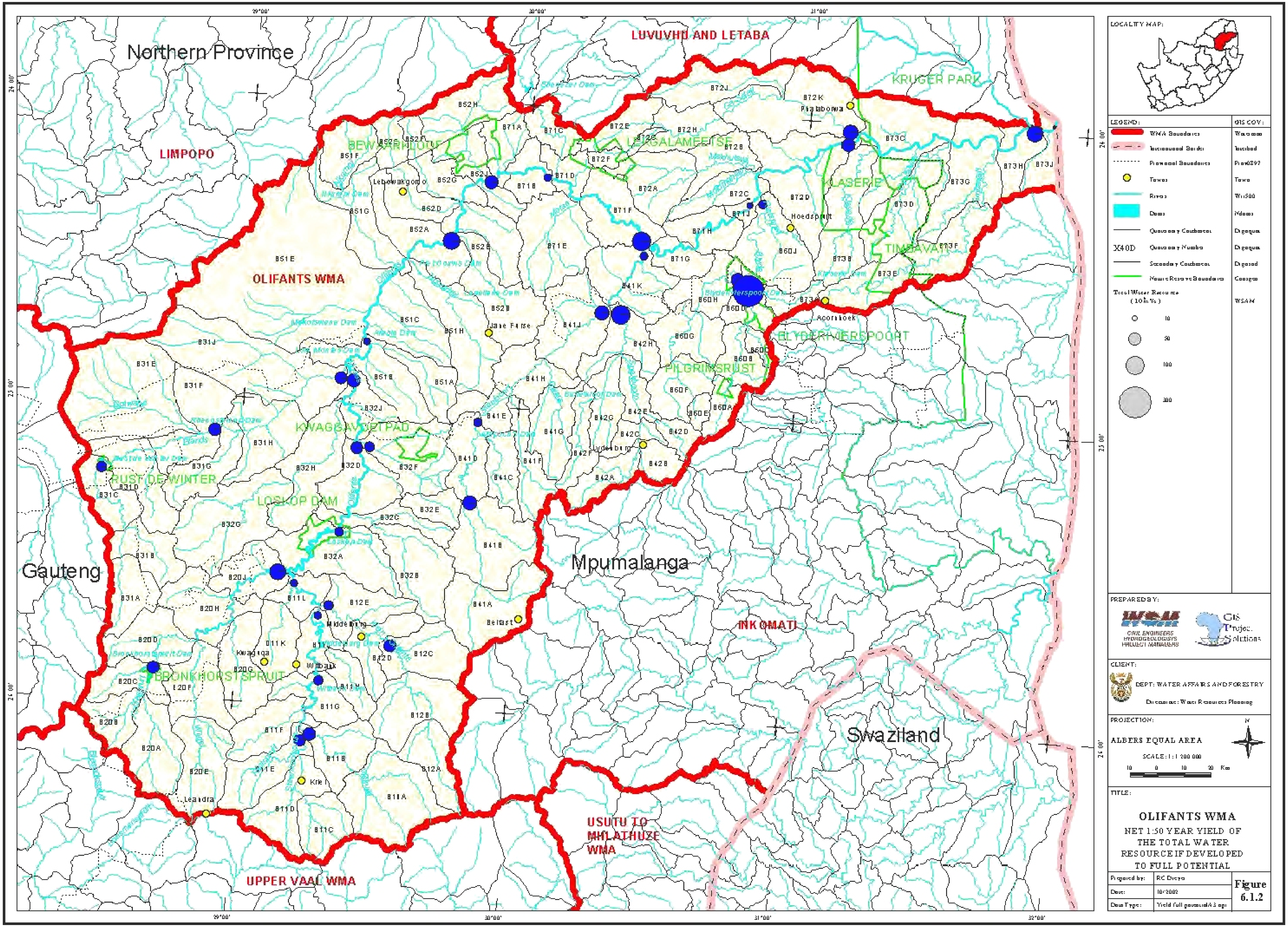
Figure 5.9.1



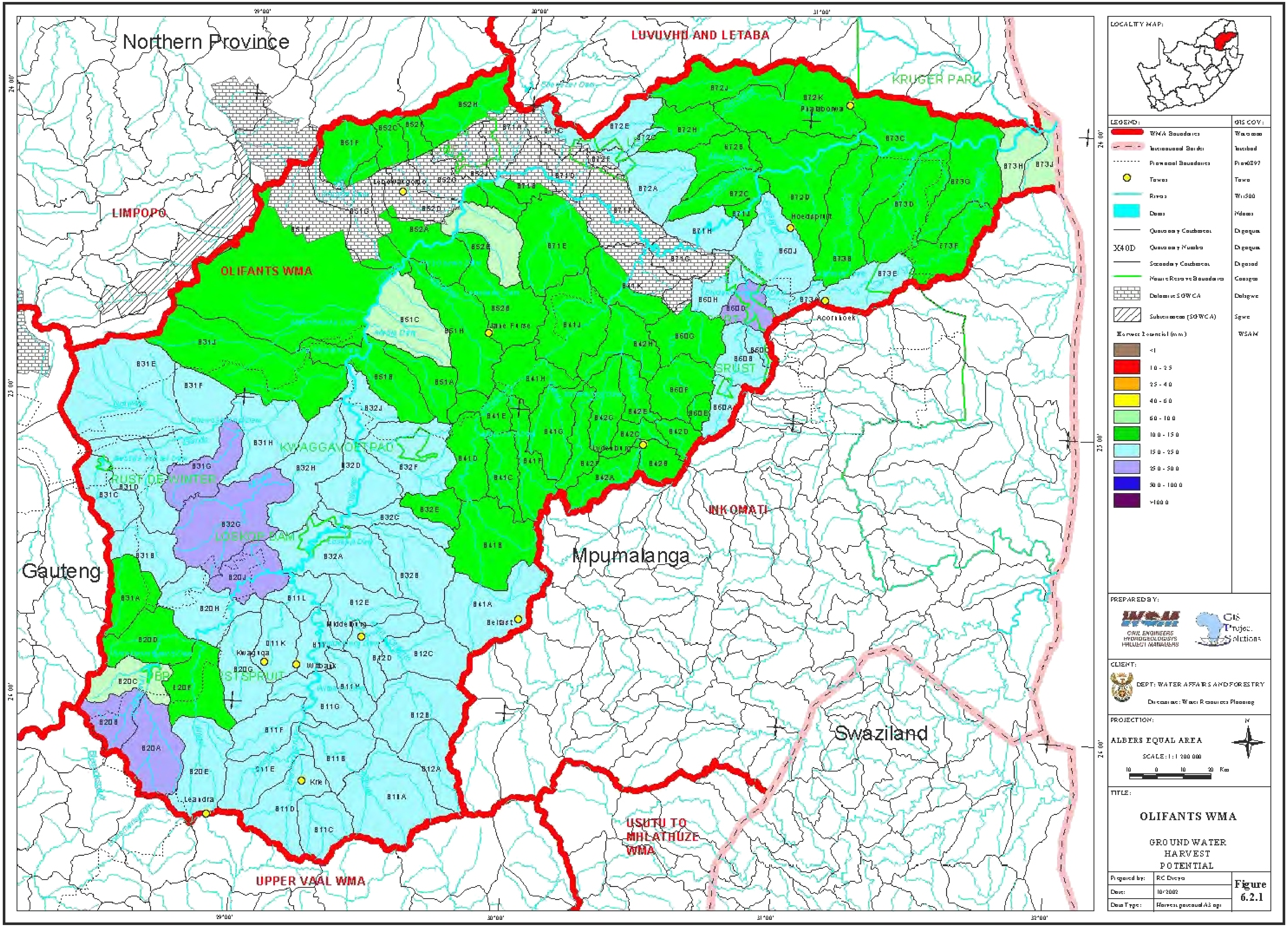
Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Loskop Dam
Witbank Dam
Middelburg Dam
Bronkhorstspruit Dam
Rust de Winter Dam
Rhenosterkop Dam
Flag Boshielo Dam
Lepellane Dam
Arabie Dam
Acornhoek
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Towns
Rivers
Dams
X40D
Water Use ($10^6 m^3/a$)
0 - 1
1 - 4
4 - 9
9 - 16
16 - 25
WSAM
PREPARED BY:
CIVIL ENGINEERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
10 0 10 20 Km
TITLE:
OLIFANTS WMA
WATER USE BY ALIEN VEGETATION
Prepared by:
Date:
10/2002
Figure 5.11.1



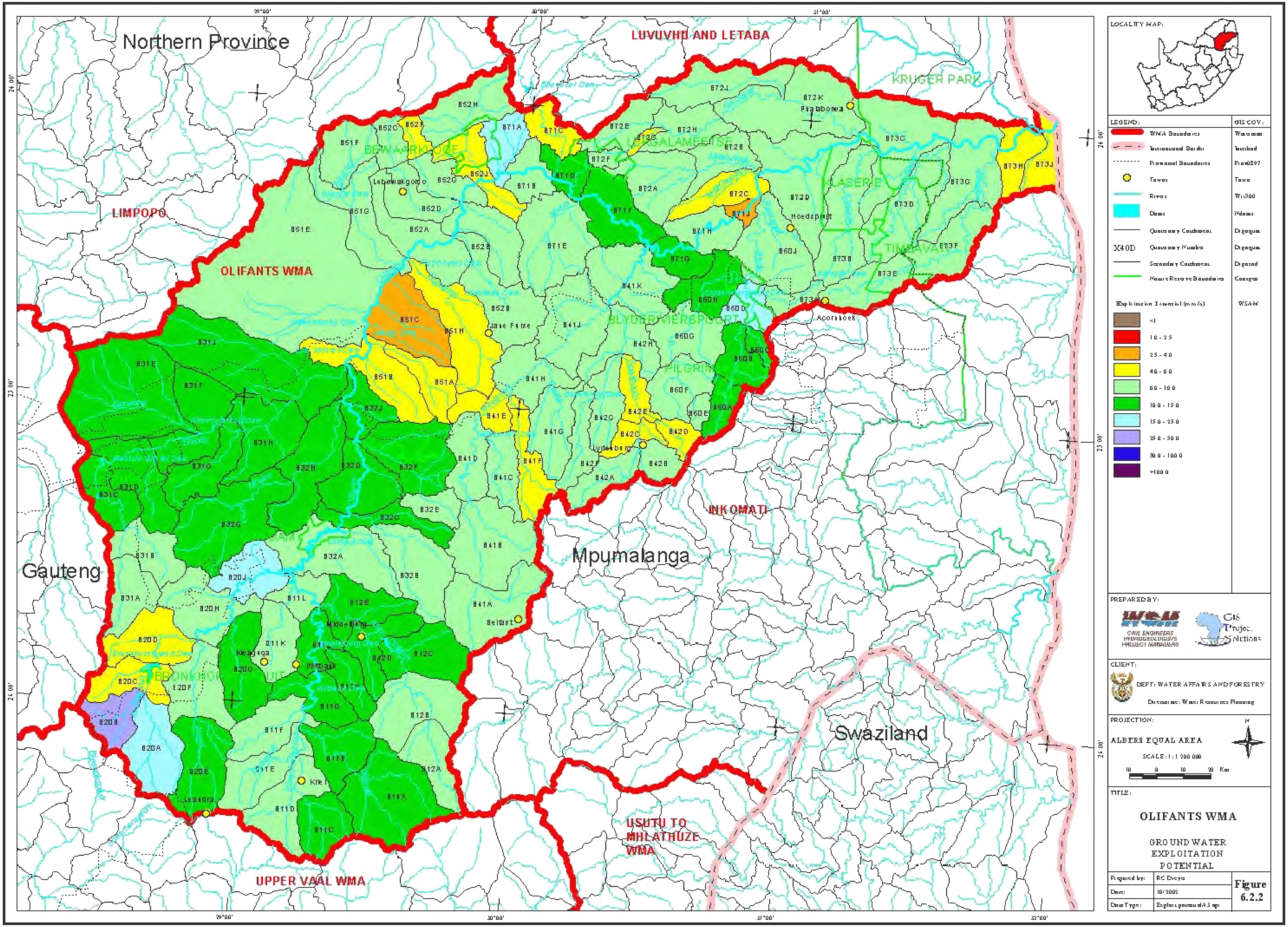
Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
BEWAARKLOOF
LEGALAMEETSE
KLASERIE
TIMBAVATI
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
BRONKHORSTSPRUIT
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
Loskop Dam
LOCALITY MAP:
LEGEND:
GIS COV:
Towns
Rivers
Dams
X40D
Total Water Resource
5
25
50
150
WSAM
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
10 0 10 20 Km
N
TITLE:
OLIFANTS WMA
NET 1:50 YEAR YIELD
OF THE TOTAL
WATER RESOURCE
AS DEVELOPED IN 1995
Prepared by:
RC Dreyer
Date:
10/2002
Figure 6.1.1



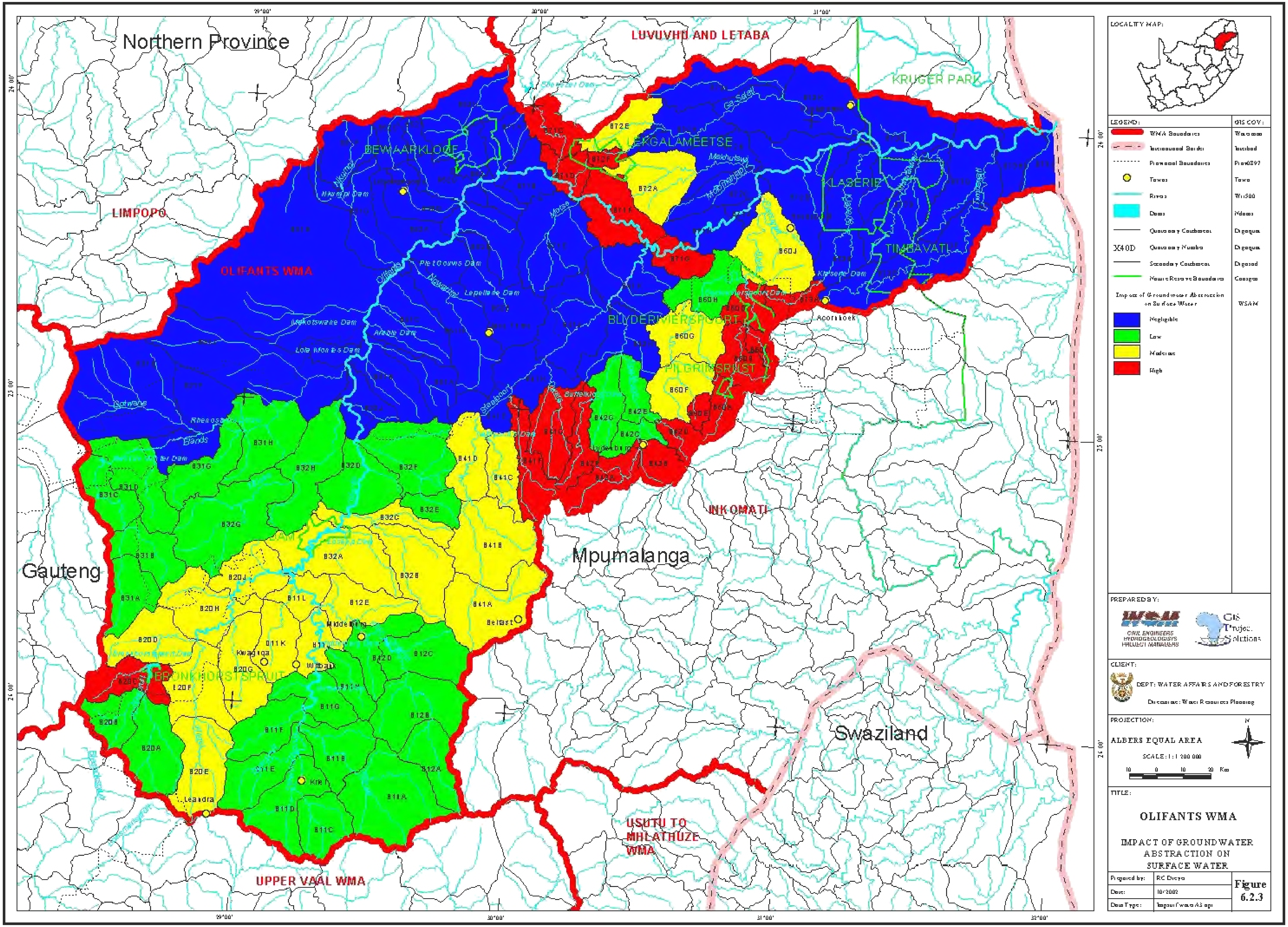
Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
LETABA
KLASERIE
TIMBAVATI
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
BRONKHORSTSPRUIT
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Towns
Rivers
Dams
Total Water Resource
(10⁶m³/a)
10
50
100
300
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE : 1 : 1 200 000
TITLE:
OLIFANTS WMA
NET 1:50 YEAR YIELD OF
THE TOTAL WATER
RESOURCE IF DEVELOPED
TO FULL POTENTIAL
Prepared by:
RC Dreyer
Date:
10/2002
Figure
6.1.2

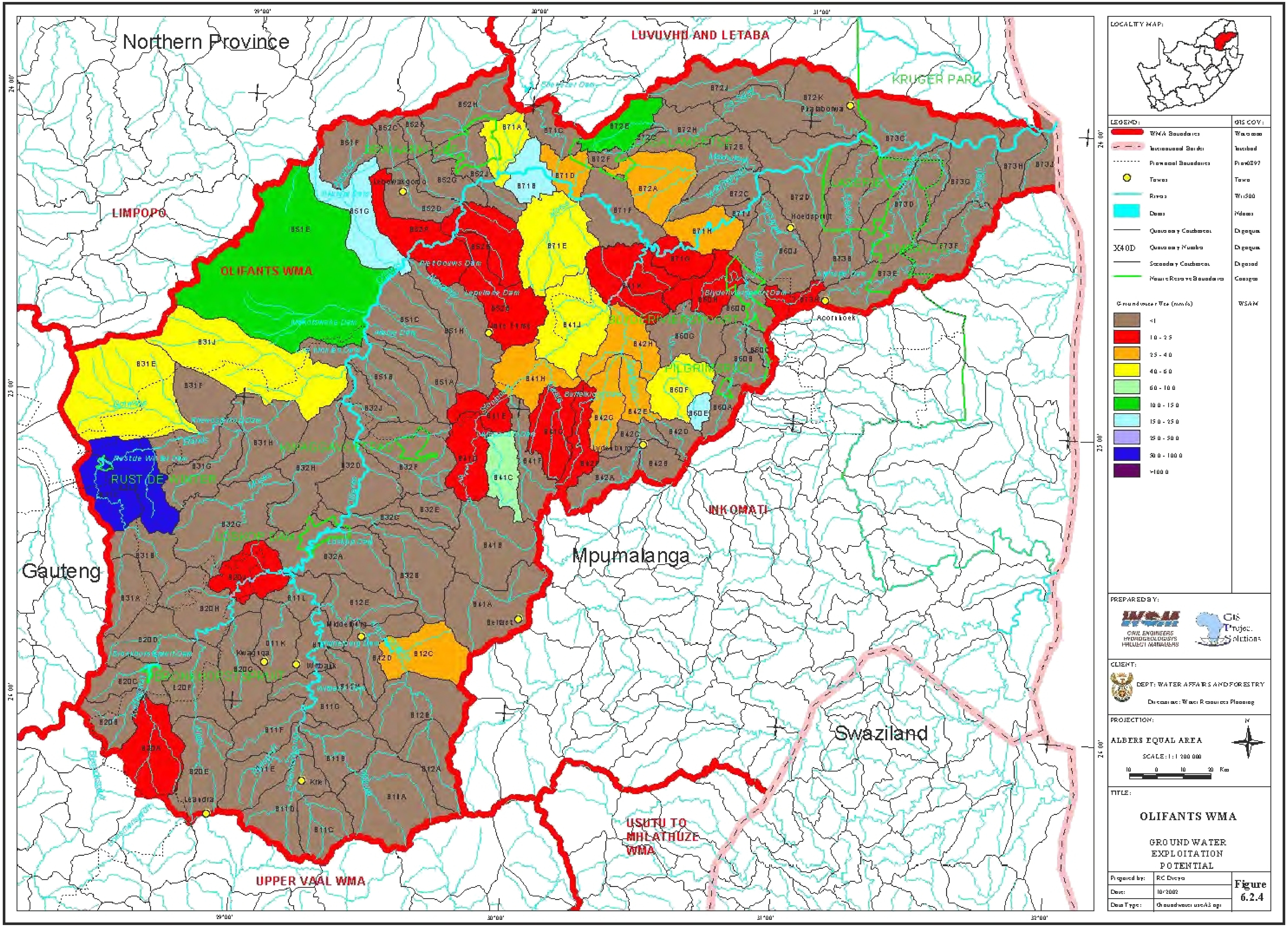


Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Jane Furse
Lydenburg
Belfast
Middelburg
Kwaguqa
Witbank
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
Harvest Potential (mm)
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
GROUND WATER HARVEST POTENTIAL
Prepared by: RC Dreyer
Date: 10/2002
Figure 6.2.1

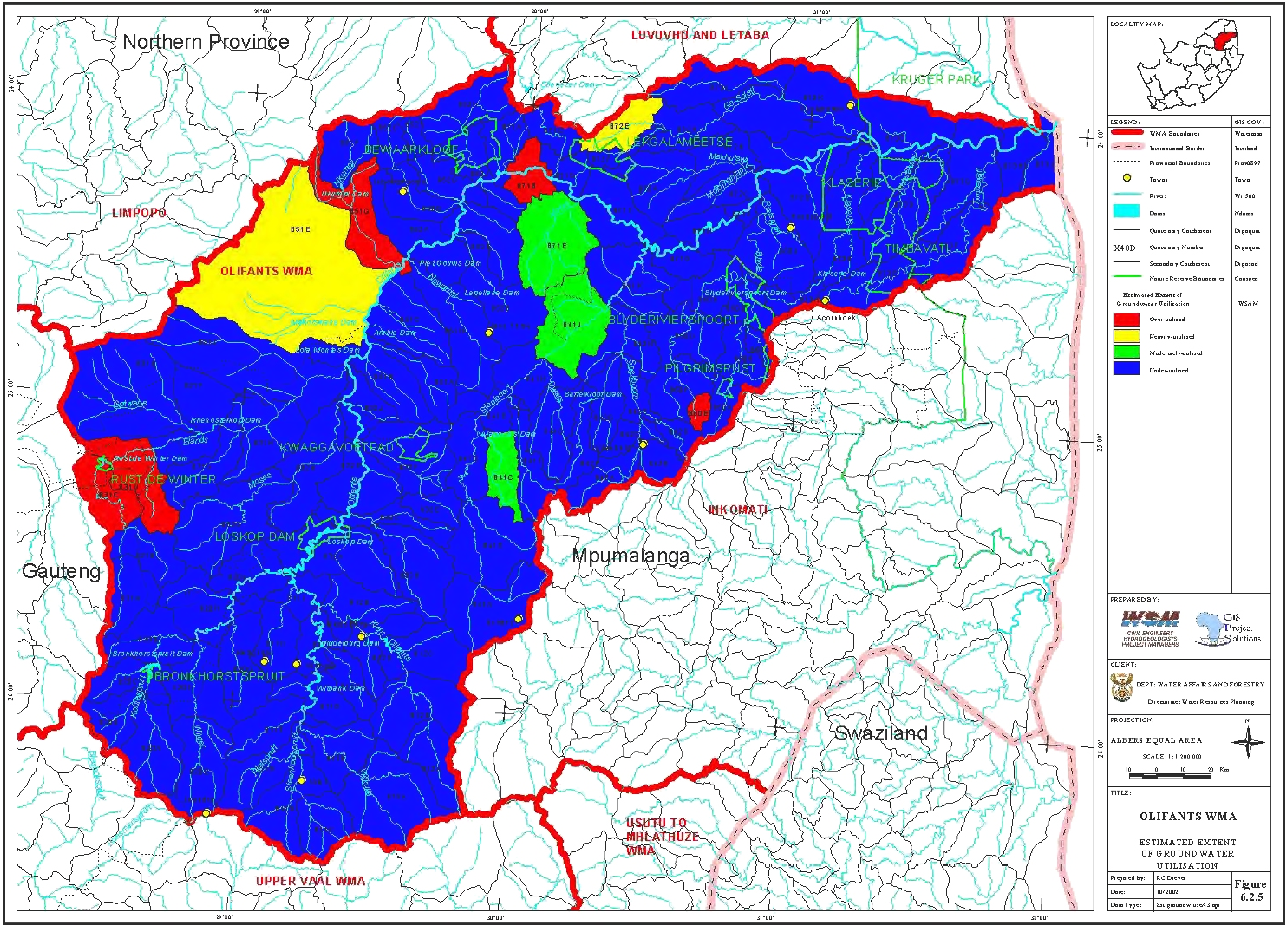


Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
<1
1.0 - 2.5
2.5 - 4.0
4.0 - 6.0
6.0 - 10.0
10.0 - 15.0
15.0 - 25.0
25.0 - 50.0
50.0 - 100.0
>100.0
WSAM
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
GROUND WATER EXPLOITATION POTENTIAL
Prepared by: RC Dreyer
Date: 10/2002
Figure 6.2.2

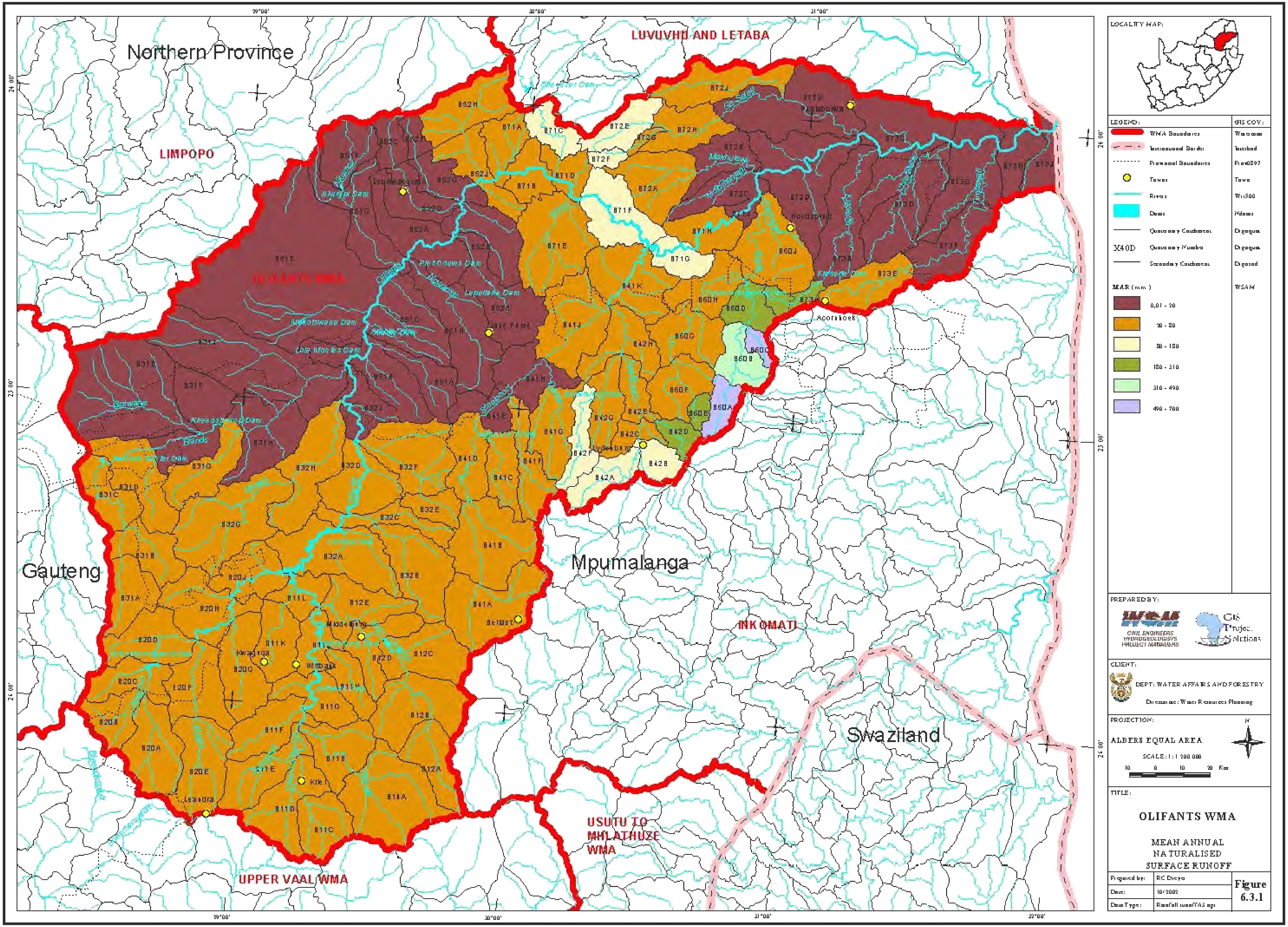

Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
BEWAARKLOOF
LEKGALAMEETSE
KLASERIE
TIMBAVATI
BLYDERIVIERSPOORT
PILGRIMSRUST
Acornhoek
INKOMATI
Mpumalanga
Gauteng
Middelburg
Belfast
Lydenburg
Kwaggafontein
Witbank
Kriel
Leandra
BRONKHORSTSPRUIT
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
Impact of Groundwater Abstraction on Surface Water
WSAM
Negligible
Low
Moderate
High
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
N
TITLE:
OLIFANTS WMA
IMPACT OF GROUNDWATER ABSTRACTION ON SURFACE WATER
Prepared by: RC Dreyer
Date: 10/2002
Figure 6.2.3



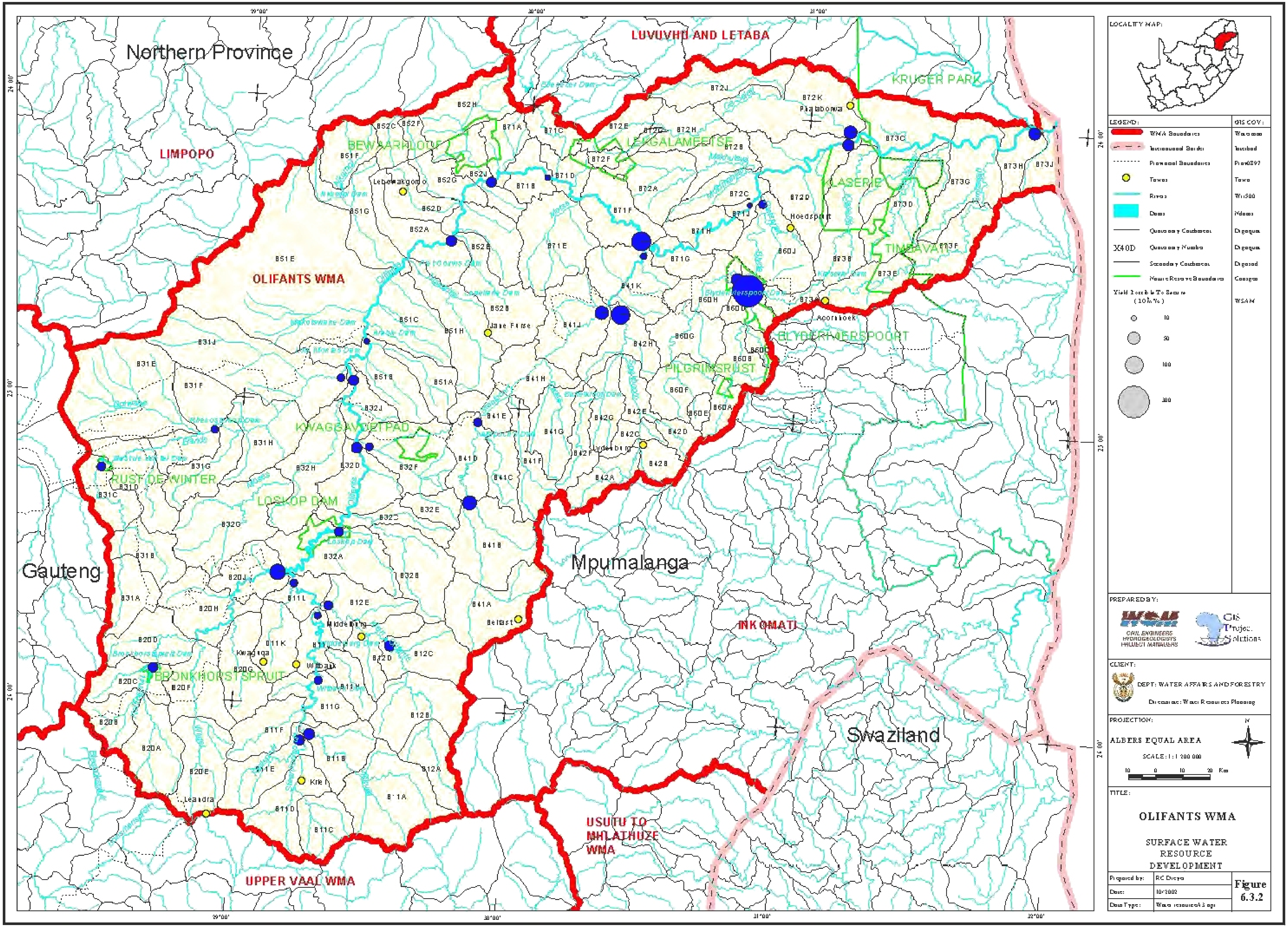
Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
RUST DE WINTER
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
Lebowakgomo
LOCALITY MAP:
LEGEND:
GIS COV:
Groundwater Use (mm/a)
<1
10 - 25
25 - 40
40 - 60
60 - 100
100 - 150
150 - 250
250 - 500
500 - 1000
>1000
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
GROUNDWATER EXPLOITATION POTENTIAL
Figure 6.2.4

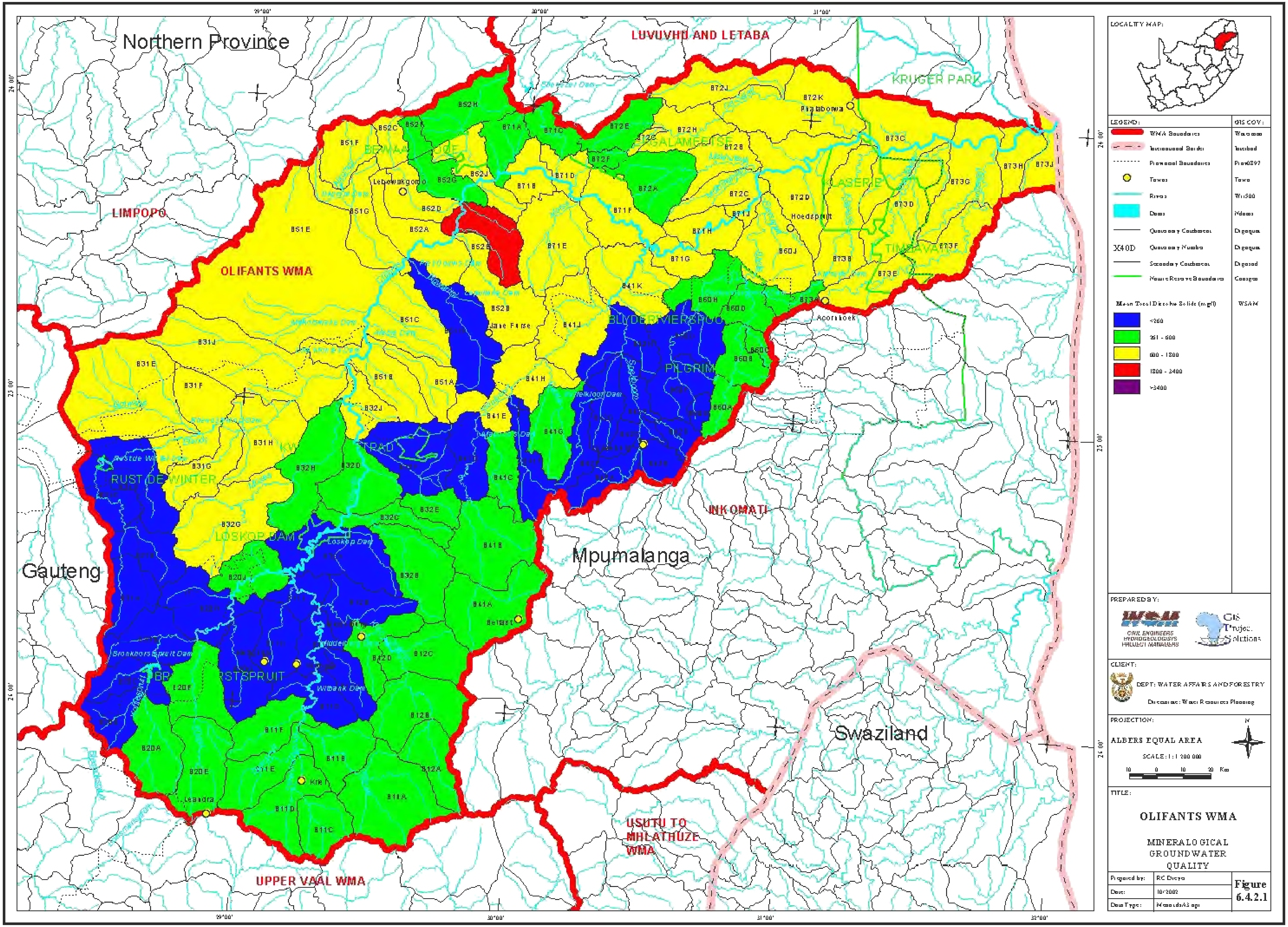


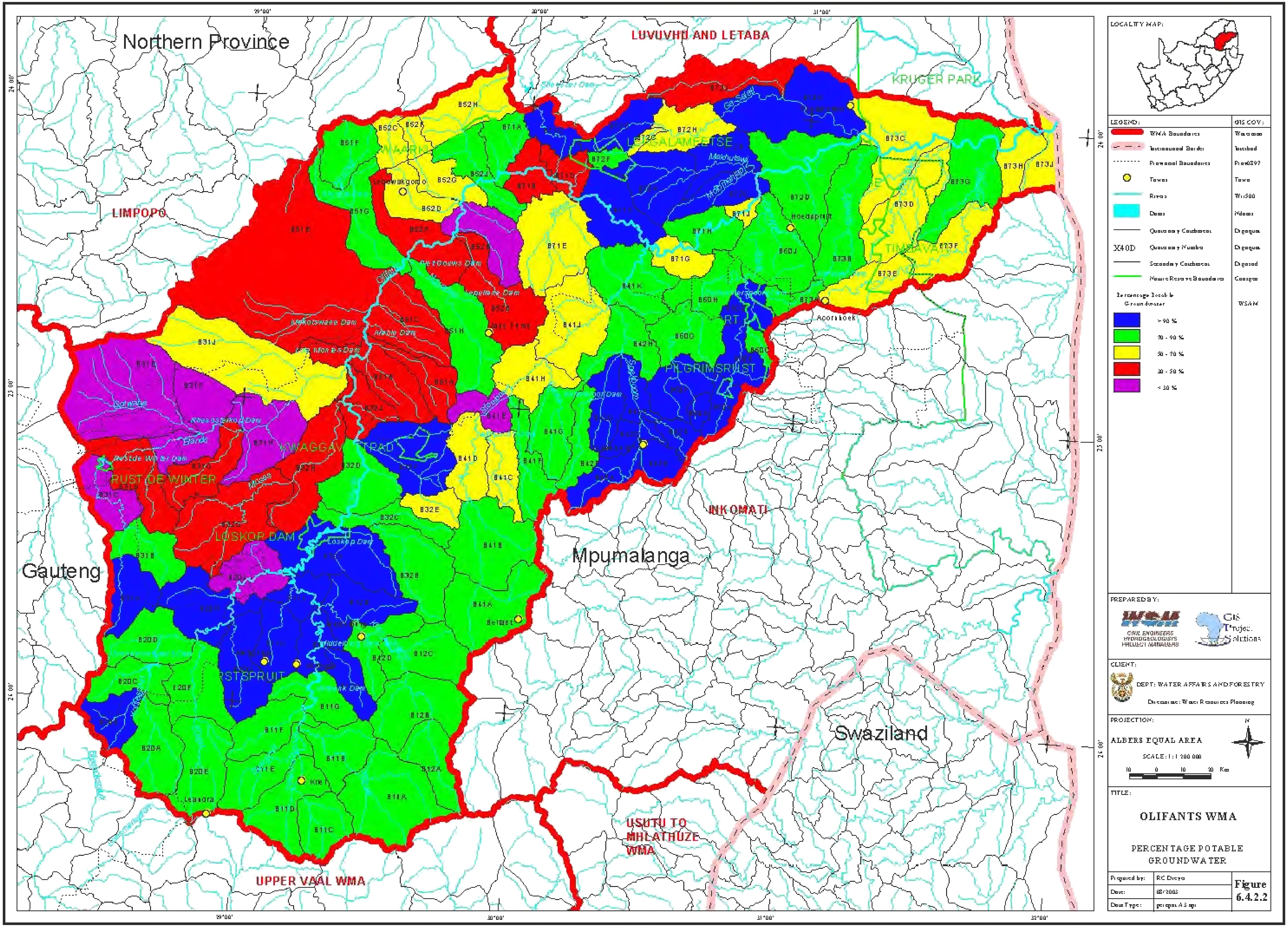
Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
BEWAARKLOOF
LEKGALAMEETSE
KLASERIE
TIMBAVATI
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
BRONKHORSTSPRUIT
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
B51E
B72E
B71E
B41J
B41C
Loskop Dam
Witbank Dam
Middelburg Dam
Rhenosterkop Dam
Rust de Winter Dam
Bronkhorstspruit Dam
Buffelskloof Dam
Lepellane Dam
Piet Gouws Dam
Arabie Dam
Acornhoek
LOCALITY MAP:
LEGEND:
GIS COV:
Estimated Extent of Groundwater Utilisation
Over-utilised
Heavily-utilised
Moderately-utilised
Under-utilised
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
ESTIMATED EXTENT OF GROUND WATER UTILISATION
Prepared by: RC Dreyer
Date: 10/2002
Figure 6.2.5

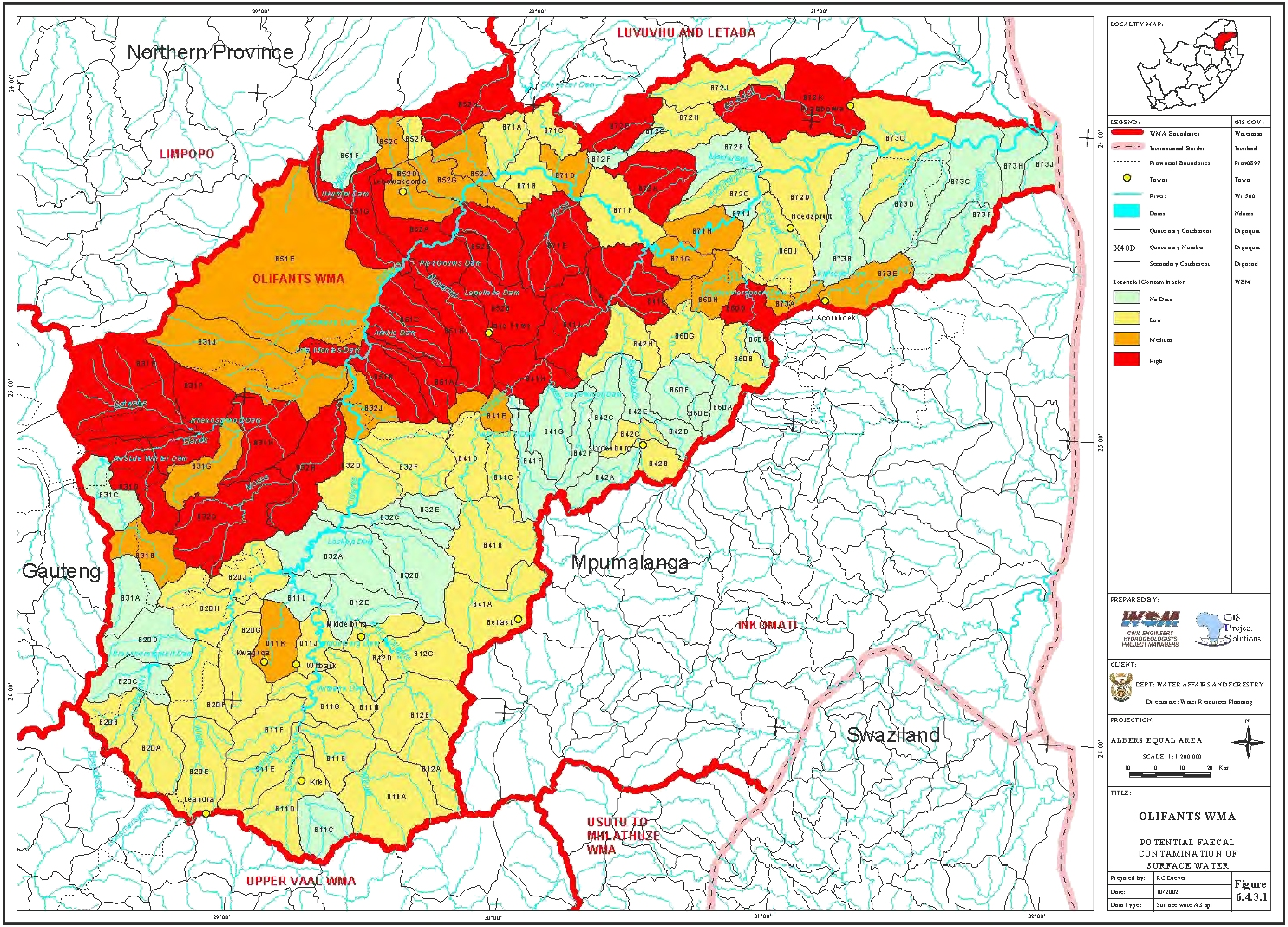


Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Marble Hall
Groblersdal
Lydenburg
Middelburg
Witbank
Kwaguqa
Kriel
Belfast
Leandra
Piet Gouws Dam
Lepellane Dam
Mokotswane Dam
Loskop Dam
Rhenosterkop Dam
Witbank Dam
Middelburg Dam
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D Quaternary Number
Secondary Catchment
MAR (mm)
0,01 - 20
20 - 80
80 - 180
180 - 310
310 - 490
490 - 700
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
MEAN ANNUAL NATURALISED SURFACE RUNOFF
Prepared by: RC Dreyer
Date: 10/2002
Figure 6.3.1

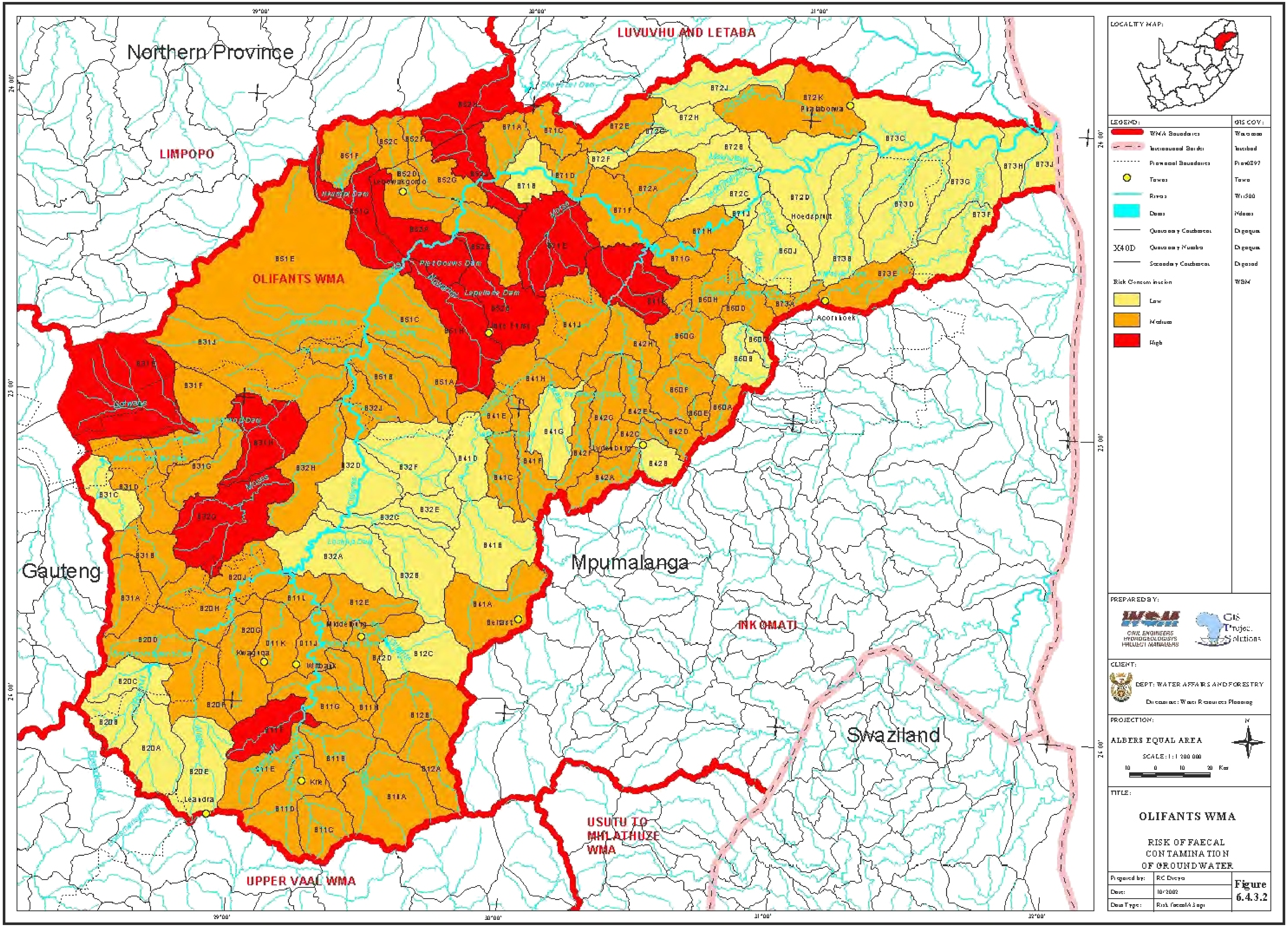

Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
BEWAARKLOOF
LEGALAMEETSE
KLASERIE
TIMBAVATI
BLYDERIVIERSPOORT
PILGRIMSRUST
KWAGGAVOETPAD
RUST DE WINTER
LOSKOP DAM
BRONKHORSTSPRUIT
Phalaborwa
Hoedspruit
Lebowakgomo
Jane Furse
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
Acornhoek
LOCALITY MAP:
LEGEND:
GIS COV:
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
TITLE:
OLIFANTS WMA
SURFACE WATER RESOURCE DEVELOPMENT
Figure 6.3.2


Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
GALAMEETSE
LASERIE
TIMBAVATI
BLYDERIVIERSPOORT
PILGRIM
RUST DE WINTER
LOSKOP DAM
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
BRONKHORSTSPRUIT
Phalaborwa
Lebowakgomo
Hoedspruit
Acornhoek
Jane Furse
Belfast
Leandra
Loskop Dam
Witbank Dam
Bronkhorstspruit Dam
Rust de Winter Dam
LOCALITY MAP:
LEGEND:
GIS COV:
Mean Total Dissolve Solids (mg/l)
WSAM
<260
261 - 600
600 - 1800
1800 - 3400
>3400
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
10 0 10 20 Km
N
TITLE:
OLIFANTS WMA
MINERALOGICAL GROUNDWATER QUALITY
Prepared by: RC Dreyer
Date: 10/2002
Figure 6.4.2.1

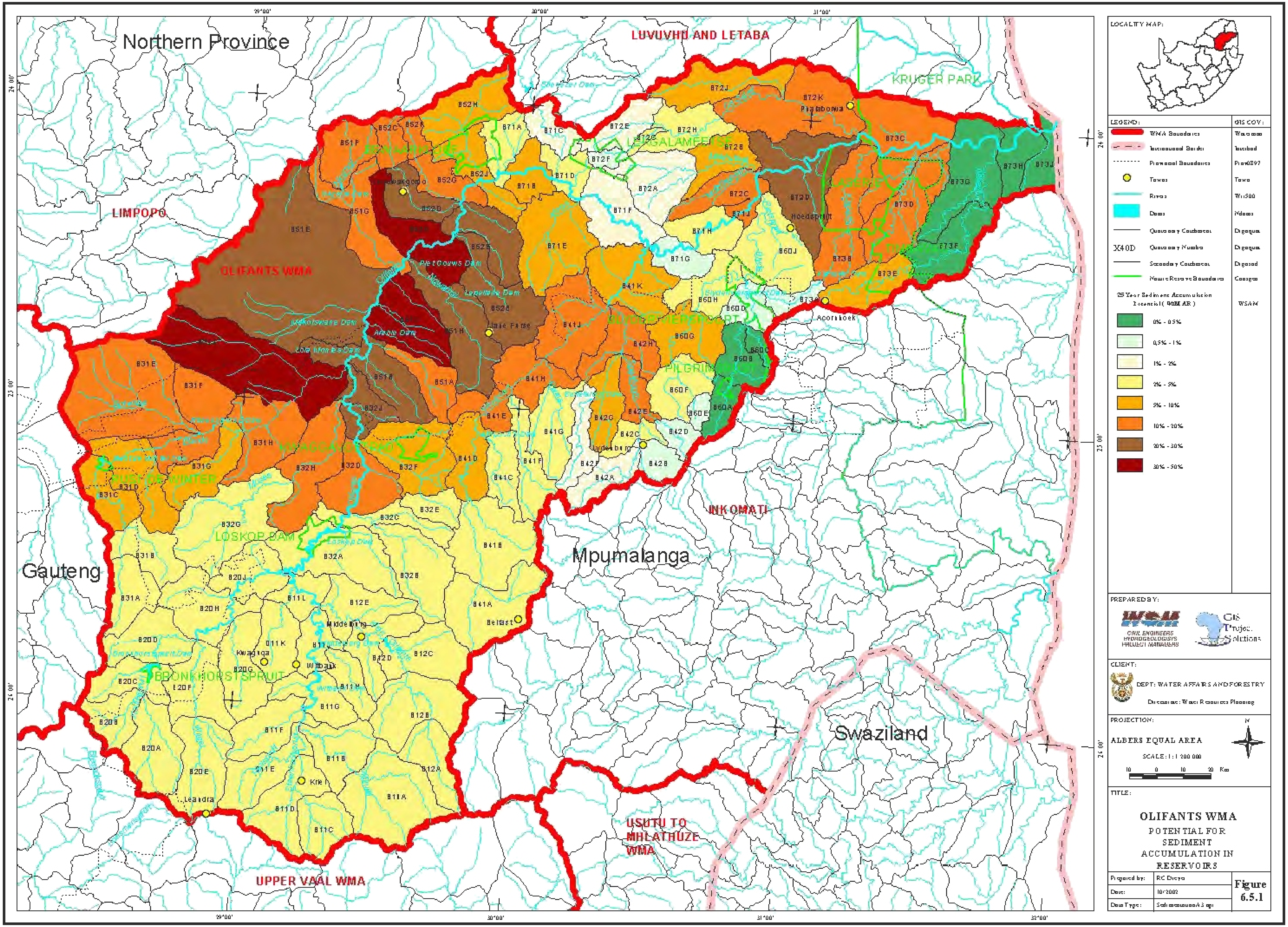

Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
RUST DE WINTER
LOSKOP DAM
PILGRIMSRUST
KWAGGAV
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
Percentage Potable Groundwater
WSAM
> 90 %
70 - 90 %
50 - 70 %
30 - 50 %
< 30 %
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
10 0 10 20 Km
TITLE:
OLIFANTS WMA
PERCENTAGE POTABLE GROUNDWATER
Prepared by: RC Dreyer
Date: 08/2003
Figure 6.4.2.2



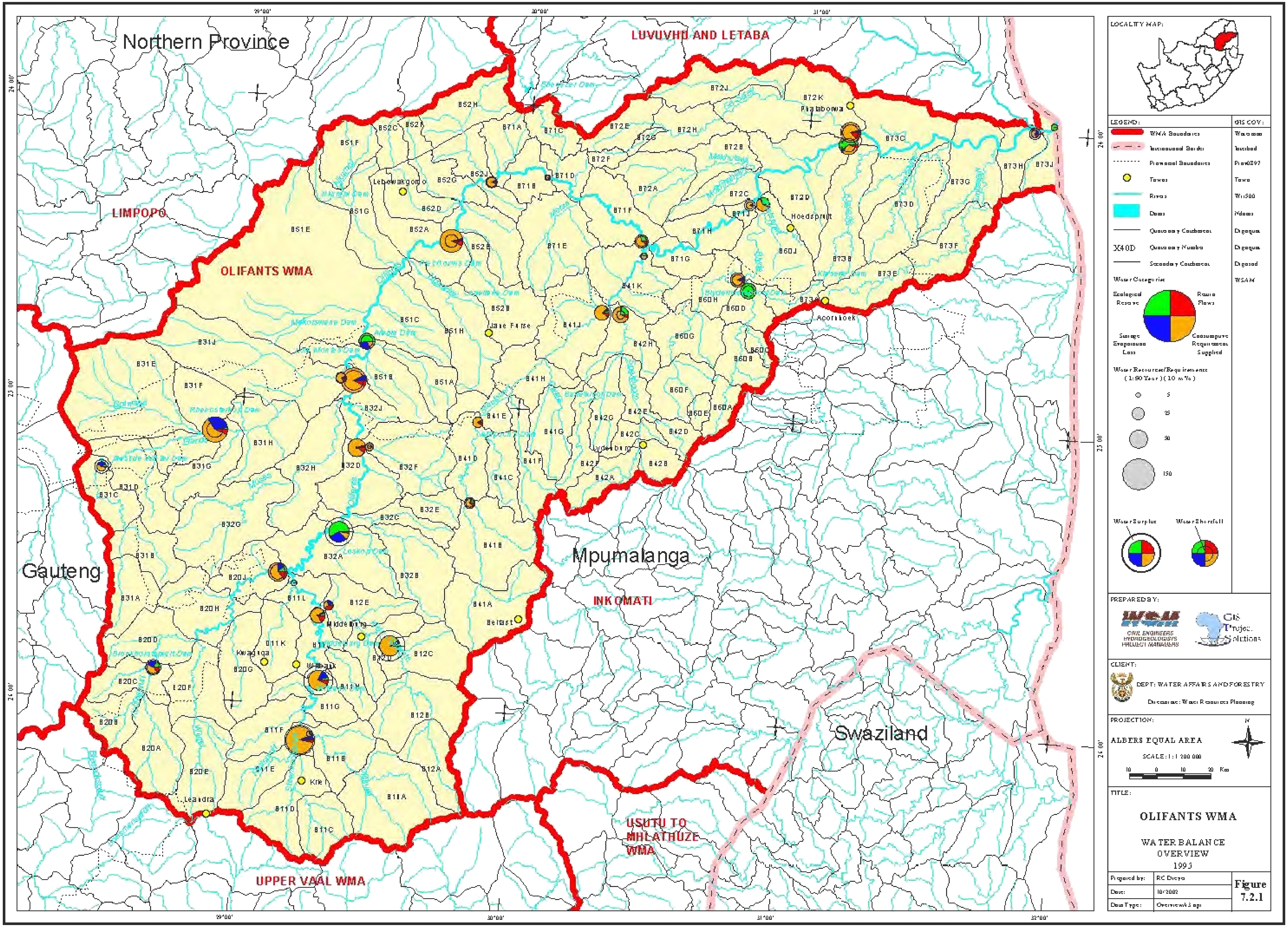
Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
Loskop Dam
Flag Boshielo Dam
Lepellane Dam
Rhenosterkop Dam
Middelburg Dam
Witbank Dam
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
No Data
Low
Medium
High
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 200 000
TITLE:
OLIFANTS WMA
POTENTIAL FAECAL CONTAMINATION OF SURFACE WATER
Prepared by: RC Dreyer
Date: 10/2002
Figure 6.4.3.1



Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Hoedspruit
Acornhoek
Lebowakgomo
Lydenburg
Belfast
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
LOCALITY MAP:
LEGEND:
Low
Medium
High
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
TITLE:
OLIFANTS WMA
RISK OF FAECAL CONTAMINATION OF GROUNDWATER
Prepared by:
RC Dreyer
Date:
10/2002
Figure 6.4.3.2



Northern Province
LUVUVHU AND LETABA
KRUGER PARK
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
LOSKOP DAM
BRONKHORSTSPRUIT
PILGRIM
Phalaborwa
Hoedspruit
Acornhoek
Lydenburg
Middelburg
Witbank
Kwaguqa
Kriel
Leandra
Belfast
LOCALITY MAP:
LEGEND:
25 Year Sediment Accumulation Potential (%MAR)
0% - 0.5%
0.5% - 1%
1% - 2%
2% - 5%
5% - 10%
10% - 20%
20% - 30%
30% - 50%
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 200 000
TITLE:
OLIFANTS WMA
POTENTIAL FOR SEDIMENT ACCUMULATION IN RESERVOIRS
Figure 6.5.1



Northern Province
LUVUVHU AND LETABA
LIMPOPO
OLIFANTS WMA
Gauteng
Mpumalanga
INKOMATI
Swaziland
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
Phalaborwa
Lebowakgomo
Hoedspruit
Acornhoek
Jane Furse
Lydenburg
Belfast
Middelburg
Kwaguqa
Witbank
Kriel
Leandra
LOCALITY MAP:
LEGEND:
GIS COV:
Water Categories
Ecological Reserve
Return Flows
Storage Evaporation Loss
Consumptive Requirement Supplied
Water Surplus
Water Shortfall
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
TITLE:
OLIFANTS WMA
WATER BALANCE OVERVIEW
1995
Figure 7.2.1