P02000/00/0301

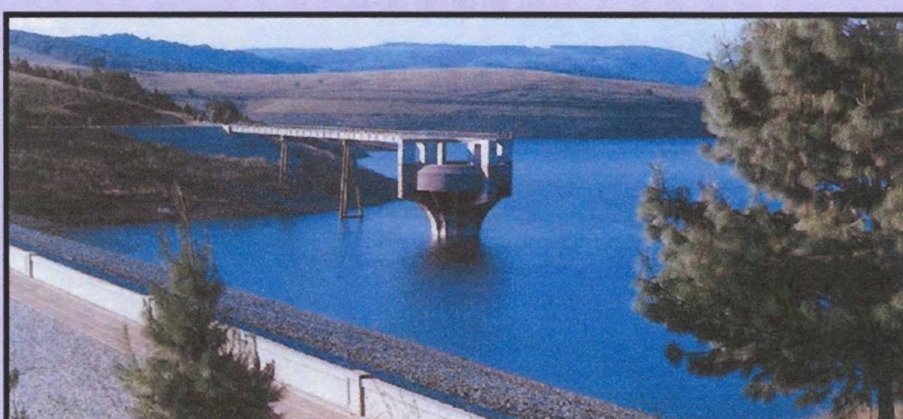
DEPARTMENT: WATER AFFAIRS AND FORESTRY

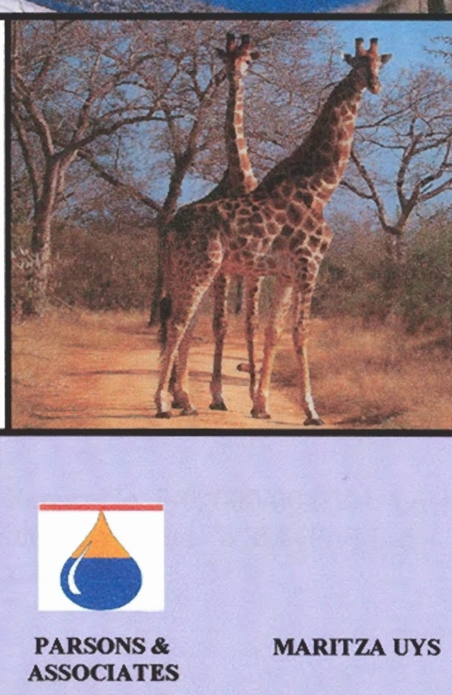
Directorate: Water Resources Planning

LUVUVHU/LETABA WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

MAIN REPORT
OCTOBER 2003





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Project Name:	Water Resources Situation Assessment
DWAF Report No:	P/02000/00/0101
Status of Report:	FINAL
First Issue:	March 2002
Final Issue:	September 2003

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LUVHUVHU/LETABA 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 study of the available water resources and quality and also patterns of water requirements that existed during 1995 in the Luvuvhu/Letaba 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: Options Analysis of the Department of Water Affairs and Forestry, while the Directorate: National 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: National 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: Integrated 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

LIST OF TABLES

LIST OF FIGURES

LIST OF DIAGRAMS

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, 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 Commission
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	Irrigation 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	Irrigation conveyance losses – High category irrigation
fILC	Irrigation conveyance losses – Low category irrigation
fIMC	Irrigation 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 ($10^6m^3/m^2$)
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 yield
$10^6m^3/a$	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

ANATOMISED	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.

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).
RESOURCE	Two kinds if water resources are recognised, namely surface water and groundwater, however these are often interdependent.
RESERVOIR	The lake formed behind a dam wall. In this report the colloquial term dam is generally used for reservoir.
RESILIENCE	The ability of an ecosystem to maintain structure and patterns of behaviour in the face of disturbance or the ability to recover following disturbance.

RESOURCE QUALITY	The quality of all the aspects of a water resource including: (a) the quantity, pattern, timing, water level and assurance of instream flow; (b) the water quality, including the physical, chemical and biological characteristics of the water; (c) the character and condition of the instream and riparian habitat; and (d) the characteristics, condition and distribution of the aquatic biota.
RESOURCE QUALITY OBJECTIVE	Quantitative and verifiable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection.
RIVER SYSTEM	A network of rivers ranging from streams to major rivers, and, in some cases, including rivers draining naturally separate basins that have been 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 maximum quantity of water obtainable on a sustainable basis from a dam in any hydrological year in a sequence of years and under specified conditions of catchment development and dam operation.

LUVUVHU/LETABA WATER MANAGEMENT AREA

CHAPTER 1: INTRODUCTION

1.1 PURPOSE OF THE STUDY

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

The Department of Water Affairs and Forestry (DWAF) has appointed consulting engineers to undertake Water Resources Situation Assessments for the purpose of gathering information and using it to reconcile the present water requirements of all the user sectors with the presently available water resources. The information produced by all the studies will be consolidated by DWAF into a national database that 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 utilisation by the central government and the future catchment management agencies.

In order to facilitate use by future catchment management agencies, the information has been presented in the form of a separate report on each water management area. This report is in respect of the Luvuvhu/Letaba Water Management Area, which falls entirely in the Northern Province.

1.2 APPROACH TO THE STUDY

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

Relevant data was used in a computerised water balance model, developed in a separate study (DWAF, 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.

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

Both the demographic data and the estimated water requirements in 1995, as supplied for the Luvuvhu/Letaba 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
- Legal aspects of water resource management
- Institutional arrangements for water supply
- Effects of alien vegetation on runoff
- Groundwater resources
- Bacteriological contamination of water resources
- Water requirements for irrigation
- Ecological classification of rivers
- Water requirements for ecological component of Reserve
- Effects of afforestation on runoff
- Storage-yield characteristics of rivers

Information from all the above studies, that is relevant to Luvuvhu/Letaba 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 Luvuvhu/Letaba Water Management Area are presented in the nine chapters that make up the main body of this report, and a number of appendices containing mainly statistics for the quaternary hydrological sub-catchments that make up the water management area. (The system used to divide the area into hydrological sub-catchments is explained in Section 2.1 of the report).

The chapter headings are:

Chapter 1:	Introduction
Chapter 2:	Physical Features
Chapter 3:	Development Status
Chapter 4:	Water Related Infrastructure
Chapter 5:	Water Requirements
Chapter 6:	Water Resources
Chapter 7:	Water Balance
Chapter 8:	Costs of Water Resources Development
Chapter 9:	Conclusions and Recommendations

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

Since the compilation of the majority of the report, including the GIS figures, a series of name changes occurred in the Northern (now Limpopo) Province, as listed below:

NORTHERN PROVINCE	**LIMPOPO PROVINCE**
Bochum	Senwabarwana
Dendron	Mowade
Ellisras	Lephalale
Louis Trichardt	Makhado
Messina	Musina
Naboomspruit	Mookgopong
Nylstroom	Modimolle
Pietersburg	Polokwane
Potgietersrus	Mokopane
Soekmekaar	Molemole

CHAPTER 2: PHYSICAL FEATURES

2.1 THE STUDY AREA

The Luvuvhu/Letaba Water Management Area (WMA) lies entirely within the Northern Province and covers24 920 km^2. The WMA is located adjacent to and shares watercourses with Zimbabwe and Mozambique. The Limpopo River demarcates the northern boundary of the WMA (see Figure 2.1.1). The Kruger National Park (KNP) lies along the eastern boundary, and occupies approximately 35% of the Water Management Area. Mozambique forms the eastern border of the KNP.

The major rivers in the WMA are the Luvuvhu River, Shingwedzi River and the Klein and Groot Letaba River, of which the latter two are tributaries of the Letaba River in South Africa (see Figure 2.1.2). The Letaba River is in turn a major tributary of the Olifants River and the confluence with the Olifants River is on the RSA/Mozambique border, within the KNP. The Shingwedzi River has its confluence with the Olifants River in Mozambique, downstream of Massingir Dam. The Luvuhu River is not part of the larger Olifants River Basin but is a tributary of the Limpopo River. The rivers originate in the higher laying mountainous zone, as described below. All these rivers flow through the Kruger National Park and into Mozambique (see Figure 2.1.2).

The topography of the Luvuvhu/Letaba WMA varies from a zone of high mountains in the west through low mountains and foothills in the central part of the WMA to the plains zone in the east. See Figure 2.1.3.

The mountainous zone or Great Escarpment, includes the northern portion of the Drakensberg mountain range, which lies on a north-south axis. The highest peaks have an elevation of more than 2 000 m above mean sea level (msl). This zone is deeply incised by the major tributaries draining the WMA. The plains zone covers most of the WMA and has gentle to flat slopes.

The Luvuvhu River sub-catchment (secondary catchment A9) is situated in the north of the WMA. The Mutale River is a major tributary of the Luvuvhu River. Other important tributaries of the Luvuvhu River include the Mutshindudi River and Dzondo River.

The Shingwedzi River has several main tributaries and includes the Mphongolo, Phugwane, Shisha and Mashakwe Rivers. A large portion of the Shingwedzi River sub-catchment (secondary catchment B9) falls within the Kruger National Park.

The Klein Letaba River has the Middle Letaba and Nsama Rivers as its main tributaries. The major tributaries of the Middle Letaba River include the Boontjies and Koedoes Rivers (tertiary catchment B82).

The Letsitele and Molototsi Rivers are the major tributaries of the Groot Letaba River (tertiary catchment B81).

The main urban areas are Tzaneen and Nkawakowa in the Groot Letaba River catchment, Giyani in the Klein Letaba River catchment and Thoyandou in the Luvuvhu River catchment. The rural population is resident throughout the WMA.

The basic unit of area used in this water resource situation assessment is the quaternary catchment. The quaternary catchments as used, were defined by Midgley *et al* (1994) in their study of water resources in South Africa, generally referred to as the WR90 study.

The primary 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*. The quaternary catchments are numbered alpha-numerically in downstream order. A quaternary catchment number, for example A92B, may be interpreted as follows:

- the letter A denotes Primary Drainage Region A;
- number 9 denotes secondary catchment area number nine of Drainage Region A;
- number 2 denotes the second tertiary catchment within the secondary catchment;
- the letter B shows that the quaternary catchment is the second in sequence downstream from the head of tertiary catchment area A92.

If a quaternary catchment number is, for example B90C, the number 0 shows that the secondary catchment has not been sub-divided into tertiary catchments.

The Luvuvhu/Letaba WMA lies within primary drainage regions A and B, and consists of secondary drainage regions A9, B8 and B9. The Water Management Area includes a total of 45 quaternary catchments. Figure 2.1.4 show the numbered quaternary sub-catchments, aswell as the hydrological sub-catchments grouped into so-called key points, as indicated by shading.

The data and results of this study are presented 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 within the selected key points.

TABLE 2.1.1: DESCRIPTION OF KEY POINTS

LOCATION OF KEY POINTS				DESCRIPTION
PRIMARY CATCHMENT		SECONDARY CATCHMENT NAME & NO.	QUARTERNARY CATCHMENT NO.'S	
NO.	NAME			
A(Part)	Limpopo	Luvuvhu River A9	A91A,B,C,D	Luvuvhu at Levubu
			A91E,F,G	Paswane Dam site
			A91H,J	Luvuvhu at Mutale
			A91K	Luvuvhu at Limpopo
			A92A,B,C,D	Mutale at Luvuvhu
B (Part)	Olifants	Letaba River B81	B81A,B	Tzaneen Dam
			B81C,D,E,F	Groot Letaba at Molototsi
			B81G,H	Molototsi
			B81J	Groot Letaba at Klein Letaba
		B82	B82A,B,C,D	Middle Letaba Dam
			B82E,F	Klein Letaba at Tabaan
			B82G,H,J	Klein Letaba at Groot Letaba
		B83	B83A,B,C,D,E	Letaba at Olifants
	B9 Shingwedzi	B90	B90A,B,C,D,E	Mphongolo
			B90F,G,H	Shingwedzi

2.2 CLIMATE

The climatic conditions vary significantly within the Luvuvhu/Letaba Water Management Area.

2.2.1 Temperature

The mean annual temperature ranges from about 18 °C in the mountainous areas to more than 28 °C in the northern and eastern parts of the WMA with an average of about 25,5 °C for the WMA as a whole. Maximum temperatures are experienced in January and minimum temperatures occur on average in July.

Table 2.2.1 summarizes temperature data for the WMA for the months January and July (Schulze *et al* 1997).

Practically no frost is experienced in the WMA. Frost occasionally occurs in the mountainous area during the winter months.

TABLE 2.2.1 TEMPERATURE DATA

Month	Temperature	Average (°C)
January	Mean Temperature Maximum Temperature Minimum Temperature Diurnal Range	27,6 29,6 19,2 10,4
July	Mean Temperature Maximum Temperature Minimum Temperature Diurnal Range	20,4 22,7 9,5 13,2

2.2.2 Precipitation

Rainfall is strongly seasonal and occurs mainly during the summer months (i.e. October to March). The peak rainfall months are January and February and rainfall occurs generally as convective thunderstorms and due to orographic cooling in the mountainous areas in the western part of the WMA. Cyclones, causing moderate to high intensity rainfall of long duration, occur occasionally in the eastern parts of the WMA.

The mean annual precipitation (see Figure 2.2.1) varies from less than 450 mm in the plains zone (northern and eastern part of the WMA) to more than 1 800 mm in the mountainous areas (south western and north western parts of the WMA).

During the driest year in five (80% exceedance probability), the annual rainfall in the Luvuvhu/Letaba WMA ranges generally between 400–600 mm in the eastern parts and up to 800 mm in the western areas.

In accordance with the rainfall patterns, the relative humidity is higher in summer than in winter. Humidity is generally highest in February (the daily mean ranges from about 70% in the west to above 72% in the east).

2.2.3 Evaporation

The average potential mean annual gross evaporation (as measured by A-pan) ranges between 1 800 mm in the extreme western mountainous region to 2 400 mm in the northern and eastern areas. The highest A-pan evaporation occurs in the period October to January and the lowest is in June. Refer to Figure 2.2.2.

2.3 GEOLOGY

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

(i) Goudplaats Basement Gneisses
(ii) They Murchison Sequence i.e.
- The Giyani Group
- The Gravelotte Group

(iii) Younger Granite Intrusives
(iv) The Schiel Complex
(v) The Soutpansberg Group
(vi) The Timbavati Gabbro
(vii) The Karoo Sequence
(viii) Quarternary Deposits

Other major sequences such as the Limpopo Mobile Belt in the north and Transvaal Sequence in the south occur on the outer fringes of the study area and will also be briefly described.

2.3.1 Description Of Major Lithologies

(i) The Goudplaats Gneisses forms the basement on which all other existing lithologies were deposited and preserved. It consists of biotite gneiss, migmatite and re-melted granitic mobilizate.

(ii) The Murchison Sequence is ancient supra-crustal rocks preserved in the basement gneisses. Two main occurrences are present in the study area.

- *The Giyani Group* is a varied assemblage of volcano-sedimentary rocks consisting of ultra mafic schists, amphibolite, banded iron formation, acid meta lavas, garnetiferous schists, quartzite, dolomite, calc-silicate rocks and granulites.

- *The Gravelotte Group* is only partially presented in the study area in the south. The greenschist sequences consist of acid meta-lavas, andesite, chlorite schists, banded iron formation, mafic meta lavas and ultra mafic schists.

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

(iii) Younger Granite Intrusives. An assortment of younger granites are intrusive into the basement complex. The more significant granite bodies are; The Lekker Smaak Granite, Willie Granite, Baderouke Granite and the Maranda Granite. They are all essentially leucocratic muscovite, biotite granites.

(iv) The Schiel Complex is of similar age to the above granite intrusives and consists of a porphyritic hypersthene syenite and hornblende granite.

(v) The Soutpansberg Group is a volcano-sedimentary sequence of rocks consisting of basalt lava at the base overlain by conglomerates and sandstones. The sequence is step faulted and dips towards the north to form the Soutpansberg mountain range.

(vi) The Timbavati Gabbro is a non-linear ultra-mafic dyke of varying width (can be larget than 1 km) which strikes in a general north/south direction. It consists of olivine gabbro.

(vii) The Karoo Sequence occurs along the northern and eastern part of the study area. It consists of shales and siltstones overlain by sandstones and capped with a thick layer of basalt lava.

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

The Limpopo Mobile belt is fractionally present in the northern corner of the study area consisting of calc-silicate rocks.

The base of the Transvaal Sequence is present in the south west corner of the study area, consisting of Black Reef Quartzite.

A simplified geological map of rock types is shown in Figure 2.3.1. Information in Table 2.3.1 may be used to identify the stratigraphic units described above.

TABLE 2.3.1: DESCRIBING THE RELATIONSHIP BETWEEN STRATIGRAPHY AND LITHOLOGY

Stratigraphy	**Symbol**	**Rock Types**
• Rooiberg Group		Acid and intermediate lavas
• Lebowa granite suite • Houtrivier, Mpuluzi, Gaborone and Cunning Moor intrusives • Mashashane, Hugomond, Matlala, Matok, Moletsi • Meinhardskraal and unnamed intrusives • Rashoop granophyre and Lebowa granite suite • Goudplaats and unnamed intrusives		Acid, intermediate or alkaline intrusives
• Soutpansberg Group and Blouberg Formation • Pietersburg Group		Assemblage of compact sedimentary and extrusive rocks
• Limpopo mobile belt, Sand River gneiss; Beit Bridge complex; Messina suite; Bulai gneiss		Assemblage of compact sedimentary extrusive and intrusive rocks
• Undifferentiated Karoo Super Group		Compact arenaceous and argillaceous strata

Stratigraphy	Symbol	Rock Types
• Duitschland, Timeball Hill, Magaliehey Quartzite		Compact sedimentary strata
• Waterberg Group and Glentig Formation		Compact, dominantly arenaceous strata
• Black Reef Formations (except where the latter is included with Godwana Formation)		Dolimate, chert and subordinate limestone
• Letaba Formation		Mafic/basic lavas
• Rustenburg Layered Suite		Mafic/ulttramafic of basic/ultrabasic intrusives

2.4 SOILS

The soils in the Luvuvhu/Letaba 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 seven occur in the WMA.

The following soil types occur in the Luvuvhu/Letaba WMA:

- Soils of the Hutton Form. These red apedal soils occur throughout the WMA over a wide range of terrain, climate and geological conditions. Hence, the soils vary from sands to clays and from deep to shallow.
- Soils of the Glenrosa Form are concentrated mainly in the north western and southeastern areas of the WMA. These shallow droughty soils overly slightly weathered rocks and occur over a wide range of terrain, climatic and geological conditions.
- Soils of the Cartref Form occur mainly in the central parts of the WMA and comprise shallow, poorly drained, course sand overlying slightly weathered rock.
- Soils of the Swartland Form occur mainly in the eastern areas in the KNP. These soils occur on gentle slopes and are dark coloured paraduplex loams overlying structured clays.

In terms of depth, texture and relief criteria, three main groupings occur in the WMA viz.:

- Moderate to deep, clayey loam, soils occur in the steep sloping areas in the western part of the WMA.
- Moderate to deep, sandy loam soils occur in the undulating central parts of the WMA.
- Shallow sandy soils occur in the flat areas in the eastern part of the WMA.

It should be noted that the base information for the above work is old and that much more detailed and reliable information exists today, which can be used for more detailed planning purposes. The interpretation of this data for a particular purpose, such as runoff response or irrigation potential will however involve considerable work and was therefore not deemed warranted for inclusion in this study.

2.5 NATURAL VEGETATION

2.5.1 Introduction

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. The distribution of the vegetation throughout the WMA can be viewed on Figure 2.5.2.1.

For the purpose of identifying and managing the heterogeneous 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 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 2.5.1.1.

These "simplified" Acocks veld type categories are used for the purposes of this report, and accordingly the description of the natural vegetation types occurring within the Water Management Area is rather broad.

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

Detailed Veld Types	No.	Simplified Veld Type
Coastal Forest and Thornveld	1	Coastal Tropical Forest
Alexandria Forest	2	
Pondoland Coastal Plateau Sourveld	3	
Knysna Forest	4	
'Ngongoni Veld	5	
Zululand Thornveld	6	
Eastern Province Thornveld	7	
North-eastern Mountain Sourveld	8	Inland Tropical Forest
Lowveld Sour Bushveld	9	
Lowveld	10	Tropical Bush and Savanna
Arid Lowveld	11	
Springbok Flats Turf Thornveld	12	
Other Turf Thornveld	13	
Arid Sweet Bushveld	14	

Detailed Veld Types	No.	Simplified Veld Type
Mopani Veld	15	
Kalahari Thornveld	16	
Kalahari Thornveld invaded by Karoo	17	
Mixed Bushveld	18	
Sourish Mixed Bushveld	19	
Sour Bushveld	20	
False Thornveld of Eastern Cape	21	False Bushveld
Invasion of Grassveld by Acacia karoo	22	
Valley Bushveld	23	Karoo and Karroid
Noorsveld	24	
Succulent Mountain Scrub	25	
Karroid Broken Veld	26	
Central Upper Karoo	27	
Western Mountain Karoo	28	
Arid Karoo	29	
Central Lower Karoo	30	
Succulent Karoo	31	
Orange River Broken Veld	32	
Namaqualand Broken Veld	33	
Strandveld	34	
False Arid karoo	35	False Karoo
False Upper Karoo	36	
False Karroid Broken Veld	37	
False Central Lower Karoo	38	
False Succulent Karoo	39	
False Orange River Broken Karoo	40	
Pan Turf Veld invaded by Karoo	41	
Karroid Merxmuellera Mountain Veld replaced by	42	
Mountain Renosterveld	43	
Highveld Sourveld and Dohne Sourveld	44	Temperate and Transitional Forest
Natal Mist Belt ‘Ngongoni Veld	45	
Coastal Renosterveld	46	
Coastal Fynbos	47	
Cymbopogon – Themeda Veld	48	Pure Grassveld
Transitional Cymbopogon – Themeda Veld	49	
Dry Cymbopogon – Themeda Veld	50	
Pan Turf Veld	51	
Themeda Veld or Turf Highveld	52	
Patchy Highveld to Cymbopogon – Themeda	53	
Turf Highveld to Highland Sourveld Transition	54	
Bakenveld to Turf Highveld Transition	55	
Highland Sourveld to Cymbopogon – Themeda	56	

Detailed Veld Types	No.	Simplified Veld Type
North-eastern Sandy Highveld Themeda – Festuca Alpine Veld Stormberg Plateau Sweetveld Karroid Merxmuellera Mountain veld	57 58 59 60	
Bankenveld Bankenveld to Sour Sandveld Transition	61 62	False Grassveld
Piet Retief Sourveld Northern Tall Grassveld Southern Tall Grassveld Natal Sour Sandveld Pietersburg Plateau False Grassveld Eastern Province Grassveld	63 64 65 66 67 68	
Fynbos	69	Sclerophyllous Bush
False Fynbos	70	False Sclerophyllous Bush

2.5.2 Natural Vegetation Types within the Luvuvhu/Letaba WMA

Tropical Bush and Savanna dominate the Luvuvhu/Letaba WMA, with smaller areas of Inland Tropical Forest occurring in the western boundaries of the WMA. The veld types are described in more detail below and illustrated also in Figure 2.5.2.1.

Tropical bush and savanna veld type dominates the central and western regions of Luvuvhu/Letaba WMA, occupying some 70% of its area. Tropical trees and shrubs are common and the dominant grass is a tall form of Themeda Triandra. Rainfall in this area ranges between 400 mm and 700 mm per annum, and occurs mainly in summer. The tropical bush and savanna occurs at altitudes between 150 m and 600 m above msl.

Inland tropical forest occurs predominantly in the mountainous regions that separate the Luvuvhu/Letaba with the Limpopo WMA in the western regions of the catchment with small patches also occurring along the northern boundary. This vegetation dominates the mountain ranges where high rainfall is experienced ranging on average from 900 mm to over 1 950 mm per annum.

2.6 ECOLOGICALLY SENSITIVE SITES

2.6.1 Sensitive Ecosystems

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

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

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

Before moving on to discussing ecosystems of concern to the study area it would be prudent to give some consideration to the definition of aquatic ecosystems, especially with respect to the national Water Act (No 36 of 1998). In general terms an ecosystem may be defined as a community of organisms and their physical environment interacting as an ecological unit. Hence, aquatic ecosystems encompass the aquatic community and water resources necessary to sustain its ecological integrity. Within the National Water Act, the water resources requirements of aquatic ecosystems are recognized and protected by the introduction of the concept of an ecological reserve, viz. the water required to protect the aquatic ecosystem of the water resources. The Reserve refers to both quantity and quality of the resource. Accordingly, development must take cognizance 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.

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.

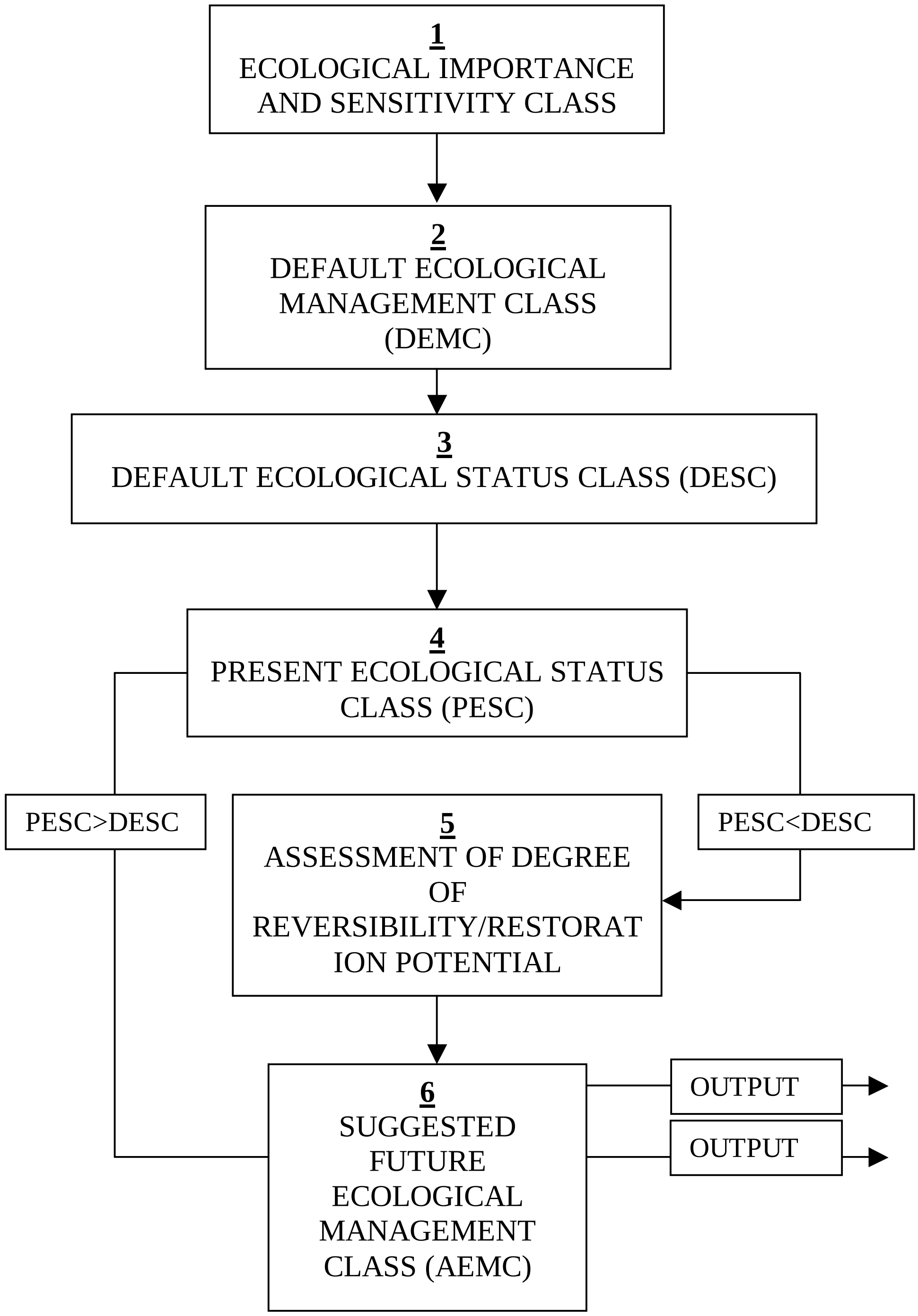


DIAGRAM 2.6.2.1: Procedure followed to determine the river classifications

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.

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

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

→ : indicates relationship.

⟶ : indicates possible direction of desirable change.

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

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

- Only lotic systems (i.e. streams and rivers and associated habitats such as lotic wetlands) can be classified and the procedure is not meant to be applied to lakes, pans, impoundments or estuaries. Although several of the components considered in this assessment may be generally applicable, the application of the procedure to systems other than rivers and streams was not attempted.
- Where a quaternary catchment contained an estuary, this procedure was only applied to the riverine part of the catchment.
- Only the mainstem river in a quaternary catchment was considered in the assessment and therefore the management class must not be applied to any tributary streams in the quaternary catchment. These tributaries and their associated water requirements do however, become relevant when a water resources situation assessment is conducted at a sub-quaternary level.
- In cases where a dam wall was present at or relatively close to the outlet of a quaternary catchment, the assessments for that quaternary catchment were based on the river upstream of the dam (i.e. upstream of the backwater effect of the dam).
- In cases where degradation has occurred along certain sections of the mainstem of a quaternary catchment, but where there are still substantial less disturbed sections, the classification was based on those less disturbed areas. The intention of this was to ensure that the ecological component of the Reserve would provide for these less disturbed sections as if they were situated at the outlet of the quaternary catchment, where the ecological component of the Reserve will be estimated for the water resources situation assessments.
- The classifications were fundamentally considered from an instream and riparian zone perspective. Although the catchment in itself plays a major role in the condition and functioning of the rivers and streams in the catchment, the purpose of this procedure was not to provide an overall assessment of the condition of each catchment.
- The riparian zone was broadly 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 reach 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 conserved or relatively natural areas along the river section serves 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 of the river of the quaternary catchment under near-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 was scored, from which the mean was calculated. This mean was used to assign a present ecological status class to the mainstem of the river in the vicinity of the outlet of the quaternary catchment.

Suggested Future Ecological Management Class (AEMC)
The potential to improve the ecological conditions was assessed only in terms of the present flow regime. Degradation of the system purely because of non-flow related changes was ignored.

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

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

2.6.3 Aquatic Ecosystems of Concern to the Study

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

The aquatic ecosystems of concern in the Luvuvhu/Letaba WMA are discussed separately for the four main river systems in the WMA, namely Luvuvhu River, Shingwedzi River, Klein Letaba River and Groot Letaba River.

The **Luvuvhu River** is one of the main tributaries of the Limpopo River and traverses the northern part of the WMA. The Mutale River is an important tributary of the Luvuvhu River. The Luvuvhu River and its tributaries are important from a conservation perspective for the following reasons:

- The Luvuvhu River and Mutale River is perennial and therefore contains numerous flow dependant species, some of which are red data species such as the Southern Barred Minnow.
- The mountain streams in the Mutshindudi area introduce cooler waters to the warmer waters of the Luvuvhu River and this mixture of hot/cold water has created a particular environment for certain flow dependent species.
- The link between the Luvuvhu River and the Limpopo River, which ultimately flows into the sea, has established a migration route for marine species. Several marine species are found in the Luvuvhu and Mutale Rivers and this situation is further assisted by the lack of weirs in the Luvuvhu and Mutale Rivers. The endangered fresh-water prawn has been recorded at several sites in the Mutale River.
- The Pafuri flood plain occurs at the confluence of the Luvuvhu and Limpopo Rivers. This area has a high conservation status.

The **Shingwedzi River** catchment has a semi arid climate and the flow is intermittent particularly in the lower reaches. The Shingwedzi River nevertheless is important from a conservation perspective in view of :

- Tiger fish occur in the lower Shingwedzi River and have been classed as being provincially threatened.
- The flow patterns in the upper Shingwedzi River have been disturbed by the construction of small dams. The riparian vegetation is however regarded as being of considerable conservation importance.

The **Klein Letaba River** is a major tributary of the Letaba River which joins the Olifants River before flowing into the Massingir Dam in Mozambique and ultimately into the Limpopo River. The Klein Letaba River, which is perennial, is important from a conservation perspective, particularly along its lower reaches in view of the very good riparian vegetation which occurs along this reach. Hot springs also occur adjacent to the river along its lower reaches and this adds to the continuous flow in the river in this area.

The **Groot Letaba River** has been highly modified by the construction of several weirs and dams, but nevertheless is considered to be important from a conservation perspective in view of flow dependent species found along the various river reaches between major obstructions. The Massingir Dam in the Olifants River is an obstruction of particular consequence as it prevents the migration of flow dependant species and marine species upstream of the dam into the Letaba and Olifants Rivers.

The ecological significance/conservation importance of the river systems falling within the Luvuvhu/Letaba WMA, as exemplified by their Ecological Importance and Sensitivity Classes (EISC), are summarised in Figures 2.6.3.1 to 2.6.3.3. Thees 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. Nevertheless, despite their modified nature, many of these river reaches, especially those in the Shingwedzi River, contain the endemic fish species referred to in the preceding paragraphs. Accordingly, developers should take cognisance of the significant risk of negative environmental impacts associated with the utilisation of these areas for further water resource developments.

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

2.6.4 Natural Heritage Sites, Proclaimed 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 Luvuvhu/Letaba WMA contains other protected areas which may be impacted directly or indirectly upon by development activities associated with water resources. These protected areas include Natural Heritage Sites as well as those areas listed in Section 2.6.1, viz. Scientific and Wilderness Areas, National Parks and Equivalent Reserves, Natural Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas, Protected Land/Seascapes.

Game and Nature Reserves

The Kruger National Park is the largest nature reserve in South Africa and occupies approximately 35% of this Water Management Area along the Northern and 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 area of the Kruger National Park is particularly noted for its very high elephant populations and also for some of the rare antelope such as sable, roan, tsessebe and nyala.

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 listed in Table 2.6.4.1.

Natural Heritage Sites

A number of natural heritage sites are situated along the eastern boundary of the WMA. Westfalia, Duplex and Goedehoop are the major proclaimed heritage sites within the catchment.

Table 2.6.4.1 contains a list of protected areas within the Luvuvhu/Letaba WMA. All water resource developments should take cognizance of these sites and it is the developer's responsibility to identify the exact proximity of activities to any of them, 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 Luvuvhu/Letaba WMA.

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

Area Name	Category
Kruger National Park	Habitat & Wildlife Management Area
Hans Merensky	Habitat & Wildlife Management Area
Grootbosch	Habitat & Wildlife Management Area
Modjadji	Habitat & Wildlife Management Area
Ebenezerdam	Habitat & Wildlife Management Area
Silver Mist	Habitat & Wildlife Management Area
Roodewal l	Habitat & Wildlife Management Area
Brackenhil	Habitat & Wildlife Management Area
Westfalia	Natural Heritage Site
Duplex	Natural Heritage Site
Goedehoop	Natural Heritage Site

2.7 CULTURAL AND HISTORICAL SITES

Development of water supplies and services can have a negative impact on the archaeological and cultural heritage by way of development of dams, pipelines, canals, water services infrastructure and enterprises following on the provisions of water.
The National Monuments Act (No. 28 of 1969) addresses 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.

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

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

Within the Luvuvhu/Letaba WMA the main rivers and their tributaries are rich in sites of archaeological/cultural interest. The nature of these sites is diverse, but consists mainly of Late Stone Age artifacts, including rock paintings, cave deposits and open scatters of debris related to occupation. Earlier material, in the form of Middle and Early Stone Age artifact scatters, is also present but less numerous, and colonial material in the form of building remains and graves also occurs. The presence of these sites implied that there is a considerable risk of damage to artifacts of archaeological/cultural/historical significance associated with water resource development within this WMA, and that extensive mitigation programmes may be required to alleviate any negative impacts.

No general listing of the sites of palaeontological, archaeological and historical significance within the Luvuvhu/Letaba WMA is available. The National Monuments Council does possess a database of National Monuments within each province, but this is only of limited use since it only lists National Monuments (as declared within the Government Gazette), and the vast majority of these occur within urban areas, which are unlikely to be impacted upon by water resources development and utilization projects. Accordingly, it is the responsibility of the developer to liaise with the National Monuments Council and South African Museum to establish whether they are aware of any sites of cultural/historical/archaeological interest within any area earmarked for development.

Moreover, it is the developer’s responsibility to ensure that the development area is surveyed for archaeological sites or artifacts, 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 Parks Act (No. 57 of 1975), and should consult with the National Monument Council on discovering sites or artifacts of palaeontological, archaeological or historical significance. Also, developers should take cognizance of the fact that the National Heritage Act superceded 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 in the Luvuvhu/Letaba WMA was driven essentially by climate, available water resources and population growth and distribution. The three zones of development coincides with the zones described in section 2.1, viz. the Great Escarpment in the west, the central part of the WMA and the plains in the east. Refer to Figures 2.1.3 and 2.2.1.

The Great Escarpment of the WMA comprises a mountainous, high rainfall area with a relatively high unit runoff. Extensive afforestation has occurred in the steep mountainous areas, whilst intensive irrigation has been developed in the areas further downstream where the topography is more gentle. The first developments occurred at the turn of the century and by the 1970's, the water resources had been extensively exploited. Crops being produced include permanent crops which earn foreign currency and cash crops for the local and national markets. The irrigation schemes were developed mainly as government irrigation schemes, for example Magoebaskloof Dam, Tzaneen Dam and Albasini Dam. A significant private investment was also made particularly in the upper Middle Letaba River valley.

The irrigation and afforestation activities provide a large number of employment opportunities.

The Central part of the WMA has a high population concentration. The area is generally semi-arid, but is however traversed by several rivers which drain the high rainfall western part of the WMA.

This area essentially comprises of former homeland areas. It was generally considered by these former administrations that irrigation provided the key to poverty alleviation. Numerous large dams and extensive irrigation schemes were accordingly developed. These schemes include Thabina Irrigation Scheme, Middle Letaba Dam, Nsami Dam, Levubu Irrigation Scheme and Mutale Irrigation Scheme. Certain of these dams also provide water for domestic purposes.

The Plains Zone in the eastern part of the WMA comprises mainly of the Kruger National Park (KNP). Refer to Figure 2.1.2. This is a semi- arid area and has limited water resources. Several small to medium dams have been constructed on the Letaba River in the KNP, to secure water supply. This is mainly a nature conservation area and therefore limited development has occurred.

A summary of the major dams (dams with a height more than 12 m, i.e. a Class 2 dam) in this WMA is given below:

Dam Name	Capacity (10^6 m^3)	Purpose
Magoebaskloof Dam	5,0	Domestic and industrial
Tzaneen Dam	157,6	Irrigation, domestic and industrial
Albasini Dam	25,6	Irrigation and domestic

Dam Name	Capacity (10^6 m^3)	Purpose
Middle Letaba Dam	174,0	Irrigation, domestic and stock water
Nsami Dam	24,4	Irrigation and domestic
Ebenezer Dam	70,1	Irrigation, domestic and industrial

3.2 DEMOGRAPHY

3.2.1 Introduction

A national study (Schlemmer *et al*, 2001) to develop water use projections to the year 2025 was undertaken for the Department of Water Affairs and Forestry, 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 focussed 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 in South Africa 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 Luvuvhu/Letaba WMA comprises residents in urban centres including Tzaneen, Duiwelskloof, Nkowakowa, Giyani and Thohoyandou and of developing rural communities who are concentrated in the former Venda, Gazankulu and Lebowa 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 47% (DWAF: WS Planning, 1999), is a major driver of **migration out** of the WMA to larger industrial centres and urban areas including Pietersburg, Johannesburg/Pretoria and Middelburg/Witbank. Migration within the WMA from the rural areas to the urban centres also occurs. Assessments of the absenteeism of potentially economically active males in the WMA during the late 1980's found that some 50% of males may be considered to be migrant workers (DBSA, 1993). 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 50% of the population do not have access to water that meets RDP standards. Health services are also poor and the literacy rate is about 53% (DWAF: WS Planning, 1999). Population movement to areas having improved services have been experienced, but no statistics are available in this regard.

Illegal aliens, 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 mainly related to the population growth rate of communities in the former homeland areas.

The former Venda areas, which are located in the northern parts of the WMA, experienced a growth rate of between 3,4%/a and 4,5%/a in the period 1960 to 1991 (DBSA, 1993).

The former Gazankulu areas, which are located in the central and southern parts of the WMA, had a particularly high population growth rate between 4,2%/a and 8,0%/a for the period 1960 to 1991 (DBSA, 1993).

The former Lebowa areas, which are located in the southern parts of the WMA, experienced a moderate to high population growth rate between 1,1%/a and 7,8%/a 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%/a (DBSA, 1998).

3.2.4 Population Size and Distribution in 1995

Table 3.2.4.1 shows the population size of the Luvuvhu/Letaba WMA in 1995, based on data obtained from the National Demographic Study.

The total population of the **Luvuvhu River catchment** amounts to about 518 000 and comprises 52 000 urban and 466 000 rural residents. The population is concentrated in the Thohoyandou area and environs. The upstream areas of the catchment have a low population density due to the intensive agricultural activity and afforestation. The north eastern parts of the catchment have a low population density due to its remoteness and the adverse semi- arid climate.

The total population of the **Shingwedzi River catchment** amounts to about 132 000 and comprises of about 7 000 urban residents and about 125 000 rural residents. The population is concentrated in the western third of the catchment as the remainder of the catchment lies within the KNP.

The total population of the **Groot Letaba River catchment** is about 462 000 and comprises of about 30 000 urban residents and about 432 000 rural residents. The population is concentrated mainly in the western part of the catchment where the urban centres and numerous villages occur. The eastern part of the catchment is semi- arid and sparsely populated.

The Klein and Middle Letaba River catchment has a total population of about 420 000 and comprises about 42 000 urban residents and 377 000 rural residents. The population is concentrated mainly in the central and western parts of the catchment in line with the previous homeland boundaries. The eastern part of the catchment is sparsely populated in view of its remoteness and semi- arid nature.

The Lower Letaba River catchment has a total population of about 3 700 and lies essentially entirely in the KNP.

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 in 1995		
Primary		Secondary		Tertiary		Urban	Rural	Total
No	Description	No	Description	No	Description			
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	10 250	49 570	59 820
					Paswane Dam site	41 700	288 900	330 600
					Luvuvhu at Mutale	0	46 740	46 740
					Luvuvhu at Limpopo	0	0	0
				A92	Mutale at Luvuvhu	0	80 470	80 470
Total in Luvuvhu River catchment						**51 950**	**465 680**	**517 630**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	350	7 962	8 312
					Groot Letaba at Molototsi	27 550	265 900	293 450
					Molototsi	1 950	142 200	144 150
					Groot Letaba at Klein Letaba	0	15 310	15 310
				B82	Middle Letaba Dam	22 450	118 200	140 650
					Klein Letaba at Tabaan	0	128 900	128 900
					Klein Letaba at Groot Letaba	19 700	130 100	149 800
				B83	Letaba at Olifants	0	3 691	3 691
Total in Letaba River catchment						**72 000**	**812 263**	**884 263**
		B9	Shingwedzi	B90	Mphongolo	7 300	72 830	80 130
					Shingwedzi	0	52 040	52 040
Total in Shingwedzi River catchment						**7 300**	**124 870**	**132 170**
Total in Luvuvhu / Letaba WMA						**131 250**	**1 402 813**	**1 534 063**

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 Luvuvhu/Letaba Water Management Area in terms of the following aspects:

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

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

3.3.2 Data Sources

The information presented has been derived from a database of macro-economic 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 analyzed. 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 utilized the 1980 and 1991 population censuses as the basis but has also updated the figures utilizing 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 desegregated 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 digitized geographic layer of WMAs was merged with the Magisterial District (MD) boundaries, and the surface area for each of the newly generated polygons was determined. The proportion of the surface area of each of the MD, which falls within each WMA, was calculated, and that proportion was used to allocate the part of a GGP figure that falls on each side of a WMA-boundary.

Trade and Community Services

To take account of the subdivision of local authority areas by MD or WMA boundaries, the number of enumerator areas (EAs) falling within each subdivision of a local authority area, as a proportion of the total number of EAs in a local authority area, was determined. This proportion was applied to the latest population figure (1996 census) of each local authority area. As EAs are of approximately equal population size, these proportions were used to calculate the approximate population for that part of a local authority area which falls within each MD, as they are subdivided by WMA boundaries. The population of each MD segment, as a proportion of the total MD population, was used to calculate the proportion of a GGP figure which should be allocated to each segment of a MD, so that these 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 which affect the kind of population distribution that is not distorted by government intervention or other external factors. The Caucasian population has typically not been influenced by the latter factors, and its distribution is therefore a better guide for determining the distribution of economic activities in these sectors.

3.3.4 Status of Economic Development

The GGP of the Luvuvhu/Letaba WMA was R5,1 bn in 1997. The most important magisterial districts in terms of contribution to GGP in this WMA are shown below:

- Thohoyando 18,1%
- Letaba 15,4%
- Phalaborwa 11,4%
- Giyani 9,8%
- Vuwani 7,9%
- Other 37,4%

Economic Profile

The composition of the Luvuvhu/Letaba WMA economy is shown in Diagram 3.3.1. The most important sectors in terms of contribution to GGP are shown below:

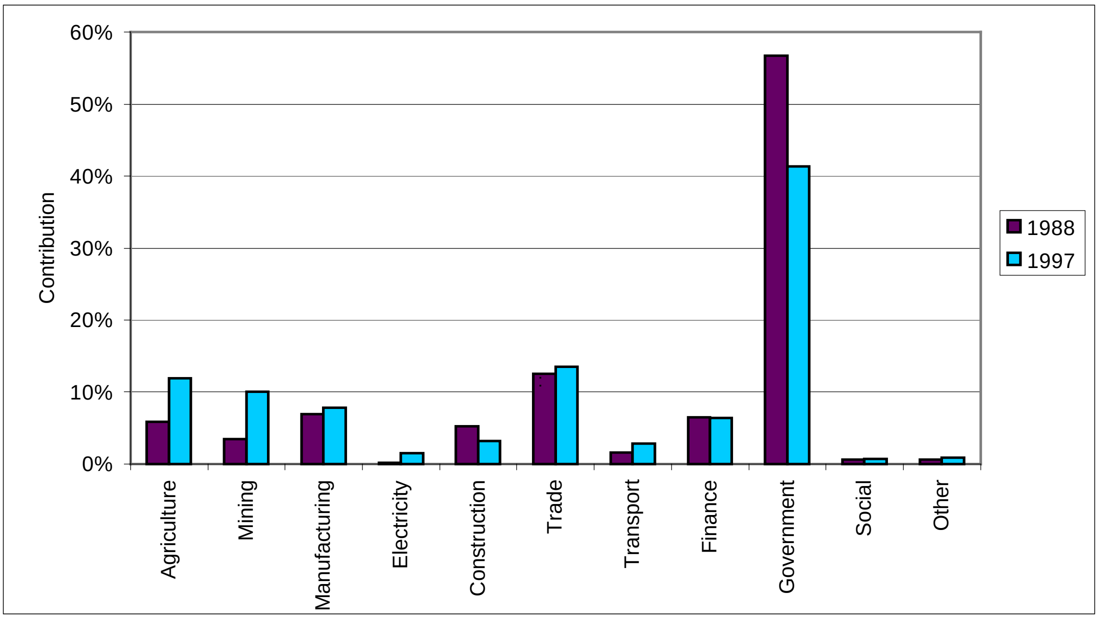
- Government 41,3%
- Trade 13,5%
- Agriculture 11,9%
- Mining 10,0%
- Other 23,3%

The Letaba district contributes approximately 45% to the total national income generated in horticulture production of which the largest portion can be attributed to vegetables and citrus. In the Bushveld Region ostrich production is also increasing although the profit margin is not often that high.

The minerals found in this WMA include complex flake graphite, ironstone, marble, fire clay, surficial limestone, magnesite, lead, barite mineralisation, and small gold deposits. The mining industry in the Lowveld subregion is dominated by the Phalaborwa Mining Company (copper) and Foskor (phosphates).

The concentration of government activities can largely be attributed to the existence of the former homeland areas of Gazankulu, Lebowa and Venda.

DIAGRAM 3.3.1: CONTRIBUTION BY SECTOR TO ECONOMY OF LUVUVHU/ LETABA WATER MANAGEMENT AREA,1988 AND 1997 (%)



Economic Growth

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

- Electricity 18,6%
- Mining 4,1%

The mining sector is an important employment creator and growth generator in the area. Due to the variety of minerals and metals found as well as the demand for coal, growth can be expected to continue.

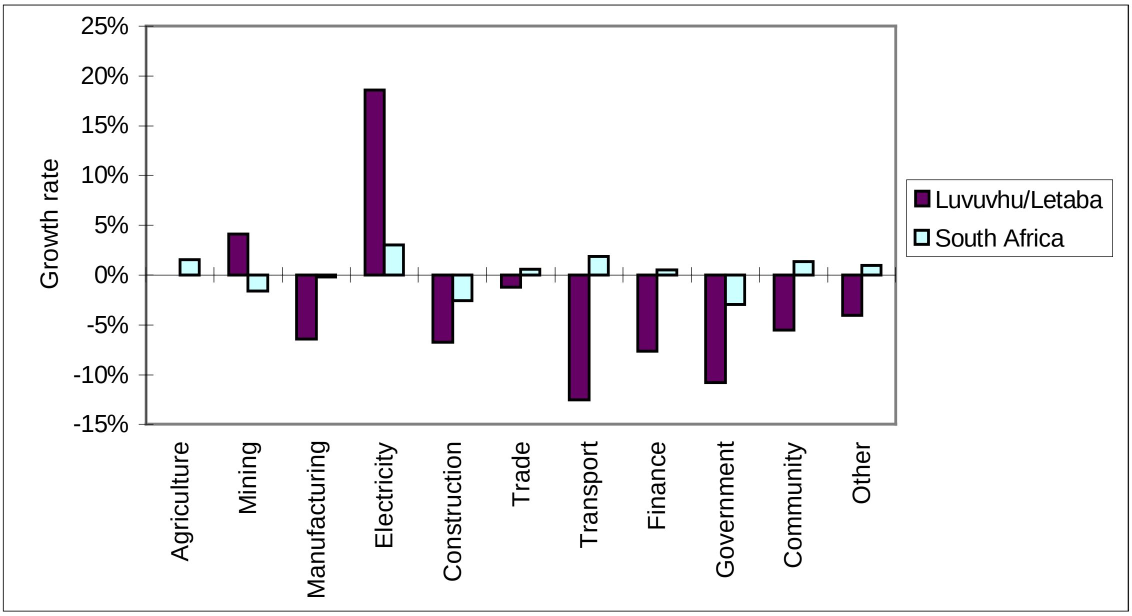
The high growth rate recorded in the electricity sector took place from a small base and could also possibly be attributed to the supply of electricity to new housing projects.

Labour

Of the total labour force of 343 000 persons, 49,4% are unemployed, which is higher than the national average of 29,3%. Forty percent (40,5%) are active in the formal economy. Fifty three percent (53,3%) of the formally employed labour force work for government, while 19,1%, are involved in agriculture, and 9,2% in trade.

In the period 1980–1994, the sectors with the highest growth rates were financial services (8,5% per annum); the government sector (6,6% per annum); construction (2,3% per annum); and manufacturing (2,0% per annum).

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



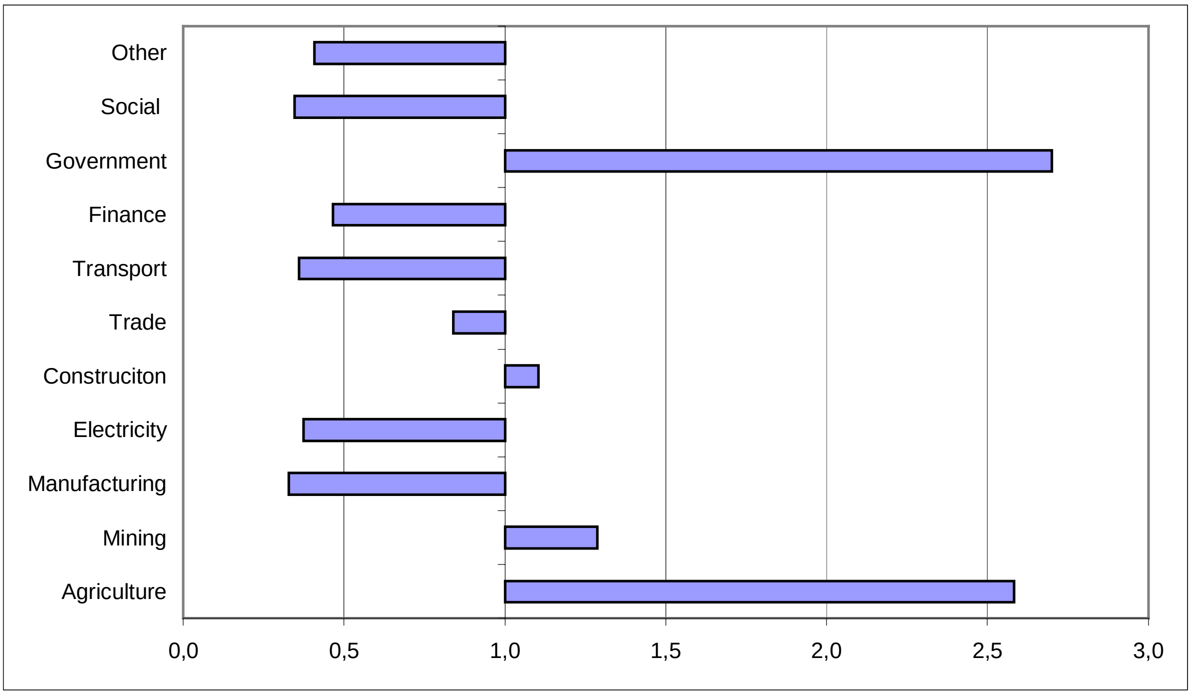
3.3.5 Comparative Advantages

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 which has the comparative advantage. The location quotient is a measure of the relative concentration of economic activities in a region as compared with another region, or as compared with a larger region of which it forms part. A location quotient for an economic sector with a value of more than one implies that the sector contributes a larger percentage to a sub-region's GGP than that sector contributes to the larger area of which the sub-region forms part. The location quotient can, however, not be equated with comparative advantage, and provides only an indication.

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

- Agriculture 2,6
- Mining 1,3
- Government 2,7
- Construction 1,1

DIAGRAM 3.3.3: LUVUVHU/LETABA GROSS GEOGRAPHIC PRODUCT LOCATION QUOTIENT BY SECTOR, 1997



The comparative advantage of the agricultural sector is largely attributed to the variety of products, the good performance of this sector in the Luvuvhu/Letaba WMA and the importance of this sector in this WMA.

The diversified mining base contributes to the comparative advantage of this sector.

The Luvuvhu/Letaba WMA does not possess a comparative advantage in trade and tourism activities, seen within a national context, even though this sector is fairly important to the regional economy.

3.4 LEGAL ASPECTS AND INSTITUTIONAL ARRANGEMENTS FOR WATER SUPPLY

3.4.1 Past History

The history of settlement in southern Africa is linked to the availability and supply of fresh water. From early times South African water law was based on the needs of white settlers who in 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 summarized as follows:

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

3.4.3 Strategies

The NWA makes provision for establishment of two water management strategies. These are the National Water Resource Strategy and the Catchment Management Strategy.

The National Water Resource Strategy is binding on the Minister of the Department of Water Affairs and Forestry, other organs of State and all water management institutions for anything contained therein, while the catchment management strategy is binding on the relevant catchment management agency and is more on a local level.

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

3.4.4 Environmental Protection

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

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

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

Section 19 of the NWA provides *inter alia* that any person who is in control of land over which pollution is taking place or who causes pollution or potential pollution to take place, must take the necessary steps to prevent this from continuing. Should this not be done, the Minister shall have the right to take the necessary steps to recover the cost of remedial work 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 authorizations issued under section 39 of the NWA; and
- Existing lawful use recognized 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, 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 authorization.

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, which results in severe economic prejudice, the applicant may claim compensation. Compensation cannot be claimed if the reduction is to provide for the Reserve, rectify a previous over-allocation or a previous unfair allocation.

Compensation must be claimed from the Water Tribunal.

The Minister has the right to attach conditions to any 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 licence;
- 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 which may have an influence on the environment.

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

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

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

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

National Environmental Management Act (Act No. 107 of 1998)

This act lays a new foundation for environmental management. The act includes 20 principles that serve as a general framework within which environmental management and implementation plans must be formulated and guide any other law concerned with the protection or management of the environment. Environment is defined as the natural environment and the physical chemical, aesthetic and cultural properties of it that influence human well-being.

To give effect to these principles this act creates the National Environmental Forum and the Committee for Environmental Co-ordination and defines the procedure for the establishment of a Coastal Management Subcommittee of the Committee for Environmental Co-ordination in order to achieve better inter-governmental co-ordination of coastal management.

This act provides for the drawing up of environmental implementation plans by certain scheduled national Government Departments and the Provinces. In addition, environmental management plans are 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. They must co-ordinate and harmonize 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 utilization 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. These 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 with water services provision. A third category is also listed and includes forums and committees established to facilitate and coordinate 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 fulfil 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;
- Lepelle Northern Water Board;
- The various Irrigations 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;
- Lowveld 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 3.4.1: Existing structures.
- Table 3.4.2: Existing forums and committees (provincial and local levels only).

TABLE 3.4.1: 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).
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.

Name	Tasks
Local level	
Water Boards: ▪ Lepelle Northern 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	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
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 3.4.2: 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 parastatals 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).
Local level		
Area Planning Form: ▪ Northern District ▪ Lowveld 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.

Name	Composition	Function
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:

Urban TLC's:

- Greater Duiwelskloof/Ga-Kgapane
- Greater Phalaborwa
- Greater Tzaneen
- Greater Louis Trichardt
- Greater Messina
- Greater Thohoyandou

Rural TLC's:

- Bolobedu/Hlanganani
- Greater Giyani
- Haenertsburg
- Hoedspruit/Makhutswi
- Letsitele/Gravelotte
- Mooketsi/Sekgosese 2
- Alldays/Louis Trichardt/Buysdorp
- Elim/Tshitale-Hlanganani/Levubu-Vuwani
- Levubu/Shingwedzi
- Mutal/Masisi/Vhutswema
- Nzhelele/Tshipise

Irrigation Boards

Name	Nearest town	Number of board members	Total scheduled area (ha)
George's Valley	Tzaneen	3	389,2
Groot Letaba Major	Tzaneen	10	9 457,3
Klaserie River	Klaserie	6	1 047,2
Letaba North Canal	Tzaneen	6	3 031,4
Letsitele River	Tzaneen	10	2 318,0
N & N	Tzaneen	6	1 197,2
Pusela	Tzaneen	6	996,5
Selati River	Trichardtsdal	3	997,6
TOTAL			**19 434,4**

A large number of Tribal authorities occur in the rural areas. It is essential to obtain input from the tribal chiefs on all water project developments.

3.5 LAND USE

3.5.1 Introduction

The limited water resources has given rise to intense competition between the ever growing water use sectors and thus land use sectors, such as agriculture, 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 Luvuvhu/Letaba WMA.

Agriculture is the largest land use sector in the WMA with irrigation areas measuring some 364 km^2. Dry-land cultivation has increasingly been converted to pastures in the commercial farming areas. Large parts of the WMA are being used for game and stock farming. Certain areas, particularly in the former Venda, Gazankulu and Lebowa were over stocked, but the stock numbers have decreased considerably due to the draught during the late 1980's and early 1990's.

Afforestation occurs in the high rainfall mountainous areas. This area also has considerable indigenous forests. A few proclaimed nature reserves also occur in the WMA.

Major industries are mainly situated within the urban areas except for a few small industries located near Letsitele adjacent to the Groot Letaba River. Gold, magnesite and coal are mined in the Mutalae, Shingwedzi and Letaba River catchments, however, there has been a decrease in mining activity in most instances. The gold mining sector has decreased considerably.

Table 3.5.1.2 gives a summary of the land use categories for the Luvuvhu/Letaba WMA.

TABLE 3.5.1.2: LAND USE BY PROVINCE AND DISTRICT COUNCIL AREA

Type of land use	Total area (km^2)
Irrigation	364
Dryland crops	3 953
Afforestation	654
Nature reserves *	7 896
Urban areas	47
Rural settlements	465
Other **	11541
TOTALS	**24 920**

** Includes all other areas. Thus the total area in the table equals the total drainage areas.
Note: The WMA falls entirely within the Northern District Council and the Northern Province.

TABLE 3.5.1.1: LAND USE BY DRAINAGE AREAS IN km²

Catchment												
Primary		**Secondary**		**Tertiary**		**Irrigation**[2]	**Dryland crops**	**Afforre= station**	**Urban**	**Rural Settlements**	**Other ****	**Catchment area**
No	**Description**	**No**	**Description**	**No**	**Description**							**(km^2)**
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	58.5	179.4	90.6	0.1	6.9	553.5	889.0
					Paswane Dam site	18.3	520.7	39.9	22.8	51.1	556.2	1,209.0
					Luvuvhu at Mutale	3.3	161.4	3.3	0.0	5.7	846.3	1,020.0
					Luvuvhu at Limpopo	0.0	0.0	0.0	0.0	0.0	669.0	669.0
				A92	Mutale at Luvuvhu	43.7	355.6	34.8	0.4	0.6	1719.0	2,154.0
Total in Luvuvhu River catchment						**123.8**	**1217.0**	**168.6**	**23.3**	**64.3**	**4344.0**	**5941.0**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	56.9	51.3	354.3	0.3	1.0	186.1	650.0
					Groot Letaba at Molototsi	132.1	724.9	60.4	22.8	82.4	1530.5	2,553.0
					Molototsi	1.6	440.4	2.7	0.0	70.3	666.0	1,181.0
					Groot Letaba at Klein Letaba	0.0	76.8	0.0	0.0	16.7	474.4	568.0
				B82	Middle Letaba Dam	35.6	204.8	43.9	0.0	62.9	1457.9	1,805.0
					Klein Letaba at Tabaan	0.8	384.1	22.9	0.0	21.8	753.4	1,183.0
					Klein Letaba at Groot Letaba	12.9	560.5	0.0	0.8	83.4	1807.5	2,465.0
				B83	Letaba at Olifants	0.0	1.0	0.0	0.0	0.0	3263.0	3,264.0
Total in Letaba River catchment						**239.9**	**2443.8**	**484.2**	**23.9**	**338.5**	**10138.8**	**13669.0**
		B9	Shingwedzi	B90	Mphongolo	0.0	208.4	1.2	0.0	30.3	2663.1	2,903.0
			Shingwedzi		Shingwedzi	0.0	83.9	0.0	0.0	31.7	2291.5	2,407.0
Total in Shingwedzi River catchment						**0.0**	**292.3**	**1.2**	**0.0**	**62.0**	**4954.5**	**5310.0**
Total in Luvuvhu / Letaba WMA						**363.7**	**3953.1**	**654.0**	**47.1**	**464.7**	**19437.4**	**24920.0**

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

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

The information on crop areas and irrigation methods was obtained from the various Water Resources Situation Assessments (River Basin Studies) and Luvuvhu and Letaba River Dam Feasibility Studies.

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, mechanical systems, micro systems and drip systems.

It is generally recognized that future growth in irrigation will be severely limited by the availability of water and new irrigation developments are not anticipated. 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 for double cropping.
Medium	Vegetables, potatoes, tobacco, coffee, cotton, seed production, lucerne and pasture for dairying. Includes double cropping.
High	Citrus, nuts, sub-tropical fruit and nuts, tea, speciality vegetables.

TABLE 3.5.2.1: IRRIGATION LAND-USE

Catchment						Irrigation area in km² by crop category (dominant irrigation method)*				
Primary		Secondary		Tertiary						
No	Description	No	Description	No	Description	Perennial	Summer	Winter	Undifferentiated	Total
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	22,15 (4)	1,26 (4)	3,49 (4)	55,09 (4)	81,99
					Paswane Dam site	2,59	8,08	1,45	14,10	27,03
					Luvuvhu at Mutale	4,10 (1)	0,55 (1)	0,00	0,00	4,65
					Luvuvhu at Limpopo	0,00	0,00	0,00	0,00	0,00
				A92	Mutale at Luvuvhu	4,61 (1)	13,35 (1)	47,84 (1)	9,44 (1)	75,24
Total in Luvuvhu River catchment						**33,45**	**23,24**	**52,78**	**79,44**	**188,91**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	56,85 (2)	0,00	0,00	0,00	56,85
					Groot Letaba at Molototsi	132,05 (4)	0,00	0,00	0,00	132,05
					Molototsi	1,60 (1)	0,00	0,00	0,00	1,60
					Groot Letaba at Klein Letaba	0,00	0,00	0,00	0,00	0,00
				B82	Middle Letaba Dam	35,59 (3)	0,00	0,00	0,00	35,59
					Klein Letaba at Tabaan	0,80 (2)	0,00	0,00	0,00	0,80
					Klein Letaba at Groot Letaba	12,89 (2)	0,00	0,00	0,00	12,89
				B83	Letaba at Olifants	0,00	0,00	0,00	0,00	0,00
Total in Letaba River catchment						**239,78**	**0,00**	**0,00**	**0,00**	**239,78**
		B9	Shingwedzi	B90	Mphongolo	3,90 (1)	0,00	0,00	0,00	3,90
					Shingwedzi	0,90 (1)	0,00	0,00	0,00	0,90
Total in Shingwedzi River catchment						**4,80**	**0,00**	**0,00**	**0,00**	**4,80**
Total in Luvuvhu / Letaba WMA						**278,03**	**23,24**	**52,78**	**79,44**	**433,49**

* (1) Flood irrigation
(2) Sprinkler system
(3) Drip systems
(4) Micro systems

3.5.3 Dryland Agriculture

Except for sugarcane, the water use of all the other dryland crops produced in South Africa is considered to be adequately accounted for in the surface water runoff used to estimate the water resources. Because of the considerable annual variation in dryland cultivation (due to climatic conditions), reliable dryland data are also not always readily available. According to preliminary investigation, dryland sugarcane is the most significant dryland crop affecting runoff, and therefore it was included in this study. For completeness, total areas of dryland cultivation were obtained from the CSIR Landcover Spacemaps (CSIR, 1999) and the areas of dryland sugarcane were subtracted from these to obtain the areas of other dryland crops shown in Table 3.5.3.1. These values serve only to give an indication of the total areas of dryland cultivation and needs to be used with caution. No sugarcane is cultivated in the Luvuvhu/Letaba WMA.

TABLE 3.5.3.1: AREAS OF DRYLAND CROPS

Catchment						Dryland Crops (km^2)
Primary		Secondary		Tertiary		
No	Description	No	Description	No	Description	Other*
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	0,0
					Paswane Dam site	0,0
					Luvuvhu at Mutale	0,0
					Luvuvhu at Limpopo	0,0
				A92	Mutale	0,0
Total in Luvuvhu River catchment						**0,0**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	0,0
					Groot Letaba at Molototsi	0,0
					Molototsi	0,0
					Groot Letaba at Klein Letaba	0,0
				B82	Middle Letaba Dam	0,0
					Klein Letaba at Tabaan	0,0
					Klein Letaba at Groot Letaba	0,0
				B83	Letaba at Olifants	0,0
Total in Letaba River catchment						**0,0**
		B9	Shingwedzi	B90	Mphongolo	0,0
					Shingwedzi	0,0
Total in Shingwedzi River catchment						**0,0**
Total in Luvuvhu / Letaba WMA						**0,0**

3.5.4 Livestock and Game Farming

Cattle are the most popular form of livestock in the Luvuvhu/Letaba WMA and are mainly reared for meat. Sheep and goats are kept in relatively small numbers, due to the hot climate, and the largest numbers are kept in the former Venda, Gazankulu and Lebowa. Intensive sheep farming is practiced by very few farmers on cultivated pastures mainly for wool and meat.

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, Eland and Rhino. The southern catchments are more popular for game farming as they are in the traditional cattle farming areas. Table 3.5.4.1 gives the numbers of livestock and game and 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 commercial forestry plantations wihtin the Luvuvhu/Letaba WMA measure about 65 400 ha. The distribution of forests is largely governed by climatic factors. They are confined to the wet mountain zones as shown in Figure 3.5.1.1. The majority of afforestation occurs in the Letaba secondary catchment where forests are confined to the upper reaches of the Groot Letaba, Letsitele, Middel Letaba and Klein Letaba River catchments.

A relatively small section, about 2 120 ha, of exotic afforestation has been established in the Mutale River catchment as part of the Thate Vondo plantation.

There are no forest areas in the Shingwedzi River catchment.

Afforestation occurs mainly in the higher lying areas in the Soutpansberg Mountain Range within the Luvuvhu catchment.

Indingenous forests occur in steep inaccessible ravines and mountainous areas.

In the Letaba secondary catchment indigenous forests are confined mainly upstream of Tzaneen Dam and concentrations also occur in the Letsitele and Thabina River catchments.

Table 3.5.5.1 shows afforestation and indigenous forest areas per keypoint.

TABLE 3.5.4.1: LIVESTOCK AND GAME

Catchment						Numbers of livestock and game*					No of ELSU
Primary		Secondary		Tertiary							
No	Description	No	Description	No	Description	Cattle & horses	Small livestock	Big game	Large antelope	Small antelope	
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	4 414	6 632	0	73	367	9 368
					Paswane Dam site	0	0	0	0	0	0
					Luvuvhu at Mutale	0	0	0	0	0	0
					Luvuvhu at Limpopo	0	0	0	0	0	0
				A92	Mutale at Luvuvhu	0	0	0	0	0	0
Total in Luvuvhu River catchment						**4 414**	**6 632**	**0**	**73**	**367**	**9 368**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	4 834	6 518	0	0	0	8 363
					Groot Letaba at Molototsi	3 045	4 105	0	0	0	5 268
					Molototsi	0	0	0	0	0	0
					Groot Letaba at Klein Letaba	1 311	1 768	0	0	0	2 268
				B82	Middle Letaba Dam	1 305	1 760	0	0	0	2 258
					Klein Letaba at Tabaan	2 321	3 130	0	0	0	4 016
					Klein Letaba at Groot Letaba	1 748	2 357	0	0	0	3 025
				B83	Letaba at Olifants	1 311	1 768	0	0	0	2 268
Total in Letaba River catchment						**15 875**		**21 405**	**0**	**0**	**27 466**
		B9	Shingwedzi	B90	Mphongolo	0	0	0	0	0	0
					Shingwedzi	662	758	0	22	11	1 134
Total in Shingwedzi River catchment						**662**		**758**	**0**	**22**	**1 134**
Total in Luvuvhu / Letaba WMA						**20 951**		**28 795**	**0**	**95**	**37 968**

- Data on game populations is very limited and therefore the information given in the table must be used with caution.
  Game in Nature Reserves not accounted for.

TABLE 3.5.5.1: AREAS OF AFFORESTATION AND INDIGENOUS FOREST

Catchment						Areas of afforestation	Areas of indigenous forest
Primary		Secondary		Tertiary			
No	Description	No	Description	No	Description	Total (km^2)	(km^2)
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	90,6	11,2
					Paswane Dam site	39,9	0,8
					Luvuvhu at Mutale	3,3	0,0
					Luvuvhu at Limpopo	34,8	0,0
				A92	Mutale	0,0	0,0
Total in Luvuvhu River catchment						**168,6**	**12,0**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	354,3	39,0
					Groot Letaba at Molototsi	60,4	31,2
					Molototsi	2,7	0,0
					Groot Letaba at Klein Letaba	0,0	0,0
				B82	Middle Letaba Dam	43,9	12,7
					Klein Letaba at Tabaan	22,9	0,0
					Klein Letaba at Groot Letaba	0,0	0,0
				B83	Letaba at Olifants	0,0	0,0
Total in Letaba River catchment						**484,2**	**82,9**
		B9	Shingwedzi	B90	Mphongolo	1,2	0,0
					Shingwedzi	0,0	0,0
Total in Shingwedzi River catchment						**1,2**	**0,0**
Total in Luvuvhu / Letaba WMA						**654,0**	**94,9**

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 5 to 10 years, resulting in the loss of much, or possibly even all, of the available water in certain catchment areas. Again, this is a debatable point requiring more research to verify these statements.

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

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 (Environmental) 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 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 Görgens (1998):

- The quality of data gathered is known to be variable as it depended on the level of expert knowledge available, the nature of the terrain and the extent and complexity of the actual invasion.
- Mapping of alien vegetation ending very abruptly (and artificially) along some or other administrative boundary.
- Mapping of riparian infestations along rivers at the coarse scale of the available GIS coverages (generally, 1:500 000 with 1:250 000 for some areas) could have led to significant under-estimates of river lengths and, therefore, of infested riparian areas. For example, a pilot comparison by the CSIR of 1:50 000 scale (a suitable scale) and 1:500 000 scale maps yielded a river length ratio of 3,0 and greater.

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

TABLE 3.5.6.1: INFESTATION BY ALIEN VEGETATION

Catchment						Alien vegetation
Primary		Secondary		Tertiary		
No	Description	No	Description	No	Description	Condensed Area (km^2)
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	167,8
					Paswane Dam site	12,2
					Luvuvhu at Mutale	1,6
					Luvuvhu at Limpopo	4,8
				A92	Mutale at Luvuvhu	1,0
Total in Luvuvhu River catchment						**187,4**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	52,6
					Groot Letaba at Molototsi	26,6
					Molototsi	1,6
					Groot Letaba at Klein Letaba	0,4
				B82	Middle Letaba Dam	12,7
					Klein Letaba at Tabaan	0,4
					Klein Letaba at Groot Letaba	2,4
				B83	Letaba at Olifants	1,7
Total in Letaba River catchment						**98,4**
		B9	Shingwedzi	B90	Mphongolo	0,0
					Shingwedzi	1,3
Total in Shingwedzi River catchment						**1,3**
Total in Luvuvhu / Letaba WMA						**287,1**

3.5.7 Urban Areas

The urban areas are small in relation to other land use in the WMA and occur mainly in the central and western parts of the WMA. The main urban areas include Tzaneen and Nkawakowa in the Groot Letaba River catchment, Giyani in the Klein Letaba catchment and Thoyandou in the Luvuvhu River catchment. The urban areas mentioned are proclaimed towns, but denser settlements having urban characteristics have also developed in areas near the towns. The urban population is about 10% of the rural population.

The rural population is resident in about 1 000 villages located throughout the WMA. The villages are well structured and laid out in formal plots.

The location of the urban areas is shown in Figure 3.5.1.1.

3.6 MAJOR INDUSTRIES AND POWER STATIONS

There are no industries in the Luvuvhu/Letaba WMA, which can be described as major or wet industries. There is however several small industries located outside the urban areas in the vicinity of Tzaneen which use water drawn mainly from the Groot Letaba River and include:

	Use ($10^6 m^3/a$)	**Allocation ($10^6 m^3/a$)**
Letaba Citrus Processors	0,24	0,24
Koedoe Co-operative	0,002	0,1
Addington Farms	0,004	0,05
Northern Canners	0,25	0,66

The latter is located in Politsi (population <100) and the water use includes domestic water use.

There are no power stations in the Luvuvhu/Letaba WMA.

3.7 MINES

3.7.1 Introduction

Mining operations in South Africa encompass a wide range of activities, which include the dressing, and beneficiation 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 operations include underground and surface mines, quarries and the operation of oil and gas wells.

Products of the mining industry in the Luvuvhu/Letaba Water Management Area include precious metals (gold) and industrial minerals (coal).

All known operating mines in the Luvuvhu/Letaba WMA are shown on Figure 3.7.1 and listed in Appendix D. Mines that 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 highlighted.

For summarising mining impacts the Luvuvhu/Letaba WMA has been divided into three sub-catchments, viz.:

- Luvuvhu / Mutale River catchment
- Letaba River catchment
- Shingwedzi 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 sub-catchment areas listed. Quantitative information is given in Chapter 5.

3.7.2 Luvuvhu/Mutale River Catchment

The Tshikondeni coal mine and the Geocapro Magnesite mine are the only mining activities in this area. Mining operations in this area do not significantly impact on the hydrology or water quality of the Luvuvhu/Mutale system as the water use is low. However, the impact of coal and magnesite mining on the economy of this area is significant, as it is one of the only major industries offering employment in this remote area.

3.7.3 Shingwedzi River Catchment

Several small gold mines were developed in the southwestern part of the Shingwedzi River catchment and include New Union, Fumani and Gemsbok. The mines have limited impact on the local economy and have indeed all been closed down in recent years. The mines utilize ground water from local boreholes and do not impact significantly on the hydrology or water quality of the Shingwedzi catchment as the water use is low.

3.7.4 Letaba River Catchment

Several small gold, antimony and magnesite mines have been developed in the northern part of the Letaba River catchment and include: Schiel, Louis Moore, Palakop, Klein Letaba and Lemonde.

The mines have limited impact on the local economy and have indeed all been closed down in recent years. The mines utilize groundwater from local boreholes and do not have any impact on the hydrology or water quality of the Klein Letaba River as the water use is low.

The Consolidated Murchison Gold Mine is located in the Olifants River WMA, but obtains its water supplies from the Groot Letaba River. The allocation from the river is about 1,75 million m^3/a and therefore the impact on the hydrology of the river is not significant.

CHAPTER 4: WATER RELATED INFRASTRUCTURE

4.1 OVERVIEW

Several bulk water schemes transfer water out of the Luvuvhu/Letaba WMA. No schemes transfer water into the WMA from adjacent WMA's. The schemes include (refer to Appendix E and Figure 4.1.1):

- Dap Naude Dam to Polokwane Municipal area (Limpopo WMA)
- Ebenezer Dam to Polokwane Municipal area (Limpopo WMA)
- Nkowakowa / Ritavi to villages in the Selati catchment (Olifants WMA)
- Thabina Dam to villages in the Selati catchment (Olifants WMA)
- Groot Letaba River to Consolidated Murchison Gold mine (Olifants WMA)
- Albasini Dam to Louis Trichardt (Limpopo WMA)

All the transfer schemes draw water from the Groot Letaba River system, except for the Albasini Dam scheme, which is located on the Luvuvhu River.

A large number of regional water supply schemes, which are located within the Luvuvhu/Letaba WMA, have been developed to supply water for domestic, irrigation and industrial purposes (refer to Annexure E). Many of these schemes transfer water across tertiary catchment boundaries and these include (refer to Figure 4.1.1):

- Giyani Regional scheme: Nsami Dam (Klein Letaba River catchment) to villages in the Groot Letaba River and Shingwedzi River catchments.
- Middle Letaba Regional scheme: Middle Letaba Dam (Klein Letaba River catchment) to villages in the Luvuvhu River and Groot Letaba River catchments.
- Malamulele west Regional scheme (Klein Letaba River catchment) to villages in the Luvuvhu River catchment.
- Vondo Dam Regional scheme (Luvuvhu River catchment) to villages in the Klein Letaba River catchment.
- Malamulele Regional scheme (Luvuvhu River catchment) to villages in the Shingwedzi River catchment.

Surface water resources are extensively developed with a large number of small to major dams constructed to meet domestic (urban and rural), irrigation and industrial water needs. The water supply schemes generally comprise of dams for storage, bulk water pipelines and canals for conveyance. Potential for further water resources development is limited, except on the Luvuvhu River and Groot Letaba River.

The groundwater resources are also extensively developed to meet domestic water supplies in rural villages and for irrigation, particularly in the Middle Letaba River catchment and upper Luvuvhu River catchment. The groundwater schemes generally comprise dispersed borehole schemes.

Table 4.1.1 shows the combined capacities of potable water supply schemes by key area.

Yields of major dams in the WMA were obtained mainly from information determined in the various River Basin Studies. More accurate information was however also obtained from several more detailed feasibility studies and pre-feasibility studies and these included Luvuvhu River Dam Feasibility Study, Groot Letaba River Water Resources Study and Klein and Middle Letaba Rivers Reconnaissance Study. Groundwater availability information was obtained from regional groundwater assessment studies.

No hydro-electric or pumped storage power stations have been constructed in the Luvuvhu/Letaba WMA and none are planned.

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

Catchment						Area (km^2)	Population	Town and Regional water supply schemes		
Primary		Secondary		Tertiary				No of people supplied	% of drainage area population	Capacity ($10^6 m^3/a$)
No	Description	No	Description	No	Description					
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	889	59 820	12 199	20	1,86
					Paswane Dam site	1 209	330 600	201 105	61	20,99
					Luvuvhu at Mutale	1 020	46 740	33 283	71	
					Luvuvhu at Limpopo	669	0	0		
				A92	Mutale at Luvuvhu	2 154	80 470	75 561	94	1,61
Total in Luvuvhu River catchment						**5 941**	**517 630**	**322 148**		
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	650	8 312	0		15,33
					Groot Letaba at Molototsi	2 553	293 450	169 245	58	14,02
					Molototsi	1 181	144 150	92 575	64	
					Groot Letaba at Klein Letaba	568	15 310	7 785	51	
				B82	Middle Letaba Dam	1 805	140 650	78 926	56	8,76
					Klein Letaba at Tabaan	1 183	128 900	28 178	22	
					Klein Letaba at Groot Letaba	2 465	149 800	96 389	64	12,26
				B83	Letaba at Olifants	3 264	3 691	0		
Total in Letaba River catchment						**13 669**	**884 263**	**473 099**		
		B9	Shingwedzi	B90	Mphongolo	2 903	80 130	85 885	107	
					Shingwedzi	2 407	52 040	13 354	26	
Total in Shingwedzi River catchment						**5 310**	**132 170**	**99 239**		
Total in Luvuvhu / Letaba WMA						**24 920**	**1 534 063**	**894 486**		

4.2 REGIONAL WATER SUPPLY SCHEMES

4.2.1 Groot Letaba System

The Groot Letaba system utilizes water from the Groot Letaba River and its tributaries to supply water to various towns including Pietersburg, Tzaneen, Haenertsburg, Duiwelskloof and to a number of villages. Extensive irrigation is also supplied with water from this system. The system covers mostly the tertiary catchment area B81 of the Luvuvhu/Letaba WMA and transfer of water occurs to the Limpopo WMA and Olifants WMA (see Diagram 4.2.1.1). The components (water schemes) making up this system are described below. The water treatment works associated with the system and their sources of raw water are shown in Table 4.2.1.1.

(i) Dap Naude Water Supply Scheme

This scheme draws water from the Dap Naude Dam, which is located in the upper reaches of the Broederstroom, tributary of the Groot Letaba River. It has a gross storage capacity of 2,1 million m^3 and a firm yield of 3,1 million m^3/a. The 1:50 year yield is 3,8 million m^3/a (DWAF, 1990).

The dam is owned by the Polokwane Municipality. Water from the dam is used for supply to Pietersburg only (refer to Diagram 4.2.1.1). Compensation water is released for irrigation in accordance with a Water Court ruling.

Raw water is conveyed over a distance of 60 km through a 572 mm and 419 mm OD steel pipeline to a 18 Mℓ/day treatment works and a service reservoir located at Pietersburg.

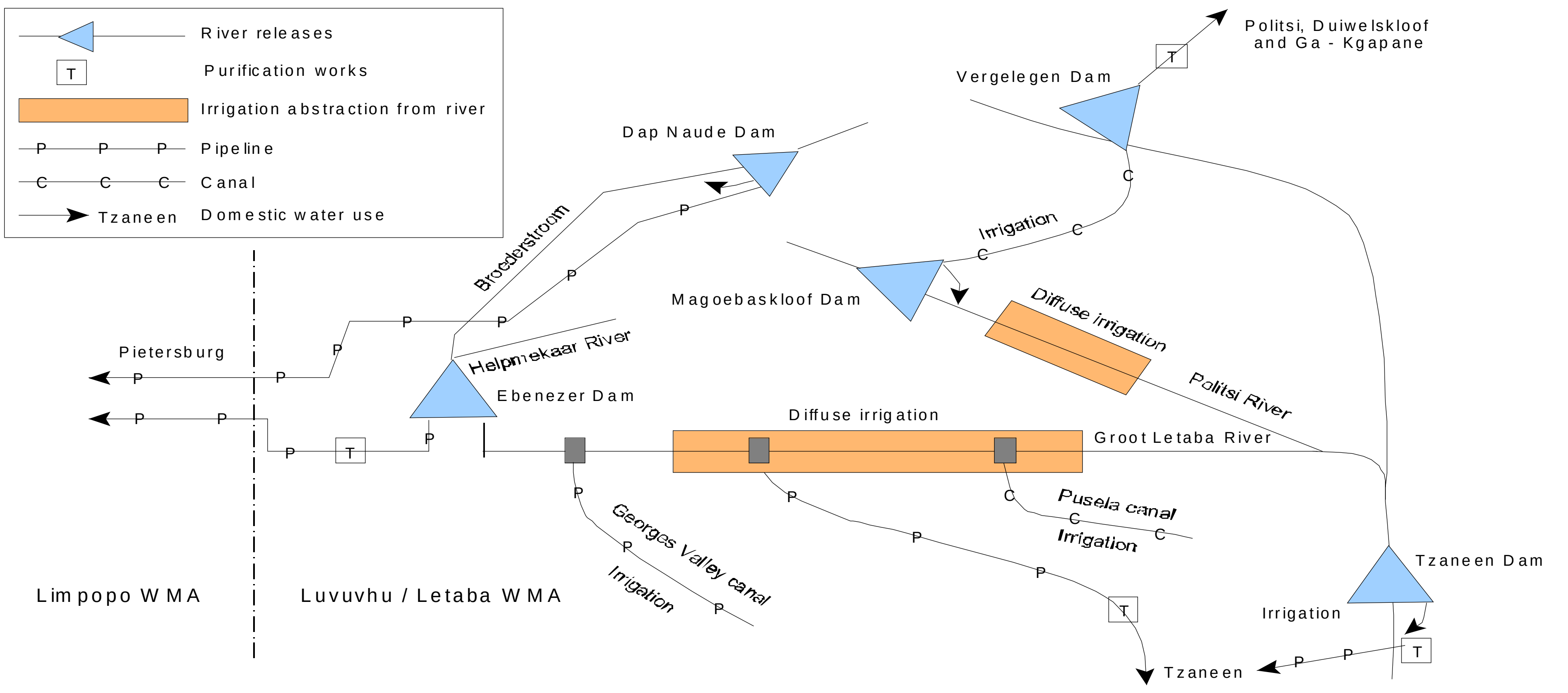
Approximately 70 ha are irrigated in the B81A catchment (in the 1950’s it was 300 ha), which is upstream of Ebenezer Dam. Water for irrigation is abstracted from farm dams constructed on the tributaries of the Broederstroom and Helpmekaar Rivers. No groundwater is used. Flow in the Broederstroom is regulated by releases from the Dap Naude Dam. Other dams include Stanford (capacity 0,32 million m^3) and Good Hope (capacity 0,8 million m^3) on the Helpmekaar River. The 1988 use was 0,3 million m^3/a.

(ii) Pietersburg Government Regional Water Supply Scheme

The Pietersburg Government Regional Water Supply Scheme (PGRWS) draws bulk water from Ebenezer Dam (gross storage capacity 70 million m^3 and firm yield 21,9 million m^3/a). Water is purified at a 42 Mℓ/day raw water treatment works located immediately downstream of the dam. Treated water is pumped through two 600 mm diameter pipelines (each 428 ℓ/s capacity – Lepelle Northern Water, 1999) to Mankweng, 20 km distant. From Mankweng water is pumped a further 22 km through a 600 mm diameter pipeline to Pietersburg (see Diagram 4.2.1.1).

This scheme is operated by Lepelle Northern Water and delivers water to Pietersburg, Seshego, Haenertsburg, Dalmada small holdings, Mankweng and numerous villages in the Mankweng area. The allocation from Ebenezer Dam for this scheme is 18,53 million m^3/a. Only $15 \times 10^6 m^3$/a is supplied due to infrastructure problems.

DIAGRAM 4.2.1.1: DAP NAUDE / EBENEZER / MAGOEBASKLOOF / TZANEEN DAM SYSTEM: SCHEMATIC LAYOUT



DAP NAUDE / EBENEZER / MAGOEBASKLOOF / TZANEEN DAM SYSTEM: SCHEMATIC LAYOUT

FIG 4.2.1.1

The remaining water in the dam is allocated for irrigation along the Groot Letaba River downstream of the dam and for Tzaneen. Water for irrigation is released from the dam and diverted further downstream into two canal systems at George's Valley weir and Pusela weir (see Diagram 4.2.1.1). The allocation amounts to 2,3 million m^3/a and 7,0 million m^3/a respectively. Pump irrigators draw water directly from the river and have an allocation of 4,6 million m^3/a. A weir located in the Groot Letaba River is used to divert some 1,2 million m^3/a to Tzaneen (see Diagram 4.2.1.1).

(iii) Magoebaskloof Dam Scheme

Raw water is drawn from the Magoebaskloof Dam located on the Politsi River, a major tributary of the Groot Letaba River, for domestic, industrial and irrigation use (see Diagram 4.2.1.1). The dam has a gross storage capacity of 5 million m^3.

A canal transfers water from the Magoebaskloof Dam to the Vergelegen Dam, from where Politsi, Duiwelskloof and Ga-Kgapane are supplied (see Diagram 4.2.1.1).

Irrigation water users draw water from the canal as well as from the Vergelegen Dam.

Westfalia Estates and Sapekoe in the B81B catchment obtain water from Hans Merensky Dam (capacity 1,23 million m^3) on the Ramadiepa River and directly from the river as well as from the Selokwe River and its tributaries. In addition, Sapekoe Estates has an allocation of 0,87 million m^3/a from Debengeni River (of which 0,6 million m^3/a is for irrigation), which is conveyed via a pipeline. Total area irrigated is 1 166 ha and water use 5,8 million m^3/a.

(iv) Vergelegen Dam Scheme

The Vergelegen Dam (capacity 0,3 million m^3) is mainly a balancing dam for accepting water from the Magoebaskloof Dam with some inflow from its own catchment.

Irrigation water is abstracted either directly from the dam basin and outlets or from a gravity pipeline. Irrigation use is estimated to be 3,2 million m^3/a.

Domestic and industrial water for Politsi, Duiwelskloof and Ga-Kgapane is drawn from the dam under gravity and conveyed to the purification works (4,93 Mℓ/day) located downstream of the dam. The water is then pumped to the Florida service reservoir near Duiwelskloof from where it is distributed.

(v) Tzaneen Dam Scheme

This scheme serves the irrigation demand along the Groot Letaba River valley, domestic and industrial water supply to Tzaneen, Nkowakowa, Letsitele, Consolidated Murchison Gold Mine, several other small industrial users and a large number of rural villages (see Diagram 4.2.1.1) (see also items viii, ix and x below).

The dam is located on the Groot Letaba River close to Tzaneen and has a gross storage capacity of about 157,6 million m^3 (DWAF, 1994).

Irrigation water is released to the Groot Letaba River from where it is either pumped directly from the river or abstracted using diversion weirs. The irrigation allocation is 105,2 million m^3/a.

Water for Tzaneen (allocation 2,4 million m^3 from Tzaneen Dam and 1,2 million m^3/a from Ebenezer Dam) is drawn directly from the dam and treated in a 6,6 Mℓ/day treatment works before being pumped to Tzaneen. Water for several other domestic and industrial users including Nkowakowa, Ritavi I, Letsitele, Murchison Gold Mine and a few other smaller users having an allocation of 7,13 million m^3 is released from the dam for abstraction from the river further downstream.

(vi) **Thapane Dam Scheme**

This scheme abstracts water from a weir in the river downstream of the Thapane Dam. The Thapane Dam is located on a tributary of the Groot Letaba River. Water is pumped to a 1,5 Mℓ/day treatment works. Treated water is pumped at 20 ℓ/s to a number of reservoirs through pipelines ranging from 200 mm dia to 90 mm dia. The total reservoir capacity is currently 3,6 Mℓ serving 21 villages. Various boreholes with a recommended combined abstraction rate of 1,4 Mℓ/day provide additional water to this area.

In addition, about 1 740 ha is irrigated in the upper reaches of the Nwanedzi and Hlangana Rivers by pumping from a number of farm dams, estimated to have a total combined storage capacity of about 10 million m^3. Some of the larger dams in the area are given in Table 4.2.1.2.

TABLE 4.2.1.2: LARGE DAMS IN THE AREA

Dam name	River	Capacity (million m^3)
De Marilac	Hlangana	0,95
Welverwacht	Hlangana	0,16
Taganashoek Dam	Taganaspruit	0,07
Jaffray	Rietbokspruit	0,16
Deer Park Dam	Nwanedzi	0,09
Modjadji 2	Trib. Nwanedzi	8,16
Duplex	Trib. Nwanedzi	0,13
Koekwe	Nwanedzi	0,32

(vii) **Thabina Dam Scheme**

The Thabina Dam is the source for the scheme. The dam has a capacity of 2,81 million m^3 and is located in the Thabina River, a tributary of the Letsitele River (a major tributary of the Groot Letaba River). The water is treated in a 6,9 Mℓ/day treatment works and is distributed through a number of pumpstations to 16 villages. The reservoirs situated at some of the villages have a combined capacity of 9,8 Mℓ. Pipe sizes range from 300 mm dia. to 100 mm dia. In addition, a large number of boreholes with a recommended abstraction rate of 14,13 Mℓ/day is available.

(viii) **Ritavi II Water Scheme**
Water is pumped directly from the Groot Letaba River and treated in a 24 Mℓ/day treatment works at Nkowakowa. It is distributed through various pumpstations and pipelines ranging from 450 mm dia to 90 mm dia and stored in 22 reservoirs having a combined capacity of 75 Mℓ, serving Nkowakowa, Dan and some 22 villages. In addition, groundwater supplies amounting to 3,0 Mℓ/day is available to 22 villages. Sewage from Nkowakowa is treated in the Nkowakowa sewerage treatment works, which has a capacity of 4,4 Mℓ/day.

(ix) **Ritavi I Water Scheme**
Water is drawn as run-of-river from the Groot Letaba River and treated in a 6 Mℓ/day treatment works at Nkamboko. The water is then pumped to six reservoirs (15,3 Mℓ) through 300 mm and 200 mm dia pipelines, currently serving 16 villages located on the northern side of the Groot Letaba River. The construction of a further four reservoirs and connecting pipework is planned as an extension to the scheme to serve a further 10 villages. Boreholes with a recommended yield of 3,5 Mℓ/day are also used.

(x) **Nondweni Water Scheme**
The supply area (5 villages) is currently served from boreholes with a recommended combined abstraction rate of 9,22 Mℓ/day. The water is pumped to 6 reservoirs with a combined capacity of 2,25 Mℓ. It is planned in future to provide 2,20 Mℓ/day from a proposed weir in the Groot Letaba River. Treatment works will also be constructed.

(xi) Letsitele Run-Of-River Irrigation
The Letsitele River is a major tributary of the Groot Letaba River. About 2 169 ha is scheduled for irrigation. Six canals currently supply run-of-river water to about 900 ha and the remaining area is irrigated from river pumps. About 1 600 ha are under permanent crops and receive a fairly assured supply of water. The remainder of the area is irrigated on an opportunistic basis.

In the lower reaches of the Thabina River, irrigation water is diverted by a weir into a canal on the right bank to irrigate some 193 ha. Impoundments on tributaries of the Thabina River including Rigo Dam (volume 1,30 million m^3) and Burgersfort Dam (volume unknown) are used to augment irrigation water supply.

TABLE 4.2.1.1: GROOT LETABA SYSTEM: BULK WATER SUPPLY INFRASTRUCTURE

Treatment works			Raw water source					
Name	Capacity (Mℓ/d)	Owner / operator	Name	1:50 Yield		Additional yield allocated to other users (10^6 m^3/a)	Owner	Operator
				10^6 m^3/a	Mℓ/day			
Pietersburg	18	Polokwane Municipality	Dap Naude Dam	3,8	10,4	Normal flow	Polokwane Municipality	Polokwane Municipality
Ebenezer	42	DWAF / LNW	Ebenezer Dam	18,53	50,8	15,1 to irrigation, Tzaneen(1)	DWAF	DWAF
Politsi	4,93	DWAF / LNW	Vergelegen Dam(2)	-	-	-	DWAF	DWAF
			Magoebaskloof Dam	1,365	3,7	6,8 to irrigation	DWAF	DWAF
Tzaneen	6,6	Tzaneen Municipality	Tzaneen Dam	2,4	6,6	106,3 to irrigation, industry, Nkowakowa and villages(1)	DWAF	DWAF
Thapane	1,5	DWAF	Thapane Dam	?		None	DWAF	DWAF
Thabina	6,9	DWAF	Thabina Dam	3,1	8,5	None	DWAF	DWAF
Nkowakowa	24	DWAF / LNW	Groot Letaba River, Tzaneen Dam	6,6	18,1	Irrigation, industry, Tzaneen, villages	DWAF	DWAF
Nkamboko	6	DWAF	Groot Letaba River, Tzaneen Dam	*	-	Irrigation, industry, Tzaneen, Nkowakowa, villages	DWAF	DWAF

(1) Includes run-of-river contribution
(2) Mainly a balancing dam
(3) Located adjacent to Pietersburg (A71A)
* Run-of-river

4.2.2 The Middle Letaba System

The Middle Letaba System utilizes water from the Koedoes, Middle Letaba, Brandboontjies and Nsami Rivers and their tributaries. These rivers all finally flow into the Klein Letaba River, which is a major tributary of the Letaba River. The water treatment works associated with the system and their sources of raw water are shown in Table 4.2.2.1. Table 4.2.2.2 shows the larger dams in the system.

Middle Letaba RWS

The Middle Letaba Dam (capacity 174 million m^3) delivers water to the Nsami Dam (capacity 24,4 million m^3) through a 60 km long water transfer concrete canal having a capacity of 4 m^3/s. On the left bank, irrigation plots have been developed alongside the canal and 11 pumpstations pump from the canal through a pipeline system to the field edge. A minimum flow has to be maintained in the canal to ensure sufficient head on the pumps. From Nsami Dam, a short canal (6 km) delivers water to irrigation plots on the left bank of the Nsami River, including 200 ha of bananas.

Other areas not linked to the system include the areas at Mabunda, the Melkplasies and Dumazi, where water is obtained directly from the Klein Letaba and Nsami Rivers. A total of 2 400 ha has been developed and equipped for irrigation. However, because of water shortages and the increased delivery of water to domestic users, the present area irrigated (including the other areas described above) is approximately 1 300 ha and the mean annual field edge requirement is estimated as 10,3 million m^3/a.

The Middle Letaba Regional Water Scheme has as its sources the Middle Letaba Dam and the Nsami Dam.

TABLE 4.2.2.1: MIDDLE LETABA SYSTEM: BULK WATER SUPPLY INFRA-STRUCTURE

Treatment works			Raw Water Source					
Name	Capacity (Mℓ/day)	Owner / operator	Name	Firm yield		Additional yield allocated to other users (10^6 m^3/a)	Owner	Opera= tor
				$10^6 m^3/a$	Mℓ/day			
Middle Letaba	24	DWAF	Middle Letaba Dam	17,8	48,8		DWAF	DWAF
Giyani	29,0	DWAF	Nsami Dam, Middle Letaba Dam	17,8	48,8	To irrigation and Giyani WTW.	DWAF	DWAF
Malamulele West	4,6	DWAF	Middle Letaba Dam (from transfer canal)	17,8	48,8		DWAF	DWAF

* Combined total system yield of Middle Letaba and Nsami Dams.

The bulk water supply scheme can be subdivided into three main sections, as described below:

- Villages supplied from a treatment works at the Middle Letaba Dam.

  Water is drawn from the Middle Letaba Dam, treated in a 24 Mℓ/day treatment works and then distributed through various pumped and gravity pipelines to 116 reservoirs with a combined capacity of 60 Mℓ. The scheme serves 89 villages.

- Villages supplied from a treatment works (Malamule West Water Works) located adjacent to the canal between Middle Letaba Dam and Nsami Dam.

  Water is released from the Middle Letaba Dam into a transfer canal that links with the Nsami Dam. Water is drawn directly from the transfer canal and treated in a 4,6 Mℓ/day treatment works after which it is pumped to 26 reservoirs serving 29 villages.

  Irrigators also abstract water from the transfer canal. At present some 1 300 ha (2 400 ha developed) is irrigated at a high risk of water supply failure.

- Villages supplied from the treatment works at Nsami Dam.

  Water from the Nsami Dam is treated in the Giyani WTW (capacity 29 Mℓ/day), from where it is distributed to 58 villages and Giyani Town. A series of pump and gravity pipelines feed the water to 75 reservoirs having a combined capacity of 88 Mℓ.

Development upstream of Middle Letaba Dam
Extensive irrigation occurs in the Middle Letaba River catchment (B82A, B82B, B82C and B82D) which is upstream of the Middle Letaba Dam, with the main crop being tomatoes. Crop rotation is being practised with land being left fallow for a period of about 3 years after the crop has been harvested. The area irrigated varies during the season, and it may be from 2 100 ha to 3 700 ha. Water is pumped directly from the river and from storage dams that have been built on the Brandboontjies, Koedoes and Middle Letaba Rivers, as listed in the table below.

During the drought of the 1980's, a large number of boreholes (320) were developed and annual groundwater usage may vary from 10% to 90% of the total irrigation usage, depending on surface water availability. On average, a 50/50 split between the sources may be accepted. Based on a planted area of 3 700 ha, the expected mean field edge water requirement is 19,5 million m^3/a.

TABLE 4.2.2.2: LIST OF DAMS IN UPPER MIDDLE LETABA RIVER AND ITS TRIBUTARIES

Dam name	River	Quat	Capacity (10^6 m^3)
Lorna Dawn	Middle Letaba	B82A	11,75
Jan van der Lith	Middle Letaba	B82A	4,5
Donkerval	Middle Letaba	B82A	1,7
Heuningplaas	Middle Letaba	B82A	0,44
Altenzur	Koedoes	B82B	0,9 (3,47*)
Dieplaagte	Gemsbokspruit	B82B	0,4
Fry	Koedoes	B82B	4,5
Van Zyl	Koedoes	B82B	2,2 (15*)
Jachtpad	Koedoes	B82B	1,88
Welgevonden	Koedoes	B82B	0,17
Calesio (Bloemfontein)	Mosukudutsi	B82B	1,7
Leeuwdraai	Brandboontjies (off channel)	B82C	0,25
Mooihoek 1	Lindersloop	B82C	0,42
Mooihoek 2	Lindersloop	B82C	0,16

Note (*): Capacity given in Dam Safety Office's database

4.2.3 The Luvuvhu/Vondo System

The Luvuvhu/Vondo System utilizes water from the Luvuvhu River and its tributaries, the Mutshindudi and Damani Rivers. Several major dams have been developed to augment water supply.

(i) **Vondo Regional Water Scheme**
The Vondo RWS draws its water from the Vondo Dam on the Mutshindudi River. The Vondo Dam has a storage capacity of 30,4 million m^3 and a firm yield of 13,3 million m^3. The firm yield was determined by operating the Frank Ravelle Dam (situated just above Vondo Dam), at its firm yield of 1,0 million m^3/a and supplying an additional 1,4 million m^3/a to Sapekoe Estates from Vondo Dam. The allocation is only applicable when storage in the dam is above 90% of full supply capacity. When the dam is below this level, then only 50% of the irrigation allocation is provided.

The water for domestic purposes is treated in the Phiphidi Treatment Works capable of treating 42 Mℓ/day.

When the plant is refurbished in the near future, it will be able to treat 47 Mℓ/day. Treated water is distributed to regional reservoirs having a combined storage capacity of 53 Mℓ. These serve three main areas: Donald Fraser (northern), Thohoyandou (central) and Vuwani (southern), consisting of 126 villages, including the Thohoyandou urban area. A small percentage of the water is transferred to villages in the Letaba River catchment.

(ii) **Tshakuma Regional Water Scheme**

The Tshakhuma Dam (storage capacity 2,1 million m^3) has a firm yield of 1,7 million m^3/a (DWAF, 1990). The treatment works (1,1 million m^3/a), pumping main and reservoir is the first phase of the Tshakhuma Scheme planned to serve 6 villages. The aim of this scheme is to reduce the dependency of the rural domestic demand of the area on the Vondo Scheme.

(iii) **Damani Regional Water Scheme**

The Damani Dam (net storage capacity 12,4 million m^3) has a firm yield of 6,4 million m^3/a) and was originally constructed to supply water to the Damani Coffee Estate which required 4,08 million m^3/a. It is now proposed to also utilize this dam in future for the proposed Damani RWS project for domestic supply.

Currently the area earmarked for the proposed Damani RWS consists of 27 villages of which most are at present supplied with water from the Vondo Scheme.

Water is currently stored in 7 reservoirs with a storage capacity of 4 Mℓ.

(iv) **Mhinga/Lambani Water Supply**

Water is drawn from a weir in the Luvuvhu River and treated in a package treatment plant near Mhinga and pumped to a 600 kℓ reservoir. This system currently serves 7 of the 20 villages in the area. Future phases are planned to serve the rest of them. About 0,35 million m^3/a is abstracted from the Luvuvhu River with shortages experienced during the drier months.

(v) **Malamulele East Regional Water Scheme**

Run-of-river water is abstracted from the Luvuvhu River near Malamulele and treated in a raw water treatment works located adjacent to the river. At present only 1,5 million m^3/a is available because of a lack of availability of water in the river, especially during the drier months. This scheme delivers water to about 55 villages. Most of the water abstracted and treated is transferred and used in the Shingwedzi River catchment.

(vi) **Albasini WS**

The Albasini Dam is located in the upper reaches of the Luvuvhu River and has a capacity of 25,6 million m^3. The dam supplies domestic water to Louis Trichardt in the Limpopo WMA, and augments irrigation water to downstream irrigation users. A water allocation of 2,5 million m^3/a has been made to Louis Trichardt and environs. However, only 1,6 million m^3/a has been available in the past. The scheduled area for irrigation is 1 845 ha having a quota of 19,4 million m^3. Water for irrigation downstream has not been released for the past decade. Irrigation downstream of Albasini Dam forms part of the Albasini Government Water Scheme and is linked to run-of-river abstraction from the Latonyanda River and from Tshakhuma Dam. Water supply for irrigation in this area is also obtained from the Mambedi Dam (capacity 7,0 million m^3/a) located on a tributary of the Luvuvhu River.

TABLE 4.2.3.1: LUVUVHU/VONDO SYSTEM: BULK WATER SUPPLY INFRASTRUCTURE

Treatment works			Raw Water Source					
Name	Capacity (Mℓ/day)	Owner / operator	Name	Firm yield		Additional yield allocated to other users (10^6 m^3/a)	Owner	Operator
				(10^6 m^3/a)	(Mℓ/day)			
Luvuvhu catchment								
Phiphidi	40	DWAF	Vondo Dam	13,3	36,4	1,4 to irrigation	DWAF	DWAF
Tshakuma	4,2	DWAF	Tshakuma Dam	1,7	4,6	Irrigation	DWAF	DWAF
Albasini	8,6	Louis Trichardt	Albasini Dam	1,6	4,4	-	DWAF	DWAF
Malamulele East	15,5	DWAF	Luvuvhu River	1,5	4,1	Irrigation	DWAF	DWAF
Mhinga	1,0	DWAF	Luvuvhu River	0,35*	1,0	-	DWAF	DWAF

* Run of river, with shortages experienced in dry months.

4.3 WATER SUPPLY INFRASTRUCTURE IN TERTIARY CATCHMENTS IN THE LUVUVHU/LETABA WMA

The Luvuvhu/Letaba WMA comprises five tertiary catchments, viz:

(i) The Groot Letaba River Catchment
(ii) The Klein and Middle Letaba River Catchment
(iii) The Luvuvhu River Catchment
(iv) The Mutale River Catchment
(v) The Shingwedzi Catchment

An overview of the water supply infrastructure in each of these catchments is given below.

4.3.1 The Groot Letaba River Catchment

The Groot Letaba River catchment includes the Groot Letaba River and tributaries of the Groot Letaba River including the Broederstroom, Politsi, Letsitele and Molototsi Rivers.

The Groot Letaba River catchment has a total population of about 461 000 and obtains water supplies from dams, run-of-river schemes and groundwater. The two main urban concentrations in this catchment include Tzaneen and Nkowakowa and smaller urban centres include Haenertsburg, Duiwelskloof, Ga-Kgapane and Lenyenye. These centres have yard connections with water borne sewage systems.

The remaining population is concentrated in a large number of villages scattered throughout mainly the central part of the catchment.

All the water supply schemes in the Groot Letaba River catchment except the Modjadji scheme, form part of the inter linked Letaba Regional Water Supply Scheme described in 4.2 above. The infrastructure between the schemes is not necessarily linked, but upstream infrastructure and water use impacts on water availability further downstream scheme components.

The Modjadji scheme however, utilizes water from the Molototsi River. It is located adjacent to the Groot Letaba River system in the B81 tertiary catchment area, but operates on its own without any significant effect on the Groot Letaba River system.

This scheme consists of 3 sub-schemes which draw water from the Modjadji Dam in the Molototsi River. Treated water from the Modjadji Water Treatment Works is then distributed to 52 villages through a series of pipelines either pumped or under gravity and stored in 4 reservoirs with a combined capacity of 19 Mℓ.

Some 50 ha is irrigated from Modjadji Dam (volume 8,16 million m^3, according to the Dam Safety Office) located on the Molototsi River.

The water schemes located in the Groot Letaba River catchment and having a dam as a source include Dap Naude Dam, Ebenezer Dam, Tzaneen Dam, Magobaskloof Dam, Thapane Dam, Thabina Dam, Letaba Regional Scheme, Nondweni weir and the Modjadji Scheme (refer to 4.2 above).

Water schemes with its source in the Groot Letaba River catchment, but which supply water users located outside its boundaries are Dap Naude Dam, Pietersburg Government RWS, Magoebaskloof Dam, Vergelegen Dam and Ritavi II Water Schemes (refer to 4.2 above).

Two schemes in the Middle/Klein Letaba River catchment supply water to villages located in the Groot Letaba River catchment (see Figure 4.1.1).

There are eight main dams in this catchment with a total storage capacity of 247,4 million m^3 (refer to Table 4.3.1).

The water is treated in 9 treatment plants with a total capacity of 91,9 Mℓ/day (refer to Table 4.2.1.1). Note that virtually all the water treated in the Ebenezer treatment works is exported out of the WMA.

TABLE 4.3.1: MAIN DAMS IN THE LUVUVHU/LETABA WMA

Name	Live storage capacity (10^6 m^3)	1:50 Year Yield Total (10^6 m^3)	Owner
Groot Letaba River catchment			
Dap Naude	1,9	3,8	Polokwane Municipality
Ebenezer	70,1	23,5	DWAF
Magoebaskloof	4,9	11,5	DWAF
Vergelegen	0,3	Dependent on transfer from Magoebaskloof	DWAF
Tzaneen	157,6	62,9	DWAF
Thabina	2,8	3,1	DWAF

Name	Live storage capacity (10^6 m^3)	1:50 Year Yield	Owner
		Total (10^6 m^3)	
Groot Letaba River catchment			
Thapane	Not available	Not available	Not available
Modjadji	8,2	Not available	Not available
Pioneer Dam	2,2	*	Kruger National Park
Engelhardt	3,8	*	Kruger National Park
Middle Letaba	184,2	24,1	DWAF
Nsami	23	0,26	DWAF
Lorna Dawn	4,7	1,7 estimate	Private
Vondo Dam	30	Not available	DWAF
Damani	12,4	Not available	DWAF
Albasini	29,7	Not available	DWAF
Mambedi River	7,2	Not available	Sapekoe
Makuleke Dam	13,0	Not available	Not available

* For ecology, yield unknown.

4.3.2 Klein and Middle Letaba River Catchment

The Klein Letaba River catchment consists of tertiary catchment area B82 and includes the catchments of the Middle Letaba River, Klein Letaba River and tributaries thereof such as the Koedoes River, Brandboontjies River and Nsami River.

The water schemes operating in this catchment are the Sekgopo and Tshitale/Sekgosese borehole schemes, the Middle Letaba “M”, “N”, “MW” and “A, B, C, D, E, F” water schemes.

Of the above schemes, the “M”, “N” and “A, B, C, D, E” schemes also supply potable water to other catchments, being Groot Letaba River and Luvuvhu/Vondo River catchments.

The water is mainly sourced from the Middle Letaba and Nsami Dams with a total combined storage capacity of 195 million m^3 (refer to Table 4.3.1).

Water is treated in three treatment plants with a capacity of 57,6 Mℓ/day (refer to Table 4.2.2.1).

The Middle Letaba/Nsami canal transfers water from the Middle Letaba Dam to the Nsami Dam and has a capacity of 4 m^3/s.

4.3.3 Luvuvhu River Catchment

The Luvuvhu River catchment consists of tertiary catchment A91 and includes catchments of the Luvuvhu River and its tributaries, including Mutshindudi River and Damani River.

The water schemes operating in this catchment are the Vondo RWS, Tshakuma and Damani RWS connected to the Vondo Scheme and the proposed Tshifudi and Mhinga Schemes.

The Malamulele West area is supplied from a source in the Middle Letaba River catchment. Part of the Mutale Scheme in the Mutale River Catchment also supplies water into this catchment.

The water is sourced from the Vondo and Phiphidi Dams, Tshahuma Dam, Damani Dam and boreholes. The main dams in the catchment have a total capacity of 44,8 million m^3 (refer to Table 4.3.1).

Water is treated at two existing treatment plants with a capacity of 46,1 Mℓ/day (refer to Table 4.2.1.1).

4.3.4 Mutale River Catchment

The Mutale River Catchment consists of tertiary catchment area A92 and includes catchments of the Mutale River, Mbodi River and tributaries thereof.

The water schemes operating in this catchment are the Mutale RWS and Masisi RWS.

(i) **Mutale RWS**
The Mutale Scheme draws water from a weir in the Mutale River, where it is treated in the 4,4 Mℓ/day Mutale Water Treatment Works and then pumped to a regional reservoir at Lukau. From here water is distributed to 130 villages within the catchment area of the Mutale River. Not all of the 130 villages are at present connected to the scheme and these rely on boreholes. A future extension of the scheme is planned in order to connect all the villages.

Water is stored in 14 reservoirs with a combined capacity of 12,7 Mℓ.

(ii) **Masisi RWS**
Currently 10 villages utilize boreholes for domestic water use. The Tshikondeni coal mine utilizes 1,5 Mℓ/day from a 0,23 million m^3 off-channel dam and from boreholes.

A proposed water scheme in this area will consist of an abstraction weir on the Mutale River, a treatment works and command reservoir.

4.3.5 Shingwedzi River Catchment

The Shingwedzi River catchment consist of tertiary catchment area A90 and comprises the catchments of tributaries of the Shingwedzi River.

Only one scheme operates in the catchment, being the Malamulele East RWS, which has its source as a weir in the Luvuvhu River situated in the Luvuvhu River catchment.

Water is treated in the Malamulele WTW having a capacity of 15,5 Mℓ/day (refer to Table 4.2.2.1).

According to information from the Basin Study, an area of 270 ha was being developed for irrigation in about 1988. Water was to be sourced from the Makuleke Dam on the Mphongolo River.

In the Madonsi Tribal Authority, 19 ha of vegetables are irrigated with water obtained from boreholes and directly from the Shingwedzi River.

4.4 IRRIGATION SCHEMES

Available details of controlled irrigation schemes are given in Table 4.4.1.

4.5 HYDRO-POWER AND PUMPED STORAGE

No hydro-power and pumped storage schemes exist in the Luvuvhu/Letaba WMA and no new possible schemes are investigated or planned for development.

TABLE 4.4.1: CONTROLLED IRRIGATION SCHEMES IN THE LUVUVHU/LETABA WMA

Scheme name	Scheduled area (ha)	Current irrigated area (ha)	Produce	Supply source	Quota (m^3/ha/a)	Present average annual use 10^6m^3/a	Infrastructure
Groot Letaba GWCA	13 282	20 000				107	
a. Georges Valley Canal	351	528	Avo's, Bananas, Mangoes	Groot Letaba River	6 617	50–100% of allocation	Diversion weir on Groot Letaba River (u/stream Tzaneen Dam), 19 km lined canal, max cap 0,196 cumec
b. Pusela Canal	813	1 224	Avo's, Bananas, Mangoes	Groot Letaba River	6 617	50 – 100% of allocation	Diversion weir on Groot Letaba River (u/stream Tzaneen Dam), 29 km main concr lined canal, max cap 1,06 cumec, 22,4 km secondary canal
b2. Pusela Canal	184	277	Avo's, bananas, mangoes	Groot Letaba River	8 915	50 – 100% of allocation	As above
c. Letaba Noord Canal	2 222	3 346	Citrus, bananas, avo's, mangoes, litchies, tobacco	Groot Letaba River	8 915	50 – 100% of allocation	Letaba Noord Canal Weir, (d/stream Tzaneen Dam, volume unkown), 43,2 km concr lined canal, max cap 2,6 cumec
c2. Letaba Noord Canal	729	1 098	Citrus, bananas, avo's, mangoes, litchies, tobacco	Groot Letaba River	10 896	50 – 100% of allocation	As above
d. N & N Canal	341	513	Citrus, bananas, avo's, mangoes, litchies, tobacco	Groot Letaba River	915	50 – 100% of allocation	N & N Weir, volume unknown, 35,4 km concrete lined main canal, max cap 1,59 cumec, 8,8 km secondary canal
d2. N & N Canal	938	1 412	Citrus, bananas, avo's, mangoes, litchies, tobacco	Groot Letaba River	10 896	50 – 100% of allocation	As above
e. Masalal Canal	726	1 093	Citrus, cotton, vegetables	Groot Letaba River	10 896	50 – 100% of allocation	Prieska Weir, volume 0,6 million cub m, 20 km unlined canal, cap unkown
f. Pump irrigators	1 776	2 674	Citrus, bananas, avo's, mangoes, litchies, tobacco	Groot Letaba River	6 617	50 – 100% of allocation	Directly from river channel
f2. Pump irrigators	859	1 293	Citrus, bananas, avo's, mangoes, litchies, tobacco	Groot Letaba River	8 915	50 – 100% of allocation	As above
f3. Pump irrigators	4344	6 541	Citrus, bananas, avo's,	Groot Letaba River	10 896	50 – 100% of	As above

Scheme name	Scheduled area (ha)	Current irrigated area (ha)	Produce	Supply source	Quota (m^3/ha/a)	Present average annual use 10^6m^3/a	Infrastructure
			mangoes, litchies, tobacco			allocation	
Politsi GWCA	1 672	1035	Avo's, tea, bananas, citrus, pecan nuts, other subtropical fruits	Magoebaskloof Dam	6 600	40 – 80% of allocation**	Magoebaskloof Dam (on Politsi), volume 5,6 million cub m, 15 km concrete canal to Vergelegen Dam (on Ramadiepa)
Letsitele Irrigation District (including the Damara I.D.)	2 125	2 485	Mangoes, litchis, citrus, bananas, paw-paw	Letsitele River	Not known	14,9 (estimate)	Three separate canal systems abstraction directly from rivers, pumped extractions (used directly or the storage dams)
Albasini GWS	1 845	Not known	Avo's, bananas, citrus, mangoes and subtropical fruits	Luvuvhu River and trib Barotta and Latonyanda	Not known	Not known	Albasini Dam (volume 25,6 million cub m), Tshakhuma Dam (volume 2,1 million cub m) and weirs on Luvuvhu, Latonyanda, Barotta and an extensive system of interlinking canals

CHAPTER 5: WATER REQUIREMENTS

5.1 WATER USE SUMMARY

Development and population growth have brought increasing pressure to bear on the resources of the Luvuvhu/Letaba 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 have their own needs, norms and expectations and have for the most part, followed a course of independent and *ad hoc* water resource development.

Except for the Ecological Reserve, agriculture is by far the largest water use sector in the Luvuvhu/Letaba WMA, followed by the afforestation and domestic water sector. The water requirements per user group are shown in Table 5.1.1. 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 and the water use/requirements are therefore also shown, at a 1:50 assurance level.

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)	309,1	158,6
Domestic (2)	26,85	32,87
Bulk water use (3)	1,1	1,1
Neighbouring States	0,0	0,0
Agriculture (4)	259,6	232,6
Afforestation	69,6	42,87
Alien vegetation	39,7	21,57
Water transfers (5)	13,45	13,45
Hydropower	0,0	0,0
TOTALS	**719,4**	**503,03**

(1) For rivers in WMA at confluences with Limpopo River, excluding main stem.
(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, livestock and game.
(5) Only transfers out of the WMA are included.

5.2. ECOLOGICAL COMPONENT OF THE RESERVE

5.2.1 Introduction

The classification of the main stem rivers in the vicinity of the outlets of the quaternary catchments is described in Section 2.6.3. On the basis of this classification, a so-called desktop method has been developed (Hughes and Münster, 1999) to provide a low-confidence estimate of the 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. 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 Luvuvhu/Letaba Water Management Area fall within the so-called 17, 18, 19 regions (Eastern Escarpment, Lowveld and Castern Foothills respectively).

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

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

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

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

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

- The seasonal distributions of the annual estimates of water requirements are based on analyses of the base flow characteristics of some 70 rivers using daily data, the results of which were then regionalised. Some individual quaternary catchments that have been allocated to a specific region may however, have somewhat different characteristics.
- Similarly, the regional parameters for the assurance rule curves have been based on the duration curve characteristics of the natural flow regimes represented by the monthly time series of flow described in Section 6.3 and some experience of setting assurance rules used at past IFR workshops. Regionalising was done by investigating a representative sample of quaternary catchments and it is therefore possible that some have been assigned to the wrong regions.
- The estimates of water required for the ecological component of the Reserve are the best estimates that can be given at this stage, but must be regarded as low confidence estimates. As more detailed estimates are made for a wider range of rivers, the estimates will be improved through modifications made to the delineation of the regions and the regional parameters that have been assigned. It is also anticipated that a better way of accounting for regional or site specific ecological considerations will be added in due course.

5.2.3 Comments on the Results

The Luvuvhu/Letaba WMA has 45 quaternary catchments of which three are considered to be of Present Ecological Status Class A, 11 of Status Class B, 16 of Status Class C and 15 of Status Class D.

The catchments having a Present Ecological Status Class A rating occur in the upper reaches of the Mutale River and the lower reaches of the Shingwedzi River in the KNP. The remainder of the Shingwedzi River quaternary catchments are considered to be of Status Class B, excepting for one upstream catchment, which is Status Class C.

It is estimated that the ecological water requirement for PESC in the middle and lower reaches of the Luvuvhu River and the Mutale River amounts to more than 25% of the virgin MAR and this situation also applies to limited quaternary catchments in the Groot Letaba River catchment. The ecological water requirements for PESC in the remainder of the quaternary catchments is generally in the order of 10% to 20% of the virgin MAR.

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 considered key points coincide with catchment or sub-catchment outlets. The selected areas of interest are taken from the list in Chapter 7.

Intra-quaternary variation in class and state is possible and there may be intra-tertiary or intra-key point variations. Appendix F1 of this report contains related information for each of the quaternary catchments.

TABLE 5.2.4.1: WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE

Catchment						**Present Ecological Class**	**Ecological Water Requirements for PESC**		
Primary		**Secondary**		**Tertiary**			**% of Virgin MAR**	**Quantity 10^6 m^3 /a**	**Impact on 1:50 yr yield+ (10^6 m^3/a)**
No	**Descrip=tion**	**No**	**Descrip=tion**	**No**	**Description**				
A (Part)	Limpopo	A9	Luvuvhu /Mutale	A91	Luvuvhu at Levubu	D	18,3	20,8	4,6
					Paswane Dam site	C	27,6	90,5	14,9
					Luvuvhu at Mutale	C	24,9	89,7	0,0
					Luvuvhu at Limpopo	C	31,8	165,1	43,1
				A92	Mutale at Luvuvhu	B	18,2	28,5	67,3
Total in Luvuvhu River catchment								**165,1**	**129,9**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	D	20,2	16,1	21,7
					Groot Letaba at Molototsi	D	18,6	39,5	3,4
					Molototsi	D	7,3	1,7	0,0
					Groot Letaba at Klein Letaba	C	25,1	60,5	0,0
				B82	Middle Letaba Dam	D	9,9	7,1	3,6
					Klein Letaba at Tabaan	C	14,2	16,1	0,0
					Klein Letaba at Groot Letaba	B	18,8	28,6	0,0
				B83	Letaba at Olifants	B	29,8	129,4	0,0
Total in Letaba River catchment								**129,4**	**28,7**
		B9	Shing=wedzi	B90	Mphongolo	B	12,4	4,4	0,0
					Shingwedzi	A	16,9	14,6	0,0
Total in Shingwedzi River catchment								**14,6**	**0,0**
Total in Luvuvhu/Letaba WMA								**309,1**	**158,6**

+ Values from WSAM: to be verified

5.2.5 Discussion and Conclusions

There is a large variation in the Present Ecological Status Class throughout the Luvuvhu/Letaba WMA. The PESC normally decreases downstream through urban and rural areas. The % of Virgin MAR varies from approximately 32% for the Luvuvhu River at the Limpopo River to the lowest % of about 7% in the Molototsi River. The overall estimated quantity for the WMA is 300 million m^3/a. This amounts to an estimated 30% of the Virgin MAR of the catchment.

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 generally have full 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 95% of the population, generally has 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 resident in relatively densely populated areas and has high population growth rates. This group has 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 of water use by this sector is shown in Figure 5.3.1.1. The urban water requirement amounts to about 4,6 million m^3/a for the Luvuvhu/Letaba WMA. The highest urban water use occurs in the Tzaneen area in the Groot Letaba River catchment.

The rural domestic water use amounts to about 28,25 million m^3/a for the Luvuvhu/Letaba WMA.

The water use is approximately evenly distributed across the WMA. The human reserve, which amounts to the basic water need, is included in the combined urban and rural water use.

TABLE 5.3.1.1: URBAN AND RURAL DOMESTIC WATER REQUIREMENTS IN 1995

Catchment						Urban* requirements (10^6 m^3 /a)	Rural domestic water (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)	Human reserve (10^6 m^3 /a)
Primary		Secondary		Tertiary						
No	Description	No	Description	No	Description					
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	0,18	0,84	1,02	1,18	0,55
					Paswane Dam site	1,62	4,64	6,26	7,42	3,02
					Luvuvhu at Mutale	0,00	0,75	0,75	0,94	0,43
					Luvuvhu at Limpopo	0,00	0,00	0,00	0,00	0,00
				A92	Mutale at Luvuvhu	0,00	1,29	1,29	1,62	0,73
Total in Luvuvhu River catchment						**1,80**	**7,52**	**9,32**	**11,16**	**4,73**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	0,03	0,02	0,04	0,19	0,08
					Groot Letaba at Molototsi	1,28	4,20	5,48	6,61	2,68
					Molototsi	0,08	2,28	2,36	2,93	1,32
					Groot Letaba at Klein Letaba	0,00	0,22	0,22	0,31	0,14
				B82	Middle Letaba Dam	0,81	1,87	2,67	3,18	1,28
					Klein Letaba at Tabaan	0,00	2,02	2,02	2,59	1,18
					Klein Letaba at Groot Letaba	0,47	2,05	2,52	3,10	1,37
				B83	Letaba at Olifants	0,00	0,10	0,10	0,16	0,03
Total in Letaba River catchment						**2,67**	**12,75**	**15,41**	**19,07**	**8,08**
		B9	Shingwedzi	B90	Mphongolo	0,13	1,17	1,30	1,60	0,73
					Shingwedzi	0,00	0,82	0,82	1,04	0,47
Total in Shingwedzi River catchment						**0,13**	**1,99**	**2,12**	**2,64**	**1,20**
Total in Luvuvhu/Letaba WMA						**4,60**	**22,26**	**26,85**	**32,87**	**14,01**

* Includes only direct urban use.

Note: The values in this table do not include water losses.

5.3.2 Urban

Introduction

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

Methodology

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

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

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

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

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

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

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

Category		Water Use ℓ/c/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 5.3.2.2.

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

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

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

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

Urban Centre Classification	Commercial	Industrial	Institutional	Municipal
Metropolitan Cities Towns Industrial Towns Isolated	0,2	0,3	0,15	0,08
Towns Special	0,30	0,15	0,08	0,03
Towns Country	0,10	0,15	0,03	0,10
New Centres	0,15	0,08	0,08	0,08

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

Water Requirements

The main urban areas with a high level of water supply services include Tzaneen – Duiwelskloof – Nkowakowa, Giyani and Thohoyandou.

Tzaneen – Duiwelskloof have mainly residents of first world development with extensive gardening development and significant commercial and industrial activity. The all-in unit water use is therefore high, particularly in view of the frost free climatic conditions. The potential for reduced water use during periods of drought is significant (probably better than 20%) due to the high unit water use.

The theoretical unit water use in the Nkowakowa, Giyani and Thohoyandou urban areas is probably in the order of 110 ℓ/c/day to 140 ℓ/c/day due to the lower level of development. Garden water needs is considerably lower and the commercial and industrial activity is low. As a consequence, the potential reduction in water use during periods of drought in terms of ℓ/c/day is relatively low (probably about 20 – 40 ℓ/c/day).

Water Losses

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

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 5,5% of the urban water use within the WMA, which implies a total loss of 0,4 million m^3/a for the WMA.

Losses in the water distribution system are 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 1,9 million m^3/a.

Return Flows

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

Effluent 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 3,87 million m^3/a.

Return flow due to impervious urban areas, create additional rainfall run off. The urban areas in this WMA are relatively small and, though the imperiousness of these areas are higher than for undisturbed veld, the increase in annual volume of runoff is negligible.

TABLE 5.3.2.4: URBAN WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

Catchment						Urban Water Requirements							Total at 1:50 yr assurance ($10^6m^3/a$)	Return flows (10^6 m^3 /a)			
Primary		Secondary		Tertiary		Direct $10^6m^3/a$	In= direct $10^6m^3/a$	Bulk conveyance losses		Distribution losses		Total ($10^6m^3/a$)		Effluent	Imper= vious urban area*	Total return flow	Return flow 1:50 yr assurance
No	Description	No	Description	No	Description			$10^6m^3/a$	%	$10^6m^3/a$	%						
A Part	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	0,2	0,1	0,0	0,0	0,1	33,3	0,4	0,3	0,10	0,00	0,10	0,10
					Paswane Dam site	1,6	1,2	0,2	7,1	0,7	25,0	3,7	3,7	1,53	0,00	1,53	1,53
					Luvuvhu at Mutale	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00
					Luvuvhu at Limpopo	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00
				A92	Mutale at Luvuvhu	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00
Total in Luvuvhu River catchment						**1,8**	**1,3**	**0,2**		**0,8**		**4,0**	**4,1**	**1,63**	**0,00**	**1,63**	**1,63**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,02
					Groot Letaba at Molototsi	1,3	0,9	0,1	4,5	0,6	27,3	2,9	2,9	1,25	0,00	1,25	1,25
					Molototsi	0,1	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,06	0,00	0,06	0,06
					Groot Letaba at Klein Letaba	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00
				B82	Middle Letaba Dam	0,8	0,3	0,1	9,1	0,3	27,3	1,5	1,5	0,60	0,00	0,60	0,60
					Klein Letaba at Tabaan	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00
					Klein Letaba at Groot Letaba	0,5	0,2	0,0	0,0	0,2	28,6	0,9	0,9	0,27	0,00	0,27	0,27
				B83	Letaba at Olifants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00
Total in Letaba River catchment						**2,7**	**1,4**	**0,2**		**1,1**		**5,4**	**5,4**	**2,18**	**0,00**	**2,18**	**2,18**
		B9	Shingwedzi	B90	Mphongolo	0,1	0,0	0,0	0,0	0,0	0,0	0,2	0,2	0,06	0,00	0,06	0,06
					Shingwedzi	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00
Total in Shingwedzi River catchment						**0,1**	**0,0**	**0,0**		**0,0**		**0,2**	**0,2**	**0,06**	**0,00**	**0,06**	**0,06**
Total in Luvuvhu/Letaba WMA						**4,6**	**2,7**	**0,4**		**1,9**		**9,6**	**9,7**	**3,87**	**0,00**	**3,87**	**3,87**

* Not applicable in this WMA with very small areas of urbanization.

5.3.3 Rural

Water Requirements

Domestic water requirements
Rural water users include domestic, subsistence farming, commercial farming and livestock and game users.

Domestic water users are located throughout the area and include domestic users of villages, settlements, farming communities and mines.

The estimates of the water requirements of the rural population are based on estimates of the population and the unit water requirements, inclusive of allowances for other related uses such as schools, clinics, commercial activities, service industries, sports fields, etc. This procedure assumes that the water use by the rural population has generally not been measured in the past and has frequently been affected by inadequate infrastructure and/or inadequate measures to ensure that water is not used wastefully.

Water is mainly used by the rural population for hygiene, other in-house use, sanitation and gardening. Other users such as schools, clinics, etc. comprise a relatively small increment to the domestic component.

The water use is therefore related tot he value orientation or level of living and development of the domestic water user.

It has also been found that for the non-farming rural communities, community size correlates well with the level of living, viz:

Community characteristic	Level of living	Typical description
Rural	Low	Remote small rural villages or scattered homesteads
Advanced rural	Low to Moderate	Small rural villages
Development urban	Moderate	Densely populated rural villages
Farming	Low to Moderate	Farming communities outside urban and rural residential areas

For each quaternary catchment the percentage of the rural population in each of the four community characterizations should therefore be estimated.

The unit water requirements were estimated for the conditions applicable in 1995 and that correspond to the levels of living that are typical of the community characteristics in the region occupied by the quaternary catchments under consideration.

The following typical unit water requirement allowances were considered applicable particularly where there is no other data available.

- Rural 30ℓ/c/day
- Advanced rural 75ℓ/c/day
- Developing urban 150ℓ/c/day
- Farming 175ℓ/c/day

The above allowances include a provision of about, 15% for other users in the rural, advanced rural and developing urban communities.

The water requirements 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.

Regarding livestock and game, water requirements corresponding to the distribution of large stock units (livestock and game) 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 much of its water mainly from groundwater 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. Water consumption by livestock and game per quaternary catchment 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 it is similar to that provided by “Glen”. Data on pigs, horses etc are defined. The main disadvantages of this data is that unlike the “Glen” data, it is not presented per primary catchment and game is not broken down into species.

TABLE 5.3.3.1.1: 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

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 4,81 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.

TABLE 5.3.3.1.2: RURAL WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

Catchment						Rural water requirements (10^6 m^3 /a)							Return flow	
Primary		Secondary		Tertiary		Domestic ($10^6m^3/a$)	Subsistence farming [(1)] ($10^6m^3/a$)	Livestock & game [(1)] ($10^6m^3/a$)	Losses		Total ($10^6m^3/a$)	Total at 1:50 yr assurance ($10^6m^3/a$)	Normal ($10^6m^3/a$)	Total at 1:50 yr assurance ($10^6m^3/a$)
No	Description	No	Description	No	Description				($10^6m^3/a$)	%				
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	0,67	0,00	0,16	0,17	20	0,99	0,87	0,0	0,0
					Paswane Dam site	4,64	0,00	0,00	0,93	20	5,57	4,86	0,0	0,0
					Luvuvhu at Mutale	0,75	0,00	0,00	0,15	20	0,90	0,79	0,0	0,0
					Luvuvhu at Limpopo	0,00	0,00	0,00	0,00	20	0,00	0,00	0,0	0,0
				A92	Mutale at Luvuvhu	1,29	0,00	0,00	0,26	20	1,62	1,36	0,0	0,0
Total in Luvuvhu River catchment						**7,52**	**0,00**	**0,16**	**1,50**		**9,01**	**7,88**	**0,0**	**0,0**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	0,02	0,00	0,14	0,03	20	0,19	0,16	0,0	0,0
					Groot Letaba at Molototsi	4,20	0,00	0,09	0,86	20	5,15	4,53	0,0	0,0
					Molototsi	2,28	0,00	0,00	0,46	20	2,74	2,55	0,0	0,0
					Groot Letaba at Klein Letaba	0,22	0,00	0,04	0,05	20	0,30	0,27	0,0	0,0
				B82	Middle Letaba Dam	1,87	0,00	0,04	0,38	20	2,29	2,10	0,0	0,0
					Klein Letaba at Tabaan	2,02	0,00	0,07	0,42	20	2,50	2,29	0,0	0,0
					Klein Letaba at Groot Letaba	2,05	0,00	0,05	0,42	20	2,52	2,33	0,0	0,0
				B83	Letaba at Olifants	0,10	0,00	0,04	0,03	20	0,16	0,15	0,0	0,0
Total in Letaba River catchment						**12,75**	**0,00**	**0,46**	**2,64**		**15,85**	**14,39**	**0,0**	**0,0**
		B9	Shingwedzi	B90	Mphongolo	1,17	0,00	0,00	0,23	20	1,40	1,31	0,0	0,0
					Shingwedzi	0,82	0,00	0,02	0,17	20	1,01	0,94	0,0	0,0
Total in Shingwedzi River catchment						**1,99**	**0.,00**	**0,02**	**0,40**		**2,41**	**2,24**	**0,0**	**0,0**
Total in Luvuvhu/Letaba WMA						**22,26**	**0,00**	**0,63**	**4,55**		**27,27**	**24,51**	**0,0**	**0,0**

(1) Direct use excluding losses

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

Only the requirements of thermal power stations are considered to be strategic water use. There are no thermal power stations in the Luvuvhu/Letaba WMA. The strategic water use is therefore zero.

5.4.3 Mining

The Luvuvhu/Letaba WMA has limited running activity with the Tshikondoni Mine in the Luvuvhu River catchment being the only significant mine. Other minor mining activities occur in the Shingwedzi River catchment and Klein Letaba River catchment. These small mines use limited ground water.

The Tshikondeni mine utilizes about 1,0 million m^3/a.

5.4.4 Other Bulk Users

There are no other non-strategic bulk water users in the Luvuvhu/Letaba WMA.

5.5 NEIGHBOURING STATES

The Letaba and Luvuvhu River catchments are part of the greater Limpopo River Basin. There are no direct abstractions by neighbouring States from the Letaba and Luvuvhu Rivers in the WMA. The downstream use in the Letaba/Olifants and the Luvuvhu/Limpopo Rivers in Mozambique has not yet been formalized in an international agreement. However, any significant increase in water use and new water resource development are subject to the procedures prescribed in the Revised Protocol on Shared Watercourses in South African Development Community, signed on 7 August 2000.

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.

The sources of information regarding areas irrigated and water allocations include mainly River Basin Studies and more detailed feasibility studies (see below):

Catchment	Study	Client	Date	Author
Luvuvhu, Mutale, Shingwedzi, Letaba	WR90	WRC	1990	SC, SRK, WRP
Mutale	Mutale River Water Resources Study	DWAF	*	DWAF Africon
Luvuvhu	Luvuvhu River Basin Study	DWAF	1990	HKS
Letaba	Letaba River Basin Study	DWAF	1990	SRK
Luvuvhu	Luvuvhu River Dam Feasibility Study	DWAF	1997*	DWAF LDC
Groot Letaba	Letaba River Dam Feasibility Study	DWAF	*	DWAF CB
Middle / Klein Letaba	Middle / Klein Letaba River Reconnaissance Study	DWAF	2001*	DWAF WSM

SC Stewart Scott
SRK Steffen Robertson & Kirsten
HKS Hill Kaplan Scott (now Gibb Africa)
LDC Consortium comprising Consult buro (now BKS), HKS and Laubsher Smith
CB Consult buro (now BKS)
* most recent and reliable hydrology

5.6.2 Water User Patterns

Rainfall generally occurs in the WMA as a result of moist air moving in from the south east and as a result the south eastern mountain slopes have high rainfall and low evaporation. The Middle Letaba River Valley lies in a rain shadow and therefore has low rainfall and high evaporation. Rainfall decreases eastwards whilst evaporation increases eastwards towards the KNP. Generally therefore, irrigation water needs increases from the mountain slopes in the west to the low lands in the east.

The most favorable irrigation areas, in terms of water needs, occur in the upper Mutale River valley, upper Luvuvhu river Valley and in the Tzaneen area.

Irrigation types include sophisticated systems used on the commercial farms whilst more rudimentary systems are generally used in the rural irrigation schemes. Irrigation methods used on commercial irrigation schemes generally include drip and micro jet systems for permanent crops with overhead sprinklers and drip systems used for cash crops. On the rural irrigation schemes, flood irrigation is generally used.

Sources of water include surface water from run-of-river schemes and dams, and from groundwater sources. Several government schemes have been developed and these occur in the Groot Letaba River and in the Luvuvhu River.

The Groot Letaba River government schemes include irrigation downstream of Ebenezer Dam, Tzaneen Dam and Magoebaskloof Dam. In the Luvuvhu River, government irrigation schemes have been developed at Albasini Dam and further downstream.

Numerous rural irrigation schemes have been developed by government and these include schemes on the Thabina River, Middle/Klein Letaba River, Luvuvhu River and Mutale River. These schemes generally comprise a weir in the river for water abstraction and a canal system for conveyance of irrigation water. The Middle Letaba Dam was constructed to augment irrigation water supplies.

Several private irrigation developments have occurred and these are located mainly in the Politsi River area, upper Middle Letaba River catchment, Letsitele River catchment and Upper Luvuvhu catchment.

The Luvuvhu/Letaba WMA has experienced severe droughts during the late 1980's and early 1990's. Water quotas were cut by as much as 50% for prolonged periods (Groot Letaba Government Irrigation Scheme) and in the case of the Albasini Dam, no irrigation water has been available for the past decade. Commercial farmers have generally met demands of drought conditions by augmenting water supplies from emergency boreholes and by scheduling irrigation application to ensure survival of the permanent crops, albeit at reduced crop production levels.

Details of the irrigation areas and irrigation water use are given in Table 5.6.2.1. Irrigation water requirements are shown in Figure 5.6.2.1.

5.6.3 Water Losses

Water losses associated with irrigation methods are included in the field edge water requirement and are shown in Table 5.6.2.1. As mentioned above in Section 5.6.2, irrigation methods used on commercial irrigation schemes generally include micro jet and drip systems on permanent crops and sprinkler and drip systems on cash crops. The former systems are very efficient (90%) with the latter being moderately efficient (75%). On the rural irrigation schemes, flood irrigation methods are often used and these are associated with low efficiency (50%).

Conveyance losses occur in canals and bulk water pipelines and are generally in the order of 10% - 30%. Water losses also occur in rivers where these are used for irrigation water conveyance as is the case in the Groot Letaba River downstream of Ebenezer Dam and downstream of Tzaneen Dam.

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 10,5%. On farm conveyance losses include conveyance losses from river, farm dam or communal canal to the field edge. These losses can be as high as 13,5% in the Luvuvhu/Letaba WMA.

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 about 21,3 million m^3/a for the WMA.

- **Additional return flow**
  The return flow from irrigation can further increase due to the increased rainfall run off (higher level of soil moisture when compared with the natural state). This increased return flow can be calculated for a seasonal or yearly crop. Based on the different crops under irrigation in the WMA the estimated additional return flow generated is 2,3 million m^3/a.

TABLE 5.6.2.1: IRRIGATION WATER REQUIREMENTS

Catchment						Field edge water requirement ($10^6m^3/a$)	Assumed canal or river losses**		On farm conveyance losses*		Total water requirement ($10^6m^3/a$)	Total water requirement at 1:50 yr assurance ($10^6m^3/a$)	Return flows		
Primary		Secondary		Tertiary			($10^6m^3/a$)	%	($10^6m^3/a$)	%			Assumed %	Total return flow ($10^6m^3/a$)	
No	Description	No	Description	No	Description									($10^6m^3/a$)	At 1:50 yr assurance
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	48,8	0,10	0,2	0,88	1,8	49,7	45,2	5	2,49	2,26
					Paswane Dam site	15,3	0,03	0,2	0,28	1,8	15,6	14,2	5	0,78	0,71
					Luvuvhu at Mutale	2,8	0,01	0,2	0,05	1,8	2,8	2,6	5	0,14	0,13
					Luvuvhu at Limpopo	0,0	0,00	0,0	0,00	0,0	0,0	0,0	5	0,00	0,00
				A92	Mutale at Luvuvhu	36,4	0,07	0,2	0,66	1,8	37,1	33,8	5	1,86	1,69
Total in Luvuvhu River catchment						**103,3**	**0,21**		**1,86**		**105,2**	**95,8**		**5,26**	**4,79**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	32,6	3,42	10,5	1,47	4,5	37,5	34	10	3,75	3,40
					Groot Letaba at Molototsi	75,8	4,55	6,0	6,82	9,0	87,2	79,1	10	8,72	7,91
					Molototsi	0,9	0,01	1,5	0,12	13,5	1,1	1,0	10	0,11	0,10
					Groot Letaba at Klein Letaba	0,0	0,00	0,0	0,00	0,0	0,0	0,0	10	0,00	0,00
				B82	Middle Letaba Dam	19,7	0,10	0,5	0,89	4,5	20,6	16,4	5	1,03	0,82
					Klein Letaba at Tabaan	0,4	0,01	1,5	0,01	3,5	0,5	0,4	5	0,03	0,02
					Klein Letaba at Groot Letaba	7,1	0,11	1,5	0,25	3,5	7,5	5,9	5	0,38	0,30
				B83	Letaba at Olifants	0,0	0,00	0,0	0,00	0,0	0,0	0,0	5	0,00	0,00
Total in Letaba River catchment						**136,50**	**8,20**	**21,50**	**9,56**	**38,50**	**154,40**	**136,80**		**14,01**	**12,55**
		B9	Shingwedzi	B90	Mphongolo	0,0	0,00	0,0	0,00	0,0	0,0	0,0	10	0,00	0,00
					Shingwedzi	0,0	0,00	0,0	0,00	0,0	0,0	0,0	10	0,00	0,00
Total in Shingwedzi River catchment						**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**		**0,00**	**0,00**
Total in Luvuvhu/Letaba WMA						**239,80**	**8,40**		**11,42**		**259,60**	**232,60**		**19,27**	**17,33**

* Source NWRS worksession – April 2001

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

5.8.1 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. Losses in the WMA due to wetlands are $0m^3/a$ and due to channel losses are 12,8 million m^3/a.

5.8.2 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 26 dams in the WMA have been estimated to be 35,2 million m^3/a.

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

TABLE 5.8.1: WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

Catchment						Losses from rivers and wetlands ($10^6 m^3/a$)	Evaporation losses from dams ($10^6 m^3/a$)	Total ($10^6 m^3/a$)
Primary		Secondary		Tertiary				
No	Description	No	Description	No	Description			
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	0,0	3,0	3,0
					Paswane Dam site	0,0	0,9	0,9
					Luvuvhu at Mutale	0,0	0,0	0,0
					Luvuvhu at Limpopo	0,0	0,6	0,6
				A92	Mutale	0,0	0,0	0,0
Total in Luvuvhu River catchment						**0,0**	**4,5**	**4,5**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	1,2	5,4	6,6
					Groot Letaba at Molototsi	8,9	5,4	14,3
					Molototsi	0,0	0,5	0,5
					Groot Letaba at Klein Letaba	2,7	0,0	2,7
				B82	Middle Letaba Dam	0,0	15,6	15,6
					Klein Letaba at Tabaan	0,0	0,0	0,0
					Klein Letaba at Groot Letaba	0,0	3,8	3,8
				B83	Letaba at Olifants	0,0	0,0	0,0
Total in Letaba River catchment						**12,8**	**30,7**	**43,5**
		B9	Shingwedzi	B90	Mphongolo	0,0	0,0	0,0
					Shingwedzi	0,0	0,0	0,0
Total in Shingwedzi River catchment						**0,0**	**0,0**	**0,0**
Total in Luvuvhu/Letaba WMA						**12,8**	**35,2**	**48,0**

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.

Commercial afforestation occurs in the high rainfall mountainous areas of the WMA. The catchments with commercial afforestation includes mainly the upper Luvuvhu River, upper Klein Letaba River, middle Letaba River and upper Groot Letaba River catchments.

The impact of commercial afforestation is greatest in the Groot Letaba river catchment which experiences effectively 52 million m^3/a afforestation water use. The Luvuvhu River catchment has an afforestation water use of about 17,6 million m^3/a.

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				
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	7,1	8,0	3,32	3,7
					Paswane Dam site	5,8	4,8	2,23	1,8
					Luvuvhu at Mutale	0,0	0,0	0,00	0,0
					Luvuvhu at Limpopo	4,7	2,2	0,90	0,4
				A92	Mutale	0,0	0,0	0,00	0,0
Total in Luvuvhu River catchment						**17,6**	**15,0**	**6,45**	**5,9**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	43,8	67,3	32,27	49,6
					Groot Letaba at Molototsi	5,8	2,3	3,11	1,2
					Molototsi	0,1	0,1	0,00	0,0
					Groot Letaba at Klein Letaba	0,0	0,0	0,00	0,0
				B82	Middle Letaba Dam	1,6	0,9	1,04	0,6
					Klein Letaba at Tabaan	0,7	0,6	0,00	0,0
					Klein Letaba at Groot Letaba	0,0	0,0	0,00	0,0
				B83	Letaba at Olifants	0,0	0,0	0,00	0,0
Total in Letaba River catchment						**52,0**	**71,2**	**36,42**	**51,4**
		B9	Shingwedzi	B90	Mphongolo	0,0	0,0	0,00	0,0
					Shingwedzi	0,0	0,0	0,00	0,0
Total in Shingwedzi River catchment						**0,0**	**0,0**	**0,00**	**0,0**
Total in Luvuvhu/Letaba WMA						**69,6**	**86,2**	**42,87**	**57,3**

5.10 HYDROPOWER AND PUMPED STORAGE

There are no existing or planned hydropower or pumped storage schemes in the Luvuvhu/Letaba WMA and therefore the associated water requirements are zero.

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

The greatest alien vegetation infestation occurs in the Luvuvhu River catchment and the average reduction in runoff for the catchment amounts to about 25,1 million m^3/a. In the Groot Letaba River, the alien vegetation reduces runoff by about 14,6 million m^3/a. (see Table 5.11.1).

Alien vegetation reduces the system 1:50 year yield by about 21,6 million m^3/a.

TABLE 5.11.1: WATER USE BY ALIEN VEGETATION IN 1995

Catchment						Average reduction in runoff		Reduction in system 1:50 yr yield	
Primary		Secondary		Tertiary		$10^6 m^3/a$	mm/a	$10^6 m^3/a$	mm/a
No	Description	No			Description				
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	23,0	25,8	10,72	12,1
					Paswane Dam site	1,6	1,4	0,63	0,5
					Luvuvhu at Mutale	0,1	0,1	0,00	0,0
					Luvuvhu at Limpopo	0,4	0,2	0,08	0,0
				A92	Mutale	0,0	0,0	0,00	0,0
Total in Luvuvhu River catchment						**25,1**	**27,5**	**11,43**	**12,6**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	11,0	16,9	8,12	12,5
					Groot Letaba at Molototsi	2,9	1,1	1,56	0,6
					Molototsi	0,0	0,0	0,00	0,0
					Groot Letaba at Klein Letaba	0,0	0,0	0,00	0,0
				B82	Middle Letaba Dam	0,7	0,4	0,45	0,3
					Klein Letaba at Tabaan	0,0	0,0	0,00	0,0
					Klein Letaba at Groot Letaba	0,0	0,0	0,01	0,0
				B83	Letaba at Olifants	0,0	0,0	0,00	0,0
Total in Letaba River catchment						**14,6**	**18,4**	**10,14**	**13,4**
		B9	Shingwedzi	B90	Mphongolo	0,0	0,0	0,00	0,0
					Shingwedzi	0,0	0,0	0,00	0,0
Total in Shingwedzi River catchment						**0,0**	**0,0**	**0,00**	**0,0**
Total in Luvuvhu/Letaba WMA						**39,7**	**45,9**	**21,57**	**26,0**

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

It is estimated that up to 50% of the total quantity of water that is supplied is not accounted for in many of the urban areas. This unaccounted for water consists of a combination of reticulation system leaks, 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 75% of total water use in the Luvuvhu/Letaba 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 0,2% of total water use in the Luvuvhu/Letaba Water Management Area. Issues such as site selection and preparation, species selection, rotation periods and plantation management all affect the efficient use of water.

Industry, mining and power generation

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

Protection of Existing Water Resources

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

- The removal of alien invading plants, which reduce surface runoff and the yield of existing resources.
- Rehabilitation of wetlands.
- Protection of groundwater resources by limiting abstraction to the sustainable yield.
- 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 Luvuvhu/Letaba Water Management Area

Based on experience elsewhere in South Africa an overall sustainable reduction in water use of up to 25% can be expected without having a detrimental effect on users. Return flows could be reduced by up to 10 % of total water use. The absence of cost recovery programmes in almost all water supply schemes and the concomitant over-use of water indicates that substantial water savings can be achieved.

Working for Water Programmes have been initiated in the Luvuvhu River catchment and Groot Letaba River catchment.

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 5.13.4.1. 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:

Groot Letaba
Politsi
Letsitele.

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

The following Government water works were constructed:
Albasini Dam
Ebenezer Dam
Tzaneen Dam
Masalal Canal
Pusela Canal
Letaba Noord Canal
N & N Canal
George's Valley Canal

A full description of the works are given in Annexure 5 of the Basin Study (Steffen, Robertson & Kirsten, 1990).

Allocations from Government water works are summarised in Table 5.13.4.2. and the details are in Appendix F.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 5.13.4.1: 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) **
Groot Letaba – Zone 1#	B81B, B81C	2 940,7	6 617	19,5
Groot Letaba – Zone 2#	B81C, B81E, B81F	3 604,7	8 915	32,1
Groot Letaba – Zone 3#	B81J, B81F	6 736,7	10 895	73,4
Politsi	B81B	1 671,6	6 600	11,03
Letsitele	B81D	2495,0	Not available	Not available

* All quaternaries that the area covers.
** Totals for the whole area only.
# 1985 values

TABLE 5.13.4.2: ARTICLE 56(3) - ALLOCATIONS FROM GOVERNMENT WATER SCHEMES

Scheme	Allocation (10^6 m^3/a)**					
	Household & Stock Watering	Municipa-lities & Water Boards	Industries	Mining	Irriga-tion	Total
Albasini Dam	0,05	2,41	0	0	2,0	4,46
Ebenhezer Dam	0,68	19,03	2,51	0,39	0,15	22,76
Tzaneen Dam	0,09	7,12	0,02	0,12	0,31	7,66
Politsi River	0,25	0,09	0,75	0	0,63	1,72
Pietersburg(from Letaba River)	0,41	2,46	0,01	0	0	2,88

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 Luvuvhu/Letaba WMA, and comparing allocations to the 1:50 year yield as listed in Table 6.1.1, the following observations are made:

- The total allocation of 4,46 million m³/a from Albasini Dam is more than its apparent yield which is in the order of 2 million m³/a.
- The allocation of 22,76 million m³/a from Ebenezer Dam is probably in line with its 1:50-year yield.
- Allocations from Tzaneen Dam of 7,66 million m³/a is more than its yield of 2,4 million m³/a, but this dam's yield is augmented from releases from Ebenezer Dam and the situation may be less severe.
- The 1:50-year yield of Magoebaskloof Dam (Politsi River scheme) is only 1,4 million m³/a and the allocations are 1,72 million m³/a.
- The allocations to Pietersburg and environs of 2,88 million m³/a is less than the stated 1:50-year yield of 3,8 million m³/a of Dap Naude Dam.

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. Groot Letaba River – Sand River transfer).
- Transfers within WMAs are transfers between and within quaternary catchments within a WMA.

The Luvuvhu/Letaba WMA does not receive water from any other WMA's but it transfers water to the following WMAs:

- Limpopo
- Olifants

Inter-WMA transfers are listed in Table 5.14.3.1. The significant water transfers within WMA are listed in Table 5.14.4.1. A full list of all transfers is given in Appendix F. The water transfer schemes are shown schematically in Figure 5.14.1.

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 13 million m^3 of water was EXPORTED from the Luvuvhu/Letaba WMA to various WMAs. The most significant exports were the:

- Dap Naude Dam to Pietersburg
- Ebenezer Dam to Polokwane Municipal area
- Nkowakowa / Ritavi to villages in the Selati catchment
- Groot Letaba River to Consolidated Murchison Gold Mine
- Albasini Dam to Louis Trichardt
- Thabina Dam to villages in the Selati catchment

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 ($10^6 m^3/a$)	Transfer quantity source WMA ($10^6 m^3/a$)		
				Transfer	Losses	Total
Inter – WMA transfer out of WMA:						
Letaba-Sand transfer system	Luvuvhu – Letaba	Limpopo				
	Dap Naude Dam B81A	Upper Sand, Pietersburg, villages A71A	-4,24	4,24	0,42	4,66
	Ebenezer Dam B81A		-5,89	5,89	0,59	6,48
Ebenezer-Fish Farm	Ebenezer Dam B81A	Olifants B71C	-0,4	0,4	0,13*	0,17
Louis Trichardt Regional Scheme	Luvuvhu – Letaba	Limpopo				
	Albasini Dam A91B	Louis Trichardt A71H	-1,8	1,8	0,18	1,98
Thabina Bulk Water Supply Scheme	Luvuvhu – Letaba	Olifants				
	Thabina Dam B81D	Sedan and Shiluwane Hospital	-0,16	0,16	0,02	0,18
Groot Letaba River to Consolidated Murshison Gold mine	Luvuvhu – Letaba	Olifants				
	Groot Letaba River B81F	Consolidated Murchison Gold mine	-0,96	0,96	0,14	1,10
Total water exports in 1995			**-13,45**			

*Mainly evaporation from ponds.

5.14.4 Transfers Within the WMA

Within the Luvuvhu/Letaba WMA there are numerous in-basin transfers, that include transfers between quaternaries and even within quaternaries. Significant transfers for urban users, and for agriculture have been listed in Table 5.14.4.1.

The most significant urban transfers are the Vondo Dam RWS to villages. The most significant agricultural user is the Tzaneen Dam Irrigation Scheme.

TABLE 5.14.4.1: TRANSFERS WITHIN WMAs IN 1995

Description Of Transfer	Source & Quaternary	Destination & Quaternary	Quantity [$10^6 m^3$]
Urban users:			
Malamulele RWS	Luvuvhu River A91F	Villages B90C, B90B, A91H	0,31
Vondo Dam RWS	Vondo Dam A91G	Village A91E, A91F, B82F	2,5
Middle Letaba Dam Transfer canal	Middle Letaba Dam B82D	Giyani WTW and Nsami Dam B82H	11,0
Malamulele West RWS	B82G	Villages B82H, A91F	0,37
Tshakuma Dam Scheme	Tshakuma Dam A91D	Villages A91E	1,1
Magoebaskloof Dam Scheme	B81B	Duiwelskloof B82C, Ga-Kgapane villages B81G	1,0 (approx)*
Ritavi II Scheme	Groot Letaba River B81C	Nkowakowa B81D	4,4 (approx)*
Giyani RWS	Klein Letaba River B82H	Groot Letaba River B81H	0,4
Middle Letaba RWS	Middle Letaba Dam B82D	Upper Klein Letaba B82F	4,0
Bulk users: (Irrigation)			
Tzaneen Dam Irrigation Scheme	Tzaneen Dam B81C	Irrigation B81C, B81E, B81F, B81J	105,2
Middle Letaba Dam Transfer canal	Middle Letaba Dam B82D	Giyani WTW and Nsami Dam B82H	9,2

* Estimated from design capacities of WTW.

5.15 SUMMARY OF WATER LOSSES AND RETURN FLOWS

A summary of the water requirements, losses and return flows are shown in Table 15.5.1. Table 5.15.2 summaries the main inter-catchment transfers of return. 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

Category		On-Site Water Requirements ($10^6 m^3/a$)	Losses		Return Flow ($10^6 m^3/a$)
			($10^6 m^3/a$)	(%)	
Irrigation		239,8	19,82	8,3	19,27
Urban		9,6	2,3	24,0	3,87
Rural		22,89	4,55	19,9	0
Bulk	a) Strategic	0	0	0	0
	b) Mining	1,1	0,1	0	0
	c) Other	0	0	0	0
Hydro-power		0	0	0	0
Rivers, wetlands, dams		158,3	48	30,3	0
TOTAL		**431,69**	**74,77**		**23,14**

TABLE 5.15.2: THE MAIN INTER-CATCHMENT TRANSFERS OF RETURN

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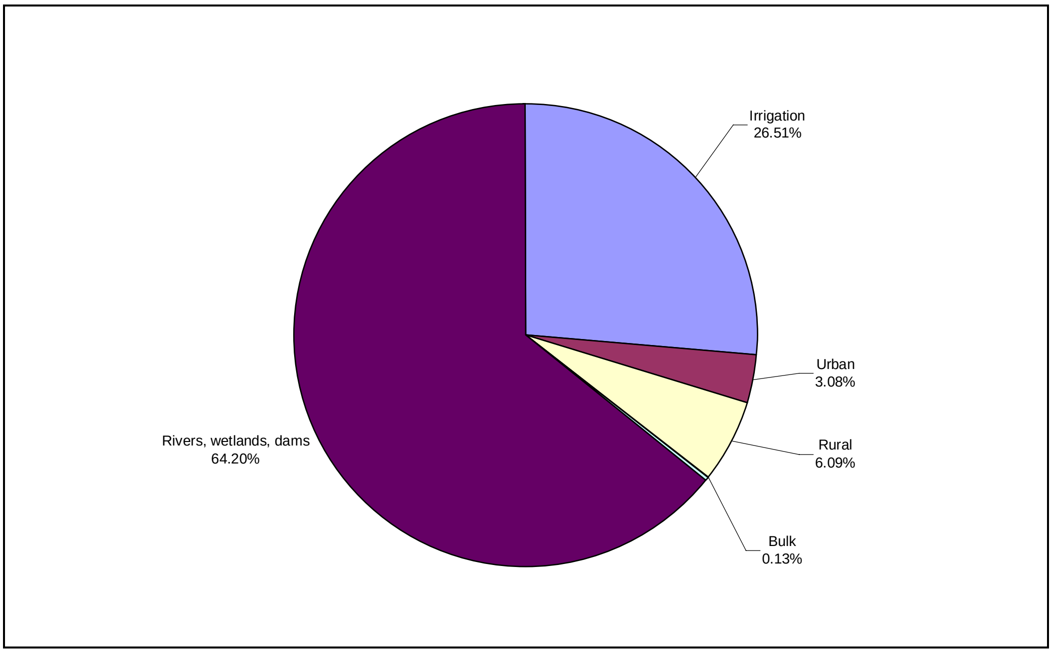
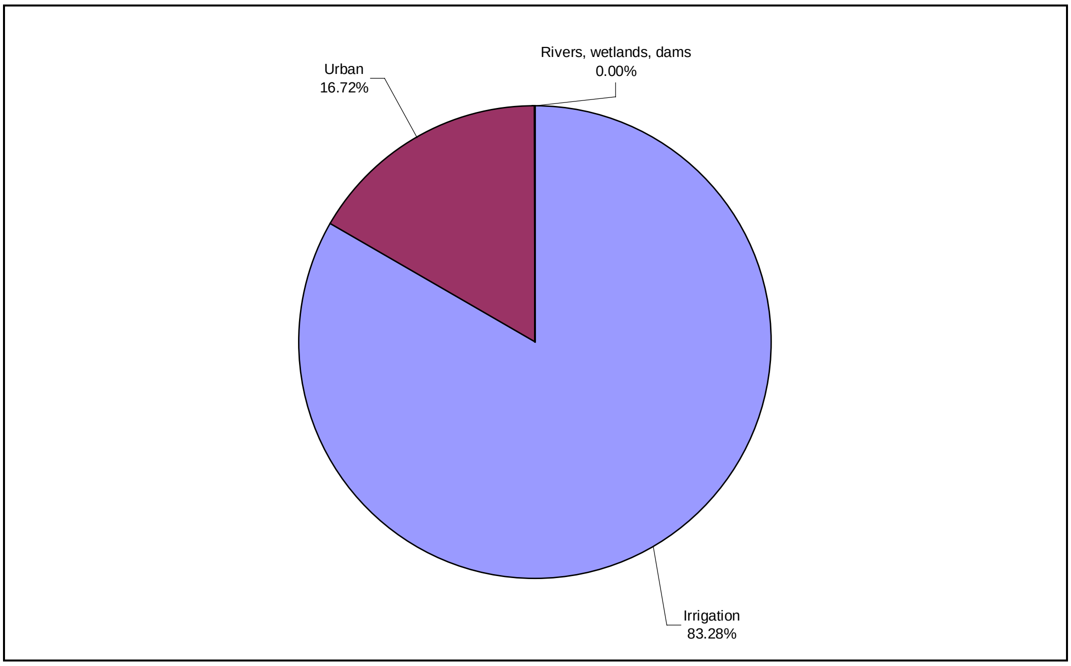
Diagram 5.15.1: Category loss as a portion of the total losses.



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

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



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

CHAPTER 6: WATER RESOURCES

6.1 EXTENT OF THE WATER RESOURCES

The Luvuvhu/Letaba WMA comprises several major rivers including Letaba, Luvuvhu, Shingwedzi and Mutale Rivers. The rivers essentially drain the mountainous western parts of the WMA and flow towards the east to join the Rio Limpopo and Elefantes Rivers in Mozambique.

The total natural MAR of the Luvuvhu/Letaba WMA amounts to about 1 040 million m^3/a (see Table 6.1.1). The Luvuvhu / Mutale River contributes some 50% of the natural MAR, the Letaba River some 42% and the Shingwedzi River only contributes some 8% of the total natural MAR in the WMA.

The average MAP in the WMA is estimated to be about 597 mm. The natural MAR, which equals an average runoff depth over the WMA of about 48 mm, translates to an average runoff of about 8% of the MAP.

A large number of dams have been constructed in the WMA to create storage to facilitate exploitation of the surface water resources. The total potential 1:50 year surface water resources yield amounts to about 601,4 million m^3/a. The total 1:50 year developed yield from surface water resources in 1995 of the WMA amounted to about 529 million m^3/a. The Luvuvhu/Mutale River catchment contributes about 58% to the total 1:50 year yield of the WMA, the Letaba River about 42% and the Shingwedzi River practically zero (1,4 million m^3/a) of the total (see Table 6.1.1 and refer to figure 6.1.1).

Average groundwater recharge is generally in the order of 2% to 3% of MAP. The groundwater exploitation potential of the WMA was estimated to be about 157,06 million m^3/a. This translates to about 1.1% of the MAP.

The Luvuvhu/Mutale River catchment contributes about 20% to the total groundwater exploitation potential, the Letaba some 64% and the Shingwedzi River catchment about 16% of the total.

Figure 6.1.2 depicts the total water resource if developed to the full potential.

TABLE 6.1.1: WATER RESOURCES

Catchment						Surface water resources (10^6 m^3 /a)			Sustainable ground water exploitation potential not linked to surface water (10^6 m^3 /a)		Total water resources (10^6 m^3 /a)	
Primary		Secondary		Tertiary		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
No	Description	No	Description	No	Description							
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	113,80	37,30	75,10	15,74	-4,10	53,04	71,00
					Paswane Dam site	214,10	72,60	138,30	1,63	0,99	74,23	139,29
					Luvuvhu at Mutale	32,20	39,90	16,40	1,17	3,61	41,07	20,01
					Luvuvhu at Limpopo	2,60	1,40	1,30	0,00	4,16	1,40	5,46
				A92	Mutale	156,40	155,20	97,50	2,09	2,86	157,29	100,36
Total in Luvuvhu River catchment						**519,10**	**306,40**	**328,60**	**20,63**	**7,53**	**327,03**	**336,13**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	79,50	26,60	44,50	3,09	-4,99	29,69	39,51
					Groot Letaba at Molototsi	132,80	148,90	71,10	7,46	9,29	156,36	80,39
					Molototsi	23,30	6,60	11,90	1,67	9,65	8,27	21,55
					Groot Letaba at Klein Letaba	5,30	1,60	2,70	0,16	4,52	1,76	7,22
				B82	Middle Letaba Dam	72,00	36,20	36,70	5,58	13,05	41,78	49,75
					Klein Letaba at Tabaan	41,20	0,30	21,00	3,21	9,68	3,51	30,68
					Klein Letaba at Groot Letaba	38,70	1,10	19,70	0,78	14,70	1,88	34,40
				B83	Letaba at Olifants	41,30	0,00	21,10	0,00	18,49	0,00	39,59
Total in Letaba River catchment						**434,10**	**221,30**	**228,70**	**21,95**	**74,40**	**243,25**	**303,10**
		B9	Shingwedzi	B90	Mphongolo	35,30	0,30	18,00	0,95	13,53	1,25	31,53
					Shingwedzi	51,20	1,10	26,10	0,63	11,96	1,73	38,06
Total in Shingwedzi River catchment						**86,50**	**1,40**	**44,10**	**1,58**	**25,49**	**2,98**	**69,59**
Total in Luvuvhu / Letaba WMA						**1 039,70**	**529,10**	**601,40**	**44,16**	**107,42**	**573,26**	**708,82**

* From WSAM – To be verified

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, its interaction with surface water, the present use, (1995) and its potential for further development.

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

The 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 which can either be abstracted as groundwater or surface water. From this, the extent to which groundwater abstraction will impact on surface water has been qualitatively evaluated (see Figure 6.2.3) and the following arbitrarily chosen classification was done:

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

The 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 than the Harvest Potential, the catchment was considered over-utilized, if the total use was greater than the exploitation potential but less than the Harvest Potential, the catchment was considered heavily utilized, if the total use was more than ⅔ of the Exploitation Potential the catchment was considered moderately-utilized and if the total use was less than ⅔ of the exploitation potential the catchment was considered under-utilized. The classification used above was arbitrarily.

From the results shown in Table 6.2.1, the developed groundwater is 41% of the potential groundwater yield.

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

CATCHMENT						GROUNDWATER EXPLOITATION POTENTIAL	TOTAL GROUNDWATER USE (1995)	UNUSED GROUNDWATER EXPLOITATION POTENTIAL	GROUNDWATER CONTRIBUTION TO BASE FLOW	PORTION OF GROUNDWATER EXPLOITATION POTENTIAL NOT CONTRIBUTING TO BASE FLOW
PRIMARY		SECONDARY		TERSIARY						
No	Description	No	Description	No	Description	(10^6 m^3/annum)	(10^6 m^3/annum)	(10^6 m^3/annum)	(10^6 m^3/annum)	(10^6 m^3/annum)
A (Part)	Limpopo	A9	Luvuvhu /Mutale	A91	Luvuvhu at Levubu	8,14	15,74	-7,60	12,24	-4,10
					Paswane Dam site	8,41	1,63	6,78	7,42	0,99
					Luvuvhu at Mutale	4,33	1,17	3,16	0,72	3,61
					Luvuvhu at Limpopo	4,16	0	4,16	0,00	4,16
				A92	Mutale at Luvuvhu	6,5	2,09	4,41	3,64	2,86
Total in Luvuvhu River catchment						**31,54**	**20,63**	**10,91**	**24,01**	**7,53**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	5,44	3,09	2,35	10,43	-4,99
					Groot Letaba at Molototsi	19,13	7,46	11,67	9,84	9,29
					Molototsi	9,65	1,67	7,98	0,00	9,65
					Groot Letaba at Klein Letaba	4,52	0,16	4,36	0,00	4,52
				B82	Middle Letaba Dam	16,38	5,58	10,80	3,33	13,05
					Klein Letaba at Tabaan	11,72	3,21	8,51	2,04	9,68
					Klein Letaba at Groot Letaba	14,7	0,78	13,92	0,00	14,70
				B83	Letaba at Olifants	18,49	0	18,49	0,00	18,49
Total in Letaba River catchment						**100,03**	**21,95**	**78,08**	**25,63**	**74,40**
		B9	Shing= wedzi	B90	Mphongolo	13,53	0,95	12,58	0,00	13,53
					Shingwedzi	11,96	0,63	11,33	0,00	11,96
Total in Shingwedzi River catchment						**25,49**	**1,58**	**23,91**	**0,00**	**25,49**
Total in Luvuvhu/Letaba WMA						**157,06**	**44,16**	**112,90**	**49,64**	**107,42**

6.3 SURFACE WATER RESOURCES

6.3.1 Background

The basis for the analysis of surface water resources for all WMAs was the synthesized 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 naturalized 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 naturalized 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 naturalized flow time series generated for the whole calibration catchment.

(3) The naturalized 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) naturalized 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-naturalized 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) naturalized flows and the re-calibrated "true" naturalized flows were within 5%, which was considered to be acceptable.

Based on the three steps described above, the WR90 naturalized 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 naturalized 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 naturalized 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 naturalized 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.

Several hydrological studies have been undertaken in the Luvuvhu/Letaba WMA and these include:

Catchment	Study	Level of detail	Client	Date	Author
Luvuvhu, Mutale, Shingwedzi, Letaba	WR90	Pitman Model Regional parameters	WRC	1990	SC, SRK, WRP
Mutale	Mutale River Water Resources Study	Pitman Model Calibration	DWAF	*	DWAF Africon
Luvuvhu	Luvuvhu River Basin Study	Pitman Model Calibration	DWAF	1990	HKS
Letaba	Letaba River Basin Study	Pitman Model Calibration	DWAF	1990	SRK
Luvuvhu	Luvuvhu River Dam Feasibility Study	Pitman Model Calibration, stochastic modelling	DWAF	1997*	DWAF LDC

Catchment	Study	Level of detail	Client	Date	Author
Groot Letaba	Letaba River Dam Feasibility Study	Pitman Model Calibration, stochastic modeling	DWAF	*	DWAF CB
Middle / Klein Letaba	Middle / Klein Letaba River Reconnaissance Study	Pitman Model Calibration, stochastic modelling	DWAF	2001*	DWAF WSM

SC Stewart Scott
SRK Steffen Robertson & Kirsten
HKS Hill Kaplan Scott (now Gibb Africa)
CB Consult buro (now BKS)
LDC Consortium comprising Consult buro (now BKS), HKS and Laubsher Smith
* most recent and reliable hydrology

The most recent and reliable hydrological analysis were undertaken in the Mutale, Luvuvhu, Middle/Klein Letaba and Groot Letaba Rivers.

River flow gauging stations have been constructed throughout the WMA, however, the distribution of the flow gauging stations is not adequate to provide measured flow records for all the rivers and for the representative river reaches. In addition, the accuracy and length of flow record at numerous stations is not acceptable.

For example, the Letaba River has 38 structures equipped to record runoff, of which 9 have a continuos record of more than 15 years. Of these, only three have a runoff record in which no more than 10 % of the data is uncertain due to gauge exceedance or malfunction. Two of the structures are dams and these stations are all located in the upper Groot Letaba River with one station located in the Middle and one in the upper Klein Letaba Rivers.

The MAR determined for catchment conditions includes indigenous forest water use, i.e. the indigenous forests are assumed to be part of the natural environment.

Details of the catchment MAR, MAP and mean annual evaporation are given in Table 6.3.1. Figure 6.3.1 shows the mean annual naturalized runoff in mm/annum.

The current developed yield was based on information generated in WSAM. The estimated 1995 developed surface water yield is about 88% of the potential surface water yield. Although apparent further development potential exists in the Shingwedzi catchment area, the cost effectiveness of the schemes may be low due to difficult dam sites leading to costly dams, expensive relocations required or distance from water demand nodes.

The total potential surface water yield in the WMA was determined by the methodology described in section 6.3.2. below.

6.3.2 Potential 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 G for each group of quaternary catchments that falls within the same hydrological zone, as defined in WR90 (Midgley, et al., 1994).

These range from 163% of the MAR in the higher rainfall quaternary catchments to 323% of the MAR in the drier quaternary catchments within the 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 optimize 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 150 %, 200 %, 300 % of the MAR as appropriate. In this method, the variability of the rivers were classified, and the storages assumed for the calculation of the dam yield were the following:

- Dams in rivers with low variability: capacity 100% of MAR
- Dams in rivers with medium variability: capacity 150% or 200% of MAR
- Dams in rivers with high variability: capacity 250% or 300% of MAR.

The detail calculations are shown in Appendix G while Figure 6.3.2 shows water resource development potential according to drainage areas.

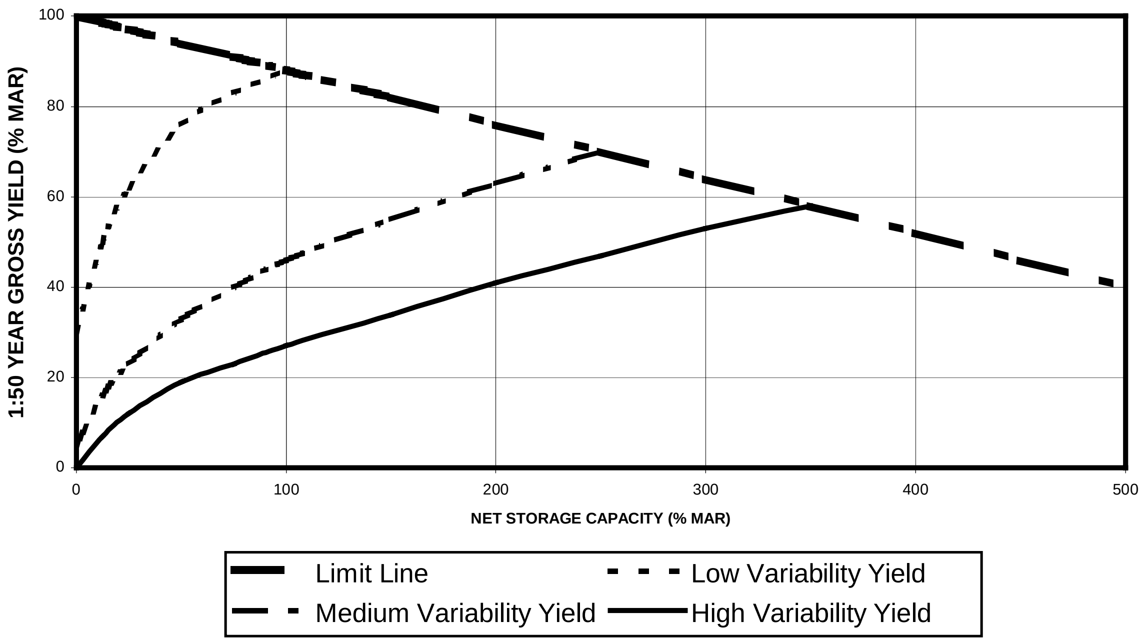


DIAGRAM 6.3.1: DAM STORAGE LIMITS

TABLE 6.3.1: SURFACE WATER RESOURCES

Catchment						Catchment area	Mean annual precipi=tation	Mean annual evapora=tion[(2)]	Naturalised MAR		Yield (1:50 yr) [(1)]	
									Incremental	Cumulative	Developed in 1995	Total potential
Primary		Secondary		Tertiary		(km^2)	(mm/a)	(mm/a)	(10^6 m^3 /a)	(10^6 m^3 /a)	(10^6 m^3 /a)	(10^6 m^3 /a)
No	**Description**	**No**	**Description**	**No**	**Description**							
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	889,0	808,0	1 577,0	113,8	113,8	37,3	75,1
					Paswane Dam site	1 209,0	835,4	1 450,0	214,1	327,9	72,6	138,3
					Luvuvhu at Mutale	1 020,0	570,0	1 734,0	32,2	360,1	39,9	16,4
					Luvuvhu at Limpopo	669,0	373,0	1 850,0	2,6	519,1	1,4	1,3
				A92	Mutale at Luvuvhu	2 154,0	540,6	1 763,0	156,4	156,4	155,2	97,5
Total in Luvuvhu River catchment						**5 941,0**				**519,1**	**306,4**	**328,6**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	650,0	1 171,0	1 500,0	79,5	79,5	148,9	44,5
					Groot Letaba at Molototsi	2 553,0	657,4	1 536,0	132,8	212,3	26,6	71,1
					Molototsi	1 181,0	560,8	1 600,0	23,3	23,3	6,6	11,9
					Groot Letaba at Klein Letaba	568,0	502,0	1 700,0	5,3	240,9	1,6	2,7
				B82	Middle Letaba Dam	1 805,0	680,9	1 589,0	72,0	72,0	36,2	36,7
					Klein Letaba at Tabaan	1 183,0	668,8	1 600,0	41,2	113,2	0,3	21,0
					Klein Letaba at Groot Letaba	2 465,0	526,7	1 650,0	38,7	151,9	1,1	19,7
				B83	Letaba at Olifants	3 264,0	544,2	1 802,0	41,3	434,1	0,0	21,1
Total in Letaba River catchment						**13 669,0**				**434,1**	**221,3**	**228,7**
		B9	Shingwedzi	B90	Mphongolo	2 903,0	473,5	1 698,0	35,2	35,3	0,3	18,0
					Shingwedzi	2 407,0	537,5	1 720,0	51,2	86,5	1,1	26,1
Total in Shingwedzi River catchment						**5 310,0**				**86,5**	**1,4**	**44,1**
Total in Luvuvhu / Letaba WMA						**24 920,0**			**1 039,6**	**1 039,7**	**529,1**	**601,4**

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

6.4 WATER QUALITY

6.4.1 Mineralogical Surface Water Quality

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

The mineralogical water quality of the surface water bodies is only described in terms of total dissolved salts (TDS). Data for the assessment were obtained from the water quality data base 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 Letaba catchment has various water quality monitoring stations throughout the catchment.

Only data sets that had data for the last five years were used. 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.

The above methodology is not appropriate for the assessment of water quality in ephemeral rivers where no flows occur for long periods of time, resulting in a low frequency of sampling.

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	Green	Ideal water quality	<260
1	Blue	Good water quality	260 - 600
2	Yellow	Marginal water quality	601 - 1800
3	Orange	Poor water quality	1801 - 3400
4	Brown	Completely unacceptable water quality	>3400

The water quality of the Luvuvhu/Letaba Water Management Area, using only the available average data, is shown in Figure 6.4.2.1.

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 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 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.

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 % potable water per quaternary catchment

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 G2 for details of the study). Maps depicting the potential vulnerability of surface water and groundwater to microbial contamination were produced at a quaternary catchment resolution. The maps provide a comparative rating of the risk of faecal contamination of the surface water and groundwater resources. The microbial information that has been provided is, however, intended for planning purposes only and is not suitable for detailed water quality assessments.

Mapping microbial contamination of surface water resources

As part of the National Microbiological Monitoring Programme a screening method was developed to identify the risk of faecal contamination in various catchments. This screening method uses a simple rule based weighting system to indicate the relative faecal contamination from different land use areas. It has been confirmed that the highest faecal contamination rate is derived from high population densities with poor sanitation services. The Programme produced a map, at quaternary catchment resolution, showing the potential faecal contamination in the selected catchments. Unfortunately, the map did not cover the entire country.

As part of this study, the same screening method was applied to produce a potential surface faecal contamination map for the whole of South Africa using national databases for population density and degree of sanitation. The portion applicable to the Luvuvhu/Letaba 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 Luvuvhu/Letaba WMA is given in Figure 6.4.3.2. This map shows the degree of potential faecal contamination in groundwater using a rating scale which ranges from low to medium to high.

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

The river quality of the Luvuvhu Secondary catchment is generally suitable for agriculture purposes and for domestic supply after the standard type of treatment. There is general decrease in Total Dissolved Solids (TDS) along the upper reaches of the Luvuvhu River, downstream of Albasini Dam, due to dilution by water from tributaries such as the Latonyanda, Dzindi and Mutshindudu Rivers.

There is also an increase in TDS along the lowest reaches and it is probably due to the increased contribution from the drier sub catchments and the geology of the lower basin. There is no available data on the water quality effects of irrigation return flows. It is suspected that these and sewage effluent lead to a decrease in water quality in the river.

There is no apparent eutrophication problem. An assessment of the trophic status of Ebenezer, Magoebaskloof and Tzaneen dams found that all three dams could be classified as oligotrophic (not enriched with nutrients). Tzaneen Dam does periodically exhibit mesotropic conditions (moderately enriched with nutrients) but it is not yet regarded as concern (Van Ginkel *et al.*, 2000). A study by the University of the North (Van Senus et al., 1991) on the Middle Letaba Dam confirmed that eutrophication is not yet a problem in the dam because low chlorophyll a concentrations were measured in the dam. Heath & Claassen (1994) concluded that Nsami Dam was not suited for recreation due to high bacterial counts in the dam and potential eutrophication problems in the dam. Current low dissolved phosphate concentrations in Nsami Dam can lead to mesotrophic conditions i.e. a moderate potential for eutrophication related water quality problems.

In the Mutale River water at Tshikondeni is considered unsuitable for domestic use based on the ammonia, nitrate and iron content and the pH of the water would be problematic for irrigation applications. In the rest of the catchment it is generally suitable for livestock and irrigation purposes and for domestic supply after the standard type of treatment.

6.5 SEDIMENTATION

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

According to the generalized sediment yield map of Southern Africa, the Letaba Secondary catchment should contain areas with above average sediment yield potential. The maximum yield that was recorded for comparable catchments located outside the catchment was 600 t/km²/annum. This may be compared to maximum observed yield values of 1 000 t/km²/annum for a large catchment (Caledon River) and 3 000 t/km²/annum for a sub catchment (of the Caledon River).

The Hutton soils on steep slopes in the upper catchment areas of the Letaba Secondary catchment possess the highest yield potential. As the existing and foreseeable land-use practices do not include large scale tillage operations, the maximum average expected yields should not be higher than 400 t/km²/annum.

Information on sediment in the Luvuvhu Secondary catchment is sparse. Only limited erosion occurs in the catchment and sediment surveys of comparable catchments suggest low rates of sedimentation. A load of 300 t/km²/annum would be a conservative estimate of the upper limit of sediment yield for the secondary catchment as a whole.

Little data is available for the Mutale Secondary catchment. It is situated in Sedimentation Region 1 and average to below average sediment yield could be expected.

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

TABLE 6.5.1: RECORDED RESERVOIR SEDIMENTATION RATES FOR RESERVOIRS IN THE LUVUVHU/LETABA 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 ($t/km^2.a$)
B81A	Groot Letaba	Ebenezer	156	1959-1986	0,690	0,898	155
B81B	Politsi	Magoebaskloof	64	1970-1986	0,179	0,179	76
B81A	Broederstroom	Dap Naude	14	1961-1987	0,185	0,185	357
B81B	Ramadiepa	Hans Merensky	88	1935-1987	0,081	0,081	25

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 Assessment (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 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 the 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 modelled correctly.

The approach taken to determine the water balance was therefore to remove the above questionable components out of the WSAM modelling procedure. This is done relatively easily. The above impacts (Ecological Reserve, etc) were then determined externally 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 as to present most of the information contained in the tables of this report. This is not only limited to water requirements but also lists land uses such as irrigated areas, afforested areas, etc.

The data 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 Appendixes to this report.

Water requirements or gains that the WSAM could not calculate were determined as follows:

Ecological Reserve

The impact of the ecological reserve on the yield of a catchment depends on the storage in that catchment. It was accepted that the water required for the ecological reserve follows the same general pattern of (i.e. mimics) the natural flow and that the storage/yield characteristics of the natural catchment could therefore also be used to estimate the yield of the catchment after allowing for the water requirements of the ecological reserve. The estimates of the impact on the yield of a catchment were made separately for each of the incremental catchments between key points. The total storage within the incremental catchment was transported to its outlet and formed the basis for determining the incremental yield of the catchment under natural conditions, both with and without provision for the ecological reserve. The yields were estimated from the storage yield characteristics used in the WSAM for any particular recurrence interval of concern. The incremental impact of the ecological reserve on the water resources of a particular key area was taken to be the difference between the impact at the downstream key point less the impact at the upstream key point.

The impact of the ecological reserve on the run-of-river yield was accepted to be the annual equivalent of the lowest 4-month water requirement for the ecological reserve. This value was used to establish the incremental impact of the ecological reserve on the yield at a key point at which there was no significant storage in the incremental catchment.

Using the above method, negative impacts are sometimes impossible. 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 lose 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 those 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 externally to the model as follows:

- The water balance produced by the WSAM, as described in paragraph 7.1.2 above, was mostly deemed to the correct. In the few instances where it was clearly incorrect an adjustment was made based on the results of other studies. These changes have been documented. 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 assumptions was applied throughout the WMA, except in the case of the upper Letaba catchment where the yield was found to be very sensitive to this assumption. Here information relating to the runoff into minor dams was obtained from a recent systems analysis.

  - 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

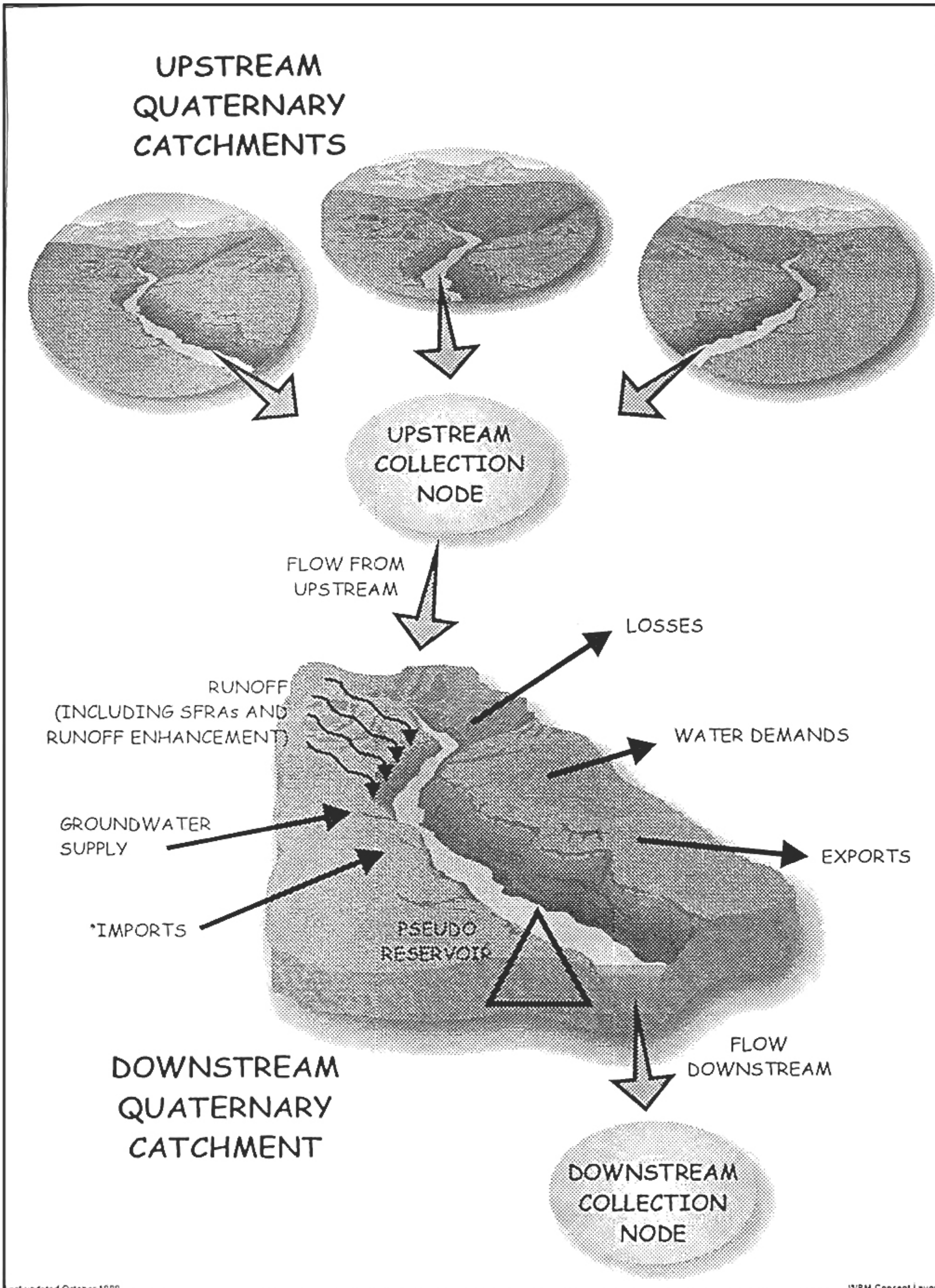
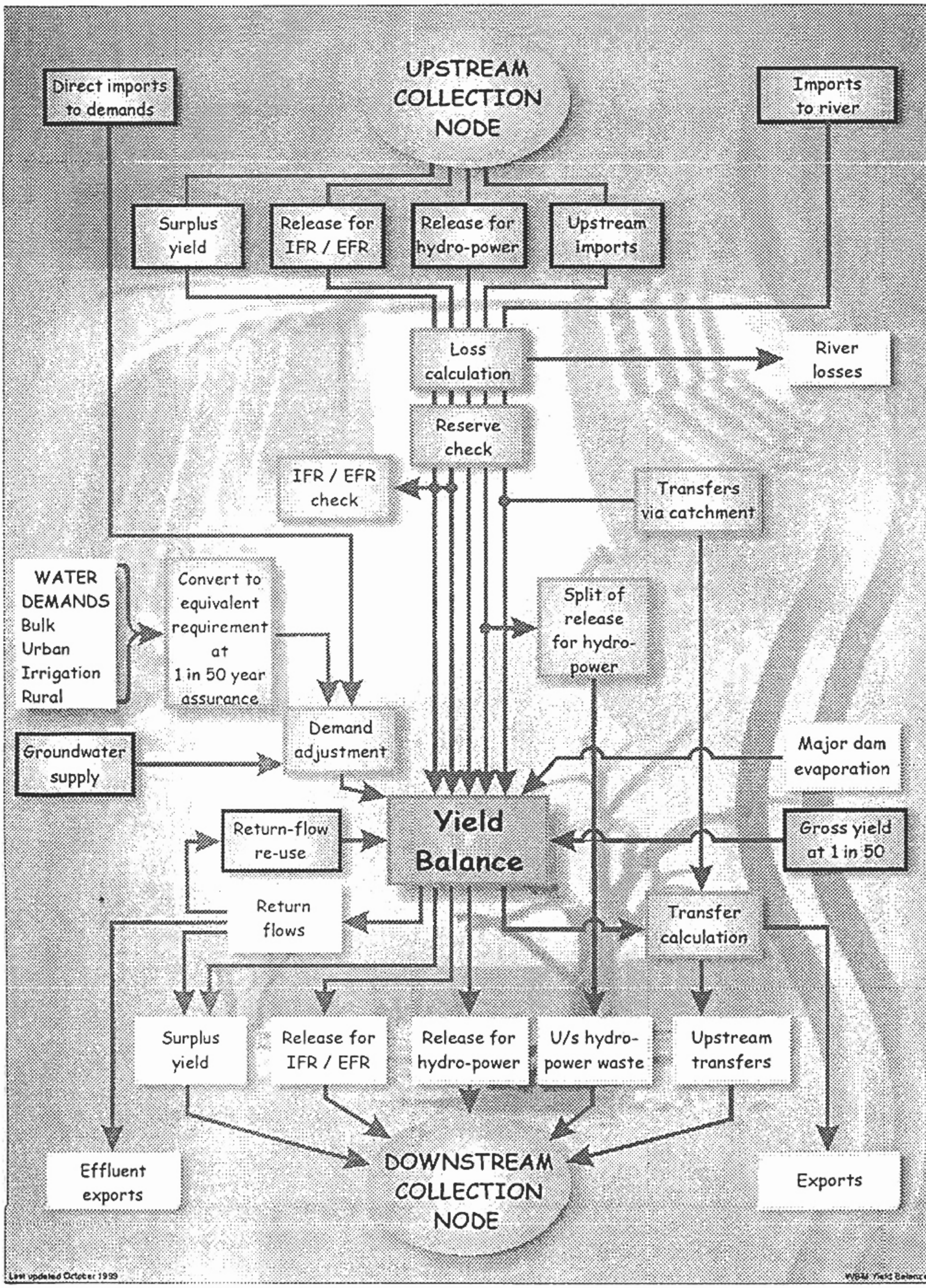


DIAGRAM 7.1.2: WATER BALANCE MODEL YIELD BALANCE ALGORITHM



7.2 OVERVIEW

Key points of interest were selected as the reporting level for the results of the study. The selection of these points and the list of quaternary catchment areas included at each key point are described in Chapter 2 (section 2.1).

In summary, Table 7.2.1 indicates the water requirements in 1995 at the different keypoints. The water balance is indicated in Table 7.2.2, where the water requirements and availability are compared. Figure 7.2.1 gives a water balance overview.

TABLE 7.2.1: WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

Catchment						Stream flow reduction activities (10^6 m^3 /a)		Water use (10^6 m^3 /a)		Water requirement (10^6 m^3 /a)							Ecological reserve (10^6 m^3/a)	Total (10^6 m^3/a)
Primary		Secondary		Tertiary		Affo=re=station	Dryland sugar cane	Alien vegeta=tion	River losses	Bulk (1)	Irriga=tion(2)	Rural (3)	Urban (4)	Hydro-power	Water transfers out of WMA	**Neigh=bouring states		
No	Descrip=tion	No	Description	No	Description													
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	3,3	0,0	10,7	0,0	0,0	45,2	0,9	0,3	0,0	1,8	0,0	4,6	66,8
					Paswane Dam site	2,2	0,0	0,6	0,0	0,0	14,2	4,9	3,7	0,0	0,4	0,0	14,9	40,9
					Luvuvhu at Mutale	0,9	0,0	0,1	0,0	0,0	2,6	0,8	0,0	0,0	0,0	0,0	0,0	4,4
					Luvuvhu at Limpopo	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	43,1	43,1
				A92	Mutale at Luvuvhu	0,0	0,0	0,0	0,0	1,1	33,8	1,4	0,0	0,0	0,0	0,0	67,3	103,6
Total in Luvuvhu River catchment						**6,4**	**0,0**	**11,4**	**0,0**	**1,1**	**95,8**	**7,9**	**4,0**	**0,0**	**2,2**	**0,0**	**129,9**	**258,7**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	32,3	0,0	8,1	1,2	0,0	34,0	0,2	0,0	0,0	10,2	0,0	21,7	107,7
					Groot Letaba at Molototsi	3,1	0,0	1,6	8,9	0,0	79,1	4,5	2,9	0,0	0,6	0,0	3,4	104,1
					Molototsi	0,0	0,0	0,0	0,0	0,0	1,0	2,6	0,1	0,0	0,0	0,0	0,0	3,7
					Groot Letaba at Klein Letaba	0,0	0,0	0,0	2,7	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	3,0
				B82	Middle Letaba Dam	1,0	0,0	0,5	0,0	0,0	16,4	2,1	1,5	0,0	0,0	0,0	3,6	25,1
					Klein Letaba at Tabaan	0,0	0,0	0,0	0,0	0,0	0,4	2,3	0,0	0,0	0,4	0,0	0,0	3,1
					Klein Letaba at Groot Letaba	0,0	0,0	0,0	0,0	0,0	5,9	2,3	0,9	0,0	0,0	0,0	0,0	9,1
				B83	Letaba at Olifants	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,2
Total in Letaba River catchment						**36,4**	**0,0**	**10,2**	**12,8**	**0,0**	**136,8**	**14,4**	**5,4**	**0,0**	**11,2**	**0,0**	**28,7**	**255,9**
		B9	Shingwedzi	B90	Mphongolo	0,0	0,0	0,0	0,0	0,0	0,0	1,3	0,2	0,0	0,0	0,0	0,0	1,5
			Shingwedzi		Shingwedzi	0,0	0,0	0,0	0,0	0,0	0,0	0,9	0,0	0,0	0,0	0,0	0,0	0,9
Total in Shingwedzi River catchment						**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**2,3**	**0,2**	**0,0**	**0,0**	**0,0**	**0,0**	**2,5**
Total in Luvuvhu / Letaba WMA						**42,8**	**0,0**	**21,6**	**12,8**	**1,1**	**232,6**	**24,5**	**9,6**	**0,0**	**13,4**	**0,0**	**158,6**	**517,0**

* Typically areas upstream of key points, but selected to suit the characteristics of each WMA.
** A column for water requirements of neighbouring states to be included only where applicable. Catchment numbers and sub-totals of quantities should be included as appropriate in the Catchment columns.
(1) Requirements of wet industries, mines, thermal power stations and any other bulk users supplied individually by a water board or DWAF.
(2) Includes conveyance and distribution losses.
(3) Requirements for rural household use, livestock and game watering, and subsistence irrigation, including losses.
(4) Requirements for urban residential, commercial, municipal and institutional use, and requirements of industries supplied by local authorities, all including water losses.

TABLE 7.2.2: WATER REQUIREMENTS AND AVAILABILITY

Catchment						Available 1:50 yr yield in 1995			Water transfers at 1:50 yr assurance		Return flows at 1:50 yr assurance		Water requirement at 1:50 yr assurance	Water balance at 1:50 yr assurance
Primary		Secondary		Tertiary		Surface water	Ground water not linked to surface water	Total	Imports	Exports	Re-usable	To sea		
No	Description	No	Description	No	Description									
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	37,3	15,7	53,0	0,0	1,8	4,6	0,0	66,8	-10,9
					Paswane Dam site	72,6	1,6	74,2	0,0	0,4	2,9	0,0	40,9	35,9
					Luvuvhu at Mutale	39,9	1,2	41,1	0,0	0,0	0,3	0,0	4,4	37,0
					Luvuvhu at Limpopo	1,4	0,0	1,4	0,0	0,0	0,0	0,0	43,1	-41,7
				A92	Mutale at Luvuvhu	155,2	2,1	157,3	0,0	0,0	3,4	0,0	103,6	57,1
Total in Luvuvhu River catchment						**306,4**	**20,6**	**327,0**	**0,0**	**2,2**	**11,2**	**0,0**	**258,7**	**77,4**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	26,6	3,1	29,7	0,0	10,2	3,4	0,0	107,7	-84,8
					Groot Letaba at Molototsi	148,9	7,5	156,4	0,0	0,6	9,2	0,0	104,1	60,8
					Molototsi	6,6	1,7	8,3	0,0	0,0	0,2	0,0	3,7	4,8
					Groot Letaba at Klein Letaba	1,6	0,2	1,8	0,0	0,0	0,0	0,0	3,0	-1,2
				B82	Middle Letaba Dam	36,2	5,6	41,8	0,0	0,0	2,2	0,0	25,1	18,9
					Klein Letaba at Tabaan	0,3	3,2	3,5	0,0	0,4	0,0	0,0	3,1	0,0
					Klein Letaba at Groot Letaba	1,1	0,8	1,9	0,0	0,0	0,9	0,0	9,1	-6,4
				B83	Letaba at Olifants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	-0,2
Total in Letaba River catchment						**221,3**	**22,0**	**243,3**	**0,0**	**11,2**	**15,9**	**0,0**	**255,9**	**-7,9**
		B9	Shingwedzi	B90	Mphongolo	0,3	1,0	1,3	0,0	0,0	0,1	0,0	1,5	-0,2
					Shingwedzi	1,1	0,6	1,7	0,0	0,0	0,0	0,0	0,9	0,8
Total in Shingwedzi River catchment						**1,4**	**1,6**	**3,0**	**0,0**	**0,0**	**0,1**	**0,0**	**2,5**	**0,6**
Total in Luvuvhu / Letaba WMA						**529,1**	**44,2**	**573,3**	**0,0**	**13,4**	**27,2**	**0,0**	**517,0**	**70,1**

7.3 THE LUVUVHU/LETABA WATER MANAGEMENT AREA

The overall water balance for the Luvuvhu/Letaba WMA is approximately minus 70 million m³/a.

The Luvuvhu/Mutale River has a balance of 77 million m^3/a. This is due to a very high surface water contribution. We suspect that this data acquired from WSAM need to be verified before it is used as the high value for Mutale at Luvuvhu is suspect. From the study by Africon (DWAF, 1999), the 1995 1:50-year developed yield in the Mutale River is in the order of 30 million m³/a and not 155 million m³/a as given in Table 6.1.1 and therefore the balance of minus 70 million m³/a in the WMA given above may be closer to **minus 195 million m³/a**.

The water balance for the Letaba River suggests a shortfall of minus 7,9 million m³/a at the outlet of the Letaba River immediately upstream of its confluence with the Olifants River.

The Shingwedzi River is essentially in balance. Limited development has occurred in this catchment and the Mphongolo River has small deficit of minus 0,2 million m³/a. The resultant balance for the Shingwedzi River is 0,6 million m³/a.

7.4 THE LUVUVHU CATCHMENT

The resultant balance for the Luvuvhu River catchment is given as 77,4 x 10^6 m³/a.

* The upper reaches of the Luvuvhu River at Levubu (refer to Table 7.2.2) has had considerable land use development particularly in terms of irrigation and abstraction for domestic water use and as a result, a deficit of minus 10,9 x 10^6 m³/a occurs. Little development has occurred along the middle reaches of the Luvuvhu River upstream of the Mutshindudi River confluence and as a result, a significant surplus of 35,9 x 10^6 m³/a occurs.
* The Luvuvhu at the Mutale River has very low water requirement and the balance is 37,0 x 10^6 m³/a. However, the zero Ecological Reserve requirement (Hughes) is suspect and requires confirmation.
* The Mutale River shows a large surface water resource, in spite of the fact that no storage dams have been developed here yet. This information, obtained from WSAM, requires verification since the resultant water balance, a positive 57,1 x 10^6 m³/a may in fact be much lower.
* The last reach of the Luvuvhu River is mostly in the KNP and has a negative balance because the only water requirement is the Ecological Reserve.

7.5 THE SHINGWEDZI CATCHMENT

The Shingwedzi River catchment comprises several tributaries which rise in areas occupied by rural villages and then flow for some two thirds of their lengths through the KNP before joining the main stream (Shingwedzi River Proper) to ultimately flow into the Limpopo River in Mozambique. In view of its limited land use, little water resource development and water use has occurred in the catchment.

- The Mfungolo River has a small deficit of minus 0,2 x 10^6 m³/a due to a relatively high rural water requirement.
- The water balance for the whole of the Shingwedzi River catchment is slightly positive, i.e. 0,6 x 10^6 m³/a, and the catchment can thus be considered to be in balance.

7.6 THE LETABA CATCHMENT

The Letaba River comprises major tributaries including the Klein Letaba River, Middle Letaba River, Molototsi River and Groot Letaba River. The catchment is highly developed for irrigation particularly in the Middle Letaba River catchment and Groot Letaba River catchment. Numerous large dams have been constructed to augment water supplies mainly for irrigation, but also for domestic water use. Significant areas of afforestation occur particularly in the upper reaches of the Groot Letaba River catchment. The afforestation is a significant user of water.

The overall balance of the Letaba system is a small deficit of minus 7,9 million m³/a, but this belies the major shortfalls which occurs in certain areas of the catchment.

- The Groot Letaba River at its confluence with the Klein Letaba River (sum 0f B81 catchments) has an overall water balance of minus 20,4 million m³/a which indicated the river is under great strain.
- Upstream of the Tzaneen Dam, there is a deficit of 84,8 million m³/a which is brought about by water requirements that have to be met by the availability from Tzaneen Dam.
- The yield of Tzaneen dam is apparantly given in the next key area (Groot Letaba at Molototsi) and this brings about a distorted reflection in this key area, of a positive balance of 60,8 x 10^6 m³/a.
- In evaluating the water balance of the Klein Letaba River (B82 catchments), it should be noted that all irrigation and rural demands is met mainly from the Middle Letaba Dam, therefore the total balance should be considered, which is positive 12,5 million m³/a.

CHAPTER 8: COSTS OF WATER RESOURCES DEVELOPMENT

8.1 SUMMARY

Table 8.1.1 indicates the costs of water resource development in the Luvuvhu/Letaba 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.

The estimated total development cost amounts to R 5 096,51 million.

TABLE 8.1.1: COSTS OF WATER RESOURCE DEVELOPMENT

Catchment						Net Storage Volume to be Supplied	Estimated Cost for Surface Water Development cost	Wellfield Yield to be Developed*	Estimated Cost for Wellfield Development	Total Cost
Primary		Secondary		Tertiary		(10^6m^3)	(R x 10^6)	($10^6m^3/a$)	(R x 10^6)	(R x 10^6)
No	Description	No	Description	No	Description					
A (Part)	Limpopo	A9	Luvuvhu / Mutale	A91	Luvuvhu at Levubu	197,60	464,01	-19,84	0,00	464,01
					Paswane Dam site	418,20	658,54	-0,64	0,00	658,54
					Luvuvhu at Mutale	96,60	332,18	2,44	19,50	351,68
					Luvuvhu at Limpopo	7,80	102,57	4,16	33,28	135,85
				A92	Mutale	350,70	606,57	0,77	6,19	612,76
Total in Luvuvhu River catchment						**1 070,90**	**2 163,86**	**7,37**	**58,97**	**2 222,83**
B (Part)	Olifants	B8	Letaba	B81	Tzaneen Dam	-132,15	-384,53	-8,08	0,00	-384,53
					Groot Letaba at Molototsi	293,82	558,45	1,83	3,66	562,12
					Molototsi	69,90	285,60	7,98	15,96	301,56
					Groot Letaba at Klein Letaba	15,90	143,04	4,36	8,72	151,76
				B82	Middle Letaba Dam	18,40	153,13	7,47	14,94	168,07
					Klein Letaba at Tabaan	123,60	372,70	6,47	12,95	385,65
					Klein Letaba at Groot Letaba	93,10	326,51	13,92	111,36	437,87
				B83	Letaba at Olifants	117,90	364,58	18,49	147,92	512,50
Total in Letaba River catchment						**600,47**	**1 819,48**	**60,52**	**315,51**	**2 134,99**
		B9	Shingwedzi	B90	Mphongolo	92,90	326,18	12,58	0,00	326,18
					Shingwedzi	153,60	412,51	11,33	0,00	412,51
Total in Shingwedzi River catchment						**246,50**	**738,69**	**23,91**	**0,00**	**738,69**
Total in Luvuvhu / Letaba WMA						**1 917,87**	**4 722,03**	**91,80**	**374,48**	**5 096,51**

* Sum totals include only positive values

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

8.2 CAPITAL COST OF DAMS

Diagram 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 is R4 722 million, which would ensure that the probable maximum surface water potential is developed by constructing storage. It must be noted that in some instances run-of-river yield is currently utilized and in the wetter, high runoff regions the provision of storage may not be required.

8.3 CAPITAL COST OF WELLFIELD DEVELOPMENT

Diagram 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 Diagram 8.1.2 is in Rand per kℓ/a of water produced.

The costs shown include for 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.

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

For the calculation of the wellfield development cost an assumption was made that there are two borehole yields that can be applied for the WMA, namely a borehole yield of 1 or 5 ℓ/s. The assumption was based on Figure 6.2.2 in which the WMA can be divided in two exploitation potential zones of more or less than 6 mm. From Diagram 8.1.2 the associated cost is R2/m^3 or R8/m^3. Where the wellfield to be developed has a negative yield, a zero cost was assumed.

DIAGRAM 8.1.1: CAPITAL COST OF DAMS

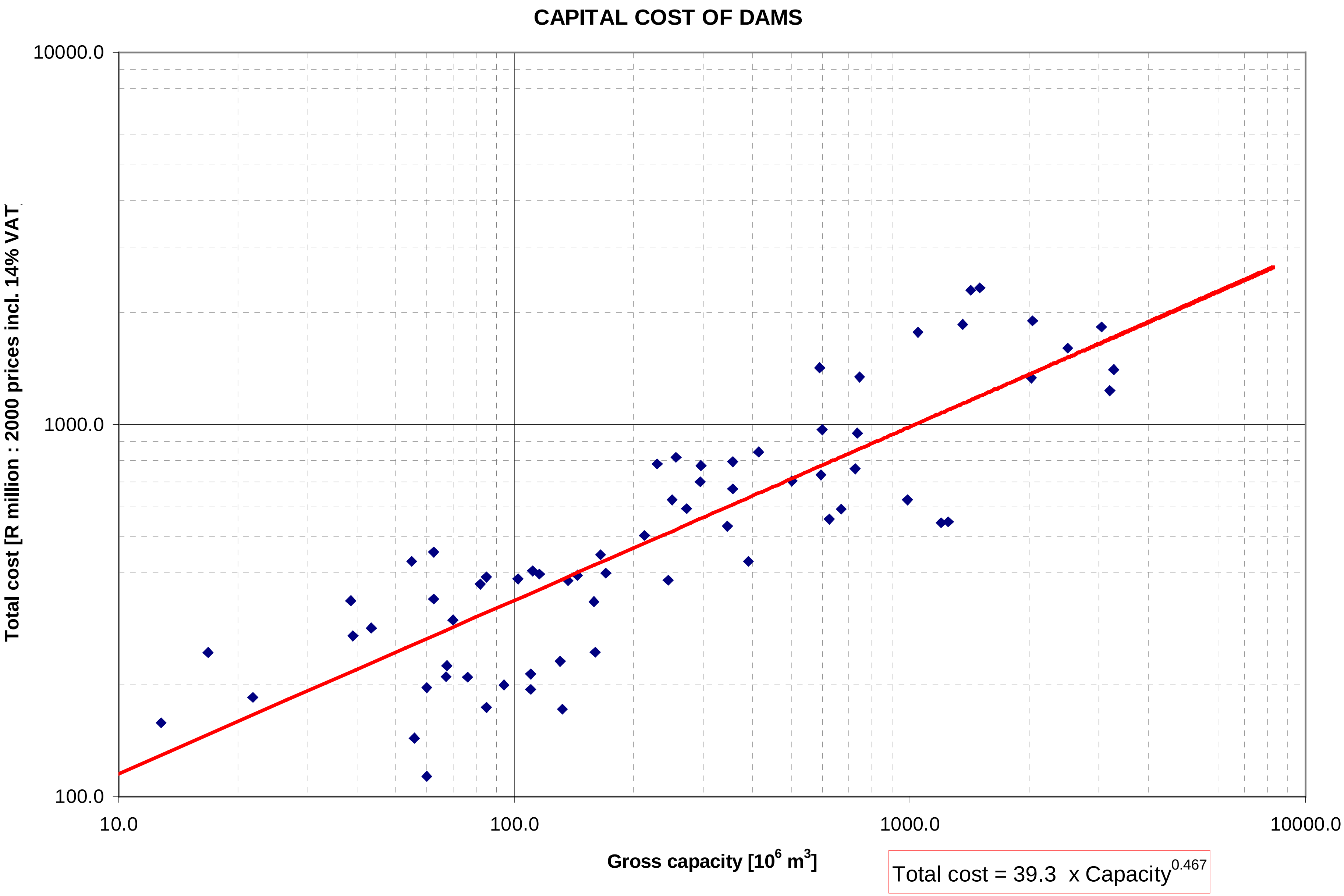
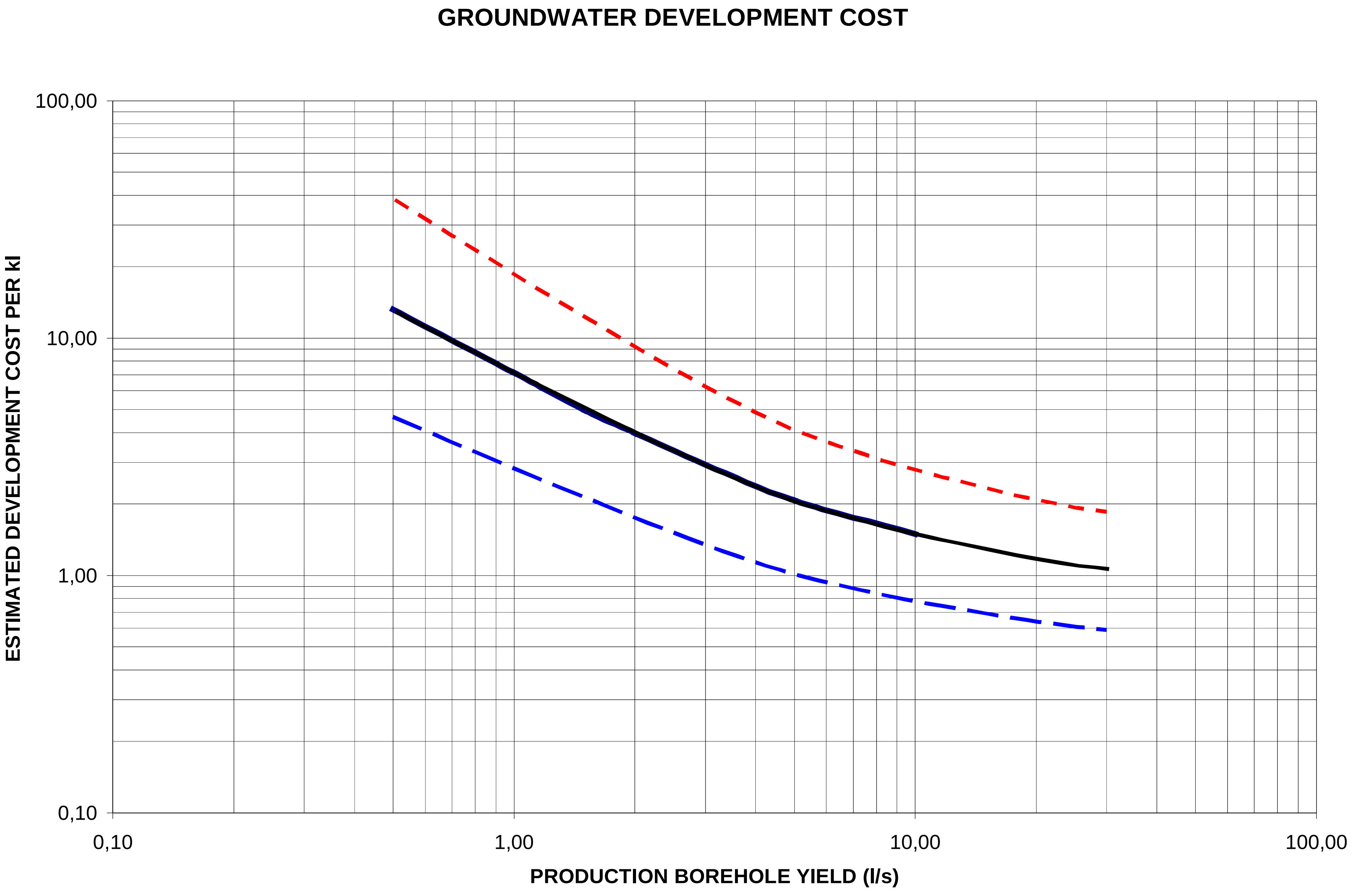


DIAGRAM 8.1.2: CAPITAL COST OF WELLFIELDS



CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 AVAILABLE DATA

Data that should be investigated further for the purpose of proper management of the Luvuhu/Letaba WMA include:

- Monitoring of **large water abstractions** from both surface and ground water resources and the recording of these in a data base. The agricultural sector is the largest water user in the Luvuhu/Letaba WMA, yet only highly incomplete information exists about the water use on individual farms. There are still many uncertainties in this field, like crop areas and actual irrigation water application versus the theoretical (design) quantities. More work needs to be done to verify crop areas. Best management practices needs to be implemented by the service providers to encourage responsible water use on farm level.

- Overgrazing should be discouraged to limit the erosion of sensitive areas.

- Outstanding information on **population** statistics and water supply infrastructure, especially in rural villages, could be collected to enable a better estimate of water requirements.

- The **river flow-gauging network** should be improved with new gauges at strategically important points in the basin, especially the downstream reaches of the rivers. 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 optimizing of water supply systems. Proper measurements are required to facilitate such assessments.

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

- 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.

Many of the issues listed above would probably be taken care of in the WSDP plans and monitoring required of water service providers by DWAF, as well as in the water use registration and ultimate licencing process.

9.2. THE LUVUVHU/LETABA WMA

Priority should be given to the monitoring and research needs associated with variables related to the largest quantities of water used in the catchment and factors which have the greatest impact on water use and water resources development. In this regard, irrigation uses most of the catchment’s exploitable water, but the quantity of water involved is among the most poorly monitored.

Regarding the second highest water use, viz Ecological Reserve, it seems imperative that the final river management classification be done. This should be followed by the final estimates of the Ecological Reserve so that a better assessment can be made of the utilizable water resources.

Domestic water use, especially in the rural areas, should be curtailed to realistic levels by water demand management strategies. Such efforts should undoubtedly lead to the existing water sources serving more people.

The accuracy of the estimated water use by alien vegetation should be improved, because it is estimated to be a relatively high consumer (viz. 21,6 million m^3/a for alien vegetation versus 24,5 million m^3/a for rural use). If alien vegetation use is indeed of this magnitude, steps should be taken to minimise it.

Urgent considerations should be given to the water management of the basin and the establishment of a Catchment Management Agency to plan, implement, operate, control and manage the water resources of the basin including the legal and institutional structure which would be required.

Aspects relating to the sub catchments are discussed below.

9.3 THE LUVUVHU CATCHMENT

The importance of existing commercial irrigation, both in terms of income generated and work opportunities provided, should be borne in mind in any development scheme.

The construction of the new Nandoni Dam will improve water supply to rural villages and secure water for increased irrigation. Inter-departmental co-ordination is required to ensure the long-term efficient use of this increased resource for irrigation by emerging farmers.

9.4 THE MUTALE CATCHMENT

The introduction of more ecologically sound agricultural practices including realistic stock levels is required to halt the current degradation of the vegetation and thus improve runoff quality and limit soil erosion.

Additional streamflow gauging weirs should be considered, particularly to assess the river channel losses between the entrance to the Mutale Poort and the confluence with the Luvuvhu River. Besides being used for flow measurements, new gauging stations and the existing gauging stations must also be used for water quality measurements and to monitor water use in certain areas. It is essential that all streamflow gauging weirs are operated effectively.

Additional rainfall and evaporation stations should be established. It is proposed that the sites and distribution of these stations be confirmed only after a survey has been conducted on the availability of suitably qualified and reliable observers in the areas of interest.

Steps need to be taken to ensure adequate representation of the various water user sectors in the Mutale River catchment on the Luvuvhu/Letaba Catchment Management Agency.

9.5 THE LETABA CATCHMENT

Additional rainfall, evaporation and streamflow gauging stations should be established.

Quantification of irrigation, domestic and industrial water use is essential to ensure equitable distribution of water in this stressed catchment.

The establishment of a Catchment Management Agency is required to properly manage the water resources in light of the ever-increasing competition between agricultural and domestic water user sectors.

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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 B

MACRO-ECONOMIC DATA

LUVUVHU/LETABA WATER MANAGEMENT AREA

3.3.1 INTRODUCTION

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

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

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

3.3.2 DATA SOURCES

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

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

The **labour** distribution provides information on the sectoral distribution of formal economic activities, as do the GGP figures, but in addition, information is provided on the extent of informal activities, as well as dependency. Dependency may be assessed from unemployment figures, as well as by determining the proportion of the total population that is economically active.

Total economically active population consists of those employed in the formal and informal sectors, and the unemployed. *Formally employed* includes employers, employees and self-employed who are registered taxpayers. *Unemployment figures* include people who are actively looking for work, but are not in any type of paid employment, either formal or informal. *Active in informal sector* includes people who are employers, employees or self-employed in unregistered economic activities, i.e. businesses not registered as such. The labour data was obtained directly from the Development Bank of Southern Africa (DBSA). The DBSA has utilised the 1980 and 1991 population censuses as the basis but has also updated the figures utilising the 1995 October Household Surveys of Statistics South Africa (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 WMAs was merged with the Magisterial District (MD) boundaries, and the surface area for each of the newly generated polygons was determined. The proportion of the surface area of each of the MD, which falls within each WMA, was calculated, and that proportion was used to allocate the part of a GGP figure that falls on each side of a WMA-boundary.

- **Trade and Community Services**

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

- **Other Sectors**

Historical factors such as the relocation of certain segments of the population to non-productive areas, and the immigration of mainly Mozambicans, especially to Mpumalanga and the Northern Province, had to be taken into account when allocating the GGP figure to the WMAs. Subsequently, for all the sectors apart from those discussed above, only the caucasion population was used to perform the calculations as described above. Economic activities in these sectors are less dependent on population *per se*, but are dependent on the same factors which affect the kind of population distribution that is not distorted by government intervention or other external factors. The caucasion 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 Luvuvhu/Letaba WMA was R5,1bn in 1997. The most important magisterial districts in terms of contribution to GGP in this WMA are shown below:

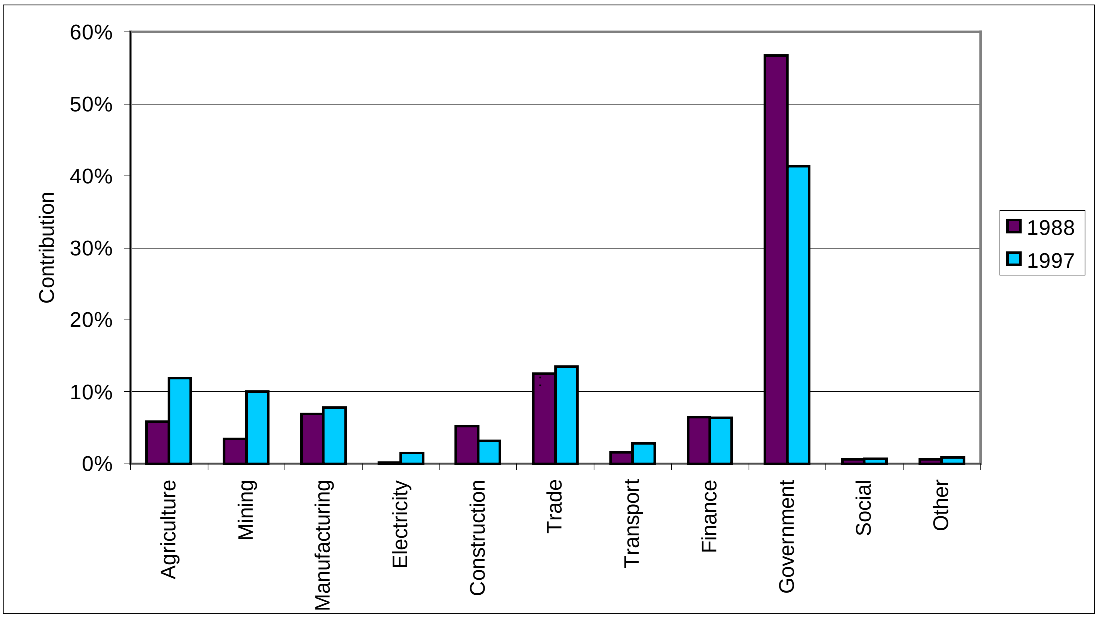
- Thohoyando 18,1%
- Letaba 15,4%
- Phalaborwa 11,4%
- Giyani 9,8%
- Vuwani 7,9%
- Other 37,4%

❒ **Economic Profile**

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

- Government 41,3%
- Trade 13,5%
- Agriculture 11,9%
- Mining 10,0%
- Other 23,3%

Figure 3.3.1: Contribution by Sector to Economy of Luvuvhu/Letaba Water Management Area, 1988 and 1997 (%)



The Letaba district contributes approximately 45% to the total national income generated in horticulture production of which the largest portion can be attributed to vegetables and citrus. In the Bushveld Region ostrich production is also increasing although the profit margin is not often that high.

The minerals found in this WMA include complex flake graphite, ironstone, marble, fire clay, surficial limestone, magnesile, lead, barile mineralisation, and small gold deposits. The mining industry in the Lowveld subregion is dominated by the Phalaborwa Mining Company (copper) and Foskor (phosphates).

The concentration of government activities can largely be attributed to the existence of the former homeland areas of Gazankulu, Lebowa and Venda.

❒ Economic Growth

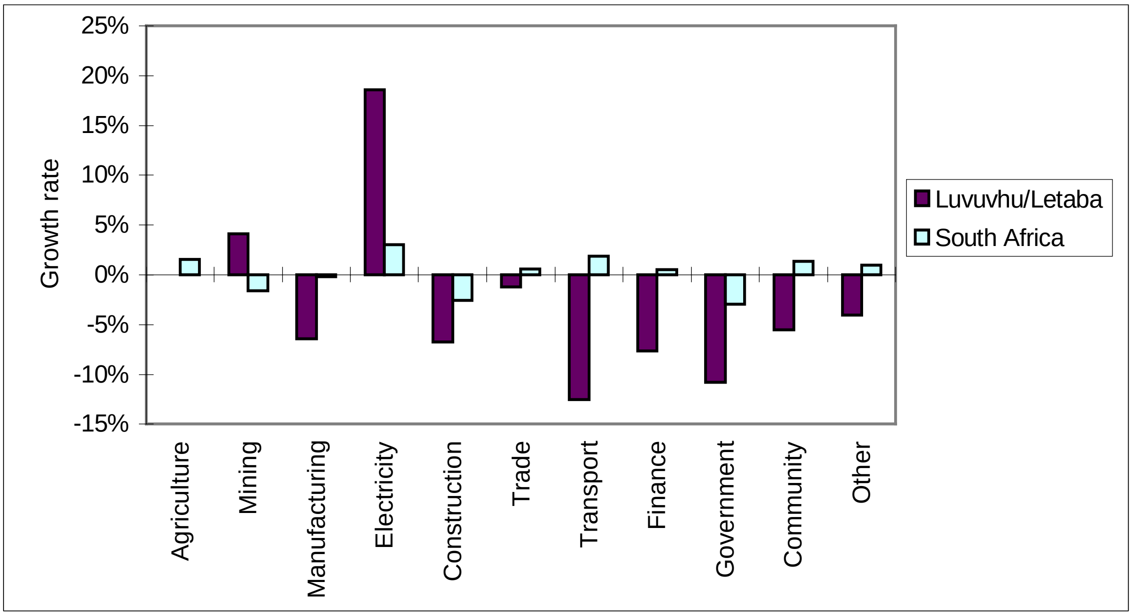
The average annual economic growth by sector is shown in Figure 3.3.2 Between 1987 and 1997 the highest growth rates were recorded in the following sectors:

- Electricity : 18.6%
- Mining : 4.1%

The mining sector is an important employment creator and growth generator in the area. Due to the variety of minerals and metals found as well as the demand for coal, growth can be expected to continue.

The high growth rate recorded in the electricity sector took place from a small base and could also possibly be attributed to the supply of electricity to new housing projects.

Figure 3.3.2: Average Annual Economic Growth by Sector of Luvuvhu/Letaba Water Management Area and South Africa, 1988-1997



❒ Labour

Of the total labour force of 343 000 persons, 49.4% are unemployed, which is higher than the national average of 29.3%. Forty percent (40.5%) are active in the formal economy. Fifty three percent (53.3%) of the formally employed labour force work for government, while 19.1%, are involved in agriculture, and 9.2% in trade.

Between the period 1980 – 1994, the sectors with the highest growth rates were financial services (8.5% per annum); the government sector (6.6% per annum); construction (2.3% per annum); and manufacturing (2.0% per annum).

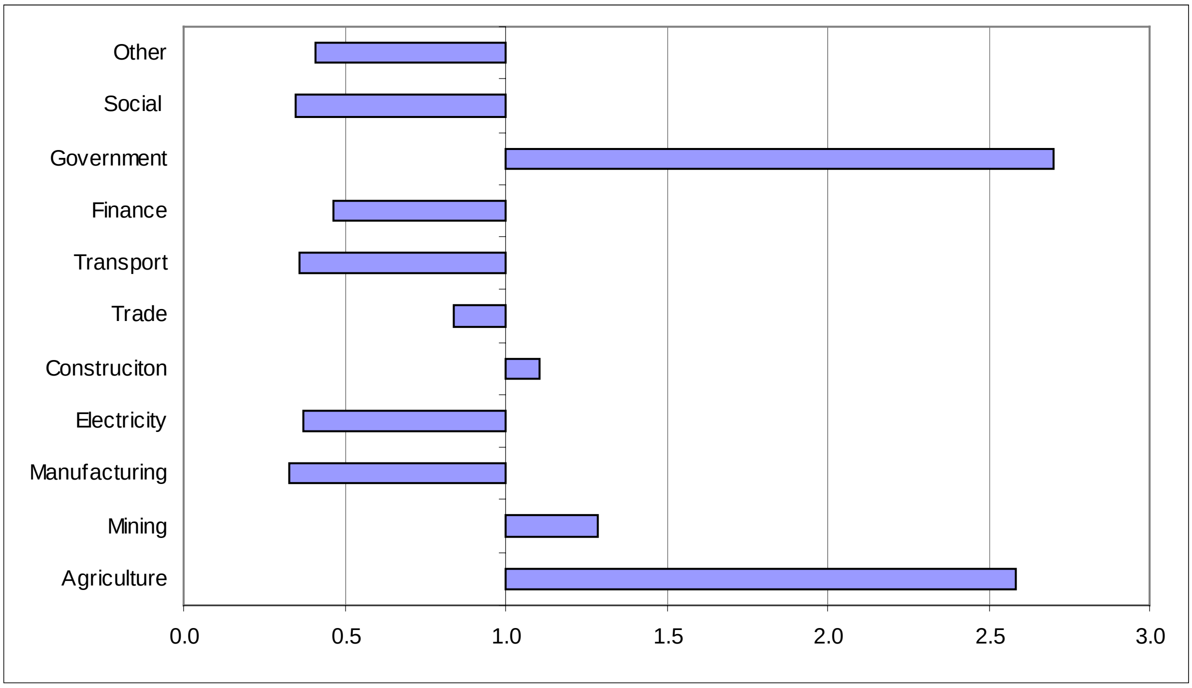
3.3.5 COMPARATIVE ADVANTAGES

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 which has the comparative advantage. The location quotient is a measure of the relative concentration of economic activities in a region as compared with another region, or as compared with a larger region of which it forms part. A location quotient for an economic sector with a value of more than one implies that the sector contributes a larger percentage to a sub-region's GGP than that sector contributes to the larger area of which the sub-region forms part. The location quotient can, however, not be equated with comparative advantage, and provides only an indication.

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

- Agriculture : 2.6
- Mining : 1.3
- Government : 2.7
- Construction : 1.1.

Figure 3.3.3: Luvuvhu/Letaba Gross Geographic Product Location Quotient by Sector, 1997



The comparative advantage of the agricultural sector is largely attributed to the variety of products, the good performance of this sector in the Luvuvhu/Letaba WMA and the importance of this sector in this WMA.

The diversified mining base contributes to the comparative advantage of this sector.

The Luvuvhu/Letaba WMA does not possess a comparative advantage in trade and tourism activities, seen within a national context, even though this sector is fairly important to the regional economy.

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 Luvuvhu/Letaba Economy, 1997 (%)**

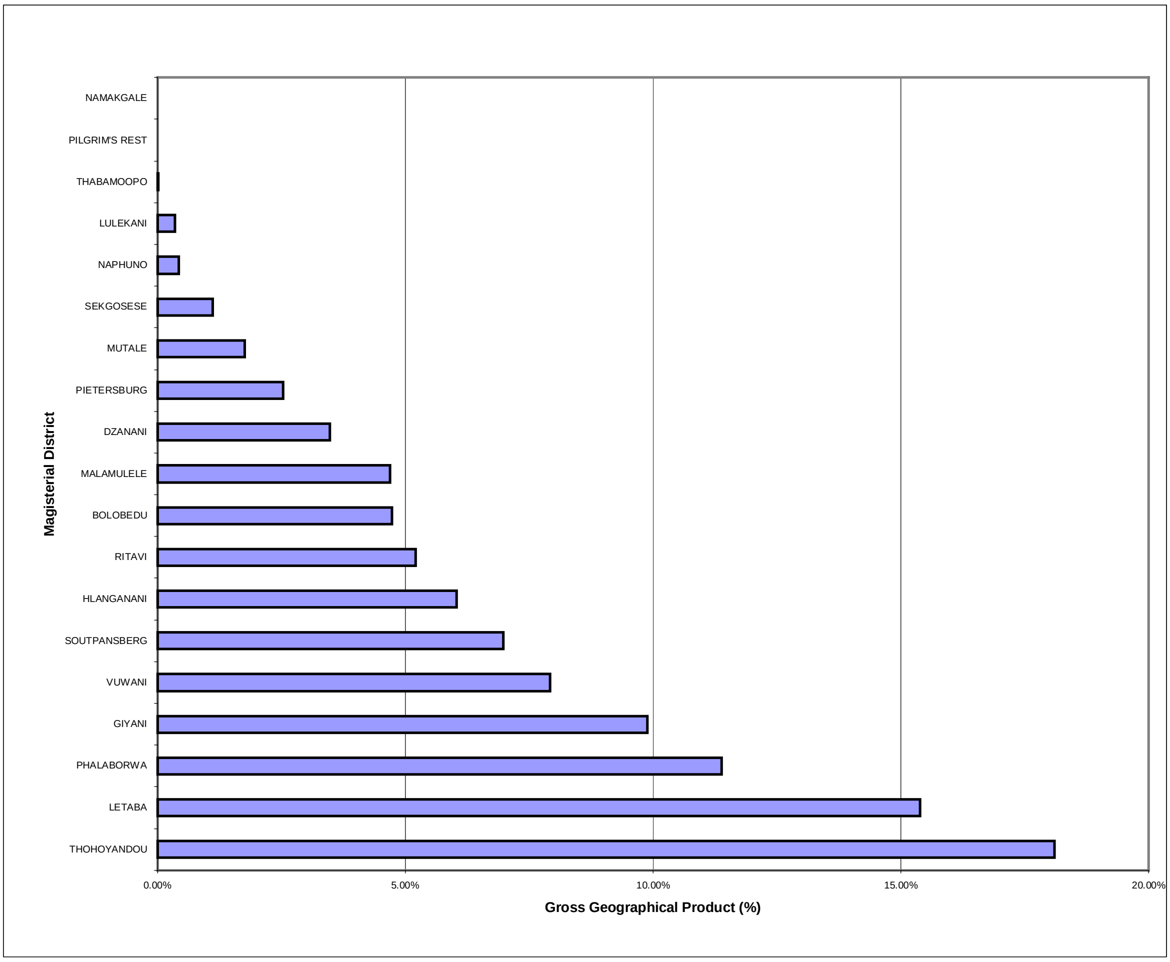


Figure B.2: **Contribution by Sector to National Economy, 1988 And 1997 (%)**

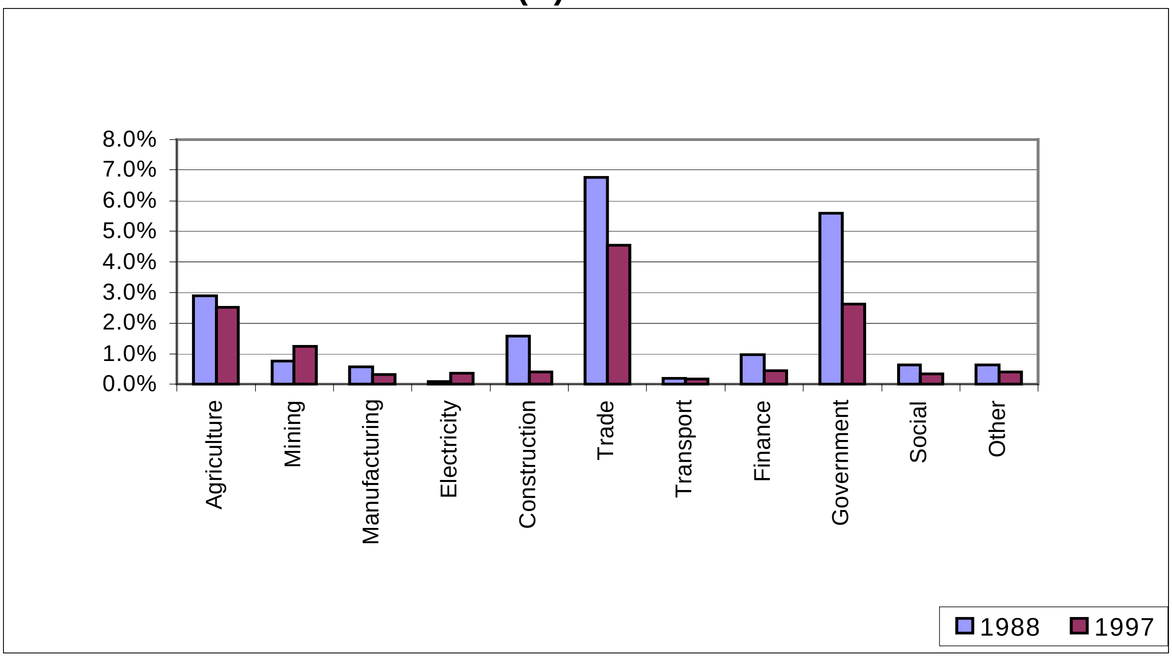


Figure B.3: **Composition of Luvuvhu/Letaba Labour Force, 1994 (%)**

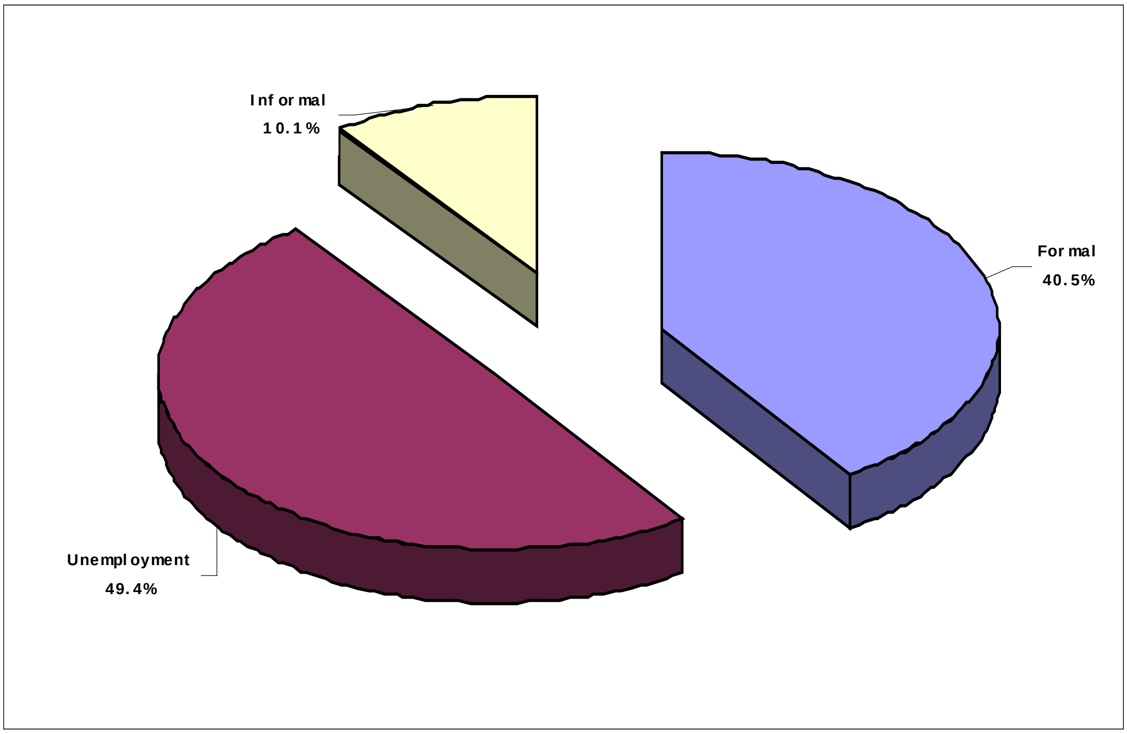


Figure B.4: **Contribution by Sector to Luvuvhu/Letaba Economy, 1980 and 1994(%)**

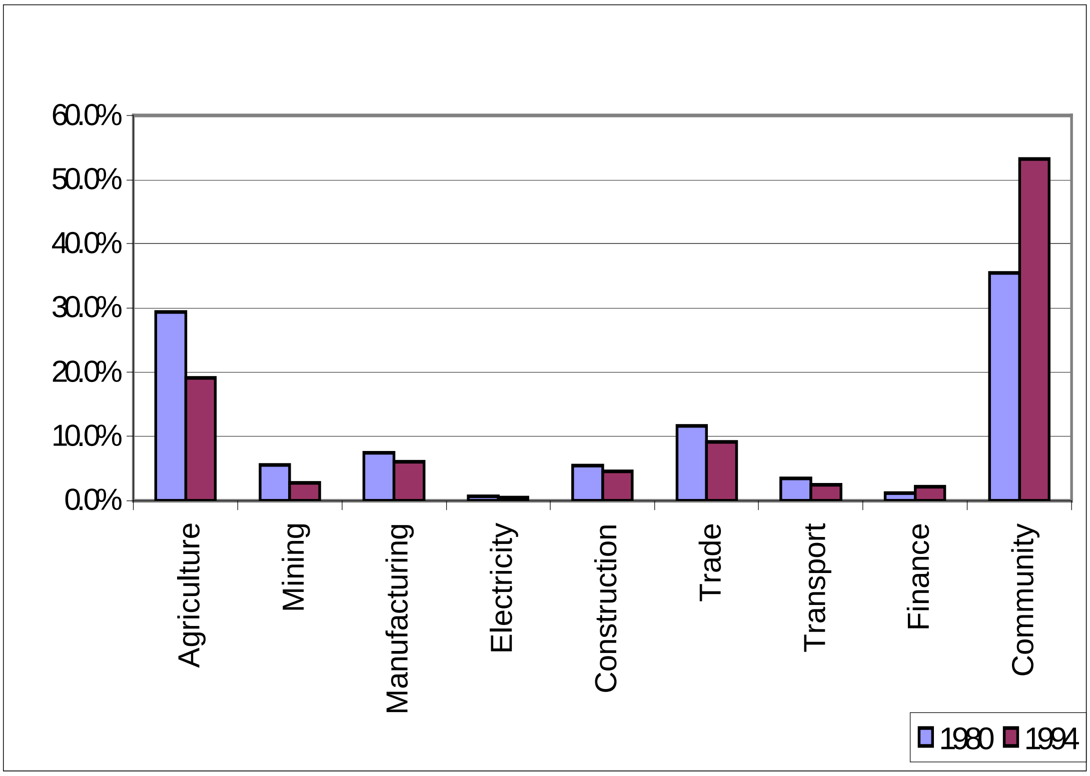


Figure B.5 **Contribution by Sectors of Luvuvhu/Letaba Employment to National Sectoral Employment, 1980 and 1994 (%)**

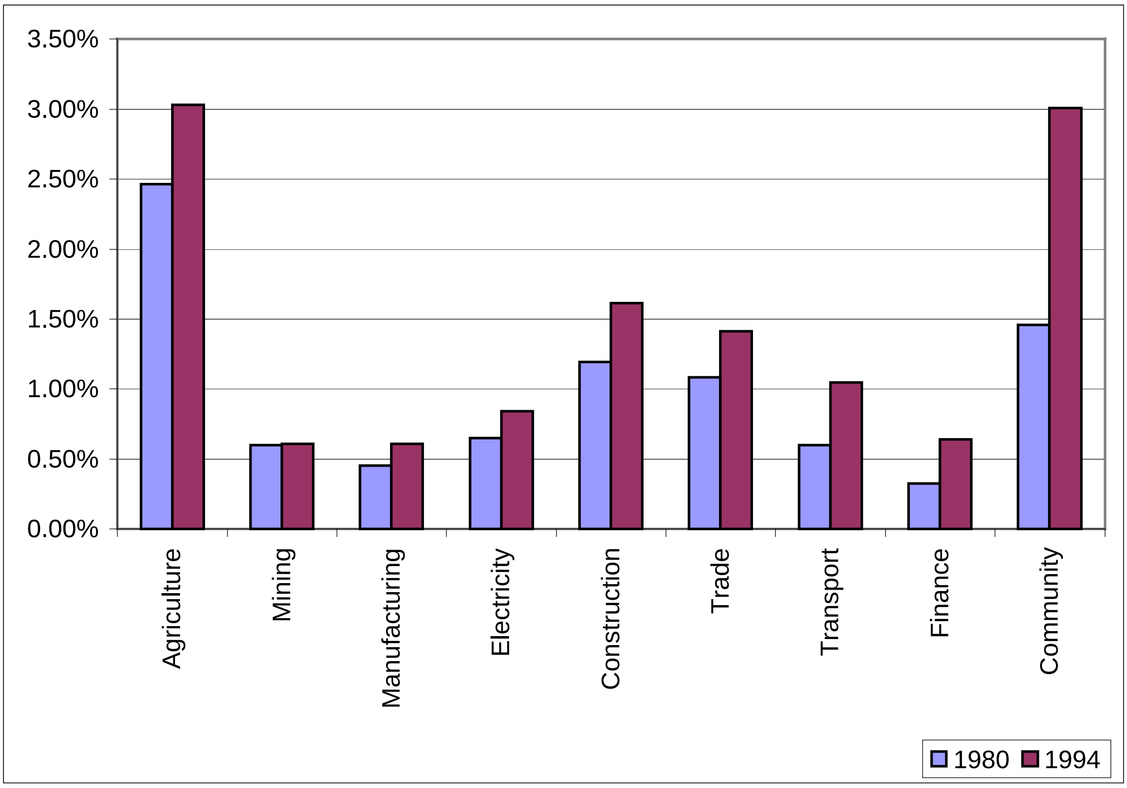


Figure B.6: **Average Annual Employment Growth by Sector of Luvuvhu/Letaba versus South Africa, 1980 to 1994 (%)**

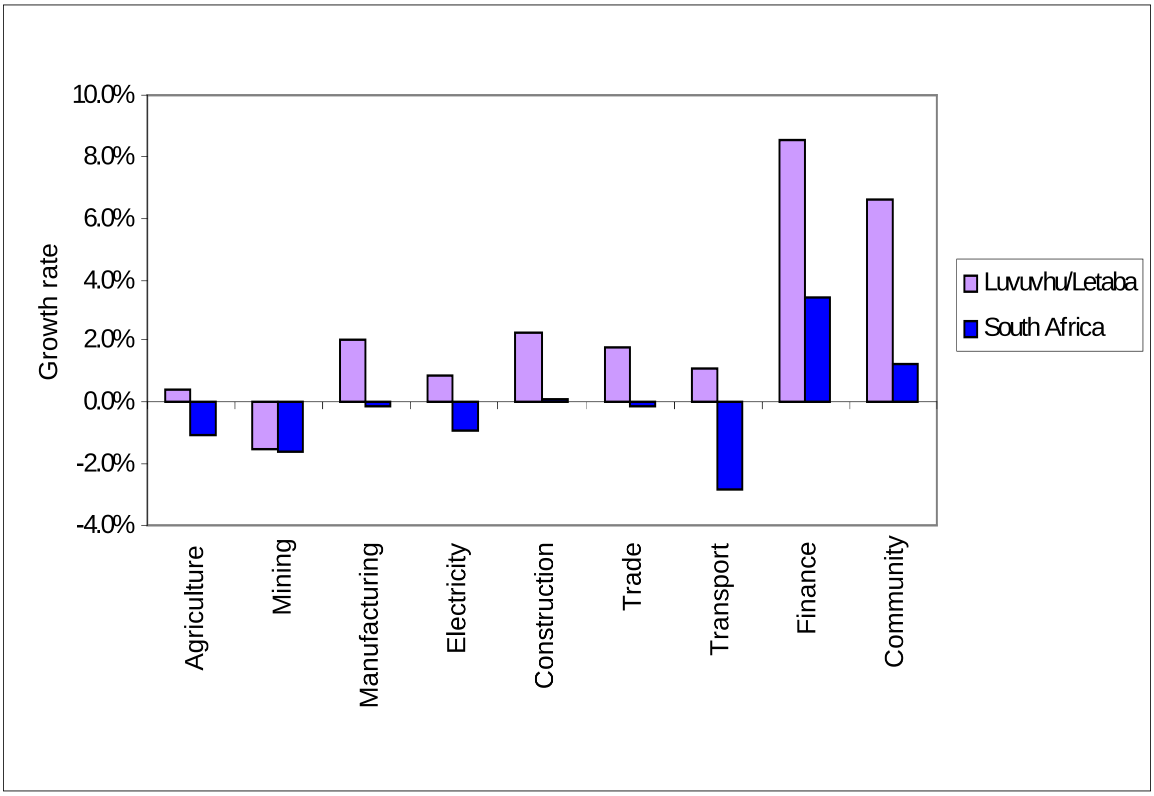
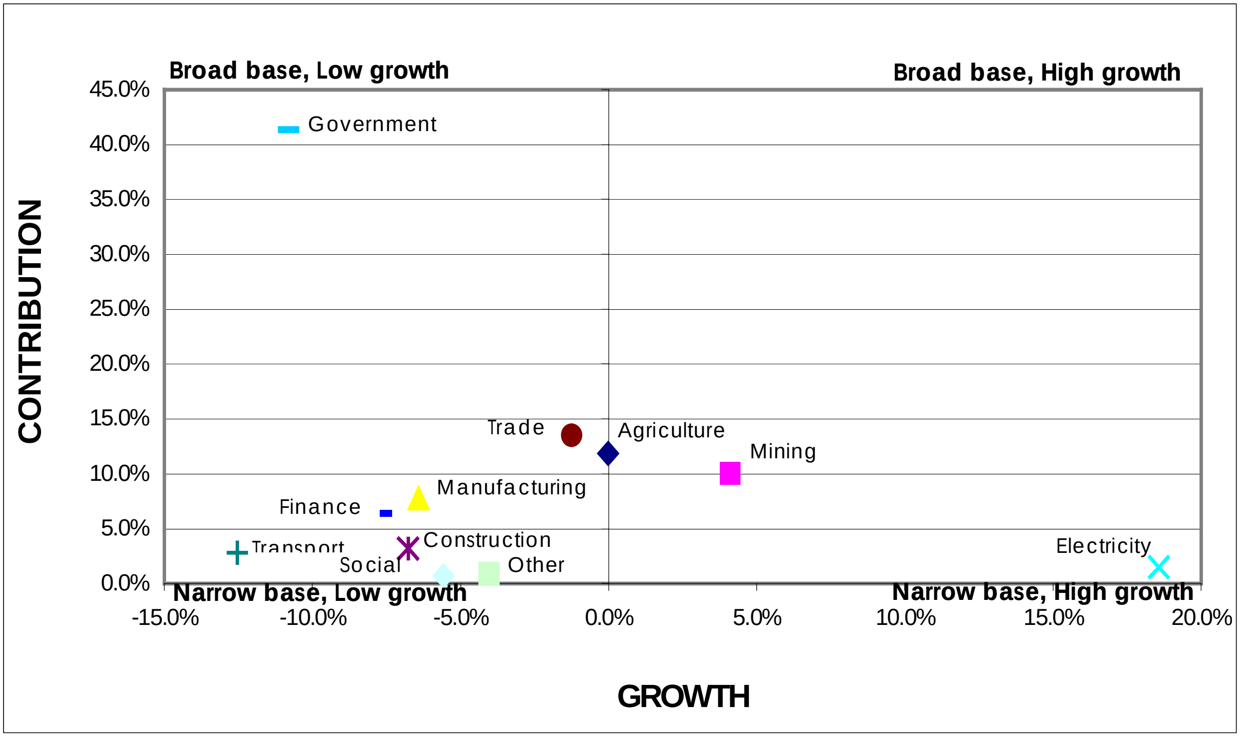


Figure B.7: Shift-Share Analysis, 1997



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

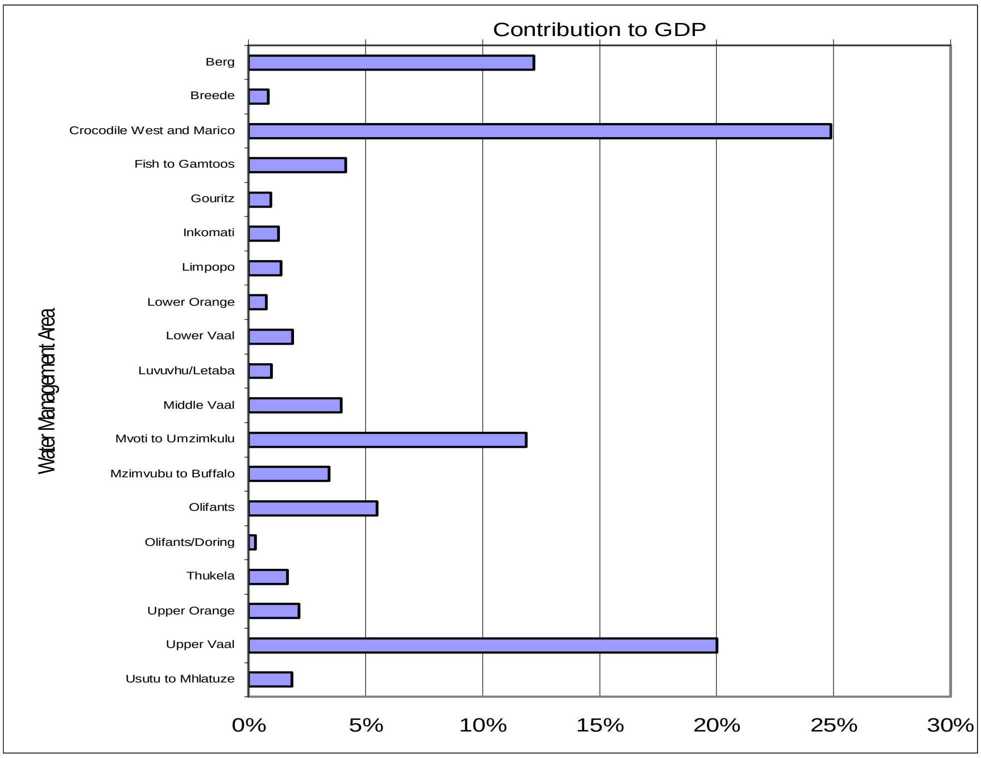
- The largest contribution to the national economy is made by the Crocodile West and Marico WMA which contributes (19.1%) to GDP. This WMA comprises, inter alia, magistrates districts of Pretoria, Johannesburg, Germiston, Kempton Park, Benoni, Thabazimbi and Lichtenburg.

- 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.

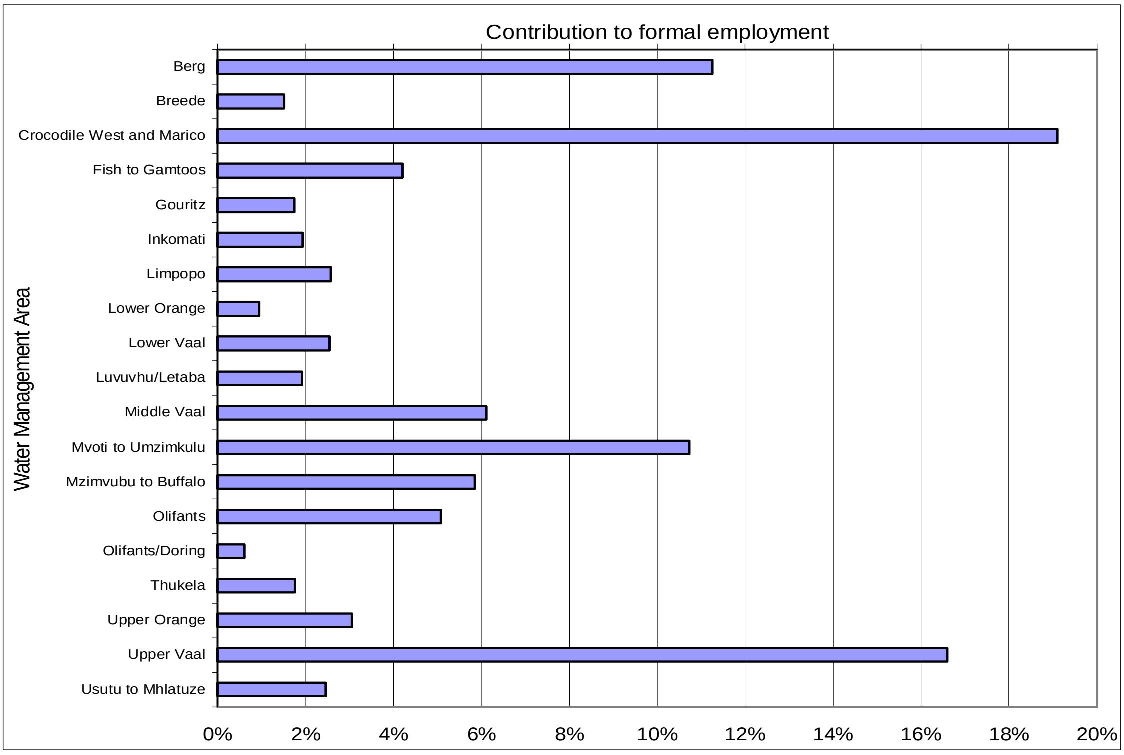
Figure B.1: Total GGP by Water Management Area (% of Country)



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.

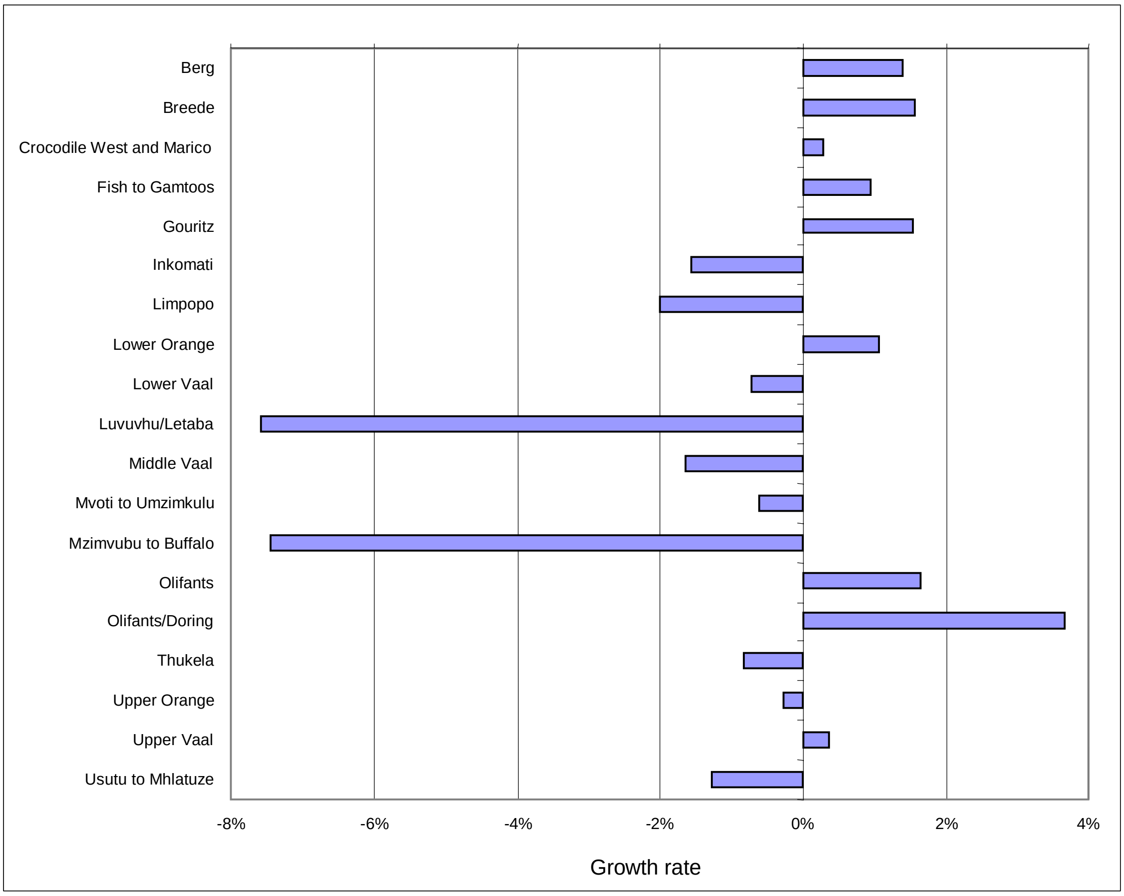
Figure B.2: Formal Employment by Water Management Area (% of country)



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.

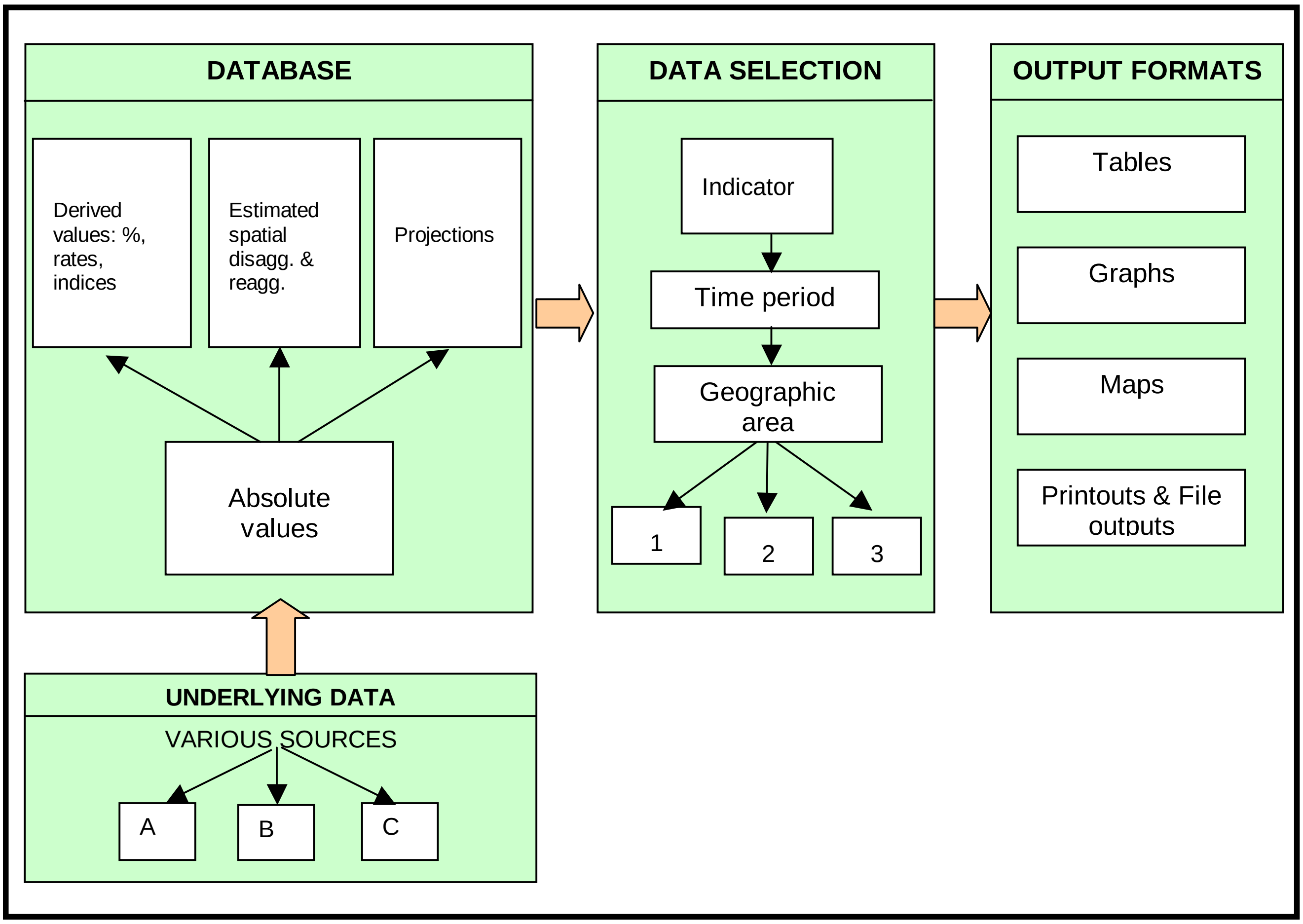
Indicator	Categories	Timespan	Geographic detail
Gross geographic product	Major sectors	1972-1997	Magisterial districts
Labour distribution	Employment/un-employment Major sectors	1980, 1991, 1994	Magisterial districts
Electricity consumption	Economic sectors, domestic	1988-1997	Local authority area, service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

D: MINES WITHIN THE LUVUVHU/LETABA WMA

Quat	Mine
A92C	NYALA MINE
B81C	READY MIX MATERIALS
B81D	LENYENYE BRICKWORKS
B81D	INYONI MINE/ASTRA
B82B	QUARRY
B82B	MAIN MINE
B82C	QUARRY
B83A	GOLDEN DAVEY MINE
B83A	SULLWALD TRANSPORT

APPENDIX E

WATER RELATED INFRASTRUCTURE

Table E1: Existing future infrastructure of water schemes in the Luvuvhu/Letaba WMA (E - Existing; N - 1994, F - 2000 and after)

Scheme Name	Water Source				Water User						
	Dam	Combined farm dams	Boreholes	Run-of-river	Domestic	Major industry	Mines	Irrigation	Treatment Works	Reservoir Capacity	Sewage Disposal
Letaba River catchment											
Dap Naude Scheme	Quaternary: B81A Name: Dap Naude Dam River: Broederstroom/Groot Letaba Gross storage capacity (Mm3) 2.1 Dead storage capacity (Mm3) Firm yield (Mm3/a) 5.6				Quaternary: A71A Name: Pietersburg Population (1995) Use 1995 (Mm3/a) 5.4 (EXPORT)				Quaternary: Pietersburg A71A Capacity (Ml/d): 18 Process: Rapid gravity sand filters	Quaternary: Number: Combined Capacity (Ml):	Quaternary: A71A Capacity (Ml/d) Process:
Ebenezer Dam Scheme	Quaternary: B81A Name: Ebenezer Dam River: Groot Letaba Gross storage capacity (Mm3) 70 Dead storage capacity (Mm3) Firm yield (Mm3/a)				Quaternary: B81A, A71A, A71B, A52H Name: Haenertsburg, Pietersburg villages Population (1995) Use 1995 (Mm3/a) Allocation : 18.5 (EXPORT)	Quaternary: Name: Use 1995 (Mm3/a)			Quaternary: B81A Capacity (Ml/d): 42 Process: Name : Ebenezer	Quaternary: Number: Combined Capacity (Ml):	Quaternary: Capacity (Ml/d) Process:
				Quaternary: River: Abstraction: pumps: canals:	Quaternary: B81C Name: Tzaneen Population (1995) Use 1995 (Mm3/a) Allocation (Mm3/a) 3.58			Quaternary: B81B, B81D Area (ha): Allocation (m3/ha/a): 66.2 Use (Mm3/a) 13.9	Quaternary: Capacity (Ml/d): Process:	Quaternary: Number: Combined Capacity (Ml):	Quaternary: Capacity (Ml/d) Process:
Magoebaskloof Dam Scheme	Quaternary: B81B Name: Magoebaskloof Dam River: Politsi Gross storage capacity (Mm3) 5 Dead storage capacity (Mm3)			Quaternary: River: Abstraction: pumps: canals:	Quaternary: B81B Name: Vergelegen Dam Population (1995) Use 1995 (Mm3/a) (TRANSFER)			Quaternary: B81B Area (ha): Allocation (M3/ha/a): Use (Mm3/a) 6.8 Water shortfall:			
Vergelegen Dam Scheme	Quaternary: B81B Name: Vergelegen Dam River: Politsi Gross storage capacity (Mm3) 0.3 Dead storage capacity (Mm3)	Quaternary: River: Gross storage capacity (Mm3) Dead storage capacity (Mm3) #530 farm dams			Quaternary: B81B Name: Politsi Population (1995) Use 1995 (Mm3/a)	Quaternary: B81B Name: Northern Canners Use 1995 (Mm3/a) 0.66		Quaternary: B82B Area (ha): Allocation (M3/ha/a): 6600 Use (Mm3/a) 2.87 Water shortfall:	Quaternary: B81B Capacity (Ml/d): Process:	Quaternary: Number: Combined Capacity (Ml):	Quaternary: Capacity (Ml/d) Process:
					Quaternary: B82C Name: Duiwelskloof Population (1995) Use 1995 (Mm3/a) 0.2 (EXPORT)					Quaternary: Number: Combined Capacity (Ml):	Quaternary: Capacity (Ml/d) Process:
					Quaternary: B81G Name: Ga-Kgapane Population (1995) Use 1995 (Mm3/a) 0.4					Quaternary: Number: Combined Capacity (Ml):	Quaternary: Capacity (Ml/d) Process:
Groot Letaba Tzaneen Dam	Quaternary: B81B Name: Tzaneen Dam River: Groot Letaba Gross storage capacity (Mm3) 159 Dead storage capacity (Mm3) Firm yield (Mm3/a)	Quaternary: River: Gross storage capacity (Mm3) Dead storage capacity (Mm3) #530 farm dams	Quaternary: Diesel: Electric: Yield (M3/d): Limited use for irrigation	Quaternary: River: Abstraction: pumps: canals: Used in combination with dams	Quaternary: B81C Name: Nkowakowa Population (1995) Use 1995 (Mm3/a) 4.38	Quaternary: B81E + B81B Name: Use 1995 (Mm3/a) 0.3	Quaternary: B81F Name: Murchison Gold Use 1995 (Mm3/a) 1.75	Quaternary: B81C, B81E, B81F, B81J Area (ha): Allocation (m3/ha/a): Use (Mm3/a) 105.2	Quaternary: Name: Nkowakowa Capacity (Ml/d): Process:	Quaternary: B81C Number: Combined Capacity (Ml):	Quaternary: B81C Name: Nkowakowa Capacity (Ml/d) Process:
					Quaternary: B81C Name: Tzaneen Population (1995) Use 1995 (Mm3/a) Allocation (Mm3/a)				Quaternary: B81C Name: Tzaneen Capacity (Ml/d): Process:	Quaternary: B81C Number: Combined Capacity (Ml):	Quaternary: B81C Name: Tzaneen Capacity (Ml/d) Process:
				Quaternary: River: Abstraction: pumps: canals: Used in combination with dams	Quaternary: B81C Name: Villages Population (1995) Use 1995 (Mm3/a) 0.28				Quaternary: Capacity (Ml/d): Process:	Quaternary: Number: Combined Capacity (Ml):	
				Quaternary: River: Abstraction: pumps: canals: Used in combination with Tzaneen Dam	Quaternary: B81E Name: Letsitele Population (1995) Use 1995 (Mm3/a) 0.42				Quaternary: Capacity (Ml/d): Process:	Quaternary: Number: Combined Capacity (Ml):	Quaternary: Capacity (Ml/d) Process:
Thapane Dam Scheme NL3/14	Quaternary: B81E Name: Thapane Dam River: Gross storage capacity (Mm3) Dead storage capacity (Mm3)		Quaternary: B81E, B81F Diesel: Electric: Wind/hand TOTAL Yield (M3/d): 1427		Quaternary: B81E, B81F Name: 21 No Villages Population (1995) Use 1995 (Mm3/a)				Quaternary: B81E Capacity (Ml/d): 1.5 Process: Disinfection Name : Thapane WTW	Quaternary: B81E, B81F Number: 6 Combined Capacity (Ml): 2.7 (E) 0.9 (N)	
Groot Letaba/Thabina Dam NL2/21	Quaternary: B81D Name: Thabina Dam River: Gross storage capacity (Mm3) 2.8 Dead storage capacity (Mm3) Firm yield (Mm3/a)		Quaternary: B81D, B72E Diesel: Electric: Wind/hand Yield (M3/d): 14130		Quaternary: B81D, B72E Name: 20 No Villages Population (1995) Use 1995 (Mm3/a)				Quaternary: B81D Capacity (Ml/d): 6.9 Process: Conventional Name : Thabina	Quaternary: B81D, B72E Number: 9 (E), 8 (N) Combined Capacity (Ml): 8.6 (E) 1.2 (N)	Quaternary: B81D Name: Lenyenye Capacity (Ml/d) 1.08 Process: Oxidation Ponds
Groot Letaba/Ritavi II NL2/20			Quaternary: B81D, B72E Diesel: Electric: Wind/hand Yield (M3/d): 2979	Quaternary: B81D River: Groot Letaba Abstraction: pumps: 96 l/s canals: Used in combination with Tzaneen Dam	Quaternary: B81D, B72E Name: 29 Villages Population (1995) Use 1995 (Mm3/a) (EXPORT)			Quaternary: Area (ha): Allocation (m3/ha/a): Use (Mm3/a) Thabina run-of-river	Quaternary: B81D Capacity (Ml/d): 24 Process: Flocculation and Filtration Name : Nkowakowa	Quaternary: B81D, B72E Number: 22 Combined Capacity (Ml): 74.75	Quaternary: B81D Capacity (Ml/d) 4.4 Process: Anaerobic Reactors, Sedimentation & Bio-filters
Groot Letaba/Letaba RWS NL3/16			Quaternary: B81E, B81F Diesel: Electric: Wind/hand Yield (M3/d): 3593	Quaternary: B81E River: Groot Letaba Abstraction: pumps: 70 + 35 l/s canals: Used in combination with Tzaneen Dam	Quaternary: B81E, B81F Name: 26 Villages Population (1995) Use 1995 (Mm3/a)				Quaternary: B81E Capacity (Ml/d): 6 Process: Conventional Name : Nkamboko	Quaternary: B81F, B81E Number: 6 (E), 1 (N) Combined Capacity (Ml): 12.8 (E) 2.5 (N) 27 (F)	
Groot Letaba/Nondweni NL7				Quaternary: B81F River: Letaba Abstraction: weir: (F) Nondweni 2.2 Ml/d	Quaternary: B81F, B81J Name: 5 No Villages Population (1995) Use 1995 (Mm3/a)				Quaternary: B81F Capacity (Ml/d): 6 Process: Conventional (F)?	Quaternary: B81F, B81J Number: 5 (E), 1 (F) Combined Capacity (Ml): 2.25 (E) 0.6 (N)	
Modjadji Scheme NL3/13M	Quaternary: B81G Name: Modjadji Dam River: Molototsi Gross storage capacity (Mm3) Dead storage capacity (Mm3) Firm yield (Mm3/a)		Quaternary: B81G Diesel: Electric: Wind/hand Yield (M3/d): 6311		Quaternary: B82B, B81G Name: 30 Villages Population (1995) Use 1995 (Mm3/a)	Quaternary: Name: Use 1995 (Mm3/a)	Quaternary: Name: Use 1995 (Mm3/a)	Quaternary: Area (ha): Allocation (M3/ha/a): Use (Mm3/a) Water shortfall:	Quaternary: B81G Capacity (Ml/d): Process: Name : Modjadji WTW	Quaternary: B81G, B82B Number: 15 (E), 10 (F) Combined Capacity (Ml): 15 (E) 2.7 (E)	Quaternary: B82B Capacity (Ml/d) Process: Kgapane Medingen
NL3/13WM village borehole schemes			Quaternary: B81G Diesel: Electric: Wind/hand Yield (M3/d): 6894		Quaternary: B81G Name: 11 Villages Population (1995) Use 1995 (Mm3/a)					Quaternary: B81G Number: 7 (E), 6 (F) Combined Capacity (Ml): 1.9 (E) 2 (F)	
NL3/15 village borehole schemes			Quaternary: B81H Diesel: Electric: Wind/hand Yield (M3/d): 368		Quaternary: B81H Name: 11 Villages Population (1995) Use 1995 (Mm3/a)					Quaternary: B81H Number: 12 (E) Combined Capacity (Ml): 1.2 (E)	
Middle Letaba/Sekgopo NL4			Quaternary: B82A Diesel: Electric: Wind/hand Yield (M3/d): 2693		Quaternary: B82A Name: Sekgopo villages Population (1995) Use 1995 (Mm3/a)					Quaternary: B82A Number: 7 (E), 5 (F) Combined Capacity (Ml): 1 (E) 3.3 (F)	
Middle Letaba/Central MC	Quaternary: B82D Name: Middle Letaba River: Middle Letaba Gross storage capacity (Mm3) 172 Dead storage capacity (Mm3) Firm yield (Mm3/a)		Quaternary: Diesel: Electric: Wind/hand Yield (m3/d): 50778		Quaternary: A91C, B82F, B82D, B82G Name: 43 Villages Population (1995) Use 1995 (Mm3/a)			Quaternary: Area (ha): Allocation (M3/ha/a): Use (Mm3/a) 25 Water shortfall:	Quaternary: B82D Name: Middle Letaba Capacity (Ml/d): 6 (E), + 18 (N) Process: Conventional Name : Middle Letaba	Quaternary: A91C, B82F, B82D, B82G Number: 82 Combined Capacity (Ml): 26 (E) 5.9 (N)	Quaternary: A91C Capacity (Ml/d) 3.84 Process: Activated sludge + Maturation Ponds
Middle Letaba/NL6MM			Quaternary: B82F Diesel: Electric: Wind/hand TOTAL		Quaternary: B82F Name: 16 Villages Population (1995) Use 1995 (Mm3/a)					Quaternary: B82F Number: 10 (E), 2 (N) Combined Capacity (Ml): 3.6 (E) 0.8 (N)	
Middle Letaba NL6MA					Quaternary: B82F Name: 9 Villages Population (1995) Use 1995 (Mm3/a)				Quaternary: Capacity (Ml/d): Process:	Quaternary: B82F Number: 4 (E) Combined Capacity (Ml): 0.9 (E) 0.6 (N)	Quaternary: Capacity (Ml/d) Process:

Scheme Name	Water Source				Water User						
	Dam	Combined farm dams	Boreholes	Run-of-river	Domestic	Major industry	Mines	Irrigation	Treatment Works	Reservoir Capacity	Sewage Disposal
Middle Letaba NL6MB			Quaternary: B81G Diesel: Electric: Wind/hand Yield (M3/d): 2093	Quaternary:	Quaternary: B81G Name: 15 Villages Population (1995) Use 1995 (Mm3/a)					Quaternary: B81G Number: 6 (E), 4 (N), 8 (F) Combined Capacity (Ml): 1.3 (E) 3 (N) 4.8 (F)	
Middle Letaba NL6MS					Quaternary: B82D Name: 6 Villages Population (1995) Use 1995 (Mm3/a)				Quaternary: Name: Capacity (Ml/d): Process:	Quaternary: B82D Number: 6 (E), 2 (N), 6 (F) Combined Capacity (Ml): 1.65 (E) 1.4 (N) 6 (F)	
Middle Letaba/Giyani NL6A + B	Quaternary: B82H Name: Nsami Dam River: Nsama Gross storage capacity (Mm3) 23 Dead storage capacity (Mm3) Firm yield (Mm3/a)		Quaternary: B82H, B82G, B82J, B81J Diesel: Electric: Wind/hand Yield (M3/d): 5605		Quaternary: B82H, B82G, B82J, B81J Name: 23 Villages Population (1995) Use 1995 (Mm3/a) (EXPORT)			Quaternary: Area (ha): Allocation (M3/ha/a): Use (Mm3/a) 1.7 Water shortfall:	Quaternary: B82H Name: Giyani WTW Capacity (Ml/d): 29 Ml/d Process: Flocculation and Filtration	Quaternary: B82H, B82G, B82J, B81J Number: 31 (E) Combined Capacity (Ml): 40 (E)	
Middle Letaba N6 C, D, E			Quaternary: B82G, B81H, B81F Diesel: Electric: Wind/hand Yield (M3/d): 18305		Quaternary: B82G, B81H, B81F Name: Giyani + 27 Villages Population (1995) Use 1995 (Mm3/a) (EXPORT)					Quaternary: B82G, B81H, B81F Number: 33 (E) Combined Capacity (Ml): 45.4 (E)	Quaternary: B82G Name: Giyani Capacity (Ml/d) 2.5 Process: Biofilters, Anaerobic Reactors, Oxidation Ponds
Middle Letaba/NL6/N			Quaternary: B82G Diesel: Electric: Wind/hand Yield (M3/d): 726	Quaternary: B82G River: Abstraction: pumps: canals: Middle Letaba Used in combination with dams	Quaternary: B82G Name: 5 Villages Population (1995) Use 1995 (Mm3/a)				Quaternary: B82G Capacity (Ml/d): 4.6 Process: Flocculation and Filtration Name : Malamulele West WTW	Quaternary: B82G Number: 6 (E) Combined Capacity (Ml): 2.1 (E)	
Middle Letaba/NL6MW			Quaternary: B90F, B82H Diesel: Electric: Wind/hand Yield (m3/d):		Quaternary: B90F, B82H Name: 8 Villages Population (1995) Use 1995 (Mm3/a) 0.14 (EXPORT)					Quaternary: B90F, B82H Number: 5 (E) Combined Capacity (Ml):	
Middle Letaba/NL6F			Quaternary: B90F, B82H Diesel: Electric: Wind/hand Yield (m3/d): 1000		Quaternary: B90F, B82H Name: 8 Villages Population (1995) Use 1995 (Mm3/a) (EXPORT)					Quaternary: B90F, B82H Number: 9 (E), 2 (N) Combined Capacity (Ml): 2.3 (E) 1.2 (N)	
Middle Letaba/NN8			Quaternary: A91F Diesel: Electric: Wind/hand Yield (M3/d):		Quaternary: A91F Name: 16 Villages Population (1995) Use 1995 (Mm3/a)					Quaternary: A91F Number: 15 (E) Combined Capacity (Ml):	
Tshitale/Sekgosese			Quaternary: B82D Diesel: Electric: Wind/hand Yield (M3/d): 6474		Quaternary: B82D Name: 8 Villages Population (1995) Use 1995 (Mm3/a)					Quaternary: B82D Number: 6 (E) Combined Capacity (Ml): 1 (E)	
Tshitale/Sekgosese			Quaternary: B82E, B82E Diesel: Electric: Wind/hand Yield (m3/d): 6474	Quaternary: B82E River: Klein Letaba Abstraction: pumps:	Quaternary: B82E, B82F Name: 43 Villages Population (1995) Use 1995 (Mm3/a)				Quaternary: B82E Capacity (Ml/d): 5.4 (F) Process:	Quaternary: B82E, B82F Number: 2 (E), 11 (F) Combined Capacity (Ml):	
Luvuvh River catchment											
Vondo NN20	Quaternary: A91G Name: Vondo Dam River: Mutshindudi Gross storage capacity (Mm3) 30 Dead storage capacity (Mm3) Firm yield (Mm3/a) 16.6		Quaternary: A92A, A91G, A91E, A91F Diesel: Electric: Wind/hand Yield (m3/d): 6474		Quaternary: A91F, A91E, A91G, A92A Name: 126 Villages and Thoyandou Population (1995) 281864 Use 1995 (Mm3/a)				Quaternary: A91G Capacity (Ml/d): 42 Process: conventional Name : Phiphidi	Quaternary: A91A, A91G, A91E, A91F Number: Combined Capacity (Ml): 53	Quaternary: Name: Thoyandou Capacity (Ml/d) Process:
Vondo NN20	Quaternary: A91G Name: Phiphide Dam River: Mutshindudi Gross storage capacity (Mm3) 0.3 Dead storage capacity (Mm3) Firm yield (Mm3/a)										
Vondo/Tshakuma NL1/2	Quaternary: A91D Name: Tshakhuma Dam River: Gross storage capacity (Mm3) 2.1 Dead storage capacity (Mm3)		Quaternary: A91D		Quaternary: A91D Name: 6 Villages River: 32674 Gross storage capacity (Mm3) Dead storage capacity (Mm3)				Quaternary: A91D Capacity (Ml/d): 1.1 (E), 3 (N) Process: conventional Name : Tshakhuma	Quaternary: A91D Number: Combined Capacity (Ml): 4.6	Quaternary: Capacity (Ml/d) Process:
Vondo Damani NN4	Quaternary: A91G Name: Damani Dam River: Gross storage capacity (Mm3) 12.4 Dead storage capacity (Mm3) Yield (M3/a): 6.4				Quaternary: A92A, A91G Name: 27 Villages Population (1995) 45000 Use 1995 (Mm3/a)			Quaternary: A91G Name : Damani Coffee Area (ha): 440 Allocation (M3/ha/a): 1050 Use (Mm3/a) 4.08 Water shortfall:	Quaternary: A91D Name : 4 (N) Area (ha): Allocation (M3/ha/a): Use (Mm3/a) Water shortfall: Damani		
Tshifudi NN19			Quaternary: A91G, A91H Diesel: Electric: Wind/hand Yield (m3/d):	Quaternary: A91G River: Abstraction: pumps: weir: (F)	Quaternary: A91H Name: 23 Villages Population (1995) 26222 Use 1995 (Mm3/a)				Quaternary: A91G Capacity (Ml/d): Process: (F)	Quaternary: A91H Number: 2 (E), 6 (F) Combined Capacity (Ml):	
Tshifudi /Mhinga NN11			Quaternary: A91H Diesel: Electric: Wind/hand Yield (m3/d):	Quaternary: A91G River: Abstraction: pumps: weir: yes	Quaternary: A91H Name: 20 Villages Population (1995) 13440 Use 1995 (Mm3/a)				Quaternary: A91H Capacity (Ml/d): 3 (F) Process: package	Quaternary: A91H Number: 1 (N), 3 (F) Combined Capacity (Ml): 0.6 (N)	
Valdezia NL9			Quaternary: A91C Diesel: Electric: Wind/hand Yield (M3/d): 455		Quaternary: A91C Name: 10 Villages Population (1995) 15500 Use 1995 (Mm3/a)						
Malamulele NNT	Quaternary: Name: River: Gross storage capacity (Mm3) Dead storage capacity (Mm3) Yield (M3/a):	Quaternary: River: Gross storage capacity (Mm3) Dead storage capacity (Mm3) #530 farm dams	Quaternary: B90A, B, C, G Diesel: Electric: Wind/hand Yield (M3/d):	Quaternary: A91F River: Luvuvhu Abstraction: pumps: canals: 1.5 Mm3/a (IMPORT)	Quaternary: B90A, B90B, B90C, B90G Name: 61 Villages Population (1995) 175000 Use 1995 (Mm3/a)				Quaternary: A91F Capacity (Ml/d): 15.5 Process: Name : Malamulele WTW	Quaternary: B90A, B90B, B90C, B90G Number: Combined Capacity (Ml): 18.2 (E)	
Mutale NN12	Quaternary: Name: River: Gross storage capacity (Mm3) Dead storage capacity (Mm3)		Quaternary: A92A, B Diesel: Electric: Wind/hand Yield (M3/d):	Quaternary: A92B River: Mutale Abstraction: pumps: canals: weir : A9M04	Quaternary: A80C, A80H, A92A, A92B, A91H, J Name: 130 Villages Population (1995) 65617 Use 1995 (Mm3/a) (EXPORT)				Quaternary: A92B Capacity (Ml/d): 4.4 Process: Flocculation and Filtration Name : Mutale WTW	Quaternary: A80C, A80H, A92A, A92B, A91H, J Number: Combined Capacity (Ml): 12.7	
Mutale /Masisi NN9	Quaternary: A92D Name: Tshikondeni Mine River: Mutale Gross storage capacity (Mm3) 0.23 Dead storage capacity (Mm3) Only used when river in flood		Quaternary: A92D Diesel: Electric: Wind/hand Yield (M3/d):	Quaternary: A92D River: Mutale Abstraction: pumps: (F) canals: weir : (F)	Quaternary: A92D Name: 10 Villages Population (1995) 3893 Use 1995 (Mm3/a)		Quaternary: A92D Name: Tshikondeni Coal Mine Use 1995 (Mm3/a) 0.5	Quaternary: A92D Name : Area (ha): Allocation (M3/ha/a): Use (Mm3/a) Water shortfall: Removable pumps	Quaternary: A92D Capacity (Ml/d): Process: (F)		
Lupepe/Nwanedi	Quaternary: A80H Name: Nwanedyi River: Nwanedyi Gross storage capacity (Mm3) Dead storage capacity (Mm3) (IMPORT)		Quaternary: A92C, D Diesel: Electric: Wind/hand Yield (M3/d):	Quaternary: River: Abstraction: pumps: canals: weir :	Quaternary: A80J, A80H, A92C, A80J, A92D Name: 43 Villages Population (1995) 31690 Use 1995 (Mm3/a)		Quaternary: A80J Name: Nyala Mine Use 1995 (Mm3/a) Magnesium	Quaternary: Name : Area (ha): Allocation (M3/ha/a): Use (Mm3/a) Water shortfall:	Quaternary: A80J Capacity (Ml/d): 0.3 Process:		

APPENDIX F

WATER REQUIREMENTS

F1. ECOLOGICAL CLASSES PER QUATERNARY CATCHMENT FOR THE OLIFANTS WMA

TABLE F1: ……………………………………………………………………………………………

Quaternary	Province	Rivers	Eisc	Demc	Pesc	Best Aemc
A91A	Northern Province	Upper trib Luvuvhu	Moderate	Class C: Moderate Risk Allowed	Class D: Largely Modified	Class D: Largely Modified
A91B	Northern Province	Upper trib luvuvhu	Low	Class D: Large Risk Allowed	Class D: Largely Modified	Class C: Moderately Modified
A91C	Northern Province	Luvuvhu	Moderate	Class C: Moderate Risk Allowed	Class D: Largely Modified	Class C: Moderately Modified
A91D	Northern Province	Latonyanda	High	Class B: Small Risk Allowed	Class D: Largely Modified	Class C: Moderately Modified
A91E	Northern Province	Dzindi	High	Class B: Small Risk Allowed	Class D: Largely Modified	Class C: Moderately Modified
A91F	Northern Province	Luvuvhu (main stem)	High	Class B: Small Risk Allowed	Class D: Largely Modified	Class B: Largely Natural
A91G	Northern Province	Mutshindudi	High	Class B: Small Risk Allowed	Class C: Moderately Modified	Class B: Largely Natural
A91H	Northern Province	Luvuvhu (main stem)	High	Class B: Small Risk Allowed	Class C: Moderately Modified	Class B: Largely Natural
A91J	Northern Province	Luvuvhu (main stem)	Very High	Class A: No Human Hazards	Class C: Moderately Modified	Class C: Moderately Modified
A91K	Northern Province	Luvuvhu (main stem)	Very High	Class A: No Human Hazards	Class B: Largely Natural	Class B: Largely Natural
A92A	Northern Province	Mutale (main stm)	High	Class B: Small Risk Allowed	Class A: Unmodified, Natural	Class A: Unmodified, Natural
A92B	Northern Province	Mutale (main stem)	High	Class B: Small Risk Allowed	Class C: Moderately Modified	Class C: Moderately Modified
A92C	Northern Province	Mutale (main stem)	High	Class B: Small Risk Allowed	Class B: Largely Natural	Class B: Largely Natural
A92D	Northern Province	Mutale (main stem)	High	Class B: Small Risk Allowed	Class C: Moderately Modified	Class C: Moderately Modified
B81A	Northern Province	Broederstroom (upstream Ebenezer)	High	Class B: Small Risk Allowed	Class D: Largely Modified	Class C: Moderately Modified
B81B	Northern Province	Great Letaba	High	Class B: Small Risk Allowed	Class D: Largely Modified	Class B: Largely Natural
B81C	Northern Province	Letsitele	Moderate	Class C: Moderate Risk Allowed	Class D: Largely Modified	Class C: Moderately Modified

TABLE F1: ………………………………………………………………………………………

Quaternary	Province	Rivers	Eisc	Demc	Pesc	Best Aemc
B81D	Northern Province	Thabina	Moderate	Class C: Moderate Risk Allowed	Class C: Moderately Modified	Class C: Moderately Modified
B81E	Northern Province	Letaba (downstream Tzaneen dam)	Moderate	Class C: Moderate Risk Allowed	Class C: Moderately Modified	Class C: Moderately Modified
B81F	Northern Province	Groot Letaba	Moderate	Class C: Moderate Risk Allowed	Class D: Largely Modified	Class C: Moderately Modified
B81G	Northern Province	Molototsi	Low	Class D: Large Risk Allowed	Class C: Moderately Modified	Class C: Moderately Modified
B81H	Northern Province	Molototsi	Low	Class D: Large Risk Allowed	Class D: Largely Modified	Class D: Largely Modified
B81J	Northern Province	Great Letaba (before enters KNP)	High	Class B: Small Risk Allowed	Class C: Moderately Modified	Class B: Largely Natural
B82A	Northern Province	Trib: Mid Letaba	Low	Class D: Large Risk Allowed	Class D: Largely Modified	Class E - F: > Class E Not Attainable In 5 Yr - Use Class D As Default
B82B	Northern Province	Trib: Mid Letaba	Low	Class D: Large Risk Allowed	Class D: Largely Modified	Class E - F: > Class E Not Attainable In 5 Yr - Use Class D As Default
B82C	Northern Province	Trib: Mid Letaba	Low	Class D: Large Risk Allowed	Class D: Largely Modified	Class E - F: > Class E Not Attainable In 5 Yr - Use Class D As Default
B82D	Northern Province	Mid Letaba (up from dam)	Moderate	Class C: Moderate Risk Allowed	Class D: Largely Modified	Class E - F: > Class E Not Attainable In 5 Yr - Use Class D As Default
B82E	Northern Province	Klein Letaba	Low	Class D: Large Risk Allowed	Class C: Moderately Modified	Class B: Largely Natural
B82F	Northern Province	Klein Letaba	Low	Class D: Large Risk Allowed	Class C: Moderately Modified	Class B: Largely Natural
B82G	Northern Province	Klein Letaba	Moderate	Class C: Moderate Risk Allowed	Class C: Moderately Modified	Class C: Moderately Modified
B82H	Northern Province	Nsami	Moderate	Class C: Moderate Risk Allowed	Class C: Moderately Modified	Class C: Moderately Modified
B82J	Northern Province	Klein Letaba	High	Class B: Small Risk Allowed	Class B: Largely Natural	Class B: Largely Natural
B83A	Northern Province	Letaba (in KNP)	High	Class B: Small Risk Allowed	Class C: Moderately Modified	Class B: Largely Natural
B83B	Northern Province	Tsende	Moderate	Class C: Moderate Risk Allowed	Class B: Largely Natural	Class B: Largely Natural

TABLE F1: ………………………………………………………………………………………

Quaternary	Province	Rivers	Eisc	Demc	Pesc	Best Aemc
B83C	Northern Province	Tsende	Moderate	Class C: Moderate Risk Allowed	Class B: Largely Natural	Class B: Largely Natural
B83D	Northern Province	Letaba (below Engelhardt)	High	Class B: Small Risk Allowed	Class C: Moderately Modified	Class C: Moderately Modified
B83E	Northern Province	Letaba (gorge)	High	Class B: Small Risk Allowed	Class B: Largely Natural	Class B: Largely Natural
B90A	Northern Province	Shisha	Low	Class D: Large Risk Allowed	Class C: Moderately Modified	Class B: Largely Natural
B90B	Northern Province	Mphongolo	Low	Class D: Large Risk Allowed	Class B: Largely Natural	Class B: Largely Natural
B90C	Northern Province	Phungwane	Low	Class D: Large Risk Allowed	Class B: Largely Natural	Class B: Largely Natural
B90D	Northern Province	Phungwane	Low	Class D: Large Risk Allowed	Class B: Largely Natural	Class B: Largely Natural
B90E	Northern Province	? KNP	Low	Class D: Large Risk Allowed	Class A: Unmodified, Natural	Class A: Unmodified, Natural
B90F	Northern Province	Shingwedzi	Moderate	Class C: Moderate Risk Allowed	Class B: Largely Natural	Class B: Largely Natural
B90G	Northern Province	Shingwedzi	Moderate	Class C: Moderate Risk Allowed	Class B: Largely Natural	Class B: Largely Natural
B90H	Northern Province	Shigwedzi (KNP)	Moderate	Class C: Moderate Risk Allowed	Class A: Unmodified, Natural	Class A: Unmodified, Natural

EISC Ecological importance and sensitivity class
DEMC default ecological management class
PESC present ecological status
BEST AEMC future ecological management class

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

ALBASINI DAM				
Consumer	**Authorization No**	**Quantity (m^3/year)**	**Usage code**	**Date**
Primary School Levubu	78/25/76	48 000	h	10/ /76
Sapekoe (Edms) Bpk	107/25/82	2 000 000	bsp	1/11/82
Municipality of Louis Trichardt	139/25/836/	2 409 428	st	23/ /83
Mr E Girardin	116/25/88	5 200	h + vs	27/9/88

GROOT LETABA RIVER (EBENEZER DAM)				
Consumer	**Authorization No**	**Quantity (m^3/year)**	**Usage code**	**Date**
Consolidated Murchison (Tvl) Goldfields		392 320	i	29/9/58
Anglo-Tvl Consolidated Investment Co	Permit 127N	448 008	i	19/11/63
Groot-Letaba-Boereklub (The Junction)		10 904	h	12/5/64
Letaba NG Sendinghospitaal (Mohlaba's Lokasie – 112 005m^3 gratis vir bsp)		143 031	bsp	4/12/64
SA Spoorwee Letsitele		99 557		17/12/64
Koedoe Kooperatiewe Sitrus		99 557	ny	26/8/69
Anglo-Tvl Consolidated Investment Co	Permit 280N	1 787 040	i	2/3/71
Mrs RS Cross		2 701	h	30/5/72
Municipality Pietersburg	Agreement	6 610 000	st	8/11/74
Gravelotte Emeralds (Pty) Ltd (Cobra Mine)				
Ebenezer View (Pty) Ltd		10 190	bsp	31/1/75
Letaba Citrus Processors (Pty) Ltd		646 050	h	2/7/75
Haenertsburg Trout Association	960/33/75	50	h	15/7/75
PM Cross	187/33/77	650		15/7/77
Shangaan Ontwikkelings Korporasie Bpk	17/33/82	4 200	in	3/3/82
JS van der Merwe	111/33/82	2 500	h	18/10/82
JBB Human	37/33/83	60	vs	8/2/83
Gazankulu-Regeringsdiens (Sisalfabriek)	130/33/83	71 760	ny	6/9/83
Transvaalse Raad vir die Ontwikkeling van Buitestedelike Gebiede – Letsitele Dorp)	73/33/84	418 290	ny	18/6/84
Mrs D Boman (Pusela Kanaal)	178/33/86	2 555	h	14/11/86
Mnr DJ Schoeman (George Valley Kanaal)	172/33/86	2 555	h + vs	10/12/86
Mr GG Burelli (Pusela Kanaal)	44/33/87	2 555	h	30/3/87
Mnr JSM Venter (Pusela Kanaal)	77/33/87	2 190	h	6/7/87
Mnr WJ Roux	103/33/87	2 500	h	29/9/87
Noord-Transvaal Waterraad	17/33/91	12 000 000	s + ny	28/3/91

GROOT LETABA RIVER (TZANEEN DAM)				
Consumer	**Authorization No**	**Quantity (m^3/year)**	**Usage code**	**Date**
Addington Farm	157/139/77	48 000	h + i	25/5/77
Nkomwaowa	2/139/77	3 500 000	h + ny	11/1/77
Addington Farm	18/139/78	46 319	bsp	16/2/78
Letabaskool en Inrigting	32/33/79	25 000	h	16/5/79
Mnr Van der Merwe Marius Smit	10/139/88	99 300	bsp	11/1/88
Letabaskool vir Gestremdes	128/139/87	17 830	bsp	19/1/88
Erf 15 Tzaneen (Edms) Bpk	23/139/90	99 300	bsp	26/3/90
Consolidated Citrus Containers (Edms) Bpk	84/139/90	25 000	h + i	17/12/90
Maranda Mining Company (Pty) Ltd (Expired 31/12/97)	32/139/91	120 000	mb	18/6/91
K Baragwanath	22/139/92	84 000	h + bsp	11/5/92
Municipality of Tzaneen	51/139/93	3 600 000	h + i	22/7/93

POLITSI RIVER (DUIWELSKLOOF PIPELINE)				
Consumer	**Authorization No**	**Quantity (m^3/year)**	**Usage code**	**Date**
Kgapane Hospitaal – Dept van Werke – Lebowa	126/158/77	20 400	hos	28/3/7
Ds JWJ van Ryssen	S21/158/82	180	h	
Mnre Westfalia Landgoed (Edms) Bpk	72/158/83	21 600	bsp	27/4/8
WJ Kemp	S1/158/84	3 600	h + vs	
JG Kleynhans	S2/158/84	3 600	h	
S Murray	S4/158/84	3 600	h	
Duiwelskloof Dorpsraad	117/158/84	53 200	brand	14/11/8
Mnr Theo Dicke	S5/158/84	3 600	h	10/1/85
CJ Botha	S2/158/85	3 600	h	10/9/85
HA Roets	S3/158/85	3 600	h	10/9/85
Westfalia Landgoed	S6/158/85	3 600	bsp	7/11/85
LJ van der Schyff	S7/158/85	3 600	h	10/12/8
JA Pohl	78/158/89	3 600	h + vs	
Letaba Buiteklub	55/158/87	18 000		4/5/87
Geluksfontein Kontantwinkel	S1/158/87	360		21/7/87
Westfalia Estates	1/158/88	800		14/1/88
Langeberg Co-Op (Pty) Ltd	82/158/88	45 000	u + i	27/7/88
WJ O'Connell	S1/158/88	3 600	h	2/9/88
Westfalia Landgoed	22/158/89	21 600	ny	28/2/89
Hans Merensky Holdings	60/158/89	21 000	h	1/6/89
Municipality of Duiwelskloof	78/158/89	30 000	h	30/6/89
Mrs EC Roets	95/158/89	3 600	h + brand	8/8/89
Duiwelskloof Municipality	S33/158/78	1 000	h	
DM Adams	S7/158/80	3 600	vs	24/3/81
PJ van Vuuren	55/158/90	3 600	h + vs	1/8/90
HL & H Mining Timber	S/70/185/91	520		18/10/91
Carnation Company (Pty) Ltd				
Sapekoe (Pty) Ltd Tzaneen	268N	331 865	i	9/9/70
Sapekoe (Edms) Bpk	110/116/78	33 000	h + i	1/11/78
Langeberg Co-Op (Pty) Ltd	142/97/84	267 859	h + i +	
		600 000	bsp	3/1/85
	83/97/88	200 000	i	26/7/88

PIETERSBURG (LETABA RIVER)				
Consumer	**Authorization No**	**Quantity (m^3/year)**	**Usage code**	**Date**
Haenertsburg dorp		9 792	st + ny	Illegible information
Mr LK de Jager (Ebenezer View (Edms) Bpk		3.650	h	
Messrs de Hoek, Sais Mills	31/112/76	19 908	H+i	
The Zion Christian Church	48/112/77	2 280	Bouth +vs	
Dept Landbou en Bosbou Lebowa	80/112/78	60 000	h	
Munisipaliteit van Pietersburg (Sien Groot Letaba)				
De Hoek Saw Mills	51/112/79	150 m³/u	Brand-bestryding Veranderlik	
Dalmada Water Koöperasie Bpk	63/112/79	180 000	h	
Dept van Werke (Lebowa) Univ. van die Noorde	76/112/82	2 300 000	st + ny	
Dept van Labou (Lebowa)	75/112/82	97 920	st +ny	
Boyne Roller Mills	34/112/83	39 000	h	
Seatch Mist Laagmeule	67/112/83	42 960	h + i	
Mev S M M Dique	S5/112/83	8 600	h + vs	
Departement Paaie	S4/112/84	3 600	h	
Frans Motimela	S1/112/85	3 600	h	
Mountain Yacht Club	S2/112/80	8 600	h	
RW Anderson	S6/112/86	3 600	h	
Pretoria Industrial Equipment	S7/112/56	3 600		
Mnr DS Steynberg	49/112/86	3 600	Bou van reservoir	
OVCON (Tvl) Civil (Pty) Ltd	Draft	7 200		
Mnr A T Brett	81/112/87	3 600	h	
Paul Hans Spahn	S1/112/88	3 600	h	
Mr C Jackson	39/112/88	600	h	
Mahgoka High School	40/112/88	9 600	h	
Haenertsburg Laerskool	S6/112/79	21 000	h	
A S Thompson	S1/112/80	3 600	h + vs	
WL Lee	S4/112/80	2 760	h	
Steven Lumber Saw Mill (Lebowa)	S6/112/80	3 600	h	
E M van Schalkwyk	S8/112/80	3 600	h	
CJ Labuschagne	S12/112/80	3 600	h	
JH de Kock	S14/112/80	1 620		
WSJ Dickenson	S15/112/80	3 600	h	
SP Render	S2/112/82	3 600	h	
Draken Industries (Pty) Ltd	S3/112/82	3 600	h	
TG Wiggill	S4/112/82	2 400		
M Gowans	S1/112/86	3 600	h	
JGG Smit	S4/112/86	3 600	h	
RW Anderson	S6/112/86	3 600	h	
Mrs FAM Stumbles	F2/112/88	3 600	h	

SCHEDULED AREAS AND WATER ALLOCATION IN THE GLGWCA

Zone 1	Farm name	River	George's valley canal	Pusela canal	Letaba noord canal	N & N canal	Masalal canal	Total scheduled area	Water allocation (mm^3/a)
I	Patente Bridge	24.3						24.3	0.2
	Tweefontein	17.1						17.1	0.1
	Paradys	1.7						1.7	0.0
	Schuinshoogte	24.1						24.1	0.2
	Onverwacht	85.3						85.3	0.6
	Goedehoop	50.5						50.5	0.3
	Georges Valley	23.6						23.6	0.2
	Vaalpunt	59.0						59.0	0.4
	Stylkop	55.6	21.4					77.0	0.5
	Letabadrift	28.7	111.6					140.3	0.9
	Lucerne	66.5						66.5	0.4
	Diggersrest		96.8					96.8	0.6
	Paardeplaats	106.1						106.1	0.7
	Ventershoek	48.8						48.8	0.3
	Roument	48.5						48.5	0.3
	Red Bank		67.6					67.6	0.4
	Grysappel	50.2						50.2	0.3
	Burrah Nullah	11.1	53.9					65.0	0.4
	Nootgedacht	14.5						14.5	0.1
	Vergelegen	14.5						14.5	0.1
	Evenrond	25.1						25.1	0.2
	Apex	34.3						34.3	0.2
	Jagersfontein	10.7		132.9				143.6	1.0
	Tzaneen	336.6						336.6	2.2
	Pusela	307.4		561.6				869.0	5.8
	Hamawasha	47.4		118.7				166.1	1.1
	Doornhoek	179.8						179.8	1.2
	Manorvlei	104.8						104.8	0.7
	Totals	**1776.2**	**351.3**	**813.2**	**0.0**	**0.0**	**0.0**	**2940.7**	**19.4**
II	Yarmorna	228.8		183.6				412.4	3.7
	Ledzee	134.5						134.5	1.2
	Mohlabas Lokasie	192.7						192.7	1.7
	Berlyn					85.0		85.0	0.8
	Broederstroom drift	195.3						195.3	1.7
	Lushof	43.1						43.1	0.4
	Fleurbaai	64.2						64.2	0.6
	Beaconsfeild				154.2			154.2	1.4
	Letabadrift				349.4			349.4	3.1
	Letaba Estates				1335.3			1335.3	11.9
	Rust				69.9			69.9	0.6
	The Junction				313.1			313.1	2.8
	Nouvengulla					215.9		215.9	1.9
	Lanquedoc					39.7		39.7	0.4
	Totals	**858.6**	**0.0**	**183.6**	**2221.9**	**340.6**	**0.0**	**3604.7**	**32.2**
III	Delhi				191.2			191.2	2.1
	La Gratitude				304.0			304.0	3.3

SCHEDULED AREAS AND WATER ALLOCATION IN THE GLGWCA

Zone 1	Farm name	River	George's valley canal	Pusela canal	Letaba noord canal	N & N canal	Masalal canal	Total scheduled area	Water allocation (mm^3/a)
	Riverside	32.4			194.3			226.7	2.5
	La Motte				39.6			39.6	0.4
	Eureka					302.8		302.8	3.3
	The Plains					272.1		272.1	3.0
	Belle Ombre					239.8		239.8	2.6
	Nagude					123.0		123.0	1.3
	Janetsi	141.6						141.6	1.5
	Mamitwaskop	61.7						61.7	0.7
	Jasi	262.9						262.9	2.9
	Labourie	128.0						128.0	1.4
	Deeside	266.7						266.7	2.9
	Henlye	84.2						84.2	0.9
	Gunyula	45.3						45.3	0.5
	Matuma	66.6						66.6	0.7
	La Parisa	149.9						149.9	1.6
	La Cotte	308.8						308.8	3.4
	Letabadrift	107.6						107.6	1.2
	Miami	38.0						38.0	0.4
	Constantia	454.8						454.8	5.0
	Mabeta	191.1						191.1	2.1
	Eiland	35.7						35.7	0.4
	Prieska	142.1					99.9	242.0	2.6
	Masalal						245.6	245.6	2.7
	Waterbok						380.7	380.7	4.1
	Nondweni	220.1						220.1	2.4
	Makuba's Lokasie	1239.4						1239.4	13.5
	Silwana's Lokasie	34.2						34.2	0.4
	Mhale	89.9						89.9	1.0
	Belasting	175.8						175.8	1.9
	Letaba Ranch	66.9						66.9	0.7
	Mhale	89.9						89.9	1.0
	Belasting	175.8						175.8	1.9
	Letaba Ranch	66.9						66.9	0.7
	Totals	**4676.3**	**0.0**	**0.0**	**729.1**	**937.7**	**726.2**	**7069.3**	**77.0**
	Grand Totals	**7311.1**	**351.3**	**996.8**	**2951.0**	**1278.3**	**726.2**	**13614.7**	**128.6**

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

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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

LIST OF FIGURES

LIST OF TABLES

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.

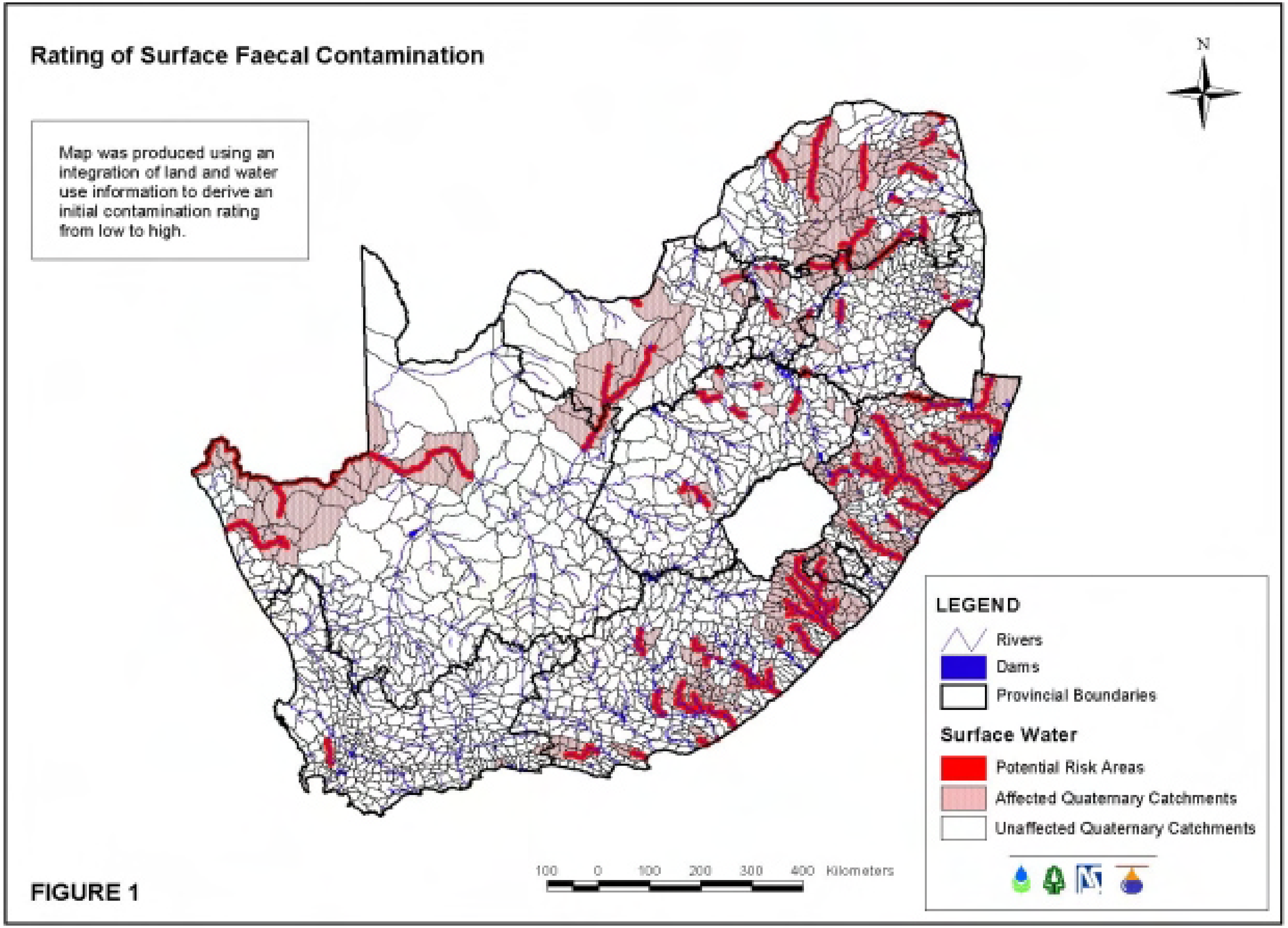

Rating of Surface Faecal Contamination
Map was produced using an integration of land and water use information to derive an initial contamination rating from low to high.
N
LEGEND
Rivers
Dams
Provincial Boundaries
Surface Water
Potential Risk Areas
Affected Quaternary Catchments
Unaffected Quaternary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

$$LU = SA + PD \quad \text{........ (3)}$$

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:

$$TLU = (LU_n) \quad \text{....... (4)}$$

Where TLU = Total land use rating per quaternary catchment
LU_n = Land use rating for n settlements, per quaternary

Each quaternary catchment was allocated a low (1), medium (2) and high (3) priority rating used to map the information using GIS. Classes were designated by the following values:

Low	=	TLU < 1000	
Medium	=	1000 < TLU <3000	
High	=	TLU > 3000	.... (5)

2.3 Results: GIS Surface Water Mapping

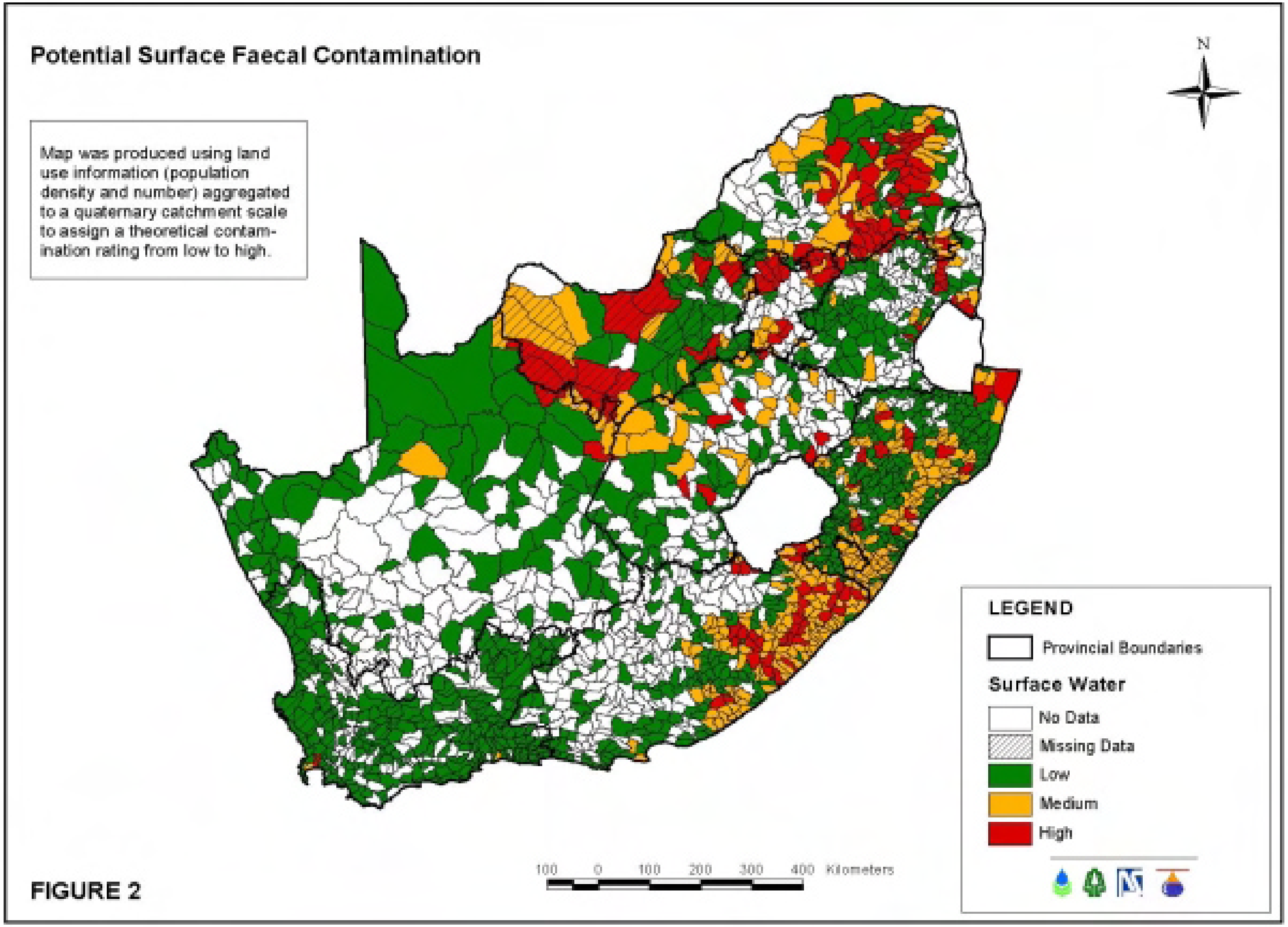
Figure 1 was plotted on GIS by firstly assembling the national coverages for the quaternary catchments, rivers and dams. The data described above were processed using the following method:

The quaternary catchments were shaded according to whether they were considered potential risk areas or not (refer to Equations 1 & 2).

Within the quaternaries at risk, the rivers were buffered and shaded red to indicate the risk to potential surface water users.

Figure 2, the potential surface faecal contamination map, was produced as follows:

The ratings (TLU) were distributed into intervals (refer to Equations 5 and 6).



Potential Surface Faecal Contamination

FIGURE 2

The quaternary catchments were then shaded according to these rating intervals indicating areas of Low, Medium or High Risk, see below.

Low	Green	TLU < 1000
Medium	Yellow	1000 < TLU < 3000
High	Red	TLU > 3000 .... (6)

Quaternary catchments with no data were unshaded.

Quaternary catchments containing missing data were hatched.

3. MAPPING GROUNDWATER RESOURCES

3.1 Background

Groundwater is an important national water resource that plays an important role in meeting water requirements in remote areas. This is particularly true in areas where rainfall is low and surface water resources are scarce.

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

Considerable work has already been carried out to map the groundwater resources in South Africa. Examples include: the national Groundwater Resources of the Republic of South Africa map produced by Vegter (1995) for the Water Research Commission (WRC), regional 1: 500 000 scale hydrogeological maps produced by DWAF, the national groundwater vulnerability map prepared by Reynders & Lynch (1993) and the aquifer classification map of Parsons & Conrad (1998). Figure 3 shows the vulnerability map used by Parsons & Conrad (1998). The existing work, particularly the vulnerability map (Figure 3), has therefore been used as a basis for assessing the potential of microbial contamination of groundwater systems.

3.2 Method

It is recognised that certain aquifers are more vulnerable to contamination than others. The DRASTIC method (Aller *et al.*, 1985) is a well-known and studied method of assessing aquifer vulnerability to contamination. Reynders & Lynch (1993) and Lynch *et al*. (1994, 1997) prepared a national scale aquifer vulnerability map using DRASTIC that was revised by Parsons & Conrad (1998) using additional data (see Figure 3).

DRASTIC is a weighting, and rating, technique that considers seven factors when estimating the groundwater vulnerability. Factors are geologically and geohydrologically based. Controls relating to the magnitude or severity of the pollution source are not considered. DRASTIC factors are shown in Table 1.

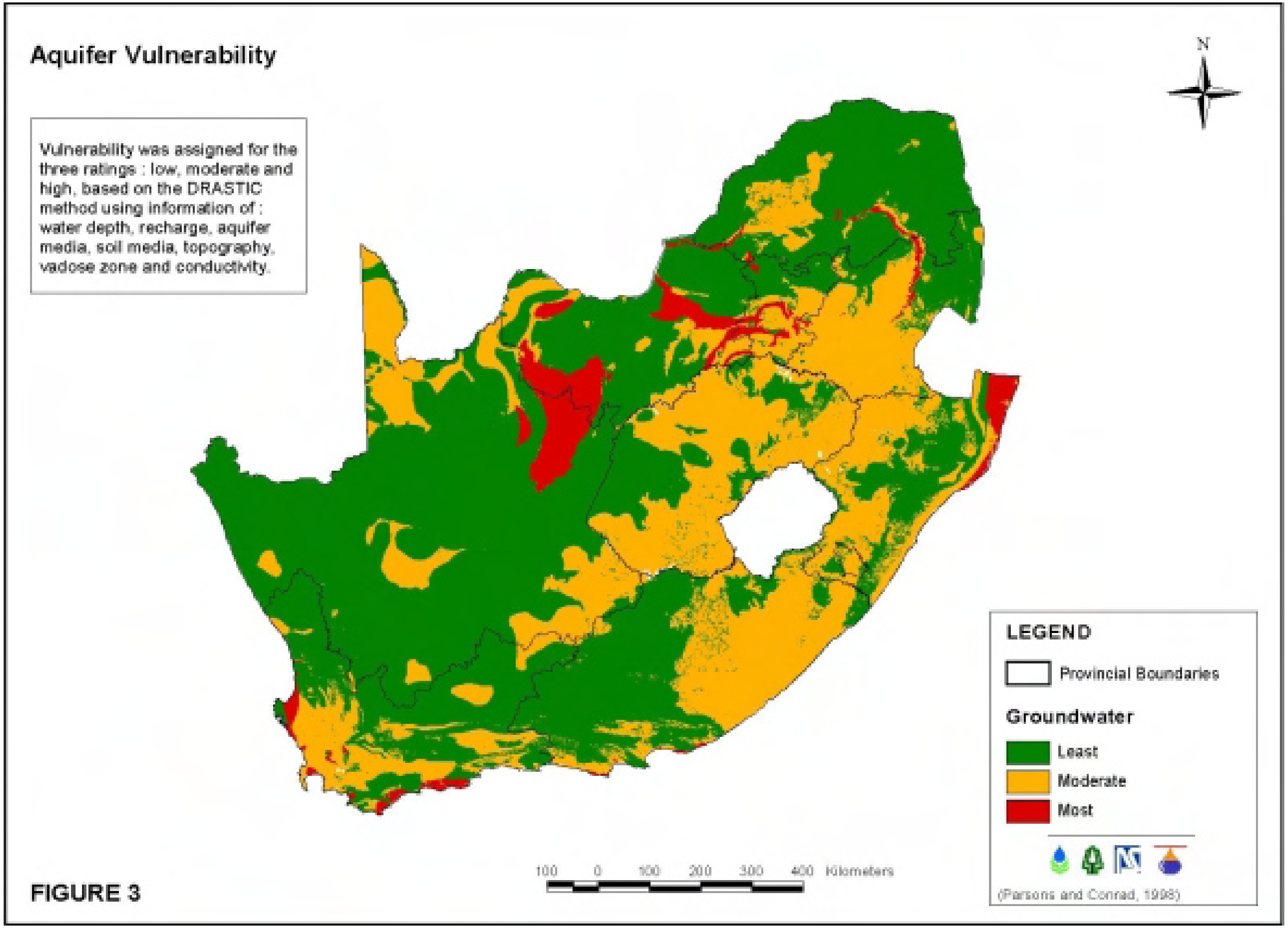

Aquifer Vulnerability
Vulnerability was assigned for the three ratings : low, moderate and high, based on the DRASTIC method using information of : water depth, recharge, aquifer media, soil media, topography, vadose zone and conductivity.
N
100 0 100 200 300 400 Kilometers
LEGEND
Provincial Boundaries
Groundwater
Least
Moderate
Most
(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:

$$I = D_R D_W + R_R R_W + A_R A_W + S_R S_W + T_R T_W + I_R I_W + C_R C_W \qquad \text{..... (7)}$$

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.

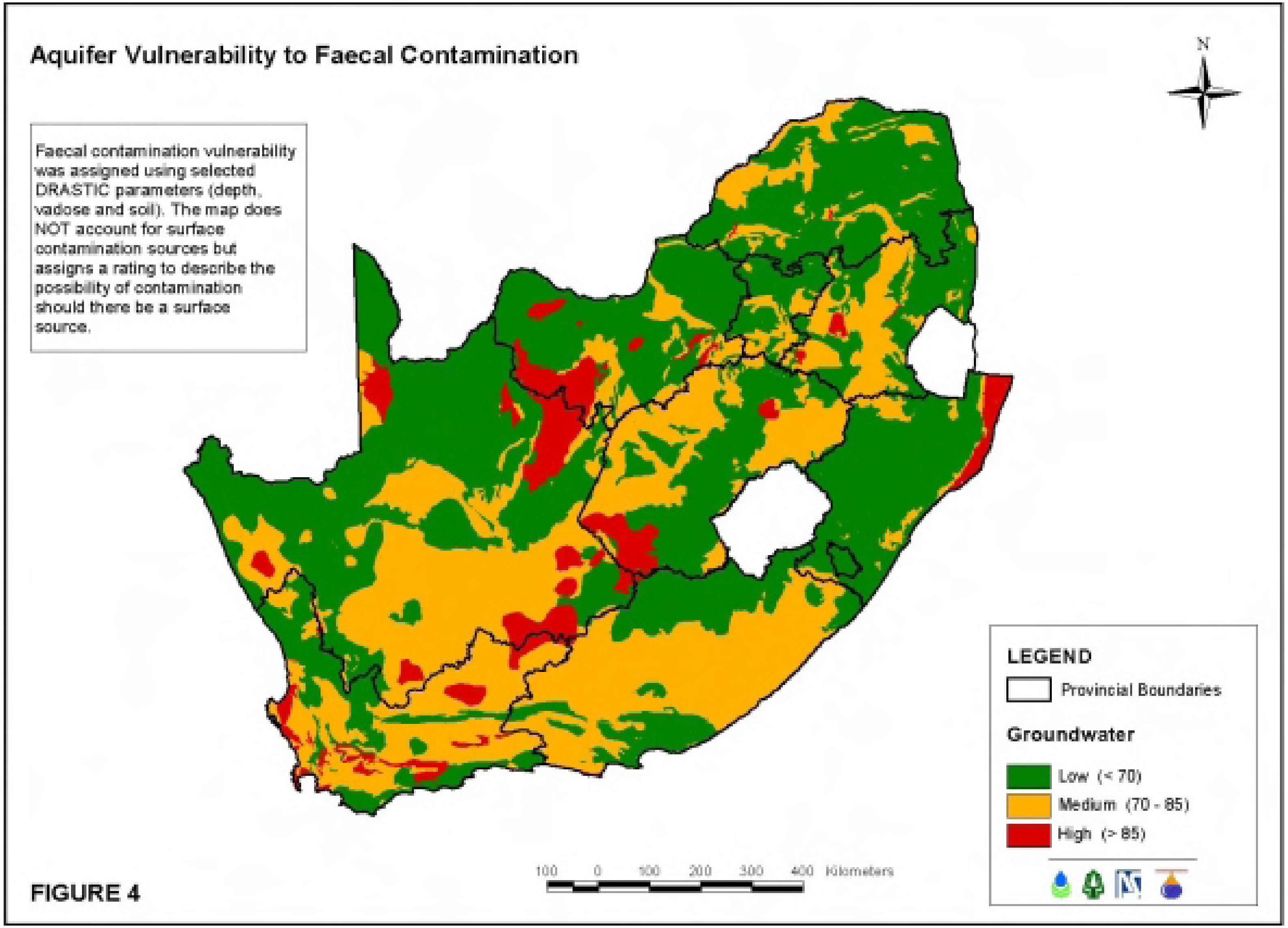

Aquifer Vulnerability to Faecal Contamination
N
Faecal contamination vulnerability was assigned using selected DRASTIC parameters (depth, vadose and soil). The map does NOT account for surface contamination sources but assigns a rating to describe the possibility of contamination should there be a surface source.
LEGEND
Provincial Boundaries
Groundwater
Low (< 70)
Medium (70 - 85)
High (> 85)
100 0 100 200 300 400 Kilometers

FIGURE 4

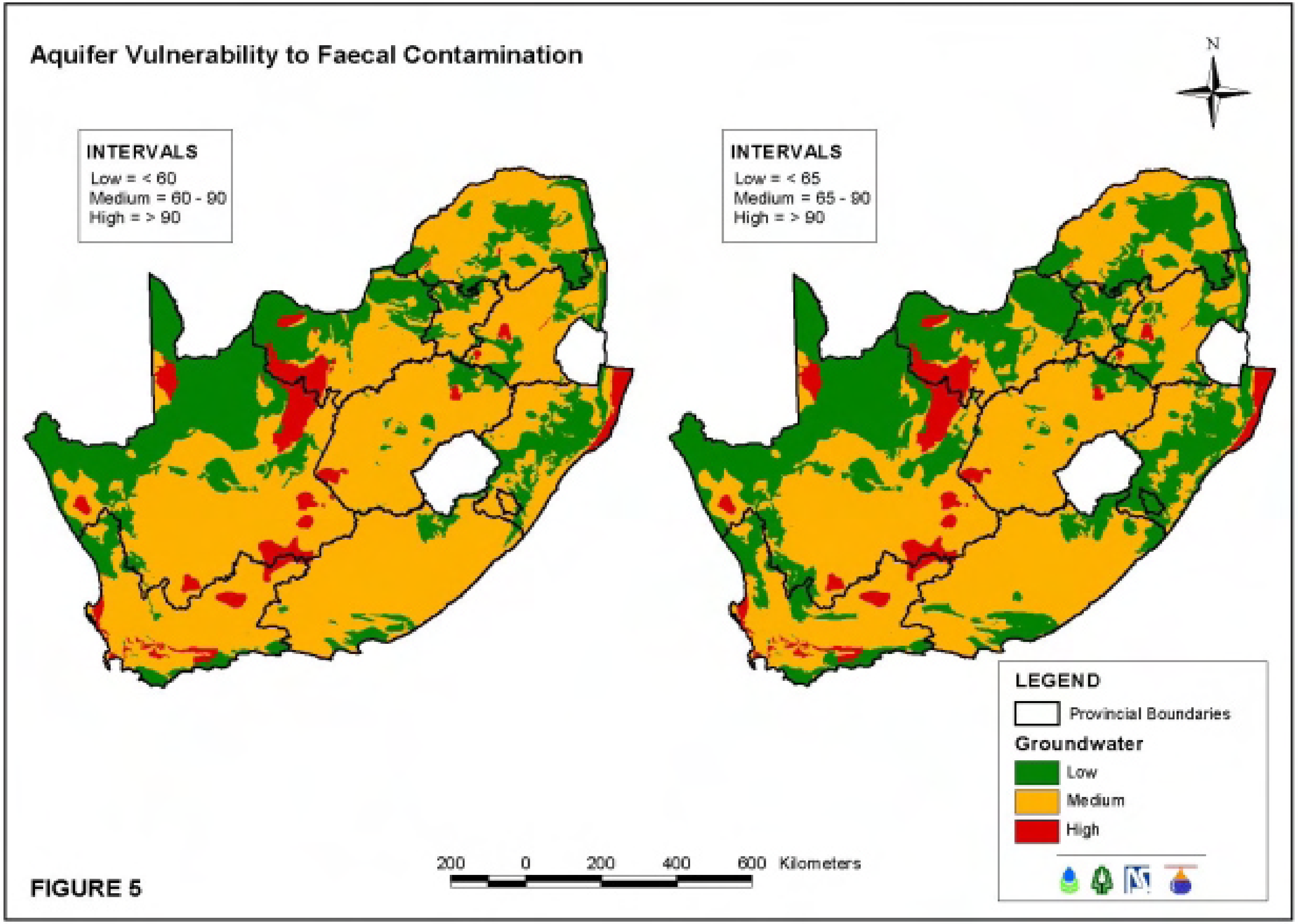

Aquifer Vulnerability to Faecal Contamination
N
INTERVALS
Low = < 60
Medium = 60 - 90
High = > 90
INTERVALS
Low = < 65
Medium = 65 - 90
High = > 90
LEGEND
Provincial Boundaries
Groundwater
Low
Medium
High
200 0 200 400 600 Kilometers

FIGURE 5

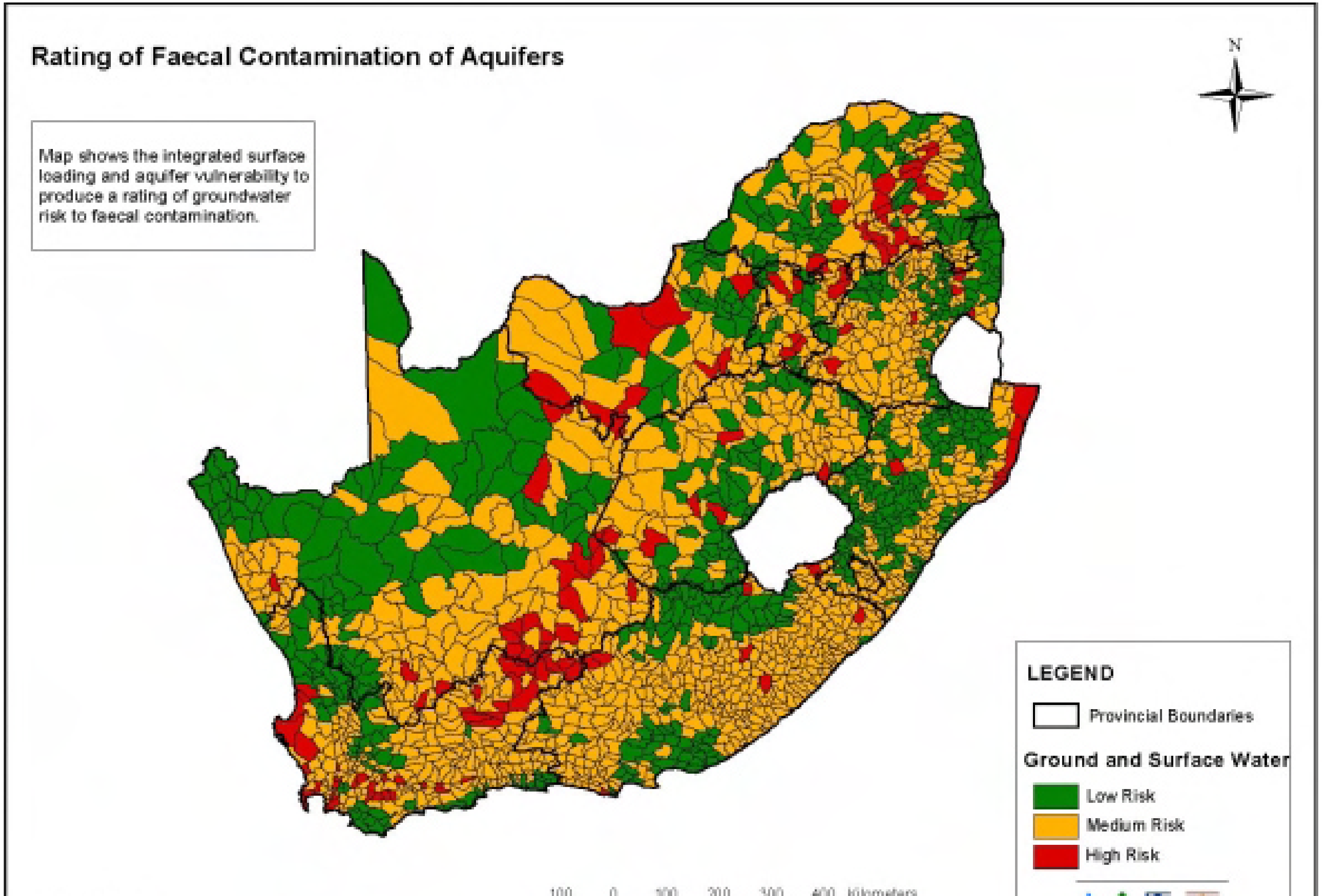

Rating of Faecal Contamination of Aquifers
Map shows the integrated surface loading and aquifer vulnerability to produce a rating of groundwater risk to faecal contamination.
N
LEGEND
Provincial Boundaries
Ground and Surface Water
Low Risk
Medium Risk
High Risk
100 0 100 200 300 400 Kilometers

FIGURE 6

4. CONCLUSIONS & RECOMMENDATIONS

- A series of maps (and their associated GIS coverages) have been produced to show the potential microbial contamination of surface water and groundwater resources in South Africa.

- Maps are produced on a quaternary catchment scale. Where more detailed spatial information is required, alternative methods should be used.

- Once sufficient microbial data are available, it is recommended that the numerical methods are calibrated, and the maps replotted.

- The surface water and groundwater maps should be used in the assessments of water quality for each water management area.

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G3. POTENTIAL DAMS

LUVUVHU LETABA													
Quat	Zone	Volume I		oMAR	Max Dam Size	KEY POINTS	Max Dam Size	Existing Dam Storage	Potential Dams	Variability Yield Used	Yield (% MAR)	Yield (mill m^3/a)	Yield/ Keypoint	Cost
		1*	2*											
A91A	H	213	200	16.5	33					Medium	66	10.9		
A91B	H	213	200	12	24					Medium	66	7.9		
A91C	H	213	200	35.5	71					Medium	66	23.4		
A91D	H	213	200	49.8	99.6	Luvuvhu at Levubu	227.60	30.00	197.60	Medium	66	32.9	75.1	464.01
A91E	H	213	200	56	112					Medium	66	37.0		
A91F	S	323	300	20	60					High	51	10.2		
A91G	H	213	200	138.1	276.2	Paswane Dam site	448.20	30.00	418.20	Medium	66	91.1	138.3	658.54
A91H	S	323	300	26.5	79.5					High	51	13.5		
A91J	X	296	300	5.7	17.1	Luvuvhu at Mutale	96.60	0.00	96.60	High	51	2.9	16.4	332.18
A91K	X	296	300	2.6	7.8	Luvuvhu at Limpopo	7.80	0.00	7.80	High	51	1.3	1.3	102.57
A92A	H	213	200	118.5	237					Medium	66	78.2		
A92B	S	323	300	31.6	94.8					High	51	16.1		
A92C	X	296	300	4.9	14.7					High	51	2.5		
A92D	X	296	300	1.4	4.2	Mutale at Luvuvhu	350.70	0.00	350.70	High	51	0.7	97.5	606.57
B81A	D	168	150	63.9	95.85					Medium	56	35.8		
B81B	D	168	150	15.6	23.4	Tzaneen dam	119.25	251.40	-132.15	Medium	56	8.7	44.5	384.53
B81C	S	323	300	17.2	51.6					High	51	8.8		
B81D	E	163	150	67.3	100.95					Medium	56	37.7		
B81E	X	296	300	29.5	88.5					High	51	15.0		
B81F	X	296	300	18.8	56.4	Groot Letaba at Molototsi	297.45	3.63	293.82	High	51	9.6	71.1	558.45
B81G	X	296	300	16.2	48.6					High	51	8.3		
B81H	X	296	300	7.1	21.3	Molototsi	69.90	0.00	69.90	High	51	3.6	11.9	285.60
B81J	X	296	300	5.3	15.9	Groot Letaba at Klein Letaba	15.90	0.00	15.90	High	51	2.7	2.7	143.04
B82A	S	323	300	23.2	69.6					High	51	11.8		
B82B	S	323	300	18.1	54.3					High	51	9.2		
B82C	S	323	300	14.2	42.6					High	51	7.2		
B82D	S	323	300	16.5	49.5	Middle Letaba Dam	216.00	197.60	18.40	High	51	8.4	36.7	153.13
B82E	S	323	300	13.6	40.8					High	51	6.9		
B82F	S	323	300	27.6	82.8	Klein Letaba at Tabaan	123.60	0.00	123.60	High	51	14.1	21.0	372.70
B82G	X	296	300	14.3	42.9					High	51	7.3		
B82H	X	296	300	10.8	32.4					High	51	5.5		
B82J	X	296	300	13.6	40.8	Kein Letaba at Groot Letaba	116.10	23.00	93.10	High	51	6.9	19.7	326.51
B83A	X	296	300	12.8	38.4					High	51	6.5		
B83B	X	296	300	8.6	25.8					High	51	4.4		
B83C	X	296	300	5.9	17.7					High	51	3.0		
B83D	X	296	300	9.5	28.5					High	51	4.8		
B83E	X	296	300	4.5	13.5	Letaba at Olifants	123.90	6.00	117.90	High	51	2.3	21.1	364.58
B90A	X	296	300	6.5	19.5					High	51	3.3		
B90B	X	296	300	9.4	28.2					High	51	4.8		
B90C	X	296	300	9	27					High	51	4.6		
B90D	X	296	300	5.3	15.9					High	51	2.7		
B90E	X	296	300	5.1	15.3	Mphongolo	105.90	13.00	92.90	High	51	2.6	18.0	326.18
B90F	X	296	300	19.5	58.5					High	51	9.9		
B90G	X	296	300	15.5	46.5					High	51	7.9		
B90H	X	296	300	16.2	48.6	Shingwedzi	153.60	0.00	153.60	High	51	8.3	26.1	412.51
				1039.7										
1* Determined from intersection of 50-year storage yield curve with limit line													601.5	5491.09
2* Adopted value after grouping of similar zones													-4889.5	

LUVUVHU LETABA			
Quat	Zone	Volume I	
		1*	2*
A91A	H	213	200
A91B	H	213	200
A91C	H	213	200
A91D	H	213	200
A91E	H	213	200
A91F	S	323	300
A91G	H	213	200
A91H	S	323	300
A91J	X	296	300
A91K	X	296	300
A92A	H	213	200
A92B	S	323	300
A92C	X	296	300
A92D	X	296	300
B81A	D	168	150
B81B	D	168	150
B81C	S	323	300
B81D	E	163	150
B81E	X	296	300
B81F	X	296	300
B81G	X	296	300
B81H	X	296	300
B81J	X	296	300
B82A	S	323	300
B82B	S	323	300
B82C	S	323	300
B82D	S	323	300
B82E	S	323	300
B82F	S	323	300
B82G	X	296	300
B82H	X	296	300
B82J	X	296	300
B83A	X	296	300
B83B	X	296	300
B83C	X	296	300
B83D	X	296	300
B83E	X	296	300
B90A	X	296	300
B90B	X	296	300
B90C	X	296	300
B90D	X	296	300
B90E	X	296	300
B90F	X	296	300
B90G	X	296	300
B90H	X	296	300

1* Determined from intersection of 50-year storage yield curve with limit line
2* Adopted value after grouping of similar zones

APPENDIX H

WATER BALANCE

H1. DATA SOURCES

LUVUVHU LETABA

Quat	Zone	Volume I			Max Dam Size	Key Points	Max Dam Size	Existing Dam Storage	Potential Dams	Volume I	
		1*	2*	oMARi						1*	2*
A91A	H	213	200	15.36	30.72						
A91B	H	213	200	11.91	23.82						
A91C	H	213	200	34.79	69.58						
A91D	H	213	200	52.11	104.22	K A91D	228.34	30.00	198.34	200.00	200
A91E	H	213	200	56.36	112.72						
A91F	S	323	300	20.05	60.15						
A91G	H	213	200	138.3	276.6	Paswane Dam P	449.47	30.00	419.47	233.33	200
A91H	S	323	300	26.48	79.44						
A91J	X	296	300	5.73	17.19	Luvuvhu at Mutale	96.63	0.00	96.63	300.00	300
A91K	X	296	300	2.82	8.46	Mutale at Limpopo	8.46	0.00	8.46	300.00	300
A92A	H	213	200	117.4	234.8						
A92B	S	323	300	31.6	94.8						
A92C	X	296	300	4.89	14.67						
A92D	X	296	300	2.08	6.24	Mutale at Luvuvhu	350.51	0.00	350.51	275.00	250
B81A	D	168	150	69.01	103.515						
B81B	D	168	150	164.1	246.15	Tzaneen dam	349.67	251.40	98.27	150.00	150
B81C	S	323	300	16.83	50.49						
B81D	E	163	150	55.18	82.77						
B81E	X	296	300	29.29	87.87						
B81F	X	296	300	18.84	56.52	Groot Letaba at Molototsi	277.65	3.63	274.02	262.50	250
B81G	X	296	300	16.11	48.33						
B81H	X	296	300	7.13	21.39	Molototsi at Groot Letaba	69.72	0.00	69.72	300.00	300
B81J	X	296	300	5.33	15.99	Groot Letaba at Klein Letaba	15.99	0.00	15.99	300.00	300
B82A	S	323	300	23.03	69.09						
B82B	S	323	300	18.04	54.12						
B82C	S	323	300	13.93	41.79						
B82D	S	323	300	16.39	49.17	Middel Letaba Dam	214.17	197.60	16.57	300.00	300
B82E	S	323	300	13.33	39.99						
B82F	S	323	300	27.43	82.29	Klein Letaba DS Middel Letaba	122.28	0.00	122.28	300.00	300
B82G	X	296	300	14.29	42.87						
B82H	X	296	300	10.8	32.4						
B82J	X	296	300	13.64	40.92	Kein Letaba at Groot Letaba	116.19	23.00	93.19	300.00	300
B83A	X	296	300	12.79	38.37						
B83B	X	296	300	8.58	25.74						
B83C	X	296	300	7.08	21.24						
B83D	X	296	300	9.45	28.35						
B83E	X	296	300	4.5	13.5	Letaba at Olifants	127.20	6.00	121.20	300.00	300
B90A	X	296	300	7.36	22.08						
B90B	X	296	300	9.39	28.17						
B90C	X	296	300	8.99	26.97						
B90D	X	296	300	5.32	15.96						
B90E	X	296	300	5.09	15.27	Shingwedzi northern tributaries	108.45	13.00	95.45	300.00	300
B90F	X	296	300	19.46	58.38						
B90G	X	296	300	15.46	46.38						
B90H	X	296	300	18.63	55.89	Shingwedzi at Mozambique	160.65	0.00	160.65	300.00	300

1* Determined from intersection of 50-year storage yield curve with limit line

2* Adopted value after grouping of similar zones

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

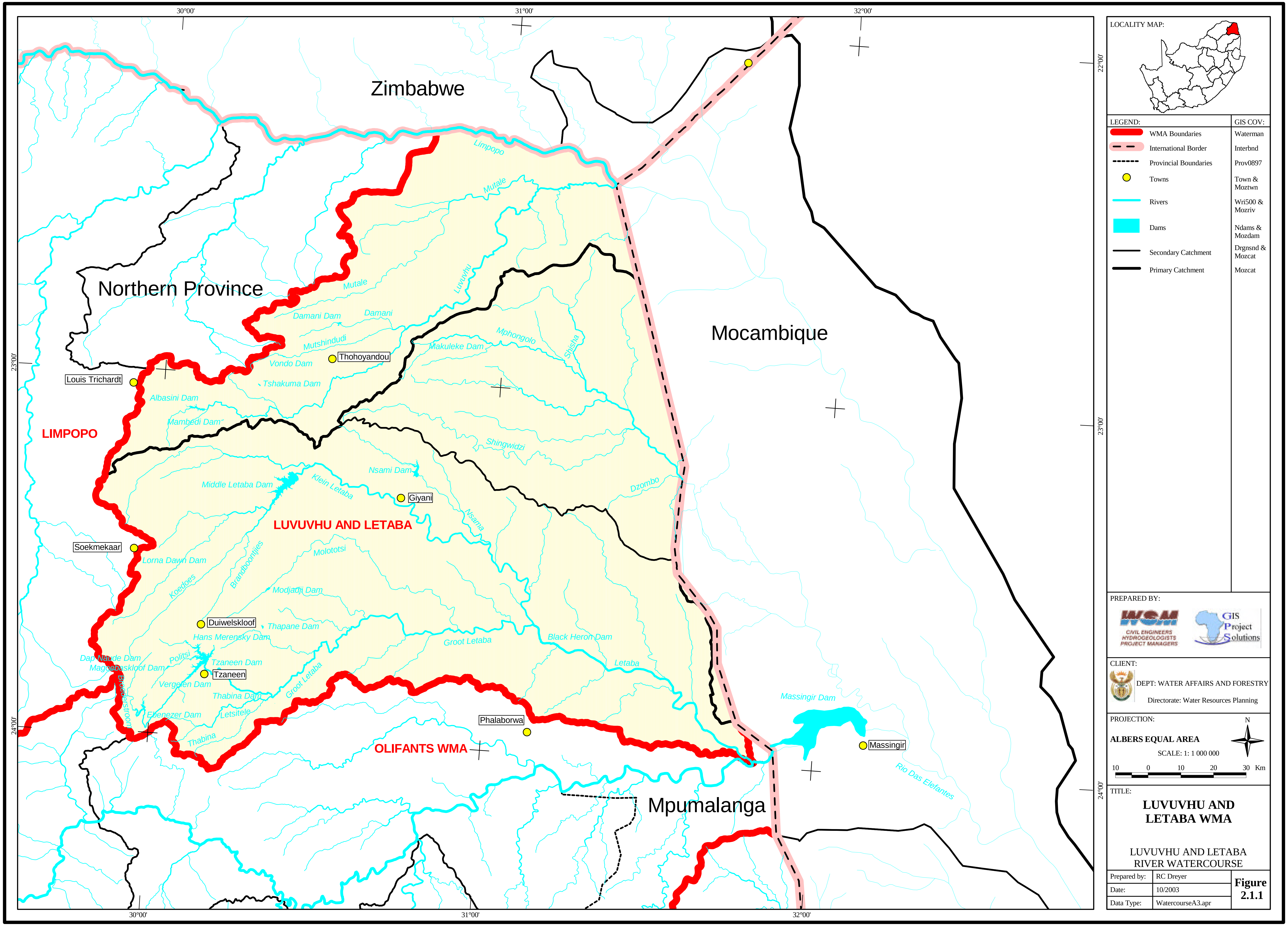
Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D16J	374	374	7	10	203	75922	0.0761	0.1584	255	95551	0.0957	0.1993
D16K	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**
0	0	0										
TOTALS	**99349**	**92568**				**20367562**	**20.4083**	**0.3027**		**25633321**	**25.6846**	**0.3810**

FIGURES



Zimbabwe
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LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Limpopo
Mutale
Luvuvhu
Damani Dam
Damani
Mutshindudi
Vondo Dam
Thohoyandou
Tshakuma Dam
Louis Trichardt
Albasini Dam
Mambedi Dam
Makuleke Dam
Mphongolo
Shisha
Shingwidzi
Dzombo
Nsami Dam
Middle Letaba Dam
Klein Letaba
Giyani
Nsama
Soekmekaar
Lorna Dawn Dam
Molototsi
Brandboontjies
Koedoes
Modjadji Dam
Duiwelskloof
Thapane Dam
Hans Merensky Dam
Groot Letaba
Black Heron Dam
Letaba
Dap Naude Dam
Magoebaskloof Dam
Politsi
Tzaneen Dam
Tzaneen
Vergelegen Dam
Thabina Dam
Groot Letaba
Broederstroom
Ebenezer Dam
Letsitele
Thabina
Phalaborwa
Massingir Dam
Massingir
Rio Das Elefantes
30°00'
31°00'
32°00'
22°00'
23°00'
24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
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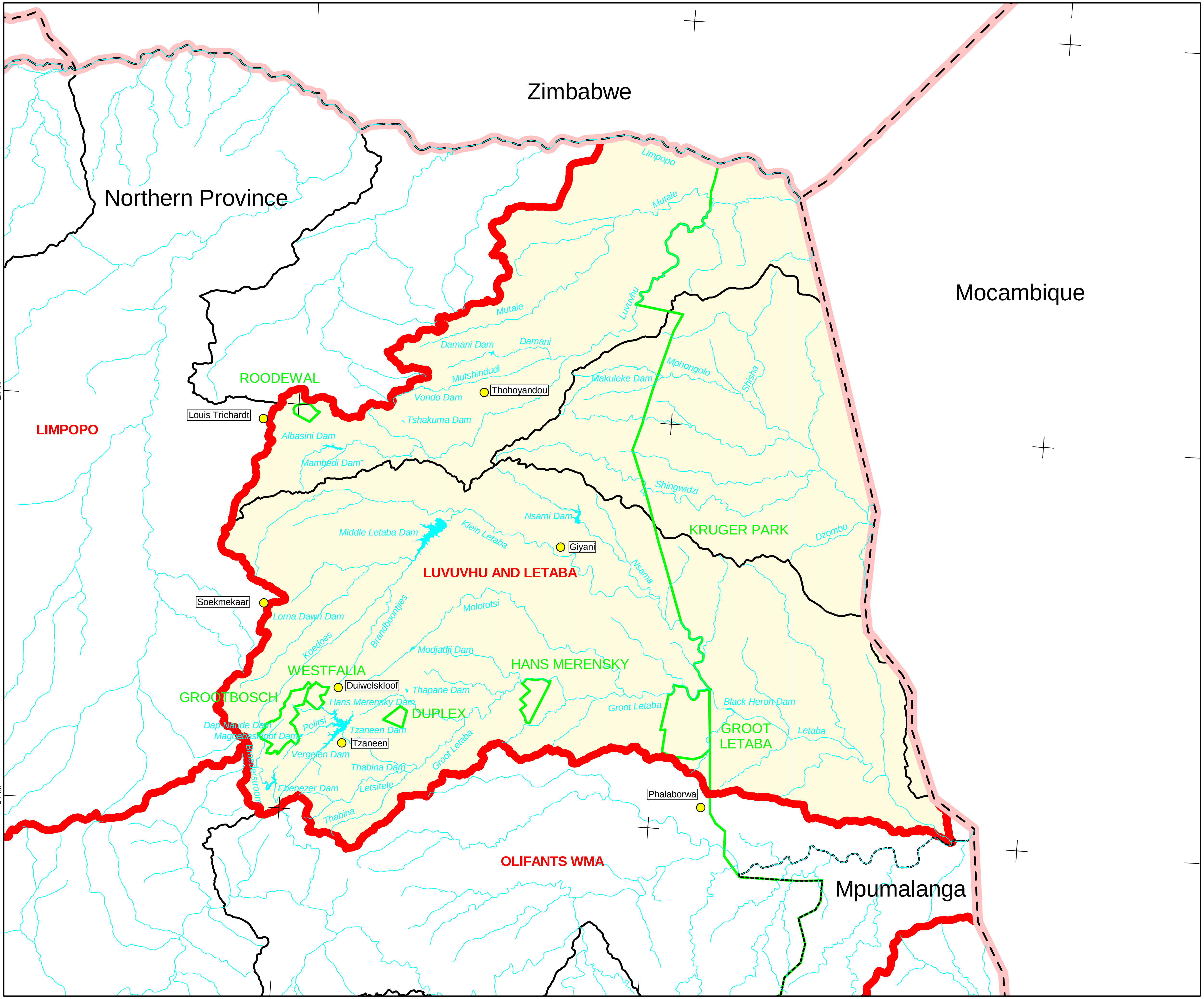
International Border
Interbnd
Provincial Boundaries
Prov0897
Towns
Town & Moztwn
Rivers
Wri500 & Mozriv
Dams
Ndams & Mozdam
Secondary Catchment
Drgnsnd & Mozcat
Primary Catchment
Mozcat
PREPARED BY:
WSM
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
N
ALBERS EQUAL AREA
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
LUVUVHU AND LETABA RIVER WATERCOURSE
Prepared by: RC Dreyer
Date: 10/2003
Data Type: WatercourseA3.apr
Figure 2.1.1



LOCALITY MAP:

BASE MAP LEGEND:

		GIS COV:
	WMA Boundaries	Waterman
	International Border	Interbnd
	Provincial Boundaries	Prov0897
	Towns	Town
	Rivers	Wri500
	Dams	Ndams
	Secondary Catchment	Drgnsnd
	Nature Reserve Boundaries	Consgeo

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Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

10 0 10 20 30 Km

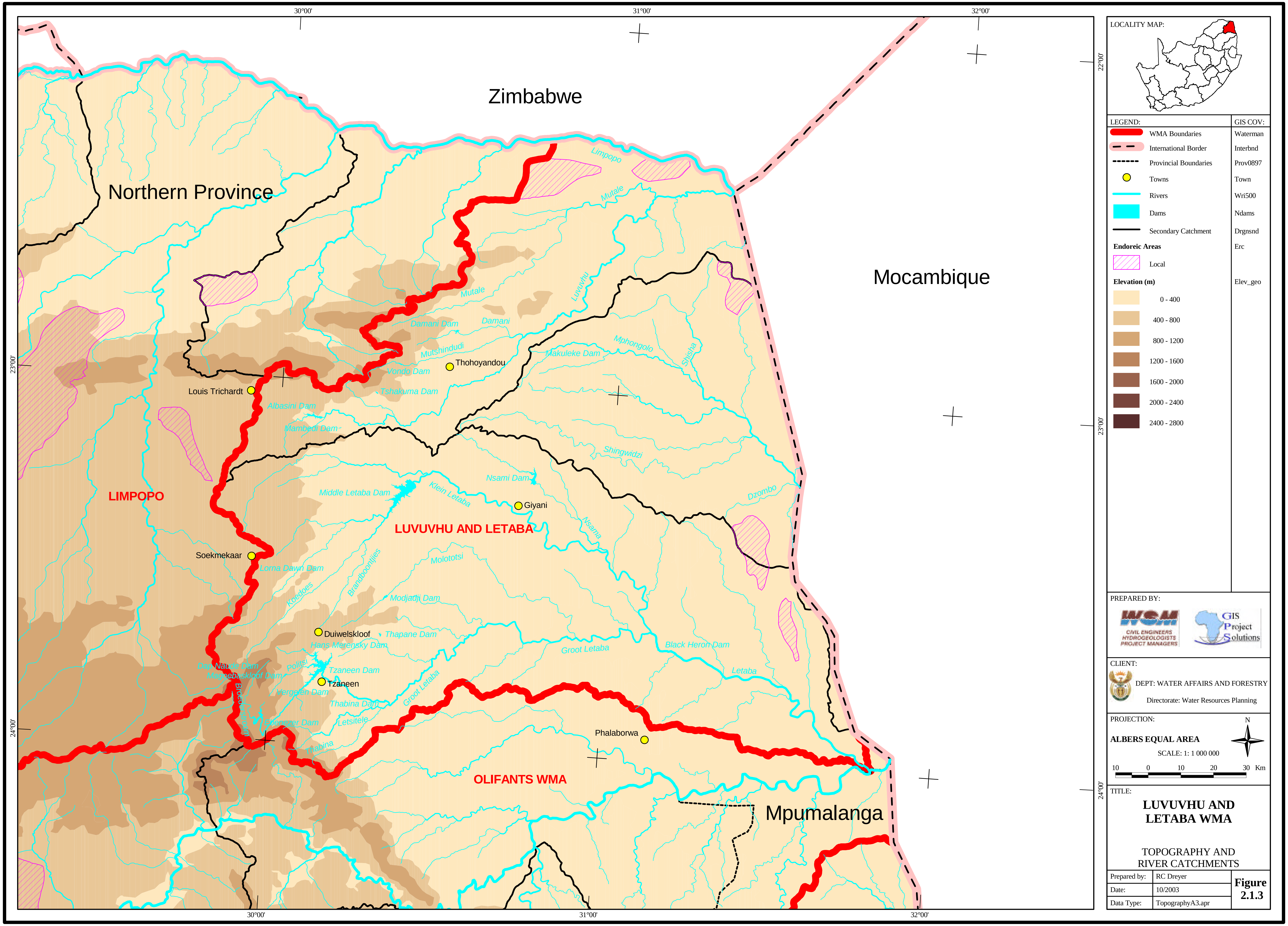
N

TITLE:

LUVUVHU AND LETABA WMA

THE STUDY AREA

Prepared by:	RC Dreyer	**Figure 2.1.2**
Date:	10/2003	
Data Type:	Study areaA3.apr	



Zimbabwe
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LIMPOPO
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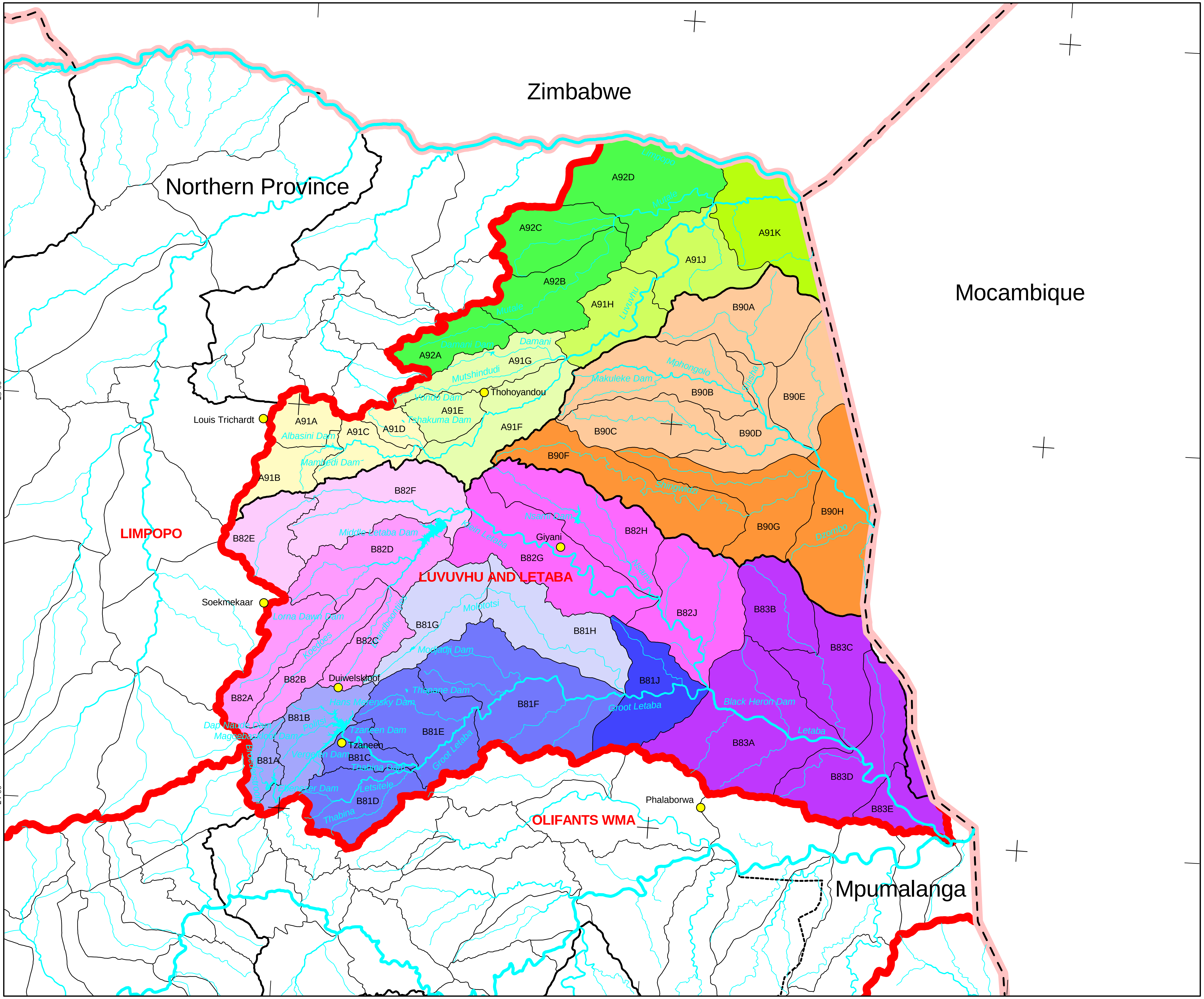
Limpopo
Mutale
Luvuvhu
Damani Dam
Damani
Mutshindudi
Makuleke Dam
Mphongolo
Shisha
Vondo Dam
Thohoyandou
Tshakuma Dam
Louis Trichardt
Albasini Dam
Mambedi Dam
Shingwidzi
Nsami Dam
Middle Letaba Dam
Klein Letaba
Giyani
Dzombo
Nsama
Soekmekaar
Lorna Dawn Dam
Molototsi
Brandboontjies
Koedoes
Modjadji Dam
Duiwelskloof
Thapane Dam
Hans Merensky Dam
Black Heron Dam
Groot Letaba
Letaba
Politsi
Tzaneen Dam
Tzaneen
Groot Letaba
Thabina Dam
Letsitele
Thabina
Phalaborwa
30°00'
31°00'
32°00'
22°00'
23°00'
24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries | Waterman
International Border | Interbnd
Provincial Boundaries | Prov0897
Towns | Town
Rivers | Wri500
Dams | Ndams
Secondary Catchment | Drgnsnd
Endoreic Areas | Erc
Local
Elevation (m) | Elev_geo
0 - 400
400 - 800
800 - 1200
1200 - 1600
1600 - 2000
2000 - 2400
2400 - 2800
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: 1 000 000
N
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
TOPOGRAPHY AND RIVER CATCHMENTS
Prepared by: RC Dreyer
Date: 10/2003
Data Type: TopographyA3.apr
Figure 2.1.3



LOCALITY MAP:

22°00'

LEGEND:

		GIS COV:
	WMA Boundaries	Waterman
	International Border	Interbnd
	Provincial Boundaries	Prov0897
	Towns	Town
	Rivers	Wri500
	Dams	Ndams
	Quaternary Catchment	Drgnquat
X40D	Quaternary Number	Drgnquat
	Secondary Catchment	Drgnsnd
	Subcatchments	WSAM

- Groot Letaba at Klein Letaba
- Groot Letaba at Molototsi
- KP A91D
- Klein Letaba D/S Middle Letaba
- Klein Letaba at Groot Letaba
- Letaba at Olifants
- Luvuvhu at Limpopo
- Luvuvhu at Mutale
- Middle Letaba Dam
- Molototsi at Groot Letaba
- Mutale at Luvuvhu
- Paswane Dam (Proposed)
- Shingwedzi Northern Tributaries
- Shingwedzi at Mocambique
- Tzaneen Dam

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Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

10 0 10 20 30 Km

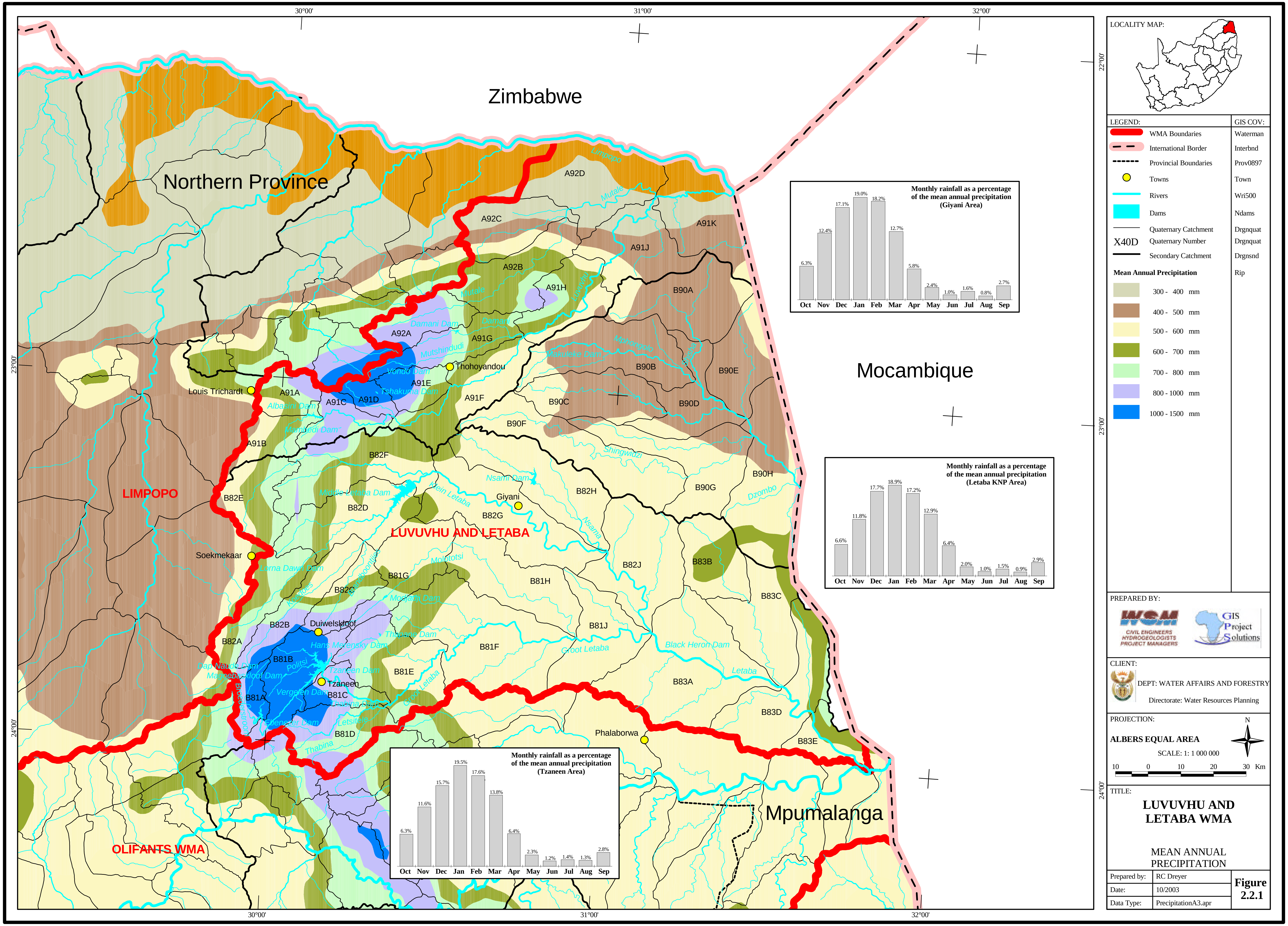
N

TITLE:

LUVUVHU AND LETABA WMA

HYDROLOGICAL SUB-CATCHMENTS

Prepared by:	RC Dreyer	**Figure 2.1.4**
Date:	10/2003	
Data Type:	Hydro sub catchA3.apr	



Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Thohoyandou
Louis Trichardt
Giyani
Soekmekaar
Duiwelskloof
Tzaneen
Phalaborwa
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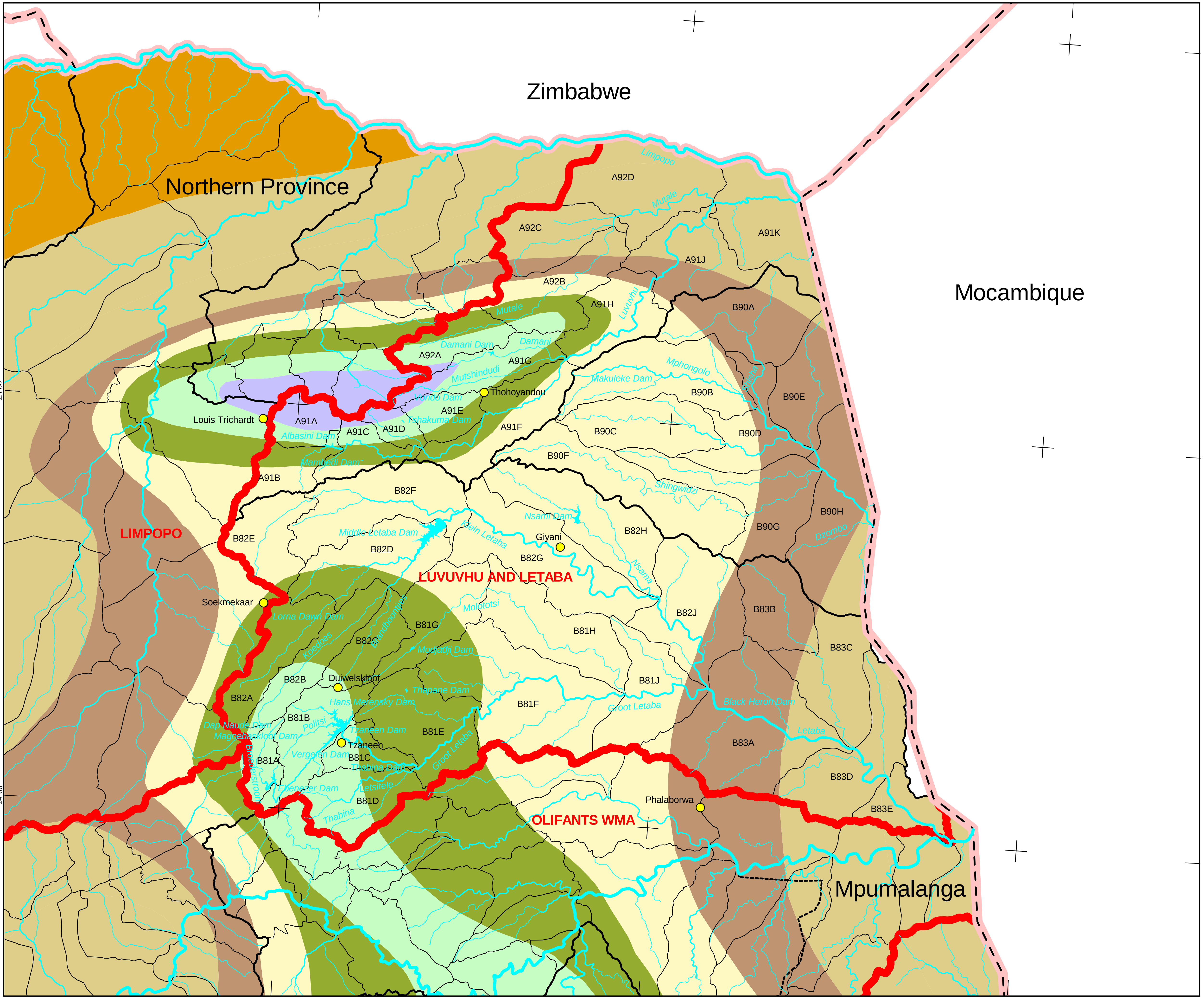
B90H
Limpopo
Mutale
Luvuvhu
Damani Dam
Mutshindudi
Vondo Dam
Tshakuma Dam
Albasini Dam
Mambedi Dam
Makuleke Dam
Mphongolo
Shingwidzi
Nsami Dam
Klein Letaba
Middle Letaba Dam
Nsama
Dzombo
Molototsi
Lorna Dawn Dam
Modjadji Dam
Thabina Dam
Hans Merensky Dam
Black Heron Dam
Groot Letaba
Letaba
Dap Naude Dam
Magoebaskloof Dam
Politsi
Tzaneen Dam
Vergelegen Dam
Ebenezer Dam
Letsitele
Thabina
30°00'
31°00'
32°00'
23°00'
24°00'
22°00'
Monthly rainfall as a percentage of the mean annual precipitation (Giyani Area)
Oct 6.3%
Nov 12.4%
Dec 17.1%
Jan 19.0%
Feb 18.2%
Mar 12.7%
Apr 5.8%
May 2.4%
Jun 1.0%
Jul 1.6%
Aug 0.8%
Sep 2.7%
Monthly rainfall as a percentage of the mean annual precipitation (Letaba KNP Area)
Oct 6.6%
Nov 11.8%
Dec 17.7%
Jan 18.9%
Feb 17.2%
Mar 12.9%
Apr 6.4%
May 2.0%
Jun 1.0%
Jul 1.5%
Aug 0.9%
Sep 2.9%
Monthly rainfall as a percentage of the mean annual precipitation (Tzaneen Area)
Oct 6.3%
Nov 11.6%
Dec 15.7%
Jan 19.5%
Feb 17.6%
Mar 13.8%
Apr 6.4%
May 2.3%
Jun 1.2%
Jul 1.4%
Aug 1.3%
Sep 2.8%
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Mean Annual Precipitation — Rip
300 - 400 mm
400 - 500 mm
500 - 600 mm
600 - 700 mm
700 - 800 mm
800 - 1000 mm
1000 - 1500 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
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
MEAN ANNUAL PRECIPITATION
Prepared by: RC Dreyer
Date: 10/2003
Data Type: PrecipitationA3.apr
Figure 2.2.1



LOCALITY MAP:

LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Quaternary Catchment	Drgnquat
X40D Quaternary Number	Drgnquat
Secondary Catchment	Drgnsnd
Mean Annual Evaporation (S-Pan)	Eip
1300 - 1400 mm	
1400 - 1500 mm	
1500 - 1600 mm	
1600 - 1700 mm	
1700 - 1800 mm	
1800 - 2000 mm	
2000 - 2200 mm	

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Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

10 0 10 20 30 Km

N

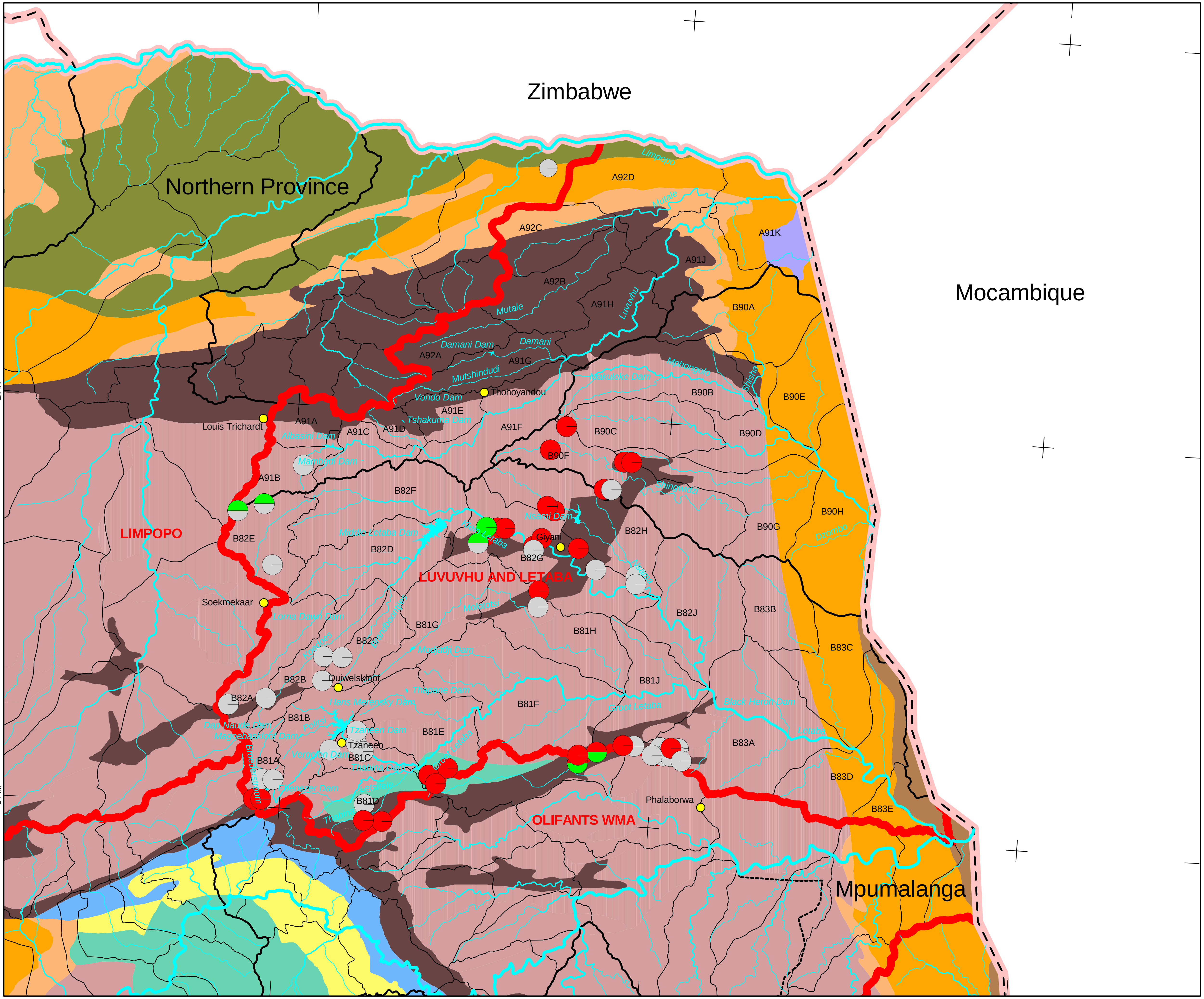
TITLE:

LUVUVHU AND LETABA WMA

MEAN ANNUAL EVAPORATION

Prepared by:	RC Dreyer
Date:	10/2003
Data Type:	EvaporationA3.apr

Figure 2.2.2



LOCALITY MAP:

LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Quaternary Catchment	Drgnquat
X40D Quaternary Number	Drgnquat
Secondary Catchment	Drgnsnd
Geology	Geol_geo
Acid and intermediate lavas	
Acid, intermediate or alkaline intrusives	
Assemblage of compact sedimentary and extrusive rocks	
Assemblage of compact sedimentary extrusive and intrusive rocks	
Compact arenaceous and argillaceous strata	
Compact sedimentary strata	
Compact, dominantly arenaceous strata	
Compact, dominantly argillaceous strata	
Consolidated porous to compact sedimentary strata	
Dolomite, chert and subordinate limestone	
Mafic / basic lavas	
Mafic / ultramafic of basic / ultrabasic intrusives	
Mainly compact tillite and shale	
Mainly compact tillite, shale and sandstone	
Mainly compact tillite	
Porous unconsolidated to semi-consolidated sediment	
Economically Important Mineral Deposits — Non Metals; Precious Metals and Stones; Non Precious Metals	Mines

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Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

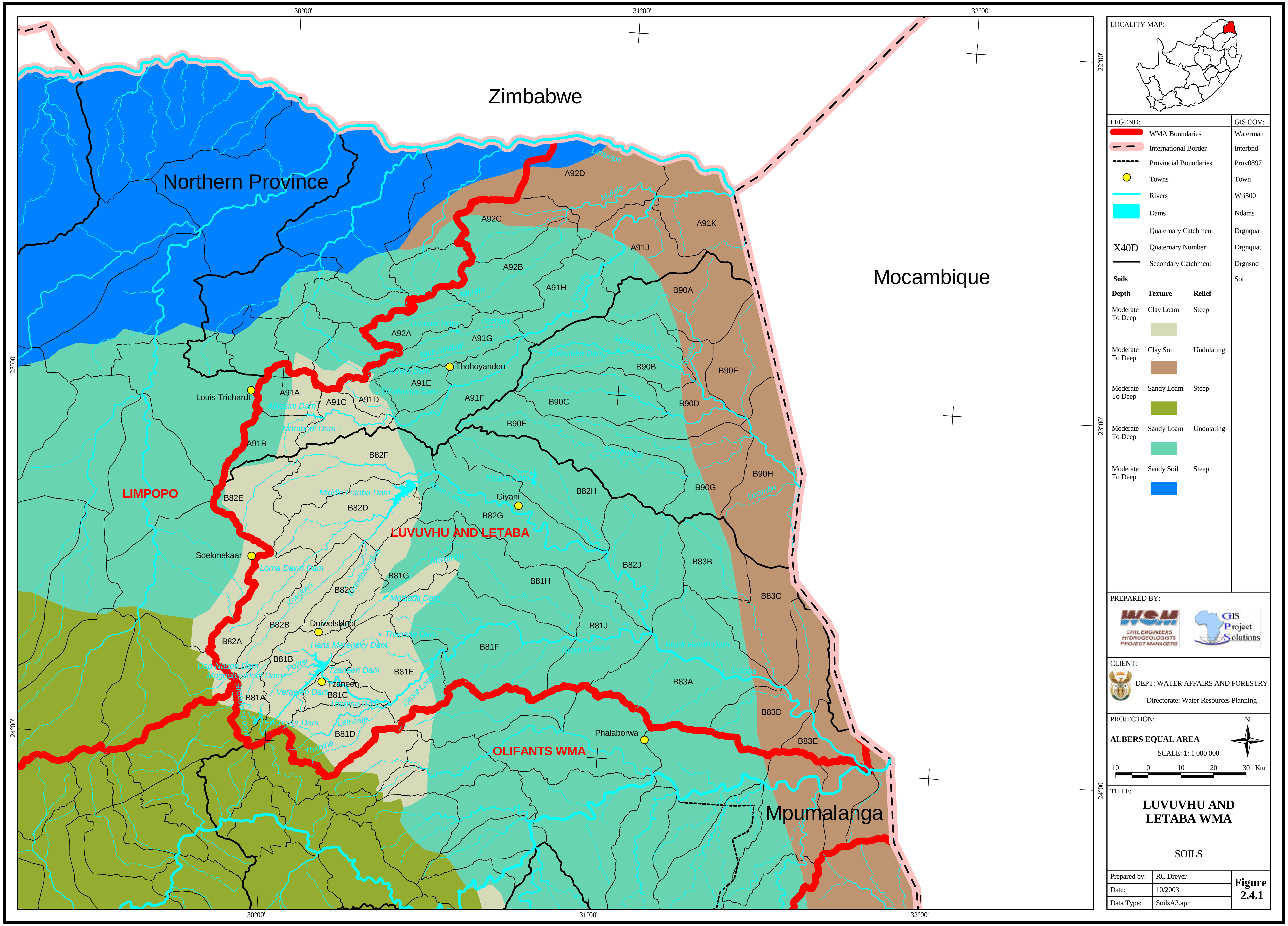
10 0 10 20 30 Km

TITLE:

LUVUVHU AND LETABA WMA

GEOLOGY

Prepared by:	RC Dreyer	**Figure 2.3.1**
Date:	10/2003	
Data Type:	GeologyA3.apr	



30°00'
31°00'
32°00'
22°00'
23°00'
24°00'
Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Limpopo
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
Tzaneen
Phalaborwa
A92D
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Middle Letaba Dam
Lorna Dawn Dam
Hans Merensky Dam
Tzaneen Dam
Magoebaskloof Dam
Vergelegen Dam
Ebenezer Dam
Mambedi Dam
Albasini Dam
Modjadji Dam
Letsitele
Thabina
Groot Letaba
Klein Letaba
Dzombo
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries | Waterman
International Border | Interbnd
Provincial Boundaries | Prov0897
Towns | Town
Rivers | Wri500
Dams | Ndams
Quaternary Catchment | Drgnquat
X40D Quaternary Number | Drgnquat
Secondary Catchment | Drgnsnd
Soils | Soi
Depth | Texture | Relief
Moderate To Deep | Clay Loam | Steep
Moderate To Deep | Clay Soil | Undulating
Moderate To Deep | Sandy Loam | Steep
Moderate To Deep | Sandy Loam | Undulating
Moderate To Deep | Sandy Soil | Steep
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CLIENT:
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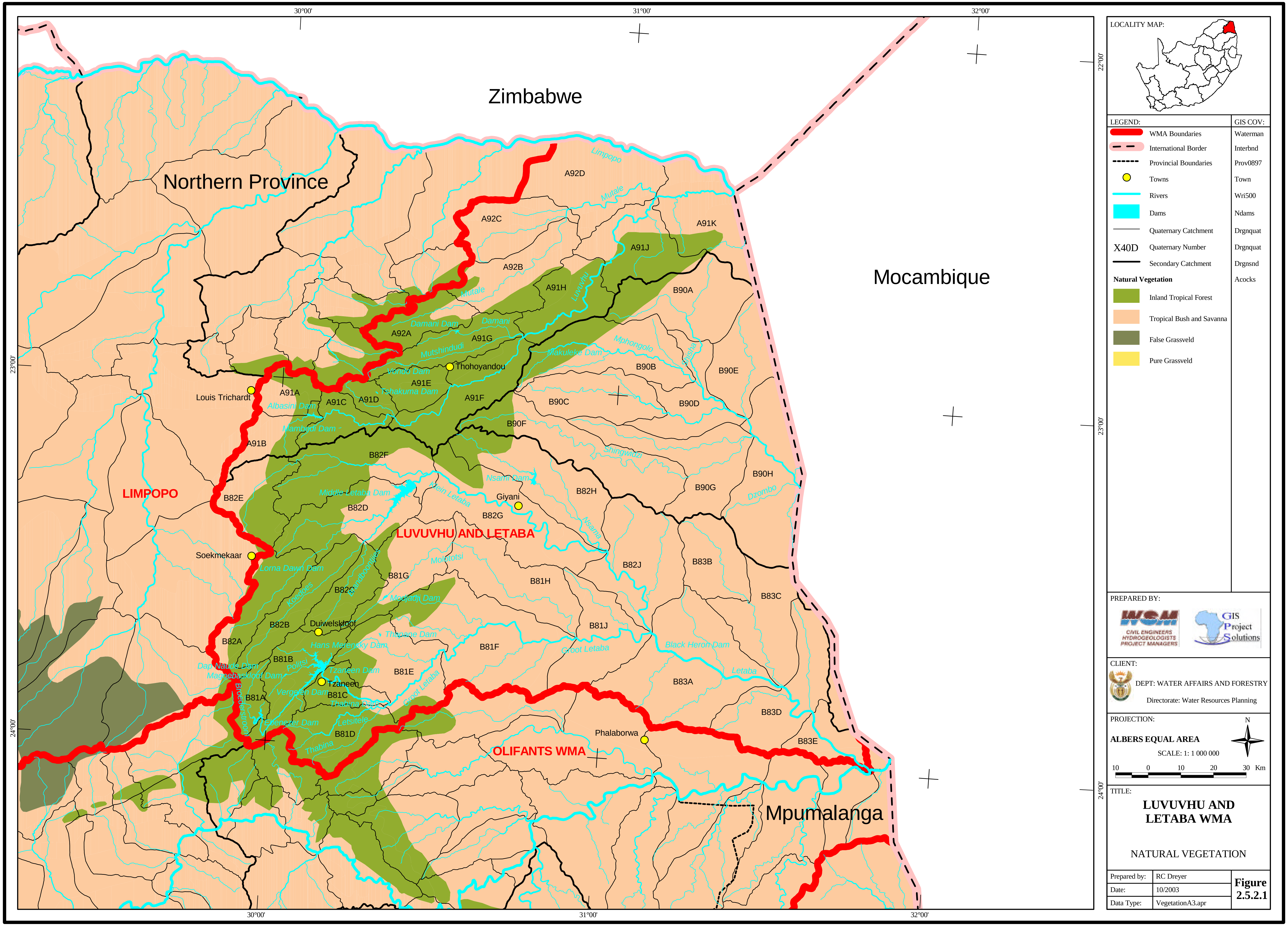
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1: 1 000 000
10 0 10 20 30 Km
N
TITLE:
LUVUVHU AND LETABA WMA
SOILS
Prepared by: RC Dreyer
Date: 10/2003
Data Type: SoilsA3.apr
Figure 2.4.1



Zimbabwe
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LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Louis Trichardt
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Soekmekaar
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Limpopo
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Dzombo
Klein Letaba
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Groot Letaba
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Thabina
Politsi
Broederstroom
Kudus
Middle Letaba Dam
Nsami Dam
Damani Dam
Damani
Mutshindudi
Vondo Dam
Tshakuma Dam
Albasini Dam
Mambedi Dam
Makuleke Dam
Lorna Dawn Dam
Modjadji Dam
Thabane Dam
Hans Merensky Dam
Tzaneen Dam
Dap Naude Dam
Magoebaskloof Dam
Vergelegen Dam
Ebenezer Dam
Thabina Dam
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30°00'
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24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Waterman
International Border
Interbnd
Provincial Boundaries
Prov0897
Towns
Town
Rivers
Wri500
Dams
Ndams
Quaternary Catchment
Drgnquat
X40D
Quaternary Number
Drgnquat
Secondary Catchment
Drgnsnd
Natural Vegetation
Acocks
Inland Tropical Forest
Tropical Bush and Savanna
False Grassveld
Pure Grassveld
PREPARED BY:
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HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10
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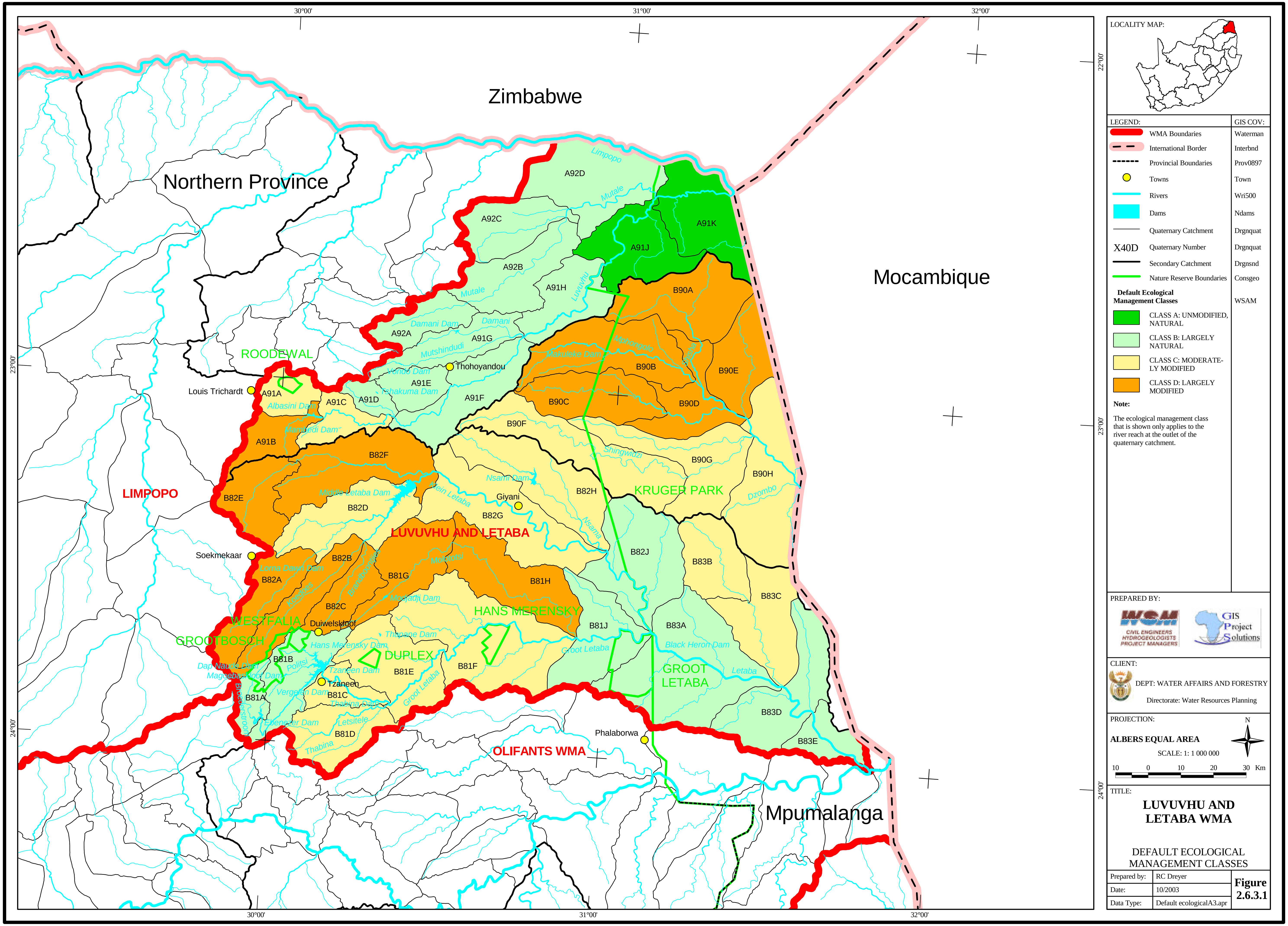
Km
TITLE:
LUVUVHU AND LETABA WMA
NATURAL VEGETATION
Prepared by:
RC Dreyer
Date:
10/2003
Data Type:
VegetationA3.apr
Figure 2.5.2.1


Zimbabwe
Northern Province
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LUVUVHU AND LETABA
OLIFANTS WMA
KRUGER PARK
ROODEWAL
HANS MERENSKY
WESTFALIA
GROOTBOSCH
DUPLEX
GROOT LETABA
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
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B83E
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Mutale
Luvuvhu
Damani Dam
Damani
Mutshindudi
Vondo Dam
Nandoni Dam
Albasini Dam
Shingwidzi
Nsami Dam
Klein Letaba
Middle Letaba Dam
Nsama
Dzombo
Molototsi
Magoebaskloof Dam
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Tzaneen Dam
Vergelegen Dam
Thabina Dam
Ebenezer Dam
Letsitele
Thabina
Groot Letaba
Black Heron Dam
Letaba
Politsi
30°00'
31°00'
32°00'
22°00'
23°00'
24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Nature Reserve Boundaries — Consgeo
Default Ecological Management Classes — WSAM
CLASS A: UNMODIFIED, NATURAL
CLASS B: LARGELY NATURAL
CLASS C: MODERATELY MODIFIED
CLASS D: LARGELY MODIFIED
Note:
The ecological management class that is shown only applies to the river reach at the outlet of the quaternary catchment.
PREPARED BY:
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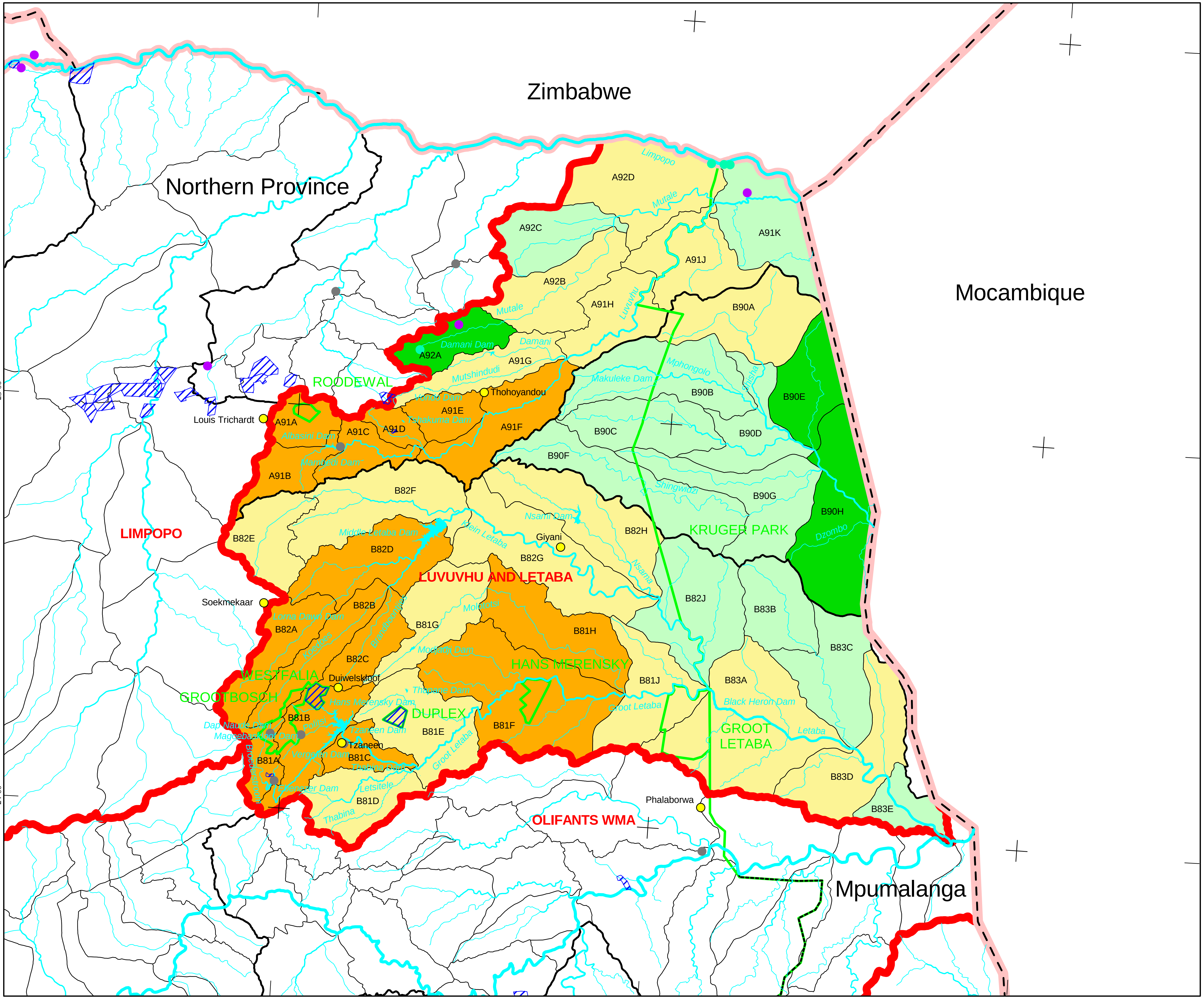
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
DEFAULT ECOLOGICAL MANAGEMENT CLASSES
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Default ecologicalA3.apr
Figure 2.6.3.1



LOCALITY MAP:

LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Quaternary Catchment	Drgnquat
X40D Quaternary Number	Drgnquat
Secondary Catchment	Drgnsnd
Nature Reserve Boundaries	Consgeo
Present Ecological Status Class	WSAM
CLASS A: UNMODIFIED, NATURAL	
CLASS B: LARGELY NATURAL	
CLASS C: MODERATELY MODIFIED	
CLASS D: LARGELY MODIFIED	
Ecologically Sensitive Sites	
Lacustrine	Lacustr
Riverine	Riverine
Manmade	Manmade
Heritage Sites and Protected Areas	Heritage

Note: The ecological status class that is shown only applies to the river reach at the outlet of the quaternary catchment.

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DEPT: WATER AFFAIRS AND FORESTRY

Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

10 0 10 20 30 Km

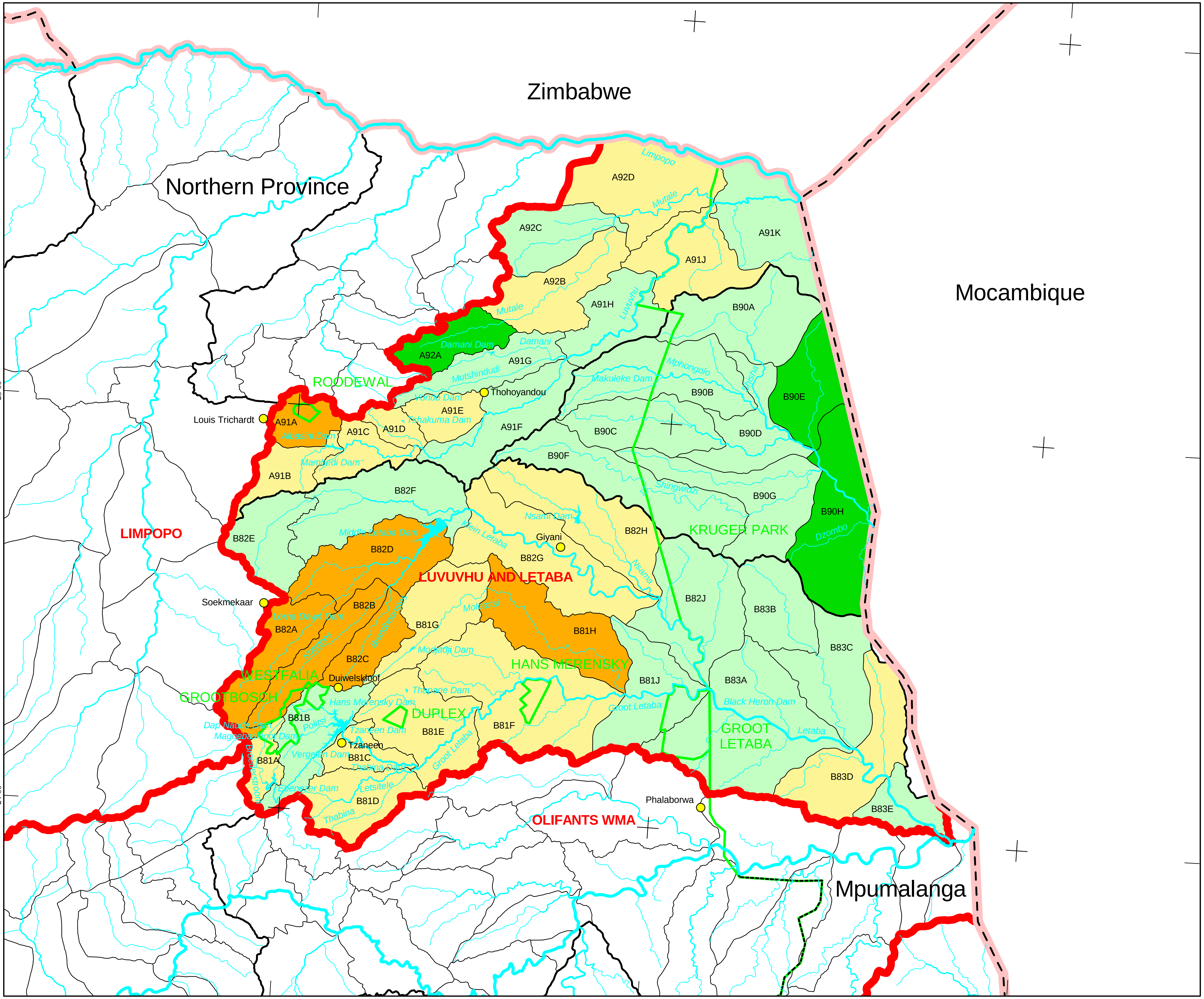
N

TITLE:

LUVUVHU AND LETABA WMA

PRESENT ECOLOGICAL STATUS CLASS AND ECOLOGICALLY SENSITIVE SITES

Prepared by:	RC Dreyer	**Figure 2.6.3.2**
Date:	10/2003	
Data Type:	Present ecologicalA3.apr	



LOCALITY MAP:

LEGEND:		GIS COV:
	WMA Boundaries	Waterman
	International Border	Interbnd
	Provincial Boundaries	Prov0897
	Towns	Town
	Rivers	Wri500
	Dams	Ndams
	Quaternary Catchment	Drgnquat
X40D	Quaternary Number	Drgnquat
	Secondary Catchment	Drgnsnd
	Nature Reserve Boundaries	Consgeo
Suggested Future Ecological Management Class		WSAM
	CLASS A: UNMODIFIED, NATURAL	
	CLASS B: LARGELY NATURAL	
	CLASS C: MODERATELY MODIFIED	
	CLASS D: LARGELY MODIFIED	

Note:

The ecological management class that is shown only applies to the river reach at the outlet of the quaternary catchment.

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CLIENT:

DEPT: WATER AFFAIRS AND FORESTRY

Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

N

SCALE: 1: 1 000 000

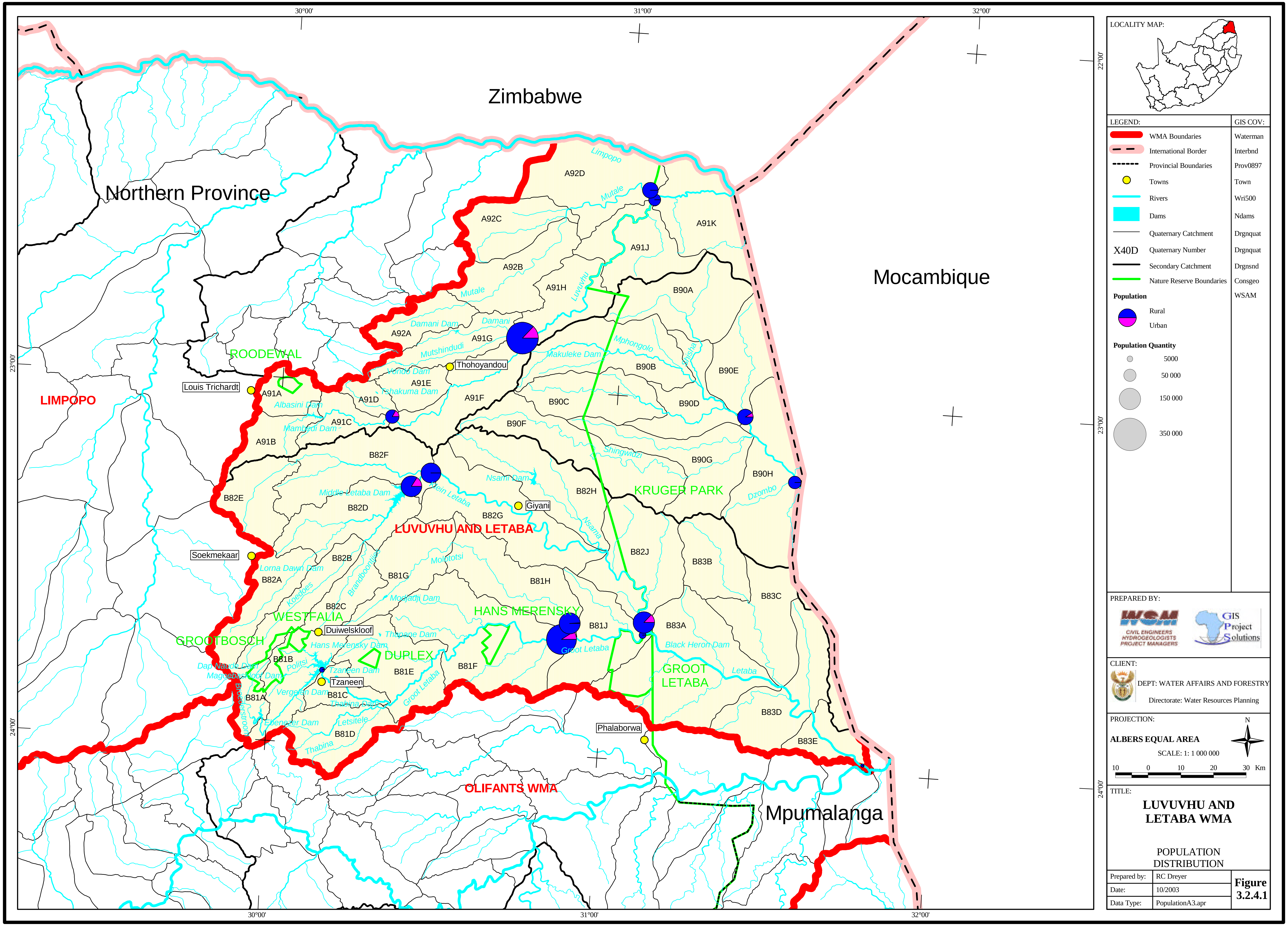
10 0 10 20 30 Km

TITLE:

LUVUVHU AND LETABA WMA

SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASS

Prepared by:	RC Dreyer	**Figure 2.6.3.3**
Date:	10/2003	
Data Type:	Future ecologicalA3.apr	



Zimbabwe
Mocambique
Northern Province
LIMPOPO
Mpumalanga
OLIFANTS WMA
LUVUVHU AND LETABA
KRUGER PARK
ROODEWAL
WESTFALIA
GROOTBOSCH
HANS MERENSKY
DUPLEX
GROOT LETABA
Thohoyandou
Louis Trichardt
Giyani
Soekmekaar
Duiwelskloof
Tzaneen
Phalaborwa
Limpopo
Mutale
Luvuvhu
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Mutshindudi
Makuleke Dam
Mphongolo
Shisha
Vondo Dam
Nandoni Dam
Tshakuma Dam
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Mambedi Dam
Shingwidzi
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Middle Letaba Dam
Klein Letaba
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Dzombo
Molototsi
Lorna Dawn Dam
Koedoes
Brandboontjies
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Black Heron Dam
Groot Letaba
Letaba
Politsi
Dap Naude Dam
Magoebaskloof Dam
Tzaneen Dam
Vergelegen Dam
Thabina Dam
Ebenezer Dam
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Thabina
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LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Nature Reserve Boundaries — Consgeo
Population — WSAM
Rural
Urban
Population Quantity
5000
50 000
150 000
350 000
PREPARED BY:
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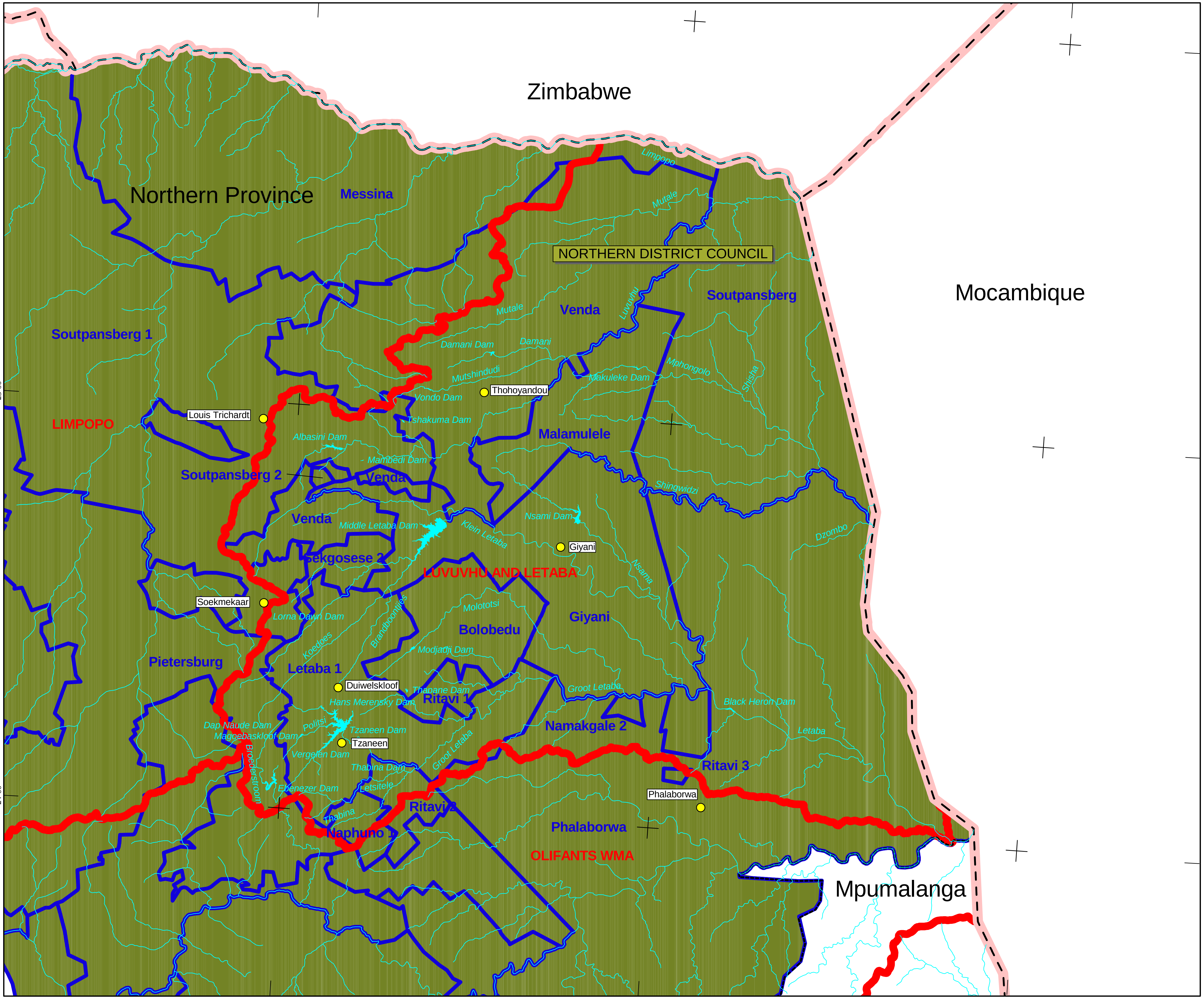
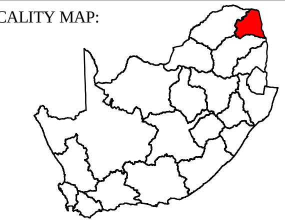
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
POPULATION DISTRIBUTION
Prepared by: RC Dreyer
Date: 10/2003
Data Type: PopulationA3.apr
Figure 3.2.4.1



LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Magisterial District Boundaries	Mag96
District Councils	SADC
Northern District Council	

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Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

10 0 10 20 30 Km

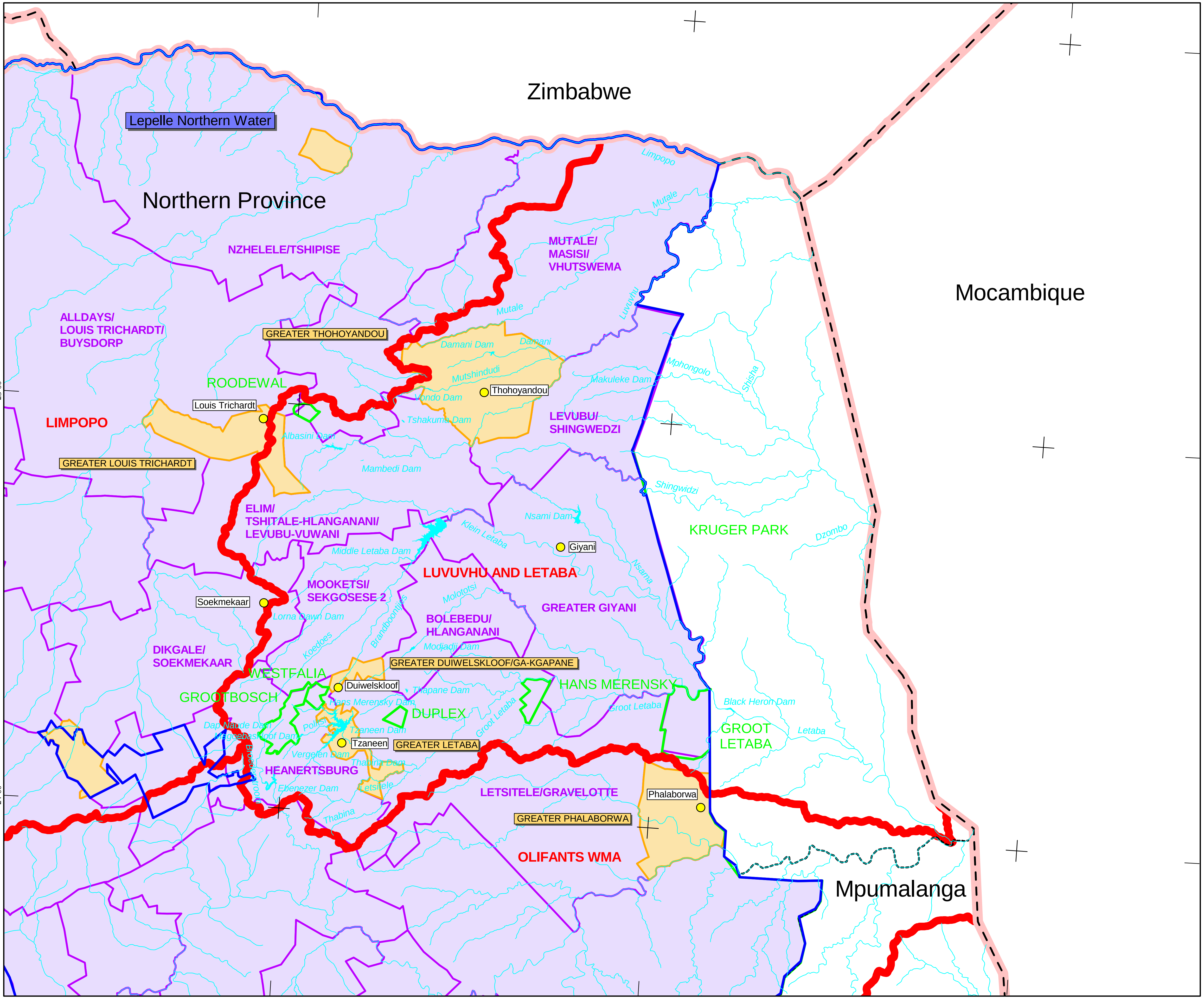
N

TITLE:

LUVUVHU AND LETABA WMA

DISTRICT COUNCILS AND MAGISTERIAL DISTRICTS

Prepared by:	RC Dreyer	**Figure 3.4.8.1**
Date:	10/2003	
Data Type:	Distcoun&magA3.apr	



LOCALITY MAP:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Nature Reserve Boundaries	Consgeo
Waterboard Boundaries	Waterbrd (adj.)
Local/Regional Councils	
Transitional Local Council	Salc
Transitional Regional Council	Sarc

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DEPT: WATER AFFAIRS AND FORESTRY

Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

N

SCALE: 1: 1 000 000

10 0 10 20 30 Km

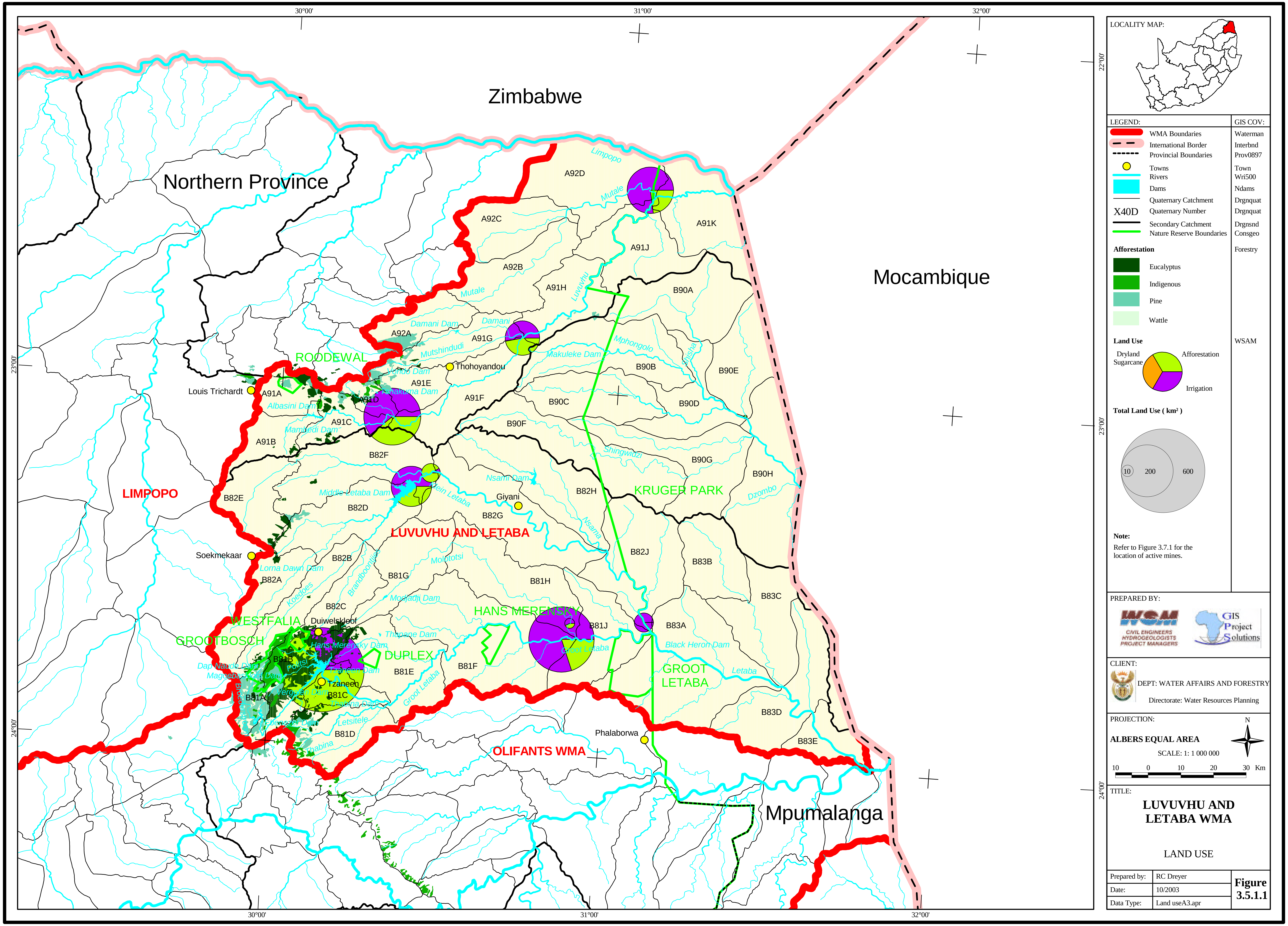
TITLE:

LUVUVHU AND LETABA WMA

INSTITUTIONAL BOUNDARIES RELATED TO WATER SUPPLY

Prepared by:	RC Dreyer
Date:	10/2003
Data Type:	InstitutionalA3.apr

Figure 3.4.8.2



30°00'
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22°00'
23°00'
24°00'
Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
KRUGER PARK
RODDEWAL
WESTFALIA
GROOTBOSCH
DUPLEX
HANS MERENSKY
GROOT LETABA
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
Tzaneen
Phalaborwa
Limpopo
Mutale
Luvuvhu
Damani Dam
Damani
Mutshindudi
Makuleke Dam
Mphongolo
Shisha
Albasini Dam
Mambedi Dam
Middle Letaba Dam
Nsami Dam
Shingwidzi
Dzombo
Nsama
Lorna Dawn Dam
Koedoes
Brandboontjie
Molototsi
Modjadji Dam
Thabane Dam
Hans Merensky Dam
Black Heron Dam
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Groot Letaba
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B83E
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Waterman
International Border
Interbnd
Provincial Boundaries
Prov0897
Towns
Town
Rivers
Wri500
Dams
Ndams
Quaternary Catchment
Drgnquat
X40D
Quaternary Number
Drgnquat
Secondary Catchment
Drgnsnd
Nature Reserve Boundaries
Consgeo
Afforestation
Forestry
Eucalyptus
Indigenous
Pine
Wattle
Land Use
WSAM
Dryland Sugarcane
Afforestation
Irrigation
Total Land Use (km²)
10
200
600
Note:
Refer to Figure 3.7.1 for the location of active mines.
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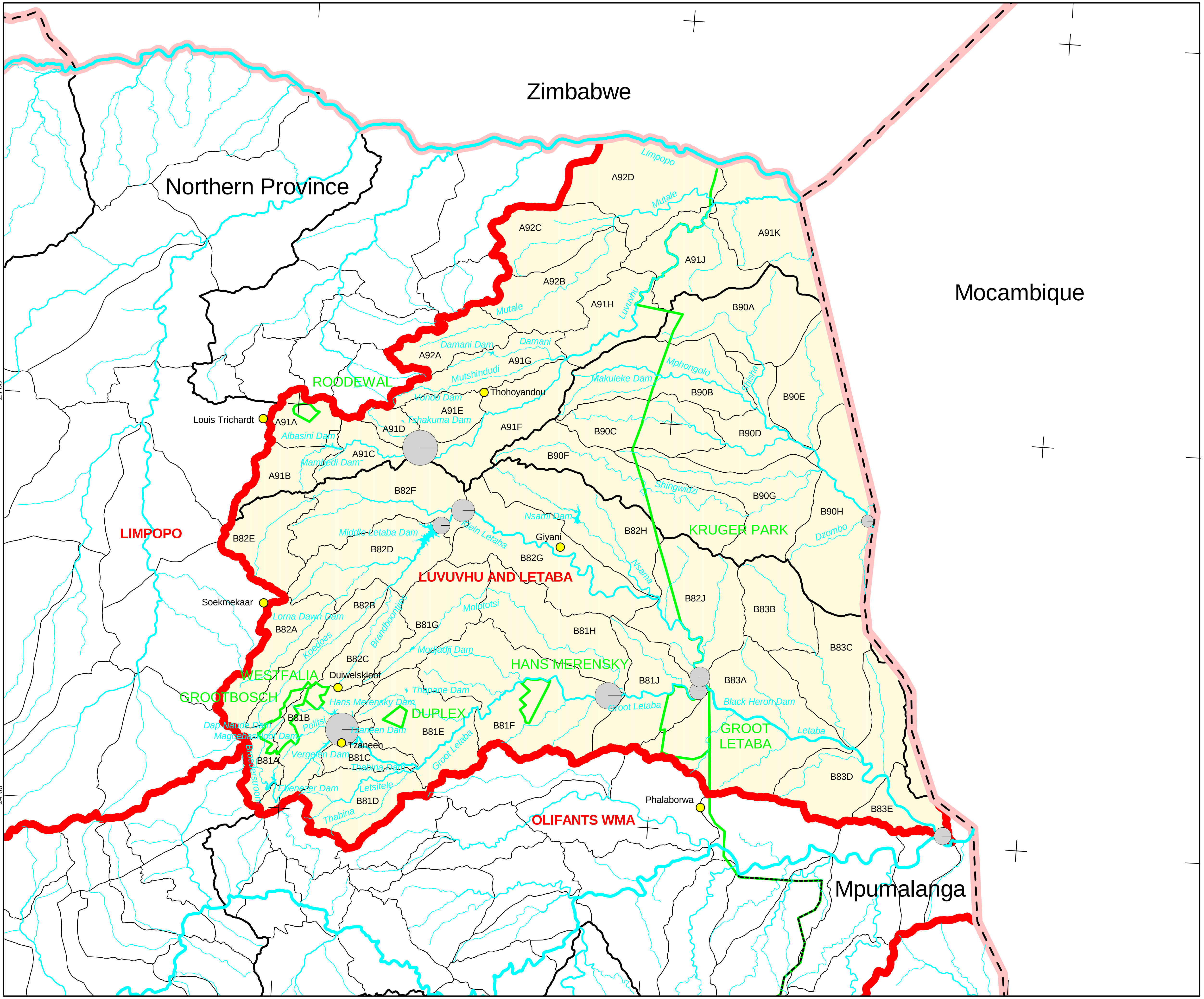
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10
0
10
20
30
Km
TITLE:
LUVUVHU AND LETABA WMA
LAND USE
Prepared by:
RC Dreyer
Date:
10/2003
Data Type:
Land useA3.apr
Figure 3.5.1.1



LOCALITY MAP:

LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Quaternary Catchment	Drgnquat
X40D Quaternary Number	Drgnquat
Secondary Catchment	Drgnsnd
Nature Reserve Boundaries	Consgeo
Livestock / Game	WSAM

Livestock & Game Quantity (ELSU's)

1000
2500
5000
10 000

Note:
Game in the Kruger Park is not shown.

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Directorate: Water Resources Planning

PROJECTION:
ALBERS EQUAL AREA
SCALE: 1: 1 000 000
10 0 10 20 30 Km
N

TITLE:
LUVUVHU AND LETABA WMA

LIVESTOCK AND GAME NUMBERS

Prepared by:	RC Dreyer
Date:	10/2003
Data Type:	LivestockA3.apr

Figure 3.5.4.1

FIGURE 3.5.5.1: AFFORESTATION

THIS FIGURE IS NOT ACCESSIBLE IN ELECTRONIC FORMAT.

IT IS AVAILABLE IN HARD COPY FROM:

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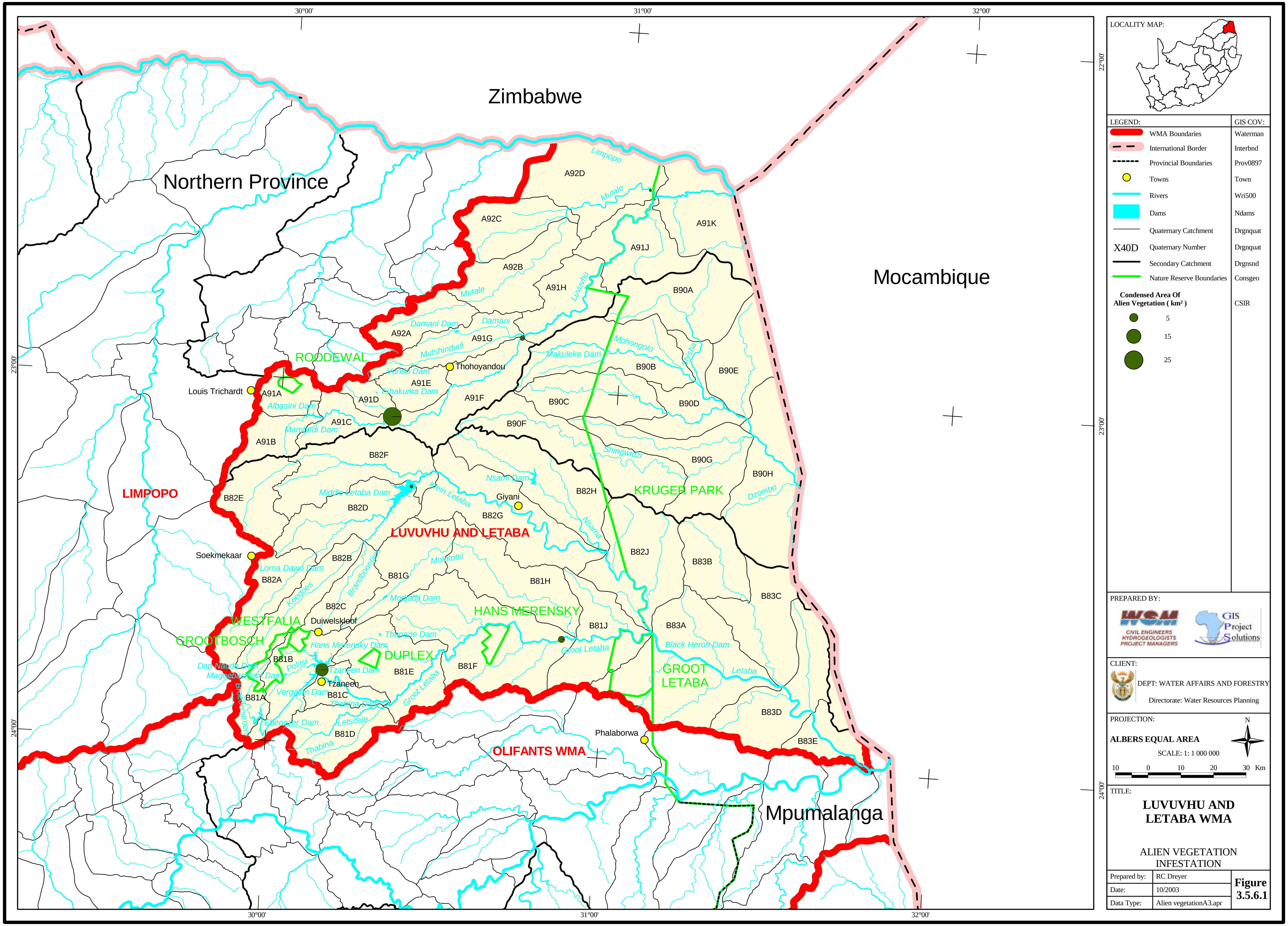
DIRECTORATE: WATER RESOURCES PLANNING



Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
RODDEWAL
WESTFALIA
GROOTBOSCH
DUPLEX
HANS MERENSKY
KRUGER PARK
GROOT LETABA
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
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Limpopo
Mutale
Luvuvhu
Mphongolo
Shisha
Damani Dam
Damani
Mutshindudi
Vondo Dam
Nzhelele
Tshakuma Dam
Albasini Dam
Mambedi Dam
Makuleke Dam
Shingwedzi
Nsami Dam
Middle Letaba Dam
Klein Letaba
Nsama
Dzombo
Molototsi
Lorna Dawn Dam
Koedoes
Brandboontjies
Modjadji Dam
Thabane Dam
Hans Merensky Dam
Politsi
Tzaneen Dam
Dap Naude Dam
Magoebaskloof Dam
Vergelegen Dam
Thabina Dam
Ebenezer Dam
Letsitele
Thabina
Broederstroom
Groot Letaba
Black Heron Dam
Letaba
30°00'
31°00'
32°00'
22°00'
23°00'
24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Nature Reserve Boundaries — Consgeo
Condensed Area Of Alien Vegetation (km²) — CSIR
5
15
25
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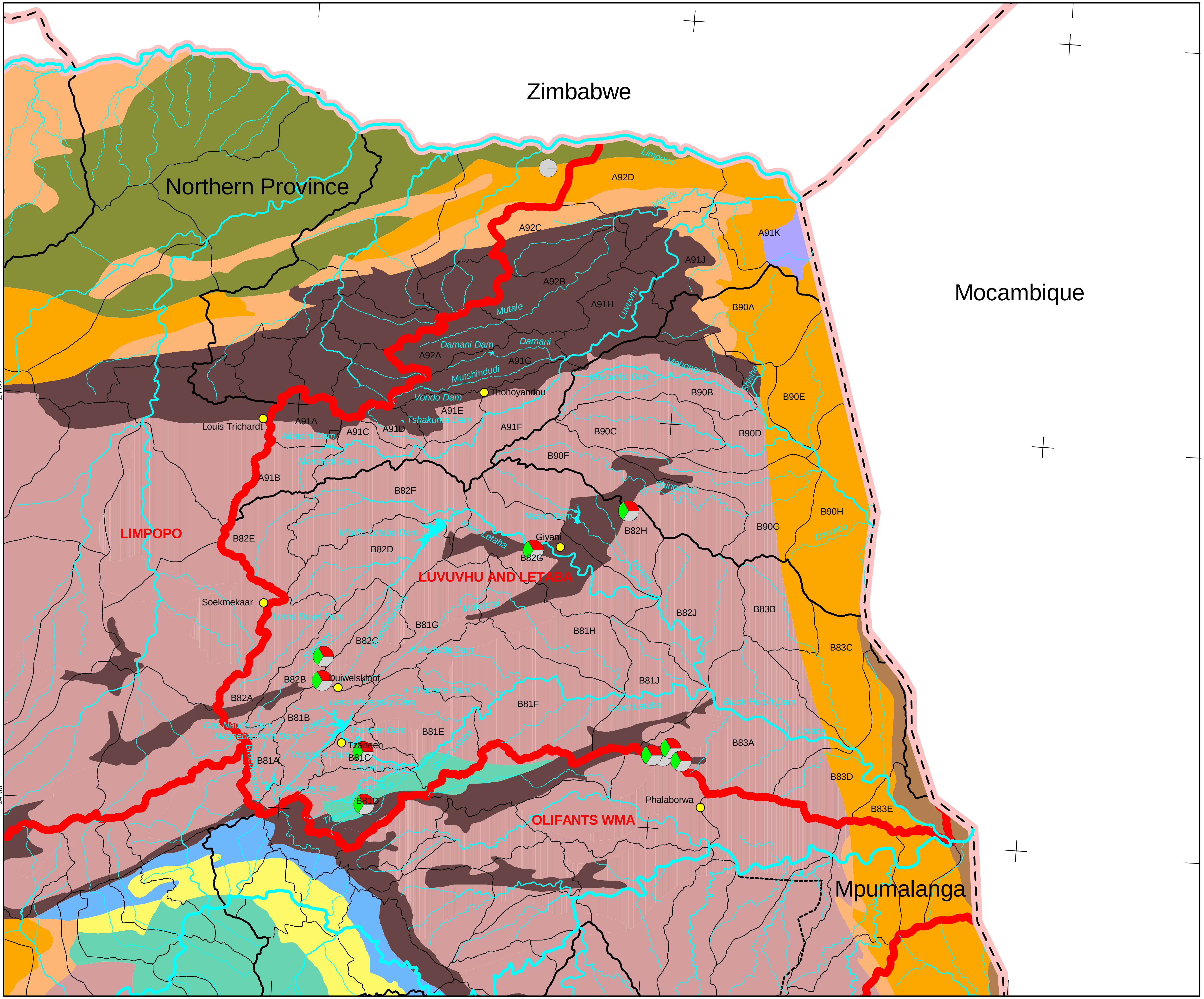
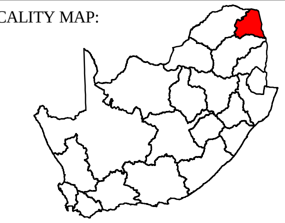
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
ALIEN VEGETATION INFESTATION
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Alien vegetationA3.apr
Figure 3.5.6.1



LOCALITY MAP:



LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Quaternary Catchment	Drgnquat
X40D Quaternary Number	Drgnquat
Secondary Catchment	Drgnsnd
Geology	Geol_geo
Acid and intermediate lavas	
Acid, intermediate or alkaline intrusives	
Assemblage of compact sedimentary and extrusive rocks	
Assemblage of compact sedimentary extrusive and intrusive rocks	
Compact arenaceous and argillaceous strata	
Compact sedimentary strata	
Compact, dominantly arenaceous strata	
Compact, dominantly argillaceous strata	
Consolidated porous to compact sedimentary strata	
Dolomite, chert and subordinate limestone	
Mafic / basic lavas	
Mafic / ulttramafic of basic / ultrabasic intrusives	
Mainly compact tillite and shale	
Mainly compact tillite, shale and sandstone	
Mainly compact tillite	
Porous unconsolidated to semi-consolidated sediment	
Active Mines	Mines
Important for Local and Regional Economy; Affects Hydrology; Affects Water Quality	
Data not available	

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Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

10 0 10 20 30 Km

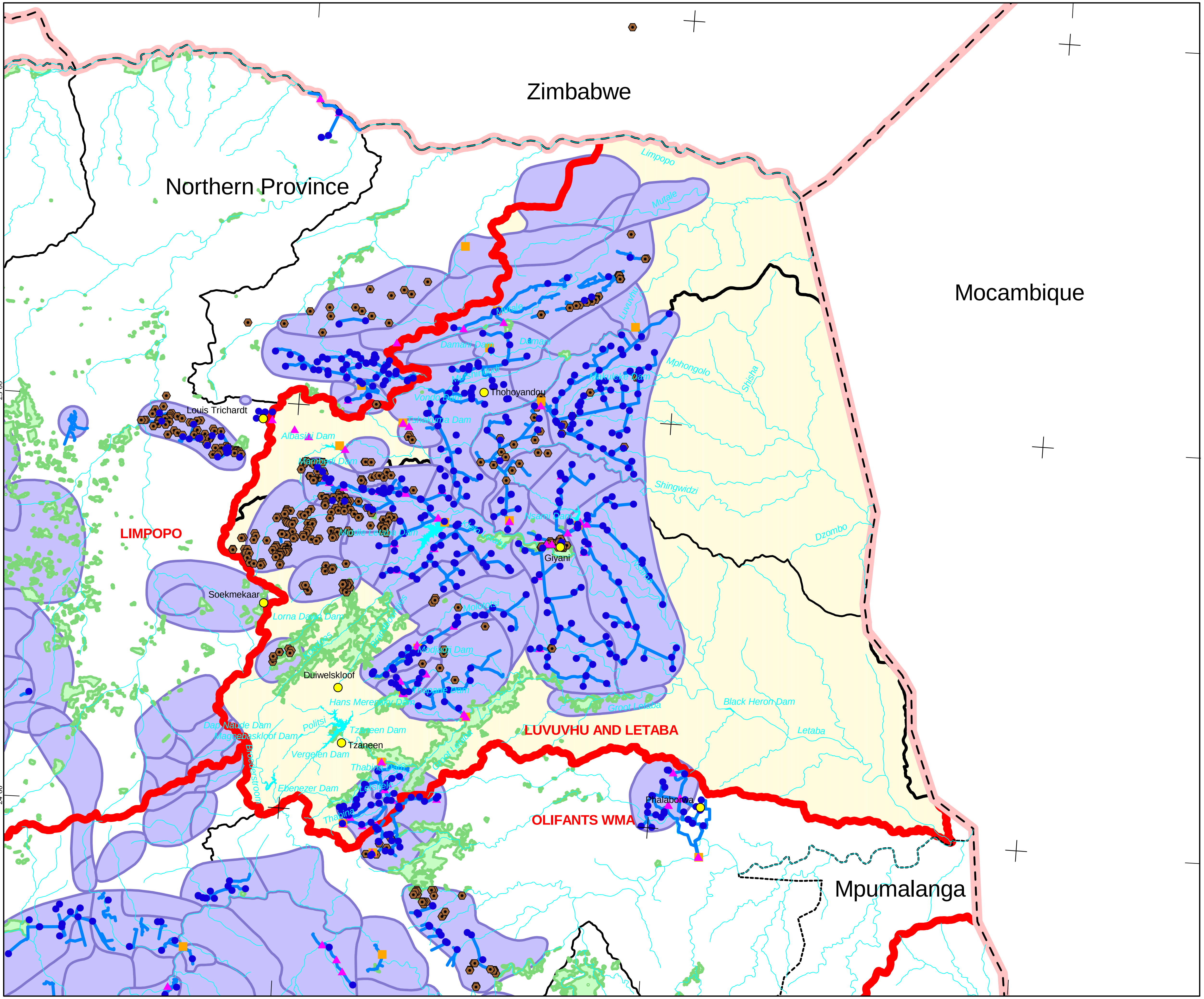
TITLE:

LUVUVHU AND LETABA WMA

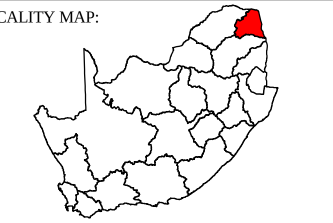
MINES

Prepared by:	RC Dreyer
Date:	10/2003
Data Type:	MinesA3.apr

Figure 3.7.1



LOCALITY MAP:



LEGEND: | GIS COV:

Legend	GIS COV
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Quaternary Catchment	Drgnquat
X40D Quaternary Number	Drgnquat
Secondary Catchment	Drgnsnd
Potable Water Scheme Supply Area	
Irrigation Scheme Supply Area	

Potable Water Infrastructure

- Bulk Supply Pipelines
- Boreholes
- Water Treatment Works
- Pump Stations
- Bulk Storage Reservoirs

Irrigation Infrastructure

- Pipeline/Canal
- Pump Stations

Bulk Infrastructure

- Pipeline/Canal
- Pump Stations

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CLIENT:

DEPT: WATER AFFAIRS AND FORESTRY

Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

10 0 10 20 30 Km

N

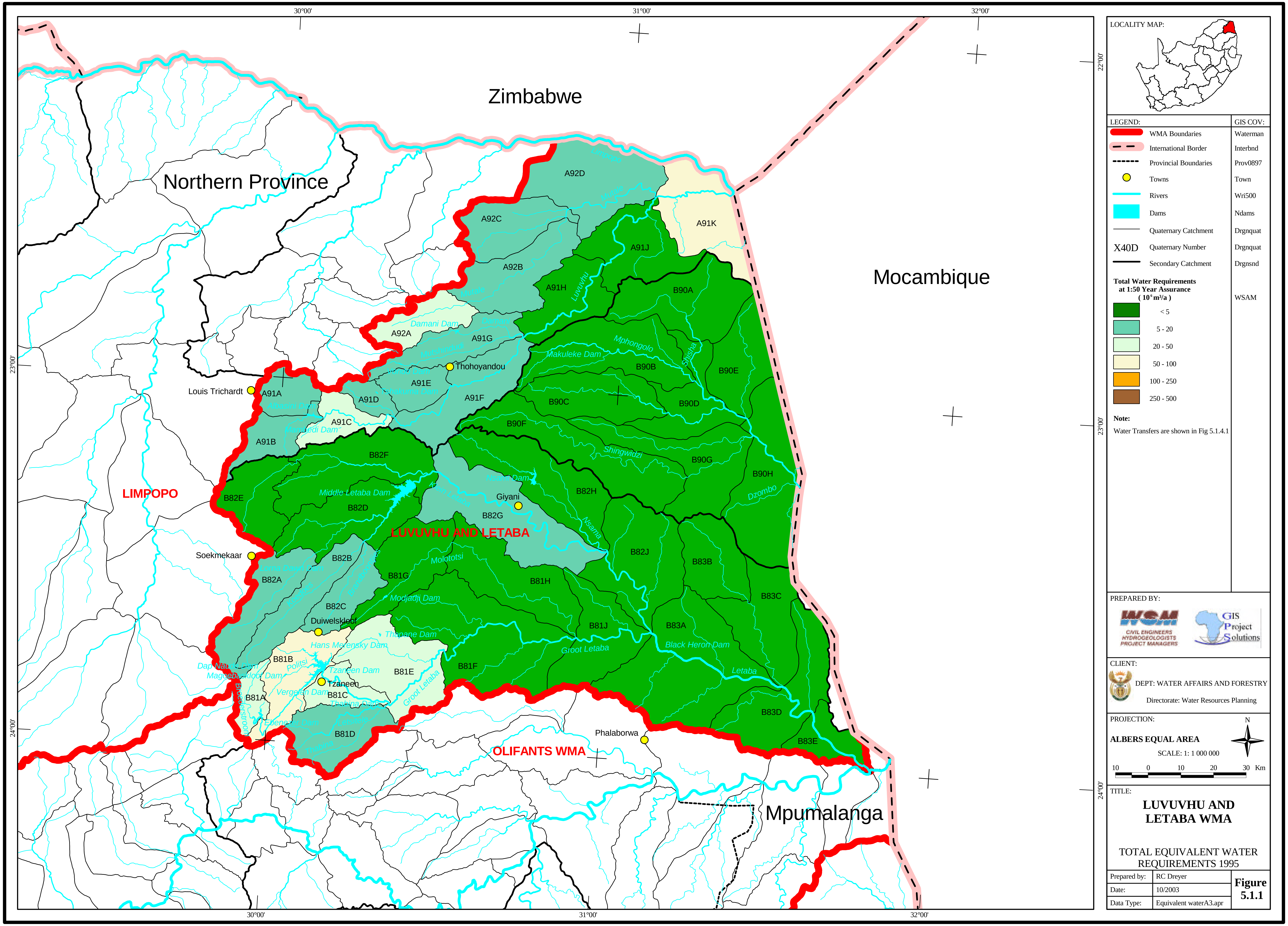
TITLE:

LUVUVHU AND LETABA WMA

WATER RELATED INFRASTRUCTURE

Prepared by:	RC Dreyer
Date:	10/2003
Data Type:	Related infrastructureA3.apr

Figure 4.1.1


Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
Tzaneen
Phalaborwa
Damani Dam
Makuleke Dam
Middle Letaba Dam
Nsami Dam
Modjadji Dam
Thabina Dam
Hans Merensky Dam
Tzaneen Dam
Magoebaskloof Dam
Vergelegen Dam
Ebenezer Dam
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Shingwidzi
Dzombo
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30°00'
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LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Waterman
International Border
Interbnd
Provincial Boundaries
Prov0897
Towns
Town
Rivers
Wri500
Dams
Ndams
Quaternary Catchment
Drgnquat
X40D
Quaternary Number
Drgnquat
Secondary Catchment
Drgnsnd
Total Water Requirements
at 1:50 Year Assurance
(10⁶ m³/a)
WSAM
< 5
5 - 20
20 - 50
50 - 100
100 - 250
250 - 500
Note:
Water Transfers are shown in Fig 5.1.4.1
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PROJECT MANAGERS
GIS
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Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
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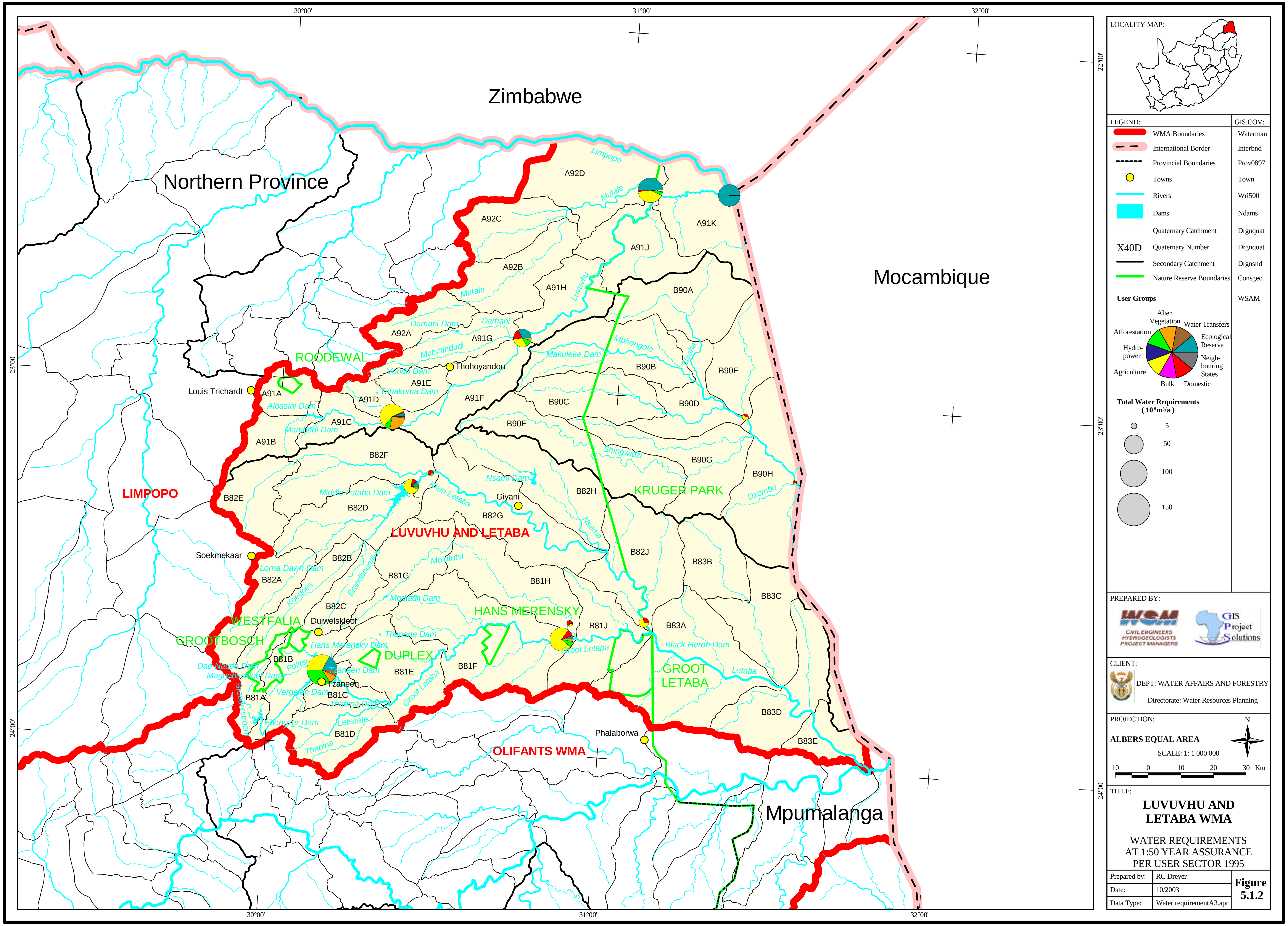
30
Km
TITLE:
LUVUVHU AND
LETABA WMA
TOTAL EQUIVALENT WATER
REQUIREMENTS 1995
Prepared by:
RC Dreyer
Date:
10/2003
Data Type:
Equivalent waterA3.apr
Figure
5.1.1



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Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
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RODDEWAL
WESTFALIA
GROOTBOSCH
DUPLEX
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GROOT LETABA
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Soekmekaar
Duiwelskloof
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Limpopo
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Damani Dam
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Mutshindudi
Vondo Dam
Phiphidi Dam
Tshakuma Dam
Albasini Dam
Mambedi Dam
Makuleke Dam
Mphongolo
Shisha
Shingwedzi
Nsami Dam
Nsama
Dzombo
Klein Letaba
Middle Letaba Dam
Molototsi
Lorna Dawn Dam
Koedoes
Brandboontjies
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Tzaneen Dam
Politsi
Dap Naude Dam
Magoebaskloof Dam
Vergelegen Dam
Thabina Dam
Ebenezer Dam
Letsitele
Thabina
Broederstroom
Groot Letaba
Black Heron Dam
Letaba
30°00'
31°00'
32°00'
22°00'
23°00'
24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Nature Reserve Boundaries — Consgeo
User Groups — WSAM
Alien Vegetation
Water Transfers
Afforestation
Ecological Reserve
Hydro-power
Neigh-bouring States
Agriculture
Bulk
Domestic
Total Water Requirements
(10⁶m³/a)
5
50
100
150
PREPARED BY:
WSM
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
WATER REQUIREMENTS AT 1:50 YEAR ASSURANCE PER USER SECTOR 1995
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Water requirementA3.apr
Figure 5.1.2

FIGURE 5.2.1.1: DESKTOP RESERVE PARAMETER REGIONS

THIS FIGURE IS NOT ACCESSIBLE IN ELECTRONIC FORMAT.

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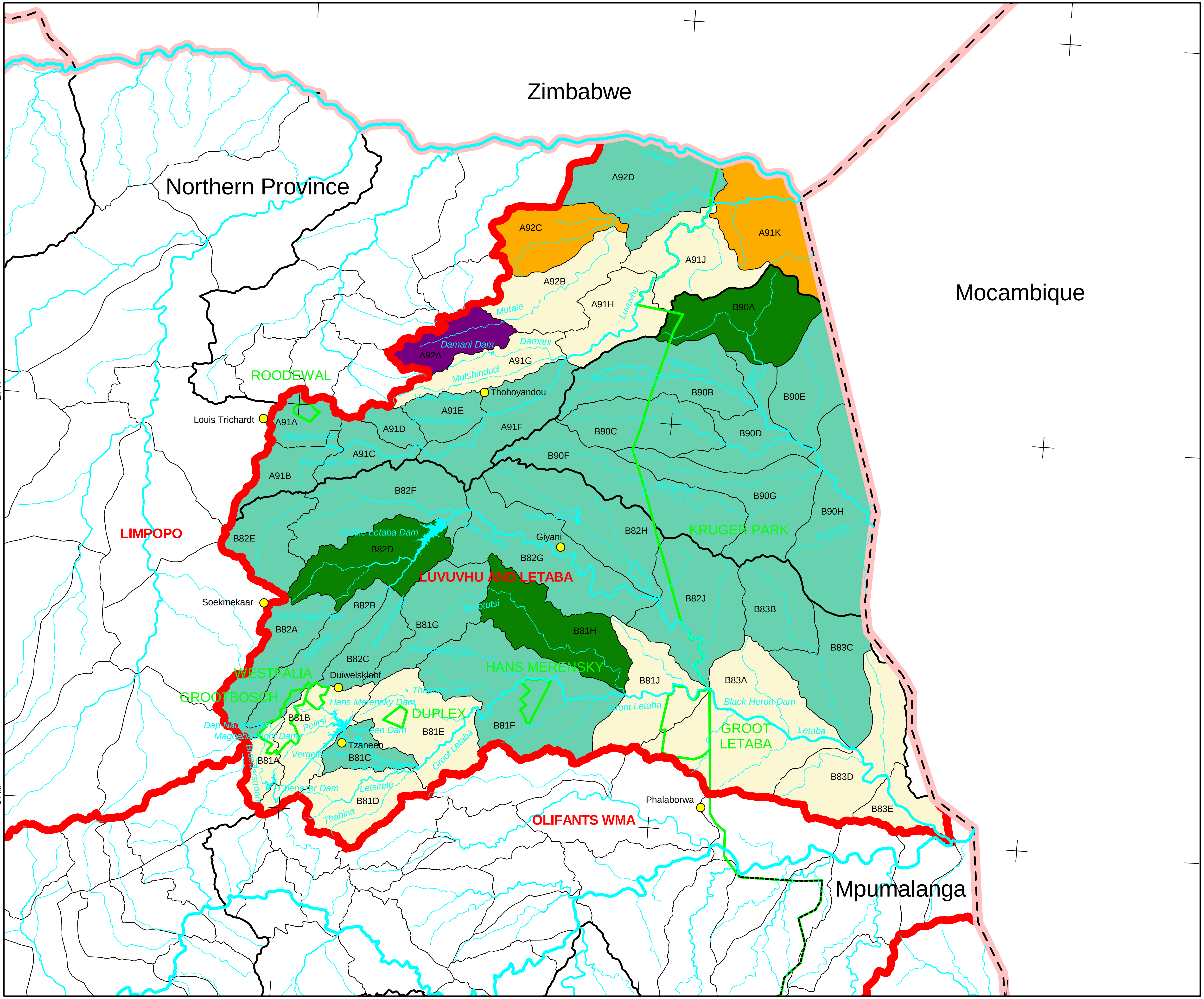
DIRECTORATE: WATER RESOURCES PLANNING



LOCALITY MAP:

LEGEND:

		GIS COV:
	WMA Boundaries	Waterman
	International Border	Interbnd
	Provincial Boundaries	Prov0897
	Towns	Town
	Rivers	Wri500
	Dams	Ndams
	Quaternary Catchment	Drgnquat
X40D	Quaternary Number	Drgnquat
	Secondary Catchment	Drgnsnd
	Nature Reserve Boundaries	Consgeo

Ecological Reserve Requirements For Present Ecological Status Classes (% of MAR) — WSAM

- < 10%
- 10% - 20%
- 20% - 30%
- 30% - 40%
- 40% - 50%
- > 50%

Note:

The indicated Reserve Requirements only apply to the river reaches at the outlets of the quaternary catchments.

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Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

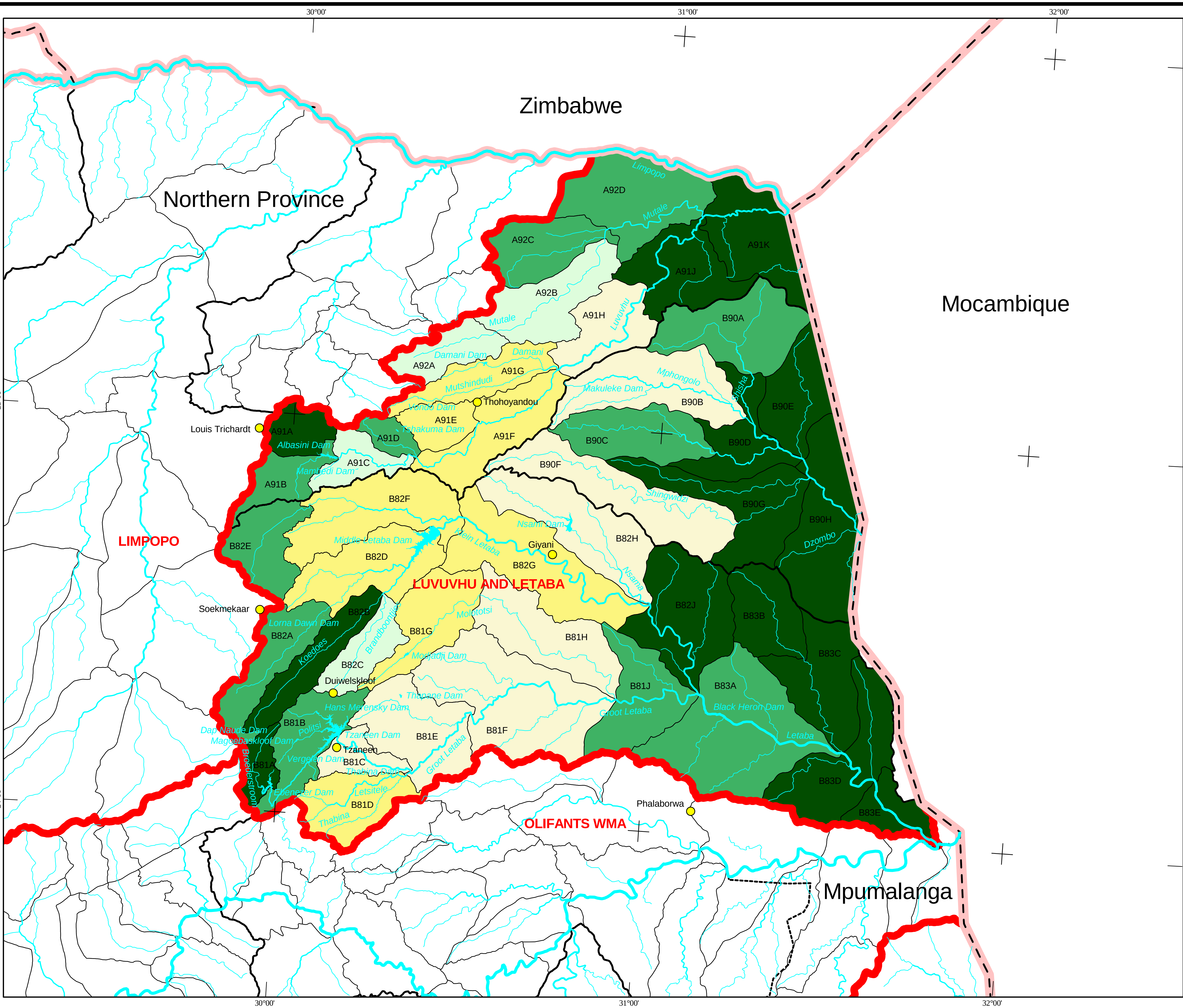
10 0 10 20 30 Km

TITLE:

LUVUVHU AND LETABA WMA

WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE

Prepared by:	RC Dreyer	**Figure 5.2.4.1**
Date:	10/2003	
Data Type:	Aquatic ecosystemA3.apr	



LOCALITY MAP:

LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Quaternary Catchment	Drgnquat
X40D Quaternary Number	Drgnquat
Secondary Catchment	Drgnsnd
Urban & Rural Total Water Requirements ($10^6 m^3/a$)	WSAM
< 0,1	
0,1 - 0,5	
0,5 - 1	
1 - 2	
2 - 5	
5 - 10	
10 - 30	

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PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

10 0 10 20 30 Km

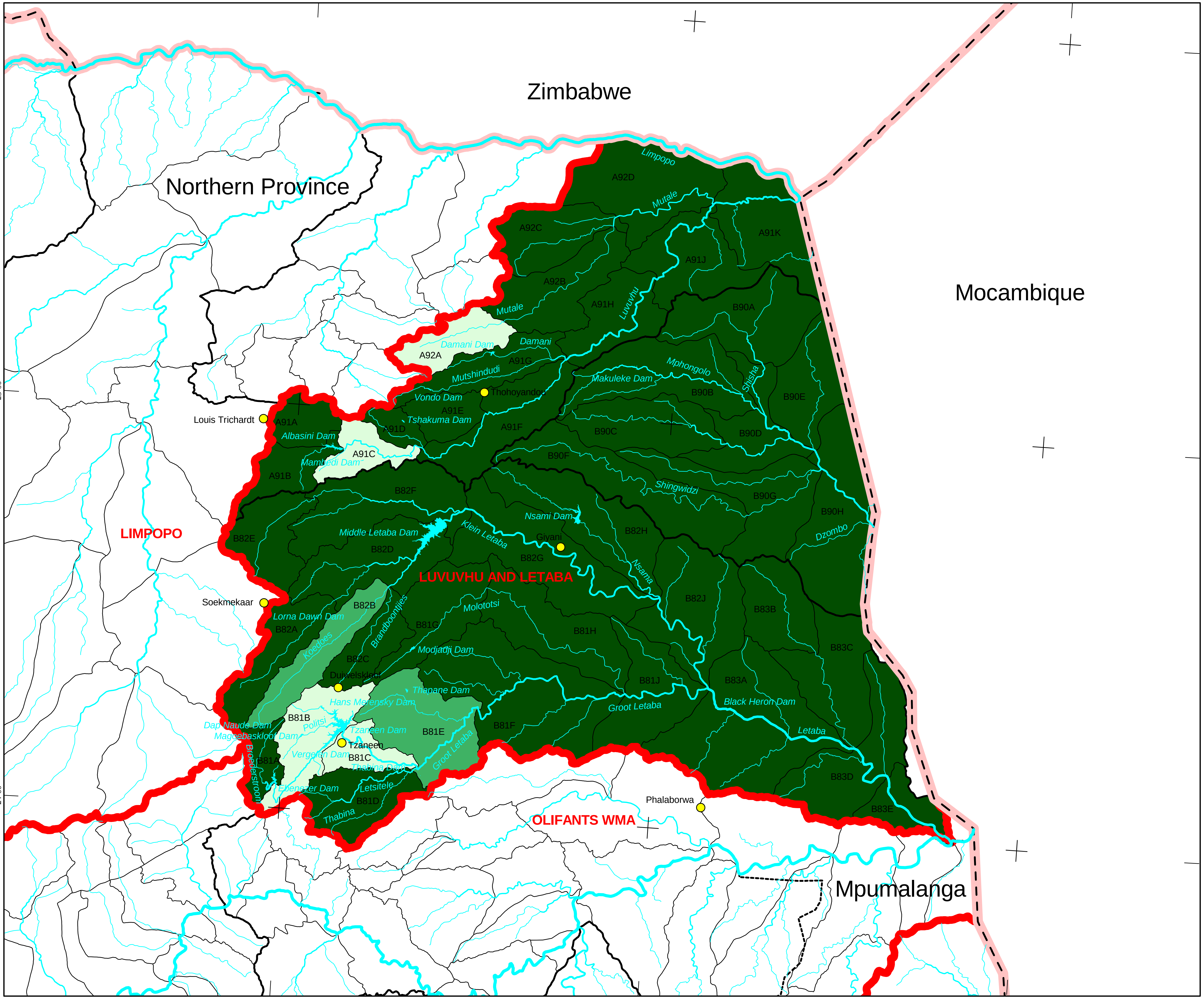
N

TITLE:

LUVUVHU AND LETABA WMA

URBAN & RURAL DOMESTIC WATER REQUIREMENTS IN 1995

Prepared by:	RC Dreyer	**Figure 5.3.1.1**
Date:	10/2003	
Data Type:	Urban & ruralA3.apr	



LOCALITY MAP:

LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Quaternary Catchment	Drgnquat
X40D Quaternary Number	Drgnquat
Secondary Catchment	Drgnsnd
Water Requirements ($10^6 m^3/a$)	WSAM
0 - 10	
10 - 20	
20 - 50	

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Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

10 0 10 20 30 Km

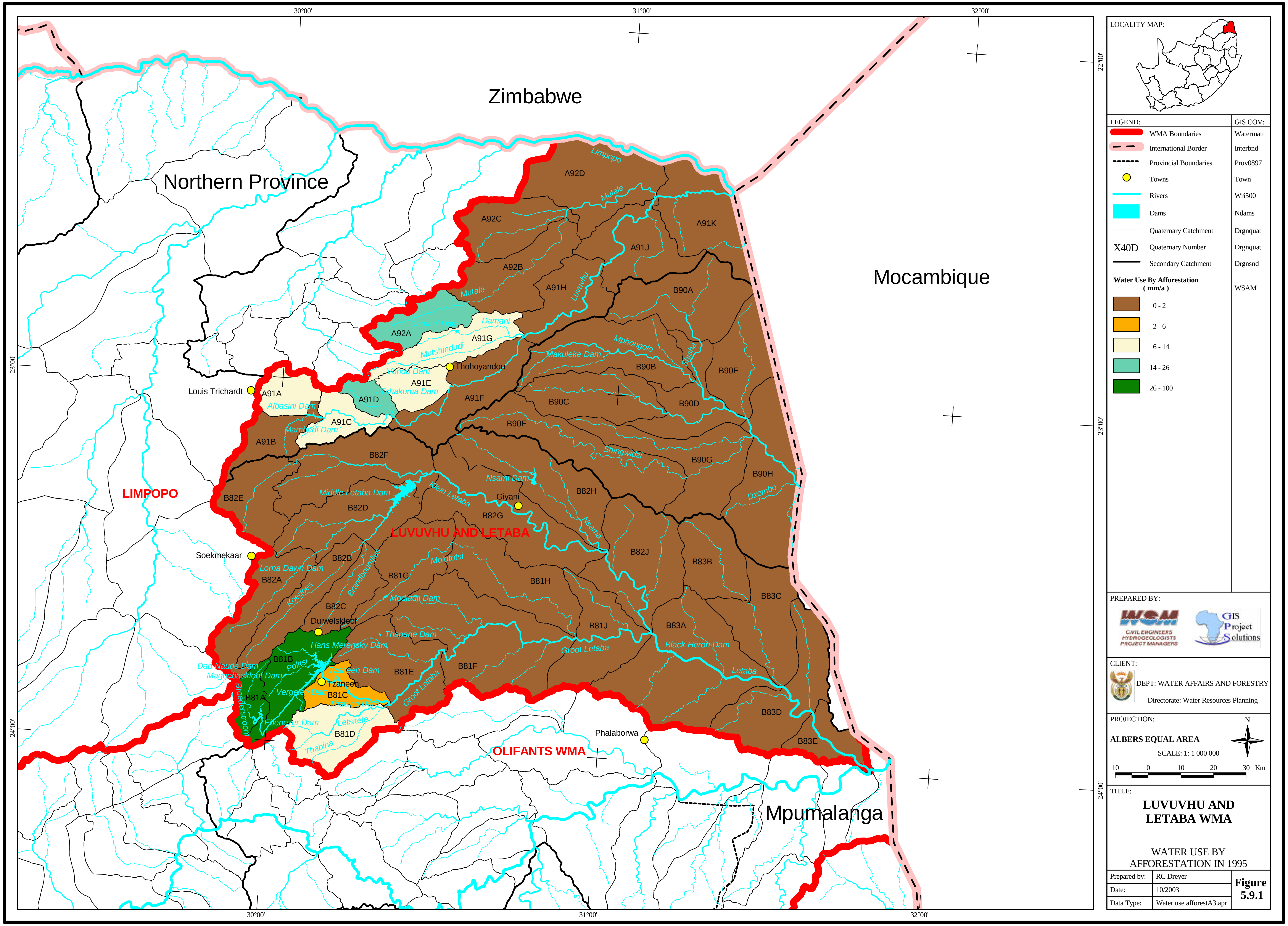
N

TITLE:

LUVUVHU AND LETABA WMA

IRRIGATION WATER REQUIREMENTS 1995

Prepared by:	RC Dreyer	**Figure 5.6.2.1**
Date:	10/2003	
Data Type:	Irrigation waterA3.apr	



Zimbabwe
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Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
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Limpopo
Mutale
Luvuvhu
Damani
Mutshindudi
Vondo Dam
Phiphidi Dam
Albasini Dam
Mambedi Dam
Makuleke Dam
Mphongolo
Shisha
Shingwidzi
Nsami Dam
Klein Letaba
Nsama
Dzombo
Middle Letaba Dam
Lorna Dawn Dam
Koedoes
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Modjadji Dam
Thapane Dam
Hans Merensky Dam
Dap Naude Dam
Magoebaskloof Dam
Politsi
Ebenezer Dam
Broederstroom
Vergelegen Dam
Tzaneen Dam
Letsitele
Thabina
Groot Letaba
Black Heron Dam
Letaba
30°00'
31°00'
32°00'
22°00'
23°00'
24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Waterman
International Border
Interbnd
Provincial Boundaries
Prov0897
Towns
Town
Rivers
Wri500
Dams
Ndams
Quaternary Catchment
Drgnquat
X40D
Quaternary Number
Drgnquat
Secondary Catchment
Drgnsnd
Water Use By Afforestation
(mm/a)
WSAM
0 - 2
2 - 6
6 - 14
14 - 26
26 - 100
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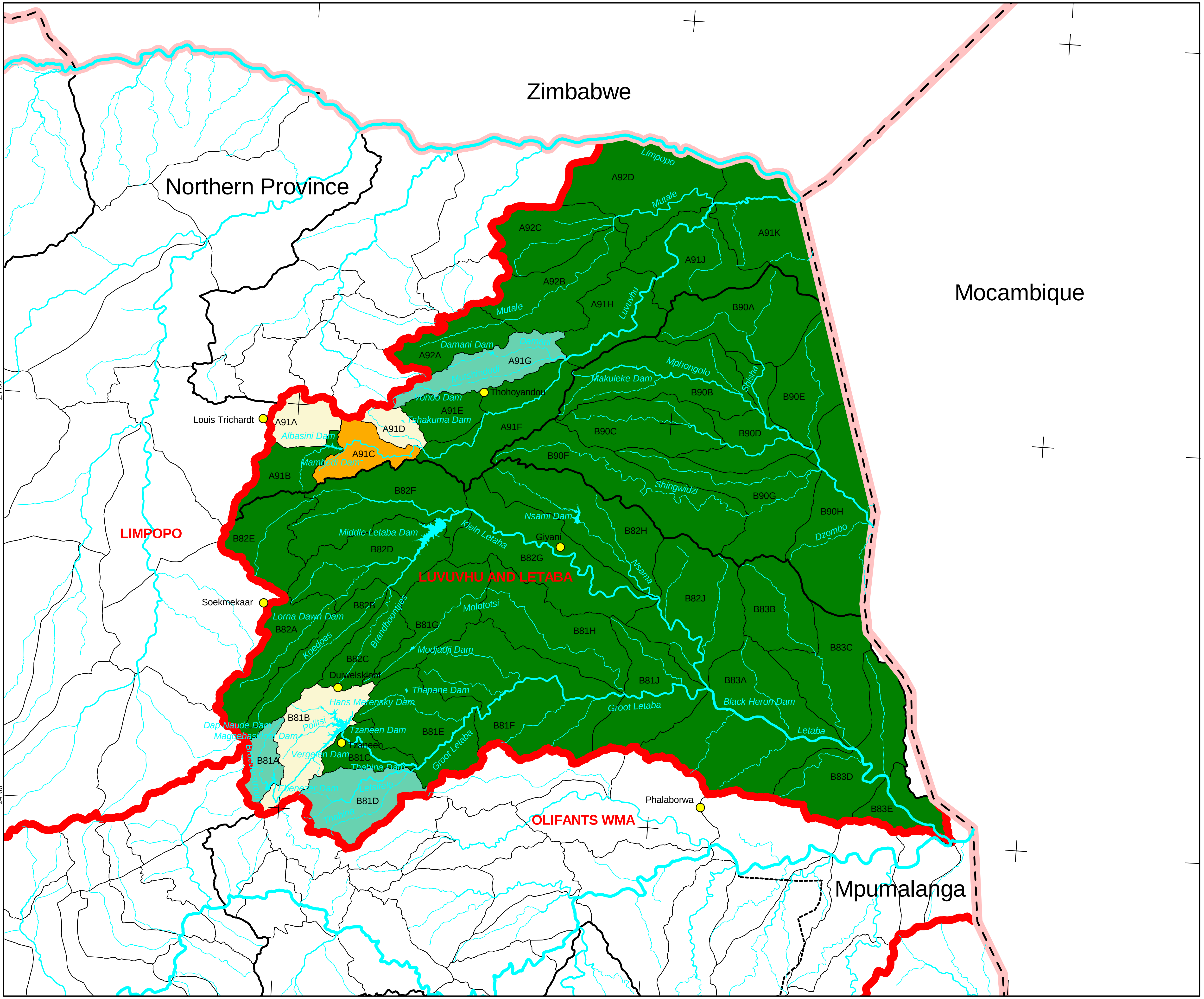
PROJECT MANAGERS
GIS
Project
Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10
0
10
20
30
Km
TITLE:
LUVUVHU AND LETABA WMA
WATER USE BY AFFORESTATION IN 1995
Prepared by:
RC Dreyer
Date:
10/2003
Data Type:
Water use afforestA3.apr
Figure 5.9.1



LOCALITY MAP:

LEGEND:	GIS COV:
WMA Boundaries	Waterman
International Border	Interbnd
Provincial Boundaries	Prov0897
Towns	Town
Rivers	Wri500
Dams	Ndams
Quaternary Catchment	Drgnquat
X40D Quaternary Number	Drgnquat
Secondary Catchment	Drgnsnd
Water Use (10^6 m³/a)	WSAM
0 - 1	
1 - 4	
4 - 9	
9 - 16	
16 - 25	

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Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

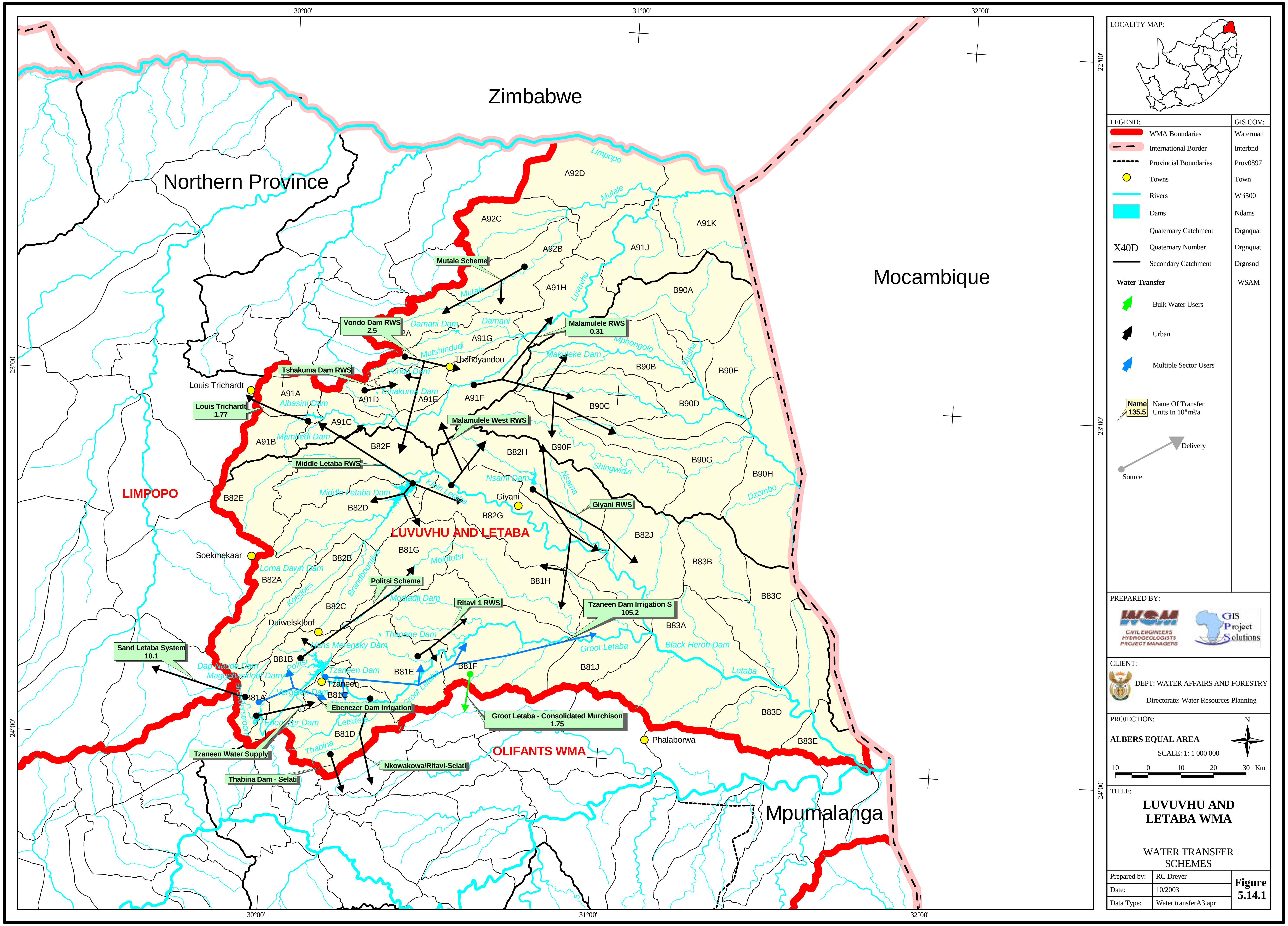
10 0 10 20 30 Km

TITLE:

LUVUVHU AND LETABA WMA

WATER USE BY ALIEN VEGETATION

Prepared by:	RC Dreyer	**Figure 5.11.1**
Date:	10/2003	
Data Type:	Water use alienA3.apr	



Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Mutale Scheme
Vondo Dam RWS 2.5
Malamulele RWS 0.31
Tshakuma Dam RWS
Louis Trichardt 1.77
Malamulele West RWS
Middle Letaba RWS
Giyani RWS
Politsi Scheme
Ritavi 1 RWS
Tzaneen Dam Irrigation S 105.2
Sand Letaba System 10.1
Ebenezer Dam Irrigation
Groot Letaba - Consolidated Murchison 1.75
Tzaneen Water Supply
Thabina Dam - Selati
Nkowakowa/Ritavi-Selati
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
Tzaneen
Phalaborwa
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D Quaternary Number
Secondary Catchment
Water Transfer
Bulk Water Users
Urban
Multiple Sector Users
Name 135.5 Name Of Transfer Units In 10⁶ m³/a
Delivery
Source
PREPARED BY:
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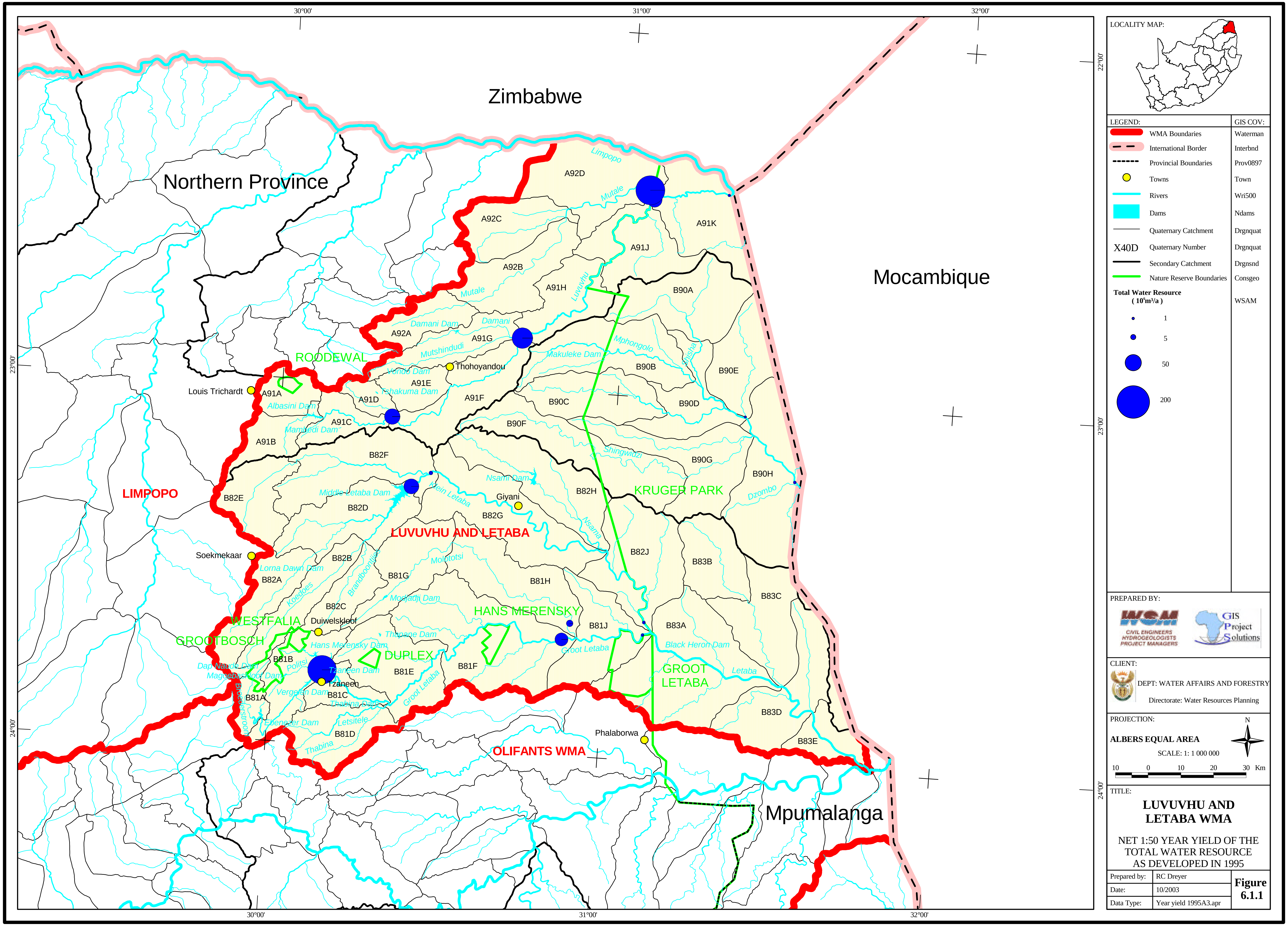
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1: 1 000 000
TITLE:
LUVUVHU AND LETABA WMA
WATER TRANSFER SCHEMES
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Water transferA3.apr
Figure 5.14.1


Zimbabwe
Northern Province
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Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
KRUGER PARK
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WESTFALIA
GROOTBOSCH
DUPLEX
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GROOT LETABA
Louis Trichardt
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Soekmekaar
Duiwelskloof
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Limpopo
Mutale
Luvuvhu
Damani Dam
Damani
Mutshindudi
Makuleke Dam
Mphongolo
Shisha
Vondo Dam
Phiphidi
Nandoni Dam
Albasini Dam
Mambedi Dam
Shingwedzi
Nsami Dam
Middle Letaba Dam
Klein Letaba
Nsama
Molototsi
Lorna Dawn Dam
Koedoes
Brandboontjies
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Black Heron Dam
Groot Letaba
Letaba
Dzombo
Dap Naude Dam
Magoebaskloof Dam
Politsi
Tzaneen Dam
Vergelegen Dam
Thabina Dam
Ebenezer Dam
Letsitele
Thabina
Broederstroom
30°00'
31°00'
32°00'
22°00'
23°00'
24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Waterman
International Border
Interbnd
Provincial Boundaries
Prov0897
Towns
Town
Rivers
Wri500
Dams
Ndams
Quaternary Catchment
Drgnquat
X40D Quaternary Number
Drgnquat
Secondary Catchment
Drgnsnd
Nature Reserve Boundaries
Consgeo
Total Water Resource (10⁶m³/a)
WSAM
1
5
50
200
PREPARED BY:
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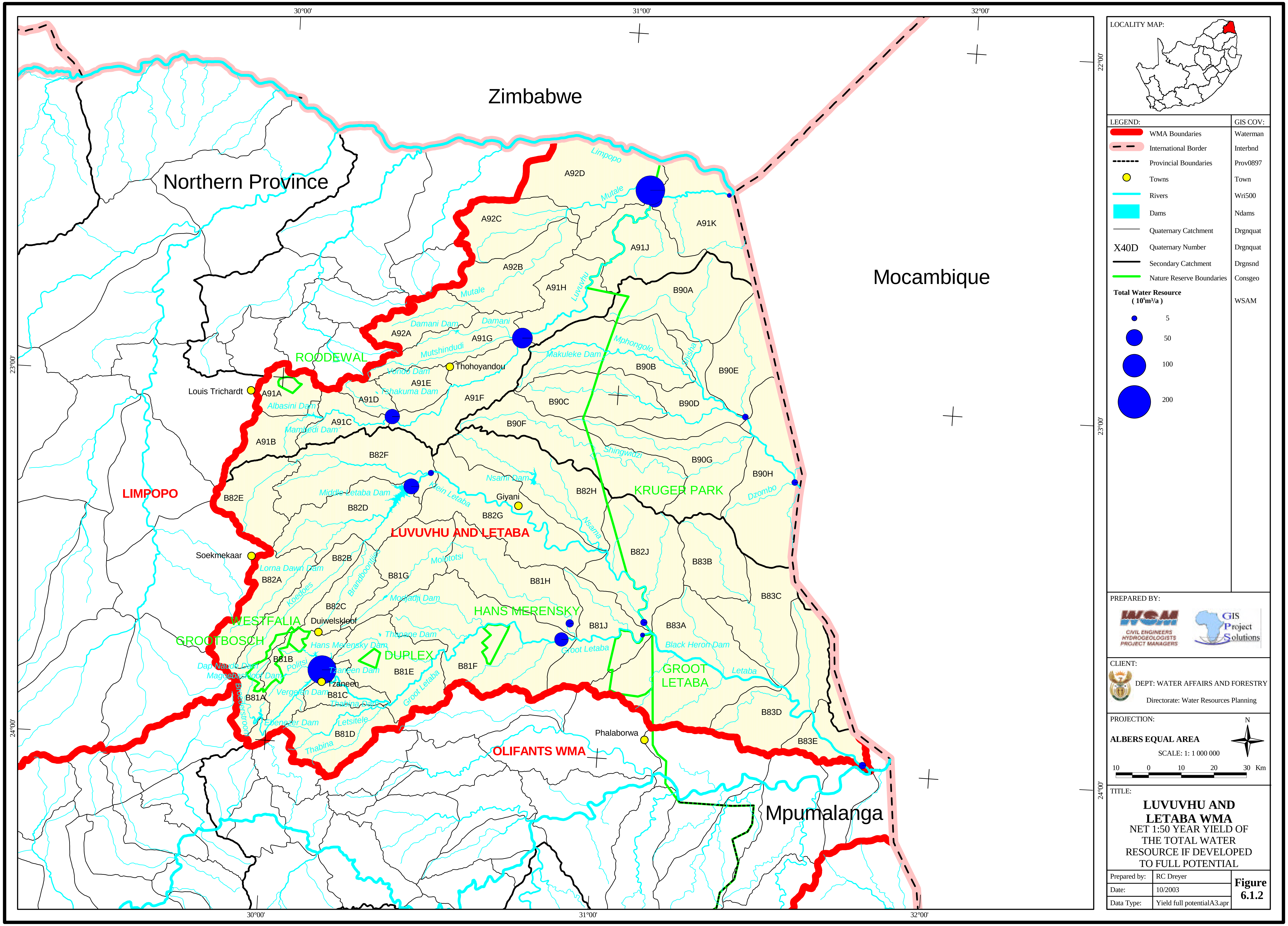
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
NET 1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE AS DEVELOPED IN 1995
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Year yield 1995A3.apr
Figure 6.1.1



Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
KRUGER PARK
RODDEWAL
HANS MERENSKY
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GROOTBOSCH
DUPLEX
GROOT LETABA
Louis Trichardt
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Giyani
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Phalaborwa
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Shingwidzi
Klein Letaba
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Letaba
Molototsi
Nsama
Dzombo
Damani Dam
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LOCALITY MAP:
LEGEND:
GIS COV:
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Quaternary Catchment — Drgnquat
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Secondary Catchment — Drgnsnd
Nature Reserve Boundaries — Consgeo
Total Water Resource (10⁶m³/a) — WSAM
5
50
100
200
PREPARED BY:
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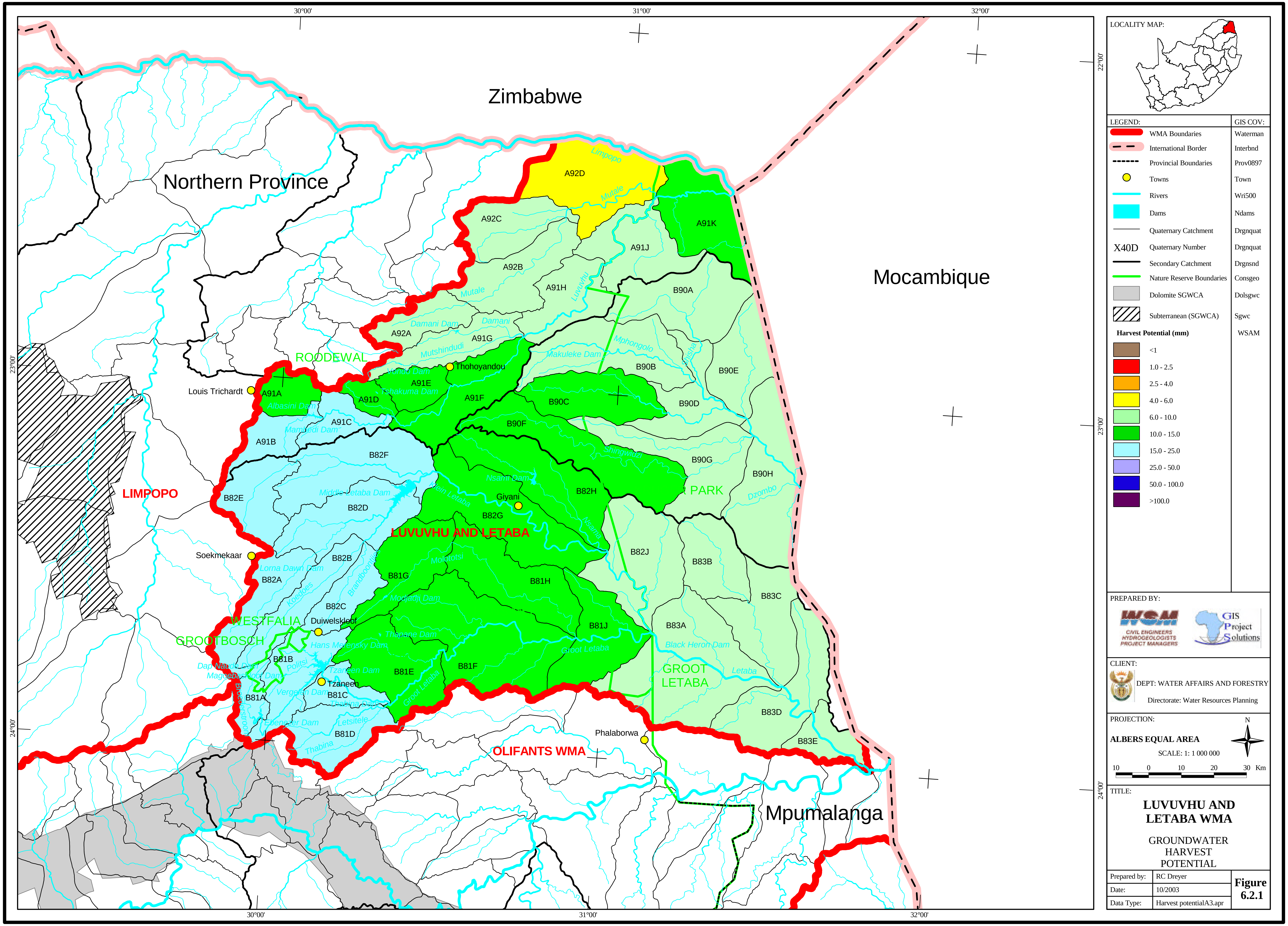
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
NET 1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE IF DEVELOPED TO FULL POTENTIAL
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Yield full potentialA3.apr
Figure 6.1.2



Zimbabwe
Northern Province
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LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
RODDEWAL
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30°00'
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Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Nature Reserve Boundaries — Consgeo
Dolomite SGWCA — Dolsgwc
Subterranean (SGWCA) — Sgwc
Harvest Potential (mm) — WSAM
<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
PREPARED BY:
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CLIENT:
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Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
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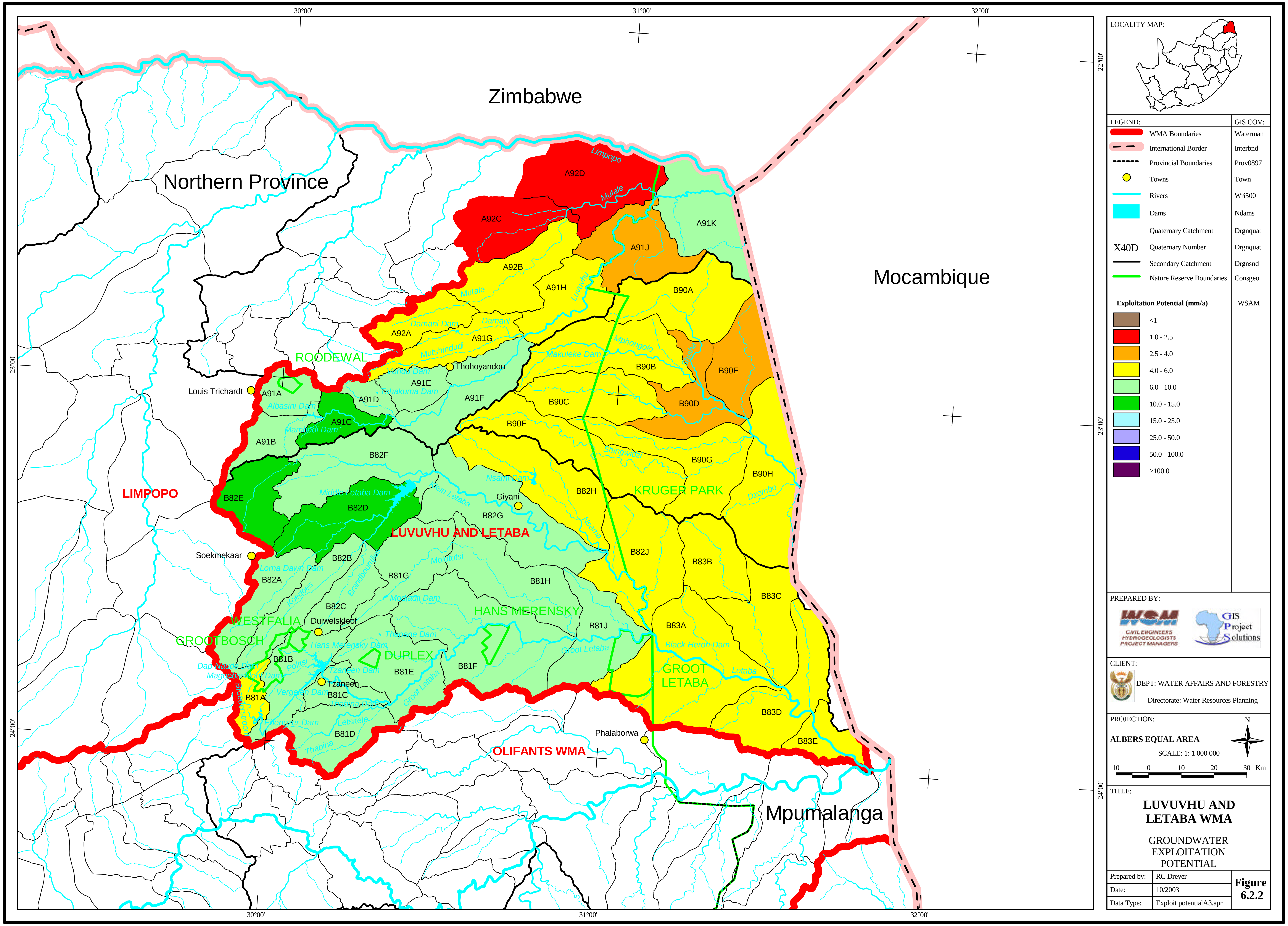
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
GROUNDWATER HARVEST POTENTIAL
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Harvest potentialA3.apr
Figure 6.2.1



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Shingwedzi
Dzombo
Klein Letaba
Groot Letaba
Letaba
Nsama
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Middle Letaba Dam
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Makuleke Dam
Albasini Dam
Mambedi Dam
Lorna Dawn Dam
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Tzaneen Dam
Black Heron Dam
Ebenezer Dam
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30°00'
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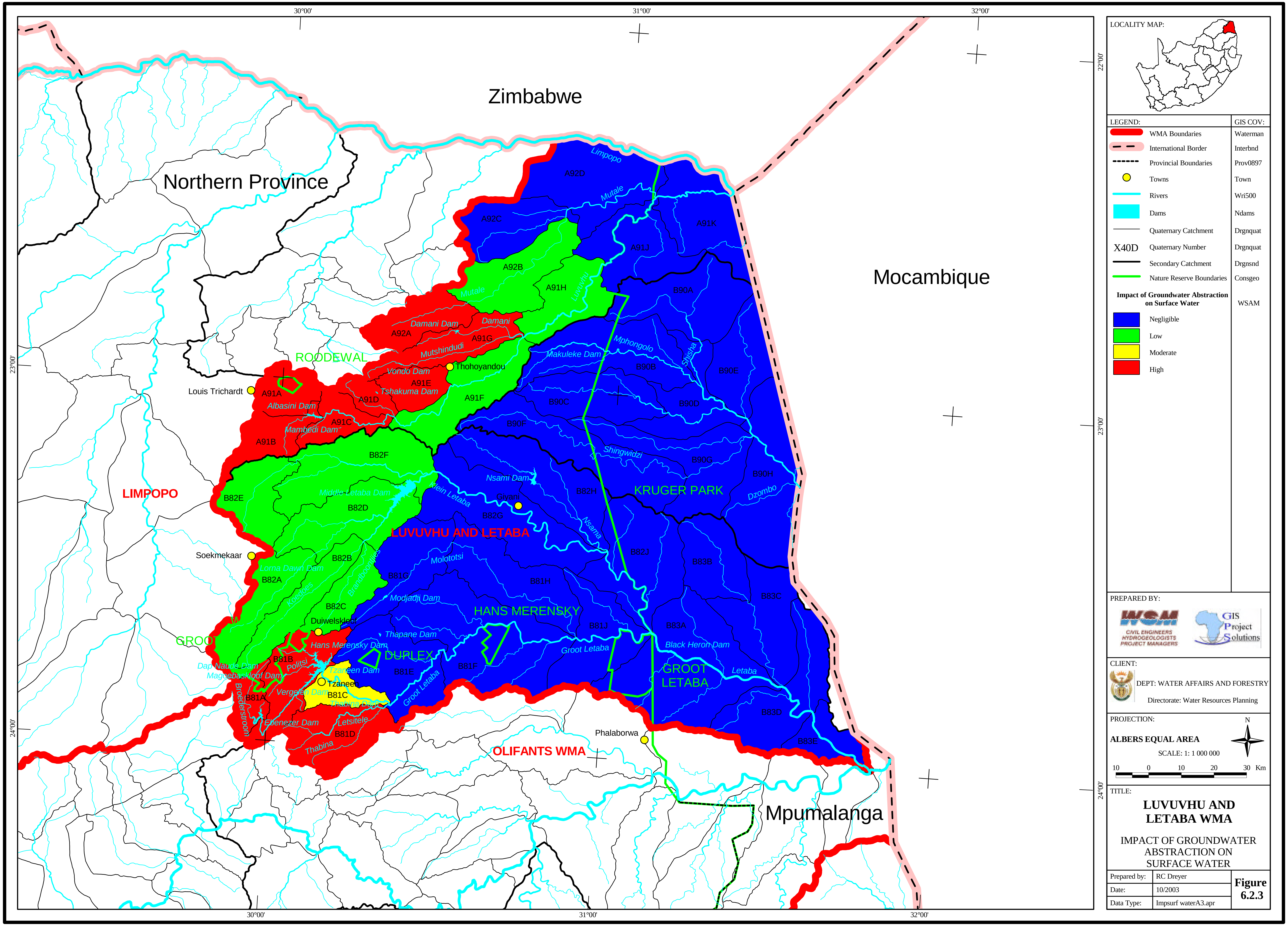
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries | Waterman
International Border | Interbnd
Provincial Boundaries | Prov0897
Towns | Town
Rivers | Wri500
Dams | Ndams
Quaternary Catchment | Drgnquat
X40D Quaternary Number | Drgnquat
Secondary Catchment | Drgnsnd
Nature Reserve Boundaries | Consgeo
Exploitation Potential (mm/a) | WSAM
<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
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: 1 000 000
10 0 10 20 30 Km
N
TITLE:
LUVUVHU AND LETABA WMA
GROUNDWATER EXPLOITATION POTENTIAL
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Exploit potentialA3.apr
Figure 6.2.2



Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
KRUGER PARK
HANS MERENSKY
GROOT LETABA
DURLEX
RODDEWAL
Louis Trichardt
Thohoyandou
Soekmekaar
Giyani
Duiwelskloof
Tzaneen
Phalaborwa
Limpopo
Mutale
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Mphongolo
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Shingwidzi
Dzombo
Klein Letaba
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Groot Letaba
Letaba
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Thabina
Politsi
Broederstroom
Makuleke Dam
Damani Dam
Vondo Dam
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Albasini Dam
Mambedi Dam
Middle Letaba Dam
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Lorna Dawn Dam
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Hans Merensky Dam
Black Heron Dam
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LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries Waterman
International Border Interbnd
Provincial Boundaries Prov0897
Towns Town
Rivers Wri500
Dams Ndams
Quaternary Catchment Drgnquat
X40D Quaternary Number Drgnquat
Secondary Catchment Drgnsnd
Nature Reserve Boundaries Consgeo
Impact of Groundwater Abstraction on Surface Water WSAM
Negligible
Low
Moderate
High
PREPARED BY:
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CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1: 1 000 000
10 0 10 20 30 Km
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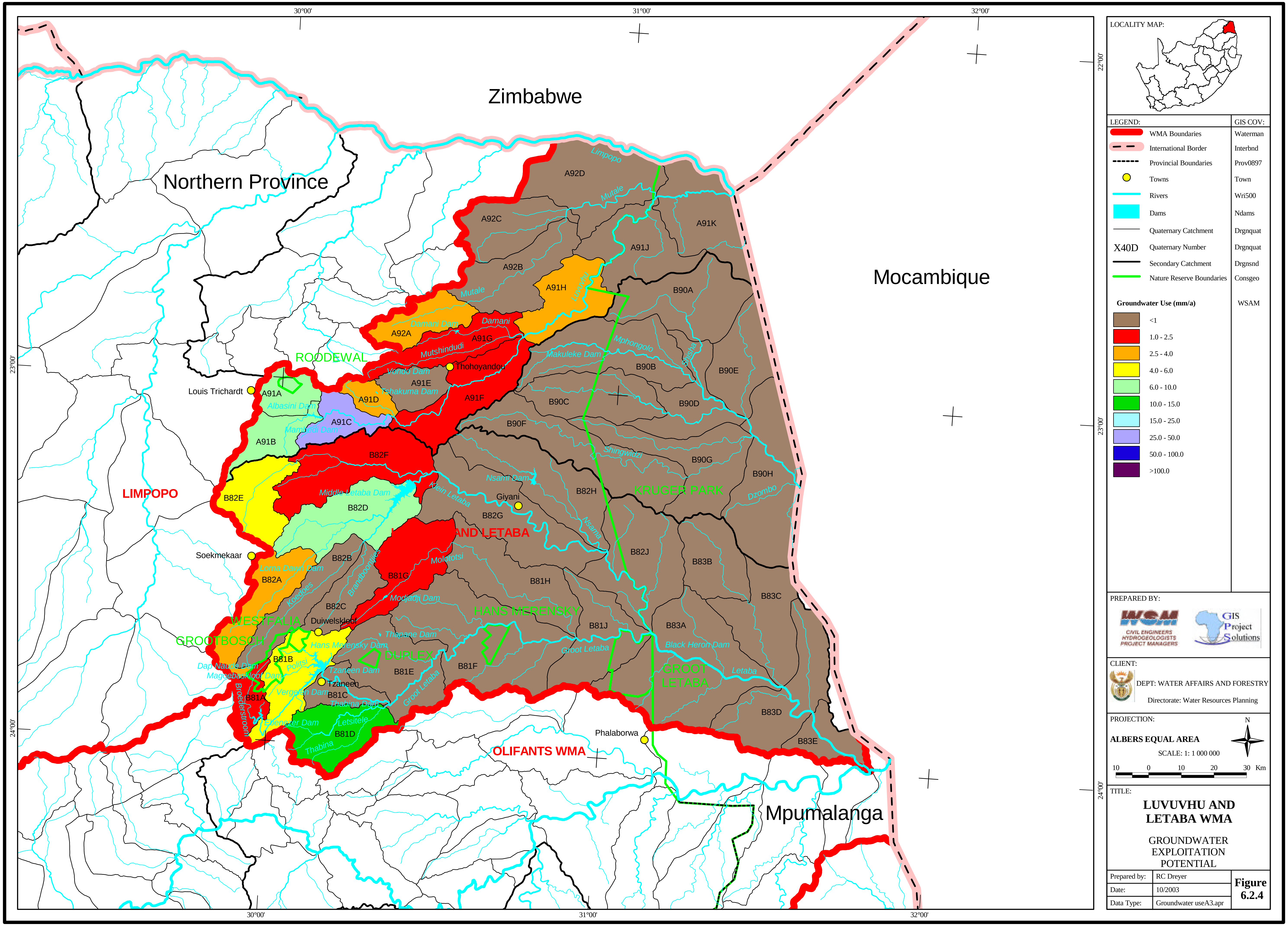
TITLE:
LUVUVHU AND LETABA WMA
IMPACT OF GROUNDWATER ABSTRACTION ON SURFACE WATER
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Impsurf waterA3.apr
Figure 6.2.3



Zimbabwe
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Shisha
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Dzombo
Klein Letaba
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Molototsi
Groot Letaba
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Magoebaskloof Dam
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Ebenezer Dam
Thabina Dam
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LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Nature Reserve Boundaries — Consgeo
Groundwater Use (mm/a) — WSAM
<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
PREPARED BY:
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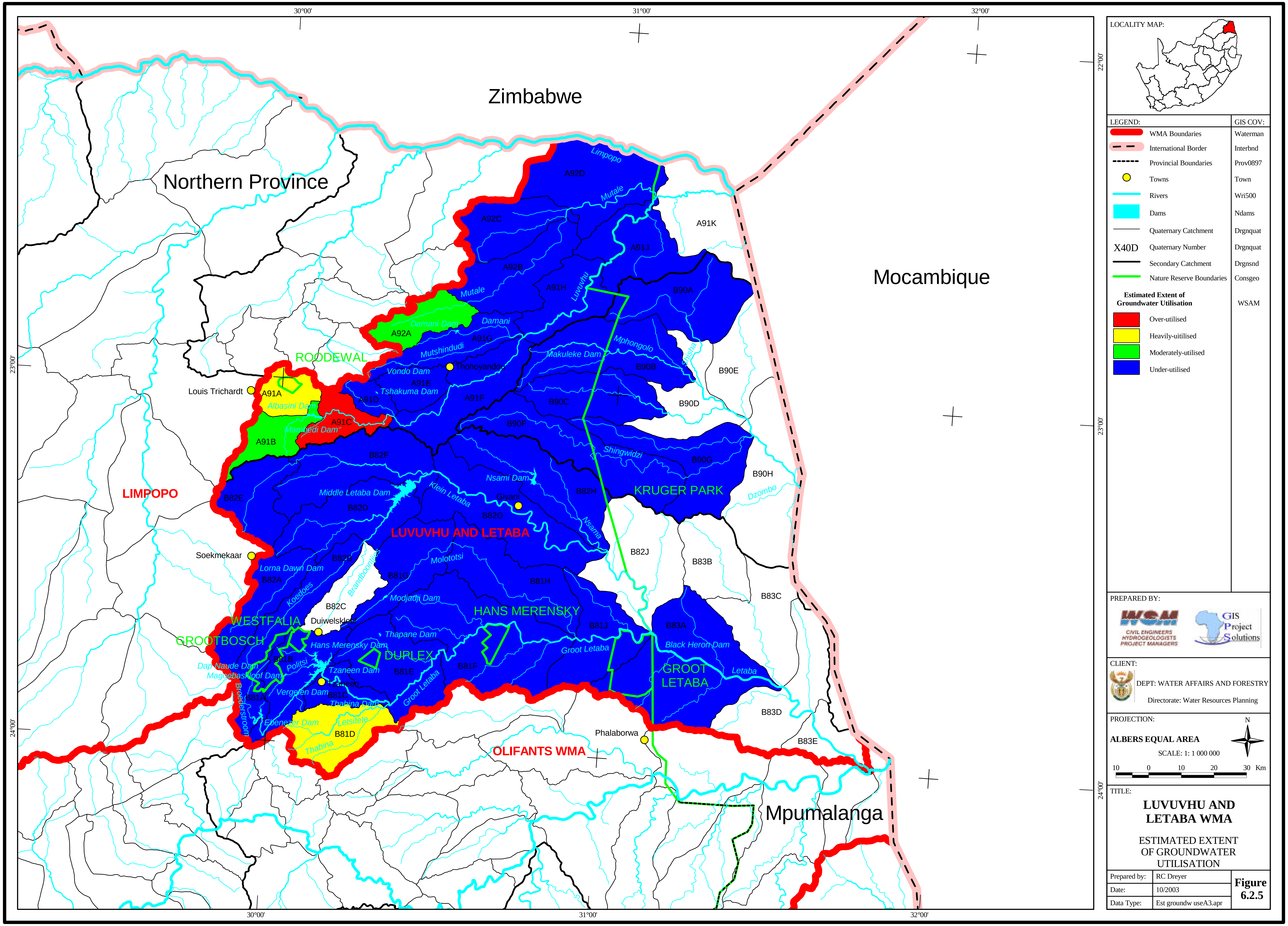
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
GROUNDWATER EXPLOITATION POTENTIAL
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Groundwater useA3.apr
Figure 6.2.4



Zimbabwe
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Mpumalanga
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LUVUVHU AND LETABA
OLIFANTS WMA
KRUGER PARK
RODDEWAL
WESTFALIA
GROOTBOSCH
HANS MERENSKY
DURLEX
GROOT LETABA
Louis Trichardt
Thohoyandou
Soekmekaar
Duiwelskloof
Tzaneen
Giyani
Phalaborwa
Limpopo
Mutale
Luvuvhu
Mutshindudi
Damani
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Vondo Dam
Tshakuma Dam
Albasini Dam
Mambedi Dam
Makuleke Dam
Mphongolo
Shingwidzi
Shisha
Dzombo
Middle Letaba Dam
Klein Letaba
Nsami Dam
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Molototsi
Lorna Dawn Dam
Koedoes
Brandboontjies
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Groot Letaba
Black Heron Dam
Letaba
Dap Naude Dam
Magoebaskloof Dam
Politsi
Tzaneen Dam
Vergelegen Dam
Thabina Dam
Broederstroom
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LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Nature Reserve Boundaries — Consgeo
Estimated Extent of Groundwater Utilisation — WSAM
Over-utilised
Heavily-uitilised
Moderately-utilised
Under-utilised
PREPARED BY:
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CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
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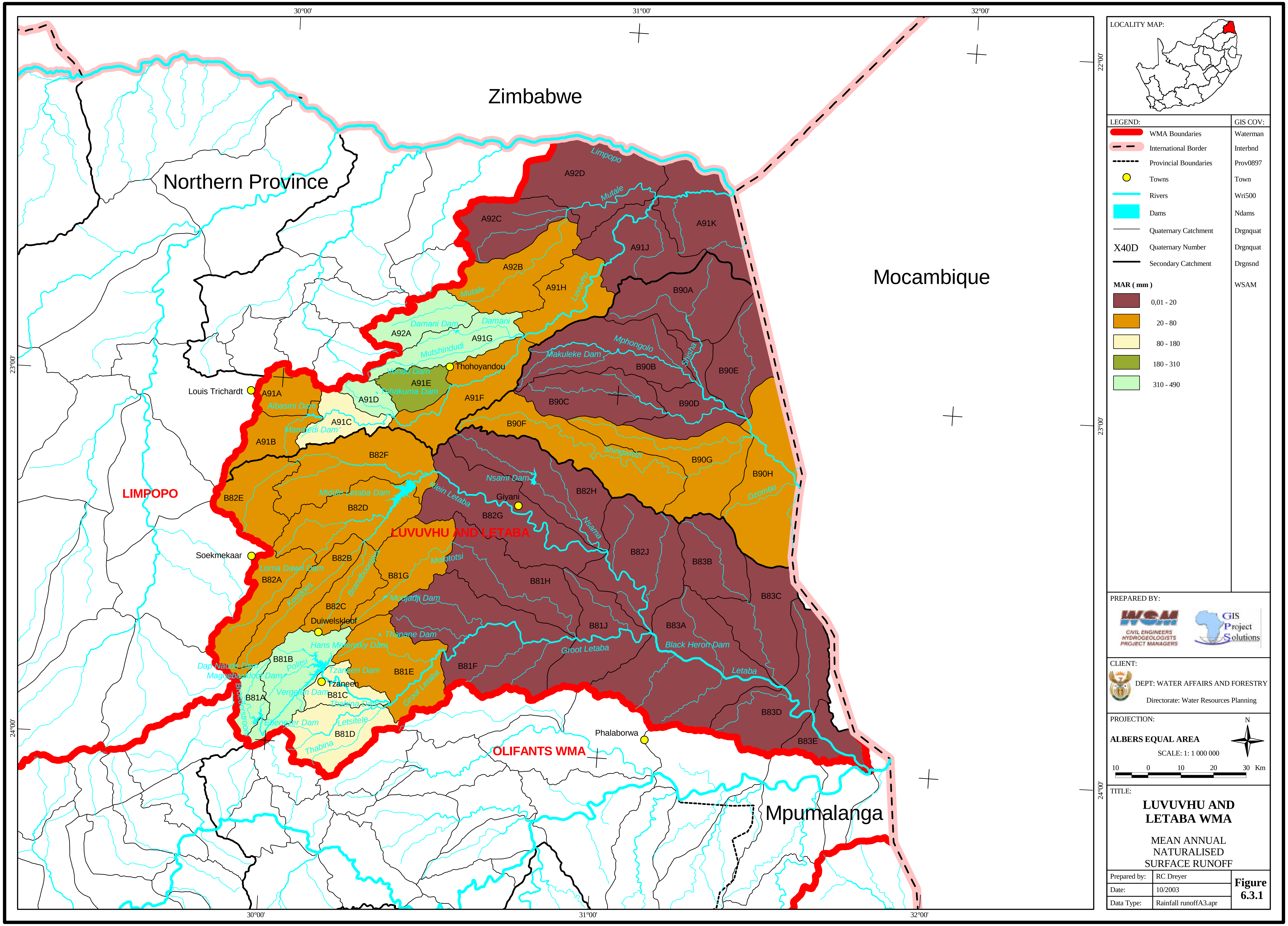
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
ESTIMATED EXTENT OF GROUNDWATER UTILISATION
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Est groundw useA3.apr
Figure 6.2.5



Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
Tzaneen
Phalaborwa
Limpopo
Mutale
Luvuvhu
Mphongolo
Shisha
Shingwedzi
Klein Letaba
Nsama
Molototsi
Groot Letaba
Letaba
Damani
Mutshindudi
Politsi
Letsitele
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Makuleke Dam
Damani Dam
Vondo Dam
Tshakuma Dam
Albasini Dam
Mambedi Dam
Middle Letaba Dam
Nsami Dam
Lorna Dawn Dam
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Black Heron Dam
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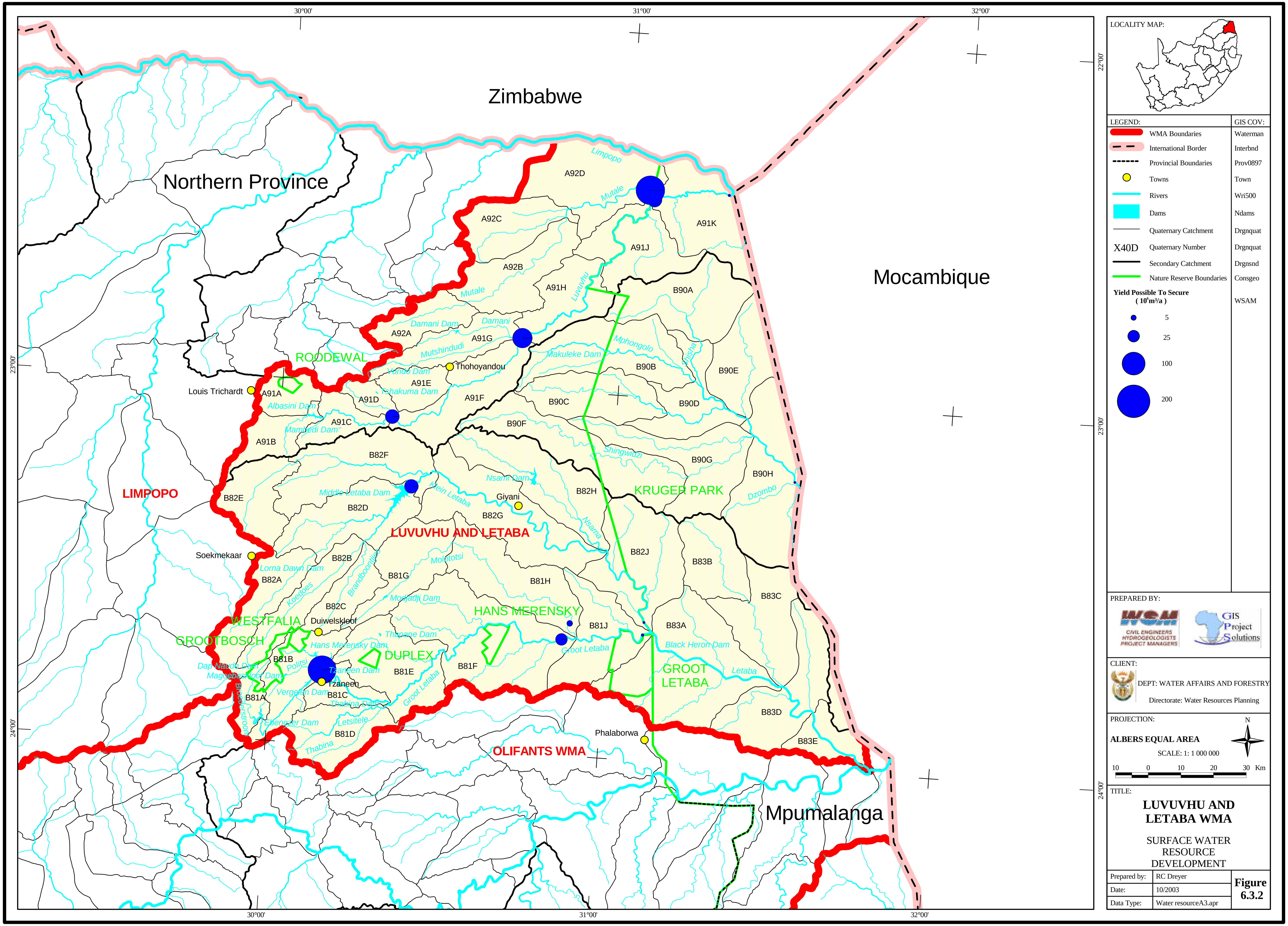
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
MAR (mm) — WSAM
0,01 - 20
20 - 80
80 - 180
180 - 310
310 - 490
PREPARED BY:
WSM CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
MEAN ANNUAL NATURALISED SURFACE RUNOFF
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Rainfall runoffA3.apr
Figure 6.3.1



Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
KRUGER PARK
RODDEWAL
WESTFALIA
GROOTBOSCH
DUPLEX
HANS MERENSKY
GROOT LETABA
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
Tzaneen
Phalaborwa
Limpopo
Mutale
Luvuvhu
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Mutshindudi
Vondo Dam
Tshakuma Dam
Albasini Dam
Mambedi Dam
Makuleke Dam
Mphongolo
Shingwidzi
Nsami Dam
Klein Letaba
Middle Letaba Dam
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Lorna Dawn Dam
Brandboontjies
Modjadji Dam
Thabene Dam
Hans Merensky Dam
Tzaneen Dam
Vergelegen Dam
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Ebenezer Dam
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Black Heron Dam
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LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries | Waterman
International Border | Interbnd
Provincial Boundaries | Prov0897
Towns | Town
Rivers | Wri500
Dams | Ndams
Quaternary Catchment | Drgnquat
X40D Quaternary Number | Drgnquat
Secondary Catchment | Drgnsnd
Nature Reserve Boundaries | Consgeo
Yield Possible To Secure (10⁶m³/a) | WSAM
5
25
100
200
PREPARED BY:
WSM CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
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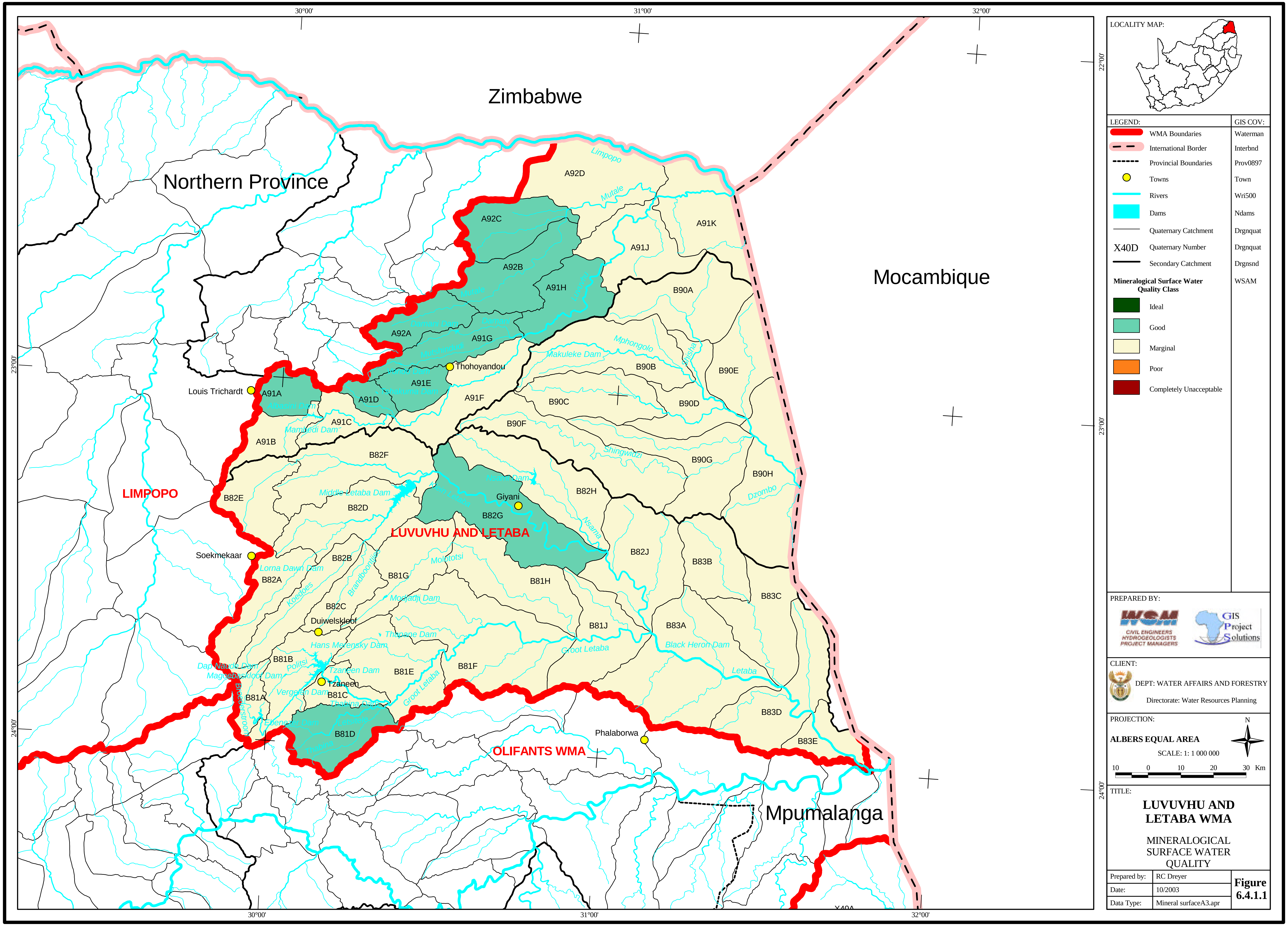
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
SURFACE WATER RESOURCE DEVELOPMENT
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Water resourceA3.apr
Figure 6.3.2


Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
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Koedoes
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Broederstroom
30°00'
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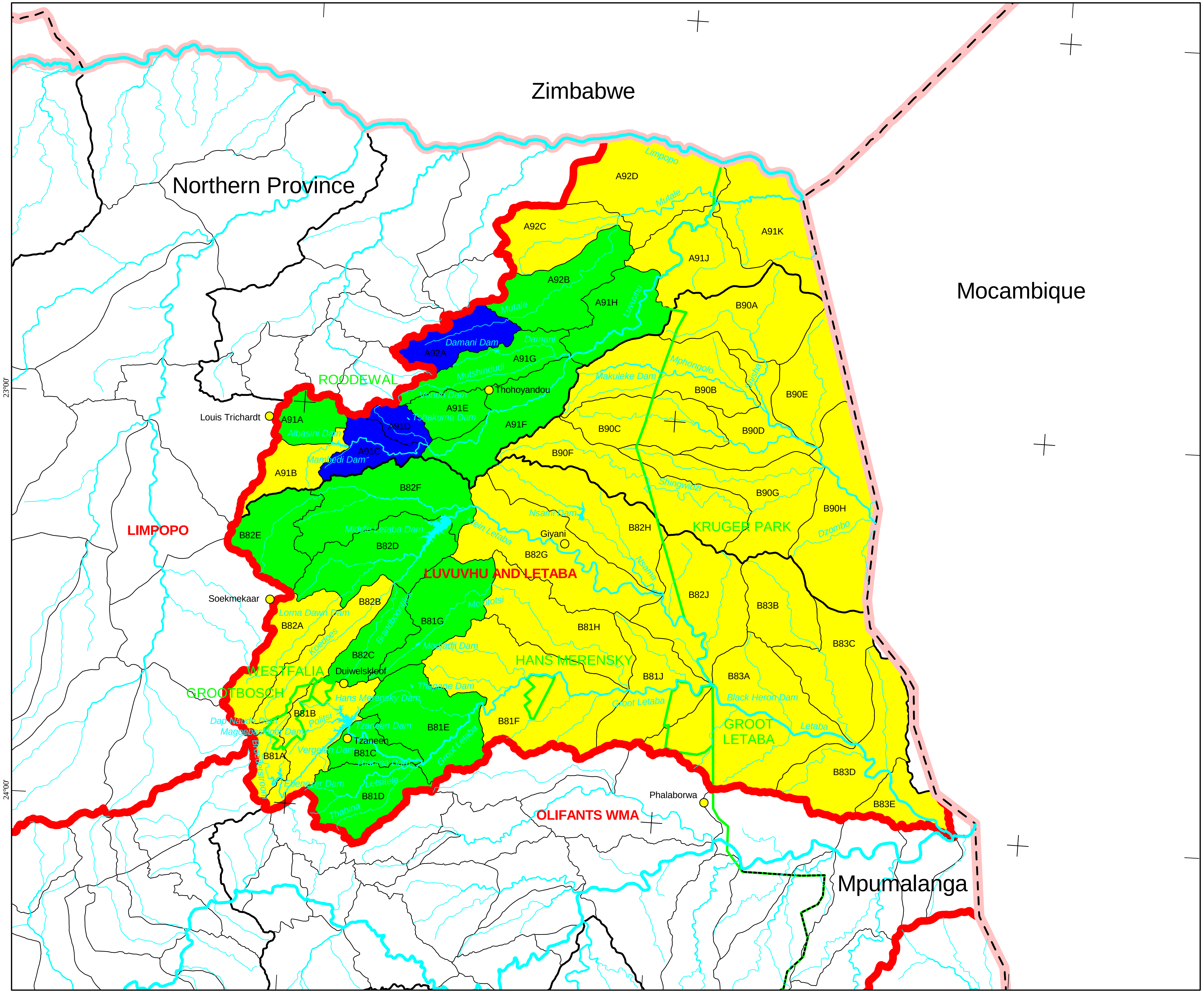
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Waterman
International Border
Interbnd
Provincial Boundaries
Prov0897
Towns
Town
Rivers
Wri500
Dams
Ndams
Quaternary Catchment
Drgnquat
X40D
Quaternary Number
Drgnquat
Secondary Catchment
Drgnsnd
Mineralogical Surface Water Quality Class
WSAM
Ideal
Good
Marginal
Poor
Completely Unacceptable
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
N
ALBERS EQUAL AREA
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
MINERALOGICAL SURFACE WATER QUALITY
Prepared by:
RC Dreyer
Date:
10/2003
Data Type:
Mineral surfaceA3.apr
Figure 6.4.1.1



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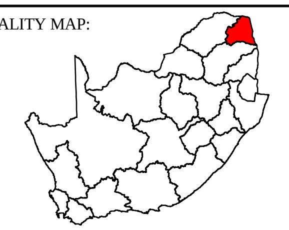

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	International Border	Interbnd
	Provincial Boundaries	Prov0897
	Towns	Town
	Rivers	Wri500
	Dams	Ndams
	Quaternary Catchment	Drgnquat
X40D	Quaternary Number	Drgnquat
	Secondary Catchment	Drgnsnd
	Nature Reserve Boundaries	Consgeo

Mean Total Dissolve Solids (mg/l)	WSAM
<260	
261 - 600	
600 - 1800	
1800 - 3400	
>3400	

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DEPT: WATER AFFAIRS AND FORESTRY

Directorate: Water Resources Planning

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1: 1 000 000

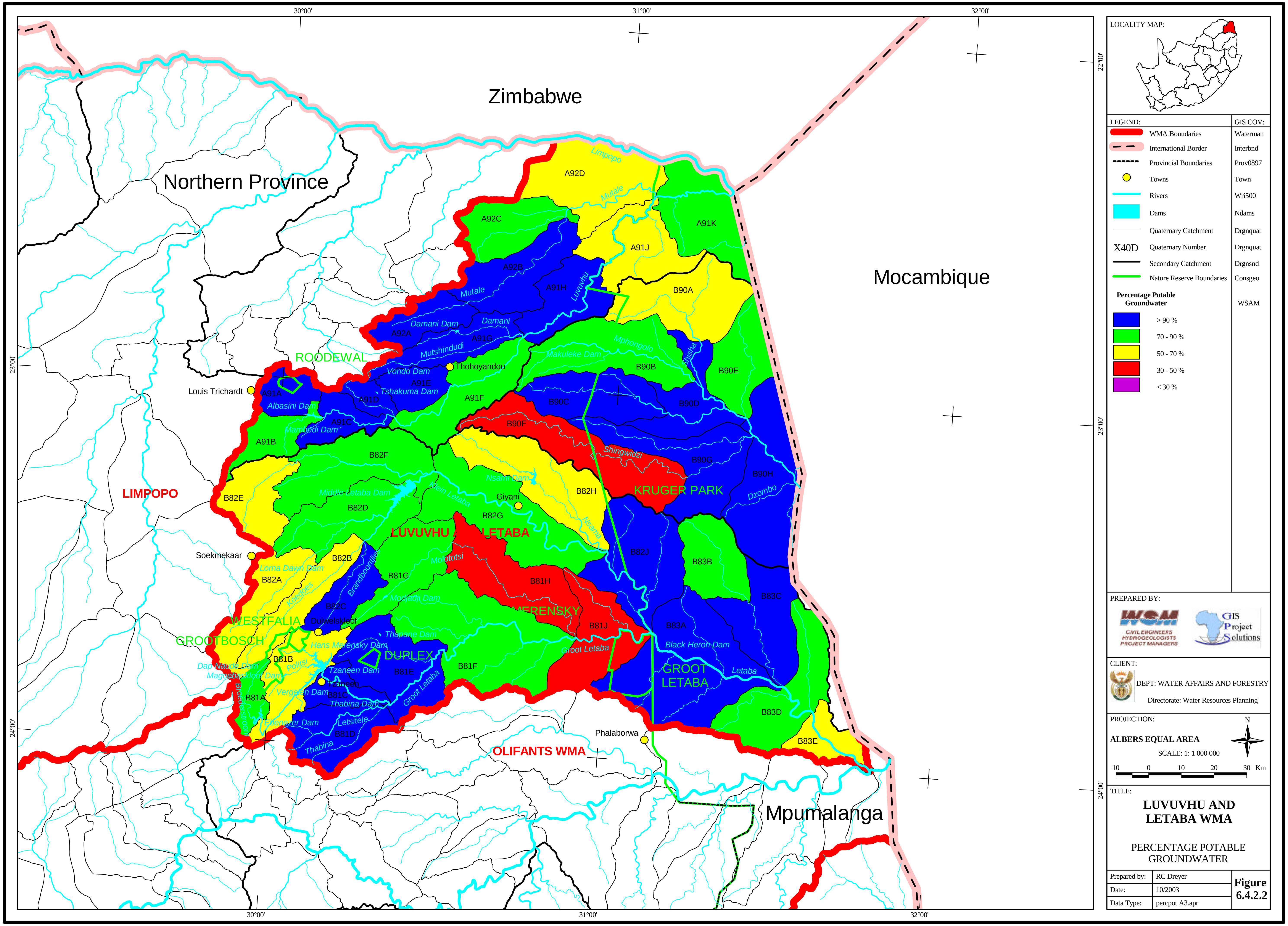
10 0 10 20 30 Km

TITLE:

LUVUVHU AND LETABA WMA

MINERALOGICAL GROUNDWATER QUALITY

Prepared by:	RC Dreyer	**Figure 6.4.2.1**
Date:	10/2003	
Data Type:	Mean tdsA3.apr	


Zimbabwe
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Mocambique
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LIMPOPO
OLIFANTS WMA
LUVUVHU
LETABA
KRUGER PARK
GROOT LETABA
RODDEWAL
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Soekmekaar
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Brandboontjie
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Hans Merensky Dam
Thapane Dam
Groot Letaba
Black Heron Dam
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23°00'
24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Nature Reserve Boundaries — Consgeo
Percentage Potable Groundwater — WSAM
> 90 %
70 - 90 %
50 - 70 %
30 - 50 %
< 30 %
PREPARED BY:
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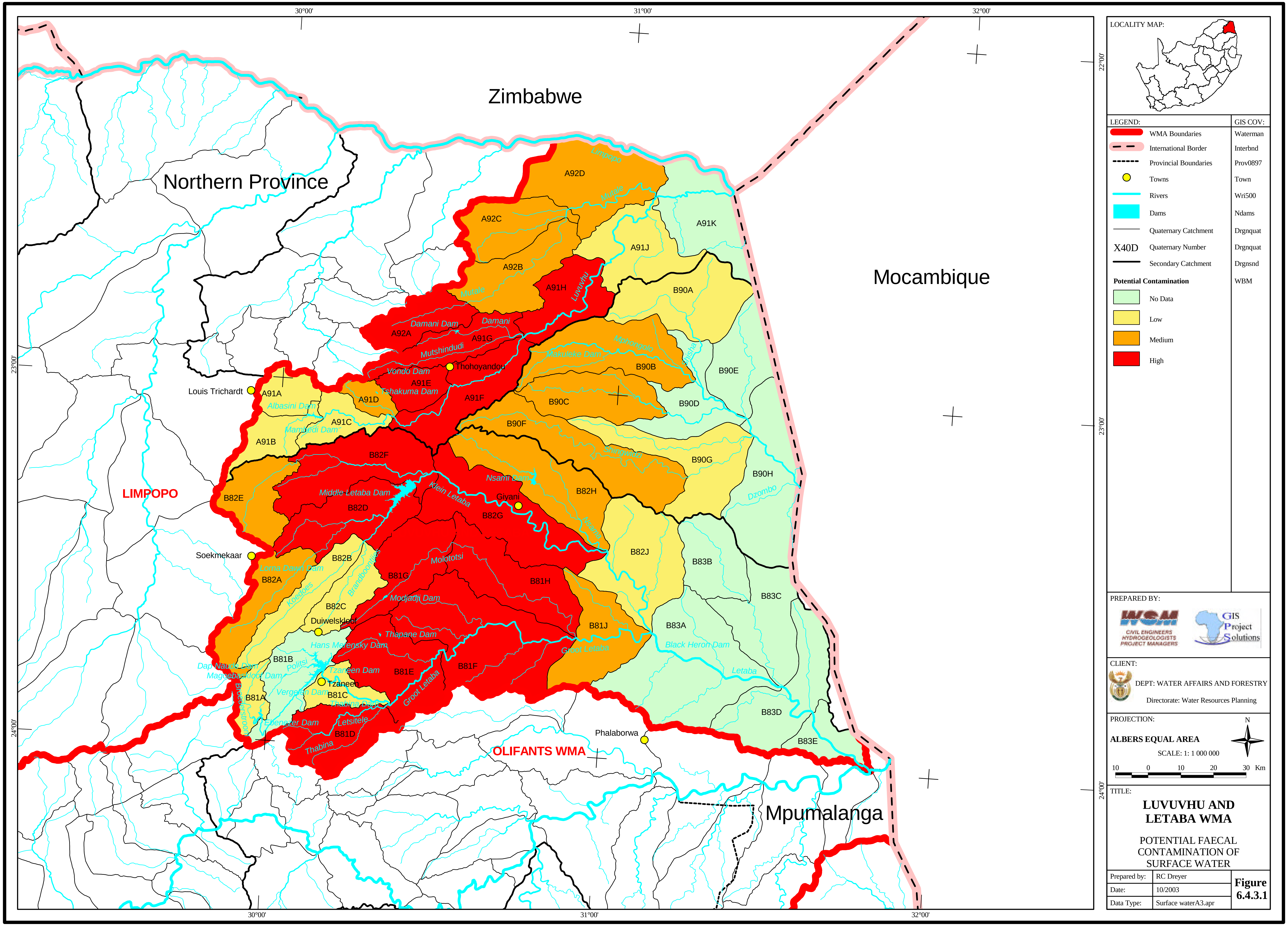
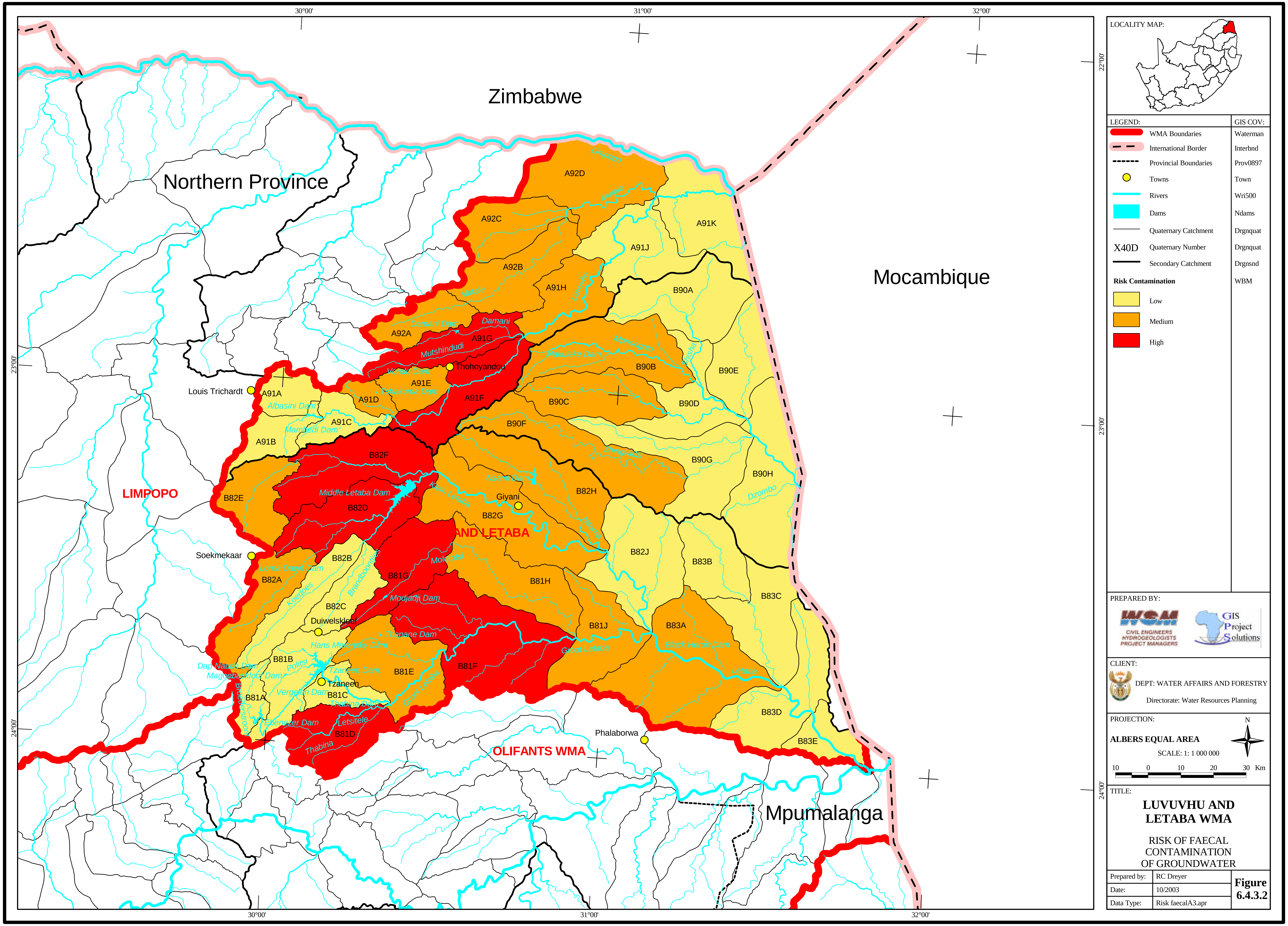
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
PERCENTAGE POTABLE GROUNDWATER
Prepared by: RC Dreyer
Date: 10/2003
Data Type: percpot A3.apr
Figure 6.4.2.2



LUVUVHU AND LETABA WMA

POTENTIAL FAECAL CONTAMINATION OF SURFACE WATER

Figure 6.4.3.1


Zimbabwe
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Mocambique
Mpumalanga
LIMPOPO
AND LETABA
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Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
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Limpopo
Mutale
Luvuvhu
Damani
Damani Dam
Mutshindudi
Vondo Dam
Phiphidi Dam
Albasini Dam
Mambedi Dam
Mahkuleke Dam
Mphongolo
Shisha
Shingwedzi
Nsami Dam
Klein Letaba
Middle Letaba Dam
Dzombo
Molototsi
Modjadji Dam
Lorna Dawn Dam
Koedoes
Brandboontjies
Thapane Dam
Hans Merensky Dam
Dap Naude Dam
Magoebaskloof Dam
Politsi
Tzaneen Dam
Vergelegen Dam
Thabina Dam
Ebenezer Dam
Letsitele
Thabina
Great Letaba
Black Heron Dam
Letaba
30°00'
31°00'
32°00'
22°00'
23°00'
24°00'
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries — Waterman
International Border — Interbnd
Provincial Boundaries — Prov0897
Towns — Town
Rivers — Wri500
Dams — Ndams
Quaternary Catchment — Drgnquat
X40D Quaternary Number — Drgnquat
Secondary Catchment — Drgnsnd
Risk Contamination — WBM
Low
Medium
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
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
RISK OF FAECAL CONTAMINATION OF GROUNDWATER
Prepared by: RC Dreyer
Date: 10/2003
Data Type: Risk faecalA3.apr
Figure 6.4.3.2

FIGURE 6.4.4.1: WATER QUALITY ISSUES

THIS FIGURE IS NOT ACCESSIBLE IN ELECTRONIC FORMAT.

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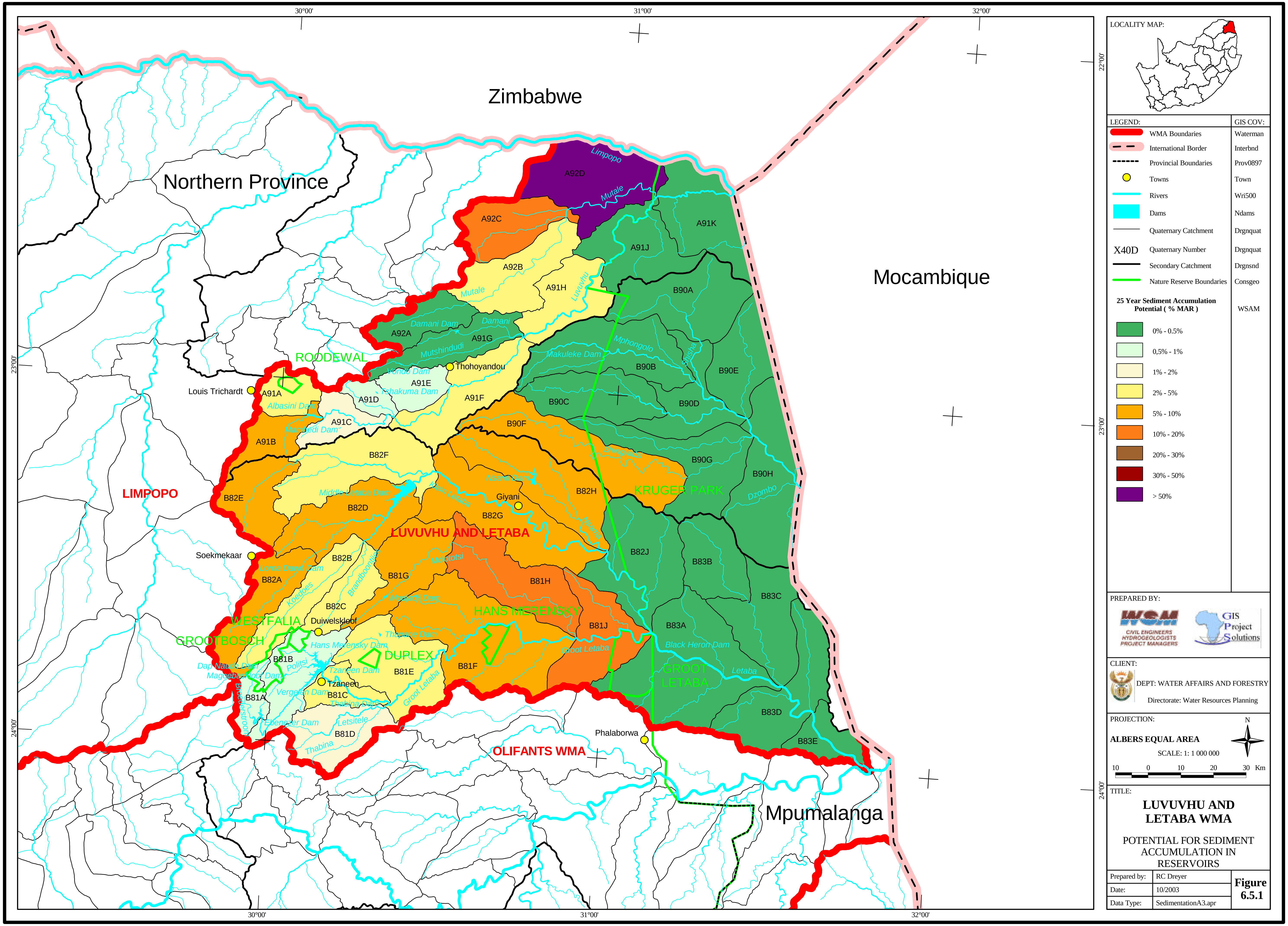
Zimbabwe
Northern Province
Mocambique
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
RODDEWAL
KRUGER PARK
HANS MERENSKY
WESTFALIA
GROOTBOSCH
DUPLEX
GROOT LETABA
Louis Trichardt
Thohoyandou
Giyani
Soekmekaar
Duiwelskloof
Tzaneen
Phalaborwa
Limpopo
Mutale
Luvuvhu
Damani Dam
Damani
Mutshindudi
Tondo Dam
Nzhelele Dam
Albasini Dam
Mambedi Dam
Makuleke Dam
Mphongolo
Shisha
Shingwedzi
Middle Letaba Dam
Nsami Dam
Klein Letaba
Molototsi
Lorna Dawn Dam
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Brandboontjies
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Groot Letaba
Black Heron Dam
Letaba
Dzombo
Dap Naude Dam
Magoebaskloof Dam
Politsi
Tzaneen Dam
Vergelegen Dam
Thabina Dam
Ebenezer Dam
Letsitele
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Broederstroom
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24°00'
LOCALITY MAP:
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WMA Boundaries | Waterman
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Rivers | Wri500
Dams | Ndams
Quaternary Catchment | Drgnquat
X40D Quaternary Number | Drgnquat
Secondary Catchment | Drgnsnd
Nature Reserve Boundaries | Consgeo
25 Year Sediment Accumulation Potential (% MAR) | WSAM
0% - 0.5%
0,5% - 1%
1% - 2%
2% - 5%
5% - 10%
10% - 20%
20% - 30%
30% - 50%
> 50%
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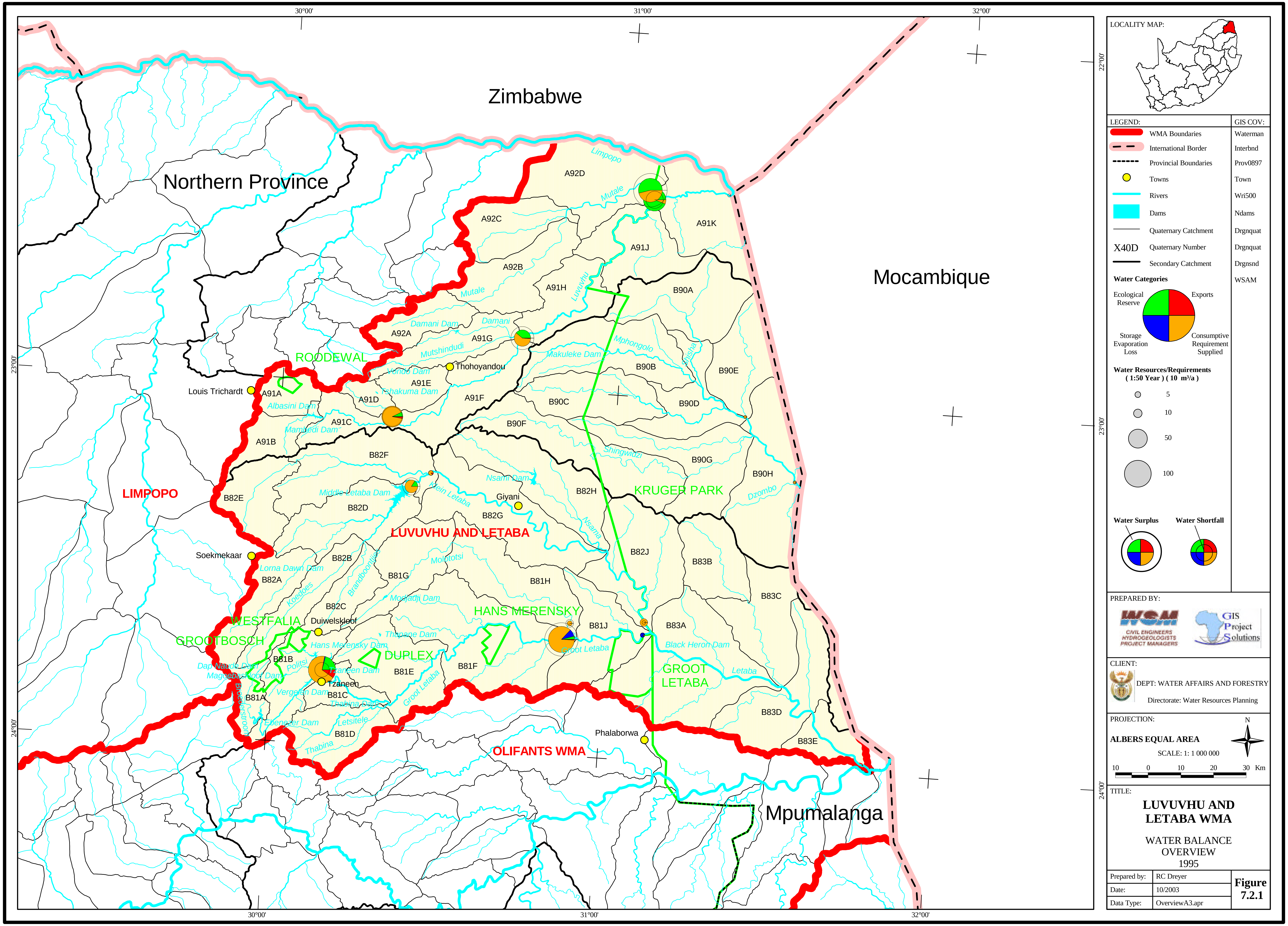
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
POTENTIAL FOR SEDIMENT ACCUMULATION IN RESERVOIRS
Prepared by: RC Dreyer
Date: 10/2003
Data Type: SedimentationA3.apr
Figure 6.5.1



Zimbabwe
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Rivers
Wri500
Dams
Ndams
Quaternary Catchment
Drgnquat
X40D
Quaternary Number
Drgnquat
Secondary Catchment
Drgnsnd
WSAM
Water Categories
Ecological Reserve
Exports
Storage Evaporation Loss
Consumptive Requirement Supplied
Water Resources/Requirements
(1:50 Year) (10 m³/a)
5
10
50
100
Water Surplus
Water Shortfall
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Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1: 1 000 000
10 0 10 20 30 Km
TITLE:
LUVUVHU AND LETABA WMA
WATER BALANCE OVERVIEW
1995
Prepared by: RC Dreyer
Date: 10/2003
Data Type: OverviewA3.apr
Figure 7.2.1