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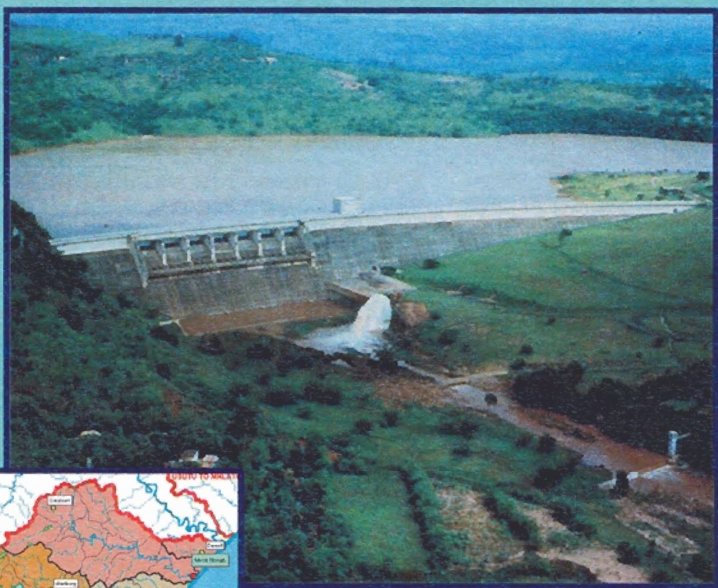
DEPARTMENT: WATER AFFAIRS AND FORESTRY

Directorate: Water Resources Planning

MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

VOLUME 1 OF 2
FEBRUARY 2003



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CONTENTS

LIST OF TABLES

LIST OF DIAGRAMS

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

AEMC	:	Suggested Ecological Management Class
CMA	:	Catchment Management Agency
CSIR	:	Centre For Scientific And Industrial Research
CSS	:	Central Statistics Services
DBSA	:	Development Bank Of Southern Africa
DEAT	:	Department Of Environmental Affairs And Tourism
DEMC	:	Default Ecological Management Class
DESC	:	Default Ecological Status Class
DME	:	Department Of Minerals And Energy
DOC	:	Dissolved Organic Carbon
DWAF	:	Department Of Water Affairs And Forestry
EA	:	Enumerator Area
EISC	:	Ecological Importance And Sensitivity Class
ELSU	:	Equivalent Livestock Units
GGP	:	Gross Geographic Product
GIS	:	Geographic Information Systems
HIS	:	Hydrological Information Services (of DWAF)
IFR	:	Instream Flow Requirement
MAE	:	Mean Annual Evaporation
MAP	:	Mean Annual Precipitation
MAR	:	Mean Annual Runoff
MD	:	Magisterial District
MMTS	:	Mooi-Mgeni Transfer Scheme
NWA	:	National Water Act (Act No. 36 of 1998)
PESC	:	Present Ecological Status Class
quat	:	Quaternary
RDP	:	Reconstruction and Development Programme
SAR	:	sodium adsorption ratio
TDS	:	Total Dissolved Salts
THM	:	trihalomethane
TLC	:	Transitional Local Council
TRC	:	Transitional Rural Council
TWP	:	Thukela Water Project
VAPS	:	Vaal Augmentation Planning Study
WMA	:	Water Management Area
WR90	:	Surface Water Resources Of South Africa 1990 (Midgely Et Al, 1994)
WRC	:	Water Research Commission
WRSA	:	Water Resources Situation Assessment
WSAM	:	Water Situation Assessment Model
WUA	:	Water User Associations

GLOSSARY OF TERMS

ANASTOMOSED	A river made up of multiple channels with stable islands, usually with a bedrock substrate.
ASSURANCE OF SUPPLY	The reliability at which a specified quantity of water can be provided, usually expressed either as a percentage or as a risk. For example "98% reliability" means that, over a long period of time, the specified quantity of water can be supplied for 98% of the time, and less for the remaining 2%. Alternatively, this situation may be described as a "1 in 50 year risk of failure" meaning that, on average, the specified quantity of water will fail to be provided in 1 year in 50 years, or 2% of time.
BASIN	The area of land that is drained by a large river, or river system.
BIOTA	A collective term for all the organisms (plants, animals, fungi. bacteria) in an ecosystem.
CAIRN	Mound of rough stones packed as a monument or landmark.
CATCHMENT	The area of land drained by a river. The term can be applied to a stream, a tributary of a larger river or a whole river system.
COMMERCIAL FARMING	Large scale farming, the products of which are normally sold for profit.
COMMERCIAL FORESTS	Forests that are cultivated for the commercial production of wood or paper products.
CONDENSED AREA	The equivalent area of alien vegetation with a maximum concentration/density that represents the more sparsely distributed alien vegetation that occurs over a large area.
CAUCASION	Of the White race
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.

DEMC	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.
ECOSYSTEM HEALTH	An ecosystem is considered healthy if it is active and maintains its organisation and autonomy over time, and is resilient to stress. Ecosystem health is closely related to the idea of sustainability.
ECOLOGICAL IMPORTANCE	A measure of the extent to which a particular species, population or process contributes towards the healthy functioning of an ecosystem. Important aspects include habitat diversity, biodiversity, the presence of unique, rare or endangered biota or landscapes, connectivity, sensitivity and resilience. The functioning of the ecosystem refers to natural processes.
EDAPHIC	Pertaining to the influence of soil on organisms. or Resulting from or influenced by factors inherent in soil rather than by climatic factors.
ENDANGERED SPECIES	Species in danger of extinction and whose survival is unlikely if the causal factors bringing about its endangered status continue operating. Included are species whose numbers have been reduced to a critically low level or whose habitat has been so drastically diminished and/or degraded that they are deemed to be in immediate danger of extinction.
ENDEMIC	Occurring within a specified locality; not introduced.

ENDOREIC	Portion of a hydrological catchment that does not contribute towards river flow in its own catchment (local) or to river flow in downstream catchments (global). In such catchments the water generally drains to pans where much of the water is lost through evaporation.
ENVIRONMENTALLY SENSITIVE AREA	A fragile ecosystem which will be maintained only by conscious attempts to protect it.
EPHEMERAL RIVERS	Rivers where no flow occurs for long periods of time.
FORMAL IRRIGATION SCHEME	The term applies to a scheme where water for irrigation purposes is stored in a dam controlled by DWAF or an Irrigation Board and supplied in predetermined quotas to irrigators registered under the scheme.
HISTORICAL FLOW SEQUENCE	A record of river flow over a defined period and under a defined condition of catchment development in the past, calculated from a record of observed flow corrected for inaccuracies, or from records of observed rainfall, or a combination of the two.
HYDROLOGICAL YEAR	The twelve-month period from the beginning of October in one year to the end of September in the following year.
INVERTEBRATE	An animal without a backbone - includes insects, snails, sponges, worms, crabs and shrimps.
IRRIGATION QUOTA	The quantity of water, usually expressed as m^3/ha per year, or mm per year, allocated to land scheduled under the scheme. This is the quantity to which the owner of the land is entitled at the point at which he or she takes delivery of the water and does not include conveyance losses to that point.
LOTIC	Flowing water.
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).
RARE	Species with small or restricted populations, which are not at present endangered or vulnerable, but which are at risk. These species are usually localised within restricted geographical areas or habitats, or are thinly scattered over a more extensive range. These may be species, which are seldom recorded but may be more common than supposed, although there is evidence that their numbers are low.
RED DATA BOOK	A book that lists species that are threatened with extinction. The concept was initiated by the International Union for the Conservation of Nature, and has since become adopted by many countries. The "Red" stands for "Danger". The categories reflect the status of the species only within the area under review, and it is sometimes the case that species, which are threatened in one region may have secure populations in other areas.
RELIABILITY OF SUPPLY	Synonymous with assurance of supply.

RESERVE	The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997) for people, who are now or who will, in the reasonably near future, be (i) relying upon; (ii) taking water from; or (iii) being supplied from, the relevant water resource; and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource as indicated in the National Water Act (Act No. 36 of 1998).
RESERVOIR	The lake formed behind a dam wall. In this report the colloquial term dam is generally used for reservoir.
RESILIENCE	The ability of an ecosystem to maintain structure and patterns of behaviour in the face of disturbance or the ability to recover following disturbance.
RESOURCE QUALITY	The quality of all the aspects of a water resource including: (a) the quantity, pattern, timing, water level and assurance of instream flow; (b) the water quality, including the physical, chemical and biological characteristics of the water; (c) the character and condition of the instream and riparian habitat; and (d) the characteristics, condition and distribution of the aquatic biota.
RESOURCE QUALITY OBJECTIVE	Quantitative and verifiable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection.
RIVER SYSTEM	A network of rivers ranging from streams to major rivers, and, in some cases, including rivers draining naturally separate basins that have been interconnected by man-made transfer schemes.
SCHEDULED LAND	Irrigable land to which a water quota has been allocated.
SPATIO — TEMPORALLY ROBUST	Does not change significantly with time in relation to spatial distribution.

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 MANAGEMENT CLASS	A class of water resource indicating the suggested management objectives of an area which could possibly be attained within 5 years. Values range from Class A (largely natural) to Class D (largely modified).
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.

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

As a component of the National Water Resource Strategy, the Minister of Water Affairs and Forestry has established water management areas and determined their boundaries. The National Water Act provides for the delegation of water resource management from central government to the regional or catchment level by establishing catchment management agencies. It is intended that the documents produced in this study as well as in the subsequent scenario studies referred to above should, in addition to contributing to the establishment of the National Water Resource Strategy, provide information for collaborative planning of water resources development and 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 Mvoti to Umzimkulu Water Management Area (WMA) which is situated mostly within the KwaZulu-Natal province, but also occupies a portion of the Eastern Cape Province. An overall water resource situation assessment for the KwaZulu-Natal Province can be derived from the data contained within each of the WMA Reports that include portions of the province. The reports for the three WMAs contained predominantly within the area of KwaZulu-Natal are as follows:

- Usutu to Mhlathuze WMA
- Thukela WMA
- Mvoti to Umzimkulu WMA
- Mzimvubu to Keiskama WMA.

The Usutu to Mhlathuze, Thukela and Mvoti to Umzimkulu WMAs are shown on the attached Figure 2.1.1.

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 for a reconnaissance level of detail was collected on land-use, water requirements, water use, water related infrastructure, water resources and previous investigations of water supply development possibilities. Relevant data was used in a computerised water balance model, developed in a separate study (DWAF, 2000a) to calculate the yield of the water resources at development levels as they were in 1995, and the maximum yield that could be obtained from future development of these resources. The water balance (the relationship between water requirements and water availability) at selected points in each water management area was also calculated.

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

In that study, water from the 1996 census, and other sources, was used to derive demographic information from 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 Mvoti to Umzimkulu Water Management Area by the national demographic study (DWAF, 2000b), are presented in this report. In addition to the separate studies on the water balance model and demography referred to above, separate studies were carried out to provide information on a national basis on:

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

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

The chapter headings are:

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

Chapter 2, 3 and 4 describe climatic and physical features, and land-uses that affected 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 resources. 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.

Note that there may appear to be anomalies in subtotals and totals indicated in the tables. This is due to the rounding up of individual data entries to the required significant figure. For example 0,06 may have been rounded up to 0,1 but 0,06 was still used to calculate the total for the WMA.

CHAPTER 2: PHYSICAL FEATURES

2.1 THE STUDY AREA

The Mvoti to Umzimkulu WMA contains no international river basins.

The Mvoti to Umzimkulu WMA encompasses the entire Southern KwaZulu-Natal Province, bounded by the Thukela River Catchment to the North, the Drakensberg Mountains to the west, the Transkei Region of the Eastern Cape Province to the south and the sea in the east. The WMA is shown on the attached Figures 2.1.1 and 2.1.2.

The main river systems in this WMA flow from west to east discharging to the sea and are as follows:

- The Mvoti River which rises in the Greytown area and passes through Stanger.
- The Mgeni River which rises above Pietermaritzburg and passes through Durban.
- The Illovo and Mlazi Rivers, both rising in the Richmond area and discharging south of Durban
- The Mkomazi River, rising in the Drakensberg along the Lesotho Border and discharging at the town of Umkomaas.
- The Mzimkulu River also rising in the Southern Drakensberg above Underberg and discharging to the sea at the town of Port Shepstone.

The Mvoti to Umzimkulu WMA incorporates a total catchment area of over 27 000 km^2 and an undeveloped Mean Annual Runoff (MAR) of 4 798 million m^3. The MAR, expressed as average unit runoff, is about 192 mm, equivalent to 20 % of the Mean Annual Precipitation (MAP) of 960 mm. MAR ranges from nearly 500 mm for the western Drakensberg area where MAP reaches nearly 1300 mm getting lower towards the east, to less than 100 mm where MAP reaches less than 800 mm in the central region. MAR increases again to over 200 mm with MAPs of up to 1500 mm in the coastal belt areas.

The Mvoti to Umzimkulu WMA is home to some five million people; 1,9 million of these people live in rural areas.

The water management area has been demarcated into quaternary catchments that are shown on Figure 2.1.1 attached for the purposes of assessing the available water resources and water requirements. The quaternary catchment is the basic unit of area as used in the report *Surface Water Resources of South Africa, 1990 (WR90)* by Midgely et al. (1994), which is the main source of the hydrological data used in this study.

In this system, drainage regions throughout the country are divided into secondary, tertiary and quaternary catchments. The quaternary catchments have been selected to have similar runoffs: the greater the runoff volume the smaller the catchment area and vice versa. The quaternary catchments are numbered alpha-numerically in downstream order. A quaternary catchment number, for example U10E, may be interpreted as follows. The letter U denotes Drainage Region U (sometimes referred to as a primary catchment). The number 1 of 10 denotes secondary sub-catchment 1 of Drainage Region U. The number 0 of 10 denotes that there are no tertiary sub-catchments in secondary sub-catchment 1. The letter E shows that the quaternary catchment is the fifth in sequence downstream from the head of the secondary or tertiary sub-catchment U10.

The Mvoti to Umzimkulu WMA consists of drainage regions U and a portion of Drainage Region T consisting of tertiary catchments T51 and T52 for the Mzimkulu River. Quaternary catchments T40F and T40G are included, incorporating the town of Port Edward.

2.1.1 The Concept of Key Areas Explained

In order to facilitate presentation of data, the concept of Key Areas was introduced. To present data at quaternary catchment level would be tedious and provide a level of detail that was excessive for the aims of this study. Tertiary catchments in some instances cover too large an area thereby not providing enough detail. Thus Key Areas were introduced to provide detail at a level that is consistent with the aims of this study.

Generally, the Key Areas are groupings of quaternary catchments to provide an area between quaternary and tertiary catchment level. Some Key Areas may comprise all the quaternary catchments in a tertiary, or even a small secondary catchment. The quaternaries are selected from a common catchment and combined up to some distinctive or strategic point on the river (called the Key Point) such as a dam or confluence of two tributaries. The Key Point may also be the outlet to sea of a river, or the boundary between two tertiary catchments. Table 2.1.3.1 presents the Key Areas and indicates the quaternary catchments that comprise each Key Area, as well as the Key Point for each Key Area.

TABLE 2.1.3.1: KEY POINTS FOR YIELD DETERMINATION

KEY AREA	KEY POINT	DESCRIPTION OF KEY POINT	COMPRISING QUATERNARIES
Mtamvuna	T40E, T40F, T40G	Outlet to sea	T40A to T40G
Upper Mzimkulu	T51C	Tertiary T51 / T52 border	T51A to T51J
Lower Mzimkulu	T52M	Outlet to sea	T52A to T52M
Upper Mkomazi	U10E	Division into manageable unit	U10A to U10E
Lower Mkomazi	U10M	Outlet to sea	U10F to U10M
Midmar Dam	U20C	Midmar Dam on Mgeni River	U20A to U20C
Mgeni mouth	U20M	Outlet to sea	U20D to U20M
Mdloti Tongati Mhlali	U30B, U30D, U30E	U3 secondary sub-catchment	U30A to U30E
Mvoti Nonati	U40J, U50A	U4 & U5 secondary sub-catchment	U40A to U40J, U50A
Mlazi	U60D, U60E, U60F	U6 secondary sub-catchment	U60A to U60F
Lovu	U70D, U70E, U70F	U7 secondary sub-catchment	U70A to U70F
KZN South Coast	U80A	U8 secondary sub-catchment	U80A to U80L

The Mvoti to Umzimkulu WMA falls mostly into KwaZulu-Natal, with portions of the Mtamvuma, Upper Mzimkulu and Lower Mzimkulu key areas falling into the Eastern Cape.

In tables in this report, sub-totals for the KwaZulu-Natal Province comprise the following Key Areas: Mvoti Nonati, Mdloti Tongati Mhlali, Mgeni Mouth, Midmar, Mlazi, Lovu, Upper Mkomazi, Lower Mkomazi, KZN South Coast, 79 % of Upper Mzimkulu, 53 % of Lower Mzimkulu, and 62 % of Mtamvuma. Sub-totals for the Eastern Cape Province comprise the following Key Areas: 21 % of Upper Mzimkulu, 47 % of Lower Mzimkulu, and 38 % of Mtamvuma.

2.2 CLIMATE

Climatic conditions vary significantly from west (Drakensberg mountain range) to east (Indian Ocean) across the Mvoti to Umzimkulu WMA.

The mean annual temperature ranges between 12 ^{0}C in the west to 20 ^{0}C at the coast with an average annual temperature for the whole WMA of 17 ^{0}C. Maximum daily temperatures are experienced in summer from December to February and minimum daily temperatures in winter during June and July.

Table 2.2.1 below summarises temperature information for January and July.

TABLE 2.2.1: TEMPERATURE DATA

MONTH	MEAN DAILY TEMPERATURES	AVERAGE (^{0}C)	INLAND	COASTAL
			RANGE (^{0}C)	RANGE (^{0}C)
January	Mean temperature	21,9	14 to 22	20 – 25
	Maximum temperature	27,5	19 to 26	26 – 28
	Minimum temperature	16,4	10 to 15	18 – 20
	Diurnal range	11,1	12 to 13	< 10
July	Mean temperature	13,3	2 to 12	14 to >16
	Maximum temperature	20,7	10 to 22	20 to 23
	Minimum temperature	6,0	-5 to 6	8 to > 10
	Diurnal range	14,7	15 to 16	13 – 14

Snowfalls on the Drakensberg mountains between April and September have a significant influence on the climate of the WMA. Frost occurs over the same period in the inland areas. The average number of heavy frost days per annum range from 31 to 60 days for the inland areas to nil for the eastern coastal area.

Figure 2.2.1 shows the rainfall distributions within the WMA.

Rainfall is strongly seasonal with in excess of 80 % of rain occurring as thunderstorms during the period October to March. The peak rainfall months are December to February in the inland areas and November to March at the coast.

Mean annual precipitation ranges from in excess of 1 500 mm in the west to between 800 mm and 1 000 mm in the central area to over 1 000 mm at the coast. Corresponding mean annual runoff figures are 200 mm to 500 mm in the West, (13 % – 33 % of MAP), less than 100 mm in the central region (22 % of MAP) and around 200 mm (20 % of MAP) at the coast.

Overall the MAP is about 960 mm, and the corresponding MAR 192 mm (20 % of MAP).

Annual variability of rainfall is indicated by the historic coefficient of variation of the rainfall record, which ranges from 25 % to 30 % in the inland areas and 20 % to 25 % at the coast.

In accordance with the rainfall pattern, relative humidity is higher in summer than in winter, with the daily mean peak for February ranging from 68 % in the inland areas to greater than 72 % at the coast and the daily mean low in July ranging from 60 % in the inland areas to greater than 68 % at the coast.

Potential mean annual gross evaporation as measured by Class A pan ranges from 1600 mm to 1800 mm in the west to 1400 mm to 1600 mm at the coast. The highest monthly Class A' pan evaporation is in December (200 mm to 220 mm) and the lowest monthly evaporation in June (80 mm to 110 mm).

Mean annual gross Simon's Pan evaporation from the Mvoti to Umzimkulu WMA are shown on Figure 2.2.2.

The median annual gross irrigation requirement (based on rainfall and Class A' pan evaporation records) ranges from 800 to 900 mm per annum inland to less than 800 mm at the coast.

The minimum mean monthly irrigation requirement is in June (ranging from 60 mm to 100 mm). The gross irrigation requirements are based on the assumption of a perennial crop with a uniform crop factor of 0,8. The requirement takes into account effective rainfall plus conveyance losses and spray drift losses that are both assumed as 10 %.

2.3 GEOLOGY

The Mvoti to Umzimkulu WMA is predominantly underlain by strata from the Karoo Supergroup. The strata are mostly of sedimentary origin, and were deposited by various sedimentary agents, ranging from rivers to ice sheets and inland seas, between 200 and 400 million years ago. Capping these sedimentary layers are igneous rocks, which because of their greater resistance to weathering form the high mountains of Lesotho. In geological terms, the deposits are fairly young. The rock types present in the area are mostly sandstones, siltstones and mudrocks, while basalt makes up the highest reaches of the drainage area.

All of the above sedimentary strata have been extensively intruded by dykes and sills of dolerite. The coastal belt consists mostly of consolidated and unconsolidated sediments of Quaternary, Tertiary and Cretaceous age. Underlying the Karoo strata are ancient sequences of sedimentary, intrusive and extrusive rocks.

The local dolerites have been extensively used as road construction material and as concrete aggregate. Coal seams are present in the Ecca Group, but are not mined, while limestone is mined from within the granites near Port Shepstone.

2.4 SOILS

Figure 2.4.1 shows a generalised soil map of the WMA demarcated into some 16 soil groupings as obtained from *Surface Water Resources of South Africa, 1990 (WR90)*. The 16 groupings were derived by the Department of Agricultural Engineering at the University of Natal using a base map which was divided into eighty-two soil types. These soil types were then analysed according to features considered most likely to influence hydrological response viz. Depth, texture and slope.

The following soil types occur in the Mvoti to Umzimkulu WMA:

- Drakensberg Escarpment (western boundary) - Moderate to deep clays on steep terrain.
- Central areas - Moderate to deep clay loams on steep terrain.
  Moderate to deep sandy loams on undulating terrain.
- Coastal belt - Moderate to deep sandy loams on undulating terrain.

It should be noted that the base information for the above work is quite old. More detailed and more reliable information is currently available for detailed planning purposes. The interpretation of the newer data for specific purposes such as run off response or irrigation potential will involve considerable work and was deemed not to be necessary for the purpose of 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 within the region but are organised into distinct communities, largely dependent on the prevailing climatic (especially rainfall) and edaphic (soil) conditions. For the purposes of identifying and managing the heterogeneous range of vegetation within South Africa, we need to be able to recognise relatively homogenous vegetation groups or types. Furthermore, for the recognised groups to be meaningful, it is essential that they are readily apparent and spatio-temporally robust.

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

Table 2.5.1.1: SIMPLIFIED ACOCKS VELD TYPE CATEGORIES

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	

DETAILED VELD TYPES	NO.	SIMPLIFIED VELD TYPE
Other Turf Thornveld	13	
Arid Sweet Bushveld	14	
Mopani Veld	15	
Kalahari Thornveld	16	
Kalahari Thornveld invaded by Karoo	17	
Mixed Bushveld	18	
Sourish Mixed Bushveld	19	
Sour Bushveld	20	
False Thornveld of Eastern Cape	21	**False Bushveld**
Invasion of Grassveld by Acacia karoo	22	
Valley Bushveld	23	**Karoo and Karroid**
Noorsveld	24	
Succulent Mountain Scrub	25	
Karroid Broken Veld	26	
Central Upper Karoo	27	
Western Mountain Karoo	28	
Arid Karoo	29	
Central Lower Karoo	30	
Succulent Karoo	31	
Orange River Broken Veld	32	
Namaqualand Broken Veld	33	
Strandveld	34	
False Arid karoo	35	**False Karoo**
False Upper Karoo	36	
False Karroid Broken Veld	37	
False Central Lower Karoo	38	
False Succulent Karoo	39	
False Orange River Broken Karoo	40	
Pan Turf Veld invaded by Karoo	41	
Karroid Merxmuellera Mountain Veld replaced by	42	
Mountain Renosterveld	43	
Highveld Sourveld and Dohne Sourveld	44	**Temperate and Transitional Forest and Scrub**
Natal Mist Belt 'Ngongoni Veld	45	
Coastal Renosterveld	46	
Coastal Fynbos	47	
Cymbopogon – Themeda Veld	48	**Pure Grassveld**
Transitional Cymbopogon – Themeda Veld	49	
Dry Cymbopogon – Themeda Veld	50	
Pan Turf Veld	51	
Themeda Veld or Turf Highveld	52	
Patchy Highveld to Cymbopogon – Themeda Veld	53	
Turf Highveld to Highland Sourveld Transition	54	
Bakenveld to Turf Highveld Transition	55	
Highland Sourveld to Cymbopogon – Themeda Veld	56	
North-eastern Sandy Highveld	57	
Themeda – Festuca Alpine Veld	58	
Stormberg Plateau Sweetveld	59	
Karroid Merxmuellera Mountain veld	60	
Bankenveld	61	**False Grassveld**
Bankenveld to Sour Sandveld Transition	62	
Piet Retief Sourveld	63	
Northern Tall Grassveld	64	
Southern Tall Grassveld	65	
Natal Sour Sandveld	66	
Pietersburg Plateau False Grassveld	67	
Eastern Province Grassveld	68	
Fynbos	69	**Sclerophyllous Bush**
False Fynbos	70	**False Sclerophyllous Bush**

2.5.2 Natural Vegetation Types within the Mvoti to Umzimkulu WMA

Figure 2.5.2.1 shows the simplified veld types for the area according to Acocks (1998).

The mapping is based on the publication *Surface Water Resources of South Africa, 1990* by Midgely et al. (1994).

The simplified vegetation types prevailing within the Mvoti to Umzimkulu WMA are as follows:

- Western (Drakensberg Escarpment);
  - Pure grassveld changing to temperate and transitional forest and scrub (west to east);
- Central Area;
  - Temperate and transitional forest and scrub incorporating some areas of false grassveld along the main river valleys, changing to coastal tropical forest towards the east;
- Coastal Area;
  - Coastal tropical forest with some areas of karroo and karroid veld along main river valleys.

2.6 ECOLOGICALLY SENSITIVE SITES

2.6.1 Sensitive Ecosystems

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

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

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

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

2.6.2 River Classification

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

The water resources situation assessment has been performed at the quaternary catchment scale of resolution as described in *Surface Water Resources of South Africa, 1990 (WR90).* 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 methods used to estimate the water requirements are described in Section 5.2.

The procedure that has been followed to determine the various classifications is illustrated in Diagram 2.6.2.1 below. The descriptions of the various ecological importance and sensitivity classes (EISC), default ecological management classes (DEMC), default ecological status classes (DESC), present ecological status classes

(PESC) and the suggested future ecological management class (AEMC) are given in Diagram 2.6.2.2.

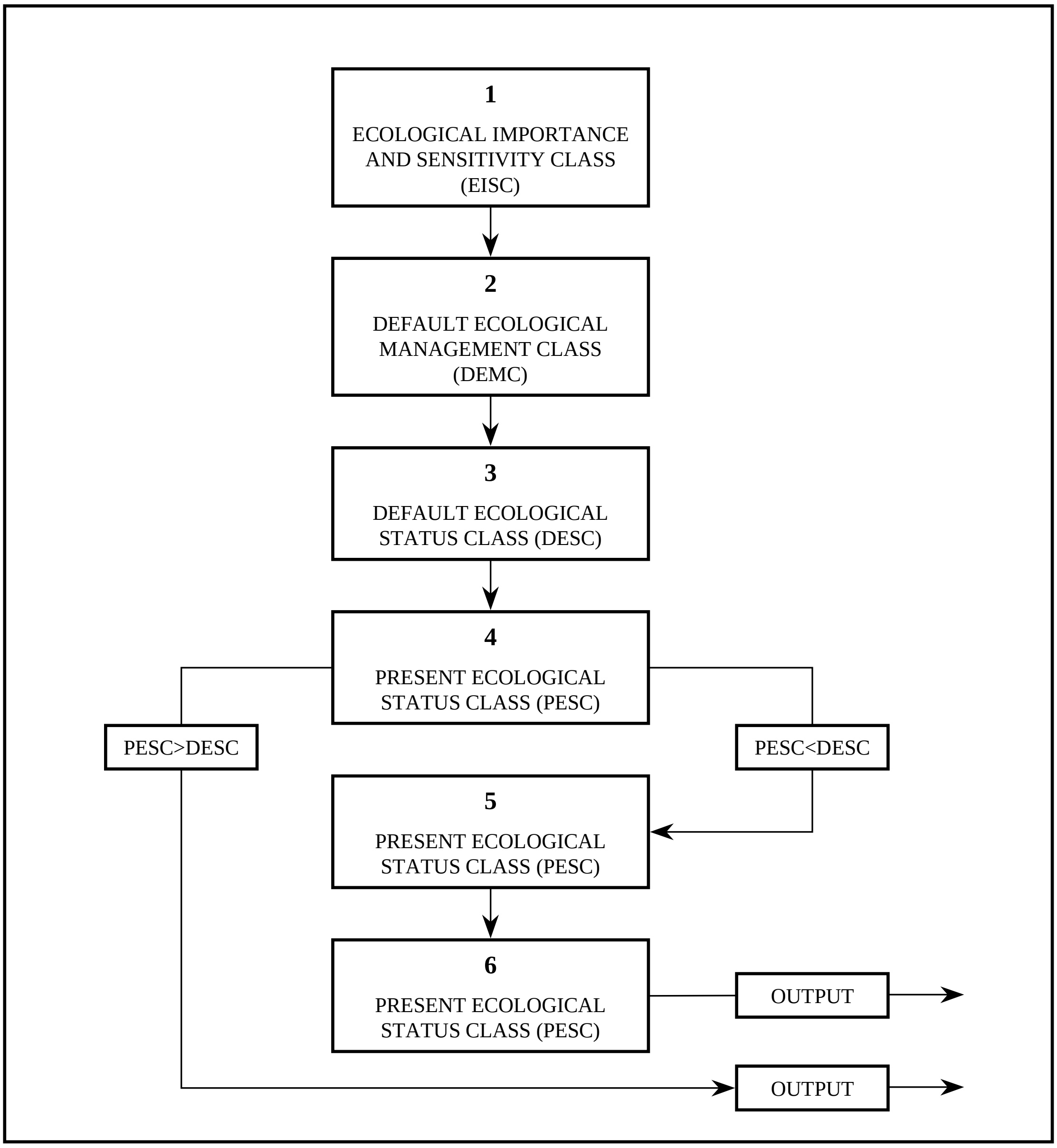

DIAGRAM 2.6.2.1: PROCEDURE FOLLOWED TO DETERMINE THE RIVER CLASSIFICATIONS

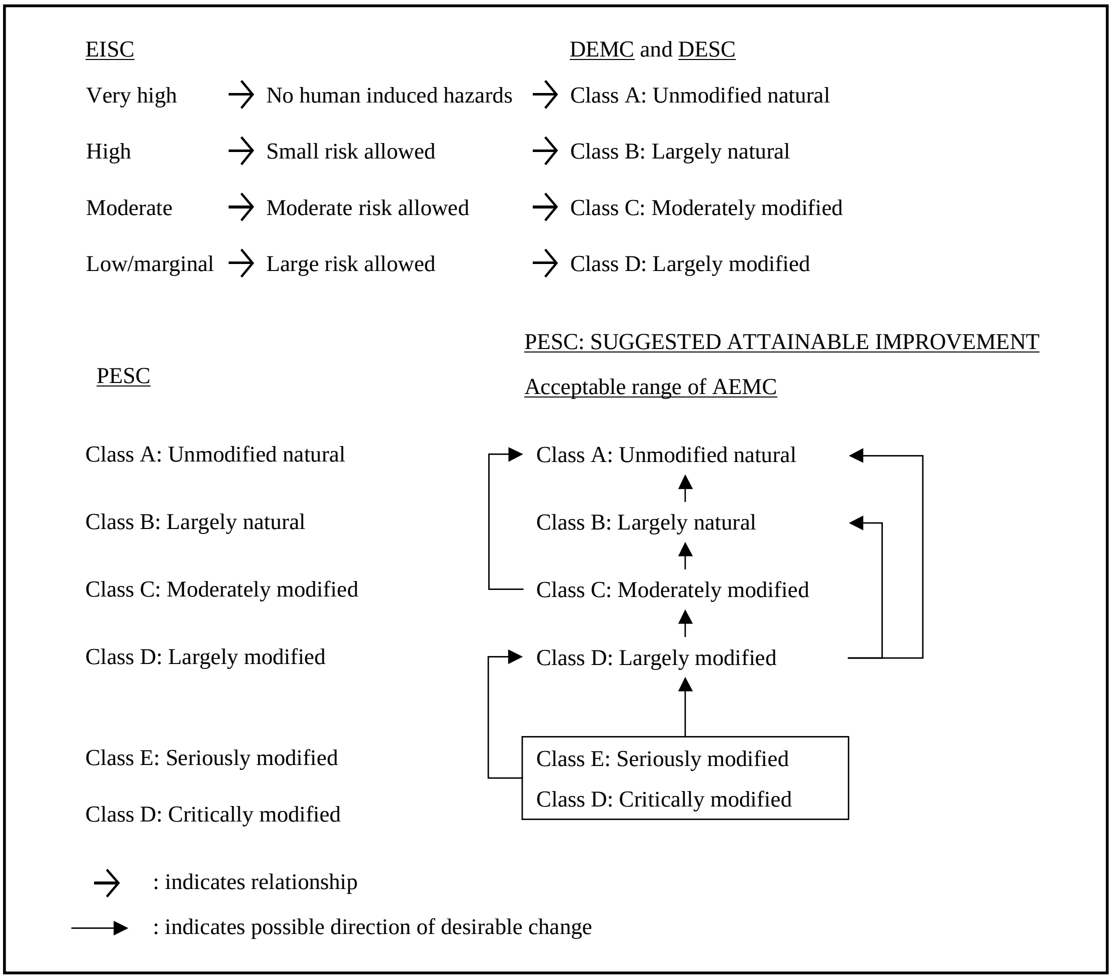

DIAGRAM 2.6.2.2: DESCRIPTIONS OF EISC, DEMC DESC, PESC AND AEMC.

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

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

The ecological importance and sensitivity classes were assessed during meetings and 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 of the original workshop.

The procedure that was adopted to classify the rivers has been 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 has not been 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 must therefore 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 is 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 is to ensure that the ecological component of the Reserve will 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 have fundamentally been 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 do a total assessment of each catchment.
- The riparian zone has broadly been regarded as that part of the river bordering on the river channel. Usually characteristic plant species and/or vegetation structure provided an indication of the extent of the riparian zone.

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

Ecological Importance and Sensitivity Class (EISC)

The following ecological aspects were considered for the estimation of the ecological importance and sensitivity class:

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, intolerant species and species diversity was taken into account for both the instream and riparian components of the river.
- Habitat diversity was also considered. This included specific habitats and river reaches with a high diversity of habitat types such as pools, riffles, runs, rapids, waterfalls and riparian forests.
- The importance of the particular river or stretch of river in providing connectivity between different sections of the river, i.e. whether it provides a migration route or corridor for species.

- The presence of conservation or relatively natural areas along the river section serving as an indication of ecological importance and sensitivity.
- The ecological sensitivity (or fragility) of the system to environmental changes. Both the biotic and abiotic components have been 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 has not been considered when determining the ecological importance and sensitivity *per se.* The ecological importance and sensitivity that has been established for the water resources situation assessments is a general and unrefined estimate. It is strongly biased towards the potential importance and sensitivity of the mainstem river of the quaternary catchment under close to unimpaired conditions.

Present Ecological Status Class (PESC)

Habitat integrity i.e. ecological integrity, condition and change from the natural condition, has been 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 river in the vicinity of the outlet of the quaternary catchment.

Suggested Future Ecological Management Class (AEMC)

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

The practicality of improving an existing modified ecological system to arrive at the suggested future ecological management class has been assessed on the basis of the changes that have occurred, by comparing the difference between the present ecological status and the default ecological status. For the purpose of these water resources situation assessments restoration has been 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 historic 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 what 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.

In the Mvoti to Umzimkulu WMA the rivers can be divided into three groups. The first group is made up of the Umzimkulu and the Mkomazi Rivers, which rise in the high Drakensberg. The Mgeni and Mvoti Rivers, which rise on the Thukela watershed well away from the high Drakensberg, the Fafa River and the Mtamvuna River, which also rise away from the high Drakensberg, make up the second group. The third group is the most numerous and comprises many small rivers along the coast.

The WMA has a very large number of estuaries and coastal lagoons (56 according to Begg, 1978). Despite this only four estuaries/lagoons are included in Table 2.6.4.1. They are the Mvoti estuary (a National Heritage site), Umhlanga lagoon, Mpenjati and Mtamvuna (all Nature Reserves). The Beachwood mangrove forest at the mouth of the Mgeni River is protected. The other 51 estuaries and lagoons are unprotected sensitive areas.

The Mkomazi and Mzimkulu Rivers are the only major rivers that do not have large dams. They are therefore unusual and are of ecological importance for this very reason.

The whole of the high Drakensberg within this WMA lies in a conservation area, the recently consolidated and re-named Ukhahlamba Natal Park. Other conservation areas, which straddle sizeable rivers, are the Karkloof Falls Nature Reserve, Oribi Gorge Nature Reserve and the Mtamvuna Nature Reserve. The rivers they straddle are ecologically sensitive.

There are four wetlands of conservation importance in the Mvoti to Umzimkulu WMA. They are, from east to west, the Mvoti Vlei, the Mgeni Vlei, the Swamp and the Ntsikeni vlei. The Swamp lies on the Pholela River at Richenau Mission some distance downstream of Himeville. The other three wetlands are near or at the sources of the rivers.

Several rivers have large waterfalls, which are barriers to the upstream migration of fish. Noteworthy falls lie in the Karkloof River, the Mgeni River (Howick Falls) and the Mzimkulu River. There are large gorges, with high cliffs below the Karkloof and Howick Falls. The steep slopes and cliffs are important habitats for many forms of wildlife.

The ecological significance/conservation importance of the river systems falling within the Mvoti to Umzimkulu WMA, as exemplified by their Ecological Importance and Sensitivity Classes (EI&SC), is summarised in Figures 2.6.3.1 to 2.6.3.3. These show, respectively for each quaternary catchment, the default ecological management class, the present ecological status class, and the suggested future ecological management class. Definitions of these EI&SC are given in the glossary of terms at the front of this report. The EI&SC of a river is an expression of its importance to the maintenance of ecological diversity and functioning on a local and wider scale, as well as the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred.

The Default Ecological Management Class (Figure 2.6.3.1) of most of the Mvoti to Umzimkulu WMA is "Moderately Modified". The entire Mkomazi River basin is one class better – " Largely Natural". Other quaternary catchments in the Largely Natural Default Ecological Management Class are the Mgeni River between Midmar Dam and Albert Falls Dam, the Karkloof catchment, the lower reaches of the Mtamvuna and Mzimkulu Rivers, two small coastal rivers and quaternary catchments T51A, U20J and U20K. Quaternary catchments T51H (Gungununu River) and T52E and T52F (Bisi River) have a Largely Modified Default Ecological Status Class. The Present Ecological Status Class of these three quaternary catchments (Figure 2.6.3.2) is Moderately Modified. Comparing Figures 2.6.3.1, 2.6.3.2 and 2.6.3.3, the Present Ecological Status Classes of many quaternary catchments are better than the Default Ecological Status Classes but there is a marked increase in the number of quaternary catchments in the Largely Modified class. The suggested Future Ecological Management Classes of large areas are Unmodified, Natural and the number of Moderately Modified and Largely Modified quaternary catchments is very much reduced.

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

As previously alluded to, the sensitive ecosystems outlined above only include those relevant to aquatic ecosystems. However, in addition to these ecosystems the Mvoti to Umzimkulu WMA contains other protected areas, which may be impacted directly or indirectly upon by development activities associated with water resources. These protected areas include Natural Heritage Sites as well as those areas listed in Section 2.6.1, viz. Scientific and Wilderness Areas, National Parks and Equivalent Reserves, Natural Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas and Protected Land/Seascapes.

There are many patches of natural mistbelt forest within the WMA. These are very sensitive areas. Karkloof forest is protected, as is the Boston House Indigenous Forest (Figure 2.6.3.2). The remaining patches of forest are important in conservation as they form refuges where forest plants and animals survive. Each patch of forest contributes to the dispersion of forest life. Hence if one forest disappears, the event has an impact on many forests. The Oribi Gorge Nature reserve is forested.

Appendix A contains a list of the 59 protected areas within the Mvoti to Umzimkulu WMA. All water resource development should take cognisance of these sites and it is the developer's responsibility to identify the exact proximity of activities to any of these sites, and to ensure that activities do not threaten the integrity of these sites. This consideration is particularly pertinent where water resource development activities impact on the supply of water resources to these areas and hence their long-term ecological sustainability.

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

2.7 CULTURAL AND HISTORICAL SITES

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

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

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

Permission for the development to proceed, with respect to their impact on cultural and historical sites 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.

The Mvoti to Umzimkulu WMA has a number of cultural and historical sites incorporating the interests of several of South Africa's cultural groups. **Appendix A** contains a list of protected cultural and historical sites.

CHAPTER 3: DEVELOPMENT STATUS

3.1 HISTORICAL DEVELOPMENT OF WATER RELATED INFRASTRUCTURE

Shongweni Dam in the Mlazi River was built in 1927 to supply water to Durban. In 1994 the FSL was raised by adding gates to the spillway. Development of the Mgeni system started in the 1960's with Henley Dam (1960) in the Msunduze River to supply Pietermaritzburg followed by Midmar (1963), Nagle (1963), Albert Falls (1975) and Inanda (1989) dams all in the Mgeni River that are operated as a system to provide water for Durban-Pietermaritzburg. The Mdloti River was dammed at Hazelmere in 1975 to provide water for irrigation and to the local towns. Mzinto Dam (1984) in the Mzinto River was built to secure water supply to Mzinto and Scottburgh and Gilbert Eyles (1960) in the Mzimkulwana River to supply Port Shepstone. Gilbert Eyles Dam is full of sediment and storage is negligible.

3.2 DEMOGRAPHY

3.2.1 Introduction

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

The study 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 categorised in order to provide a basis for developing estimates of urban water use for the entire country (see Section 5.3).

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

- The Development Bank of Southern Africa.
- The Demographic Information Bureau.

- The Bureau for Market Research.
- Local authority estimates, where available.

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

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

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

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

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

3.2.3 Historical Population Growth Rate

Information on historical growth trends is not available.

3.2.4 Population Size and Distribution in 1995

The population distribution for the Mvoti to Mzimkulu WMA is presented in Table 3.2.4.1 and is illustrated in Figure 3.2.4.1. The population in this WMA is largely urban at 62% of the population.

TABLE 3.2.4.1: POPULATION IN 1995

CATCHMENT						POPULATION IN 1995		
PRIMARY		SECONDARY		KEY AREA				
No.	Description	No.	Description	No.	Description	Urban	Rural	Total
T	MZIMKULU	T4	Mtamvuna			73 200	251 900	325 100
		T5		T51	Upper Mzimkulu	1 450	72 450	73 900
				T52	Lower Mzimkulu	9 500	232 900	242 400
			Sub-total Mzimkulu			10 950	305 350	316 300
	TOTAL IN MZIMKULU					84 150	557 250	641 400
U	MVOTI	U1		U10	Upper Mkomazi	350	44 240	44 590
				U10	Lower Mkomazi	3 700	102 900	106 600
			Sub-total Mkomazi U10			4 050	147 140	151 190
		U2		U20A-C	Midmar	150	19 750	19 900
				U20D-M	Mgeni Mouth	417 400	339 200	756 600
			Sub-total Mgeni U20			417 550	358 950	776 500
		U3	Mdloti / Tongaat	U30		18 250	176 700	194 950
		U4 & U5	Mvoti Nonati	U40 & U50		45 100	292 300	337 400
		U6	Mlaze	U60		2 500 000	75 860	2 575 860
		U7	Lovu	U70		0	56 960	56 960
		U8	KZNSouth Coast	U80		45 100	263 000	308 100
	TOTAL IN MVOTI					3 030 050	1 370 910	4 400 960
	TOTAL IN EASTERN CAPE					32 531	220 335	252 866
	TOTAL IN KWAZULU-NATAL					3 081 669	1 707 825	4 789 494
	TOTAL IN MVOTI TO MZIMKULU WMA					3 114 200	1 928 160	5 042 360

3.3 MACRO-ECONOMICS

3.3.1 Introduction

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

- The present economic development of the Mvoti to Umzimkulu WMA on a sectoral basis, taking into account the context of economic development in South Africa.
- The comparative advantages of the Mvoti to Umzimkulu 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 Mvoti to Umzimkulu WMA was R62bn in 1997. The most important magisterial districts in terms of contribution to GGP in this WMA are shown below:

- Durban 57,5%
- Pietermaritzburg 11,7%
- Pinetown 8,3%
- Inanda 5,0%
- Other 17,5%

Economic Profile

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

- Manufacturing 28,4%
- Trade 19,1%
- Government 14,2%
- Finance 13,9%
- Other 24,4%

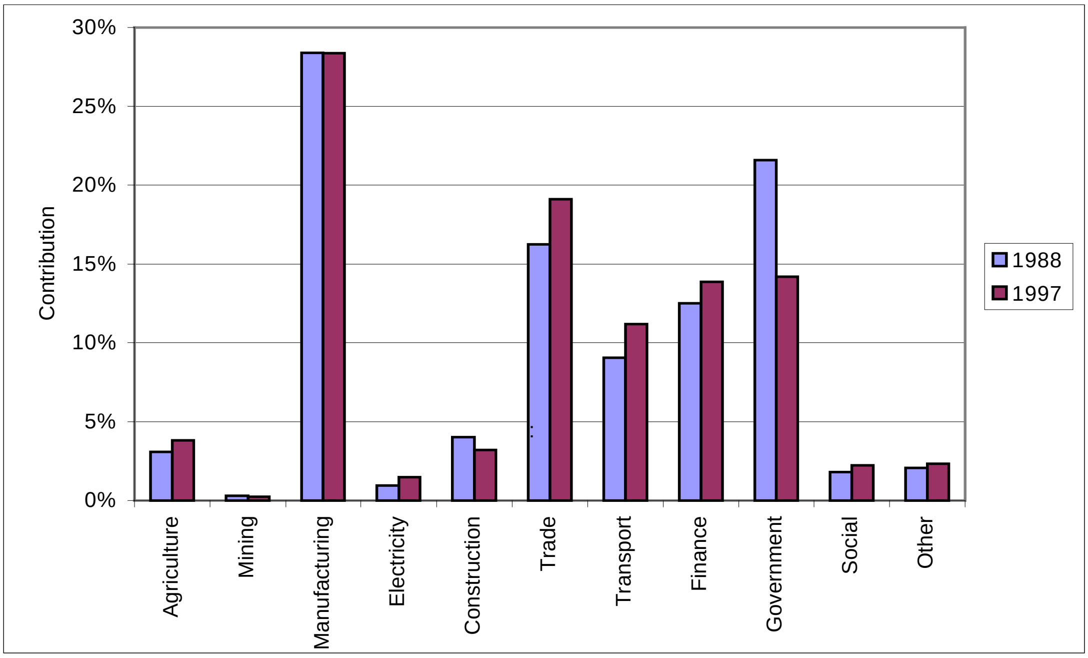

DIAGRAM 3.3.4.1: CONTRIBUTION BY SECTOR TO ECONOMY OF MVOTI TO UMZIMKULU WATER MANAGEMENT AREA, 1988 AND 1997 (%)

The manufacturing sector in this WMA is well developed with a range of activities, which include metal products, machinery, basic steel and non-ferrous metals, soles and leather, food, paper milling etc. Most of the industrial development takes place in the Durban area. Since 1994, the petroleum refineries experienced increasing demand due to growth in the use of petrol and diesel fuel. Durban has become a major production and distribution centre for refined petroleum products. Some of the larger manufacturers in the area include a steel supplier in Morburg and the Sappi Saccor Mill in the Ugu Region. The presence of this mill provides a relatively secure market for private timber growers. The importance of the manufacturing sector is enhanced by the proximity to Eastern Cape Markets, the clustering of firms in subsectors, the natural resource base for industry (timber, sugar, marble and limestone) and the Durban harbour.

The Durban-Pinetown area is the largest commercial centre in this WMA. Commercial activities are concentrated in the Durban CBD area where services such as banking, insurance and other financial activities are well developed. Another important trade node is Stanger/KwaDuze. The informal sector and small, medium and micro size enterprises have become increasingly important, both nationally and regionally. As employment creation by large formal businesses declined, growth of these enterprises has had a positive impact on the trade sector.

The importance of the government and financial sectors could be attributed to the concentration of local government, corporate head offices and military services in the larger urban centres such as Durban and Pietermaritzburg.

Economic Growth

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

Electricity	:	4,5%
Social Services	:	1,8%
Agriculture	:	1,7%
Trade	:	1,7%

The growth in the electricity sector can be attributed to multiple new projects initiated in the area. For example, Durban Electricity, which is the major retailer of electricity in the WMA. The purpose of this project is to connect households to electrical supply. Secondly, major infrastructure projects are undertaken to extend water and waste services and develop new supply and processing facilities.

Growth in the trade sector can be attributed to the development of a number of shopping centres in the area. Examples of such development include the Gateway Shopping Centre, commercial developments in Umhlanga and the Umgeni Business Park.

In the community services sector, growth is mainly the result of a number of projects undertaken such as the new academic hospital for KwaZulu-Natal and the Intersite Empowerment Initiatives which are of projects aimed at creating opportunities for disadvantaged communities.

The growth in the agricultural sector could be ascribed to the performance of specific industries such as sugar, timber, tea and banana production. Areas such as Umbumbulu with its rainfall and high soil fertility could, in future, further increase the quality and quantity of agricultural output.

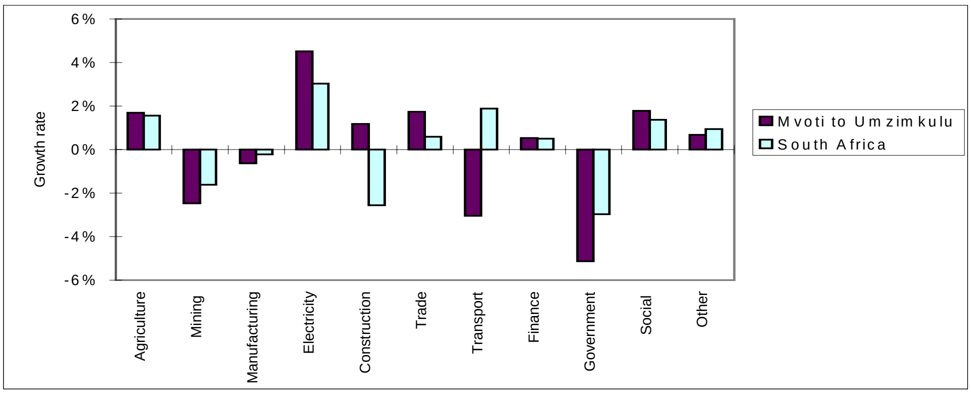

DIAGRAM 3.3.4.2: COMPOUND ANNUAL ECONOMIC GROWTH BY SECTOR OF MVOTI TO UMZIMKULU WATER MANAGEMENT AREA AND SOUTH AFRICA, 1988-1997

Labour

Of the total labour force of 1,4m persons in 1994, 27,9% were unemployed, which is lower than the national average of 29,3%. Fifty seven percent (56,8%) are active in the formal economy. Approximately 35% of the formally employed works in the government sector, while 27,2% are employed in the manufacturing sector and 11,6% in the trade sector.

Employment growth was recorded in the government sector (2,4% per annum); trade sector (2,2% per annum); and the manufacturing sector (1,1% 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 3.3.5.1 shows the location quotients for Mvoti to Umzimkulu WMA. The Diagram shows that, based on the location quotients for 1997, the Mvoti to Umzimkulu WMA economy is relatively more competitive than the remainder of South Africa in the following economic activities:

- Transport : 1,4
- Manufacturing : 1,2
- Trade : 1,19
- Construction : 1,1.

The comparative advantage of the manufacturing sector can be ascribed to the diversity of industrial activities in this WMA. A variety of industrial activities have been identified, e.g. soles and leather, food, paper products, textiles, metal products, sappie paper mill, etc. The Ugu Region also benefits from the presence of a few large manufacturers and wholesalers in the clothing sector, the food and beverages sector, while the presence of the Sappi-Saccor Mill provides a secure market for private timber growers.

The comparative advantage of the trade sector can be ascribed to well developed commercial centres, in areas such as Durban, Pietermaritzburg and Stanger. The tourism industry is well developed and contributes to the comparative advantage of the trade sector.

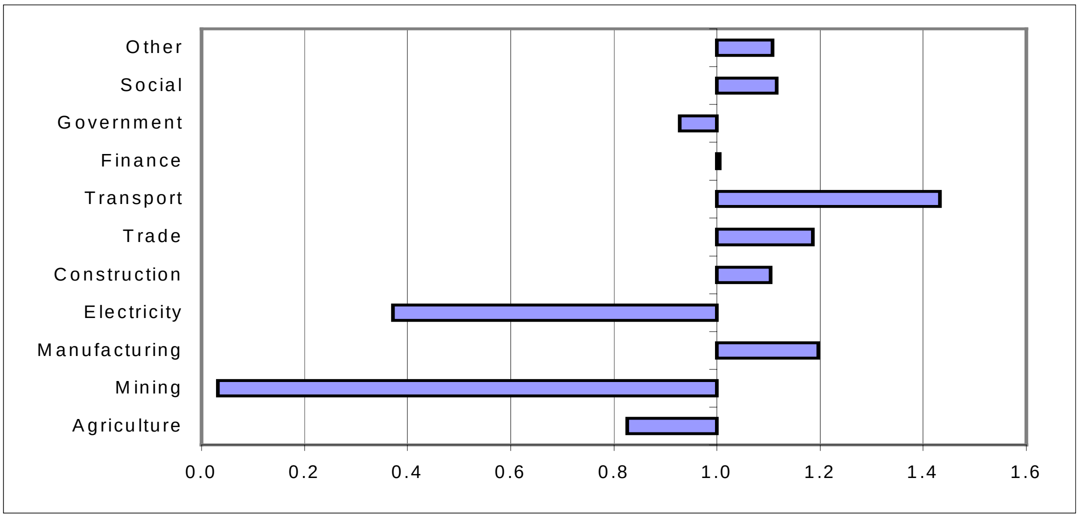

DIAGRAM 3.3.5.1: MVOTI TO UMZIMKULU GROSS GEOGRAPHIC PRODUCT LOCATION QUOTIENT BY SECTOR, 1997

The comparative advantage of the construction sector is the result of new housing programmes that set out to address the housing backlog.

The transport sector's significance can be attributed to the N3 leading into the area as well as to import and export activities through the Durban harbour and the associated warehousing and distribution networks.

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 summarised as follows:

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

3.4.3 Strategies

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

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

3.4.4 Environmental Protection

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

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

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

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

3.4.5 Recognition of Entitlements

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

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

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

3.4.6 Licensing

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

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

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

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

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

Compensation must be claimed from the Water Tribunal.

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

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

3.4.7 Other legislation

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

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

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

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

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

These Acts are the following:

Physical Planning Act (Act No. 125 of 1991)

Under this act no land use, development or subdivision may be permitted unless in accordance with an approved plan.

Development Facilitation Act (Act No. 67 of 1995)

This act prescribes the set of principles with which all development projects and all land use and land use planning should comply, and which will serve as guidelines for the administration of land use and development schemes.

Restitution of Land Rights (Act No. 22 of 1994)

This act is aimed at the restitution of land to those who have been deprived thereof in terms of discriminatory laws. Claims are lodged with the Land Claims Commission. It is because of this act that when a transfer of water entitlements is approved in terms of the NWA an indemnity is required from the transferor that a claim was not lodged against the land in terms of the Restitution of Land Rights Act.

Environmental Conservation Act (Act No. 73 of 1989)

This act provides for the effective protection and control of the environment. It makes provision for the declaration of an environmental conservation policy.

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

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

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

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

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

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

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

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

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

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

Conservation of Agriculture Resources Act (Act No. 43 of 1983)

This act is to provide for control over the utilisation of the natural agricultural resources in order to promote the conservation of the soil; the water resources and vegetation and the combating of weeds and invader plants. Except for weeds and invader plants, this act does not apply to land in an urban area.

3.4.8 Institutions Created Under the National Water Act

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

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

A second institution, is that of Water User Associations (WUA) that will operate on a restricted local level and are in effect cooperative associations of individual water uses who wish to undertake related water activities for a mutual benefit. Irrigation Boards established under the Water Act of 1956 had until 29 February 2000 to transform into a

WUA. All 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.

The 5 district councils, 27 magisterial districts that comprise each district council, 18 irrigation boards and 30 Transitional Local Councils can be found in Appendix C. There are no Transitional Regional Councils in the Mvoti to Mzimkulu WMA, but the Durban Metro is included in this WMA. Figure 3.4.8.1 illustrates the district councils and magisterial districts. Figure 3.4.8.2 indicates the institutional boundaries related to water supply.

3.5 LAND-USE

3.5.1 Introduction

Section 3.5 gives an overview of land use for afforestation, irrigation, stock and game farming, nature reserves, urban areas, rural settlements, mining and industry. The extent of alien vegetation is also described.

Table 3.5.1.1 summarises the land use described in the rest of this chapter. Table 3.5.1.2 lists the same land use, but grouped per District Council instead of Key Area. The largest listed land uses in this WMA are for dryland sugarcane and afforestation, followed by nature reserves. The predominant irrigated crops in this WMA are sugarcane and dairy pastures. The Mvoti to Mzimkulu WMA contains some large urban centres including the Greater Durban Metropolitan area and the city of Pietermaritzburg. In general, the size of the urban areas are small in comparison to the rural areas.

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

KEY AREA	IRRIGATION FIELD AREA	IRRIGATION CROP AREA	DRYLAND SUGAR CANE	AFFORESTATION	INDIGENOUS FORESTS	ALIEN VEGETATION	NATURE RESERVES *	URBAN	RURAL SETTLEMENTS	OTHER	TOTAL **
Mtamvuna	6,9	7,0	231,0	151,6	68,1	133,5	51,96	23,1	453,41	1096,4	2216,0
Upper Mzimkulu	21,0	25,4	0,0	73,0	35,4	23,8	491,14	2,1	177,70	1921,9	2746,0
Lower Mzimkulu	38,7	42,0	179,0	510,7	87,5	229,7	19,68	6,3	463,35	2397,0	3932,0
Upper Mkomazi	18,4	22,0	0,0	26,7	11,3	20,2	707,34	0,0	122,37	834,7	1741,0
Lower Mkomazi	57,8	57,8	75,6	337,8	41,6	23,6	0,00	7,2	388,46	1713,9	2646,0
Midmar	42,6	42,6	0,0	124,7	24,7	20,8	37,75	3,4	20,27	650,9	925,0
Mgeni Mouth	52,1	55,2	580,4	404,3	82,2	60,6	49,13	225,1	563,82	1496,4	3514,0
Mdloti Tongati Mhlali	50,9	50,9	506,8	4,0	9,6	76,5	7,47	17,4	482,52	154,8	1310,0
Mvoti Nonati	71,9	72,7	369,7	576,3	10,1	156,3	7,19	14,4	705,02	1124,1	3035,0
Mlazi	42,5	42,5	338,6	101,4	9,0	40,6	3,20	246,8	191,81	549,1	1523,0
Lovu	16,2	19,0	274,3	206,3	8,8	22,3	0,00	25,0	311,70	225,5	1090,0
KZN South Coast	13,4	13,4	399,0	218,4	14,3	43,7	22,45	25,1	893,98	906,8	2537,0
TOTAL	432,4	450,5	2 954,4	2 735,3	402,5	851,4	1 397,31	595,9	4 774,4	13071,5	27215,0

* The following attributes, taken from the Consgeo coverage supplied by DWAF, were used to calculate the area of nature reserves in the Mvoti to Mzimkulu WMA: Game Reserves, National, Nature Reserve, Provincial, S/F Nature Reserve
** Total does not include ‘Irrigation Crop Area’.

TABLE 3.5.1.2: LAND USE BY PROVINCE AND DISTRICT COUNCIL AREA IN KM^2

DISTRICT COUNCILS IN KWAZULU-NATAL	IRRIGATION FIELD AREA	IRRIGATION CROP AREA	DRYLAND SUGAR CANE	AFFORESTATION	INDIGENOUS FORESTS	ALIEN VEGETATION	NATURE RESERVES*	URBAN AREAS	RURAL SETTLEMENTS	OTHER	TOTALS **
SPLIT BETWEEN DISTRICT COUNCILS											
RC5 INDLOVU***	280,5	294,3	1 296,6	1 935,2	209,6	295,7	1 286,4	126,0	1 558,8	7 079,1	14 068,0
RC6 ILEMBE***	60,0	60,8	688,3	25,0	11,8	59,2	7,2	90,4	1 214,2	923,7	3 079,8
RC7 UGU	35,1	36,4	805,5	461,8	80,4	258,2	79,6	54,2	1 497,0	2 181,5	5 453,4
RC8 DURBAN METRO	37,0	37,0	164,1	3,2	1,3	88,9	8,6	324,9	182,7	533,4	1 344,1
WILD COAST***	19,8	21,9	0,0	310,1	99,4	149,3	15,5	0,3	321,8	2 353,6	3 269,7
SPLIT BETWEEN PROVINCES											
KWAZULU-NATAL	407,1	422,7	2 782,8	2 422,5	328,1	688,1	1 262,8	583,7	4 347,0	10 983,6	23 940,4
EASTERN CAPE	25,3	27,8	171,6	312,7	74,5	163,5	0,0	12,2	427,5	2 087,6	3 274,6
TOTAL AREA (km2)	432,4	450,5	2 954,5	2 735,3	402,5	851,4	1 262,8	595,8	4 774,4	13 071,2	27 215,0

* The following attributes, taken from the Consgeo coverage supplied by DWAF, were used to calculate the area of nature reserves in the Mvoti to Mzimkulu WMA: Game Reserves, National, Nature Reserve, Provincial, S/F Nature Reserve
** Total does not include ‘Irrigation Crop Area’.
*** These District Councils extend into other WMAs. The values given in this table indicate only those areas within the Mvoti to Mzimkulu WMA.

3.5.2 Irrigation

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

TABLE 3.5.2.1: IRRIGATION LAND USE

CATCHMENT						IRRIGATED AREA BY CROP CATEGORY (km^2)				
PRIMARY		SECONDARY		KEY AREA						
No	Description	No	Description	No	Description	Perennial	Summer	Winter	Undifferentiated	Total
T	MZIMKULU	T4	Mtamvuna			6,8	0,1	0,1	0,0	7,0
				T51	Upper Mzimkulu	16,5	4,4	4,4	0,0	25,4
				T52	Lower Mzimkulu	35,5	3,3	3,3	0,0	42,0
		T5	Subtotal Mzimkulu			52,0	7,7	7,7	0,0	67,4
	TOTAL IN MZIMKULU					58,8	7,8	7,8	0,0	74,4
U	MVOTI			U10	Upper Mkomazi	14,9	3,5	3,5	0,0	22,0
				U10	Lower Mkomazi	54,9	0,0	0,0	3,0	57,8
		U1	Sub-total Mkomazi			69,8	3,5	3,5	3,0	79,8
				U20	Midmar	40,3	0,0	0,0	2,2	42,6
				U20	MgeniMouth	26,2	3,1	3,1	22,7	55,2
		U2	Sub-total Mgeni			66,5	3,1	3,1	25,0	97,8
		U3	Mdloti Tongati Mhlali			50,9	0,0	0,0	0,0	50,9
		U4 U5	Mvoti Nonati			71,2	0,8	0,8	0,0	72,7
		U6	Mlazi			27,6	0,0	0,0	14,9	42,5
		U7	Lovu			13,3	2,9	2,9	0,0	19,0
		U8	KZN South Coast			13,4	0,0	0,0	0,0	13,4
	TOTAL IN MVOTI					312,7	10,3	10,3	42,8	376,1
	TOTAL IN EASTERN CAPE					22,8	2,5	2,5	0,0	27,8
	TOTAL IN KWAZULU-NATAL					348,7	15,6	15,6	42,8	422,7
	TOTAL IN MVOTI TO MZIMKULU WMA					371,5	18,1	18,1	42,8	450,5

* The predominant method of irrigation in this WMA is by sprinkler systems.

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 predominant method of irrigation in the Mvoti - Mzimkulu WMA is by overhead sprinkler – commonly used for maize, wheat and pastures. Micro jet systems are usually used for irrigation of bananas. Drip irrigation is often used for fruit trees. Sugar cane irrigation generally comprises 20% flood irrigation and 80% sprinklers.

It is generally recognised that future growth in irrigation will be severely limited by the availability of water. In more water-scarce areas it may even become necessary to curtail some irrigation to meet the growing requirements of domestic and urban water use. In order to do this it will be necessary to base such decisions on sound economic principles that include the economic return per unit of water. Although acknowledged to be fairly generalised, only three income categories of irrigated crops, namely low, medium and high have been 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 and wheat.
Medium	Vegetables, sugarcane and dairy pastures.
High	Citrus, bananas and sugarcane.

*The predominant crops in the Mvoti - Mzimkkulu WMA are sugarcane and dairy pastures, followed by maize and wheat. The other crops such as vegetables, citrus and bananas are grown in small quantities.

The above categories include for double cropping of the different crop types where appropriate. The information on crop areas and irrigation was obtained from: Midgely et al (1994); DWAF (1990); DWAF and Umgeni Water (1994); DWAF and Southern Natal JSB (1995); DWAF (1998a); DWAF and Umgeni Water (1998); DWAF and Umgeni Water (1999a). Input was also received from: Clive Arendse, personal communication, Durban, 12/06/2000; James Perkins, personal communication, Durban, 15/03/2000; Stephen Mallory, personal communication, Pretoria, various dates; and T. Erasmus, personal communication, Howick, 16/09/1998.

3.5.3 Dryland Farming

Except for sugarcane, the water use of all dryland crops produced in South Africa has been 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 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. Dryland sugarcane covers 2954,4 km^2 of land in this WMA. Information on other dryland crops in the Mvoti to Mzimkulu WMA is not readily available.

The existing dryland sugarcane areas per key area are shown in Table 3.5.3.1. Figure 3.5.2.1 shows the dryland sugarcane areas per key area.

TABLE 3.5.3.1: AREAS OF DRYLAND CROPS

CATCHMENT						DRYLAND CROPS (km^2)
PRIMARY		SECONDARY		KEY AREA		
NO.	DESCRIPTION	NO.	DESCRIPTION	NO.	DESCRIPTION	SUGAR CANE
T	MZIMKULU	T4	Mtamvuna			231,0
				T51	Upper UMzimkulu	0,0
				T52	Lower Mzimkulu	179,0
		T5	Subtotal Mzimkulu			179,0
	TOTAL IN MZIMKULU					410,0
U	MVOTI			U10	Upper Mkomazi	0,0
				U10	Lower Mkomazi	75,6
		U1	Sub-total Mkomazi			75,6
				U20	Midmar	0,0
				U20	Mgeni Mouth	580,4
			Sub-total Mgeni			580,4
		U3	Mdloti Tongati Mhlali			506,8
		U4 & U5	Mvoti Nonati			369,7
		U6	Mlazi			338,6
		U7	Lovu			274,3
		U8	KZN South Coast			399,0
	TOTAL IN MVOTI					2 544,4
	TOTAL IN EASTERN CAPE					171,6
	TOTAL IN KWAZULU-NATAL					2 782,8
	TOTAL IN MVOTI TO MZIMKULU WMA					2 954,4

3.5.4 Livestock and Game Farming

Figure 3.5.4.1 indicates livestock numbers and Table 3.5.4.1 lists Equivalent Live Stock Units for this WMA. Cattle are the predominant livestock in KwaZulu-Natal, but only the third most predominant livestock in the Eastern Cape. Sheep followed by goats are the most predominant livestock in the Eastern Cape. Pigs and goats feature quite prominently in KwaZulu-Natal when compared with other provinces. There are few sheep compared with other provinces. KwaZulu-Natal has the largest number of donkeys and mules, and the third largest number of horses compared with the other provinces. The Eastern Cape has the largest number of horses compared with other provinces. (Information from the National Department of Agriculture Directorate: Veterinary Services. Data received were not official census figures, but figures collected by state veterinarians and animal health technicians in the field during 1999.)

There are no game or nature reserves found in the Eastern Cape portion of this WMA. With just over 5% of the land surface area in KwaZulu-Natal dedicated to game and nature reserves, wild game contributes significantly to the animal population in KwaZulu-Natal. All of the big five game (lion, leopard, rhino, elephant, buffalo) can be found in KwaZulu-Natal, with elephant and lion not confirmed in the Mvoti to Mzimkulu WMA. Small game and buck abound in the reserves. As some game reserves are unsure of certain of their game populations, numbers of game are not readily available. The impact of game on the water balance is considered small enough not to warrant more detailed information. (Information obtained from personal communications via fax with numerous Game Parks.)

TABLE 3.5.4.1: LIVESTOCK AND GAME

CATCHMENT							NO. OF ELSU*
PRIMARY		SECONDARY		KEY AREA			
No	Description	No	Description	No	Description	Area (km^2)	
T	MZIMKULU	T4	Mtamvuna			2 216	70 210
				T51	Upper Mzimkulu	2 746	75 360
				T52	Lower Mzimkulu	3 932	65 780
		T5	Subtotal Mzimkulu			6 678	141 140
	TOTAL IN MZIMKULU					8 894	211 350
U	MVOTI			U10	Upper Mkomazi	1 741	54 800
				U10	Lower Mkomazi	2 646	94 070
		U1	Sub-total Mkomazi			4 387	148 870
				U20	Midmar	925	52 570
				U20	Mgeni Mouth	3 514	111 600
		U2	Sub-total Mgeni			4 439	164 170
		U3	Mdloti Tongati Mhlali			1 310	29 330
		U4 U5	Mvoti Nonati			3 035	76 840
		U6	Mlazi			1 523	38 640
		U7	Lovu			1 090	37 620
		U8	KZN South Coast			2 537	74 360
	TOTAL IN MVOTI					18 321	569 830
	TOTAL IN EASTERN CAPE					3 275	73 676
	TOTAL IN KWAZULU-NATAL					23 940	707 504
	TOTAL IN MVOTI TO MZIMKULU WMA					27 215	781 180

* ELSU conversion factors can be found in Appendix D

3.5.5 Afforestation and Indigenous Forests

The total afforested area in the catchment is approximately 3 138 km^2 comprising approximately 2 735 km^2 of exotic plantation and 402 km^2 of indigenous forest. The spatial distribution of exotic plantation and indigenous forest is presented in Table 3.5.5.1.

TABLE 3.5.5.1: AREAS OF AFFORESTATION AND INDIGENOUS FOREST

CATCHMENT						AREAS OF AFFORESTATION				AREAS OF INDIGENOUS FOREST (km²)
PRIMARY		SECONDARY		KEY AREA						
NO	DESCRIPTION	NO.	DESCRIPTION	NO.	DESCRIPTION	EUCALYPTUS (km²)	PINE (km²)	WATTLE (km²)	TOTAL (km²)	
T	MZIMKULU	T4	Mtamvuna			35,3	115,2	1,1	151,6	68,1
				T51	Upper UMzimkulu	1,7	71,3	0,0	73,0	35,4
				T52	Lower Mzimkulu	230,1	267,1	13,5	510,7	87,5
		T5	Subtotal Mzimkulu			231,9	338,3	13,5	583,7	123,0
	TOTAL IN MZIMKULU					267,1	453,6	14,6	735,3	191,1
U	MVOTI			U10	Upper Mkomazi	0,0	26,7	0,0	26,7	11,3
				U10	Lower Mkomazi	162,8	157,4	17,6	337,8	41,6
		U1	Sub-total Mkomazi			162,8	184,2	17,6	364,5	52,9
				U20	Midmar	52,9	70,9	0,9	124,7	24,7
				U20	Mgeni Mouth	97,4	194,6	112,3	404,3	82,2
			Sub-total Mgeni			150,3	265,5	113,2	529,0	106,9
		U3	Mdloti Tongati Mhlali			0,6	1,2	2,2	4,0	9,6
		U4 & U5	Mvoti Nonati			120,7	119,6	336,0	576,3	10,1
		U6	Mlazi			28,9	47,5	25,0	101,4	9,0
		U7	Lovu			150,7	20,9	34,6	206,3	8,8
		U8	KZN South Coast			213,2	0,0	5,2	218,4	14,3
	TOTAL IN MVOTI					827,1	639,0	533,8	1 999,9	211,5
	TOTAL IN EASTERN CAPE					121,7	184,3	6,7	312,7	74,5
	TOTAL IN KWAZULU-NATAL					972,5	908,3	541,7	2 422,5	328,1
	TOTAL IN MVOTI TO MZIMKULU WMA					1 094,3	1 092,5	548,4	2 735,2	402,6

3.5.6 Alien Vegetation

The impacts of the widespread infestations by alien plants in South Africa are increasingly recognised. The total incremental water use of invading alien plants was estimated at 3 300 million m³/a by Le Matre et al. (1999) but this estimate is not widely recognised by the water resources planning community. This estimate is almost twice as high as the estimate for stream flow reduction resulting from commercial afforestation. Le Matre et al. (1999) estimate that the impact will increase significantly in the next 5 to10 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.

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

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

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

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 data base on alien vegetation infestation have been highlighted by Görgens (1998):

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

- Riparian infestation identification in a particular catchment with the simple statement: "all rivers are invaded". In these cases, all the river lengths appearing in the particular coverages were assigned a uniform infested "buffer" strip of specific width, say 20m.
- Small rivers not reflected on the smaller scale mapping were not accounted for and therefore infestation along these particular rivers was not mapped or quantified.

Figure 3.5.6.1 indicates alien vegetation infestation. Table 3.5.6.1 indicates the infestation by alien vegetation in terms of the condensed area. The condensed area is obtained by multiplying the actual area covered by alien vegetation by a scaling factor. The relationships, as defined by the CSIR, between density class, canopy cover, and scaling factor are the following:

DENSITY CLASS	CANOPY COVER %	SCALING FACTOR
Rare	< 0,1	0,0001
Occasional	< 5	0,025
Scattered	5 – 25	0,15
Moderate	25 – 75	0,50
Dense	> 75	0,875

TABLE 3.5.6.1: INFESTATION BY ALIEN VEGETATION

CATCHMENT						CONDENSED AREA OF ALIEN VEGETATION (km^2)
PRIMARY		SECONDARY		KEY AREA		
No.	Description	No.	Description	No.	Description	
T	MZIMKULU	T4	Mtamvuna			133,5
				T51	Upper UMzimkulu	23,8
				T52	Lower Mzimkulu	229,7
		T5	Subtotal Mzimkulu			253,5
	TOTAL IN MZIMKULU					387,0
U	MVOTI			U10	Upper Mkomazi	20,2
				U10	Lower Mkomazi	23,6
		U1	Sub-total Mkomazi			43,8
				U20	Midmar	20,8
				U20	Mgeni Mouth	60,6
			Sub-total Mgeni			81,3
		U3	Mdloti Tongati Mhlali			76,5
		U4 & U5	Mvoti Nonati			156,3
		U6	Mlazi			40,6
		U7	Lovu			22,3
		U8	KZN South Coast			43,7
	TOTAL IN MVOTI					464,4
	TOTAL IN EASTERN CAPE					163,5
	TOTAL IN KWAZULU-NATAL					687,9
	TOTAL IN MVOTI TO MZIMKULU WMA					851,4

3.5.7 Urban Areas

The extent of land use for urban areas within the Mvoti - Mzimkulu WMA is summarised in Table 3.5.7.1.

TABLE 3.5.7.1: PERCENTAGE OF LAND AREA COVERED BY URBAN DEVELOPMENT

KEY AREA	URBAN AREAS (km^2)	GROSS AREA OF SUBCATCHMENT (km^2)	URBAN AREAS (% of total area)
Mtamvuna	23,1	2 216	1,04
Upper Mzimkulu	2,1	2 746	0,08
Lower Mzimkulu	6,3	3 932	0,16
Upper Mkomazi	0,0	1 741	0,00
Lower Mkomazi	7,2	2 646	0,27
Midmar	3,4	925	0,37
Mgeni Mouth	225,1	3 514	6,41
Mdloti Tongati Mhlali	17,4	1 310	1,33
Mvoti Nonati	14,4	3 035	0,48
Mlazi	246,8	1 523	16,20
Lovu	25,0	1 090	2,30
KZN South Coast	25,1	2 537	0,99
TOTAL	5 95,9	27 215	2,19

The Mvoti to Umzimkulu WMA has the highest degree of urbanisation in KwaZulu-Natal. The Greater Durban Metropolitan area (Mlazi River key area) comprises the magisterial districts of Camperdown, Chatsworth, Durban, Inanda, Pinetown, Umbumbulu and Umlazi with a total population of 2,42 million people. The city of Pietermaritzburg and the towns of Richmond, Howick and Ballito fall into the Mgeni Mouth key area with a combined population of 0,431 million people. The only urban area in the Upper Mkomazi key area is Impendle with a population of 350 people. The largest centres can be located in Figure 3.5.2.1.

3.6 MAJOR INDUSTRIES AND POWER STATIONS

The major industries in the Mvoti - Mzimkulu WMA are presented according to the urban centres in Table 3.6.1, and can be located in Figure 3.5.2.1. Power stations are listed in Table 3.6.2 and additional data can be found in Table 3.6.3.

TABLE 3.6.1: MAJOR INDUSTRIES*

PLACE	QUATERNARY	INDUSTRY
Umzinto	T52K	Tweefontein Timbers
Umzinto	T52M	CG Smith sugar mill Sinina Cement factory Umzinto Carbonates
Scottburgh	U10M	Sappi Saicor pulp mill
Pietermaritzburg / Howick	U20E	Agryl Poultry Stock Owners Feed Lot Triple A Feedlot
Pietermaritzburg	U20J	Tanners (Edendale & Sutherland)
Umhlanga Rocks	U30D	Tongaat Hulett Maidstone sugar mill
Umvoti	U40J	Gledhow sugar Mill Glendale sugar Mill
Durban	U60E	AECI chemicals
Sezela	U80H	CG Smith sugar mill
Camperdown	U60F	Anglovaal - Feralloys Ltd

* Data from Midgely et al (1994) adjusted according to DWAF (1990); DWAF and Umgeni Water (1994); DWAF and Umgeni Water (1994); DWAF and Southern Natal JSB (1995); DWAF and Umgeni Water (1998); DWAF and Umgeni Water (1999a).

TABLE 3.6.2: POWER STATIONS

QUATERNARY CATCHMENT	NAME	TYPE	GENERATING CAPACITY (MW)	OWNER
U20E	Dunlop Howick Hydropower station	Hydropower	0,5	BTR – Sarmcol

TABLE 3.6.3: POWER STATION DETAILS

CHARACTERISTIC	STATION
	Dunlop Howick Hydro power station
Quat No.	U20E
Locality Lat. Long.	29°29’10” S 30°14’10” E
Rated capacity (MW)	0,5 MW
Peak capacity (generator limitation)	0,5 MVA
Rated head	90 m
Load factor	90 %
Amount of water	22,4 million m^3/a (0,71 m^3/s)
Water abstraction	From Midmar Dam (U20C)
Water return	Between Howick Falls and Albert Falls dams

The Dunlop Howick Hydropower Station abstracts 22,4 million m^3/a of water from Midmar Dam (Midmar key area) and returns it to the Mgeni River between Howick Falls and Albert Falls dams (Mgeni Mouth key area).

3.7 MINES

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.

The main product of the mining industry in the Mvoti to Mzimkulu Water Management Area is sand, followed by quartzite. No precious metals and minerals, energy commodities or ferrous and non-ferrous metals are mined in this WMA.

Table 3.7.1 presents the list of mines registered with the Department of Minerals and Energy (DME) as mining the commodities listed in the table. No data on precise location (latitude and longitude) was available from the DME. Therefore only some operating mines in the Mvoti to Mzimkulu WMA are shown on Figure 3.7.1.

TABLE 3.7.1: ACTIVE MINES*

NAME OF MINE	OWNER	COMMODITY	MAGISTERIAL DISTRICT	NAME OF FARMS	TYPE OF MINING
Avoca I	Corobrik (Pty) Ltd	Clay	Durban	Let Option Site No 16038	Surface
North Coast Road Quarry	Corobrik (Pty) Ltd	Clay	Durban	Farm Durban North; Lot 3256	Surface
Ideal Brick (Pty) Ltd	Ideal Brick (Pty) Ltd	Clay Shale Coal Sand	Inanda	Cotton Lands 1575	Opencast
Dorning Crushers	Dorning Crushers	Dolerite	Mount Currie	Badfontein 241 Ptn 9 & 10	Opencast
Ixopo Quarries	Ixopo Quarries (Pty) Ltd	Dolerite	Ixopo	Ellerton 2226 Sub 26	Opencast Surface
Willowfountain Quarries	Q And M Holdings	Dolerite Shale	Pietermaritzburg	& Rem Of 8 Wilgefontein 869 Sub 240; 234	Opencast Surface
Alpha Stone Pietermaritzburg	Alpha (Pty) Ltd	Dolerite Shale Soil	Pietermaritzburg	Natal Crushers 14967	Surface
South Coast Stone Crushers	South Coast Stone Crushers (Pty) Ltd	Dwyka	Port Shepstone	Remainder Lot 16 Marburg 5152	Surface
Rmm - Ridgeview Quarry	Lafarge South Africa	Dwyka Quartzite Soil	Pinetown	Bellair 823 Cato Manor 812	Opencast
Margate Quarry	South Coast Stone Crushers (Pty) Ltd	Dwyka Refuse Quartzite Sand Sandstone Soil Andesite	Port Shepstone	Bakeberg 14348 Plot 11 & 16 Uvongo Lot 2000 & 2005	Opencast
Stanger Quarry	Bay Stone Sales (Pty) Ltd	Dwyka Sand	Lower Thukela	Nowoti 15345	Surface
Umlaas Road Crushers	Alpha Ltd	Dwyka Sand	Camperdown	Dadelfontein 885 Vaalkop	Surface
Zululand Quarries	Zululand Quarries (Pty) Ltd	Dwyka Sand	Lower Thukela	Thorny Park Estates 2621	Opencast Surface
Scottsburgh Quarry	Lewarne	Dwyka Soil	Umzinto	Amahlongwa Mission Reserve No.8317 D1/42-23/254	Surface
Natal Granite Quarries (Pty) Ltd	Kelgran Africa (Pty) Ltd	Granite-Ds	Cato Ridge	Iwanda Location 4675; Ptn Izotsha	Opencast

NAME OF MINE	OWNER	COMMODITY	MAGISTERIAL DISTRICT	NAME OF FARMS	TYPE OF MINING
				4666; Ptn Of Location	
LTA Maritzburg Quarries	LTA Construction (Pty) Ltd	Gravel Refuse Sand	Pietermaritzburg	Mpushini Lot 19	Surface
Natal Portland - Simuma	Natal Portland Cement Co (Pty) Ltd	Limestone Sand Shale	Port Shepstone	Eedeswold 5120 Ptn 9 Simuma 11486	Opencast
Idwala Carbonates	Idwala Industrial Holdings (Pty) Ltd	Limestone Shale	Port Shepstone	2 Oribi Flats 10886(Sub 1 Of) 21 Oribi Flats 10886(Sub 1 Of) Le Joncquet No 7922 The Glen No 6500(Sub A Of)	Opencast
Lafarge - Blue Rock Quarry	Lafarge South Africa	Quartzite	Pinetown		Opencast
King Williams Quarry	Lafarge South Africa	Quartzite Dolerite Soil	Pinetown	King William's Town Commonage	Opencast
Lta Sterkspruit Aggregates	Lta Construction (Pty) Ltd	Quartzite Refuse	Camperdown	Sterkspruit 7962	Opencast
Rmm - Inanda Quarry	Lafarge South Africa	Quartzite Soil	Ndwedwe	Inanda Mission Reserve 4579	Opencast
Verulam Quarries	Alpha Ltd	Quartzite Soil	Inanda	Rem Of Roodekranz 828 Hb	Surface
Coedmore Quarries	Alpha Ltd	Quartzite Soil	Durban	Bellair 823	Surface
C Sawyers Bricks & Blocks	Ih Brick And Block Cc	Sand	Port Shepstone	Impenjati Lagoon Adjacent To L Jericho 7870; Sub 4 (Of 3) Umtamvuna 12689	Opencast
Moodleys Sand Suppliers Cc	S Moodley	Sand	Umzinto	Umkomaas Sub 3 Woodland Lodge	Opencast
V A Isaacs Sand Suppliers	Va Isaacs	Sand	Inanda	Lot 417Sub 148 & 149 A Sub Of 16 Zeekoevallei 880 Umlaas River	Opencast
Yc Naidoo Cartage	Yc Naidoo	Sand	Durban	Lot 1029 Isipingo - 19/16/2390 Umbogintwini River	Opencast
Pigeon Rocks	Jacobs Transport	Sand	Mount Currie	Matatiele Town Commonage Pigeon Rocks Ptn	Surface
Kulu Crete	Jh Brick & Block Cc	Sand Gravel	Port Shepstone	Lot 5470 The Bushes	Opencast
Mpambanyoni Sands	Crookes Bros Ltd	Sand Gravel	Umzinto	Renishaw Estate	Opencast
Riverbend Farm	H R Kelly	Sand Gravel	Port Shepstone	South Broom 13471 Ptn 8	Opencast
Penjati Farm / Mpenjati	Joymac Farm Cc	Sand Gravel	Port Shepstone	Mpenjati FarmSub 21 Of Jerico 7870 Trafalga	Opencast
Maharaj Sand Quarry	Maharaj Brothers	Sand Laterite	Lower Thukela	Charlottedale 6014	Opencast
Sandop Sand Works	Sandop	Sand Quartzite	Camperdown	Kafferdrift 906 Sub 187 Of 121	Opencast
Lafarge - Sand Div - Hazelmere	Lafarge South Africa	Sand Refuse	Umbumbulu	Clermont Klein Zeekoe Vallei 803	Opencast

NAME OF MINE	OWNER	COMMODITY	MAGISTERIAL DISTRICT	NAME OF FARMS	TYPE OF MINING
				Mdloti River Mount Edgecombe Umbogintwini Lots 165 – 168 Umgeni Drift Umkomaas Virginia Beach Roadhouse	
Corobrik - Avoca 2	Corobrik (Pty) Ltd	Shale Clay	Durban	Avoca E/21 & E/15 Glenanil 909 Rem Of Ptn 2 Of R Melkhoutekraal Sub 527	Opencast
Corobrik - Avoca Ex	Corobrik (Pty) Ltd	Shale Clay	Durban	Avoca Ext Rem Of Sub 1 Farm 1100 Lot 23 Glenanil 909	Opencast
Hays Quarry		Siltstone-Ds Limestone Shale	Pietermaritzburg	Groenkloof 900 Sub 4	Opencast

* Department: Minerals and Energy (2001).

3.8 WATER RELATED INFRASTRUCTURE

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

CHAPTER 4: WATER-RELATED INFRASTRUCTURE

4.1 OVERVIEW

The Durban-Pietermaritzburg corridor and surrounding areas to the north and south encompass one of South Africa's largest urban areas and is also amongst the country's earliest settlements. Hence, there is an innumerable amount of water related infrastructure in place. Several dams and waterworks have been constructed over the years that have since been decommissioned and new supply schemes have taken their place. In other parts of the WMA water supply infrastructure is non-existent.

The Mooi-Mgeni transfer scheme is the only transfer into the Mvoti to Mzimkulu WMA. Water is transferred from the Mooi River to the Mgeni system. There are no transfers out of the WMA. Numerous smaller transfers occur within the WMA.

Approximately 1,9 million people live in rural areas within the WMA. A high proportion of these communities do not have reticulated water supply. Communities depend on groundwater obtained from protected springs and boreholes.

4.2 REGIONAL AND TOWN WATER SUPPLY

This section describes water supply to some of the larger towns in the Mvoti to Umzimkulu WMA.

Water supply by Umgeni Water (water board) can be divided into the following systems:

- Durban supply system
- Inland supply system (Greater Pietermaritzburg area)
- North Coast Supply system
- South Coast Supply system.

The Durban supply system provides water to the greater Durban area, which extends from Phoenix in the north, to Umlazi in the south and Pinetown in the west. Water is gravity fed to various waterworks from where it is distributed for reticulation (DWAF and Umgeni Water, 1994).

Durban Heights Waterworks, which supplies 70% of Greater Durban's potable water, receives water from Nagle Dam and Inanda Dam. Albert Falls Dam provides balancing storage for Nagle Dam. Water is abstracted from the Mgeni River at Clermont downstream of Inanda Dam. Water is pumped into the Wiggins tunnel, and vertical shaft pipes at Durban Heights can draw water from the tunnel up to the plant itself. Wiggins Waterworks supplies the remaining 30% of Greater Durban's potable water. It also receives raw water from the Nagle Dam and Inanda Dam.

The greater Pietermaritzburg area (Pietermaritzburg/Cato Ridge/Upper Pinetown) obtains its raw water supply from Midmar and Henley Dams. The Howick, H.D.Hill, D.V. Harris and Umlaas Road Waterworks receive raw water from Midmar Dam, while the Mill Falls Waterworks receives water from Henley Dam.

The North Coast Supply system consists of Hazelmere Dam on the Mdloti River, the Hazelmere water treatment plant and the associated bulk water supply pipelines stretching from Verulam in the south to Stanger in the north. Water is distributed to most towns along the north coast including Tongaat, which also utilizes water directly from the Tongati River.

The South Coast Supply system depends on Nungwane Dam for its raw water supply. Water is abstracted at the dam wall and flows under gravity to the Amanzimtoti Waterworks. Potable water is supplied to Amanzimtoti, Kwamakhuta and some rural KwaZulu areas.

The largest water supply scheme along the bottom half of coastline in the Mvoti to Umzimkulu WMA is the Mzimkhulwana/Mzimkulu Scheme, which supplies the area between Hibberdene and Ramsgate including Port Shepstone. Abstractions can be made from a weir in the Mzimkhulwana River in Oribi Gorge and from a pumping station at St Helen’s Rock on the Mzimkulu River. Because of lower pumping costs water is abstracted from the Mzimkhulwana River in preference to the Mzimkulu River. There are times when the flow is too low in the Mzimkhulwana River and the full requirement has to be abstracted from the Mzimkulu River. Water supply to other towns and boroughs along the South Coast is directly from the numerous rivers that cross the region or from small dams on these rivers.

Other major formal water consumers in the Mvoti to Umzimkulu WMA are the towns of Richmond, Ixopo, Umkomaas and Tongaat.

Richmond mainly receives water from the Beaulieu Dam on the Lovu River. In addition water is abstracted from two boreholes which contribute 25% of the potable water consumed.

Ixopo receives its water from the Ixopo River, a tributary of the Mkomazi River. Water is gravity fed into town from the Rawlton Dam and from the Isodore Dam, which are both situated on the Ixopo River.

The town of Umkomaas receives its water from SAICCOR (South African Industrial Cellulose Corporation (Pty) Ltd). Water is pumped from a temporary storage dam in the Mkomazi River to SAICCOR, purified and later sold to Umkomaas.

Tongaat obtains its raw water (for domestic use, the sugar mill and irrigation) from a canal into which water is diverted from the Tongati and Mona rivers.

4.3 IRRIGATION SCHEMES

Table 4.3.1 indicates controlled irrigation schemes in the Mvoti to Umzimkulu WMA.

TABLE 4.3.1: CONTROLLED IRRIGATION SCHEMES IN MVOTI TO UMZIMKULU WMA IN 1995

QUATERNARY CATCHMENTS	IRRIGATION DISTRICT	SCHEDULED AREA (ha)	CURRENT IRRIGATED AREA (ha)	PRODUCE	SUPPLY SOURCE	PRESENT AVERAGE ANNUAL USE [(1)] (10^6 m^3/a)
U10H,J,L U60A,B U70A-C	Illovo	1006	1006	Sugar/ Maize/ Wheat	Beaulieu Dam/ Lovu River	5,4
U10J-L	Ixopo	801	801	Maize/ Wheat/Pasture	St. Isidore Dam	4,0
U20B-F	Karkloof	924	924	Maize/ Wheat/Pasture	Karkloof River	3,9
U30E, U40H,J U50A	Lower Umvoti	2572	2572	Sugar/Citrus	Mvoti River	16,6
U20D-G U40A,C	Mpolweni/ Sterkspruit	1000	1000	Veg /Sugar/ Maize/ Wheat/ Pasture	Mpolweni River	5,4
U10H,J	Mzalanyoni	230	230	Veg / Sugar/Pasture	Lilydale Dam	1,1
T51A-C, F,G,J	Ngwangwane	875	875	Sugar/ Maize/ Wheat/ Pasture	Mzimkulu River	4,3
T52A	Nkonzo River	940	940	Pasture/ Sugar/ Maize/ Wheat	Mzimkulu River	4,3
T51B-E, U10C,E	Polela	1036	1036	Pasture/ Sugar/ Maize/ Wheat	Mzimkulu River	5,1
U20H,J U60A-C	Umlaas	4455	4455	Sugar/ Veg / Maize/ Wheat/ Pasture	Thornley Dam/ Mapstone Dam/ Bainesfield Dam	22,2
U20F, U40A-D,F	Umvoti	2475	2475	Sugar/ Veg/ Citrus	Craigieburn Dam/Mvoti River	18,6
T40B, T52H,J,K	Umzimkulwana	436	436	Sugar/ Maize/ Wheat/ Pasture	Mzimkhulwana River	2,3
T51A-F,J	Underberg	1540	1540	Pasture/ Sugar/ Maize/ Wheat	Mzimkulu River	7,5

1. Quantities include conveyance losses

4.4 TRANSFER SCHEMES

4.4.1 Mooi-Mgeni (Mearns) Transfer Scheme

This scheme pumps water from Mearns weir in the Mooi River within the Thukela WMA through a pipeline system into the headwaters of the Lions River from where it gravitates into Midmar Dam, at the head of the Mgeni System. The 1995 capacity of the scheme was 50 million m^3/a.

4.5 INFRASTRUCTURE IN THE MVOTI TO UMZIMKULU WMA

The WMA has a total population of 5 million people. The level of potable water supply varies from household taps in developed areas, to standpipes in the townships, to none in some of the rural areas. The main water resource infrastructure is dams supplying the water requirements to the Durban-Pietermaritzburg region. The larger towns along the coast south of this region rely on schemes drawing water from the major rivers.

Table 4.5.1 details the major storage dams in this WMA which are defined for the purposes of this study as dams with a full supply capacity in excess of 2,5 million m^3.

TABLE 4.5.1: MAIN DAMS IN THE MVOTI TO UMZIMKULU WMA

DAM NAME	QUAT. NO.	LIVE STORAGE CAPACITY (million m^3/a)	USE	OWNER	HISTORICAL YIELDS (million m^3/a)
Albert Falls(1)	U20E	288,1	Domestic/industrial	DWAF	-
Inanda(1)	U20L	242,0	Domestic/industrial	DWAF	293
Midmar	U20E	175,1	Domestic/industrial	DWAF	83
Nagle(1)	U20G	23,2	Domestic/industrial	Umgeni Water Board	-
Hazelmere	U30A	17,9	Domestic/industrial	DWAF	29,5
Henley	U20J	5,4	Domestic/industrial	Umgeni Water Board	9
Shongweni	U60D	3,7	Domestic/industrial	Umgeni Water Board	13,5
Mapstone	U60A	3,4	Irrigation	Umlaas Irrigation Board	Unknown
St Isidore	U10K	3,0	Irrigation	Ixopo Irrigation Board	Unknown
Surrey	U20B	2,5	Irrigation	Rowles G.H & Rowe M.N	Unknown
Thornlea	U60B	2,5	Irrigation	Umlaas Irrigation Board	Unknown

Note: Main dams have been defined in this report as dams with a full supply capacity exceeding 2,5 million m^3

* The yields quoted in the table above are for dams operated on their own and not in a systems context.

** Storage volume above lowest drawdown level

(1) The Albert Falls, Nagle and Inanda Dams are operated as a system to deliver a historical yield of 293 million m^3/a (Mgeni Systems Analysis, 1994).

4.6 HYDRO POWER AND PUMPED STORAGE SCHEMES

The only hydro power station in the Mvoti to Umzimkulu WMA is the Dunlop Howick Hydro power station. There are no pumped storage schemes.

TABLE 4.6.1: HYDROPOWER STATIONS

CHARACTERISTIC	DUNLOP HOWICK HYDRO POWER STATION
Quat No.	U20E
Locality Lat. Long.	29°29’10” S 30°14’10” E
Rated capacity (MW)	0,5 MW
Peak capacity (generator limitation)	0,5 MVA
Rated head	90 (m)
Load factor1)	90 %

CHAPTER 5: WATER REQUIREMENTS

5.1 SUMMARY OF WATER REQUIREMENTS

The following water use sectors are present in the WMA:

- Environmental requirement
- Domestic (rural and urban)
- Bulk water use
- Hydropower
- Agriculture
- Afforestation
- Alien vegetation
- Water transfers

The total water requirement of each of these sectors in 1995 is indicated in Table 5.1.1 as well as the requirement at 1:50 year assurance. Distribution losses and conveyance losses are included in the values given for water requirements, including water transfers, but return flows have not been subtracted.

The ecological Reserve represents the greatest water requirement in the WMA, nearly half of the total water requirement. It includes the requirement of riverine ecosystems and is the requirement at the outlet to the WMA. For coastal catchments, the value indicated is the instream flow requirement at the river mouth and should not be confused with the Estuarine Flow Requirements, which have not been determined. At 1:50 year assurance levels the ecological Reserve requirement is substantially lower.

The second biggest water requirement is for domestic usage due to the large population in this WMA. This is closely followed by agricultural water requirements. Bulk usage due to mines and industries is low for the Mvoti to Umzimkulu WMA.

Water is required at different assurances of supply depending on the user group. For instance, domestic usage requires a greater assurance of supply than agriculture because people are not willing to accept a breakdown in supply at their homes. An equivalent 1 in 50 year assurance requirement is included in the tables in this chapter. This is a theoretical concept that represents the flow for which supply should break down only once every 50 years on average.

Figure 5.1.1 shows the total equivalent water requirements for the Mvoti to Umzimkulu WMA in 1995.

TABLE 5.1.1: WATER REQUIREMENTS PER USER GROUP IN 1995

USER GROUP	ESTIMATED WATER REQUIREMENT (million m^3/a)	REQUIREMENT / USE AT 1:50 YEAR ASSURANCE (million m^3/ a)
Ecological Reserve (5)	1152,6	179,0
Domestic (1)	156,1	155,5
Bulk water use (4)	72,3	72,4
Neighbouring States	0,0	0,0
Agriculture (2)	391,4	360,2
Afforestation	217,8	217,8
Alien vegetation	141,6	141,6
Water transfers (3)	0,0	0,0
Hydropower	0,0	0,0
TOTALS	2131,9	1126,6

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

Figure 5.1.2 shows water requirements at equivalent 1:50 year assurance per user sector in 1995.

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

USER GROUP	REQUIREMENT IN EASTERN CAPE (million m^3/a)	REQUIREMENT IN KWAZULU NATAL (million m^3/a)	TOTAL REQUIREMENT (million m^3/a)
Domestic	4,7	152,3	157,0
Bulk water use	0,0	72,4	72,4
Agriculture	7,1	353,1	360,2
Afforestation	27,3	190,5	217,8
Alien vegetation	28,8	112,8	141,6
Water transfers	0,0	0,0	0,0
Hydropower	0,0	0,0	0,0
TOTALS	67,8	881,2	949,0

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. These desktop Reserve parameter regions are described and shown in Figure 5.2.1.1.

The instream flow requirements that were determined previously were mostly based on the 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 the Mvoti to Umzimkulu Water Management Area fall within the so-called T-drainage coastal, T-drainage interior, Southern Natal and Drakensberg regions.

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

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

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

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

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

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

5.2.3 Comments on the Results

There are two considerations with regard to the confidence that may be placed in the results of the desk top evaluation of the state of each quaternary catchment. The first is the bias inherent in the environmental expertise of the specialists who undertook the evaluation. In the case of the Mvoti to Umzimkulu WMA, the evaluation of the quaternary catchments was for the most part undertaken by a Kwazulu-Natal Nature Conservation Service freshwater ichthyologist. He was able to make major inputs from a provincial fish distribution data base which he had built up over many years. Not only was he familiar with fish distribution, but also with general river ecosystem condition, since he had personally collected the fish data in the data base. The other expert input was on the macroinvertebrate communities, but this data was not as extensive as the fish data and was scattered in reports and publications. The quaternary catchment evaluations were consequently biased towards the fish component of the ecosystems, supported by macroinvertebrate data at places.

The experts made their own assessments of their confidence in the scores allocated to the various ecosystem characteristics in each quaternary catchment. The confidence estimates suggest that there is a high degree of confidence in the ecological Reserve estimates for 13 of the 21 Key Points in the WMA. Key Points with low confidence assessments were T52M (Umzimkulu River lowest quaternary), U50A (Nonati River catchment), U70E (Umgababa River) and U80A to U80L (coastal rivers) because conditions at these points are not well known

Scrutiny of the confidence placed by the evaluators in their own evaluations of non Key Point quaternary catchments reveals that there are some rivers or river reaches that are very poorly known. They include the quaternary catchments T52E to T52K (the entire Bisi River catchment, a quaternary catchment in the lower Umzimkulu and the upper quaternary catchment of the Mzimkulwana that flows into Oribi Gorge Nature Reserve) and quaternary catchments U70B to U70E (Lovu River). There are also some isolated quaternary catchments where assessments were made with low confidence. These were T52B (the Cabane River), U20K (Mqeku River), U30C (upper Tongati River) and U30E (Umhlali River).

5.2.4 Presentation of Results

Table 5.2.4.1 shows the water requirements at selected Key Points in the WMA. The Key Points considered co-incide with catchment or sub-catchment outlets, or with other specific features of the region such as the confluence of two rivers or simply the division into manageable working areas. The Key Points shown are selected areas from the list given in Chapter 7. It is possible that there can be intra-quaternary catchment variation in class and state, so there may be intra-tertiary or intra-Key Point variation. The quaternary information is contained in Appendix E.

Water requirements for the ecological component of the Reserve is shown in Figure 5.2.4.1. It must be noted that data for this figure is not available at the quaternary level.

TABLE 5.2.4.1: WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE

KEY POINT	PRESENT ECOLOGICAL STATUS CLASS (PESC)	RIVERINE ECOLOGICAL WATER REQUIREMENTS FOR PESC		
		% VIRGIN MAR	CUMULATIVE VOLUME (million m^3/a)	IMPACT ON 1:50 YEAR YIELD (million m^3/a)
Mtamvuna (T40E)	B	31,2	133,0	16,4
Upper Mzimkulu (T51C)	C	22,3	176,3	24,2
Lower Mzimkulu (T52M)	B	31,3	429,7	31,7
Upper Mkomazi (U10E)	B	34,0	229,9	14,0
Lower Mkomazi (U10M)	C	23,8	256,9	18,0
Midmar Dam (U20C)	C	25,0	50,4	25,8
Mgeni mouth (U20M)	D	16,3	109,9	30,0
Mdloti Tongati Mhlali (U30B)	D	10,9	23,3	6,8
Mvoti Nonati (U40J)	C	20,6	78,5	11,9
Mlazi (U60F)	D	12,5	23,0	1,4
Lovu (U70E)	B	27,5	36,9	0,5
KZN South Coast (U80)	B to D	13,9	46,0	14,0
Total requirement for WMA*			1 137,2	194,7

* Sum of values for quaternary catchments discharging to the sea or across the boundaries of the WMA where there is not a single point of exit. Value at lowermost quaternary where it is the only exit point.

5.2.5 Discussion and Conclusions

The impact of the ecological Reserve on the Mgeni System, estimated at 56 million m^3/a, is relatively small because of the low ecological management class of the lower Mgeni River. The impact, relative to the available yield, is highest at Midmar Dam with the additional impact of the Albert Falls, Nagle and Inanda Dams estimated to be only 30 million m^3/a. The impact of the ecological Reserve on the undeveloped rivers in the south, namely the Mkomazi, Mzimkulu and Mtamvuna is much higher, and the methodologies applied for this water resources situation assessment indicate that the ecological Reserve requires the entire available run-of-river yield in most cases. If this is indeed the case, the repercussion on the financial viability of the Catchment Management Agency will be serious since dams will need to be constructed to supply the water requirements that are currently met from run-of-river, unless the users are curtailed, which will cause other negative impacts. Clearly further work is required to assess the impact of the ecological Reserve in run-of-river situations.

5.3 URBAN AND RURAL

5.3.1 Introduction

This WMA is characterised by highly developed, densely populated urban centres as well as sparsely populated rural areas. Durban is one of South Africa's most important harbours and largest cities and is expected to continue growing in size.

Of the three WMAs that fall within Kwazulu-Natal Province (the other two being Thukela and Usuthu to Mhlathuze) the Mvoti to Umzimkulu WMA is the only one where the urban population outstrips the rural population. The urban population is roughly one and a half times greater than the rural population. The estimated total population in the WMA is 5 million people. It is important to note that the rural population relies for water supply mainly on groundwater, rivers and springs.

The main urban settlements are Durban and Pietermaritzburg with significant urban requirements from Greytown, Stanger, Howick, Ballito, Richmond, Ixopo, Umzinto, Scottburgh, Port Shepstone, Margate, Port Edward, Harding and Underberg.

The National Water Act (Act No. 36 of 1998) stipulates the provision of the Human Reserve which is defined as follows: "The basic human needs reserve provides for the essential needs of individuals served by the water resource in question and includes water for drinking, for food preparation and for personal hygiene." The Human Reserve was taken as 25 l/capita/day and has been included in the water requirements shown in Table 5.3.1.1.

Figure 5.3.1.1 shows urban and rural domestic water requirements for the Mvoti to Umzimkulu WMA as at 1995.

TABLE 5.3.1.1: URBAN AND RURAL DOMESTIC WATER REQUIREMENTS IN 1995

CATCHMENT						URBAN REQUIREMENTS (million m^3/a)	RURAL DOMESTIC REQUIREMENTS (million m^3/a)	COMBINED URBAN AND RURAL DOMESTIC REQUIREMENTS (million m^3)	REQUIREMENT AT 1:50 YEAR ASSURANCE (million m^3)	HUMAN RESERVE (million m^3/a)
PRIMARY		SECONDARY		KEY AREAS						
No.	Description	No.	Description	No.	Description					
T	MZIMKULU	T40	Mtamvuna			5,4	3,2	8,6	8,8	2,3
		T50	Mzimkulu	T51	Upper Mzimkulu	0,1	0,8	0,9	1,0	0,7
				T52	Lower Mzimkulu	0,5	2,7	3,1	3,3	2,1
					Subtotal Mzimkulu	0,6	3,5	4,1	4,4	2,8
			Subtotal Mzimkulu			6,0	6,7	12,7	13,1	5,1
U	MVOTI	U10	Mkomazi	U10	Upper Mkomazi	0,0	0,5	0,5	0,5	0,4
				U10	Lower Mkomazi	0,2	1,2	1,4	1,5	0,9
					Subtotal Mkomazi	0,2	1,7	1,9	2,0	1,3
		U20	Mgeni	U20	Midmar Dam	0,0	0,2	0,2	0,3	0,2
				U20	Mgeni mouth	22,3	3,9	26,2	26,2	3,1
					Subtotal Mgeni	22,4	4,1	26,4	26,5	3,3
		U30	Mdloti Tongati Mhlali			1,0	2,0	3,0	3,2	1,6
		U40 U50	Mvoti Nonati			3,0	3,3	6,3	6,5	2,7
		U60	Mlazi			97,8	0,9	98,7	97,0	0,7
		U70	Lovu			0,0	0,7	0,7	0,7	0,5
		U80	KZN South Coast			3,4	3,0	6,4	6,6	2,4
			Sub-total Mvoti			127,8	15,6	143,4	142,4	12,5
	TOTAL IN EASTERN CAPE					2,3	2,7	4,9	5,1	2,0
	TOTAL IN KWAZULU-NATAL					131,5	19,6	151,2	150,4	15,6
	TOTAL IN MVOTI TO UMZIMKULU WMA					133,8	22,3	156,1	155,6	17,6

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

5.3.2 Urban

Introduction

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

Methodology

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Urban Centre Classification	Commercial	Industrial	Institutional	Municipal	Total
Metropolitan					
Cities	0,2	0,3	0,15	0,08	0,73
Towns Industrial					
Towns Isolated					
Towns Special	0,30	0,15	0,08	0,03	0,56
Towns Country	0,10	0,15	0,03	0,10	0,38
New Centres	0,15	0,08	0,08	0,08	0,39

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

The urban population living on the boundaries of major towns is continuing to grow. These are generally categorised by informal settlements with inadequate water supply. The water supply and sanitation requirement for people migrating to urban areas is likely to remain in excess of provision for several years to come. Water consumption in such areas exceeds that in the rural areas but is much lower than in the developed urban areas.

The urban water requirements by drainage area in 1995 are listed in Table 5.3.2.4.

TABLE 5.3.2.4: URBAN WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

CATCHMENT						Urban Water Requirements							Total At 1:50 Yr Assurance (million m^3/a)	Return Flows			
PRIMARY		SECONDARY		KEY AREAS													
								Bulk conveyance losses		Distribution losses							
No	Description	No	Description	No	Description	Direct (million m^3/a)	Indirect (million m^3/a)	(million m^3/a)	%	(million m^3/a)	%	Total (million m^3/a)		Effluent (million m^3/a)	Impervious Urban Area (million m^3/a)	Total Return Flow (million m^3/a)	Return Flow At 1:50 Yr Assurance (million m^3/a)
T	Mzimkulu	T40	Mtamvuna			5,4	2,9	0,6	5	2,2	20	11,1	10,9	5,1	1,8	7,0	6,9
		T50	Mzimkulu	T51	Upper Mzimkulu	0,1	0,0	0,0	5	0,0	20	0,2	0,2	0,1	0,2	0,3	0,3
				T52	Lower Mzimkulu	0,5	0,2	0,0	5	0,2	20	0,9	0,9	0,4	0,5	0,8	0,8
					Subtotal Mzimkulu	0,6	0,2	0,1	5	0,2	20	1,1	1,1	0,5	0,6	1,1	1,1
			Subtotal Mzimkulu			6,0	3,1	0,6	5	2,4	20	12,2	12,1	5,6	2,5	8,1	8,0
U	MVOTI	U10	Mkomazi	U10	Upper Mkomazi	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,0	0,0	0,0	0,0
				U10	Lower Mkomazi	0,2	0,1	0,0	5	0,1	20	0,4	0,4	0,2	0,5	0,7	0,7
					Subtotal Mkomazi	0,2	0,1	0,0	5	0,1	20	0,4	0,4	0,2	0,5	0,7	0,7
		U20	Mgeni	U20	Midmar Dam	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,0	0,3	0,3	0,3
				U20	Mgeni mouth	22,3	15,8	2,5	5	10,2	20	50,8	50,4	45,0	18,1	63,1	63,0
					Subtotal Mgeni	22,4	15,8	2,5	5	10,2	20	50,8	50,5	45,0	18,4	63,4	63,3
		U30	Mdloti Tongati Mhlali			1,0	0,6	0,1	5	0,4	20	2,1	2,1	1,0	1,5	2,5	2,5
		U40 U50	Mvoti Nonati			3,0	2,0	0,3	5	1,3	20	6,7	6,6	3,2	1,2	4,4	4,4
		U60	Mlazi			97,8	80,0	11,9	5	47,4	20	237,1	234,8	92,9	20,2	113,1	112,6
		U70	Lovu			0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,0	2,0	2,0	2,0
		U80	KZN South Coast			3,4	1,9	0,4	5	1,4	20	7,1	7,0	3,3	2,1	5,4	5,4
			Sub-total Mvoti			127,8	100,4	15,2	5	60,8	20	304,2	301,5	145,6	46,0	191,6	190,9
	TOTAL IN EASTERN CAPE					2,3	1,2	0,2	5	0,9	20	4,7	4,6	2,1	1,0	3,1	3,1
	TOTAL IN KWAZULU-NATAL					131,5	102,3	15,6	5	62,3	20	311,7	309,0	149,1	47,5	196,6	195,8
	TOTAL IN MVOTI TO UMZIMKULU WMA					133,8	103,5	15,9	5	63,2	20	316,4	313,5	151,2	48,4	199,7	198,9

Water losses

Water losses in urban areas contribute a substantial amount to the total water requirement. Water losses can be broken down into two components, namely:

Losses in the bulk supply system: Losses in the bulk supply system of 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 % of the urban water use within the WMA, which implies a total loss of 18,8 million m^3/a for the WMA.

Losses in the water distribution system: Distribution losses include losses due to leaking pipes and reservoirs. Distribution losses can range from 10% of the urban water use to as high as 30% of the urban water use in places where proper maintenance is not done. Distribution losses were taken as 20% of urban water usage giving an estimated total loss of 98,4 million m^3/a.

Return flows

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

Effluent from residential and industrial areas: Effluent generated from residential and industrial areas is directly proportional to the water used. The water use is further dependent on the standard of living and type of industries. All these factors have been taken into consideration when estimating the return flow. The total return flow has been estimated as 203,93 million m^3/a.

Return flow due to impervious urban areas: Additional rainfall run off is created due to the impervious areas created in urban areas. On average <u>one eighth</u> of the urban areas in the WMA are effectively paved and it is assumed that 84% of rain falling on these areas runs off into the river system. (WR90 values/own inputs into model) The impervious area in the WMA totals 76,4 km^2 and the return flow generated from these areas is 48,47 million m^3/a, but at a low assurance for reuse.

5.3.3 Rural

Water requirements

Rural water usage can be split into the categories of domestic, livestock and subsistence irrigation.

(a) Domestic

The per capita rural water usage in 1995 was estimated as 33,5 litres/capita/day as outlined in Table 5.3.3.1.

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

USER CATEGORY	UNIT WATER REQUIREMENTS			
	DIRECT USE (l/capita/day)	DISTRIBUTION LOSSES (l/capita/day)	DISTRIBUTION LOSSES (%)	TOTAL (l/capita/day)
Rural	26,8	6,7	20	33,5

(b) Livestock

The water requirements of livestock and game correspond to the distribution of livestock and game as described in Section 3.5.4. The water requirement for the WMA was done on a pro rata basis based on the average water consumption of an equivalent livestock unit.

The unit water requirement per "equivalent large stock unit" is taken as 45 litres per day. It will take several more smaller species (that consume less than 45 litres per day) than larger animals to make up an equivalent large stock unit. The two extremes are springbok and elephant. It takes 10,3 springbok and 0,3 elephant to make up 1 equivalent large stock unit i.e. 10,3 springbok consume the same amount of water as 0,3 elephant. A table showing the relationship between various livestock and game species and ELSU is contained in Appendix D.

Thus to calculate the water requirement for livestock and game in the WMA the number of equivalent large stock units was first calculated and multiplied by 45 litres/ELSU/day.

(c) Subsistence Irrigation

In this WMA subsistence irrigation is negligible.

The rural domestic water requirements by drainage area in 1995 are listed in Table 5.3.3.2.

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

CATCHMENT						Rural Water Requirements							Return Flows	
PRIMARY		SECONDARY		KEY AREAS		Domestic (million m^3/a)	Subsistence Farming (1) (million m^3/a)	Livestock & Game (1) (million m^3/a)	Losses		Total (million m^3/a)	Total At 1:50 Yr Assurance (million m^3/a)	Normal (million m^3/a)	Total At 1:50 Yr Assurance (million m^3/a)
No	Description	No	Description	No	Description				(million m^3/a)	%				
T	UMZIMKULU	T40	Mtamvuna			3,2	0,0	1,2	1,1	20	5,5	5,8	0,0	0,0
		T50	Mzimkulu	T51	Upper Mzimkulu	0,8	0,0	1,2	0,5	20	2,6	2,8	0,0	0,0
				T52	Lower Mzimkulu	2,7	0,0	1,1	0,9	20	4,7	5,0	0,0	0,0
					Subtotal Mzimkulu	3,5	0,0	2,3	1,5	20	7,3	7,8	0,0	0,0
			Subtotal Umzimkulu			6,7	0,0	3,5	2,5	20	12,7	13,6	0,0	0,0
U	MVOTI	U10	Mkomazi	U10	Upper Mkomazi	0,5	0,0	0,9	0,4	20	1,8	1,8	0,0	0,0
				U10	Lower Mkomazi	1,2	0,0	1,5	0,7	20	3,4	3,5	0,0	0,0
					Subtotal Mkomazi	1,7	0,0	2,4	1,0	20	5,2	5,4	0,0	0,0
		U20	Mgeni	U20	Midmar Dam	0,2	0,0	0,9	0,3	20	1,4	1,4	0,0	0,0
				U20	Mgeni mouth	3,9	0,0	1,8	1,4	20	7,1	7,6	0,0	0,0
					Subtotal Mgeni	4,1	0,0	2,7	1,7	20	8,5	9,0	0,0	0,0
		U30	Mdloti Tongati Mhlali			2,0	0,0	0,5	0,6	20	3,1	3,3	0,0	0,0
		U40 U50	Mvoti Nonati			3,3	0,0	1,3	1,1	20	5,7	6,1	0,0	0,0
		U60	Mlazi			0,9	0,0	0,6	0,4	20	1,9	2,0	0,0	0,0
		U70	Lovu			0,7	0,0	0,6	0,3	20	1,6	1,7	0,0	0,0
		U80	KZN South Coast			3,0	0,0	1,2	1,1	20	5,3	5,6	0,0	0,0
			Sub-total Mvoti			15,6	0,0	9,4	6,3	20	31,3	33,2	0,0	0,0
	TOTAL IN EASTERN CAPE					2,7	0,0	1,2	0,9	20	4,8	5,1	0,0	0,0
	TOTAL IN KWAZULU-NATAL					19,6	0,0	11,7	7,9	20	39,2	41,7	0,0	0,0
	TOTAL IN MVOTI TO UMZIMKULU WMA					22,3	0,0	12,9	8,9	20	44,1	46,8	0,0	0,0

(1) No information available on water use for subsistence farming. Assumed to be zero.

Water losses

Bulk supply and distribution losses: The losses in the rural supply systems vary from 10% of the rural water use in well maintained systems up to 30% in poorly maintained areas. In this WMA a 20% loss of rural water use has been applied. The total losses in the bulk supply to the rural consumers and the losses in the distribution system are estimated at 8,9 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 has been taken as zero.

5.4 BULK WATER USE

5.4.1 Introduction

This section deals with industries, mines and thermal powerstations, which have 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 powerstations 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".

The lower Mgeni catchment is the most developed area of the WMA supporting IThetweni and Pietermaritzburg Metropolitan areas. Development has also concentrated along the southern coastal strip supporting sugar mills, pulp mill and tourism. The interior is primarily rural and agricultural.

5.4.2 Strategic

For the purposes of this study only the requirements of thermal power stations have been considered to be strategic water use. There are no strategic water users in this WMA.

5.4.3 Mining

A complete list of mines within the WMA is provided in Section 3.7 as compiled by the Department of Minerals and Energy. No information on water requirements was available for these mines. The mines are all quarries for sand or rock and the processes do not require significant quantities of water. Accordingly no allowance has been made for water requirements in the WMA specifically for mining operations.

5.4.4 Other Bulk Users

Major industrial water users are Tongaat Hulett Group (Ltd) at Tongaat, South African Industrial Cellulose Corporation (Pty) Ltd (SAICCOR) at Umkomaas and Illovo Sugar Estates at Illovo.

The SAICCOR plant situated along the Mkomazi River estuary is by far the largest bulk industrial user in the Mvoti to Umzimkulu WMA. SAICCOR abstracts raw water directly from the Mkomazi River. Tongaat Hulett Group (Ltd) abstracts water from the Tongati River for the sugar mill at Maidstone and for the irrigation of several sugarcane estates. The Illovo Sugar Estates abstract water from the Lovu River for use in the processing plant.

TABLE 5.4.4.1: BULK INDUSTRIAL WATER REQUIREMENTS

CATCHMENT						ON SITE BULK USE (million m^3/a)	CONVEYANCE LOSSES		TOTAL WATER REQUIREMENT	TOTAL WATER REQUIREMENT AT 1:50 YR ASSURANCE (million m^3/a)	RETURN FLOW (million m^3/a)	RETURN FLOW AT 1:50 YR ASSURANCE (million m^3/a)
PRIMARY		SECONDARY		KEY AREAS								
No.	Description	No.	Description	No.	Description		(million m^3/a)	%				
T	MZIMKULU	T40	Mtamvuna			0,0	0,0	10	0,0	0,0	0,0	0,0
		T50	Mzimkulu	T51	Upper Mzimkulu	0,0	0,0	10	0,0	0,0	0,0	0,0
				T52	Lower Mzimkulu	3,7	0,4	10	4,1	4,1	0,7	0,7
					Subtotal Mzimkulu	3,7	0,4	10	4,1	4,1	0,7	0,7
			Subtotal Mzimkulu			3,7	0,4	10	4,1	4,1	0,7	0,7
U	MVOTI	U10	Mkomazi	U10	Upper Mkomazi	0,0	0,0	10	0,0	0,0	0,0	0,0
				U10	Lower Mkomazi	47,1	5,2	10	52,4	52,4	37,1	37,1
					Subtotal Mkomazi	47,1	5,2	10	52,4	52,4	37,1	37,1
		U20	Mgeni	U20	Midmar Dam	0,0	0,0	10	0,0	0,0	0,0	0,0
				U20	Mgeni mouth	0,9	0,1	10	1,0	1,0	0,3	0,3
					Subtotal Mgeni	0,9	0,1	10	1,0	1,0	0,3	0,3
		U30	Mdloti Tongati Mhlali			5,8	0,6	10	6,4	6,4	3,0	3,0
		U40 U50	Mvoti Nonati			3,8	0,4	10	4,2	4,2	0,8	0,8
		U60	Mlazi			2,7	0,3	10	3,0	3,0	0,2	0,2
		U70	Lovu			0,0	0,0	10	0,0	0,0	0,0	0,0
		U80	KZN South Coast			1,2	0,1	10	1,3	1,3	0,3	0,4
			Sub-total Mvoti			61,4	6,8	10	68,2	68,3	41,7	41,8
	TOTAL IN EASTERN CAPE					1,7	0,2	10	1,9	1,9	0,3	0,3
	TOTAL IN KWAZULU-NATAL					63,4	7,0	10	70,4	70,5	42,1	42,2
	TOTAL IN MVOTI TO UMZIMKULU WMA					65,1	7,2	10	72,3	72,4	42,4	42,5

5.5 NEIGHBOURING STATES

There are no transfers to neighbouring states from the Mvoti to Umzimkulu WMA.

5.6 IRRIGATION

5.6.1 General

Detailed information on irrigation water usage is not readily obtainable. Irrigation water requirements were therefore estimated from available information on irrigated areas, typical quotas, and assurances of supply. This was obtained from previously conducted studies of this WMA, information provided mainly verbally by irrigation boards, Government Water Schemes operating staff and DWAF.

The total theoretical water requirement was calculated using the Water Situation Assessment Model (WSAM) developed for DWAF. The model has been found to be highly sensitive to the level of detail of data entered. For the Mvoti to Umzimkulu WMA it was deemed appropriate to use the theoretical water requirement to represent the actual water requirement.

5.6.2 Water Use Patterns

Irrigation usage can be split into the following user groups:

- Government water schemes
- Irrigation Board schemes
- Private irrigators

Private irrigators are the largest water users of the three and represent the fastest growing irrigation demand, although their use is difficult to assess. A major proportion of the water for private irrigation is drawn from small farm dams. Irrigation is mainly from rivers in the WMA.

Figure 5.6.2.1 shows irrigation water requirements for the Mvoti to Umzimkulu WMA as at 1995.

TABLE 5.6.2.1: IRRIGATION WATER REQUIREMENTS

CATCHMENT						Field Edge Water Requirement (million m^3/a)	Conveyance Losses		Total Theoretical Water Requirement (WSAM) (million m^3/a)	Total Actual Water Requirement (million m^3/a)	Total Water Requirement At 1:50 Year Assurance (million m^3/a)	Return Flows Total Return Flow (million m^3/a)	
PRIMARY		SECONDARY		KEY AREAS									
No	Description	No	Description	No	Description		(million m^3/a)	%				Normal	At 1:50 Yr Assurance
T	MZIMKULU	T40	Mtamvuna			2,3	0,3	10	2,5	2,5	2,2	0,3	0,2
		T50	Mzimkulu	T51	Upper Mzimkulu	9,2	1,0	10	10,2	10,2	8,8	1,0	0,9
				T52	Lower Mzimkulu	17,0	1,9	10	18,9	18,9	16,5	1,9	1,6
					Subtotal Mzimkulu	26,2	2,9	10	29,1	29,1	25,3	2,9	2,5
			Subtotal Mzimkulu			28,5	3,2	10	31,6	31,6	27,5	3,2	2,7
U	MVOTI	U10	Mkomazi	U10	Upper Mkomazi	7,8	0,9	10	8,7	8,7	7,8	0,9	0,8
				U10	Lower Mkomazi	25,2	2,8	10	28,0	28,0	25,1	2,8	2,5
					Subtotal Mkomazi	33,0	3,7	10	36,7	36,7	32,9	3,7	3,3
		U20	Mgeni	U20	Midmar Dam	17,4	1,9	10	19,4	19,4	16,9	1,9	1,7
				U20	Mgeni mouth	20,4	2,3	10	22,6	22,6	19,4	2,3	1,9
					Subtotal Mgeni	37,8	4,2	10	42,0	42,0	36,3	4,2	3,6
		U30	Mdloti Tongati Mhlali			29,0	3,2	10	32,2	32,2	27,5	3,2	2,8
		U40 U50	Mvoti Nonati			50,2	5,6	10	55,8	55,8	47,9	5,6	4,8
		U60	Mlazi			18,4	2,0	10	20,5	20,5	17,5	2,0	1,7
		U70	Lovu			9,3	1,0	10	10,3	10,3	8,8	1,0	0,9
		U80	KZN South Coast			8,6	1,0	10	9,5	9,5	8,2	1,0	0,8
			Sub-total Mvoti			186,3	20,7	10	207,0	207,0	179,1	20,7	17,9
	TOTAL IN EASTERN CAPE					10,8	1,2	10	12,0	12,0	10,4	1,2	1,0
	TOTAL IN KWAZULU-NATAL					204,0	22,7	10	226,6	226,6	196,2	22,7	19,6
	TOTAL IN MVOTI TO UMZIMKULU WMA					214,8	23,9	10	238,6	238,6	206,6	23,9	20,6

5.6.3 Water Losses

Water losses due to irrigation can typically be split into canal/river losses and on farm conveyance losses. However these volumes are not easily obtainable and a reasonable estimate for irrigation losses was assumed to be 10% of the field edge water requirement.

5.6.4 Return flows

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

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. The leaching return flow component was not determined in this study.

Additional return flow
The return flow from irrigation can further increase due to the increased runoff from rainfall because of elevated soil moisture from irrigation. This increased return flow can be calculated for a seasonal or annual crop but was not determined in this study.

These return flows will vary from year to year depending on actual irrigation. Generally return flows are accepted as averaging at approximately 10% of the total water requirement and accepted for this study.

5.7 DRYLAND SUGARCANE

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

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

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

The impact of the reduction in runoff on catchment yield was determined in the same manner as for afforestation and alien vegetation.

Figure 5.7.1 shows water requirements for dryland sugarcane for the Mvoti to Umzimkulu WMA in 1995.

TABLE 5.7.1: WATER REQUIREMENTS OF DRYLAND SUGARCANE

CATCHMENT						AVERAGE WATER USE		REDUCTION IN SYSTEM 1:50 YEAR YIELD	
PRIMARY		SECONDARY		KEY AREAS					
No.	Description	No.	Description	No.	Description	(million m^3/a)	(mm/a)	(million m^3/a)	(mm/a)
T	MZIMKULU	T40	Mtamvuna			10,0	4,5	10,0	4,5
		T50	Mzimkulu	T51	Upper Mzimkulu	0,0	0,0	0,0	0,0
				T52	Lower Mzimkulu	7,7	1,9	7,7	1,9
					Subtotal Mzimkulu	7,7	1,9	7,7	1,9
			Subtotal Mzimkulu			17,6	6,4	17,6	6,4
U	MVOTI	U10	Mkomazi	U10	Upper Mkomazi	0,0	0,0	0,0	0,0
				U10	Lower Mkomazi	3,4	1,3	3,4	1,3
					Subtotal Mkomazi	3,4	1,3	3,4	1,3
		U20	Mgeni	U20	Midmar Dam	0,0	0,0	0,0	0,0
				U20	Mgeni mouth	32,5	9,2	32,5	9,2
					Subtotal Mgeni	32,5	9,2	32,5	9,2
		U30	Mdloti Tongati Mhlali			22,9	17,5	22,9	17,5
		U40 U50	Mvoti Nonati			20,1	6,6	20,1	6,6
		U60	Mlazi			16,4	10,8	16,4	10,8
		U70	Lovu			10,9	10,0	10,9	10,0
		U80	KZN South Coast			16,2	6,4	16,2	6,4
			Sub-total Mvoti			122,4	61,8	122,4	61,8
	TOTAL IN EASTERN CAPE					7,4	2,6	7,4	2,6
	TOTAL IN KWAZULU-NATAL					132,6	65,6	132,6	65,6
	TOTAL IN MVOTI TO UMZIMKULU WMA					140,1	68,2	140,1	68,2

5.8 WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

Losses due to rivers and wetlands are considered to be small in relation to runoff for this WMA and therefore were not calculated.

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 235 dams in the WMA have been estimated to be as much as 61,5 million m^3/a.

TABLE 5.8.1: WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

CATCHMENT						LOSSES FROM RIVERS AND WETLANDS (million m^3/a)	EVAPORATION LOSSES FROM DAMS (million m^3/a)	TOTAL (million m^3/a)
PRIMARY		SECONDARY		KEY AREAS				
No	Description	No.	Description	No.	Description			
T	MZIMKULU	T40	Mtamvuna			0,0	0,1	0,1
		T50	Mzimkulu	T51	Upper Mzimkulu	0,0	2,0	2,0
				T52	Lower Mzimkulu	0,0	0,5	0,5
					Subtotal Mzimkulu	0,0	2,5	2,5
			Subtotal Mzimkulu			0,0	2,6	2,6
U	MVOTI	U10	Mkomazi	U10	Upper Mkomazi	0,0	0,7	0,7
				U10	Lower Mkomazi	0,0	3,0	3,0
					Subtotal Mkomazi	0,0	3,8	3,8
		U20	Mgeni	U20	Midmar Dam	0,0	7,5	7,5
				U20	Mgeni mouth	0,0	12,3	12,3
					Subtotal Mgeni	0,0	19,7	19,7
		U30	Mdloti Tongati Mhlali			0,0	0,6	0,6
		U40 U50	Mvoti Nonati			0,0	1,9	1,9
		U60	Mlazi			0,0	1,8	1,8
		U70	Lovu			0,0	0,5	0,5
		U80	KZN South Coast			0,0	0,5	0,5
			Sub-total Mvoti			0,0	28,9	28,9
	TOTAL IN EASTERN CAPE					0,0	0,7	0,7
	TOTAL IN KWAZULU-NATAL					0,0	30,8	30,8
	TOTAL IN MVOTI TO UMZIMKULU WMA					0,0	31,5	31,5

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.

Wattle, pine and eucalyptus are all grown in this WMA. The total afforestation area of 2 762 km^2 has a reduction in runoff of 217,8 million m^3/annum.

Figure 5.9.1 shows water use by afforestation for the Mvoti to Umzimkulu WMA in 1995.

TABLE 5.9.1: WATER USE BY AFFORESTATION IN 1995

CATCHMENT						AVERAGE WATER USE		REDUCTION IN SYSTEM 1:50 YEAR YIELD	
PRIMARY		SECONDARY		KEY AREAS					
No.	Description	No.	Description	No.	Description	(million m^3/a)	(mm/a)	(million m^3/a)	(mm/a)
T	MZIMKULU	T40	Mtamvuna			16,5	7,5	16,5	7,5
		T50	Mzimkulu	T51	Upper Mzimkulu	7,7	2,8	7,7	2,8
				T52	Lower Mzimkulu	42,3	10,7	42,3	10,7
					Subtotal Mzimkulu	50,0	13,6	50,0	13,6
			Subtotal Mzimkulu			66,5	21,0	66,5	21,0
U	MVOTI	U10	Mkomazi	U10	Upper Mkomazi	5,2	3,0	5,2	3,0
				U10	Lower Mkomazi	26,5	10,0	26,5	10,0
					Subtotal Mkomazi	31,7	13,0	31,7	13,0
		U20	Mgeni	U20	Midmar Dam	14,7	15,9	14,7	15,9
				U20	Mgeni mouth	37,0	10,5	37,0	10,5
					Subtotal Mgeni	51,7	26,4	51,7	26,4
		U30	Mdloti Tongati Mhlali			0,2	0,2	0,2	0,2
		U40 U50	Mvoti Nonati			33,4	11,0	33,4	11,0
		U60	Mlazi			6,8	4,5	6,8	4,5
		U70	Lovu			15,4	14,2	15,4	14,2
		U80	KZN South Coast			11,9	4,7	11,9	4,7
			Sub-total Mvoti			151,3	74,0	151,3	74,0
	TOTAL IN EASTERN CAPE					27,7	8,5	27,7	8,5
	TOTAL IN KWAZULU-NATAL					190,1	86,5	190,1	86,5
	TOTAL IN MVOTI TO UMZIMKULU WMA					217,8	95,1	217,8	95,1

5.10 HYDROPOWER AND PUMPED STORAGE

The only hydropower station in the Mvoti to Umzimkulu WMA is the Dunlop Howick Hydropower station that abstracts water from Midmar Dam and returns the water between Howick Falls and Albert Falls Dam.

TABLE 5.10.1: WATER REQUIREMENTS FOR HYDRO-ELECTRIC POWERSTATIONS AND PUMPED STORAGE SCHEMES

CHARACTERISTIC	DUNLOP HOWICK HYDRO POWER STATION
Quaternary sub-catchment	U20E
Sources of water	Midmar Dam
Peak generating capacity (MW)	0,5
Load factor %	90
Water circulated (million m^3/a)	22,7
Return flow (million m^3/a)	22,7
Water requirement (million m^3/a)	0
Losses (million m^3/a)	0

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 total area of alien vegetation in the WMA is 1 068 km². Infestation is the highest in the Mtamvuna and Lower Mzimkulu Key Areas. The total reduction in system yield for the WMA by alien infestation is 26,9 million m^3/a for a total water use of 141,6 million m^3/a.

Figure 5.11.1 shows water use by alien vegetation for the Mvoti to Umzimkulu WMA in 1995.

TABLE 5.11.1: WATER USE BY ALIEN VEGETATION IN 1995

CATCHMENT						**AVERAGE WATER USE**		**REDUCTION IN SYSTEM 1:50 YEAR YIELD**	
PRIMARY		**SECONDARY**		**KEY AREAS**					
No.	**Description**	**No.**	**Description**	**No.**	**Description**	**(million m^3/a)**	**(mm/a)**	**(million m^3/a)**	**(mm/a)**
T	MZIMKULU	T40	Mtamvuna			23,3	10,5	23,3	10,5
		T50	Mzimkulu	T51	Upper Mzimkulu	6,4	2,3	6,4	2,3
				T52	Lower Mzimkulu	38,7	9,8	38,7	9,8
					Subtotal Mzimkulu	45,2	12,2	45,2	12,2
			Subtotal Mzimkulu			68,5	22,7	68,5	22,7
U	MVOTI	U10	Mkomazi	U10	Upper Mkomazi	7,4	4,3	7,4	4,3
				U10	Lower Mkomazi	3,9	1,5	3,9	1,5
					Subtotal Mkomazi	11,3	5,7	11,3	5,7
		U20	Mgeni	U20	Midmar Dam	4,8	5,2	4,8	5,2
				U20	Mgeni mouth	8,6	2,5	8,6	2,5
					Subtotal Mgeni	13,5	7,7	13,5	7,7
		U30	Mdloti Tongati Mhlali			11,3	8,6	11,3	8,6
		U40 U50	Mvoti Nonati			21,0	6,9	21,0	6,9
		U60	Mlazi			5,6	3,7	5,6	3,7
		U70	Lovu			3,3	3,1	3,3	3,1
		U80	KZN South Coast			7,1	2,8	7,1	2,8
			Sub-total Mvoti			73,1	38,5	73,1	38,5
	TOTAL IN EASTERN CAPE					28,4	9,1	28,4	9,1
	TOTAL IN KWAZULU-NATAL					113,2	52,1	113,2	52,1
	TOTAL IN MVOTI TO UMZIMKULU WMA					141,6	61,2	141,6	61,2

5.12 WATER CONSERVATION AND DEMAND MANAGEMENT

5.12.1 Introduction

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

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

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

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

- Water conservation is the minimisation of loss or waste, the preservation, care and protection of water resources and the efficient and effective use of water. Water conservation should be both an objective in water resource and water services management as well as a strategy.
- Water demand management is the adaptation and implementation of a strategy (policies and initiatives) by a water institution to influence the water requirements and use of water in order to meet any of the objectives of economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services and political acceptability. Water supply institutions should set water demand goals and targets by managing the distribution systems and consumer requirements in order to achieve the above objectives.

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

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

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

5.12.2 Background

Water resources and supply

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

Environment

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

Neighbouring states

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

Basic water supply needs

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

Existing water services

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

Irrigation

Irrigation accounts for an estimated 16,5 % of total water use in the Mvoti to Umzimkulu Water Management Area. Irrigation losses are often quite significant and it is estimated that losses can be as much as 65 to 75% (flood and sprinkler respectively). Some irrigation system losses return to the river systems but the quality is usually reduced. 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 10 % of total water use in the Mvoti to Umzimkulu Water Management Area. Issues such as site selection and preparation, species selection, rotation periods and plantation management all affect the efficient use of water.

Industry, mining and power generation

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

5.12.3 Legal and Regulatory Framework

General

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

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

Water Services Act

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

National Water Act

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

Codes of Practice

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

5.12.4 The Role of Water Conservation and Demand Management

Security of supply

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

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

Protection of the aquatic environment

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

Protection of existing water resources

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

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

Economic efficiency

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

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

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

Social development, equity and accountability

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

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

5.12.5 Planning Considerations

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

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

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

5.12.6 Water Conservation and Demand Management Measures

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

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

5.12.7 Objectives of the National Water Conservation and Demand Management Strategy

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

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

5.12.8 Water Conservation in South Africa

History

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

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

The Working for Water programme

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

Water restrictions

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

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

It was difficult to determine the financial effects of water restrictions. In the Vaal River Supply Area the reduction in water requirements due to water restrictions for the Rand Water, Goldfields and Vaal River supply areas for the period 1982 to 1984 was almost

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

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

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

- The overall reduction in water use depends on a number of factors. However, when water use is reduced beyond 30% it can be detrimental to the user from a financial and motivational perspective.
- Voluntary reduction in water use fails to achieve the savings possible with mandatory steps.
- The most effective methods of reducing water use are higher tariffs, restriction of garden watering times, the banning of domestic hose pipe usage and allotting quotas to industry, bulk consumers and irrigators.
- The most effective motivations are pamphlets/newsletters, higher tariffs and punitive measures.
- The major interventions required to reduce both physical and non-physical losses from pipe networks are leak detection/monitoring, replacing old plumbing and the repair/monitoring of meters.
- The most effective methods of saving water used by commerce and industry are technical adjustments, recycle/re-use and promotion campaigns.
- The ratio of return flow to water use is not materially changed by changes in water use.

The measures implemented during the drought in the mid-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 Mvoti to Umzimkulu 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.

No significant water conservation measures were undertaken prior to or during 1995 in the Mvoti to Umzimkulu WMA. The water conservation drive gained momentum with the introduction of the new National Water Act in 1998. Since then, Durban has implemented water conservation measures primarily through increasing the cost of water and this has lead to significant savings in water usage.

5.13 WATER ALLOCATIONS

5.13.1 Introduction

Section 3.4 of this report, titled "LEGAL ASPECTS AND INSTITUTIONAL ARRANGEMENTS FOR WATER SUPPLY", outlines historic laws and regulations under which water was allocated in the past and the current National Water Act under which allocations will be made subsequent to 1998.

5.13.2 Allocations and Permits Issued under the Old Water Act

The following permits have been issued and allocations made in this WMA under the old Water Act of 1956 (including earlier Water Court Orders):

- Article 63: Irrigation scheduling and quotas from Government Water Schemes.
- Article 56(3): Allocations to other users from Government Water Schemes.
- Article 62: Scheduling and quotas from Government Water Control Areas.
- Industrial, mining and effluent permits (including Articles 12, 12B and 21).
- Other allocations (including Section 9B permits, Water Court orders and legislation such as the Vaal River Development Scheme Act (Act 38 of 1934)).

5.13.3 Water Control Areas in the Water Management Area

Refer to Section 3.4 of this report, titled "LEGAL ASPECTS AND INSTITUTIONAL ARRANGEMENTS FOR WATER SUPPLY".

5.13.4 Permits and Other Allocations

The following permits have been issued and allocations made in this WMA (including earlier Water Court Orders):

(a) Article 63: Irrigation scheduling and quotas from Government Water Schemes - see Table 5.13.4.1.
(b) Article 56(3): Allocations to other users from Government Water Schemes - see Table 5.13.4.2.
(c) Article 62: Scheduling and quotas from Government Water Control Areas - see Table 5.13.4.3.
(d) Industrial, mining and effluent permits (including Articles 12, 12B and 21) - see Table 5.13.4.4.

Water Court Orders and detailed information on allocations is listed in Appendix E.

TABLE 5.13.4.1: LE 63 - SCHEDULING AND QUOTAS FROM GOVERNMENT WATER SCHEMES

SCHEME	QUATERNARY CATCHMENTS	SCHEDULING (ha)	QUOTA	ALLOCATION
			(m^3 /ha/a)	(million m^3/a)
Mdloti Government Water scheme	U30	2916,8	4600	13,42
Totals for WMA				13,42

TABLE 5.13.4.2: ARTICLE 56(3) – SUMMARY OF ALLOCATIONS FROM GOVERNMENT WATER SCHEMES

GOVERNMENT WATER SCHEME*	TOTAL ALLOCATION (million m^3/a)
Mdloti River	12,15
Umgeni River (Albert Falls Dam)	0,90
Umgeni River (Midmar Dam)	423,55
Totals for WMA	436,60

* Individual permit holders for each government water scheme are listed in Appendix E

TABLE 5.13.4.3: ARTICLE 62 – SCHEDULING AND QUOTAS IN GOVERNMENT WATER CONTROL AREAS

WATER CONTROL AREA	SCHEDULING (ha)	QUOTA (m^3/ha/a)	ALLOCATION (million $m^{3/}$a)
Umgeni River	3873	6100	23,6

TABLE 5.13.4.4: ARTICLE 12 & 21 – INDUSTRIAL, MINING AND EFFLUENT PERMITS

QUATERNARY CATCHMENT	ABSTRACTION/ DISCHARGE	TOTAL FLOW (millionm^3/a)
Article 12		
T502	A	0,5
U200	A	5,1
U202	A	6,6
U300	A	0,3
U402	A	0,3
U403	A	8,4
U500	A	2,2
U600	A	36,5
U601	A	0,1
U602	A	2,5
U603	A	0,1
U700	A	3,0
U800	A	2,4
U802	A	1,1
Total		69,1
Article 21		
T400	D	1,2
T402	D	1,4
T502	D	0,7
U100	D	64,2
U200	D	32,2
U201	D	0,2
U202	D	1,2
U203	D	0,0
U300	D	0,1
U301	D	2,9
U302	D	4,5
U400	D	0,9
U402	D	0,0
U403	D	9,7
U600	D	74,3
U601	D	8,6
U602	D	139,9
U603	D	11,3
U700	D	0,2
U800	D	0,2
U801	D	0,0
U803	D	0,7
U804	D	1,2
Total		355,7

* See Appendix E for detailed information

5.13.5 Allocations in Relation to Water Requirements and Availability

In 1995 the water resources of the WMA were already over allocated. Reduced runoff due to excessive landuse, leaks in reticulation systems and wastage of water all influenced the situation. A drought in the region led to serious water restrictions.

Since 1995, water conservation and demand management have proved immensely successful in reducing the demand. However, the system is still over allocated and moves to improve the situation have been undertaken. Mearns Weir and Midmar Dam will be raised to supplement the needs of the greater Durban-Pietermaritzburg region. The raising of Hazelmere Dam, which currently supplies the North Coast system or the construction of a new dam, is being investigated.

5.14 EXISTING WATER TRANSFERS

5.14.1 Introduction

Water transfers out of a quaternary catchment are considered as a water requirement imposed on the catchment, while water transfers into a catchment represent a resource available for use within the catchment. Water transfers to augment the supply of water for urban, industrial and agricultural use are categorised as follows:

- Transfers to and from neighbouring states.
- Transfers between Water Management Areas (e.g. Thukela – Vaal transfer).
- Transfers within WMAs are transfers between and within quaternary catchments within a WMA (e.g transfers by Umgeni Water to the various MLCs and TLCs within the Mgeni Basin).

The Mvoti to Umzimkulu WMA receives water from the Thukela WMA and does not transfer water to another WMA.

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

Figure 5.14.1.1 indicates water transfers for the Mvoti to Umzimkulu WMA as at 1995.

5.14.2 Transfers to and from Neighbouring States

There are no transfers to neighbouring states.

5.14.3 Inter-WMA Transfers

There is only one transfer into the WMA from the Thukela WMA, namely the Mearns Transfer Scheme.

TABLE 5.14.3.1: AVERAGE INTER-WATER MANAGEMENT AREA TRANSFERS UNDER 1995 DEVELOPMENT CONDITIONS

DESCRIPTION OF TRANSFER	SOURCE	RECEIVER WMA	INFRASTRUCTURE CAPACITY (m^3/s)	AVERAGE ACTUAL ANNUAL TRANSFER VOLUME (million m^3/a)	IMPACT ON YIELD RECEIVER WMA (million m^3/a)	TRANSFER QUANTITY MVOTI TO UMZIMKULU WMA (million m^3/a)		
						IMPACT ON YIELD	LOSSES	TOTAL
Inter-WMA transfers into WMA:								
Mearns Transfer Scheme	Mearns Weir (V20D)	Midmar catchment (U20B)	3,2	50,0	34,0	34,0	0,0	34,0
Total water imports in 1995				50,0	34,0	34,0	0	34,0
Total water exports in 1995				0,0	0,0	0,0	0,0	0,0

5.14.4 Transfers Within-WMA

Within the Mvoti to Umzimkulu WMA there are numerous within-basin transfers, that include transfers between quaternary catchments and even within quaternary catchments. Significant transfers by urban users (including water boards), bulk users (industry & mines) and agriculture (for irrigation) have been listed in Table 5.14.4.1.

TABLE 5.14.4.1: AVERAGE TRANSFERS WITHIN THE MVOTI TO UMZIMKULU WMA AT 1995 DEVELOPMENT LEVELS

DESCRIPTION OF TRANSFER	SOURCE & QUATERNARY	DESTINATION & QUATERNARY	QUANTITY (million m^3/a)
Mtamvuna Scheme	Mtamvuna River (T40E)	Port Edward (T40F)	0,71
Mtamvuna Scheme	Mtamvuna River (T40E)	Port Edward (T40F)	0,81
	Mzimkulu River (T51C)	Himeville (T51D)	0,12
	Mzimkulu River and Dam (T52D)	Umzimkulu (T52C)	0,20
Mzimkulwana/Mzimkulu Scheme	Mzimkulwana River (T52L)	Port Shepstone (T40G)	9,50
Mzimkulwana/Mzimkulu Scheme	Mzimkulwana River (T52L)	Margate (T52M)	0,00
Mzimkulwana/Mzimkulu Scheme	Mzimkulwana River (T52L)	Hibberdene (U80D)	0,30
	Mkomazi River (U10M)	Mkomaas (U80L)	0,77
Umgeni Water: Inland Supply system	Midmar Dam (U20C)	New Hanover/Cool Air (U20F)	0,30
Umgeni Water: Inland Supply system	Midmar Dam (U20C)	Howick (U20E)	1,91
Umgeni Water: Inland Supply system	Midmar Dam (U20C)	Albert Falls and Wartberg (U20G)	0,10
Umgeni Water: Inland Supply system	Midmar Dam (U20C)	Vulindela (U20H)	0,00
Umgeni Water: Inland Supply system	Midmar Dam (U20C)	Pietermaritzburg (U20J)	32,60
Umgeni Water: Durban Supply system	Midmar Dam (U20C)	Durban (U60F)	2,90
Umgeni Water: Durban Supply system	Nagle Dam (U20G)	Durban (U60F)	182,50
Umgeni Water: Durban Supply system	Inanda Dam (U20L)	Durban (U60F)	81,40
Umgeni Water: North Coast Supply system	Hazelmere Dam (U30A)	Ballito and Groutville (U30E)	1,52
Umgeni Water: North Coast Supply system	Hazelmere Dam (U30A)	Stanger (U40J)	0,08
Umgeni Water: North Coast Supply system	Hazelmere Dam (U30A)	Durban (U60F)	4,30
Umgeni Water	Mdloti River (U30A)	Tongaat Hulett (Maidstone) (U30D)	0,64
Urban return flows	Mpumulanga (U60F)	Mlazi River (U60D)	1.18
Urban return flows	Kwa Mashu (U60F)	Mgeni Estuary (U20M)	9.86
Urban return flows	J Ponds (U60F)	Mlazi Estuary (U60D)	0.33
Urban return flows	Dassenhoek (U60F)	Mlazi Estuary (U60D)	0.07
Urban return flows	Kwa Ndengezi (U60F)	Mlazi River (U60D)	0.39
Urban return flows	Hammersdale (U60F)	Sterkspruit River (U60C)	3.29
Umgeni Water: South Coast Supply system	Nungwane Dam (U70D)	Durban (U60F)	5,90
Mtwalume Scheme	Mtwalume River (U80F)	Ifafa (U80G)	0,00
Mtwalume Scheme	Mtwalume River (U80F)	Sezela (U80H)	0,40
Industrial supply	Ifafa (U80G)	CG Smith at Sezela (U80H)	0,60

5.15 SUMMARY OF WATER LOSSES AND RETURN FLOWS

Total losses in the WMA from irrigation, urban, rural and bulk supply amount to 225,2 million m^3/a. Losses from dams are an estimated 31,4 million m^3/a, amounting to a total loss in the WMA of 256,6 million m^3/a. Return flow from irrigation, urban and bulk use in the WMA totals 279,3 million m^3/a.

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

CATEGORY		ON-SITE WATER REQUIREMENTS (million m^3/a)	LOSSES (million m^3/a)	LOSSES (%)	TOTAL WATER REQUIREMENTS (million m^3/a)	RETURN FLOW (million m^3/a)
Irrigation		214,7	23,9	10	238,6	23,9
Urban		237,3	79,1	25	316,4	199,7
Rural		35,2	8,8	5	44,0	0,0
Bulk	a) Strategic	0,0	0,0	0	0,0	0,0
	b) Mining	0,0	0,0	0	0,0	0,0
	c) Other	65,1	7,2	10	72,3	42,5
Hydro-power		0,0	0,0	0	0,0	0,0
Rivers, wetlands, dams		N/A	31,4		N/A	N/A
TOTAL		552,3	150,4	22	671,3	266,0

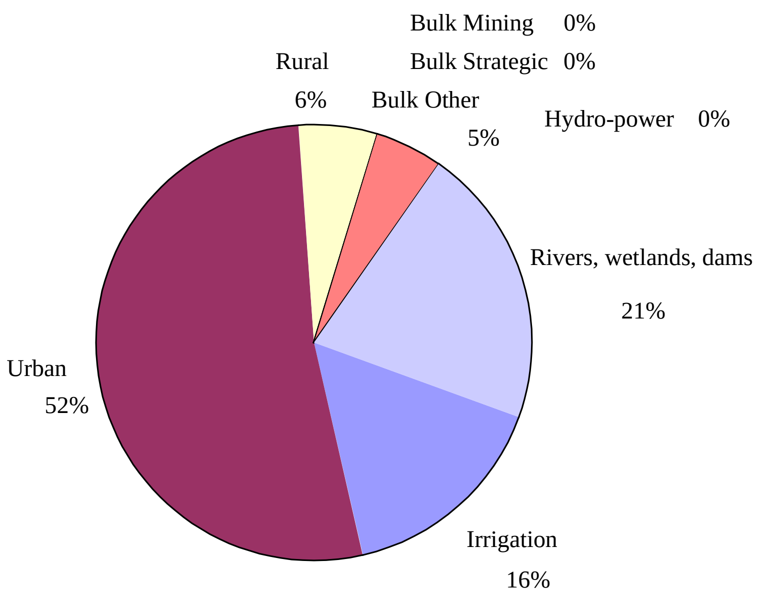

DIAGRAM 5.15.1: WATER LOSSES IN THE MVOTI TO UMZIMKULU WMA

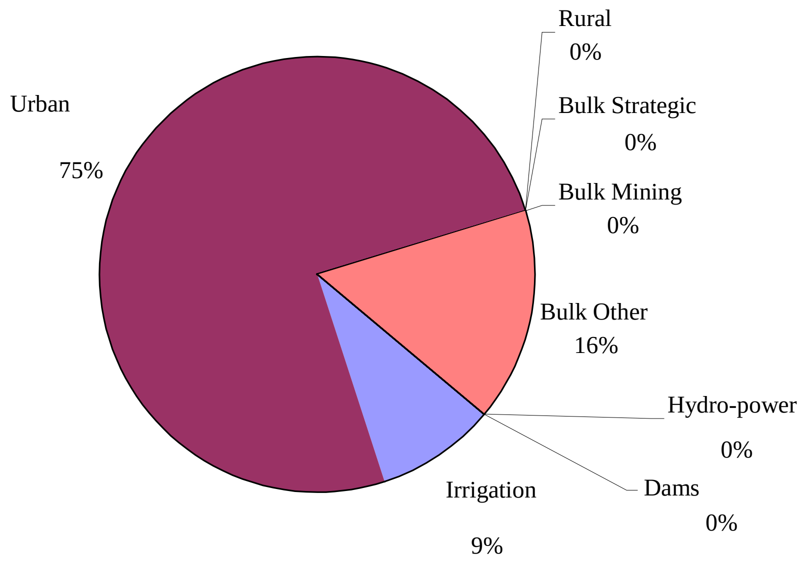

DIAGRAM 5.15.2: RETURN FLOWS IN THE MVOTI WMA

The Mvoti to Umzimkulu WMA is the only WMA in the Kwazulu-Natal province with urban return flows between quaternary catchments. These are solely from the reticulation system in and around Durban.

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

DESCRIPTION	SOURCE CATCHMENT	RECEIVING CATCHMENT	QUANTITY (million m^3/a)
	Mpumulanga (U60F)	Mlazi River (U60C)	1,18
Durban Supply system	Kwa Mashu (U60F)	Mgeni Estuary (U20M)	9,86
	J Ponds (U60F)	Mlazi Estuary (U60D)	0,33
	Dassenhoek (U60F)	Mlazi River (U60D)	0,07
	Kwa Ndengezi (U60F)	Mlazi River (U60D)	0,39
	Hammersdale (U60F)	Sterkspruit River (U60C)	3,29
Durban Supply system	Durban North (U60F)	Mgeni Estuary (U20M)	11,83

Note: These quantities are included in Table 5.15.1

CHAPTER 6: WATER RESOURCES

6.1 EXTENT OF WATER RESOURCES

The total natural MAR of the Mvoti to Umzimkulu WMA is 4 798 million m^3. Groundwater in the Mvoti to Umzimkulu WMA is largely undeveloped with scope for an additional approximately 380 million m^3/a to be utilised (approximately 65 times the current use). The ground and surface water yields per key area can be found in Table 6.1.1. It should however be noted that surface water yields have not had the ecological Reserve deducted from them (i.e. the yield has been calculated as if the ecological Reserve were zero). The effect of including the ecological Reserve will be to decrease the surface water availability for other uses. The extent to which this will occur is yet to be seen, as there is no clear and consistent mandate for dealing with the Reserve as of yet. The water balance in Chapter 7 will give an idea of how the ecological reserve will impact the yields.

The method of determining the full potential yield was derived by adding to the water resources as developed in 1995 the unused exploitable groundwater potential, obtained from the database supplied by the Client. Figure 6.1.1 and Figure 6.1.2 indicate the net 1:50 year yield of the total water resource as developed in 1995 and as developed to full potential respectively. There has been very little water resource development in this WMA. There is potential for many more dams and increasing the utilisable surface yield significantly.

TABLE 6.1.1: WATER RESOURCES

CATCHMENT						SURFACE WATER RESOURCES (million m^3/a)			SUSTAINABLE GROUNDWATER EXPLOITATION POTENTIAL NOT LINKED TO SURFACE WATER (million m^3/a)		TOTAL WATER RESOURCE (million m^3/a)	
PRIMARY		SECONDARY		TERTIARY								
No.	Description	No.	Description	No	Description	NAT-MAR	1:50 YEAR DEVELOPED YIELD IN 1995	1:50 YEAR TOTAL POTENTIAL YIELD	DEVELOPED IN 1995	TOTAL POTENTIAL	1:50 YEAR DEVELOPED IN 1995	1:50 YEAR TOTAL POTENTIAL
T	MZIMKULU	T4	Mtamvuna			426,2	25,6	25,6	0,1	25,4	25,7	51,0
		T5	Mzimkulu	T51	Upper Mzimkulu	790,5	22,0	22,0	0,4	22,0	22,4	44,1
				T52	Lower Mzimkulu	582,6	29,9	29,9	0,9	36,0	30,8	65,9
			Sub-total Mzimkulu			1373,1	51,9	51,9	1,3	58,0	53,2	109,9
	TOTAL IN MZIMKULU					1799,3	77,5	77,5	1,4	83,4	78,9	160,9
U	MVOTI	U1	Mkomazi	U10	Upper Mkomazi	676,1	20,6	20,6	0,1	8,6	20,7	29,2
				U10	Lower Mkomazi	403,5	18,9	18,9	0,6	19,0	19,5	37,9
			Sub-total Mkomazi			1079,6	39,5	39,5	0,8	27,6	40,3	67,1
		U2	Mgeni	U20	Midmar	201,6	119,4	119,4	0,0	8,3	119,4	127,6
				U20	MgeniMouth	472,6	233,8	233,8	1,2	76,7	234,9	310,5
			Sub-total Mgeni			674,2	353,1	353,1	1,2	85,0	354,3	438,1
		U3	Mdloti Tongati Mhlali			213,6	47,1	47,1	0,1	36,3	47,3	83,4
		U4 & U5	Mvoti Nonati			381,2	51,9	51,9	0,8	64,2	52,7	116,1
		U6	Mlazi			184,1	243,4	243,4	0,1	34,5	243,5	277,9
		U7	Lovu			134,0	17,9	17,9	0,2	23,5	18,1	41,5
		U8	KZN South Coast			331,5	13,3	13,3	1,4	33,3	14,8	46,6
	TOTAL IN MVOTI					2998,2	766,3	766,3	4,6	304,4	770,9	1070,7
	TOTAL IN EASTERN CAPE					604,8	28,5	28,5	0,5	31,2	29,0	59,7
	TOTAL IN KWAZULU-NATAL					4 192,7	815,4	815,4	5,4	356,5	820,8	1 171,9
	TOTAL IN MVOTI / MZIMKULU WMA					4 797,5	843,8	843,8	5,9	387,8	849,8	1 231,6

6.2 GROUNDWATER

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

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

The Groundwater Harvest Potential (Seward and Seymour, 1996) was used as the basis for the evaluation. The Harvest Potential is defined as the maximum volume of groundwater that is available for abstraction without depleting the aquifer systems, and takes into account recharge, storage and drought periods (see Figure 6.2.1).

The Harvest Potential was 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).

The interaction of the groundwater and the surface water was assessed by evaluating the base flow component of the surface water, or more specifically the contribution of the Harvest Potential to the base flow. This contribution can be seen as water that can either be abstracted as groundwater or surface water. From this, the extent to which groundwater abstraction will reduce the base flow component of the surface water has been qualitatively evaluated (see Figure 6.2.3). Where the contribution of groundwater to the base flow component of the surface flow is zero the impact will be negligible, where the contribution is less than 30% of the base flow the impact will be low, where the contribution is between 30% and 80% of the base flow the impact will be moderate, and where the contribution to base flow is more than 80% the impact will be high. This assessment of the interaction of groundwater and the base flow component of the surface water can however, not be used directly to determine the additional contribution of groundwater abstraction to the total utilisable water resource without also taking account of the effect of surface water storage capacity and the reduction in surface water runoff that is caused by the increase of groundwater recharge (induced recharge) that results from groundwater abstraction. The estimates of utilisable surface water given in Section 6.3 have been derived on the basis of no groundwater abstraction. For the purpose of this water resources assessment the proportion of the utilisable groundwater not contributing to the base flow of the surface water that can be added to the utilisable surface water to estimate the total utilisable resources has therefore been ignored.

The existing groundwater use was determined by Baron and Seward (2000). The information was then verified at a workshop held in the Mvoti to Umzimkulu WMA by the water resources situation assessment team. This provided local input to the estimates of groundwater use provided by Baron and Seward which were then adjusted accordingly (see Table 6.2.1 and Figure 6.2.4).

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

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

CATCHMENT						GROUNDWATER EXPLOITATION POTENTIAL (million m^3/a)	GROUNDWATER USE IN 1995 (million m^3/a)	UNUSED GROUNDWATER EXPLOITATION POTENTIAL IN 1995 (million m^3/a)	GROUNDWATER CONTRIBUTION TO SURFACE BASE FLOW (million m^3/a)	PORTION OF GROUNDWATER EXPLOITATION POTENTIAL NOT CONTRIBUTING TO SURFACE BASE FLOW (million m^3/a)
PRIMARY		SECONDARY		TERTIARY						
No.	Description	No.	Description	No.	Description					
T	MZIMKULU	T4	Mtamvuna			25,39	0,09	25,31	45,81	0,00
				T51	Upper Mzimkulu	22,02	0,39	21,63	43,57	0,00
				T52	Lower Mzimkulu	35,99	0,88	35,11	62,17	0,00
		T5	Sub-total Mzimkulu			58,01	1,27	56,74	105,74	0,00
	TOTAL IN MZIMKULU					83,40	1,36	82,05	151,55	0,00
U	MVOTI			U10	Upper Mkomazi	8,60	0,13	8,46	28,65	0,00
				U10	Lower Mkomazi	19,01	0,64	18,37	39,89	0,00
		U1	Sub-total Mkomazi			27,61	0,77	26,83	68,54	0,00
				U20	Midmar	8,26	0,01	8,24	13,07	0,00
				U20	MgeniMouth	76,71	1,36	75,35	64,65	12,06
		U2	Sub-total Mgeni			84,96	1,37	83,59	77,72	12,06
		U3	Mdloti Tongati Mhlali			36,32	0,12	2,4	33,92	2,40
		U4&U5	Mvoti Nonati			64,20	0,66	0,08	64,12	0,08
		U6	Mlazi			34,51	0,10	0,42	34,09	0,42
		U7	Lovu			23,53	0,14	0	25,47	0,00
		U8	KZN South Coast			33,26	1,41	0	69,69	0,00
	TOTAL IN MVOTI					304,39	4,58	299,81	373,55	14,96
	TOTAL IN EASTERN CAPE					31,24	0,53	30,71	55,89	0,00
	TOTAL IN KWAZULU-NATAL					356,55	5,41	351,15	469,21	14,96
	TOTAL IN MVOTI / MZIMKULU WMA					387,79	5,94	381,86	525,10	14,96

6.3 SURFACE WATER RESOURCES

6.3.1 Streamflow Data

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

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

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

(1) The afforestation water use time series based on the Van der Zel 15-year rotation curve was generated.

(2) This time series (the result of (1)) was then subtracted from the Van der Zel-based naturalised flow time series generated for the whole calibration catchment.

(3) The naturalised flow from the afforested portion of the catchment (Van der Zel-based) was used to obtain an afforestation water use time series based on the CSIR curves. This result was added to the result of (2), yielding a time series of adjusted (CSIR-based) naturalised flows.

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

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

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

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

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

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

The most important limitations of the method described above are :

- The updated afforestation water use was estimated by means of the CSIR curves (as described in (3)), but the uncorrected naturalised flows based on the original Van der Zel curves were used as input into this calculation. As a refinement, one could consider the possibility of repeating the process by estimating afforestation water use using the newly adjusted naturalised flows, and not the original WR90 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 quaternary catchments with and without afforestation. Changing the MARs of only afforested quaternary catchments therefore made the naturalised MAR of the total catchment less accurate, as the MARs of unafforested catchments were not adjusted.

The better 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.

Most of the hydrology for the Mvoti to Umzimkulu WMA was sourced from the WR90 study. The Mgeni River Catchments (U20) hydrology was updated with information from the Mgeni Systems Analysis (DWAF and Umgeni Water : 1994) the hydrology for which was detailed and is considered reliable. (Figure 6.3.1.1 indicates the final mean annual naturalised runoff.)

TABLE 6.3.1.1: SURFACE WATER RESOURCES

CATCHMENT						CATCH-MENT AREA (km^2)	MEAN ANNUAL PRECIPI-TATION (mm)	MEAN ANNUAL EVAPO-RATION (mm) (2)	NATURALISED MAR		YIELD (1:50 YEAR) (1)	
PRIMARY		SECONDARY		TERTIARY					INCREMENTAL (million m^3)	CUMULATIVE (million m^3)	DEVELOPED IN 1995 (million m^3/a)	TOTAL POTENTIAL (million m^3/a)
No.	Description	No	Description	No.	Description							
T	MZIMKULU	T4	Mtamvuna			2 216,0	926,6	1 191,0	426,2	426,2	25,6	25,6
				T51	Upper Mzimkulu	2 746,0	1 050,0	1 304,0	790,5	790,5	22,0	22,0
				T52	Lower Mzimkulu	3 932,0	853,2	1 181,0	582,6	1 373,0	29,9	29,9
		T5	Sub-total Mzimkulu			6 678,0	1 903,2	2 485,0	1 373,1	1 373,1	51,9	51,9
	TOTAL MZIMKULU					8 894,0			1 799,3	1 799,3	77,5	77,5
U	MVOTI			U10	Upper Mkomazi	1 741,0	1 129,0	1 300,0	676,1	676,1	20,6	20,6
				U10	Lower Mkomazi	2 646,0	884,1	1 209,0	403,5	1 079,6	18,9	18,9
		U1	Sub-total Mkomazi			4 387,0			1 079,6	1 756,1	39,5	39,5
				U20	Midmar	925,0	978,1	1 262,0	201,6	201,6	119,4	119,4
				U20	MgeniMouth	3 514,0	920,4	1 202,0	472,6	674,2	233,8	233,8
		U2	Sub-total Mgeni			4 439,0			674,2	674,2	353,1	353,1
		U3	Mdloti Tongati Mhlali			1 310,0	989,6	1 200,0	213,6	213,6	47,1	47,1
		U4& U5	Mvoti Nonati			3 035,0	908,1	1 244,0	381,2	381,2	51,9	51,9
		U6	Mlazi			1 523,0	870,8	1 200,0	184,1	184,1	243,4	243,4
		U7	Lovu			1 090,0	909,2	1 200,0	134,0	134,0	17,9	17,9
		U8	KZN South Coast			2 537,0	911,0	1 200,0	331,5	331,5	13,3	13,3
	TOTAL IN MVOTI					18 321,0			2 998,2	2 998,2	766,3	766,3
	TOTAL IN EASTERN CAPE					3 274,6			604,8		28,5	28,5
	TOTAL IN KWAZULU-NATAL					23 940,4			4 192,7		815,4	815,4
	TOTAL IN MVOTI / MZIMKULU WMA					27 215,0			4 797,5		843,8	843,8

1. The ecological Reserve has not been deducted from the yields shown.
2. Class S Pan.

6.3.2 Yield Analysis

In order to estimate the total potential yield available from the catchments within the Water Management Area, it is necessary to postulate future storage dams with a maximum net storage capacity. Dams that will capture and regulate all the runoff from a catchment are not economical to build. In the drier areas where the runoff is more variable the sizes of such dams also become prohibitive. A simple technique, based on past experience, has therefore been developed whereby plausible estimates of maximum feasible dam size have been derived for the entire South Africa and which will provide consistent results throughout the country. The water balance model will however, be enhanced in future to contain additional functionality to allow users to optimise the likely maximum storage capacity.

The technique that was adopted introduces a limit line to the net storage-gross yield relationship for a 50-year recurrence interval, as shown in Diagram 6.3.2.1. 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 6.3.2.1. This is illustrated by means of the typical net storage-gross yield relationships shown in Diagram 6.3.2.1 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% and 200% of the MAR as appropriate. Figure 6.3.2.1 indicates the potential yield.

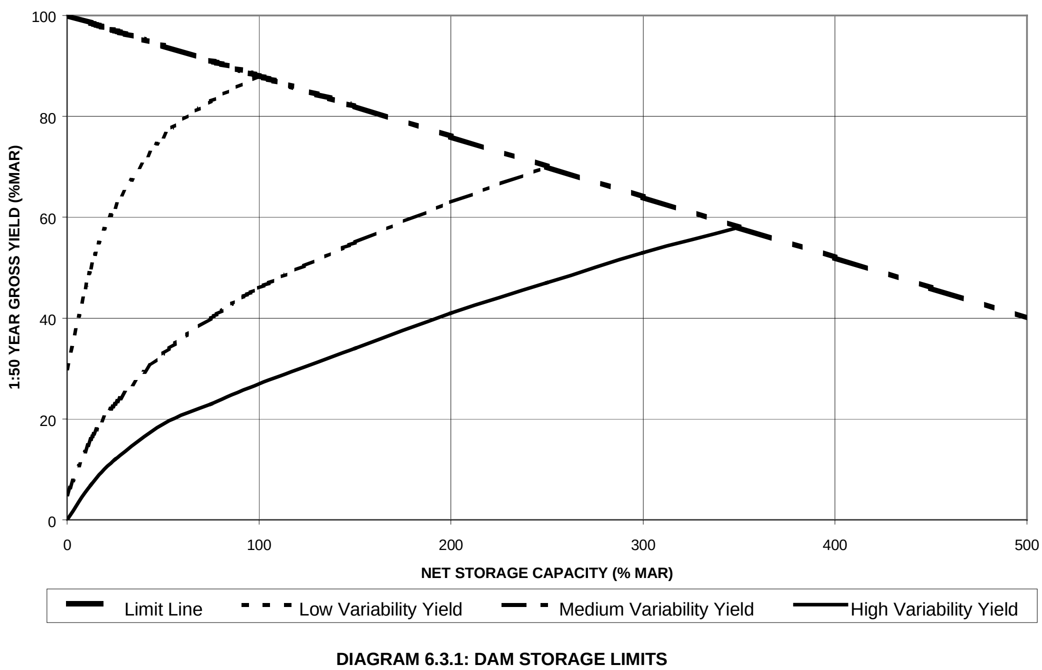

DIAGRAM 6.3.2.1: DAM STORAGE LIMITS

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 solids (TDS). Data for the assessment were obtained from the water quality database of the Department of Water Affairs and Forestry.

The surface water quality monitoring stations that were used to provide the data are shown in Figure 6.4.1.1. Appendix F indicates the monitoring station that was used for each individual quaternary catchment. As can be seen from Figure 6.4.1.1, much of the Mvoti – Mzimkulu WMA is ungauged in terms of water quality. Only 14 gauges were used in a WMA with 90 quaternary catchments, with many of the gauges situated in the upper reaches of the catchment. This is an issue that needs to be addressed.

Only data sets that had data for at least 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.

Details of the TDS for the various catchments are given in Appendix F.

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

TABLE 6.4.1.1: CLASSIFICATION SYSTEM FOR MINERALOGICAL WATER QUALITY

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

Where water quality data were available (only 36 of 90 quaternary catchments were classified, from only 9 monitoring stations), water quality was assessed at a quaternary catchment level of resolution. The final classification of the mineralogical surface water quality of a quaternary catchment was based on both average conditions and extreme conditions. For this purpose the data set was inspected for the worst two-year period observed. The average concentration and the maximum were used to determine the class of the water as shown in Table 6.4.1.2. Appendix F contains a summary of the methodology used in determining the water classes for each quaternary catchment.

TABLE 6.4.1.2: OVERALL CLASSIFICATION

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

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

TABLE 6.4.1.3: SUMMARY OF MINERALOGICAL SURFACE WATER QUALITY OF THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

SECONDARY CATCHMENT	NO OF QUATERNARY CATCHMENTS	NO OF QUATERNARY CATCHMENTS IN CLASS					
		BLUE	GREEN	YELLOW	RED	PURPLE	NO DATA
T4	7	5	0	0	0	0	2
T5	21	7	1	0	0	0	13
U1	12	8	1	0	0	0	3
U2	12	1	0	0	0	0	11
U3	5	1	0	0	0	0	4
U4	9	3	0	0	0	0	6
U5	1	0	0	0	0	0	1
U6	6	1	1	0	0	0	4
U7	6	0	0	1	0	0	5
U8	11	3	1	2	0	0	5

Details of the TDS values and final water classes for each quaternary catchment are given in Appendix F.

Where available, the mineralogical surface water quality of the Mvoti to Umzimkulu Water Management Area is generally good with only 3 out of 36 classified quaternary catchments registering marginal water quality. No quaternary catchments have had their water quality classified as poor or unacceptable. However, a large number of quaternary catchments (54 of 90) remain unclassified.

6.4.2 Mineralogical Groundwater Quality

The groundwater quality is one of the main factors affecting the development of available groundwater resources. Although there are numerous problems associated with water quality, some of which are easily corrected, total dissolved solids (TDS), nitrates (NO_3 as N) and fluorides (F) are thought to represent the majority of serious water quality problems that occur.

The water quality has been evaluated in terms of TDS and potability. The information was obtained from WRC Project K5/841 (Simonic, 2000). The mean TDS together with the highest value, lowest value and range is given for each catchment where analyses were available. Where no analyses were available an estimate of the mean was made using Vegter's maps (Vegter, 1995). The potability evaluation done by Simonic (2000) was based on the evaluation of chloride, fluoride, magnesium, nitrate, potassium, sodium, sulfate and calcium using the Quality of Domestic Water Supplies, Volume I (DWAF, 1998c).

The portion of the groundwater resources considered to be potable has been calculated as that portion classified as ideal, good and marginal (Class 0, 1 and 2) according to the classification system given in Section 6.4.1. Water classified as poor and unacceptable (Class 3 and 4) has been considered to be **not** potable.

In catchments where no information was available estimates of the portion of potable groundwater were made using Vegters maps (Vegter, 1995).

Figure 6.4.2.1 gives an evaluation of the mean TDS per quaternary catchment and Figure 6.4.2.2 gives an estimate of the percentage of potable groundwater 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 G 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 Mvoti to Umzimkulu 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 catchment scale. The portion applicable to the Mvoti to Umzimkulu WMA is given in Figure 6.4.3.2. This map shows the degree of potential faecal contamination in groundwater using a rating scale that ranges from low to medium to high.

Conclusions and recommendations

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

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

6.4.4 Water Quality Issues

Water quality monitoring in the Mvoti to Umzimkulu WMA indicates that quality is not a concern. However, only three of the ten quaternary catchments that support industry are monitored and their water quality is rated as good. The remaining seven unclassified quaternary catchments may be found to have very poor water quality due to industry that may also affect downstream quaternary catchments. Of particular concern are quaternary catchments U20E (Mgeni River) and U20J (tributary of Mgeni River) that have large industry and a large degree of urbanisation (Howick and Pietermaritzburg respectively) and no water quality monitoring points in the quaternary catchments or downstream of them. The Mgeni River flows through the outskirts of Durban in quaternary catchment U20M and is therefore likely to be even more degraded before flowing into the sea.

The large number of quaternary catchments that have not been classified is of concern – an issue that needs to be addressed.

6.5 SEDIMENTATION

Figure 6.5.1 indicates the potential for sediment accumulation in a 25 year period in reservoirs. The sediment yield per quaternary catchment in tonnes/annum and the 25 year sediment volume in million m^3 are tabulated for every quaternary catchment in the Mvoti to Umzimkulu water management area and included in Appendix F. Table 6.5.1, taken from Rooseboom (1992), addresses erodability and likely sediment yield for a number of dams in this WMA.

TABLE 6.5.1: RECORDED RESERVOIR SEDIMENTATION RATES FOR RESERVOIRS IN THE VICINITY OF THE MVOTI TO UMZIMKULU WMA

QUATERNARY CATCHMENT NO.	RIVER	DAM NAME	ECA (km^2)	PERIOD	V_T (million m^3)	V_{50} (million m^3)	SEDIMENT YIELD (t/km^2.a)
U20E	Mgeni	Albert Falls	716	1974 - 1983	0,295	0,832	31
U20E	Mgeni	Midmar	928	1965 - 1983	0,204	0,330	10
U20J	Mzinduzi	Henley	238	1942 - 1987	0,355	0,370	42
U30A	Mdloti	Hazelmere	377	1975 - 1987	4,679	10,099	723
U60D	Mlaze	Shongweni	231	1927 - 1987	6,853	6,414	231

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

Source of data: Rooseboom (1992)

Reservoir sedimentation as at the last survey can be found in Table 6.5.2 for a number of dams. From this table it can be seen that sedimentation is generally low in the Mvoti to Umzimkulu WMA (with the exception of the Hazelmere Dam and Shongweni Dam) and is not likely to have a large impact on dam yields. (It must be noted in the case of Shongweni Dam that the rate of sedimentation translates to less than 1% per annum, which is still higher than the other dams in this WMA bar Hazelmere Dam.)

TABLE 6.5.2: SEDIMENTATION AS A PERCENTAGE OF ORIGINAL CAPACITY FOR SELECTED RESERVOIRS

DAM	QUATERNARY	SEDIMENTATION AS A PERCENTAGE OF THE ORIGINAL CAPACITY*	PERIOD
Albert Falls	U20E	0,1	1974 – 1983
Inanda	U20L	2,7	1988 – 1990
Midmar	U20E	1,3	1965 – 1996
Nagle	U20G	0,0	1950 – 1987
Hazelmere	U30A	25,3	1975 – 1993
Henley	U20J	7,3	1942 – 1987
Shongweni	U60D	62,6	1927 – 1990

* As a percentage of the total, raised capacity
Source: Richard Strauss, personal communication, Pretoria, 4 October 2001.

CHAPTER 7: WATER BALANCE

7.1 METHODOLOGY

7.1.1 The Water Situation Assessment Model

The Water Situation Assessment Model (WSAM) was developed with the purpose of providing a reconnaissance level decision support tool. The model is intended to provide a broad overview of the water situation in South Africa taking into account all significant water uses and resources. The model can produce output at a variable resolution, down to quaternary catchment scale.

The data input to the model was gathered by various organisations and individuals, but the Water Resources Situation Assessments (WRSA) were the main vehicle for providing data for the model. Appendix H lists the organisations responsible for the various components of the data. This list also gives the reader a good indication of the type of data in the database.

The intention was to use the WSAM to determine the water balance for the WRSA reports and also to use the WSAM reporting tools to produce as many of the tables in the WRSA reports as was practical. However, due to various unresolved developmental problems with the WSAM, another approach was adopted, as described in this section. For this reason, the WSAM is not described in any detail in this report. The reader is referred to the WSAM user manual for more information on this model.

7.1.2 Determining the Water Balance

The water balance is simply the difference between the water resource and the sum of all the water requirements and losses. While the water requirements and losses are easily abstracted from the database, to estimate the water resource directly from the known yields of dams would be difficult and impractical. The main reason for this is that the run-of-river component of the resource is difficult to determine without some form of modelling, especially where there are multiple dams and abstractions and the different modes of operation of the dams influence the yields.

The water balance produced by the WSAM is not yet correct in all cases due to the following unresolved problems:

- The ecological Reserve has spurious impacts on the water balance, which do not appear to be correct;
- The impacts of afforestation and alien vegetation, as reported on the balance do not appear to be correct;
- It is not possible to model actual known river losses; and
- Return flows from irrigation are not modelled correctly.

The approach taken to determine the water balance was therefore to remove the above questionable components out of the WSAM modelling procedure. This is done relatively easily. The above impacts (ecological Reserve, etc.) were then determined external to the model and added or subtracted from the WSAM water balance as appropriate. This procedure achieved a resultant water balance that seemed to be in reasonable agreement with other estimates in most cases.

7.1.3 Determining the water requirement

The water requirements determined by the WSAM are mostly accepted to be correct. In order to facilitate the production of the WRSA reports, this data was abstracted from the WSAM into a spreadsheet and various worksheets set up, which reference this abstracted data. These worksheet were structured so a to present most of the information contained in the tables of this report. This is not only limited to water requirements but also lists land uses such as irrigated areas, afforested areas, etc.

The data was abstracted in two different formats: at key area resolution (incremental between key points) and at quaternary catchment resolution. The key area data has been aggregated by the WSAM except for a few parameters relating mainly to irrigation, which the WSAM did not aggregate correctly. In these cases, default values were used. A list of these parameters and the default values is attached as Appendix H. The data at quaternary catchment resolution was abstracted for information purposes only. It is attached in the Appendixes to this report.

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

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

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

Using the above method, negative impacts are sometimes possible. The reason for this is that the water required for the ecological Reserve at an upstream point may become available for use further downstream, if the ecological Reserve is less at the downstream point.

Water losses
The WSAM models losses as a function of the flow in the river. The water loss under natural flow conditions is used in the WSAM to calculate the water loss under the altered flow conditions. While this is conceptually correct, it is found to be very difficult to model the known loss under current conditions. For this reason, the WSAM was run with zero losses and the known losses taken into account external to the model when determining the water balance.

Irrigation return flows
The average return flow from irrigation in South Africa according to the WSAM is in the order of 3%. This is clearly erroneous and not in accordance with the 10% to 15% default agreed upon at various workshops. Irrigation return flows were therefore calculated external to the model and were usually assumed to be 10%. Where the consultant and/or other persons had more detailed information of the return flows that could be expected these were adopted instead.

7.1.4 Determining the water resource

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

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

7.2 OVERVIEW

This section gives an overview of the water balance situation at key points in the WMA, and for the WMA as a whole. Table 7.2.1 tabulates the water requirements per key area, and Table 7.2.2 tabulates the water balance. Figure 7.2.1 illustrates the water balance.

TABLE 7.2.1: WATER REQUIREMENTS BY DRAINAGE AREA IN 1995 AT EQUIVALENT 1:50 YEAR ASSURANCE

CATCHMENT						Streamflow reduction activities		Water use		Water requirement							
PRIMARY		SECONDARY		KEY AREA													
No	Description	No	Description	No	Description	Afforestation (million m^3/a)	Dryland Sugar Cane (million m^3/a)	Alien Vegetation (million m^3/a)	Dam Losses (million m^3/a)	Bulk(1) (million m^3/a)	Irrigation (2) (million m^3/a)	Rural(3) (million m^3)	Urban(4) (million m^3/a)	Hydropower (million m^3/a)	Water Transfers Out Of WMA (million m^3/a)	Ecological Reserve (million m^3/a)	Total (million m^3/a)
T	MZIMKULU	T4	Mtamvuna			16,5	10,0	23,3	0,1	0,0	2,2	5,8	10,9	0,0	0,0	16,4	85,3
				T51	Upper Mzimkulu	7,7	0,0	6,4	2,0	0,0	8,8	2,8	0,2	0,0	0,0	24,2	52,2
				T52	Lower Mzimkulu	42,3	7,7	38,7	0,5	4,1	16,5	5,0	0,9	0,0	0,0	31,7	147,3
		T5	Subtotal Mzimkulu			50,0	7,7	45,2	2,5	4,1	25,3	7,8	1,1	0,0	0,0	55,9	199,5
	TOTAL IN MZIMKULU					66,5	17,6	68,5	2,6	4,1	27,5	13,6	12,1	0,0	0,0	72,3	284,8
U	MVOTI			U10	Upper Mkomazi	5,2	0,0	7,4	0,7	0,0	7,8	1,8	0,0	0,0	0,0	14	37,0
				U10	Lower Mkomazi	26,5	3,4	3,9	3,0	52,4	25,1	3,5	0,4	0,0	0,0	18	136,4
		U1	Sub-total Mkomazi			31,7	3,4	11,3	3,8	52,4	32,9	5,4	0,4	0,0	0,0	32	173,4
				U20	Midmar	14,7	0,0	4,8	7,5	0,0	16,9	1,4	0,0	0,0	0,0	25,8	71,2
				U20	MgeniMouth	37,0	32,5	8,6	12,3	1,0	19,4	7,6	50,4	0,0	0,0	30	198,8
		U2	Sub-total Mgeni			51,7	32,5	13,5	19,7	1,0	36,3	9,0	50,5	0,0	0,0	55,8	270,0
		U3	Mdloti Tongati Mhlali			0,2	22,9	11,3	0,6	6,4	27,5	3,3	2,1	0,0	0,0	6,8	81,3
		U4 U5	Mvoti Nonati			33,4	20,1	21,0	1,9	4,2	47,9	6,1	6,6	0,0	0,0	11,9	153,2
		U6	Mlazi			6,8	16,4	5,6	1,8	3,0	17,5	2,0	234,8	0,0	0,0	1,4	289,3
		U7	Lovu			15,4	10,9	3,3	0,5	0,0	8,8	1,7	0,0	0,0	0,0	0,5	41,1
		U8	KZN South Coast			11,9	16,2	7,1	0,5	1,3	8,2	5,6	7,0	0,0	0,0	14	71,9
	TOTAL IN MVOTI					151,3	122,4	73,1	28,9	68,3	179,2	33,2	301,5	0,0	0,0	122,4	1080,2
	TOTAL IN EASTERN CAPE					27,7	7,4	28,4	0,7	1,9	10,5	5,1	4,6	0,0	0,0	26,3	112,6
	TOTAL IN KWAZULU-NATAL					190,1	132,6	113,2	30,8	70,5	196,2	41,7	309,0	0,0	0,0	168,4	1 252,4
	TOTAL IN MVOTI TO UMZIMKULU WMA					217,8	140,1	141,6	31,5	72,4	206,7	46,8	313,5	0,0	0,0	194,7	1 365,0

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

TABLE 7.2.2: WATER REQUIREMENTS AND AVAILABILITY

CATCHMENT: PRIMARY No	CATCHMENT: PRIMARY Description	SECONDARY No	SECONDARY Description	KEY AREA No	KEY AREA Description	Available 1:50 year yield in 1995: Surface Water (million m³/a)	Available 1:50 year yield in 1995: Ground-Water Not Linked To Surface Water (million m³/a)	Available 1:50 year yield in 1995: Total (million m³/a)	Water transfers at 1:50 year assurance: Imports (million m³/a)	Water transfers at 1:50 year assurance: Exports (million m³/a)	Return flows at 1:50 year assurance - Re-usable (million m³/a)	Water Requirements At 1:50 Year Assurance (1) (million m³/a)	Water Balance (2) At 1:50 Year Assurance (million m³/a)	Receiving (million m³/a)	Transfer Down (million m³/a)	Revised Balance
T	MZIMKULU	T4	Mtamvuna			25,6	0,1	25,7	9,5	0,0	7,3	85,3	-52,3	0,0	0,0	-52,3
				T51	Upper Mzimkulu	22,0	0,4	22,4	0,0	0,0	1,1	52,2	-28,7	0,0	0,0	-28,7
				T52	Lower Mzimkulu	29,9	0,9	30,8	0,0	9,8	3,3	147,3	-113,2	0,0	0,0	-113,2
		T5	Subtotal Mzimkulu			51,9	1,3	53,2	9,5	9,8	4,4	199,5	-141,9	0,0	0,0	-141,9
	TOTAL IN MZIMKULU					77,5	1,4	78,9	9,5	9,8	11,7	284,8	-194,2	0,0	0,0	-194,2
U	MVOTI			U10	Upper Mkomazi	20,6	0,1	20,7	0,0	0,0	0,8	37,0	-15,5	0,0	0,0	-15,5
				U10	Lower Mkomazi	18,9	0,6	19,5	0,0	0,8	40,9	136,4	-76,0	0,0	0,0	-76,0
		U1	Sub-total Mkomazi			39,5	0,8	40,3	0,0	0,8	41,6	173,4	-91,5	0,0	0,0	-91,5
				U20	Midmar	119,4	0,0	119,4	34,0	37,8	2,0	71,2	50,2	34,0	0,0	84,2
				U20	MgeniMouth	233,8	1,2	234,9	34,9	263,9	66,0	198,8	102,1	0,0	0,0	102,1
		U2	Sub-total Mgeni			353,1	1,2	354,3	68,9	301,7	68,0	270,0	152,3	34,0	0,0	186,3
		U3	Mdloti Tongati Mhlali			47,1	0,1	47,3	0,0	4,4	8,4	81,3	-25,6	0,0	0,0	-25,6
		U4 U5	Mvoti Nonati			51,9	0,8	52,7	0,1	0,0	10,1	153,2	-90,4	0,0	0,0	-90,4
		U6	Mlazi			243,4	0,1	243,5	277,0	27,0	118,3	289,3	72,5	0,0	0,0	72,5
		U7	Lovu			17,9	0,2	18,1	0,0	5,9	2,9	41,1	-20,1	0,0	0,0	-20,1
		U8	KZN South Coast			13,3	1,4	14,8	1,1	0,0	6,7	71,9	-50,4	0,0	0,0	-50,4
	TOTAL IN MVOTI					766,3	4,6	770,9	347,0	339,8	256,0	1080,2	-53,3	54,5	0,0	-19,3
	TOTAL IN EASTERN CAPE					28,5	0,5	29,0	3,6	4,6	4,6	112,6	-79,0	0,0	0,0	-79,0
	TOTAL IN KWAZULU-NATAL					815,3	5,5	820,8	352,9	345,0	263,1	1 252,4	-168,5	34,0	0,0	-134,5
	TOTAL IN MVOTI TO UMZIMKULU WMA					843,8	6,0	849,8	366,0	349,6	267,7	1 365,0	-247,5	34,0	0,0	-213,5

(1) To avoid double accounting, water exports within the WMA are not included in the "Water Requirements" column. Water losses and water exports from the WMA are included.
(2) Surpluses indicated by a+ and deficits by a-

7.3 GENERAL DISCUSSION OF WATER BALANCE

The Water Balance at 1: 50 year Assurance in Table 7.2.2 is obtained by subtracting the Water Requirements from the sum of the Total Available streamflow and Return Flows. If there is a positive balance in the Key Area, it is 'transferred down' to the downstream key area (Receiving). A negative balance is not 'transferred down', but may be mitigated in full or part by Receiving a positive inflow 'transferred down' by an upstream Key Area.

Eight of the twelve key areas in the Mvoti to Umzimkulu WMA have a negative water balance at a 1:50 year assurance. This is because in the past water was allocated for development without consideration to the requirement of the ecological Reserve.

The ecological Reserve utilises about 18% of the total water requirements in the Mvoti to Umzimkulu WMA. The ecological Reserve requirements are highest in the Mzimkulu primary catchment and range from 47% to 62% of the water requirements in the quaternary catchments. The Mvoti primary catchment has a range of ecological requirements from the Mlazi key area that requires less than half a percent of the quaternary catchment's total water requirements, to the Upper Mkomazi key area that requires 57% of the total water requirements in the respective quaternary catchments. The ecological Reserve requirement of the KZN South Coast quaternary catchment at 36% of the quaternary catchment's total water requirement is it's largest requirement.

Each key area in the Mvoti to Umzimkulu WMA has an irrigation requirement. Irrigation utilises about 20% of the total water requirements. It is the largest requirement in the Mdloti-Tongati-Mhlali, Mvoti-Nonati and Lovu key areas (48%, 51% and 45% of the key area's water requirements respectively). The irrigation component is the second highest requirement for the Upper Mzimkulu, Lower Mzimkulu, Upper Mkomazi and KZN South Coast key areas. Irrigation is an important component of the water requirements for all key areas. It is the second highest requirement at 15% of the WMA's requirements, after urban requirements (35%).

Although many of the urban requirements are fairly small, the largest water requirement in the Mvoti – Mzimkulu WMA is the urban requirement in the Mlaze key area (286 million m^3/a). It alone requires more than 25% of the total water requirement in the WMA. The Mgeni Mouth urban requirement of 51 million m^3/a is the fifth largest requirement in the Mvoti-Mzimkulu WMA, and comprises 28% of the Mgeni Mouth total water requirements. The urban requirement is also a large component for the Mtamvuna key area (31% of Mtamvuna's water requirements).

Bulk supply for the Lower Mkomazi key area is the third largest requirement in the WMA, and comprises 48% of the water requirement in the Lower Mkomazi key area.

CHAPTER 8: COSTS OF WATER RESOURCE DEVELOPMENT

This chapter gives an estimate of the costs of developing dams and/or wellfields in the WMA to secure the potential maximum yield.

8.1 METHODOLOGY

Diagram 8.1.1 presents a curve for approximating the capital costs of dams and Diagram 8.1.2 for approximating the capital costs of wellfields together with the estimated development cost for different borehole yields with an upper and lower range. The costs in Diagram 8.1.2 include all evaluations, borehole siting, drilling, test pumping and equipping of the boreholes with positive displacement pumps and electrically driven motors. The cost will however vary from area to area depending mainly on the following factors, viz.:

- availability of existing information
- borehole yield obtainable
- drilling depth
- drilling success rate
- drilling conditions

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

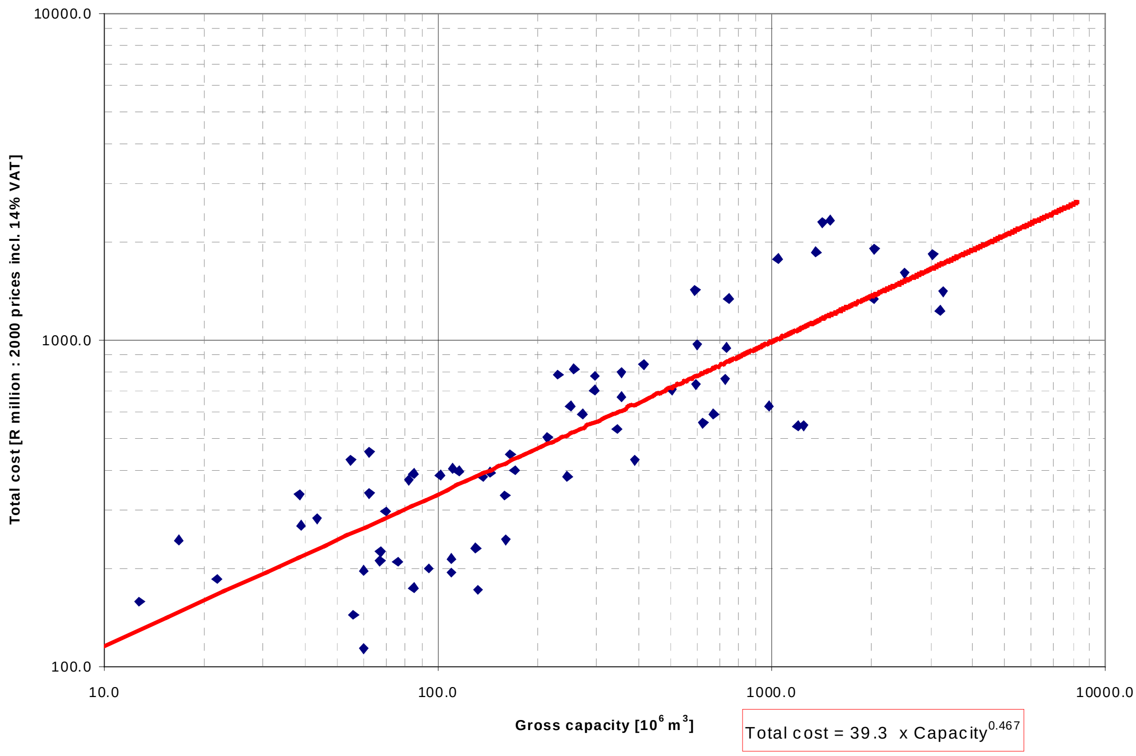

DIAGRAM 8.1.1: CAPITAL COSTS OF DAMS
Source : Circular 30/99

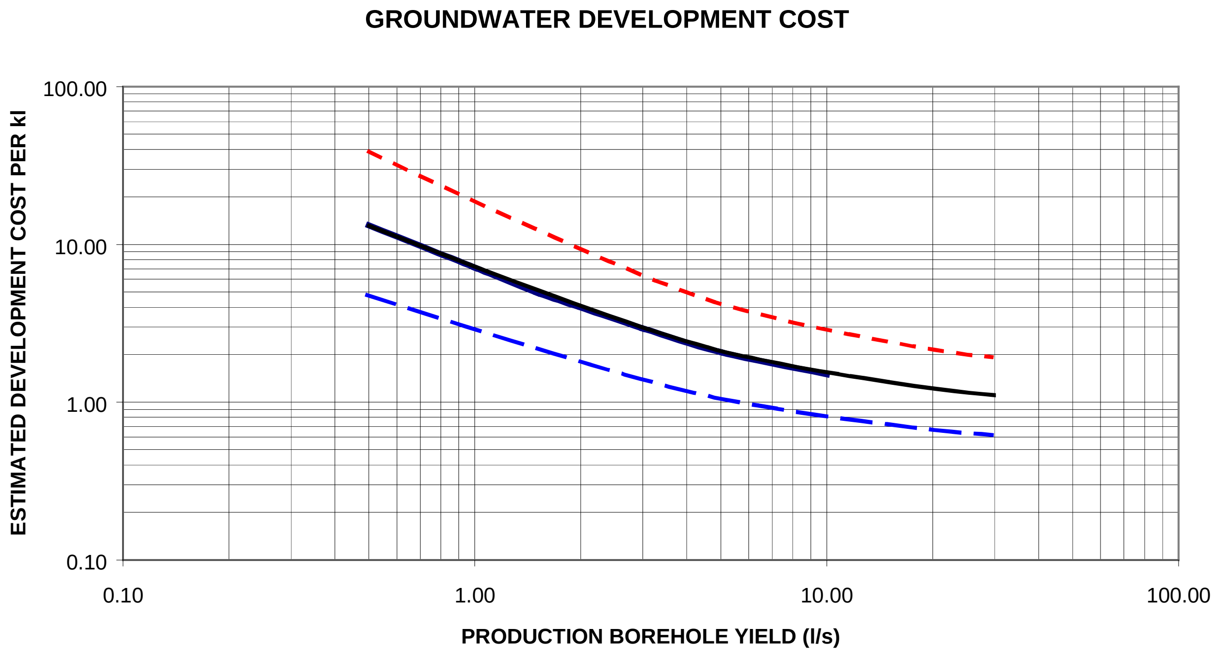

DIAGRAM 8.1.2: GROUNDWATER DEVELOPMENT COST

TABLE 8.1.1: COSTS OF FUTURE WATER RESOURCE DEVELOPMENT IN THE MVOTI TO UMZIMKULU CATCHMENT

QUATERNARY	SCHEME NO.	STORAGE VOLUME (million m^3)	INCREMENTAL SURFACE WATER YIELD [1] (million m^3/a)	DAM COSTS as at 2000 [2] (R million)
U10D	Impendle Dam[4]	810	335	897 [3]
U10F	Smithfield Dam[4]	137	135	391 [3]
U10M	Ngwadini Dam[4]	517 1033 1549	122 186 246	727 [3] 1005 [3] 1214 [3]
U20C	Raising of Midmar Dam	60,3	[5]	267 [3]
U30A	Hazelmere Dam raising	17	9	8
U40E	Isithundu Dam	51 (phase I)	200	298

[1] Depends on IFR.
[2] Includes VAT at 14%.
[3] Estimation from Diagram 8.1.1.
[4] These three dams together form part of the proposed Mkomazi - Mgeni transfer scheme to Pietermaritzburg / Durban. See the write up for detailed information.
[5] See explanation in the Midmar Dam key area section.
DWAF and Umgeni Water (1998); DWAF and Umgeni Water (1996); Pieter van Rooyen, personal communication, Pretoria, 7 September 2001; George David, personal communication, Pretoria, 18 October 2001; Dawie de Vaal, personal communication, Pretoria, 18 October 2001; Campbell Abrahamson, personal communication, Johannesburg, October 2001; and John Hansford, personal communication, Johannesburg, October 2001.

8.2 THE MKOMAZI - MGENI TRANSFER SCHEME

This scheme comprises three dams on the Mkomazi River:

- Smithfield Dam – Lower Mkomazi key area
- Impendle Dam – Upper Mkomazi key area
- Ngwadini Dam – Lower Mkomazi key area

Smithfield Dam will be built in the first phase of the Mkomazi-Mgeni Transfer scheme. The expected date for delivery of water is not likely to be before 2020. Impendle Dam will constitute the second phase of the scheme and is unlikely to be implemented before 2025. It would appear that the preferred size of Impendle Dam is 810 million m^3, although other capacities have been investigated. It is likely that Ngwadini Dam will not be built for approximately 50 years and therefore details for it have not been finalised. The yields indicated for Ngwadini Dam in Table 8.1.1 include for Impendle and Smithfield Dams in the system model. The quoted yields for Impendle and Smithfield Dams are independent yields for each dam.

The flow of water through the transfer scheme will occur as follows: Impendle – Smithfield – Baynesfield – Umlaas Rd – Pietermaritzburg / Durban. (George David, personal communication, Pretoria, 18 October 2001.)

8.3 THE MIDMAR CATCHMENT

Mearns Weir and Springgrove Dam (Thukela WMA) are proposed to supply an interbasin transfer to Pietermaritzburg and Durban via Midmar Dam. Mearns Weir and Springgrove Dam are to supplement the yield at Midmar Dam and have thus been included in the Mooi-Mgeni Transfer Scheme yield model. Phase I of the Mooi-Mgeni Transfer Scheme (MMTS) will include the raising of Midmar Dam as well as construction of Mearns Weir. (The existing weir is small enough to be considered to have negligible storage.) This will increase Midmar Dam's current firm yield from 83 million m^3/a to 113 million m^3/a (based on simulation using historic time series). Individual yields for raising of Midmar Dam and construction of Mearns weir have not been determined as the raising of Midmar Dam would not result in a significantly greater yield without additional water supplied from Mearns weir. Therefore, the raising of Midmar Dam is pointless without the simultaneous construction of Mearns weir, and individual yields would be meaningless. Thus, construction of Mearns Weir together with the raising of Midmar Dam will result in an incremental firm yield of 30 million m^3/a from Midmar Dam. Phase II of the MMTS will involve construction of Springgrove Dam. Inclusion of Springgrove Dam in the MMTS yield model increases firm yield from 113 million m^3/a to 174 million m^3/a – an increase in firm yield of 61 million m^3/a at Midmar Dam.

8.4 THE MDLOTI / TONGATI CATCHMENT

It is proposed to raise Hazelmere Dam on the Mdloti River by 7m thereby increasing yield by approximately 9 million m^3/a. The raising is expected to produce additional water for urban use along the North Coast by 2010 or sooner depending on the Umgeni Water Master Plan for the North Coast. (Campbell Abrahamson, personal communication, Johannesburg, October 2001; and John Hansford, personal communication, Johannesburg, October 2001.)

8.5 THE MVOTI / NONATI CATCHMENT

The Isithundu Dam on the Mvoti River is proposed as an alternative to raising of Hazelmere Dam. The proposed dam would be 58m high dam and include provision to raise it by 15m in the future.

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 GENERAL COMMENT

The water resources situation assessment model requires information for analysis and water balance at a macro level. Only information that was readily available for the Mvoti to Mzimkulu WMA was sourced. Data was required in some instances at a greater level of detail than previous studies could provide.

It should be noted that data for this study was captured at a quaternary level (macro level) from desktop studies. The information entered for each data set is based predominantly on available study information, or from sources prepared to assist in providing information for this situation assessment. Completeness of the data sets can only be achieved through availability of information and confidence that the information is reliable. There are some glaring gaps in data and accuracy necessitating additional data to be sourced if the confidence of the situation assessment needs to be improved.

9.2 CONCLUSIONS

The results of the situation assessment, summarised in Section 7, indicate that the Mvoti to Umzimkulu WMA would experience shortfalls during times of drought given 1995 levels of development and demands. However, the results are somewhat misleading as the water balance includes for full irrigation and domestic supplies during times of drought.

During a 1:50 year drought event it would be normal to reduce supply to irrigators, typically to 10% or less of the allocation. If irrigators were supplied 10% of the quota, (20,7 million m^3/annum as opposed to 206,7 million m^3/annum) the indicated deficit in the WMA would reduce from 213,5 million m^3/annum to about 27,5 million m^3/annum.

The allowance made for the Reserve was some 194,7 million m^3/annum. Apart from merely representing an average volume to be supplied it should be borne in mind that the infrastructure in the WMA was developed without allowing for the Reserve (prior to the legislation). Therefore the results indicate that water resources in the area are sufficient provided that irrigation supplies can be curtailed during severe droughts and that less than the full Reserve is supplied under such circumstances.

Once a full Reserve determination has been done for all rivers in the WMA it may become necessary to develop some further infrastructure to meet the requirements of the Reserve. The study also showed that there is still significant development potential in the WMA.

9.3 RECOMMENDATIONS

9.3.1 Resources

Streamflow
Data for the Mgeni River is detailed and considered reliable. The remaining data was taken from WR90 and could be improved upon with increased distribution and accuracy of gauging stations.

Dams
Information on major dams proved to be reasonably accurate as supplied, but random checks identified inconsistencies in reliability of the source information. The dam capacities and quaternary locations required confirmation.

Information on minor and farm dams was obtained and proved to be extensive. Random checks proved the data to be sufficiently reliable.

Information on future dams was readily available and sufficiently accurate.

Groundwater
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. Harvest potential could be significantly underestimated in the wetter parts of the country.

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. The yield appears to be underestimated in some areas such as catchment W70.

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.

Inter-basin transfers
Information on inter-basin transfers was readily available from previous studies and local information. Locations and information on future transfers were obtained at a suitably accurate level. Differences between average annual transfers, infrastructural capacity and impact on yield were refined where hydrological models were already set up.

Water quality
A large number of quaternaries (54 of 90 in total) are unclassified with respect to mineralogical surface water quality. As with the biological data set, water quality has a direct impact on, amongst other items, development downstream and cost of treatment of water for domestic use.

Biological
There is a lack of biological data from previous studies. Biological data has a significant impact on the potable nature of water for downstream users, as it indicates the treatment of water required for domestic abstraction uses. The cost of treatment will impact on

development and determine what types of development are viable options and whether development will be delayed until funding is available.

9.3.2 Use

Bulk, strategic, mining, other use

Information was sourced from WR90 and some organisations with relevant information. A list of operational mines and commodity mined was obtained from the Department of Minerals and Energy. Although there are numerous mines listed in this WMA, only one mines coal. Sand, quartzite, soil and shale are the predominant commodities which do not have a large impact on the water balance. Thus the level of detail of mining operations in this WMA is considered to be sufficient for the purposes of this study.

Rural use – basic, irrigation, cattle

Study of rural water use is required for this WMA. Poor quality information was available for a nominal set, but was not sufficient to satisfactorily complete the data capture for this set. There were no reports to refer to for this information, and especially cattle stock numbers were scarce.

A basic domestic water use of 25 l/person/day was assumed. There was no information on rural water use for irrigation. However, the impact of this is small and therefore a full study will not greatly improve the overall reliability of the water balance.

Irrigation

Further study on the irrigation data for the Mvoti to Mzimkulu WMA is required, as information from a variety of sources was conflicting. It was especially difficult to obtain sufficiently reasonable details of sugarcane irrigation. As irrigation has a large impact on the water balance, it is important to obtain accurate information on irrigation.

There are large areas operated by privately owned irrigation boards. Much useful information was gleaned first hand from these boards, but cross-checking against other sources indicated discrepancies. The actual water usage for irrigation in the Mvoti to Mzimkulu WMA needs to be confirmed. Data sources in reports are getting a bit dated. More recent reports use irrigation data from older reports. It is recommended that a review of irrigation in this WMA be conducted to provide clarity on the situation.

Urban

The urban data set is a good example of data that is incomplete, inaccurate or generally not readily available.

Questionnaires were composed and circulated to all municipalities and transitional local councils in the Mvoti to Mzimkulu WMA. The questions ranged from water abstraction to domestic use, industrial supply to population numbers and treatment works. Of the 16 questionnaires sent out, 5 were returned. Of these, most had large amounts of data missing in the information supplied. Additional information was obtained from the larger TLCs through direct communication with them, which improved the accuracy of information from these TLCs. All information should have been readily accessible at the municipalities or TLCs, but the response indicates otherwise. Two options for obtaining the information is to provide funds to each municipality to complete the forms, or alternately to invest in a field study to obtain the information. This will remove the onus of providing the information from the municipality completely and in so doing obtaining a standard and acceptable accuracy of data that will provide a complete data set for use in this assessment model.

IFR / EFR
Some rivers are poorly known making assessment of their ecological requirements difficult and inaccurate.

9.3.3 Stream flow Reduction Activities

Afforestation and Alien vegetation
The CSIR compiled these data sets from LandSat images. Areas of both afforestation and alien vegetation are inaccurate, as there is an overlap between the two data sets.

Urban return flows
Few local municipalities and transitional local councils returned questionnaires sent to them. Of those returned, a nominal number included information on urban return flows. A full study of this aspect is required to complete population of the data set, as this WMA is the most populated in KwaZulu-Natal.

Dryland sugar cane
It was difficult to obtain sufficiently accurate details of dry land sugar cane. Further study on the dryland sugar cane data for the Mvoti to Mzimkulu WMA is required, as information from a variety of sources was conflicting. Dryland sugar cane was identified, but the extent of areas could not be conclusively determined.

9.3.4 Infrastructure

Infrastructure information obtained from the GIN Model was supplemented with information from reports. Information on major schemes was acceptable. Information on regional schemes was not as readily available. Additional detailed work on the GIN model is required in order to abstract accurate infrastructure information for this WMA.

9.4 PRIORITIES FOR FUTURE WORK

The most important data sets that require additional data collection are irrigation and ecological requirements. Apart from these, no priorities can be allocated to additional studies required other than to estimate the effect that improved information will have on the final result. The following recommendations are listed accordingly.

1. Obtain correct details of urban water abstraction, use, treatment and return flows (including quality of returns) by funding a study of each municipality. Urban water use is the largest demand in this WMA.
2. Investigate fully the conflicting and missing data on irrigation in this WMA. A full verification is required as irrigation has the second largest demand for water in this WMA.
3. Improve estimates for IFRs as they require the third largest amount of water in the WMA. Much work still needs to be done in refining the environmental reserve requirements.
4. Collect dryland sugar cane data.
5. Determine details of water quality at quaternary level to improve resolution of the data set. This WMA has large gaps in the mineralogical surface water quality data that need to be addressed.

6. Implement a full microbiological study to complete the TDS data set at quaternary level of detail.
7. The hydrology of the Mvoti to Mzimkulu WMA could be improved, starting with additional and more accurate stream flow gauging.
8. Data on rural water use could be improved upon.

It has been shown throughout the data collection process that there are limitations to data captured from desktop studies. In gathering data captured in this WMA, the best efforts have been made to collect complete data of the highest accuracy with the greatest attention to maintaining details of source information.

Recommendations have been made above to enhance areas of the data felt to be incomplete or of insufficient accuracy. It is hoped that the water resources situation assessment will present a set of base data that will be developed and enhanced to provide a dynamic workable quaternary based water balance for planning initiatives at national, provincial and local levels.

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APPENDICES

NOTE: BLANKS INDICATE THAT DATA WAS NOT READILY AVAILABLE

APPENDIX A

NATURAL, CULTURAL AND HISTORICAL SITES

PROTECTED NATURAL AREAS AND NATURAL HERITAGE SITES WITHIN THE MVOTI-MZIMKULU WMA

AREA NAME	CATEGORY	GRID REFERENCE	
		LONGITUDE	LATITUDE
Giants Castle	Game Reserve	29.47669	-29.21796
Umvoti Vlei	Nature Reserve	30.56238	-29.15734
Blinkwater	Nature Reserve	30.46617	-29.23068
Highmoor	S/F Nature Reserve	29.58054	-29.33115
Karkloof	Nature Reserve	30.24021	-29.29778
Mkhomazi	S/F Nature Reserve	29.55381	-29.44170
Umvoti Estuary	SANHP	31.31324	-29.39561
Little Kilgobbin	SANHP	30.09419	-29.38413
High Moor	S/F Nature Reserve	29.63005	-29.40828
Albert Falls	Nature Reserve	30.39014	-29.43711
High Moor	S/F Nature Reserve	29.66685	-29.42010
Loteni	Nature Reserve	29.51770	-29.44914
Cobham	S/F Nature Reserve	29.40531	-29.59551
Kronsberg	SANHP	30.52704	-29.46942
Boston House Indigenous Forest	SANHP	30.05341	-29.47114
Umgeni Vlei	Nature Reserve	29.83065	-29.49113
Midmar	Nature Reserve	30.17338	-29.51440
Vergelegen	Nature Reserve	29.45192	-29.53450
The Fextal	SANHP	29.94692	-29.52696
Queen Elizabeth Park	Nature Reserve	30.32131	-29.56566
7 Mile Bush	Nature Reserve	29.65236	-29.58975
Hazelmere	Nature Reserve	31.02809	-29.58634
Boston House Indigenous Forest	SANHP	30.03400	-29.61869
Doreen Clark	Nature Reserve	30.29068	-29.57976
Wahroonga	SANHP	30.13142	-29.60392
Garden Castle	S/F Nature Reserve	29.22805	-29.77457
Umhlanga Lagoon	Nature Reserve	31.09665	-29.70661
Himeville	Nature Reserve	29.51972	-29.74910
Krantzkloof	Nature Reserve	30.84205	-29.75980
The Swamp	Nature Reserve	29.61638	-29.76838
Tanglewood Farm Trust	SANHP	30.83655	-29.82177
Shongweni Dam	SANHP	30.66332	-29.86485
Pigeon Valley Park	SANHP	30.97998	-29.86255
North Park	Nature Reserve	30.88175	-29.87252
Bluff	Nature Reserve	31.05565	-29.87351
Kenneth Stainbank	Nature Reserve	30.93569	-29.90802
Hope Valley	SANHP	30.57978	-29.93544
Game Valley Estates	SANHP	30.07650	-29.93134
Game Valley Estates	SANHP	30.06974	-29.92407
Game Valley Estates	SANHP	30.08899	-29.94300
Reunion	Nature Reserve	30.99297	-29.93280
Coleford	Nature Reserve	29.45572	-29.94919
Siverglen	SANHP	30.88004	-29.93468
Vernon Crookes	Nature Reserve	30.58704	-30.28166
Mehlomnyama	Nature Reserve	30.34139	-30.60515
The Valleys	SANHP	30.42470	-30.66391
Oribi Gorge	Nature Reserve	30.27146	-30.71332
Ian Ellis	Nature Reserve	30.44389	-30.75173
Mbumbazi	Nature Reserve	30.28328	-30.82272
Skyline	Nature Reserve	30.38684	-30.81916

Umtamvuma	Nature Reserve	30.17588	-30.98010
Frederika	SANHP	30.32577	-30.91560
Mpenjati	Nature Reserve	30.27990	-30.97205
Mgeni Vlei	Palustrine wetland	29.81667	-29.48333
Mvoti Vlei	Palustrine wetland	30.58333	-29.15000
Ntsikeni Vlei	Palustrine wetland	29.46667	-30.13333
The Swamp	Palustrine wetland	29.60000	-29.78333
Fafa	Riverine wetlands	30.36667	-30.31667
Lions River Flats	Riverine wetlands	30.13333	-29.46667
Mgeni at Howick Falls	Riverine wetlands	30.11667	-29.50000
Mkomazi	Riverine wetlands	30.50000	-30.11667
Mtamvuna	Riverine wetlands	30.08333	-30.83333
Mvoti	Riverine wetlands	30.58333	-29.20000
Tugela River Mouth	Riverine wetlands	30.50000	-29.21667

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

CULTURAL AND HISTORICAL SITES FOR THE MVOTI-MZIMKULU WMA

AREA NAME	CATEGORY	GRID REFERENCE
Adam Kok's Laager	Monuments / National Monuments	T31
Adam Kok's Mission	Monuments / National Monuments	T31
Bandstand (Kokstad)	Monuments / National Monuments	T31
Boy Scouts Monument, Kokstad	Monuments / National Monuments	T31
Cape Mounted Rifles Monument, Kokstad	Monuments / National Monuments	T31
Kokstand Bandstand	Monuments / National Monuments	T31
Matatiele Museum	Monuments / National Monuments	T31
Old Town Hall, Kokstad	Monuments / National Monuments	T31
Town Hall, Kokstad	Monuments / National Monuments	T31
War Memorial, Matatiele	Monuments / National Monuments	T31
Lighthouse at Port Shepstone	Monuments / National Monuments	T40
Himeville Fort	Monuments / National Monuments	T51
Himeville Museum	Monuments / National Monuments	T51
Himeville Old Resedency	Monuments / National Monuments	T51
Mpongweni Cave, Cobham	Monuments / National Monuments	T51
Old Residency, Himeville	Monuments / National Monuments	T51
Residency, Himeville	Monuments / National Monuments	T51
Cecil John Rhodes Memorial, Lions Kloof	Monuments / National Monuments	U10
Collingham Caves	Monuments / National Monuments	U10
Alexandra Road Police Station	Monuments / National Monuments	U20
Allerton Laboratory	Monuments / National Monuments	U20
Andries Pretorius' House	Monuments / National Monuments	U20
Anglo-Zulu War Memorial	Monuments / National Monuments	U20
Bergtheil Museum	Monuments / National Monuments	U20
Bushmans River Pass Monument	Monuments / National Monuments	U20
Butine House	Monuments / National Monuments	U20
Church of the Covenant	Monuments / National Monuments	U20
City Hall	Monuments / National Monuments	U20
Conservatiore De Hamerstein	Monuments / National Monuments	U20
Daniel Lindley Plaque	Monuments / National Monuments	U20
Dorchester House	Monuments / National Monuments	U20
Fairfell Farmstead	Monuments / National Monuments	U20
Fort Napier	Monuments / National Monuments	U20
Girls High School	Monuments / National Monuments	U20
Government House (Old)	Monuments / National Monuments	U20
John Dube House	Monuments / National Monuments	U20
Loop Street Police Station	Monuments / National Monuments	U20
Lutheran Church	Monuments / National Monuments	U20
Maritzburg College	Monuments / National Monuments	U20
Mount Edgecombe Ganesha Temple	Monuments / National Monuments	U20
Norfolk Villa	Monuments / National Monuments	U20
Old Alberton State Vetinary Laboratory	Monuments / National Monuments	U20
Old Central Block, Natal University	Monuments / National Monuments	U20
Old Government House	Monuments / National Monuments	U20
Old Harward Boys School	Monuments / National Monuments	U20
Old Longmarket Street Girls School	Monuments / National Monuments	U20
Old Model Boys' School	Monuments / National Monuments	U20
Old Natal Houses of Parliament	Monuments / National Monuments	U20
Old Natal University Central Block	Monuments / National Monuments	U20
Old New Germany Lutheran Church	Monuments / National Monuments	U20
Old Pentrich Railway Station	Monuments / National Monuments	U20
Old Satya Vardhak Sabah Crematorium	Monuments / National Monuments	U20
Old Voortrekker Road, Worlds View	Monuments / National Monuments	U20

Old YMCA Building	Monuments / National Monuments	U20
Owsthorne House	Monuments / National Monuments	U20
Plane Tree Avenue	Monuments / National Monuments	U20
Post Office	Monuments / National Monuments	U20
Presbyterian Church	Monuments / National Monuments	U20
Prison Cell Block	Monuments / National Monuments	U20
Prisoner of War Church	Monuments / National Monuments	U20
Publicity House	Monuments / National Monuments	U20
Sans Souci	Monuments / National Monuments	U20
Satya Vardhak Crematorium	Monuments / National Monuments	U20
Scottsville Primary School	Monuments / National Monuments	U20
Sherwood Foresters' Monument	Monuments / National Monuments	U20
Shri Juggernathi Puri Temple, Tongaat	Monuments / National Monuments	U20
Shuter House	Monuments / National Monuments	U20
Tweedie Research Centre	Monuments / National Monuments	U20
Umbilo Waterworks	Monuments / National Monuments	U20
Victoria Hall, Maritzburg College	Monuments / National Monuments	U20
Voortrekker Museum	Monuments / National Monuments	U20
Wayland	Monuments / National Monuments	U20
Weeping Cross of Delville Wood	Monuments / National Monuments	U20
World's View	Monuments / National Monuments	U20
Birthplace of General Louis Botha, Greytown	Monuments / National Monuments	U40
Fort Ahrens, Hermannsberg	Monuments / National Monuments	U40
Hermannsburg Lutheran Church	Monuments / National Monuments	U40
Hermannsburg Mission House	Monuments / National Monuments	U40
Hermansburg Mission Station	Monuments / National Monuments	U40
Memorial to Policemen, Bambatha Uprising	Monuments / National Monuments	U40
Town Hall, Greytown	Monuments / National Monuments	U40
Apostolistic Faith Mission Church	Monuments / National Monuments	U60 / U20
Atherton	Monuments / National Monuments	U60 / U20
Bartholomew Diaz Monument	Monuments / National Monuments	U60 / U20
Caister Lodge	Monuments / National Monuments	U60 / U20
Cenotaph	Monuments / National Monuments	U60 / U20
Colinton	Monuments / National Monuments	U60 / U20
Congella Battlefield Monument	Monuments / National Monuments	U60 / U20
Congella, Cedar Road No 41	Monuments / National Monuments	U60 / U20
Cottam Grove Hotel	Monuments / National Monuments	U60 / U20
Curries Drinking Fountain	Monuments / National Monuments	U60 / U20
Dick King Statue	Monuments / National Monuments	U60 / U20
Dutch Reformed Church	Monuments / National Monuments	U60 / U20
Farewell Square	Monuments / National Monuments	U60 / U20
Headquaters of the Durban Light Infantry	Monuments / National Monuments	U60 / U20
Indian War Memorial	Monuments / National Monuments	U60 / U20
Lillieshell	Monuments / National Monuments	U60 / U20
Memorial Tower Building, University of Natal	Monuments / National Monuments	U60 / U20
Monaltrie	Monuments / National Monuments	U60 / U20
Musgrave Road No 73	Monuments / National Monuments	U60 / U20
Narainsamy Temple	Monuments / National Monuments	U60 / U20
Natal Herbarium, Botanical Gardens	Monuments / National Monuments	U60 / U20
Point Railway Station	Monuments / National Monuments	U60 / U20
Post Office	Monuments / National Monuments	U60 / U20
Quadrant House	Monuments / National Monuments	U60 / U20
Queens Tavern	Monuments / National Monuments	U60 / U20
Riche's Building	Monuments / National Monuments	U60 / U20
Riverside Soofie Mosque and Mausoleum	Monuments / National Monuments	U60 / U20

Shree Ambalavanaar Alayam Temple	Monuments / National Monuments	U60 / U20
St Loui's Roman Catholic Church	Monuments / National Monuments	U60 / U20
Sufi Saheb Badsha Peer Darbar (Mosque)	Monuments / National Monuments	U60 / U20
Trevean	Monuments / National Monuments	U60 / U20
Umbilo Shree Ambalavanaar Alayam Temple	Monuments / National Monuments	U60 / U20
Baynesfield Estate Museum	Monuments / National Monuments	U70
Blarney Cottage, Byrne	Monuments / National Monuments	U70
Carnarvon Masonic Lodge	Monuments / National Monuments	U70
Cattle Dip Tank	Monuments / National Monuments	U70
Joseph Baynes Mausoleum	Monuments / National Monuments	U70
Old Nel's Rust Dairy, Bainsfield Estate	Monuments / National Monuments	U70
Richmond Byrne and District Museum	Monuments / National Monuments	U70
Clansthal Lighthouse	Monuments / National Monuments	U80
Green Point Lighthouse	Monuments / National Monuments	U80
Howick Waterfall	Natural Heritage Site	U20
Nhlangakazi Mountain, Noodsberg	Natural Heritage Site	U30
Sea Cow Lake	Natural Heritage Site	U60 / U20
The Kwini (The Lagoon)	Natural Heritage Site	U60 / U20
Umbilo River	Natural Heritage Site	U60 / U20
Umgeni River	Natural Heritage Site	U60 / U20
Umshlanga River, Umshalanga Rocks	Natural Heritage Site	U60 / U20
Mpambanyoni River, Scottburgh	Natural Heritage Site	U80
Umkomaas, South Coast	Natural Heritage Site	U80
Bilanhlolo River, Ramsgate	Natural Heritage Site *	T40
Itshe Lika Shaka	Natural Heritage Site *	U40
Mavivane Stream	Natural Heritage Site *	U40
Shaka's Zulu Army Raids, 1821 / 2, Umgeni River	Natural Heritage Site *	U60 / U20
Sezela River	Natural Heritage Site *	U80
St Helen's Rock	Natural Heritage Site*	T40
Lion's Kloof, Umkomaas	Natural Heritage Site*	U10
Itshe Lika Ndikimba (Rock of Ndikimba)	Natural Heritage Site*	U30
Umshlatuzana River, Cannibal Presence	Natural Heritage Site*	U60 / U20
Catholic Cathederal, Kokstad	Historical / Cultural / Religious Significance	T31
Dutch Reformed Church	Historical / Cultural / Religious Significance	T31
East Griqualand Kokstad Mueseum	Historical / Cultural / Religious Significance	T31
Kokstad Magisatrates Court	Historical / Cultural / Religious Significance	T31
Kokstad Museum	Historical / Cultural / Religious Significance	T31
Magistrate's Court, Matatiele	Historical / Cultural / Religious Significance	T31
Royal Hotel, Matatiele	Historical / Cultural / Religious Significance	T31
Town Hall, Mataiele	Historical / Cultural / Religious Significance	T31
Batstone's Drift	Historical / Cultural / Religious Significance	T40
Bazelys Harbour Works	Historical / Cultural / Religious Significance	T40
Enxolobeni C. P. School	Historical / Cultural / Religious Significance	T40
Fynne's Grave	Historical / Cultural / Religious Significance	T40
German Church	Historical / Cultural / Religious Significance	T40
Isandludlu Port	Historical / Cultural / Religious Significance	T40
Kniesel's Castle	Historical / Cultural / Religious Significance	T40
Marburg	Historical / Cultural / Religious Significance	T40
Margate Monster	Historical / Cultural / Religious Significance	T40
Ndongeni Ka Xoki's Grave	Historical / Cultural / Religious Significance	T40
Norweigan Church	Historical / Cultural / Religious Significance	T40
Port Shepston Lighthouse	Historical / Cultural / Religious Significance	T40
Port Shepstone Maritime Museum	Historical / Cultural / Religious Significance	T40
Sea Shell Museum	Historical / Cultural / Religious Significance	T40
Shaka's Bush	Historical / Cultural / Religious Significance	T40

St John (San Joao) Shipwreck)	Historical / Cultural / Religious Significance	T40
Umzimkulu Breakwater	Historical / Cultural / Religious Significance	T40
Reichenau Mission, Pevensy	Historical / Cultural / Religious Significance	T51
Yellowood Church	Historical / Cultural / Religious Significance	T51
Agricultural Hall	Historical / Cultural / Religious Significance	U10
Border Mounted Rifles Hall	Historical / Cultural / Religious Significance	U10
Buddist Retreat Centre	Historical / Cultural / Religious Significance	U10
Collingham Shelter, 2929 BD	Historical / Cultural / Religious Significance	U10
Dead Men's Tree	Historical / Cultural / Religious Significance	U10
Ixopo Prison	Historical / Cultural / Religious Significance	U10
Mariathal Mission	Historical / Cultural / Religious Significance	U10
Old Plough Hotel	Historical / Cultural / Religious Significance	U10
African Art Centre	Historical / Cultural / Religious Significance	U20
African Art Gallery	Historical / Cultural / Religious Significance	U20
Alexandra Park	Historical / Cultural / Religious Significance	U20
Allison's Saddlery Building	Historical / Cultural / Religious Significance	U20
Asoka Theatre, Westville	Historical / Cultural / Religious Significance	U20
Bandstand (Pmb)	Historical / Cultural / Religious Significance	U20
Blackhouse Printers	Historical / Cultural / Religious Significance	U20
Buchanan Street Baths	Historical / Cultural / Religious Significance	U20
Cannibal Haunts , Valley of a Thousand Hills	Historical / Cultural / Religious Significance	U20
Clark House, Maritzburg College	Historical / Cultural / Religious Significance	U20
Cleote's Cannon	Historical / Cultural / Religious Significance	U20
Clock Tower Building	Historical / Cultural / Religious Significance	U20
Comrades House Museum	Historical / Cultural / Religious Significance	U20
Comrades Marathon House Museum	Historical / Cultural / Religious Significance	U20
Dudgeon's Standard Bank	Historical / Cultural / Religious Significance	U20
Edendale Township	Historical / Cultural / Religious Significance	U20
Edgar's Building	Historical / Cultural / Religious Significance	U20
Exquisite Art and Antiqu Gallery	Historical / Cultural / Religious Significance	U20
Fine Victorian Building, Longmarket Street	Historical / Cultural / Religious Significance	U20
Fine Victorian Building, Pietermaritz Street	Historical / Cultural / Religious Significance	U20
Fine Victorian Villa, Burger Street	Historical / Cultural / Religious Significance	U20
First National Bank No 1	Historical / Cultural / Religious Significance	U20
First National Bank No 2	Historical / Cultural / Religious Significance	U20
Foley-Marianni Bridge	Historical / Cultural / Religious Significance	U20
Gallery Moya	Historical / Cultural / Religious Significance	U20
Gandhi Settlement	Historical / Cultural / Religious Significance	U20
German Field Guns	Historical / Cultural / Religious Significance	U20
Girls Colegiate School	Historical / Cultural / Religious Significance	U20
Greys Hospital Museum	Historical / Cultural / Religious Significance	U20
Hambanathi Village	Historical / Cultural / Religious Significance	U20
Harwins' Arcade	Historical / Cultural / Religious Significance	U20
Hilton College	Historical / Cultural / Religious Significance	U20
Hilton Hotel	Historical / Cultural / Religious Significance	U20
Hitching Rails	Historical / Cultural / Religious Significance	U20
Holly Shelter	Historical / Cultural / Religious Significance	U20
Howick Clinic	Historical / Cultural / Religious Significance	U20
Howick Local History Museum	Historical / Cultural / Religious Significance	U20
Inanda Girls Seminary	Historical / Cultural / Religious Significance	U20
Indigo Vats	Historical / Cultural / Religious Significance	U20
Italian Church	Historical / Cultural / Religious Significance	U20
Izintaba Cultural Zulu Village	Historical / Cultural / Religious Significance	U20
J.H. Isaacs Building	Historical / Cultural / Religious Significance	U20
Jack Heath Art Gallery	Historical / Cultural / Religious Significance	U20

John Bird House	Historical / Cultural / Religious Significance	U20
Kelevin House	Historical / Cultural / Religious Significance	U20
Lighthouse, Umshlanga	Historical / Cultural / Religious Significance	U20
Lindley Mission Station	Historical / Cultural / Religious Significance	U20
Longmarket Street School	Historical / Cultural / Religious Significance	U20
Macorie House	Historical / Cultural / Religious Significance	U20
Macrorie House	Historical / Cultural / Religious Significance	U20
Marion Villa	Historical / Cultural / Religious Significance	U20
Marionhill Monastery	Historical / Cultural / Religious Significance	U20
Mc Auslins Chambers	Historical / Cultural / Religious Significance	U20
Mc Fairlane Bridge	Historical / Cultural / Religious Significance	U20
Mc Namee's	Historical / Cultural / Religious Significance	U20
Merchiston Preparitory School	Historical / Cultural / Religious Significance	U20
Metropolitan Church	Historical / Cultural / Religious Significance	U20
mhama Ganhi Statue	Historical / Cultural / Religious Significance	U20
Michaelhouse School, Balgowen	Historical / Cultural / Religious Significance	U20
Military Cemetary, Howick	Historical / Cultural / Religious Significance	U20
Natal Government Raillway Headquaters	Historical / Cultural / Religious Significance	U20
Natal Mounted Police Headquaters	Historical / Cultural / Religious Significance	U20
Natal Musuem	Historical / Cultural / Religious Significance	U20
natal Parliament Building	Historical / Cultural / Religious Significance	U20
Natal Parliament Building	Historical / Cultural / Religious Significance	U20
Natal Railway Museum	Historical / Cultural / Religious Significance	U20
Nelson Mandela's Arrest Site	Historical / Cultural / Religious Significance	U20
Nizamia Madressa Islamic School	Historical / Cultural / Religious Significance	U20
Ohlange Institution	Historical / Cultural / Religious Significance	U20
Old Colonial Building	Historical / Cultural / Religious Significance	U20
Old Presbytarian Church	Historical / Cultural / Religious Significance	U20
Old St Mary's Church	Historical / Cultural / Religious Significance	U20
Old Stock Exchange	Historical / Cultural / Religious Significance	U20
Old Supreme Court	Historical / Cultural / Religious Significance	U20
Old Victoria Club Building	Historical / Cultural / Religious Significance	U20
Overpark House	Historical / Cultural / Religious Significance	U20
Pavillion, Alexandra Park	Historical / Cultural / Religious Significance	U20
Phezulu Cultural Village, Hillcrest	Historical / Cultural / Religious Significance	U20
Pietermaritzburg City Hall	Historical / Cultural / Religious Significance	U20
Pietermaritzburg Post Office	Historical / Cultural / Religious Significance	U20
Pinetown Museum	Historical / Cultural / Religious Significance	U20
Poole's Building	Historical / Cultural / Religious Significance	U20
Queen Victoria's Statue	Historical / Cultural / Religious Significance	U20
Railway Station	Historical / Cultural / Religious Significance	U20
Reid's Building	Historical / Cultural / Religious Significance	U20
S.H.A.D.E.	Historical / Cultural / Religious Significance	U20
Shel Midden, Umshlanga Rocks	Historical / Cultural / Religious Significance	U20
Shepston Forest	Historical / Cultural / Religious Significance	U20
Shepston House	Historical / Cultural / Religious Significance	U20
Siva Soobramoniar and Marriaman Temple	Historical / Cultural / Religious Significance	U20
Slave Bell	Historical / Cultural / Religious Significance	U20
South African War Memorial	Historical / Cultural / Religious Significance	U20
St Anne's Diocesan College, Hilton	Historical / Cultural / Religious Significance	U20
St Charles's College	Historical / Cultural / Religious Significance	U20
St George's Garrison Church	Historical / Cultural / Religious Significance	U20
St Luke's Church	Historical / Cultural / Religious Significance	U20
St Mary's Church (Anglican)	Historical / Cultural / Religious Significance	U20
St Peter's Bells	Historical / Cultural / Religious Significance	U20
St Peter's Church	Historical / Cultural / Religious Significance	U20
Tatham Art Gallery	Historical / Cultural / Religious Significance	U20

The O'Donnell Gallery	Historical / Cultural / Religious Significance	U20
Town Hill Mental Hospital	Historical / Cultural / Religious Significance	U20
village of Esithumba	Historical / Cultural / Religious Significance	U20
Voortrekker Graveyard	Historical / Cultural / Religious Significance	U20
Voortrekker House	Historical / Cultural / Religious Significance	U20
Voortrekker House No 2	Historical / Cultural / Religious Significance	U20
War Memorial Arch	Historical / Cultural / Religious Significance	U20
Whitehorn and Gough's Building	Historical / Cultural / Religious Significance	U20
Widoe Retief's House	Historical / Cultural / Religious Significance	U20
Winston Churchill Theatre	Historical / Cultural / Religious Significance	U20
World War Two Tank	Historical / Cultural / Religious Significance	U20
YMCA Building	Historical / Cultural / Religious Significance	U20
Ambush Rock, Keate's Drift	Historical / Cultural / Religious Significance	U40
Fort Buckingham	Historical / Cultural / Religious Significance	U40
Greytown Mosque	Historical / Cultural / Religious Significance	U40
Greytown Museum	Historical / Cultural / Religious Significance	U40
Hermansburg Laager	Historical / Cultural / Religious Significance	U40
Louis Botha's Birthplace, Greytown	Historical / Cultural / Religious Significance	U40
Ruins of Fort Ahrens	Historical / Cultural / Religious Significance	U40
Sarie Marais Grave, Greytown Area	Historical / Cultural / Religious Significance	U40
Shaka's Tree	Historical / Cultural / Religious Significance	U40
Shree Vishnu Mandir Temple, Greytown	Historical / Cultural / Religious Significance	U40
Umvoti Laager, Greytown Area	Historical / Cultural / Religious Significance	U40
Umvoti Mounted Rifles Hall, Greytown	Historical / Cultural / Religious Significance	U40
Bayview Muslim Cultural Society Mosque	Historical / Cultural / Religious Significance	U60
Chatsworth Community Arts Centre	Historical / Cultural / Religious Significance	U60
christ the King Lutheran Church	Historical / Cultural / Religious Significance	U60
Esithumba	Historical / Cultural / Religious Significance	U60
Indunakezi	Historical / Cultural / Religious Significance	U60
Radha Krishna Centre	Historical / Cultural / Religious Significance	U60
Shri Luxmi Temple	Historical / Cultural / Religious Significance	U60
Shri Shwami Sivanad Divine Life Ashram	Historical / Cultural / Religious Significance	U60
Sivan Kovil Temple	Historical / Cultural / Religious Significance	U60
Temple of Understanding	Historical / Cultural / Religious Significance	U60
AACSA	Historical / Cultural / Religious Significance	U60 / U20
Abbobaker Mansions	Historical / Cultural / Religious Significance	U60 / U20
Adam's Mission	Historical / Cultural / Religious Significance	U60 / U20
Addington Hospital Centenary Museum	Historical / Cultural / Religious Significance	U60 / U20
African Art Centre	Historical / Cultural / Religious Significance	U60 / U20
Albert Park	Historical / Cultural / Religious Significance	U60 / U20
Alfresco Art Show	Historical / Cultural / Religious Significance	U60 / U20
Alice Street Bus Sheds	Historical / Cultural / Religious Significance	U60 / U20
Ashraf Supply Store	Historical / Cultural / Religious Significance	U60 / U20
B.A. Naidoos Building	Historical / Cultural / Religious Significance	U60 / U20
Badsha Pir Tomb	Historical / Cultural / Religious Significance	U60 / U20
Bartle Arts Trust (Bat Centre)	Historical / Cultural / Religious Significance	U60 / U20
Bat Centre	Historical / Cultural / Religious Significance	U60 / U20
Bayside Gallery	Historical / Cultural / Religious Significance	U60 / U20
Bellair Congregational Church	Historical / Cultural / Religious Significance	U60 / U20
Bellair Railway Station	Historical / Cultural / Religious Significance	U60 / U20
Bellair Senior Primary School	Historical / Cultural / Religious Significance	U60 / U20
Berea Road (Route)	Historical / Cultural / Religious Significance	U60 / U20
Biology Collections, UND	Historical / Cultural / Religious Significance	U60 / U20
Bond Wharehouse	Historical / Cultural / Religious Significance	U60 / U20
Brittania Hotel	Historical / Cultural / Religious Significance	U60 / U20
Burman Bush	Historical / Cultural / Religious Significance	U60 / U20
Canaan Settlement	Historical / Cultural / Religious Significance	U60 / U20

Cato Manor	Historical / Cultural / Religious Significance	U60 / U20
Cato Manor Hindu Temple	Historical / Cultural / Religious Significance	U60 / U20
Charlestown	Historical / Cultural / Religious Significance	U60 / U20
Chelsea Villa	Historical / Cultural / Religious Significance	U60 / U20
City Hall	Historical / Cultural / Religious Significance	U60 / U20
Clarence Road School	Historical / Cultural / Religious Significance	U60 / U20
Colonial Mutual Building	Historical / Cultural / Religious Significance	U60 / U20
Congella	Historical / Cultural / Religious Significance	U60 / U20
Congregational Church	Historical / Cultural / Religious Significance	U60 / U20
Dick King's Grave	Historical / Cultural / Religious Significance	U60 / U20
Dick King's House	Historical / Cultural / Religious Significance	U60 / U20
Dube's Grave, Inanda	Historical / Cultural / Religious Significance	U60 / U20
Dumcree Hotel	Historical / Cultural / Religious Significance	U60 / U20
Durban Art Gallery	Historical / Cultural / Religious Significance	U60 / U20
Durban Club	Historical / Cultural / Religious Significance	U60 / U20
Durban Cultural Centre	Historical / Cultural / Religious Significance	U60 / U20
Durban Girls College	Historical / Cultural / Religious Significance	U60 / U20
Durban High School	Historical / Cultural / Religious Significance	U60 / U20
Durban Hindu Temple	Historical / Cultural / Religious Significance	U60 / U20
Durban Light Infantry Regimental Headquaters	Historical / Cultural / Religious Significance	U60 / U20
Durban Natural Science Museum	Historical / Cultural / Religious Significance	U60 / U20
Ebuhleni	Historical / Cultural / Religious Significance	U60 / U20
Elephant House	Historical / Cultural / Religious Significance	U60 / U20
Elizabeth Gordon Gallery	Historical / Cultural / Religious Significance	U60 / U20
Emmanuel Cathedral	Historical / Cultural / Religious Significance	U60 / U20
Emoyeni	Historical / Cultural / Religious Significance	U60 / U20
Escombe Terrace 5 - 15	Historical / Cultural / Religious Significance	U60 / U20
Escombe Terrace No 3	Historical / Cultural / Religious Significance	U60 / U20
Escombe Terrace, Point	Historical / Cultural / Religious Significance	U60 / U20
Expo 85 Offices	Historical / Cultural / Religious Significance	U60 / U20
Fernando Pessoa Bust	Historical / Cultural / Religious Significance	U60 / U20
Fort Victoria	Historical / Cultural / Religious Significance	U60 / U20
Gallery 343	Historical / Cultural / Religious Significance	U60 / U20
Gandhi Library	Historical / Cultural / Religious Significance	U60 / U20
Ganesa Temple	Historical / Cultural / Religious Significance	U60 / U20
Gate Retiring Rooms	Historical / Cultural / Religious Significance	U60 / U20
Geology Display Centre	Historical / Cultural / Religious Significance	U60 / U20
Glenelg	Historical / Cultural / Religious Significance	U60 / U20
Glenwood High School	Historical / Cultural / Religious Significance	U60 / U20
Greenachres	Historical / Cultural / Religious Significance	U60 / U20
Grey Street Nos 117/123	Historical / Cultural / Religious Significance	U60 / U20
Grosvenor Hotel	Historical / Cultural / Religious Significance	U60 / U20
Howard Memorial College, UND	Historical / Cultural / Religious Significance	U60 / U20
Inanda Area (riral Zulu Settlement)	Historical / Cultural / Religious Significance	U60 / U20
Indian Opinion Building	Historical / Cultural / Religious Significance	U60 / U20
Isipingo Rail Hindu Mariaman Temple	Historical / Cultural / Religious Significance	U60 / U20
Islamic Vision	Historical / Cultural / Religious Significance	U60 / U20
Ismail Building	Historical / Cultural / Religious Significance	U60 / U20
Jacobs Concentration Camp	Historical / Cultural / Religious Significance	U60 / U20
John Ross Statue	Historical / Cultural / Religious Significance	U60 / U20
Juma Musjid Mosque	Historical / Cultural / Religious Significance	U60 / U20
Kathonian Building	Historical / Cultural / Religious Significance	U60 / U20
Killie Campbell Museum	Historical / Cultural / Religious Significance	U60 / U20
King's House	Historical / Cultural / Religious Significance	U60 / U20
Kingsfold	Historical / Cultural / Religious Significance	U60 / U20
Kingsmead Cricket Pavillion	Historical / Cultural / Religious Significance	U60 / U20

KNSA Gallery	Historical / Cultural / Religious Significance	U60 / U20
Lamontville Township	Historical / Cultural / Religious Significance	U60 / U20
Landsdowne House	Historical / Cultural / Religious Significance	U60 / U20
Little Chelsea	Historical / Cultural / Religious Significance	U60 / U20
Llanberis	Historical / Cultural / Religious Significance	U60 / U20
Madressa Arcade	Historical / Cultural / Religious Significance	U60 / U20
Mahatma Gundhi Bust	Historical / Cultural / Religious Significance	U60 / U20
Manning Road Methodist Church	Historical / Cultural / Religious Significance	U60 / U20
Maris Stella Convent	Historical / Cultural / Religious Significance	U60 / U20
Maritime Museum	Historical / Cultural / Religious Significance	U60 / U20
Merebank Concentration Camp	Historical / Cultural / Religious Significance	U60 / U20
Meyrick Bennet House	Historical / Cultural / Religious Significance	U60 / U20
Milton Road Nos 2 - 8	Historical / Cultural / Religious Significance	U60 / U20
Mkhumbane Stream, Cato Manor	Historical / Cultural / Religious Significance	U60 / U20
Morewag	Historical / Cultural / Religious Significance	U60 / U20
Natal Mountain Rifles Club	Historical / Cultural / Religious Significance	U60 / U20
Natalia School	Historical / Cultural / Religious Significance	U60 / U20
Nazareth House	Historical / Cultural / Religious Significance	U60 / U20
Noth Pier	Historical / Cultural / Religious Significance	U60 / U20
Old Fort	Historical / Cultural / Religious Significance	U60 / U20
Old Fort Road, No 44 - The Jewish Club	Historical / Cultural / Religious Significance	U60 / U20
Old House Museum	Historical / Cultural / Religious Significance	U60 / U20
Old Railway Station	Historical / Cultural / Religious Significance	U60 / U20
Old Theatre Royale	Historical / Cultural / Religious Significance	U60 / U20
Original St Mary's Church	Historical / Cultural / Religious Significance	U60 / U20
Our Lady Of Vilankanni Church	Historical / Cultural / Religious Significance	U60 / U20
Out Buildings to King's House	Historical / Cultural / Religious Significance	U60 / U20
Overport Mosque	Historical / Cultural / Religious Significance	U60 / U20
Peace Cottage, Umshlanga Rocks	Historical / Cultural / Religious Significance	U60 / U20
Phoenix	Historical / Cultural / Religious Significance	U60 / U20
Piont Police Station	Historical / Cultural / Religious Significance	U60 / U20
Playhouse Theatre	Historical / Cultural / Religious Significance	U60 / U20
Point Fire Station	Historical / Cultural / Religious Significance	U60 / U20
Point Road Yacht Club	Historical / Cultural / Religious Significance	U60 / U20
Point Road, Nos 162 / 166	Historical / Cultural / Religious Significance	U60 / U20
Point Road, Nos 68 / 72	Historical / Cultural / Religious Significance	U60 / U20
Point Road, Nos 76	Historical / Cultural / Religious Significance	U60 / U20
Point Road, Nos 78 / 80	Historical / Cultural / Religious Significance	U60 / U20
Point Road, Nos 86 / 92	Historical / Cultural / Religious Significance	U60 / U20
Port Captain's Offices	Historical / Cultural / Religious Significance	U60 / U20
Port Natal Administration Board Building	Historical / Cultural / Religious Significance	U60 / U20
Portview	Historical / Cultural / Religious Significance	U60 / U20
Private Garden and Bead Museum	Historical / Cultural / Religious Significance	U60 / U20
Queen Bridge Mosque	Historical / Cultural / Religious Significance	U60 / U20
Receiver of Revenue Building	Historical / Cultural / Religious Significance	U60 / U20
Rope Shed, Point	Historical / Cultural / Religious Significance	U60 / U20
Rosehill Farmhouse	Historical / Cultural / Religious Significance	U60 / U20
Rosie Dry, Point	Historical / Cultural / Religious Significance	U60 / U20
Royal Hotel	Historical / Cultural / Religious Significance	U60 / U20
Sastri College	Historical / Cultural / Religious Significance	U60 / U20
Sericraft Gallery	Historical / Cultural / Religious Significance	U60 / U20
Shree Angalaman Temple	Historical / Cultural / Religious Significance	U60 / U20
Shree Gengaiammen Temple	Historical / Cultural / Religious Significance	U60 / U20
Shree Muruga Kadaval Temple	Historical / Cultural / Religious Significance	U60 / U20
Shree Nivasa Perumal Kouvil	Historical / Cultural / Religious Significance	U60 / U20
Shree Sanathan Dharma Mandir	Historical / Cultural / Religious Significance	U60 / U20
Shri Poongavana	Historical / Cultural / Religious Significance	U60 / U20

Shri Ranganather Alayam	Historical / Cultural / Religious Significance	U60 / U20
Shri Vishnu Temple	Historical / Cultural / Religious Significance	U60 / U20
Shrine, Telegu Cemetery	Historical / Cultural / Religious Significance	U60 / U20
Sibulungu	Historical / Cultural / Religious Significance	U60 / U20
Signal Road No 60	Historical / Cultural / Religious Significance	U60 / U20
Sirdar Road Temple Compound	Historical / Cultural / Religious Significance	U60 / U20
Smith Street, Route	Historical / Cultural / Religious Significance	U60 / U20
Soofie Mosque (Sufi Saheb Badsha Peer Darbar)	Historical / Cultural / Religious Significance	U60 / U20
South Pier	Historical / Cultural / Religious Significance	U60 / U20
Springfield Flats	Historical / Cultural / Religious Significance	U60 / U20
St Henry's Marist Brothers College	Historical / Cultural / Religious Significance	U60 / U20
St James Church	Historical / Cultural / Religious Significance	U60 / U20
St James Hotel	Historical / Cultural / Religious Significance	U60 / U20
St John's Church	Historical / Cultural / Religious Significance	U60 / U20
St Paul's Church	Historical / Cultural / Religious Significance	U60 / U20
St Thomas's Church	Historical / Cultural / Religious Significance	U60 / U20
Surat Hindu Association	Historical / Cultural / Religious Significance	U60 / U20
Surrey Mansions	Historical / Cultural / Religious Significance	U60 / U20
Technikon Natal Gallery	Historical / Cultural / Religious Significance	U60 / U20
The Durban Jewish Club	Historical / Cultural / Religious Significance	U60 / U20
The Manor House	Historical / Cultural / Religious Significance	U60 / U20
The Mansions	Historical / Cultural / Religious Significance	U60 / U20
The Park Street Synagogue	Historical / Cultural / Religious Significance	U60 / U20
Trinity Congregational Church	Historical / Cultural / Religious Significance	U60 / U20
Umgeni Road Temple Complex	Historical / Cultural / Religious Significance	U60 / U20
Umlazi Township	Historical / Cultural / Religious Significance	U60 / U20
University of Durban-Westville Gallery	Historical / Cultural / Religious Significance	U60 / U20
University of Natal : Howard College	Historical / Cultural / Religious Significance	U60 / U20
Vasco Da Gama Clock	Historical / Cultural / Religious Significance	U60 / U20
Victoria Bar	Historical / Cultural / Religious Significance	U60 / U20
Victoria Street Market	Historical / Cultural / Religious Significance	U60 / U20
Vishnu and Shiva Temples, Sea Cow Lake	Historical / Cultural / Religious Significance	U60 / U20
Voortrekker Camp, Congella	Historical / Cultural / Religious Significance	U60 / U20
Walnut Road Theatre	Historical / Cultural / Religious Significance	U60 / U20
Warehouses, Point Road	Historical / Cultural / Religious Significance	U60 / U20
Warriors' Gate Moth Museum	Historical / Cultural / Religious Significance	U60 / U20
Wemtworh Art Centre	Historical / Cultural / Religious Significance	U60 / U20
West Street Cemetery	Historical / Cultural / Religious Significance	U60 / U20
West Street Mosque	Historical / Cultural / Religious Significance	U60 / U20
West Street, Route	Historical / Cultural / Religious Significance	U60 / U20
Whaling Station (Defunct)	Historical / Cultural / Religious Significance	U60 / U20
Winston Churchill Plaque	Historical / Cultural / Religious Significance	U60 / U20
Wylie House	Historical / Cultural / Religious Significance	U60 / U20
Zanzibarian Mosque	Historical / Cultural / Religious Significance	U60 / U20
Zulu Figure, Durban City Hall	Historical / Cultural / Religious Significance	U60 / U20
Zulu Hunting Camp, Berea	Historical / Cultural / Religious Significance	U60 / U20
Zulu Images, Old Receiver of Revenue Building	Historical / Cultural / Religious Significance	U60 / U20
Byrne Church	Historical / Cultural / Religious Significance	U70
St Mary Magdelene Church	Historical / Cultural / Religious Significance	U70
Kwambhodwe/Kwalembe Tourist House	Historical / Cultural / Religious Significance	U80
Park Rynie	Historical / Cultural / Religious Significance	U80
Umdoni Park, South Coast	Historical / Cultural / Religious Significance	U80
Umzumbe Morrison Post	Historical / Cultural / Religious Significance	U80

APPENDIX B

MACRO-ECONOMIC DATA

APPENDIX B.1

GRAPHS: GROSS GEOGRAPHIC PRODUCT LABOUR AND SHIFT-SHARE

APPENDIX B.1 : GRAPHS: GROSS GEOGRAPHIC PRODUCT, LABOUR AND SHIFT-SHARE

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).

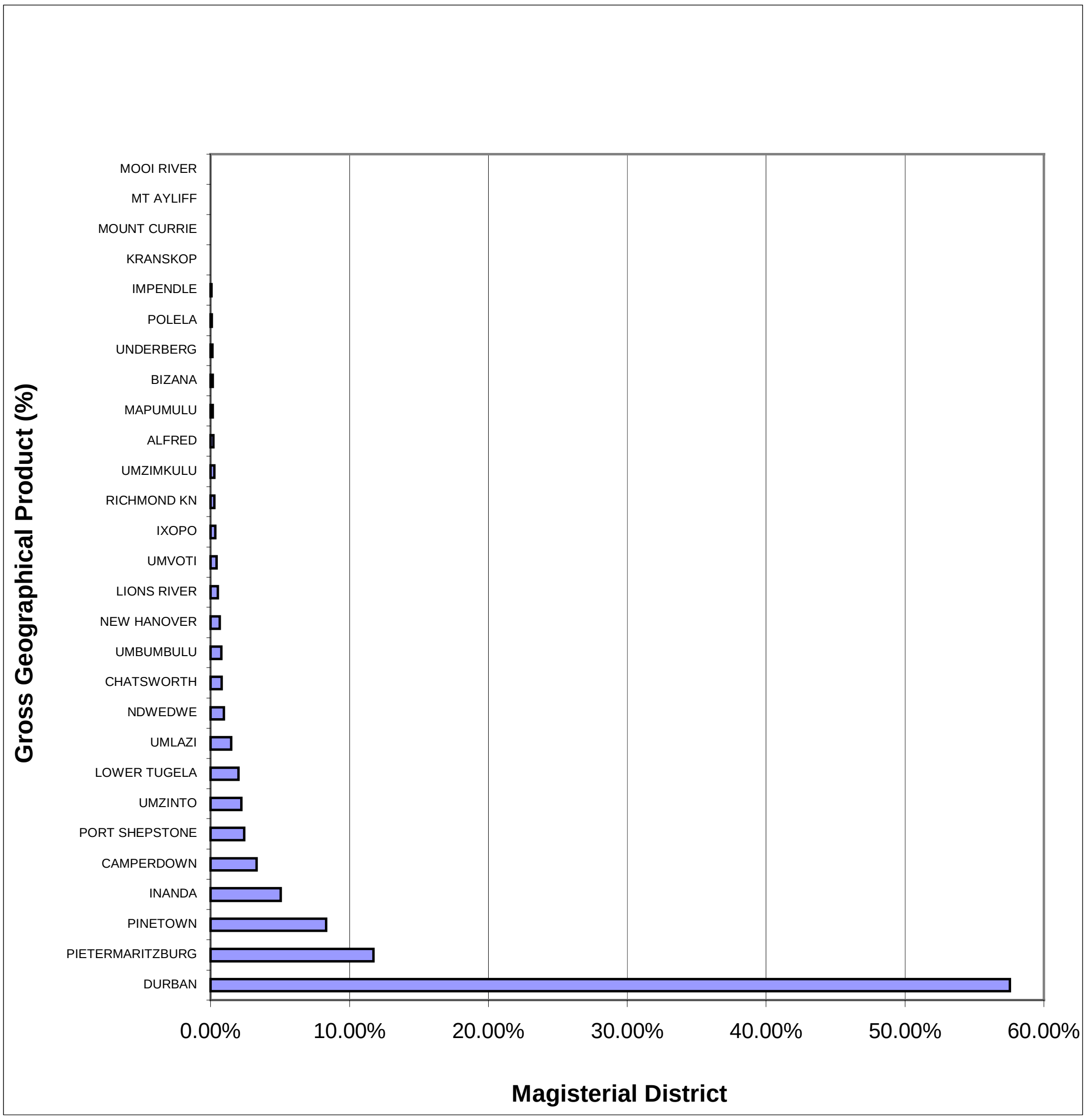

Figure B.1: Contribution by Magisterial District to Mvoti to Umzimkulu Economy, 1997 (%)

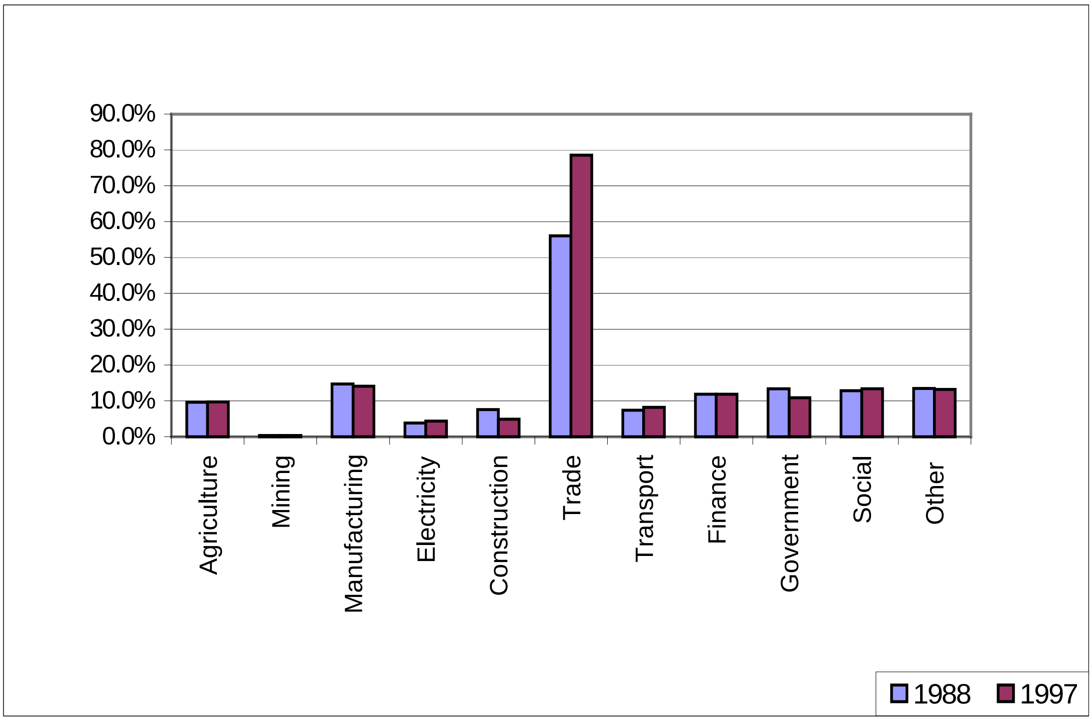

Figure B.2: Contribution by Sector to National Economy, 1988 and 1997 (%)

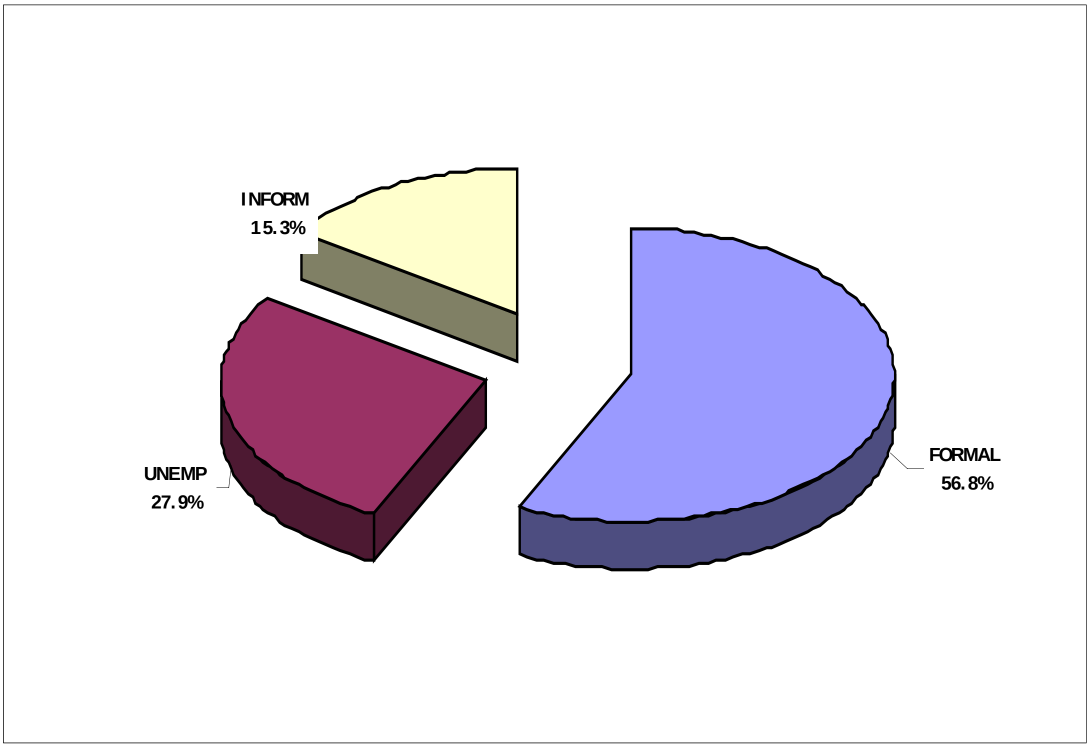

Figure B.3: Composition of Mvoti to Umzimkulu Labour Force, 1994 (%)

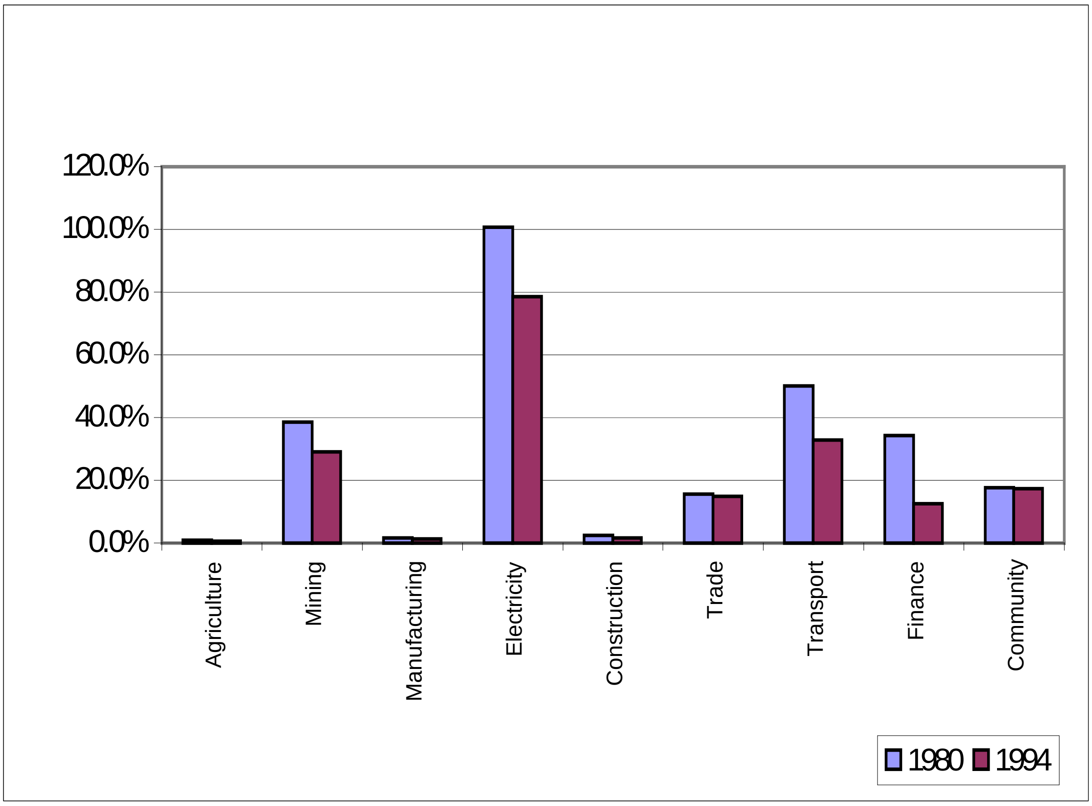

Figure B.4: Contribution by Sector to Mvoti to Umzimkulu Employment, 1980 and 1994(%)

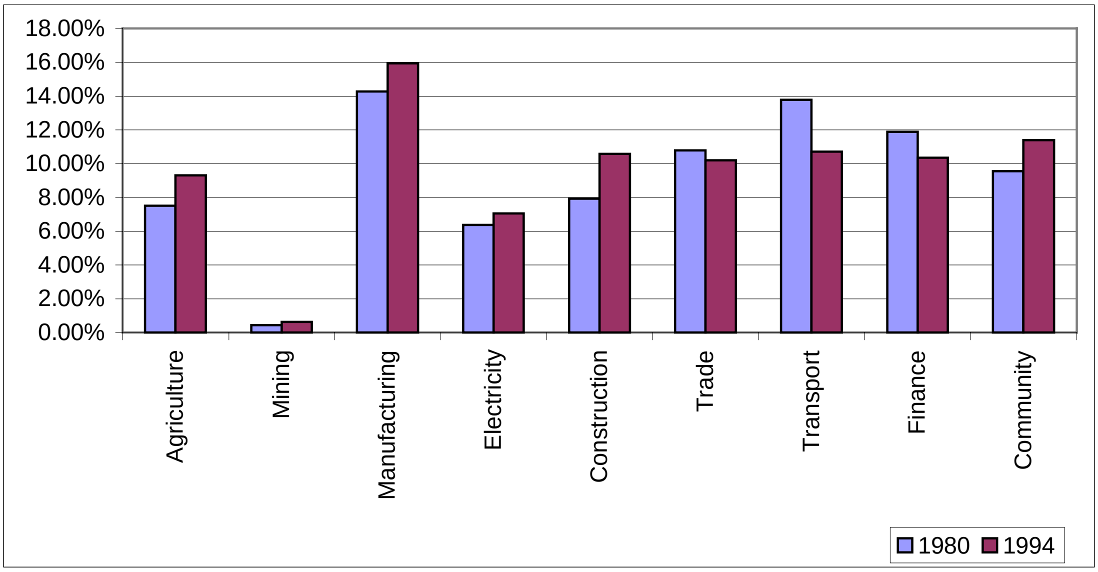

Figure B.5: Contribution by Sectors of Mvoit to Umzimkulu Employment to National Sectoral Employment, 1980 and 1994 (%)

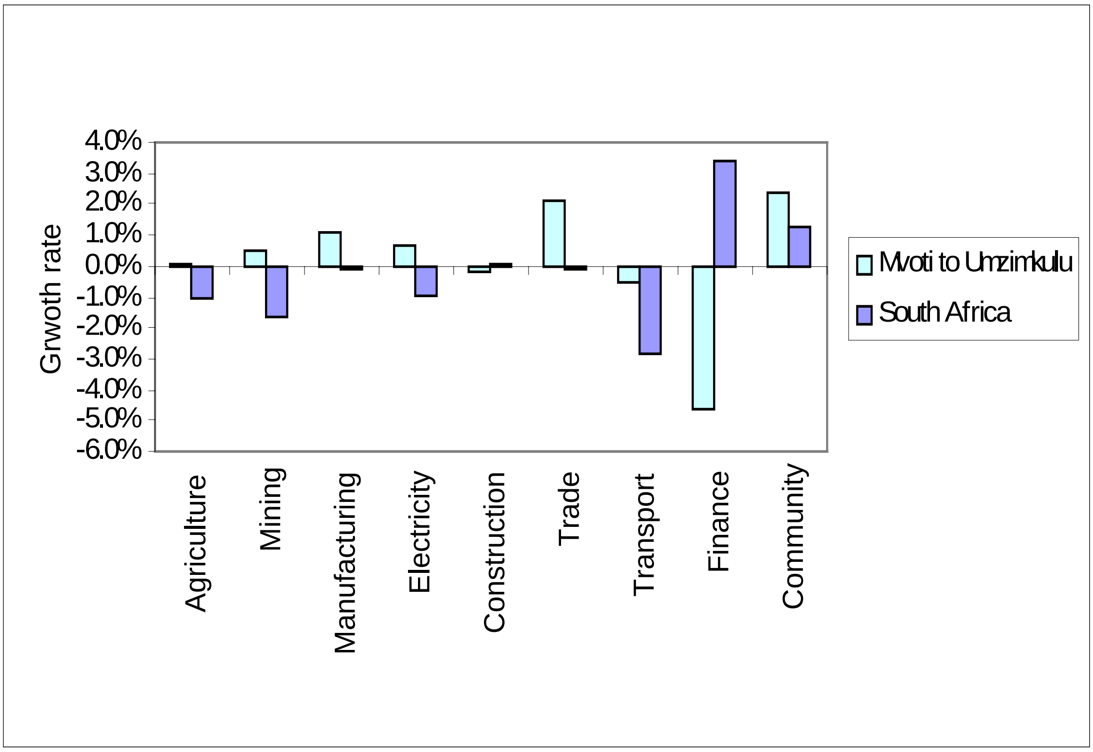

Figure B.6: Average Annual Employment Growth by Sector of Mvoti to Umzimkulu versus South Africa, 1980 to 1994 (%)

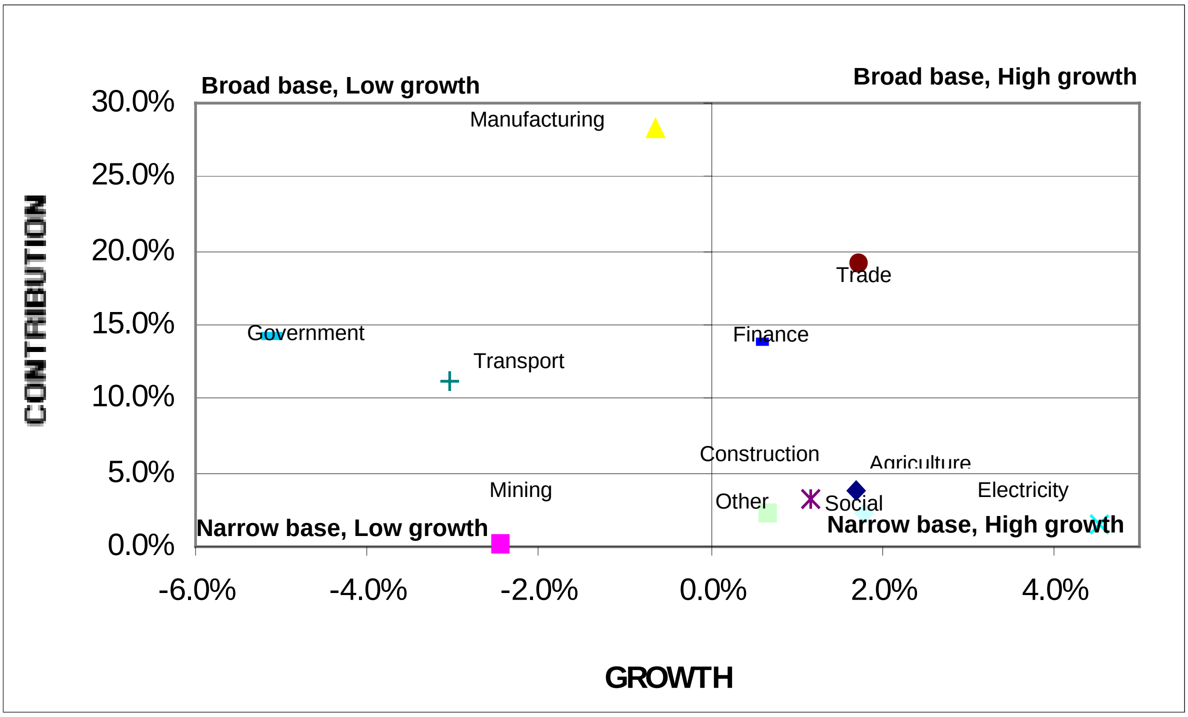

Figure B.7: Shift-Share analysis (%)

APPENDIX B.2

WATER MANAGEMENT AREAS IN NATIONAL CONTEXT

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.

- 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.

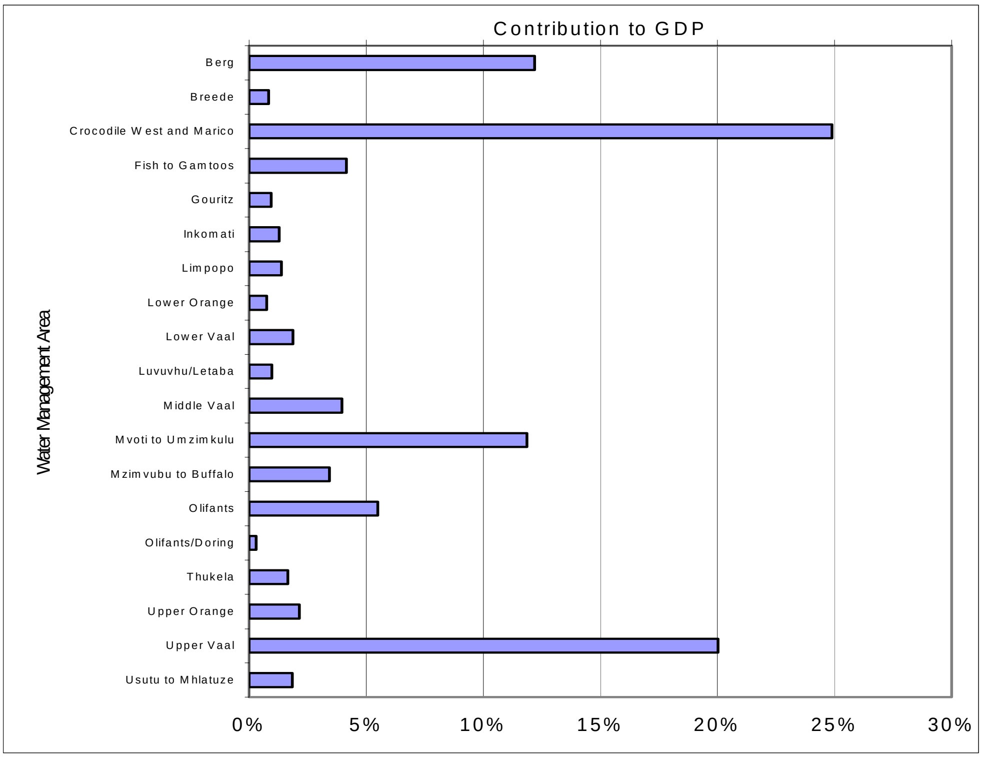

Figure B.1: Total GGP by Water Management Area (% of Country)

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.

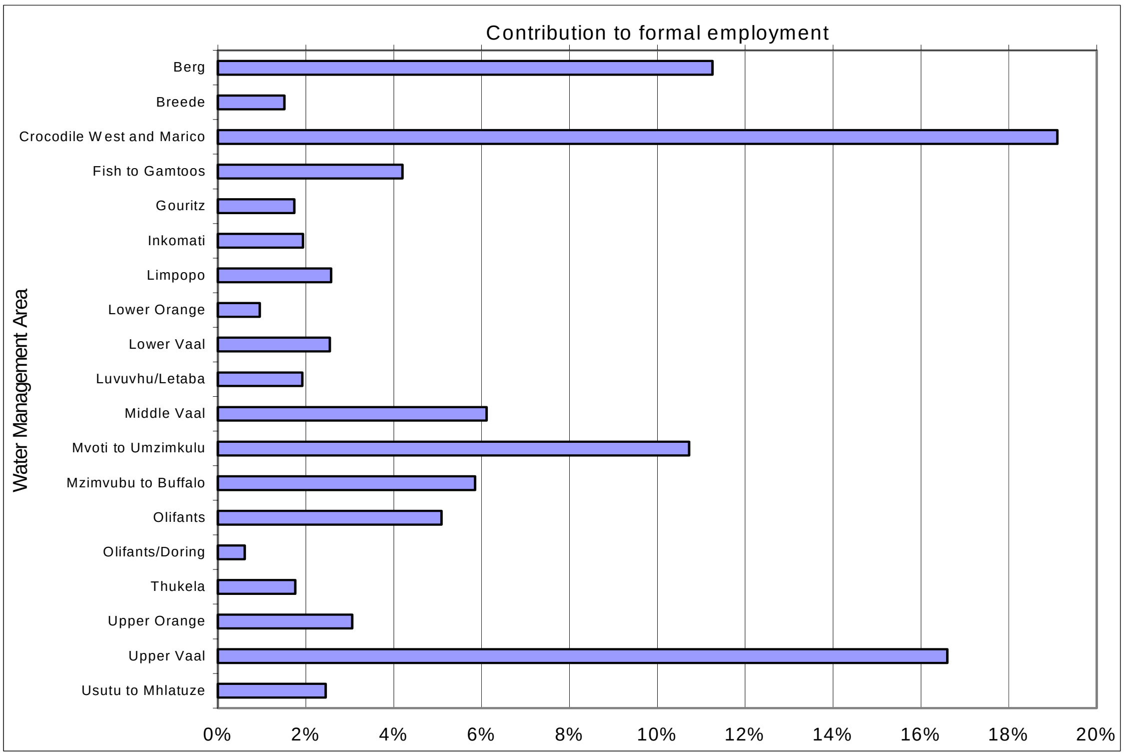

Figure B.2: Formal Employment by Water Management Area (% of country)

- 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.

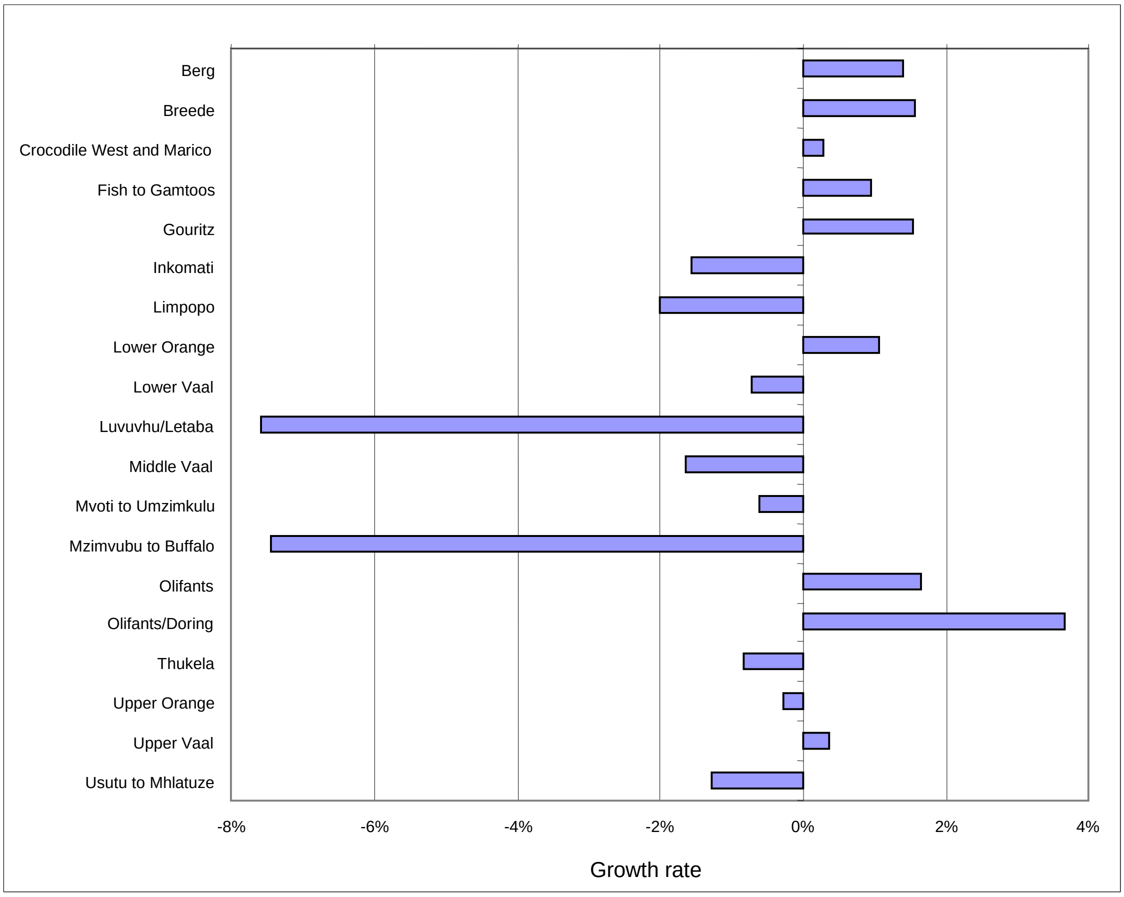

Figure B.3: Average Annual Economic Growth by Water Management Area, 1988-1997 (%)

APPENDIX B.3

ECONOMIC SECTOR DESCRIPTION

- **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

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.

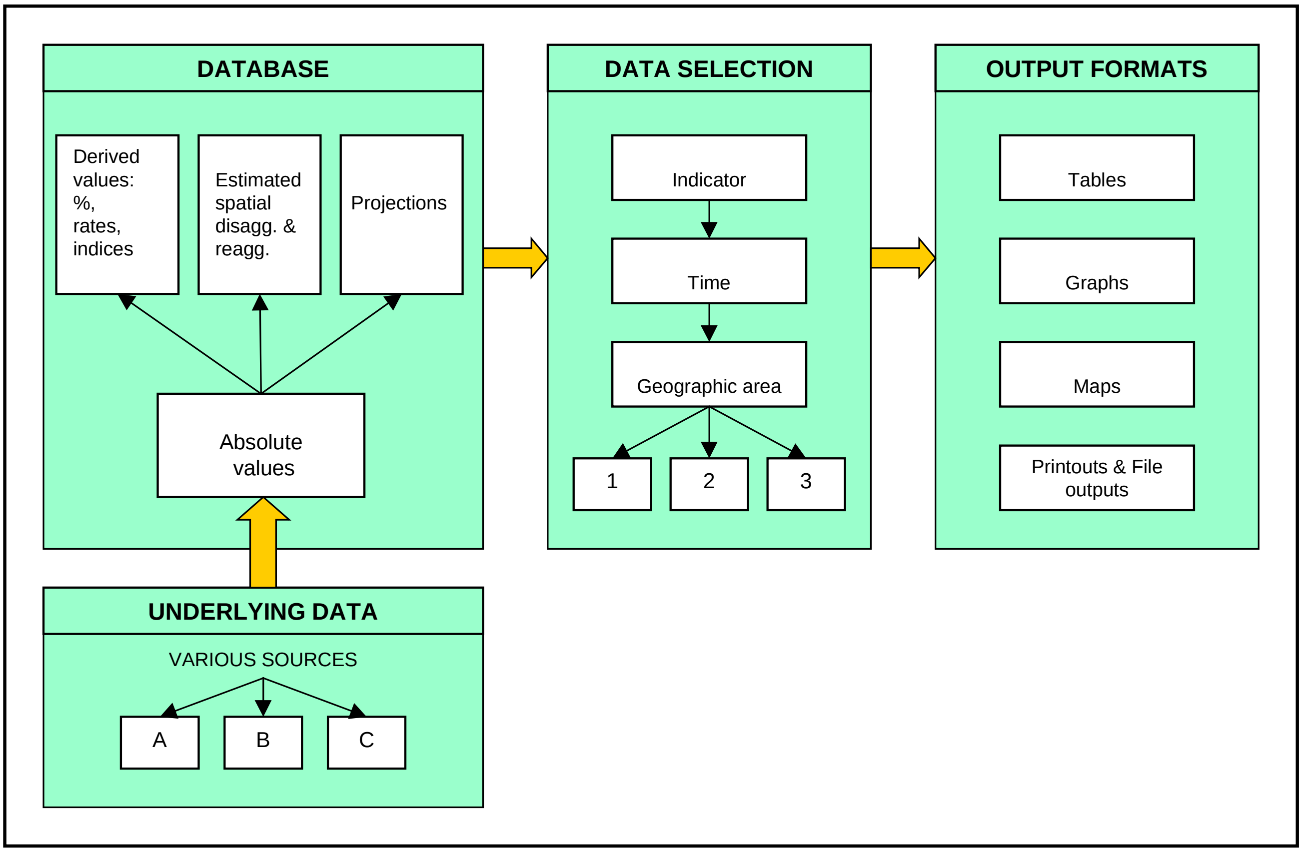

Diagram 1: Overview of Economic Information System

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

DISTRICT COUNCILS

<table>
<tr><th rowspan="2">District Council</th><th colspan="2">Quaternaries comprising the District Council</th></tr>
<tr><th>Quats in the Mvoti - Mzimkulu WMA</th><th>Quats not in the Mvoti - Mzimkulu WMA</th></tr>
<tr><td>RC5 INDLOVU</td><td>T51A-J
T52A, C-D, F
U10A-L
U20A-L
U30A
U40A-H
U60A-C, E
U70A-D
U80B, E, J</td><td>T31A-J
T32A-D
T33A
V20A-J
V40B, E
V50A-B
V60G, K
V70A-B, F-G</td></tr>
<tr><td>RC6 ILEMBE</td><td>U10L-M
U20K-M
U30A-E
U40G-J
U50A
U60D-E
U70C-F</td><td>V50B-D</td></tr>
<tr><td>RC7 UGU</td><td>T40A-G
T52D, J-M
U10L-M
U80A-L</td><td></td></tr>
<tr><td>RC8 DURBAN METRO</td><td>U20J, -M
U30B, D
U60C-F
U70D, F</td><td></td></tr>
<tr><td>WILD COAST</td><td>T40A, C-E
T51G-J
T52A-H</td><td>T31C, E, -J
T32E-H
T33A-K
T34A-K
T35A
T36A-B
T60A-K</td></tr>
</table>

MAGISTERIAL DISTRICTS IN THE MVOTI - MZIMKULU WMA THAT COMPRISE EACH DISTRICT COUNCIL

DISTRICT COUNCIL	MAGISTERIAL DISTRICT
KEI	Transkei
RC1 UTHUNGULU	Kranskop*
RC3 UMZINYATHI	Kranskop*
RC4 UTHUKELA	Mooirivier*
RC5 INDLOVU	Camperdown Impendle* Kranskop* Lions River* Mapumulo* Mooirivier* Mount Currie New Hanover Pietermaritzburg Polela Richmond Transkei Umvoti* Underberg
RC6 ILEMBE	Camperdown Inanda Lower Tugela* Mapumulo* Ndwedwe New Hanover Pinetown Richmond Umbumbulu UMlaze
RC7 UGU	Alfred Bizana Impendle Port Shepstone Umzinto
RC8 DURBAN METRO	Camperdown Chatsworth Durban Inanda Pinetown Umbumbulu UMlaze
WILD COAST	Bizana Mount Ayliff Mount Currie Transkei

*Magisterial district in both Mvoti - Mzimkulu and Thukela WMAs

LIST OF IRRIGATION BOARDS

Illovo
Ixopo
Karkloof
Lower Umvoti
Mnyamvubu
Mzalanyoni
Mpolweni / Sterkspruit
Mzalanyoni
Ngwangwane
Nkonzo River
Polela
Umlaas
Umvoti
Umzumkulwana
Underberg
Injambili
Merrivale
Middle Umgeni

LIST OF TRANSITIONAL LOCAL COUNCILS

Ashburton
Bizana
Cool Air
Creighton
Dalton
Dolphin Coast
Durban Metro
Harding
Hibberdene
Hilton
Himeville
Howick
Impendle
Impenjati
Ixopo
Kwadukuza/Stanger
Margate
New Hanover
Nkwazi
Pennington
Pietermaritzburg/Msunduzi
Port Shepstone
Richmond
Scottburgh
Umkomaas
Umtamvuna
Umzimkulu
Umzinto
Underberg
Wartburg

APPENDIX D

LAND USE DATA

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.

APPENDIX E

WATER REQUIREMENTS

PRESENT ECOLOGICAL STATUS CLASS PER QUAT IN THE MVOTI-MZIMKHULU WMA

QUAT NO.	RIVER NAME/S	PRESENT ECOLOGICAL STATUS CLASS (PESC)
T40A	Mtamvuna	B
T40B	Weza	C
T40C	Ludeke	B
T40D	Mtamvuna	B
T40E	Mtamvuna	B
T40F	Mbizana	C
T40G	Zotsha?	C
T51A	Mzimuti source to Mzinkulu conf	A
T51B	Mzimkulu	C
T51C	Mzimkulu, Underberg to Centocow	C
T51D	Polela	B
T51E	Polela, Himeville to Umzimkulu confl.	C
T51F	Ngwangwane, source to Ndowane confl.	B
T51G	Ndowane to Ngwangwane confluence	C
T51H	Ngununu	C
T51J	Ngwagwane	C
T52A	Mzimkulu Polela to Cubane	C
T52B	Cubane trib of Mzimkulu	C
T52C	Mzimkulu, Cabane confl to Umzimkulu village	C
T52D	Mzimkulu, village to Bisi confl.	C
T52E	Bisi source to Little Bisi confl	C
T52F	Little Bisi to Bisi Confl.	C
T52G	Bisi, L Bisi confl to R 56 road	C
T52H		C
T52J	Mzimkulu, Bisi confl to Tengwe confl	B
T52K	Umzimkulwane source to top of Oribi Gorge	D
T52L	Mzimkulwane in Oribi Gorge	B
T52M	Mzimkulu Tengwane confl to estuary	B
U10A	Mkomzana	B
U10B	Mkomazi	B
U10C	Mkomazana	B
U10D	Inzinga	B
U10E	Mkumazi	B
U10F	Mkumazi	B
U10G	Mkumazi	B
U10H	Mkumazi	B
U10J	Mkomazi	B
U10K	Lufafa	B
U10L	Mkumazi	B
U10M	Mkumazi	C
U20A	Mgeni	B
U20B	Lions	C
U20C	Mgeni	C
U20D	Karkloof River	B
U20E	Mgeni	C
U20F	Mpolweni	C
U20G	Mgeni	C
U20H	Mzunduzi	C
U20J	Mzunduzi	D

U20K	Mqueku	B
U20L	Mgeni	C
U20M	Mgeni	D
U30A	Mdhloti source to Hazelmere Dam	B
U30B	Mdloti, Hazelmere D to estuary	D
U30C	Tongaat, source to Mona confl..	C
U30D	Tongaat Mona to estuary	C
U30E	Umhlali R	C
U40A	Umvoti, source to Mispah	C
U40B	Mvoti to head of Umvoti gorge	C
U40C	Ikamanzi to Umvoti confl	C
U40D	Umvoti, head of Umvoti gorge to near Mt Elias	B
U40E	Umvoti, Mt Elias to Hlimbitwe confl.	B
U40F	Upper Hlimbitwa	C
U40G	Lower Hlimbitwa	B
U40H	Umvoti Hlimbitwa confl to Glen Mill	B
U40J	Umvoti Glen Mill to estuary	C
U50A	Whole Nonoti catchment	C
U60A	Mlaas headwaters	C
U60B	Umlaas Baynesfield to Tala valley	C
U60C	Umlaas Tala to Shongweni	C
U60D	Mlaas shongweni to inland end of Mlaas canal	D
U60E	Mbokodweni	B
U60F	Mhlatuzana	D
U70A	Lovu, source to Richmond	C
U70B	Lovu, Richmond to 30 degrees south	B
U70C	Lovu	B
U70D	Lovu Coastal	B
U70E	Mgababa	B
U70F	Amanzimtoti	B
U80A	Mtentweni	C
U80B	Umzumbe to NE of Kwadeshula	B
U80C	Umzumbe NE of kwadushula to sea	B
U80D	Mfazazane	C
U80E	Mtwalume source to Qaha confl	B
U80F	Mtwalume, Qaha confl to sea	B
U80G	Fafa	C
U80H	Mkumbane	D
U80J	Umpambanyoni, source to Mquha confl	B
U80K		B
U80L	Mahlongwa	B

ARTICLE 56(3): INDIVIDUAL PERMIT HOLDERS FOR GOVERNMENT WATER SCHEMES

Mdloti River		**m^3/annum**
1. Verulam Investors	:	2 000
2. M. A. Jackson	:	32 000
3. Mdloti Beach Town Board	:	25 000
4. Umgeni Water Board (urban and industrial)	:	10 950 000
5. Umgeni Water Board (domestic and industrial)	:	472 800
6. Mdloti (Natal Parks Board)	:	5 700
7. Tongaat Huletts Properties Ltd	:	642 600
8. Graded Sands	:	18 250
		12 148 550

Umgeni River

1. R & L Freese	:	2 455
2. Dr R.N. Stephenson	:	2 455
3. Maryland Farms	:	2 455
4. Mrs R Carr	:	7 300
5. R. Peattie	:	30 000
6. C.A. Eskine	:	4 920
7. Natal Parks, Game and Fish Board	:	3 600
8. M.G. Haines	:	7 380
9. B.V. Daniel	:	2 500
10. T.F. Bartlett	:	2 460
11. D.G. Kok	:	3 400
12. Stockowners Feedlot	:	365 000
13. M.G. Haines	:	2 460
14. Argule Poutry Farm C.C.	:	36 000
15. Albert Falls Water Ski Club	:	2 700
16. A.A.A. Feedlot	:	193 440
17. Albert Falls Investments (Pty) Ltd	:	320
18. Top Crop Nursery	:	144 000
19. Thornhill Estates	:	6 000
		903 569

Umgeni River (Midmar Dam)

1. City of Durban	:	82 964 500

2.	Cancor Feedlots (Pty) Ldt	:	84 524
3.	Umgeni Water Board	:	340 078 530
4.	Natal Parks, Game and Fish Board	:	8 400
5.	Watburg Health Committee	:	400 000
6.	J.M. Forbes and Sons (Pty) Ltd	:	1 312
7.	Messrs Forbes Transport and Agencies C.C.	:	15 800
			423 553 166

ARTICLE 12 & 21 – INDUSTRIAL, MINING AND EFFLUENT PERMITS

Permit No.	Permit type (B Article 21, N Article 12)	Permit Status (0 valid, 1 additional, 2 closed)	Quat	Abstraction/ Discharge	Total flow (million m^3/a)
Article 12					
1382	N	0	T502	A	0.29
1385	N	0	T502	A	0.22
67	N	0	U200	A	3.32
279	N	0	U200	A	0.55
477	N	0	U200	A	0.00
677	N	0	U200	A	0.38
830	N	0	U200	A	0.14
1062	N	0	U200	A	0.11
1099	N	0	U200	A	0.03
1099	N	0	U200	A	0.02
1099	N	0	U200	A	0.03
1253	N	0	U200	A	0.14
1352	N	0	U200	A	0.36
349	N	0	U202	A	0.08
371	N	0	U202	A	1.01
1224	N	0	U202	A	5.53
1242	N	0	U300	A	0.12
1255	N	0	U300	A	0.19
1255	N	0	U300	A	0.01
68	N	0	U402	A	0.30
485	N	0	U403	A	8.40
495	N	0	U500	A	2.19
67	N	0	U600	A	0.22
112	N	0	U600	A	0.10
210	N	0	U600	A	0.19
225	N	0	U600	A	0.38
261	N	0	U600	A	0.84
284	N	0	U600	A	0.20
316	N	0	U600	A	0.17
349	N	0	U600	A	0.13
449	N	0	U600	A	1.02
507	N	0	U600	A	3.30
601	N	0	U600	A	0.27
617	N	0	U600	A	0.74
619	N	0	U600	A	1.20
627	N	0	U600	A	0.15
628	N	0	U600	A	0.13
640	N	0	U600	A	2.65
654	N	0	U600	A	0.15
710	N	0	U600	A	16.43
833	N	0	U600	A	1.12
845	N	0	U600	A	0.47
926	N	0	U600	A	0.37
1084	N	0	U600	A	0.76
1128	N	0	U600	A	0.31
1130	N	0	U600	A	0.54
1155	N	0	U600	A	0.07
1179	N	0	U600	A	0.53
1180	N	0	U600	A	0.17
1216	N	0	U600	A	0.24
1224	N	0	U600	A	0.09
1224	N	0	U600	A	0.55

1241	N	0	U600	A	0.12
1285	N	0	U600	A	0.11
1365	N	0	U600	A	0.21
1367	N	0	U600	A	0.54
1368	N	0	U600	A	0.37
1369	N	0	U600	A	0.37
1372	N	0	U600	A	0.34
1438	N	0	U600	A	0.96
702	N	0	U601	A	0.10
833	N	0	U602	A	1.12
833	N	0	U602	A	1.12
1160	N	0	U602	A	0.09
1160	N	0	U602	A	0.04
1260	N	0	U602	A	0.04
1260	N	0	U602	A	0.09
1299	N	0	U603	A	0.12
320	N	0	U700	A	1.83
438	N	0	U700	A	0.73
917	N	0	U700	A	0.34
1299	N	0	U700	A	0.12
1414	N	0	U800	A	0.62
1414	N	0	U800	A	1.32
1414	N	0	U800	A	0.43
1414	N	0	U802	A	1.11
279	N	2	U200	A	0.33
1333	N	2	U202	A	0.99
112	N	2	U600	A	0.55
210	N	2	U600	A	0.16
743	N	2	U700	A	9.25
187	N	2	U800	A	0.97
187	N	2	U800	A	0.25
187	N	2	U800	D	0.00
187	N	2	U800	D	0.00
Total					69.13
Article 21					
123	B	0	T400	D	0.15
130	B	0	T400	D	0.00
458	B	0	T400	D	0.75
1546	B	0	T400	D	0.26
502	B	0	T402	D	0.82
1125	B	0	T402	D	0.44
1347	B	0	T402	D	0.15
967	B	0	T502	D	0.66
1004	B	0	U100	D	0.24
1712	B	0	U100	D	12.78
1712	B	0	U100	D	6.21
1712	B	0	U100	D	45.00
20	B	0	U200	D	0.04
486	B	0	U200	D	2.56
601	B	0	U200	D	23.40
793	B	0	U200	D	2.50
962	B	0	U200	D	0.48
1368	B	0	U200	D	0.18
1526	B	0	U200	D	0.03
1573	B	0	U200	D	3.01
1312	B	0	U201	D	0.20
473	B	0	U202	D	1.01
947	B	0	U202	D	0.16
1430	B	0	U202	D	0.04
1377	B	0	U203	D	0.04
1442	B	0	U203	D	0.01

1496	B	0	U203	D	0.00
95	B	0	U300	D	0.13
547	B	0	U301	D	1.83
1015	B	0	U301	D	0.22
1148	B	0	U301	D	0.88
524	B	0	U302	D	0.82
1041	B	0	U302	D	1.39
1334	B	0	U302	D	1.10
1379	B	0	U302	D	1.22
1427	B	0	U400	D	0.86
147	B	0	U402	D	0.01
147	B	0	U402	D	0.02
269	B	0	U403	D	1.64
1456	B	0	U403	D	8.07
302	B	0	U600	D	4.80
1360	B	0	U600	D	4.38
1376	B	0	U600	D	0.06
1523	B	0	U600	D	36.87
1525	B	0	U600	D	28.10
1640	B	0	U600	D	0.05
33	B	0	U601	D	0.00
983	B	0	U601	D	0.10
1177	B	0	U601	D	0.96
1242	B	0	U601	D	7.30
1307	B	0	U601	D	0.22
651	B	0	U602	D	5.40
1134	B	0	U602	D	0.22
1360	B	0	U602	D	83.95
1361	B	0	U602	D	49.28
1612	B	0	U602	D	1.04
840	B	0	U603	D	8.03
1022	B	0	U603	D	3.27
80	B	0	U700	D	0.00
448	B	0	U700	D	0.25
191	B	0	U800	D	0.18
564	B	0	U801	D	0.00
1048	B	0	U803	D	0.74
406	B	0	U804	D	1.24
520	B	0	U804	D	0.00
1246	B	2	T400	D	0.26
1472	B	2	U100	D	27.00
1472	B	2	U100	D	45.00
1610	B	2	U200	D	23.40
385	B	2	U202	D	36.87
385	B	2	U202	D	7.30
717	B	2	U202	D	25.55
1448	B	2	U202	D	0.48
1115	B	2	U600	D	0.58
515	B	2	U602	D	1.04
651	B	2	U602	D	1.75
515	B	2	U603	D	0.64
Total					355.72

WATER COURT ORDERS

QUAT	RIVER	APPLICANT	AUTHORIZED VOLUME OF WATER
U100	Ixopo	Hodgson Extract Co. (Pty) Ltd.	
U201	Umgeni	Albert Falls Power Co. Ltd	60 cusec for power generation. Non-consumptive.
	Umgeni	Albert Falls Power Co. Ltd	Legal chitchat. Nothing new.
U202	Umgeni	Natal Estates Ltd	40 cusec for irrigation, 10 cusec for industrial, to be returned.
U202	Umgeni	Natal Estates Ltd	Legal chitchat. Nothing new.
U202	Umkabela	Wartburg Health Committee	Umkabela stream, Wartburg Committee impound up to 68 191m3 & abstract from Umkabela, 227 m3/day.
U202	Umgeni	Natal Estates Ltd	Base flow in river reduced.
U202	Umgeni	City Council of Durban	Storage & abstraction permit for Nogle Dam.
	Umgeni	S A Board Mills Ltd	9 092 m3/day
U202	Umhlangane	Coronation Brick & Tile Co. Ltd	Umhlangane river; 223 m3/day (1970) Industrial purpose.
U301	Umhloti	Natal Estates Ltd	Umhloti, Natal Estates Ltd, 6 cusecs of surplus flow to irrigate 977 acres of non rip land.
U301	Umhloti	Verulam Town Board	Umhloti, Verulam T. Board, 2728m3/day
U302	Umhloti	African Building Board Corp. Ltd & Canelands Properties Ltd.	Umhloti river, Canelands Prop. Ltd, 4 cusecs Primary, Secondary & Tertiary use.
U401	Umvoti	Hodgson Extract Co. Ltd	Umvoti Extract Hodgson Co. 6.5 cusecs, 6.2 returned flow, cooling purposes. Winter 3 cusecs, 2.8 returned
U601	Umlaas	Durban Corporation	Umlaas, 727 m3/day.
	Umlaas	Shell & BP South African Petroleum Refineries (Pty) Ltd.	
U603	Isipingo & Umbongitwini	Prospecton Sugar Estates Ltd	Authority to direct Isipingo River into Umbongitwini River.
U700	Umkomaas	S A Industrial Cellulose Corp. (Pty) Ltd	Umkomaas river, Abstraction – 90 922 m3/day, only if 3 cusecs flows
U700	Umkomaas	S A Industrial Cellulose Corp. (Pty) Ltd	Abstractor impound within or without Umkomaas river 90 922 m3/day
U700	Umkomaas	S A Industrial Cellulose Corp. (Pty) Ltd	54 553 m3/day (in addition to previous 90 922 m3/day).
U700	Umgababa	Umgababa Minerals Ltd	2 273 m3/day
U803	Umzimai	Umzinto RWSC	Umzimai – Umzinto RWSC
U803	Mtwalume	Umzinto R.W.S.C.	4 546 m3/day
	Mtwalume	C G Smith Sugar Ltd	1.108 m3/day

WATER TRANSFERS IN THE MVOTI-MZIMKHULU WMA AS AT 1995

From	To	From Sector*	To Sector*	Description	Max million m^3/a	Actual million m^3/a	Losses million m^3/a
Transfers into Mvoti-Mzimkhulu WMA							
V20D	U20B	SRD	SRD	To Midmar catchment from Mearns Weir	50	50.00	0
Transfers originating in Mvoti-Mzimkhulu WMA							
T40E	T40F	SRD	SRU	Mtamvuma River abstraction	2.01	0.71	0
T40E	T40F	SRD	SSU	Abstraction from the Mtamvuma river for Port Edward: Refer to Southern Natal catchment study	2.3	0.81	0
T51C	T51D	SRD	SSU	Run of river abstraction from the Mzimkulu river for Himeville: refer to southern KZN catchment study	0.2	0.12	0
T52D	T52C	SRD	SSU	Run of Umzimkulu river and Dam abstraction for Umzimkulu: refer to the southern KZN catchment study	0.2	0.20	0
T52L	T40G	SRD	SSU	Abstraction from the Mzimkhulwana river for Port shepstone: Refer to the Southern KZN catchment study	9.5	9.50	0
T52L	T52M	SRD	SSU	Mkimkulwana river for Margate	5.77	0.00	0
T52L	U80D	SRD	SSU	Abstraction from the Mzimkhulwana river for Hibberdene : Refer to the Southern KZN catchment study	0.3	0.30	0
U10M	U80L	SRD	SSU	Mkomaas abstraction from the Mkomazi river - southern KZN study	0.77	0.77	0
U20C	U20F	SRD	SSU	Midmar dam to New Hanover / Cool Air	0.3	0.30	0
U20C	U20E	SRD	SSU	Midmar Dam to Howick: Piped flow	3.2	1.91	0
U20C	U20G	SRD	SSU	Midmar dam to Albert Fall and Wartberg	0.1	0.10	0
U20C	U20H	SRD	SRU	Midmar dam to Vulindlela	0	0.00	0
U20C	U20J	SRD	SSU	Midmar dam for PMB: Refer to Umgeni S	32.6	32.60	0
U20C	U60F	SRD	SSU	Midmar dam to Durban: Refer to Umgeni S	2.9	2.90	0
U20G	U60F	SRD	SSU	Nagle dam for Durban: UW Board data	182.5	182.50	0
U20L	U60F	SRD	SSU	Inanda Dam for Durban: UW Board data	81.4	81.40	0
U30A	U30E	SRD	SSU	Hazlemere Dam to Ballito and Groutville	1.52	1.52	0
U30A	U40J	SRD	SSU	Hazelmere Dam to Stanger	0.08	0.08	0
U30A	U60F	SRD	SSU	Hazelmere dam for Durban: UW Board data	4.3	4.30	0
U30A	U30D	SRD	SSO	Tongaat Huletts (Maidstone) abstraction from the Mdloti river	0.64	0.64	0
U60F	U60C	URF	SRD	Mpumulanga to Mlazi River - Major Urban return flows	1.314	1.18	0.1
U60F	U20M	URF	SRD	Kwa Mashu to Mgeni Estuary	10.95	9.86	0.1
U60F	U60D	URF	SRD	J Ponds to Mlazi Estuary	0.365	0.33	0.1
U60F	U60D	URF	SRD	Dassenhoek to Mlazi River (at intake Umlaas wks) - Major Urban return flows	0.073	0.07	0.1

From	To	From Sector*	To Sector*	Description	Max million m^3/a	Actual million m^3/a	Losses million m^3/a
U60F	U60D	URF	SRD	Kwa Ndengezi to Mlazi River (at intake Umlaas wks) - Major Urban return flows	0.438	0.39	0.1
U60F	U60C	URF	SRD	Hammersdale to Sterkspruit River - Major Urban return flows	3.65	3.29	0.1
U60F	U20M	URF	SRD	Durban North to Mgeni Estuary	13.14	11.83	0.1
U70D	U60F	SRD	SSU	Nungwane dam fro Durban (Amanzimtoti): Umgeni SA reports 1994 & 1998	5.9	5.90	0
U80F	U80G	SRD	SSU	Run of river abstraction from the Mtwalume river for Ifafa	0.4	0.00	0
U80F	U80H	SRD	SSU	Run of river abstraction for Sezela from the Mtwalume river : refer to Southern KZN catchments study 1995	0.4	0.40	0
U80G	U80H	SRD	SSO	Run of River abstraction from Ifafa river for CG Smith at Sezela: Refer southern KZN catchment study 1995	0.6	0.60	0

*URF - Effluent from urban areas
SRD - Transfers to rivers
SSB - Strategic bulk water user
SSM - Mine bulk user
SSO - Other bulk water users
SSU - Direct urban water user

APPENDIX F

WATER RESOURCES

DETAILED INFORMATION ON GROUNDWATER

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 quarternary catchment was taken from the WSAM and multiplied by 45 P/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 quarternary 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).

Total Use

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.

TOTAL DISSOLVED SOLIDS (TDS) IN EACH QUATERNARY

METHODOLOGY TO ESTIMATE THE TDS CONCENTRATION IN THE NATURAL RUNOFF

The following assumptions were made:

1. The TDS concentration in the natural runoff forms the baseline for TDS mass balance calculations. The other water quality input parameters, such as increase in TDS by bulk use etc., are then added to the TDS in the natural runoff.
2. The TDS concentration in the natural, unimpacted runoff is the same across the whole of a tertiary catchment. There are no spatial differences in TDS in natural runoff in different parts of a tertiary catchment.
3. It was assumed that the sampling points in the headwaters of a catchment were probably natural of largely unimpacted by manmade activities. These sampling points were taken to represent the TDS concentrations of natural runoff. In some catchments like the Mkuze catchment, sampling points in the headwaters had much higher median TDS concentrations and it was known that acid mine drainage had a large negative impact on water quality in the catchment.

The TDS concentration in the natural runoff was estimated as follows:

1. The study area was divided into tertiary catchments because very few monitoring stations could be found at a quaternary scale which could be regarded as mostly natural.
2. For each tertiary catchment, the most upstream monitoring points were identified.
3. The mean, median and number of TDS observations at the selected sampling points were then calculated.
4. The mean/median concentrations were then compared to each other to provide a guide for the range of natural or largely unimpacted TDS concentrations in that tertiary catchment.
5. As a rule, the sampling station with the lowest median TDS concentrations and a fair data record (> 100 observations) was selected to represent the natural runoff TDS concentration in a tertiary.
6. It was found that the median natural TDS concentrations varied between about 40 - 70 mg/l TDS and rarely exceeded 100 mg/l.
7. If there were no sampling points in the headwaters of a tertiary catchment, the natural TDS concentration of an adjacent catchment was used.

Some exceptions to the rule:

1. When the median TDS concentration in the headwater sampling point exceeded 100 mg/l, other sampling points in the catchment were also examined to determine whether the sampling point was a true reflection of unimpacted conditions in the catchment. The Mhlatuze catchment is an example where TDS concentrations all exceed 100 mg/l.
2. In some catchments, the headwater sampling points were affected by coal mining activities. Some of the sampling points in the headwaters of the Mfolozi River (Vryheid area), the Buffalo River (Newcastle area) and the Mkuze River clearly showed elevated TDS concentrations. These sampling points were not considered as largely natural and discarded for the analysis.

NATURAL SURFACE WATER RUNOFF TDS SAMPLING STATIONS

Tertiary catchment	Natural runoff TDS (mg/l)	Station used	Station	Number samples	First sample	Last sample
T40	66	T4H001Q01	MTAMVUNA RIVER AT GUNDRIFT/MTAMVUNA	368	Sep-71	Feb-98
T51	44	T5H003Q01	POLELA RIVER AT COXHILL/HIMEVILLE	418	Nov-76	Feb-98
T52	44	T5H003Q01	POLELA RIVER AT COXHILL/HIMEVILLE	418	Nov-76	Feb-98
U10	56	U1H005Q01	MKOMAZI RIVER AT LOT 931821/CAMDEN	474	Dec-76	Feb-98
U20	47	U2H006Q01	KARKLOOF RIVER AT SHAFTON	793	Jan-70	Aug-95
U30	83	U3H001Q01	TONGATI RIVER AT RIET KUIL	367	Nov-71	Nov-92
U40	72	U4H002Q01	MVOTI RIVER AT MISTLEY	393	Jun-77	Feb-98
U50	53	U7H007Q01	LOVU RIVER AT BEAULIEU ESTATE	512	Jan-77	Feb-98
U60	58	U6H002Q01	MLAZE RIVER AT NOOITGEDACHT	345	Mar-80	Feb-98
U70	53	U7H007Q01	LOVU RIVER AT BEAULIEU ESTATE	512	Jan-77	Feb-98
U80	161	U8H001Q01	FAFA RIVER AT COWICK/NEVER DESPAIR	104	Nov-86	Feb-98

SURFACE WATER TDS VALUES AND FINAL WATER CLASS

Quat.	Station	TDS - MAX	TDS - AVG	Maximum value class	Average value class	Water Class (Colour)
T40A	T4H001	105	78	Blue	Blue	Purple
T40B	T4H001	105	78	Blue	Blue	Blue
T40C	T4H001	105	78	Blue	Blue	Blue
T40D	T4H001	105	78	Blue	Blue	Blue
T40E	T4H001	105	78	Blue	Blue	Blue
T40F	-	-	-			
T40G	-	-	-			
T51A	T5H004	83	54	Blue	Blue	Blue
T51B	T5H004	83	54	Blue	Blue	Blue
T51C	T5H003	78	54	Blue	Blue	Blue
T51D	T5H003	78	54	Blue	Blue	Blue
T51E	T5H003	78	54	Blue	Blue	Blue
T51F	T5H004	83	54	Blue	Blue	Blue
T51G	T5H004	83	54	Blue	Blue	Blue
T51H	-					
T51J	-					
T52A	-	-	-			
T52B	-	-	-			
T52C	-	-	-			
T52D	-	-	-			
T52E	-	-	-			
T52F	-	-	-			
T52G	-	-	-			
T52H	-	-	-			
T52J	-	-	-			
T52K	T5H012	328	226	Green	Blue	Green
T52L	-	-	-			
T52M	-	-	-			
U10A	U1H005	128	70	Blue	Blue	Blue
U10B	U1H005	128	70	Blue	Blue	Blue
U10C	U1H005	128	70	Blue	Blue	Blue
U10D	U1H005	128	70	Blue	Blue	Blue
U10E	U1H005	128	70	Blue	Blue	Blue
U10F	U1H005	128	70	Blue	Blue	Blue
U10G	U1H005	128	70	Blue	Blue	Blue
U10H	U1H005	128	70	Blue	Blue	Blue
U10J	-	-	-			
U10K	-	-	-			
U10L	-	-	-			
U10M	U1H006	385	129	Green	Blue	Green
U20A	-					Blue
U20B	-	-	-			
U20C	-	-	-			
U20D	-	-	-			
U20E	-	-	-			
U20F	-	-	-			
U20G	-	-	-			
U20H	-	-	-			
U20J	-	-	-			
U20K	-	-	-			
U20L	-	-	-			
U20M	-	-	-			
U30A	-	-	-			
U30B	-	-	-			
U30C	U3H001	104	83	Blue	Blue	Blue
U30D	-	-	-			

Quat.	Station	TDS - MAX	TDS - AVG	Maximum value class	Average value class	Water Class (Colour)
U30E	-	-	-			
U40A	U4H002	161	87	Blue	Blue	Blue
U40B	U4H002	161	87	Blue	Blue	Blue
U40C	U4H002	161	87	Blue	Blue	Blue
U40D	-	-	-			
U40E	-	-	-			
U40F	-	-	-			
U40G	-	-	-			
U40H	-	-	-			
U40J	-	-	-			
U50A	-	-	-			
U60A	U6H002	251	76	Blue	Blue	Blue
U60B	U6H003	465	292	Green	Green	Green
U60C	-	-	-			
U60D	-	-	-			
U60E	-	-	-			
U60F	-	-	-			
U70A	-	-	-			
U70B	-	-	-			
U70C	-	-	-			
U70D	-	-	-			
U70E	U7R001	796	333	Yellow	Green	Yellow
U70F	-	-	-			
U80A	-	-	-			
U80B	-	-	-			
U80C	-	-	-			
U80D	-	-	-			
U80E	U8H002	187	150	Blue	Blue	Blue
U80F	U8H002	187	150	Blue	Blue	Blue
U80G	U8H001	226	169	Blue	Blue	Blue
U80H	U8R001	397	281	Green	Green	Green
U80J	U8H003	634	421	Yellow	Green	Yellow
U80K	U8H003	634	421	Yellow	Green	Yellow
U80L	-	-	-			

SEDIMENT YIELDS

Quat	Sedimentation tonnes/a	Sediment after 25 yrs 10^6 m^3	Quat	Sedimentation tonnes/a	Sediment after 25 yrs 10^6 m^3
T40A	38 500	0.71	U20C	43 000	0.80
T40B	51 400	0.95	U20D	36 000	0.67
T40C	43 900	0.81	U20E	30 000	0.56
T40D	68 700	1.27	U20F	41 000	0.76
T40E	89 700	1.66	U20G	74 000	1.37
T40F	62 000	1.15	U20H	34 000	0.63
T40G	55 000	1.02	U20J	123 000	2.28
T51A	61 000	1.13	U20K	50 000	0.93
T51B	39 000	0.72	U20L	73 000	1.35
T51C	85 000	1.57	U20M	80 000	1.48
T51D	26 000	0.48	U30A	81 000	1.50
T51E	47 000	0.87	U30B	49 000	0.91
T51F	57 000	1.06	U30C	53 000	0.98
T51G	47 000	0.87	U30D	40 000	0.74
T51H	96 000	1.78	U30E	58 000	1.07
T51J	49 000	0.91	U40A	16 000	0.30
T52A	71 000	1.31	U40B	20 000	0.37
T52B	47 000	0.87	U40C	20 000	0.37
T52C	48 000	0.89	U40D	45 000	0.83
T52D	98 000	1.81	U40E	63 000	1.17
T52E	43 000	0.80	U40F	39 000	0.72
T52F	77 000	1.43	U40G	50 000	0.93
T52G	41 000	0.76	U40H	67 000	1.24
T52H	64 000	1.19	U40J	46 000	0.85
T52J	68 000	1.26	U50A	46 000	0.85
T52K	79 000	1.46	U60A	16 000	0.30
T52L	33 000	0.61	U60B	59 000	1.09
T52M	58 000	1.07	U60C	80 000	1.48
U10A	65 000	1.20	U60D	41 000	0.76
U10B	61 000	1.13	U60E	52 000	0.96
U10C	41 000	0.76	U60F	61 000	1.13
U10D	52 000	0.96	U70A	18 000	0.33
U10E	51 000	0.94	U70B	58 000	1.07
U10F	59 000	1.09	U70C	55 000	1.02
U10G	55 000	1.02	U70D	32 000	0.59
U10H	71 000	1.31	U70E	19 000	0.35
U10J	78 000	1.44	U70F	13 000	0.24
U10K	56 000	1.04	U80A	35 000	0.65
U10L	54 000	1.00	U80B	60 000	1.11
U10M	53 000	0.98	U80C	42 000	0.78
U20A	45 000	0.83	U80D	27 000	0.50
U20B	53 000	0.98	U80E	73 000	1.35
U80F	31 000	0.57	U80J	72 000	1.33
U80G	53 000	0.98	U80K	39 000	0.72
U80H	54 000	1.00	U80L	24 000	0.44

APPENDIX G

DETAILS OF THE MICROBIOLOGICAL WATER QUALITY STUDY

WATER RESOURCES SITUATION ASSESSMENTS

DEPARTMENT: WATER AFFAIRS & FORESTRY
DIRECTORATE: WATER RESOURCE PLANNING

POTENTIAL VULNERABILITY OF SURFACE WATER & GROUNDWATER TO MICROBIAL CONTAMINATION

AUGUST 2001

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SUMMARY

This report forms part of the Water Resources Situation Assessments undertaken for the Department of Water Affairs and Forestry. Information is provided on the potential microbial contamination of surface water and groundwater resources in South Africa.

For surface water, initial mapping information was taken from the National Microbiological Monitoring Program where priority contaminated areas were identified and mapped. As part of this project, it was necessary to produce a surface contamination map for the whole country. A national surface faecal contamination map was produced using population density and sanitation type available from DWAF databases. A three category rating system was used (low, medium and high) to describe the surface faecal contamination. This information was delineated on a quaternary catchment basis for the whole country.

For groundwater, the first step involved the development of a groundwater vulnerability map using the depth to groundwater, soil media and impact of the vadose zone media. A three category rating system was used (least, moderate, most) to describe the ease with which groundwater could be contaminated from a source on the surface. The second step involved using the surface contamination and aquifer vulnerability maps to derive a groundwater contamination map. The derived map shows the degree of faecal contamination that could be expected of the groundwater for all areas in South Africa.

Conclusions and recommendations

- Maps were produced that provide an overall assessment of potential microbial contamination of the surface water and groundwater resources of South Africa.

- Spatial resolution of the maps is based on a quaternary catchment scale. It is recommended that these maps are not used to derive more detailed spatial information.

- Once sufficient microbial data are available, it is recommended that the numerical methods, and their associated assumptions, be checked, and the maps replotted where necessary.

CONTENTS LIST

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.

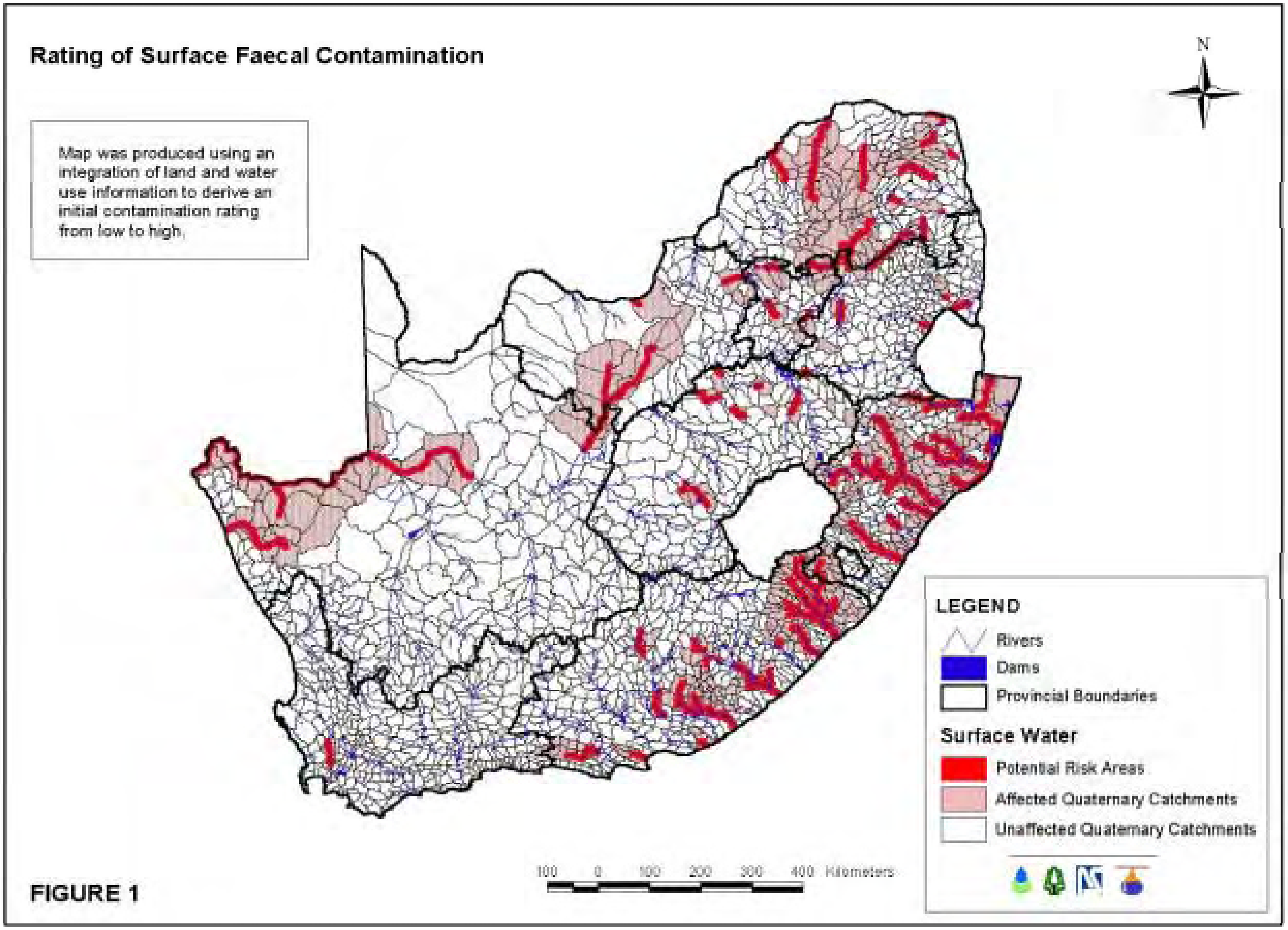

Figure 1: Rating of surface faecal contamination

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).

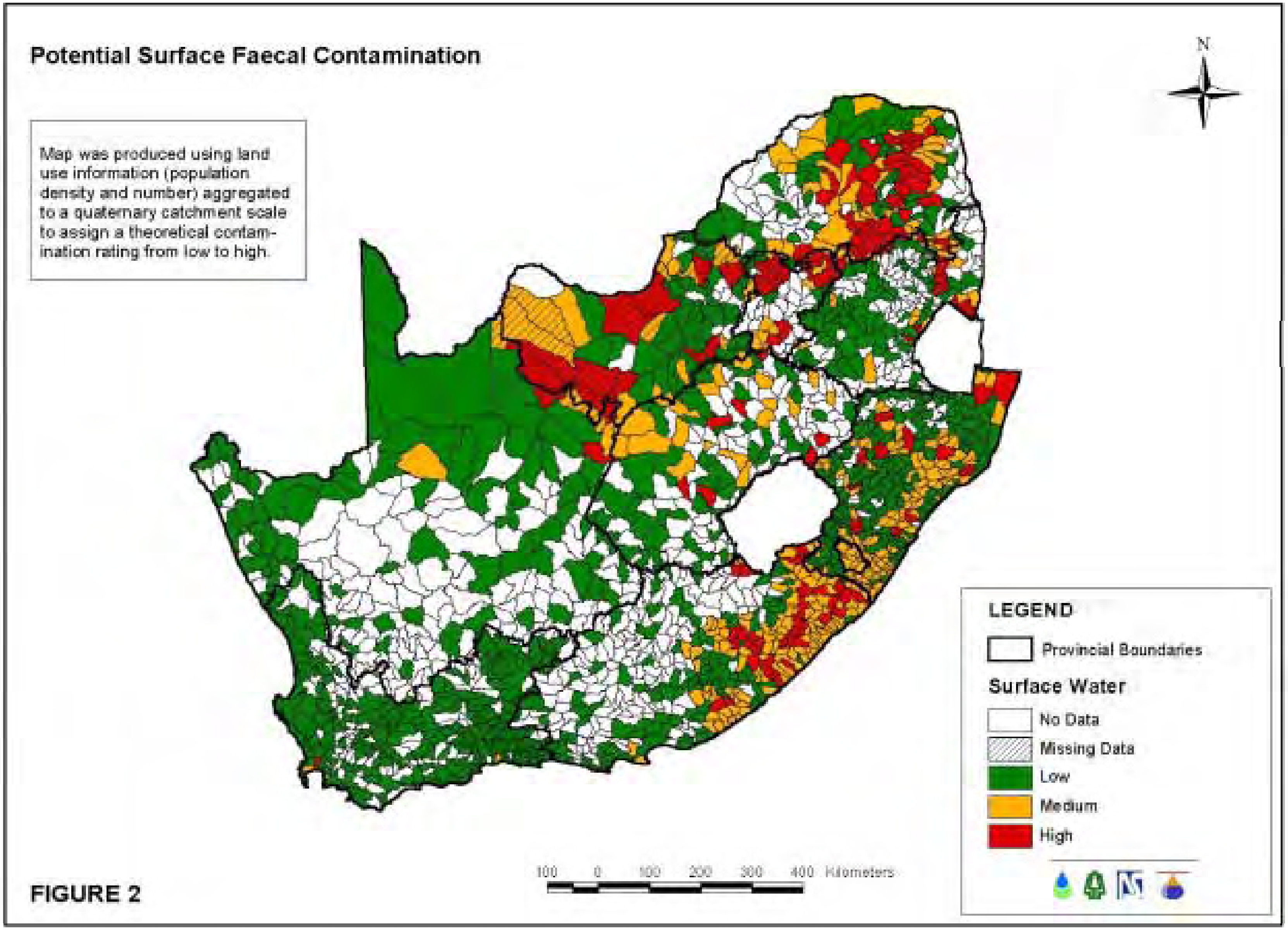

Figure 2: Potential surface faecal contamination

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.

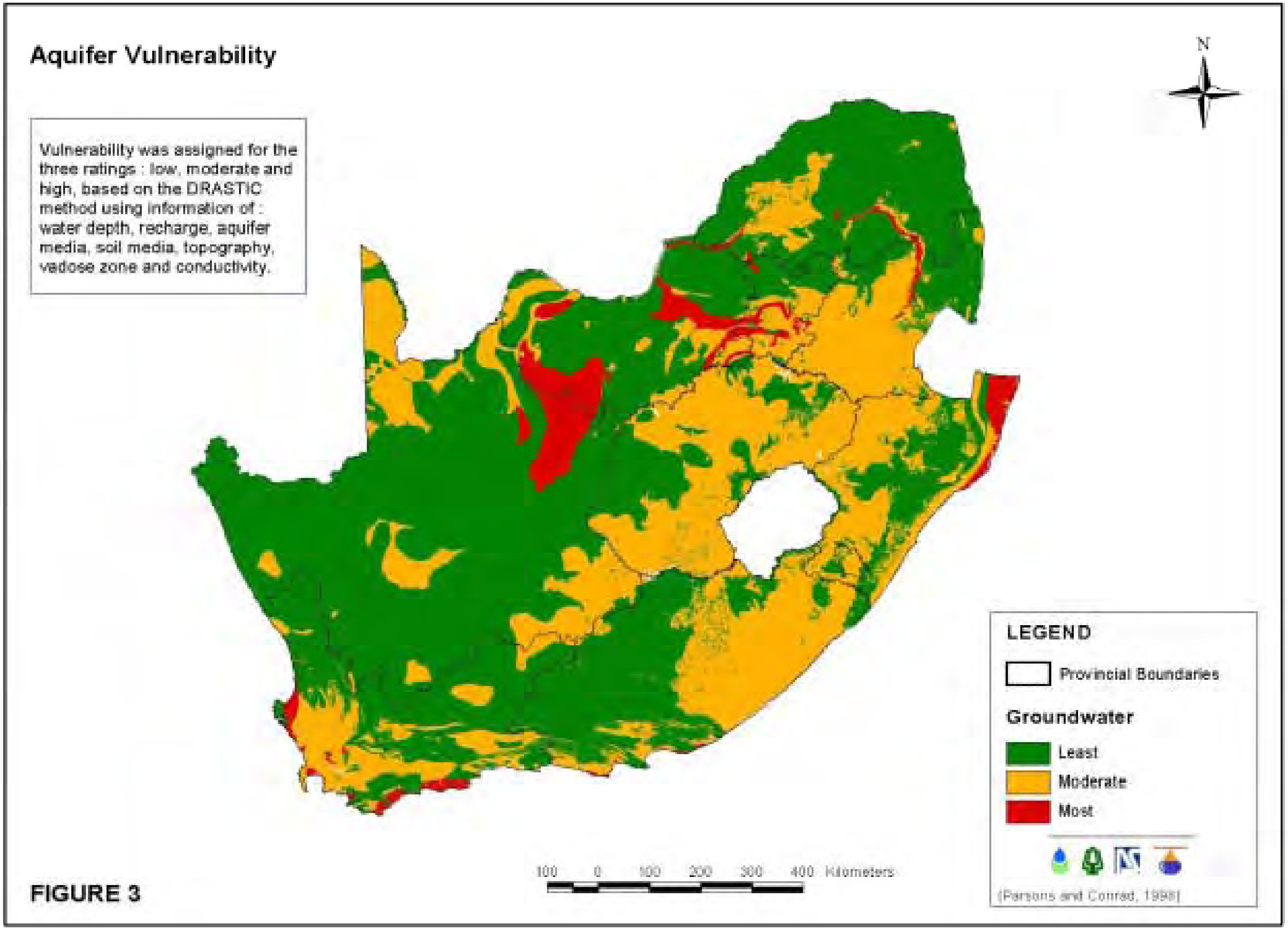

Figure 3: Aquifer vulnerability

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).

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.

[1] A similar approach was used by Xu & Braune (1995) where they used the factors D, A and S, and used the weightings assigned by DRASTIC and not Pesticide DRASTIC.

3.3 Aquifer vulnerability map

Three DRASTIC groundwater coverages were used to produce an indication of vulnerability of groundwater contamination, namely, depth to groundwater, soil media and vadose.

Each grid element on the DRASTIC coverages was allocated a rating, that was multiplied by a weighting factor (Depth = 5, Soil = 5, Vadose = 4) to produce a score. These three coverages were intersected and their scores added to produce a relative index for each point on the resulting coverage. An additional assumption was applied that assigned a low vulnerability to all areas with a Depth score of less than or equal to 2. This was used to account for deep infiltration of groundwater (over 35 metres) where long residence time and filtration will reduce the degree of contamination.

The relative index (RI) obtained for each grid allowed for grouping into high, medium and low categories. However, setting the intervals for the three categories proved difficult because of sensitivity to the interval chosen. A large percentage of indices fell in the interval of 60 to 80. It was thus decided to use the interval of 70 to 85 to allow for equal distribution between high, medium and low vulnerability areas (see Figure 4), namely:

Low	Green	$RI < 70$	
Medium	Yellow	$70 < RI < 85$	
High	Red	$RI > 85$	.... (9)

To illustrate the sensitivity to the interval chosen the map was replotted using two further intervals of 60-90 and 65-90 (see Figure 5).

Because of attenuation mechanisms that control microbial contamination entering the subsurface, it was considered conceptually correct to only consider D, S and I. Comparison of Figures 3 and 4 shows remarkable similarity and confirms that the vulnerability *per se* is largely controlled by the three factors (D, S and I), which promotes confidence in the resultant microbial contamination vulnerability map.

A limitation of the study is the inability to validate results obtained. Little information is available regarding groundwater microbial contamination. Monitoring data, from selected areas, should be collected to assess the validity of the vulnerability assessment presented in this report.

3.4 Groundwater faecal contamination

Figure 2 (*Potential Surface Faecal Contamination)* and Figure 4 (*Aquifer vulnerability to Faecal Contamination)* maps were intersected to produce a combined *Risk of Faecal Contamination of Aquifers* map on a quaternary basis, see Figure 6.

A total rating score was calculated for each quaternary (e.g. two medium risk areas and one high risk area gives 2 + 2 + 3). This total was then divided by the total number of different risk areas present in each quaternary to produce an average risk value. Each quaternary catchment was shaded according to this average risk value.

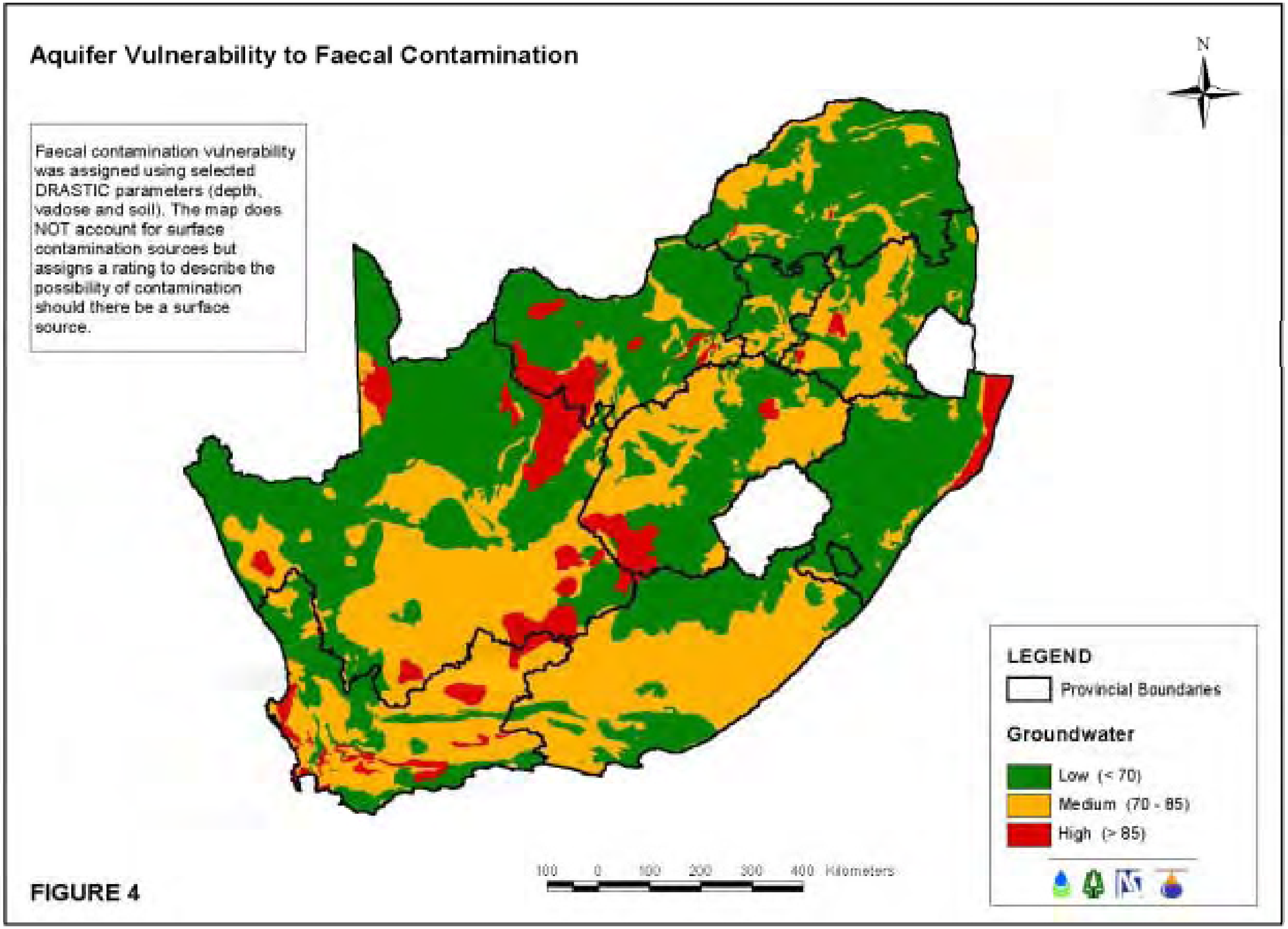

Figure 4: Aquifer vulnerability to faecal contamination

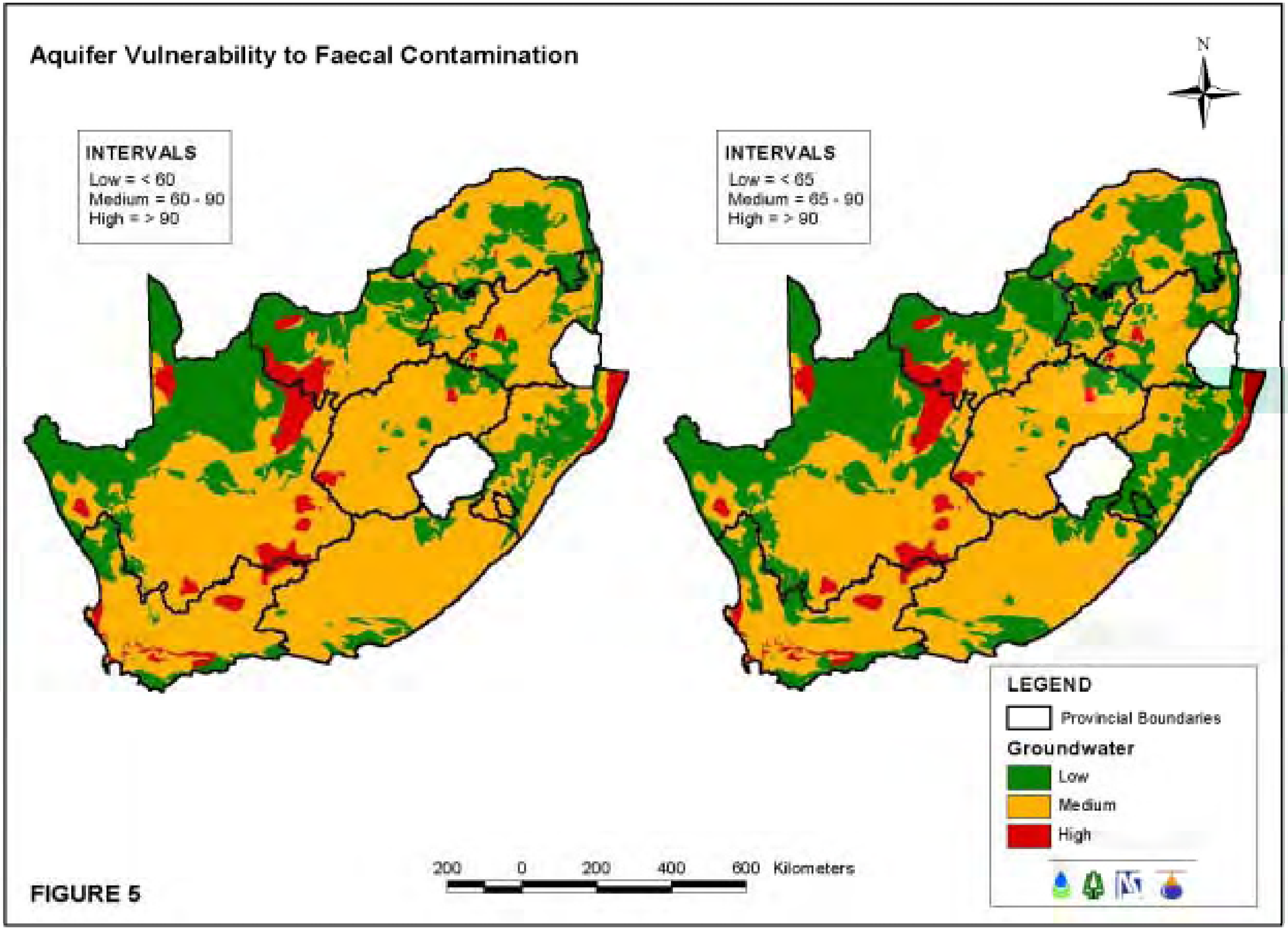

Figure 5: Aquifer vulnerability to faecal contamination

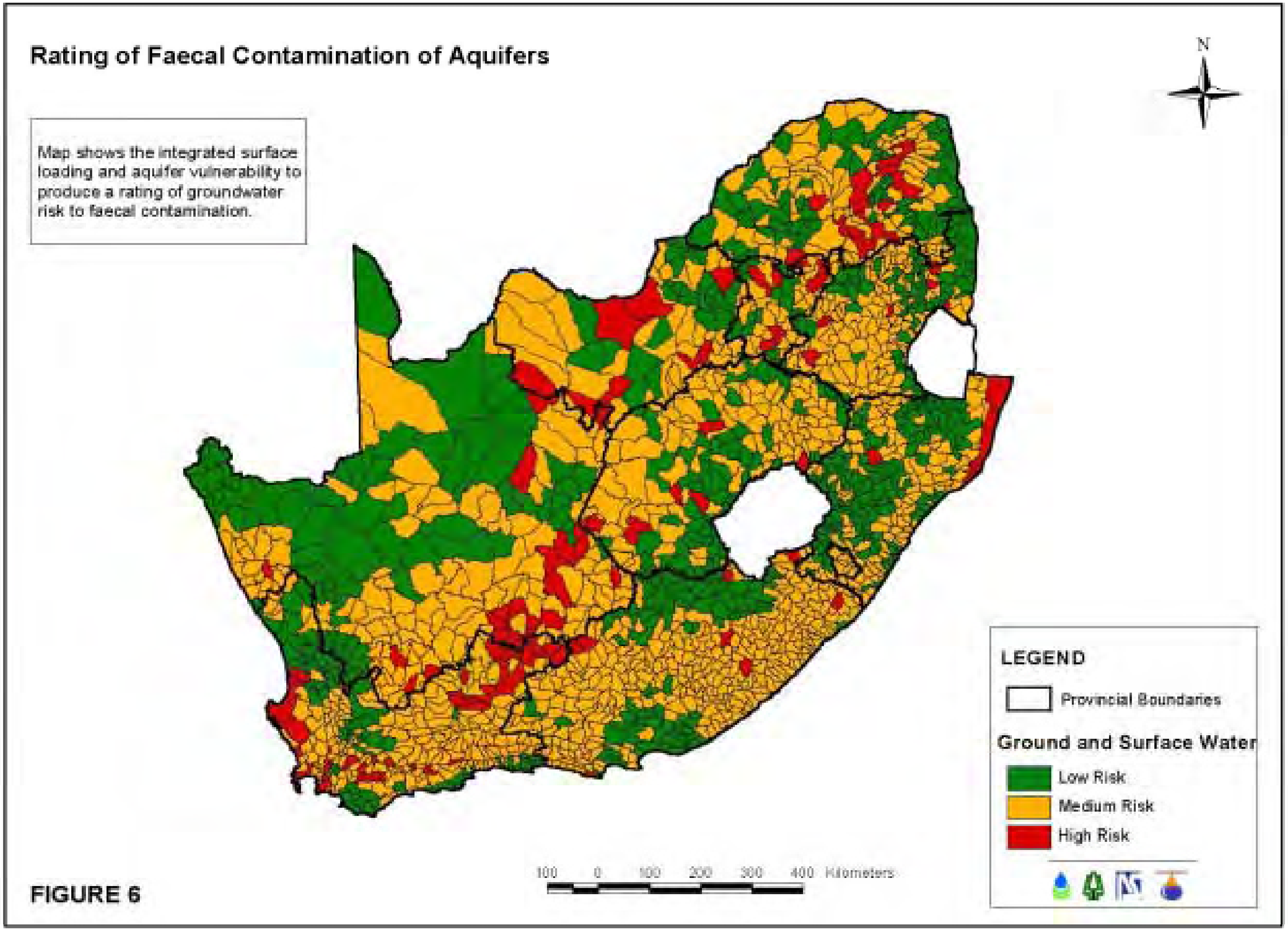

Figure 6: Rating of faecal contamination of aquifers

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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APPENDIX H

WATER BALANCE

LISTS OF ORGANISATIONS RESPONSIBLE FOR THE VARIOUS COMPONENTS OF THE DATA

Data type	Responsible organisation
Afforestation	CSIR
Alien vegetation	CSIR
Industrial, urban and strategic water use	WRSA consultants
Ground Water	WSM Consulting Engineers
Dams	DWAF
Transfer schemes	WRSA consultants
Run-of-river yields	Arcus Gibb
Population	Markdata
Ecological Reserve	IWR, Prof Hughes
Irrigation - Areas and crop types - Efficiency and losses - Evapotraspiration and crop factors	 WRSA consultant WRSA consultant WRP
Storage-draft-frequency curves	WRP

PARAMETERS FOR WHICH WSAM DID NOT AGGREGATE KEY AREA DATA CORRECTLY, AND THEIR DEFAULT VALUES

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
iIPMi	Irrigation efficiency – Medium category irrigation (factor)	0.75
iIPHi	Irrigation efficiency – High category irrigation (factor)	0.75
oRTLi	Rural losses (factor)	0.2

LIST OF PARAMETERS IN THE WATER BALANCE AND THE DEFAULT VALUES

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
AAAAi	Area under alien vegetation	N/A	<ATC	0	km^2
AARPi	Alien vegetation - Riparian proportion	0.1?	1	0	factor
ACAUi	Area under dry-land sugar cane	N/A	<ATC	0	km^2
ADMAi	Full supply area of major dams	N/A	352	0	km^2
ADMIi	Full supply area of minor dams	N/A	50	0	km^2
aDOFi	Area of off-channel storage dam	N/A	150	0	km^2
aFCAi	Area under afforestation	N/A	<ATC	0	km^2
aFINi	Indigenous forest area	N/A	<ATC	0	km^2
aFRPi	Afforestation - Riparian proportion	0	1	0	factor
aIHAi	Area under high categories of irrigation	N/A	<ATC	0	km^2
aILAi	Area under low categories of irrigation	N/A	<ATC	0	km^2
aIMAi	Area under medium categories of irrigation	N/A	<ATC	0	km^2
aISAi	**Estimated field area**	N/A	<ATC	0	km^2
aMTCi	Area of subcatchment (Gross)	N/A	110000	0	km^2
aNAEi	Urban area	N/A	400	0	km^2
cEDCo	Default ecological management class index	2.1	4.1	1.1	class index
cEMCo	Environmental management class	2.1	4.1	1.1	class index
cEPCo	Present ecological status class index	2.1	4.1	1.1	class index

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
cESCo	Suggested ecological management class index	2.1	4.1	1.1	class index
cGWSo	Groundwater supply before imports and exports				million m^3/a
cIQCo	Check to indicate if the irrigation requirement is greater than the quota				Boolean
dLRLo	River losses				million m^3/a
dMRTo	Accumulated MAR at catchment outlet for disturbed flow				million m^3/a
dYCTo	Total cumulative yield in quat				million m^3/a
dYDMo	Yield of major dams before abstractions and releases				million m^3/a
dYISo	Incremental gross yield for streamflow reduction activities				million m^3/a
dYUPo	Incremental yield from upstream catchments-Virgin flow				million m^3/a
eMRTo	**Accumulated natural MAR at catchment outlet**				million m^3/a
fBMFi	Return flow factor as a proportion of oBMRi	0.2	0.7	0	factor
fBMLi	Mining water losses as a proportion of oBMRi	0.1	0.2	0.01	factor
fBOFi	Return flow factor as a proportion of oBORi	0.2	0.7	0	factor
fBOLi	Other bulk water losses as a proportion of oBORi	0.1	0.3	0.01	factor
fBSFi	Return flow as a proportion of oBSRi	0	0.6	0	factor
fBSLi	Strategic bulk water losses as a proportion of oBSRi	0.05	0.2	0.01	factor
fDDAi	Dead storage as a proportion of full supply volume	0.05	0.5	0	factor
fDIQi	Factor to reduce infow to minor dams due to locality of dams	0.5	1	0	factor
fDMIi	Minor dam influence - 0:none; 1:increasing yield	0.5	0.9	0.1	factor
fDMQi	Factor to reduce infow to major dams due to locality of dams	1	1	0	factor
fEDRi	Default IFR as a percentage of MRT	N/A	80	0	%
fEERi	Total estuarine flow requirement as a percentage of MRT	N/A	80	0	%
fEIYo	1:50 year IFR requirement factor				%
fENDi	Endoreic catchment area	N/A	<ATC	0	km^2
fEPMi	Total IFR as a percentage of MRT	N/A	60	0	%
fEPRi	Present IFR as a percentage of MRT	N/A	60	0	%
fEREi	Weather modification runoff enhancement as a proportion of MAR	0	0	0	factor
fESRi	Suggested IFR as a percentage of MRT	N/A	60	0	%
fEURo	Proportion of demand upstream of the IFR check	1	1	0	factor
fGBDo	Groundwater factor (influence of groundwater supply on surface runoff)				factor
fGBFi	Baseflow as a proportion of MAR	N/A	0.6	0	factor
fGCCi	Factor to correct data for inadequacies in borehole census	1	1	0.5	factor
fGECi	Coefficient to convert harvest potential to exploitable potential	0.5	0.8	0.3	factor
fGIQi	Portion of boreholes with irrigable water	1	1	0	factor
fGPQi	Portion of boreholes with potable water	0.5	1	0	factor

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
fGUQo	Portion of boreholes with useable water quality	N/A	1	0	factor
fHEYi	Proportion of hydropower releases not contributing to IFR demand	0.1	1	0	factor
fHPWi	Proportion of water released not of benefit to d/s users	0.1	1	0	factor
fIFHi	Irrigation return flow parameter for high category irrigation	0.3?	0.7	0.25	factor
fIFLi	Irrigation return flow parameter for low category irrigation	0.3?	0.7	0.25	factor
fIFMi	Irrigation return flow parameter for medium category irrigation	0.3?	0.7	0.25	factor
fIFPi	Irrigation return flow parameter	**0.3**	0.6	**0.25**	factor
fIHCi	Conveyance loss factor to field edge - high category of irrigation	0.1?	0.5	0	factor
fIHEi	Crop factor for Penman Monteith data conversion for high category crops	0.6	1	0.3	factor
fIHLi	Leaching requirements factor for high categories of irrigation	1	1.2	1	factor
fILCi	Conveyance loss factor to field edge - low category of irrigation	0.1?	0.5	0	factor
fILEi	Crop factor for Penman Monteith data conversion for low category crops	0.6	1	0.3	factor
fILLi	Leaching requirements factor for low categories of irrigation	1	1.2	1	factor
fIMCi	Conveyance loss factor to field edge - medium category of irrigation	0.1?	0.5	0	factor
fIMEi	Crop factor for Penman Monteith data conversion for medium category crops	0.6	1	0.3	factor
fIMLi	Leaching requirements factor for medium categories of irrigation	1	1.2	1	factor
fIPHi	Application efficiency factor for high categories of irrigation	0.75	0.9	0.5	factor
fIPLi	Application efficiency factor for low categories of irrigation	0.75	0.9	0.5	factor
fIPMi	Application efficiency factor for medium categories of irrigation	0.75	0.9	0.5	factor
fITFo	Irrigation return flow as a portion of the total irrigation requirement				factor
fLRLi	River loss factor to adjust for 1:50 year conditions	0.7	1	0.5	factor
fLSCi	Loss sensitivity factor	**1**	**1**	**0**	factor
fNUCi	Runoff coefficient for paved areas	0.84	1	0	factor
fNUIi	Proportion of urban area impervious	0.125	1	0	factor
fQRUi	Re-use coefficient	0	1	0	factor
fRCUi	Rural Collective Consumptive Coefficient	1	1	0	factor
fRDIi	Dry Drought IFR Factor	0.01	0.1	0	factor
fRRIi	Drought IFR Factor	0.05	0.2	0	factor
fRSIi	Proportion of rural population dependent on subsistence irrigation	N/A	0.6	0	factor
fSMAi	Conversion Factor for average major dam area over the critical period	0.66	1	0	factor
fSMIi	Conversion Factor for average minor dam area over the critical period	1	1	0	factor
fSOFi	Conversion Factor for average off-channel dam area over the critical period	0.66	1	0	factor
fUBLi	Urban bulk transport loss as a proportion of gUTRo	0.05	0.3	0.01	factor
fUCSi	Portion of clean return flow reaching the	0	0.1	0	factor

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
	river system				
fUDLi	Urban distribution loss as a proportion of gUTRo	0.2	0.5	0.05	factor
fUL1i	Proportion of use in serviced housing [1] not contributing to effluent/sewage	0.45	1	0.1	factor
fUL2i	Proportion of use in serviced housing [2] not contributing to effluent/sewage	0.2	1	0.1	factor
fUL3i	Proportion of use in serviced housing [3] not contributing to effluent/sewage	0.35	1	0.1	factor
fUL4i	Proportion of use in serviced housing [4] not contributing to effluent/sewage	0.8	1	0.1	factor
fUL5i	Proportion of use in serviced housing [5] not contributing to effluent/sewage	1	1	0.8	factor
fUL6i	Proportion of use in serviced housing [6] not contributing to effluent/sewage	1	1	0.8	factor
fUL7i	Proportion of use in serviced housing [7] not contributing to effluent/sewage	**1?**	1	0.1	factor
fULIi	Proportion of indirect water use not contributing to effluent/sewage	0.35	1	0.1	factor
fUP1i	Proportion of urban population in serviced housing [1]	0.21	1	0	factor
fUP2i	Proportion of urban population in serviced housing [2]	0.09	1	0	factor
fUP3i	Proportion of urban population in serviced housing [3]	0.27	1	0	factor
fUP4i	Proportion of urban population in serviced housing [4]	0.26	1	0	factor
fUP5i	Proportion of urban population in serviced housing [5]	0.1	1	0	factor
fUP6i	Proportion of urban population in serviced housing [6]	0.05	1	0	factor
fUP7i	Proportion of urban population in serviced housing [7]	0.02	1	0	factor
fURPi	Proportion of urban return flow exported to other catchment	0	1	0	factor
fXEUo	Portion of water transferred that is available to IFR				factor
fY05i	1:5 assurance factor	1.25	2	1	factor
fY10i	1:10 assurance factor	1.25	2	1	factor
fY20i	1:20 assurance factor	1.125	1.5	1	factor
fY50i	1:2 assurance factor	1.25	2	1	factor
fYC1i	1:100 assurance factor	0.93	1	0.8	factor
fYCAi	Constant describing the storage-yield curve	8.5	30	0.5	factor
fYCBi	Constant describing the storage-yield curve	0.4	0.8	0.2	factor
fYCCi	Constant describing the storage-yield curve	2	50	0	factor
fYD1i	1:1000 000 assurance factor	0.65	0.8	0.5	factor
fYD2i	1:500 assurance factor	0.78	0.9	0.7	factor
fYD5i	1:200 assurance factor	0.87	1	0.7	factor
fYMAi	constant describing the storage yield curve for minor dams	9	50	0.5	factor
fYMBi	exponent describing the storage yield curve for minor dams	0.4	0.7	0.1	factor
fYMCi	constant describing the storage yield curve for minor dams	0	0	0	factor
fYRAi	Lowest average monthly flow based on lowest three consecutive months	N/A	0.7*MAR	0	million m^3/a
gBDRi	Low flow proportion for bulk users	0.33	0.5	0.2	factor

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
gBMRo	Mine bulk water use including losses - Gross				million m^3/a
gBORo	Other bulk water use including losses - Gross				million m^3/a
gBSRo	Strategic bulk water use including losses - Gross				million m^3/a
gGHPi	Harvest potential	N/A	700	0	million m^3/a
gIAAi	Gross actual irrigation supply before assurance	N/A	300	0	million m^3/a
gIARo	Gross actual irrigation use after assurance				million m^3/a
gIDHi	Low flow proportion for high irrigation crops	0.4?	1	0	factor
gIDLi	Low flow proportion for low irrigation crops	0.3?	1	0	factor
gIDMi	Low flow proportion for medium irrigation crops	0.4?	1	0	factor
gIHRo	Irrigation use by high value crops for 1:50 year assurance				million m^3/a
gILMo	Irrigation use by medium value crops for 1:50 year assurance				million m^3/a
gILRo	Irrigation use by low value crops for 1:50 year assurance				million m^3/a
gIQRo	Irrigation quota volume (1:50)				million m^3/a
gRCRo	1:50 year per capita rural water use				l/c/d
gRDRi	Low flow proportion for rural users	0.4	1	0	factor
gRICo	Per capita volume used for subsistence irrigation 1:50 Year				l/c/d
gRIRo	Subsistence irrigation after 1:50 year conversion				million m^3/a
gRPCi	Per capita rural water requirement	25	150	10	l/c/d
gRSRo	1:50 year water consumption per large stock unit				l/c/d
gRURo	Rural water use				million m^3/a
gUC1o	Per capita use in serviced housing [1] for 1:50 year assurance				l/c/d
gUC2o	Per capita use in serviced housing [2] for 1:50 year assurance				l/c/d
gUC3o	Per capita use in serviced housing [3] for 1:50 year assurance				l/c/d
gUC4o	Per capita use in serviced housing [4] for 1:50 year assurance				l/c/d
gUC5o	Per capita use in serviced housing [5] for 1:50 year assurance				l/c/d
gUC6o	Per capita use in serviced housing [6] for 1:50 year assurance				l/c/d
gUC7o	Per capita use in serviced housing [7] for 1:50 year assurance				l/c/d
gUDRi	Low flow proportion for urban users	0.3	1	0	factor
gUIRo	Indirect urban use adjusted for 1:50 year assurance				million m^3/a
gUTRo	Total urban water demand including losses				million m^3/a
nBMRo	Mine on site water consumption for 1:50 year assurance				million m^3/a
nBMYo	Mine bulk water consumption - Nett				million m^3/a

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
nBORo	Other on site bulk water consumption for a 1:50 year assurance				million m^3/a
nBOYo	Other bulk water consumption - Nett				million m^3/a
nBSRo	Strategic on site water consumption for a 1:50 year assurance				million m^3/a
nBSYo	Strategic bulk water consumption - Nett				million m^3/a
nDISo	Minor dam storage during year NYR				million m^3
nDMSo	Major dam storage during year NYR				million m^3
nEHAo	Annual Environmental low flow				million m^3/a
nELDo	Environmental low flow for the dry season				million m^3/a
nELWo	Environmental low flow for the wet season				million m^3/a
nICAo	Actual nett consumptive use by Irrigation				million m^3/a
nMRTo	**Natural MRT**				million m^3/a
oAFRm	Afforestation				
oALVm	Alien Vegetation				
oARDo	Use by alien vegetation				million m^3/a
oBMFo	Total return flow from mines (includes decant/dewatering)				million m^3/a
oBMGi	Groundwater decant/dewatering	N/A	50	0	million m^3/a
oBMIo	Amount of water imported to mines				million m^3/a
oBMOo	Amount of water imported to other bulk users				million m^3/a
oBMRi	Mines on site supply	N/A	50	0	million m^3/a
oBMSo	Amount of water imported to strategic users				million m^3/a
oBMXi	Proportion of the mine usage return flow that is exported	0	1	0	factor
oBOFo	Return flow for other bulk users				million m^3/a
oBOOi	Other bulk users' on site supply	N/A	100	0	million m^3/a
oBOXi	Proportion of the other bulk users' return flows that is exported	0	1	0	factor
oBSFo	Return flow for strategic bulk users				million m^3/a
oBSRi	Strategic users on-site supply	N/A	100	0	million m^3/a
oBTXi	Proportion of the strategic users' return flow exported	0	1	0	factor
oBWUm	Bulk Water Use				
oBYBo	Yield balance				million m^3/a
oBYDo	Yield balance for dry flow				million m^3/a
oBYWo	Yield balance for wet flow				million m^3/a
oCKRo	Balance satisfies human reserve for rural				Boolean

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
	users				
oCKUo	Balance satisfies human reserve for urban users				Boolean
oCRDo	Runoff reduction due to dry-land sugar-cane				million m^3/a
oCREo	Cumulative enhancement impacts				million m^3/a
oCRIo	Cumulative SFRA and enhancement impacts				million m^3/a
oCUDi	Unit reduction in runoff due to dry-land sugar cane	N/A	UNR	0	mm/a
ODBmillion m	Demand Balance Model				
oDFUo	Total return flow re-used within the catchment				million m^3/a
oDICi	Reservoir basin characteristics - minor	0.24?	2	0.1	m^-1
oDIEo	Evaporation losses from minor dams				million m^3/a
oDISi	Total (Gross) full supply capacity of minor dams	N/A	50	0	million m^3
oDMCi	Reservoir basin characteristics - major	0.24?	1	0.1	m^-1
oDMEo	Evaporation losses from major dams				million m^3/a
oDMSi	Total (Gross) full supply capacity of major dams	N/A	5343	0	million m^3
oDMWo	Total demand to be supplied from yield in wet season				million m^3/a
oDOEo	Evaporation losses from off-channel storage dams				million m^3/a
oEBAo	IFR Balance				million m^3/a
oECBo	IFR check balance				million m^3/a
oECKo	Environmental check				Boolean
oEDFo	Equivalent 1:50 year default IFR				**%?**
oEDRo	Environmental requirement of downstream catchment				million m^3/a
oEFRo	Nett instream flow requirement of downstream catchment				million m^3/a
oENVo	Equivalent 1:50 year IFR requirement in the current catchment				million m^3/a
oEPRo	Equivalent 1:50 year present IFR				**%?**
oESRo	Equivalent 1:50 year suggested IFR				**%?**
oEWIo	Wet Drought IFR				million m^3/a
oFRDo	Reduction in runoff due to afforestation				million m^3/a
oGBFo	Baseflow volume				million m^3/a
oGBMo	Maximum no. of usable boreholes				number
oGBNi	Theoretical No. of boreholes	N/A	5000	0	number
oGBSi	**Proportion of gGWSo? that affects baseflow**				factor
oGBYi	Borehole yield	N/A	5	0	l/s
oGEPo	Exploitable Groundwater potential				million m^3/a
oGPHi	Hours of pumping per day	8	24	0	h/day
oGRDo	Reduction in MAR due to groundwater abstraction				million m^3/a
OGWmilli	Groundwater Model				

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
on m					
oGWMo	Maximum amount of utilisable groundwater				million m^3/a
oGWSo	Groundwater use in a catchment				million m^3/a
OGYmillion m	Gross Yield Model				
oHEYo	Contribution of hydropower releases to the environment				million m^3/a
oHPRi	Water released for the generation of power	N/A	3000	0	million m^3/a
oHPWo	Hydropower wastage				million m^3/a
oHURm	Human Reserve				
oHWEo	Environment contribution from wasted hydro power				million m^3/a
oHYDm	Hydropower				
oIAFi	Actual Irrigation Return flow factor	0.1	0.4	0.05	factor
oIAFo	Actual irrigation Return flow				million m^3/a
oIBTm	Inter-basin Transfers				
oICHo	Consumptive water use by high categories of irrigation				million m^3/a
oICLo	Consumptive water use by low categories of irrigation				million m^3/a
oICMo	Consumptive water use by medium categories of irrigation				million m^3/a
oIEHi	Effective rainfall for high categories of irrigation	0.5*MAP	1*MAP	0	mm/a
oIELi	Effective rainfall for low categories of irrigation	0.5*MAP	1*MAP	0	mm/a
oIEMi	Effective rainfall for medium categories of irrigation	0.5*MAP	1*MAP	0	mm/a
oIEPi	Evapotranspiration as Penman Monteith	N/A	3000	1000	mm/a
oIERm	Instream and Estuarine Flow Requirements				
oIFSi	Irrigation return flow switch 0- Actual Return Flow; 1- Theoretical Return Flow	1	1	0	Switch
oIHFo	Return flow from high category crops				million m^3/a
oIHRo	Irrigation water use by high value crops				million m^3/a
oILFo	Return flow from low category crops				million m^3/a
oILRo	Irrigation water use by low value crops				million m^3/a
oIMFo	Return flow from medium category crops				million m^3/a
oIMRo	Irrigation water use by medium value crops				million m^3/a
oIQUi	Irrigation quota volume per unit area	N/A	2	0	m/a
oIRGm	Irrigation Model				
oIRSi	Irrigation switch 0-Actual Use; 1-Theoretical Use; 2-Irrigation Quota;	1	2	0	Switch
~~oISBo~~	~~Increase in TDS by bulk user~~	~~1000~~	~~4000~~	~~10~~	~~mg/l~~
oISMi	Increase in TDS as a result of mining water use	1000	8000	200	mg/l
oISOi	Increase in TDS as a result of other bulk use	1000	4000	200	mg/l

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
oISRi	Increase in TDS as a result of rural water use	150	1000	100	mg/l
oISSi	Increase in TDS as a result of strategic industry use	1000	4000	500	mg/l
oISUi	Increase in TDS as a result of urban use	200	1000	50	mg/l
oITBo	Theortical Irrigation requirement before application of assurance values				million m^3/a
oITRo	Total Water Use by Irrigation (1:50)				million m^3/a
oIWIo	Amount of water imported to irrigation				million m^3/a
oIYmillion m	Incremental Yield Model				
oMAEi	Mean annual S-pan evaporation	N/A	3000	1000	mm/a
oMAPi	Mean annual precipitation in the catchment	N/A	2000	5	mm/a
oMARi	Mean annual runoff (gross virgin)	N/A	500	0	million m^3/a
oNUQo	Increased runoff from urbanization				million m^3/a
oNWQo	Enhanced runoff due to activities associated with weather modification				million m^3/a
oNYRi	Year under consideration	1995	2025	1995	number
oNYSi	Year for which dam storage is provided	1995	2025	1995	number
oPOPi	Total urban population	N/A	3000000	0	number
oPORi	Rural population	N/A	300000	0	number
oPSIi	Ratio between salt load in return flow to load in water supply	**0.2??**	**1??**	**0??**	factor
oPSPi	Reservoir spill TDS/supply TDS	0.6	1	0.25	factor
oPSRo	Human/social reserve requirement				million m^3/a
oRARo	River Contribution to the IFR				million m^3/a
oRCDo	Run of river yield for disturbed flow in current catchment- Dry period				million m^3/a
oRCUo	Rural consumptive use				million m^3/a
oRCWo	Run of river yield for disturbed flow in current catchment- Wet period				million m^3/a
oRDIo	Dry Drought IFR				million m^3/a
oRICi	Per capita requirement for subsistence irrigation	50	200	15	l/c/d
oRIRo	Subsistence Irrigation use				l/c/d
oRLOm	River Loss Model				
oROEm	Runoff Enhancements				
oROWo	Run of river yield for disturbed flow - Wet period				million m^3/a
oRRFo	Rural return flow				million m^3/a
oRRYm	Run of River Yield				
oRSRi	Water requirement per large stock unit	45	100	5	l/lsu/d
oRSRo	Human/social reserve requirement for rural users				million m^3/a
oRSUi	No. of large stock units	N/A	500000	0	number
oRTLi	Total loss (bulk plus distribution) as proportion of gRURo	0.2	0.4	0.1	factor
ORUmillion m	Rural Use Model				
oRVCm	Reservoir Characteristics				

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
oRWIo	Amount of water imported to Rural				million m^3/a
oSEDi	Sedimentation	N/A	1000000	1000	tonnes/a
oSEQo	Equivalent upstream storage				million m^3
oSEVo	Total storage in the catchment				million m^3
oSFRm	Stream Flow Reduction				
oSIDi	IFR switch for dams	1	1	0	Switch
oSIRi	IFR switch for rivers	1	1	0	Switch
oSMNm	Sedimentation				
oSUGm	Dry-land Sugar Cane				
oTFMi	TDS concentration in groundwater discharge	3000	5000	200	mg/l
oTSGi	Average TDS concentration of groundwater	500	15000	10	mg/l
oTSNi	Average TDS of natural runoff	100	2500	20	mg/l
oTSUi	Salt load added to urban runoff	50??	500	20	tonnes/km ^2/a
oUBNm	Urban Use Model				
oUC1i	Per capita use in serviced housing [1]	320	1000	100	l/c/d
oUC2i	Per capita use in serviced housing [2]	320	1000	100	l/c/d
oUC3i	Per capita use in serviced housing [3]	160	1000	50	l/c/d
oUC4i	Per capita use in serviced housing [4]	90	1000	20	l/c/d
oUC5i	Per capita use in serviced housing [5]	10	320	5	l/c/d
oUC6i	Per capita use in serviced housing [6]	6	320	2	l/c/d
oUC7i	Per capita use in serviced housing [7]	**90**	500	10	l/c/d
oUCFo	Clean water return flow				million m^3/a
oUCIo	Clean return flows imported				million m^3/a
oUCRo	Total urban consumptive water use				million m^3/a
oUDRo	Direct urban water use				million m^3/a
oUIRi	Indirect urban use (sum of industrial commercial institutional & municipal)	N/A	500	0	million m^3/a
oURFo	Return flow reaching the river				million m^3/a
oUSAm	Water Usage Models				
oUSRo	Human/social reserve requirement for urban users				million m^3/a
oUTFo	Effluent generated in the catchment				million m^3/a
oUTLo	Total urban loss				million m^3/a
oUWIo	Amount of water imported to Urban users				million m^3/a
OWBmilli on m	Water Balance Model				
OWQmilli on m	Water Quality Model				
OWRmilli on m	Water Resources Model				
oXCEo	Clean return flows exported				million m^3/a
oXCKo	Transfer Check	1	1	0	Boolean
oXEHo	Amount of transferred water contributing to IFR as well as to power				million m^3/a

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
	generation				
oXGEo	Groundwater exported				million m^3/a
oXGWo	Groundwater imported				million m^3/a
oXHPo	Amount of transferred water available for power generation				million m^3/a
oXMEo	Return flow exported - mining				million m^3/a
oXOEo	Return flow exported - other				million m^3/a
oXRVo	Inter Basin Transfer Volume for via transfers				million m^3/a
oXSEo	Return flow exported - strategic				million m^3/a
oXUEo	**Urban** return flow (sewage/effluent) exported to other catchment				million m^3/a
oXUIo	**Urban** return flow imported for sewage processing				million m^3/a
oXWEo	Total exports				million m^3/a
oYADo	Total demand to be supplied from yield in dry season				million m^3/a
OYBmillion m	Yield Balance Model				
oYCDo	Total yield for disturbed flow				million m^3/a
oYCEo	Total yield for enhanced flow				million m^3/a
oYCFo	Total return flow for the catchment				million m^3/a
oYERo	Balance satisfies downstream IFR				Boolean
oYRDo	Run of river yield for disturbed flow - Dry period				million m^3/a
oYREo	Run of river yield for enhanced flow				million m^3/a
oYRVo	Run of river yield for virgin flow				million m^3/a
oYSBo	Balance satisfies strategic bulk users				Boolean
oYSOo	Balance satisfies human reserve				Boolean
oYTDo	Total yield including run of river for disturbed flow				million m^3/a
oYTEo	Total yield including run of river for enhanced flow				million m^3/a
oYTRo	Total return flow to downstream catchment				million m^3/a
oYTVo	Total yield including run of river for virgin flow				million m^3/a
oYUDo	Incremental yield from upstream catchments-Disturbed flow				million m^3/a
oYUEo	Incremental yield from upstream catchments-enhanced flow				million m^3/a
oYURo	Run of river used				million m^3/a
uAUDi	Unit reduction in runoff due to alien vegetation	N/A	UNR	0	mm/a
uFUDi	Unit reduction in runoff due to afforestation	N/A	UNR	0	mm/a
uMARo	Natural MAR expressed as unit runoff				mm/a
uPRRi	Minimum rural per capita requirement	25	150	5	l/c/d

Parameter Name	Description	Default Value	Upper Limit	Lower Limit	Units
uPURi	Minimum urban per capita requirement	25	150	5	l/c/d
vLRLi	**Average river water loss for VIRGIN flow conditions**	N/A	100	0	million m^3/a
vYCVo	Total yield-Virgin flow				million m^3/a
vYISo	Incremental gross yield				million m^3/a
vYRAi	Portion dry flow as % MAR	N/A	20	0	%
yAIYo	Reduction in yield due to alien vegetation				million m^3/a
yBDFo	Combined deficit for the wet & dry & annual balances in the catchment				million m^3/a
yBEBo	Effective Yield balance				million m^3/a
yBSRo	Combined surplus for the wet & dry & annual balances in the catchment				million m^3/a
yCIYo	Reduction in yield due to dry-land sugar cane				million m^3/a
yENDo	Equivalent IFR drought requirement				million m^3/a
yFIYo	Reduction in yield due to afforestation				million m^3/a
yHPBo	Water release for power generation that is beneficial to d/s users				million m^3/a
yHPYo	Hydropower that contributes to the yield				million m^3/a
ySMIo	Yield from minor dams				million m^3/a
yUSPm	User Defined Parameters				
yUSRm	User Parameter Groups				
yXFRo	Transfer volume that can be used for yield				million m^3/a
yXWIo	Water imported **(into demand sectors only)**				million m^3/a
yYIEo	Incremental gross yield for runoff enhancements				million m^3/a
yYOFi	Yield from off-channel storage dams	N/A	500	0	million m^3/a
yYUBo	Impact of urbanisation on yield				million m^3/a
yYWBo	Impact of weather modifications on yield				million m^3/a

PARAMETER DATA AT QUATERNARY LEVEL

LANDUSE

	Alien vegetation Km2 AAAAi	Dry-land sugarcane km2 aCAUi	Afforestation km2 aFCAi	Indigenous forests km2 aFINi	Irrigated area km2 aISAi	Urban area km2 aNAEi
T40A	12.77	0	9.027	22.93	0.37	0
T40B	79.68	0	123.6	8.437	0.55	0
T40C	3.99	0	5.08	2.429	0.43	0
T40D	11.12	0	9.646	9.4	0.8	0.4758
T40E	6.04	0	1.519	11.94	0.98	0
T40F	7.56	43	2.761	3.701	2.047	4.79
T40G	12.38	188	0	9.293	1.755	17.79
T51A	1.97	0	0	0	2.805	0
T51B	1.76	0	2.786	0	1.732	0
T51C	3.33	0	26.82	11.9	3.63	0
T51D	1.12	0	8.06	0	1.237	2.08
T51E	1.69	0	12.36	0	1.98	0
T51F	1.86	0	0	0	1.897	0
T51G	1.78	0	2.029	0	1.567	0
T51H	8.44	0	17.94	13.95	4.042	0
T51J	1.8	0	3.017	9.591	2.063	0
T52A	3.07	0	62.26	6.413	6.845	0
T52B	2.99	0	6.846	7.221	4.532	0
T52C	3.36	0	53.54	0.7849	4.625	0
T52D	4.83	0	67.93	0	11.47	0
T52E	13.07	0	66.49	9.018	0.247	0
T52F	83.73	0	113.8	20.45	0.495	0
T52G	7.75	0	25.48	15.71	0.262	0
T52H	10.1	0	5.151	0	0.555	0
T52J	7.36	37	10.39	0	2.775	0
T52K	63.63	64	98.86	0	3.237	2.09
T52L	14.11	27	0	20.49	1.387	0
T52M	15.68	51	0	7.427	2.313	4.24
U10A	1.41	0	0	0	5.2	0
U10B	6.49	0	0	0	5.032	0
U10C	4.08	0	0	0	3.631	0
U10D	4.46	0	0.745	0	4.576	0
U10E	3.71	0	25.97	11.31	0	0
U10F	3.04	0	24.21	13.4	0	0
U10G	2.91	0	26.19	7.957	8.993	0
U10H	3.66	0	112.5	1.194	13.67	0
U10J	4.21	26	99.61	19.05	15.09	4.22
U10K	4.42	19	62.8	0	10.87	2.78
U10L	2.67	16	12.49	0	9.2	0
U10M	2.7	14.6	0	0	0	0.18
U20A	6.76	0	45.81	4.693	25.46	0
U20B	7.67	0	42.74	9.618	7.79	0
U20C	6.33	0	36.18	10.4	9.31	3.38
U20D	2.92	9.7	72.3	41.8	7.507	0
U20E	2.17	49.59	101.4	10.57	7.982	8.24
U20F	9.36	224.9	160.8	17.18	11.41	0.75
U20G	10.49	200.6	38.05	0	12.97	0.37
U20H	1.57	0	5.556	1.61	0.8	0
U20J	5.88	2.35	20.56	10.15	1.43	85.18
U20K	2.16	86.97	5.632	0.8684	10	0
U20L	1.89	0.97	0	0	0	0.15
U20M	24.13	5.4	0	0	0	130.4
U30A	3.46	26.15	2.475	7.896	0	0
U30B	37.58	84.07	0	0	30	5.76
U30C	2.35	42.48	1.552	1.658	7.2	0
U30D	26.52	112.3	0	0	5.4	9.38
U30E	6.6	241.8	0	0	8.3	2.27
U40A	66	37.8	178.6	3.496	7.41	0
U40B	47.18	46.4	170.7	0	13.06	5.59
U40C	5.53	31.6	75.92	0	6.825	0
U40D	9.49	15.2	24.2	0	0	0
U40E	2.35	30.5	4.812	4.146	2.632	0
U40F	15.07	27.9	116.1	0	13.4	0
U40G	2.52	10.5	0	0	0	0
U40H	2.96	42.83	0	0	5.89	0
U40J	2.17	127	2.584	0	22.7	7.94
U50A	3.06	0	3.468	2.422	0	0.91
U60A	0.56	10.89	47.47	7.143	4.1	0
U60B	3.09	204.9	48.26	1.083	19.2	0.12
U60C	10.72	71.99	0.5192	0	19.2	13.21
U60D	4.51	0	0	0.7524	0	53.46
U60E	3.18	48.65	4.52	0	0	21.99

U60F	18.52	2.13	0.5976	0	0	158
U70A	9.39	0.41	72.97	8.81	4.25	0
U70B	6.34	110.4	110.5	0	4.25	7.95
U70C	2.73	145.5	22.8	0	4.25	0
U70D	2.61	18.02	0	0	2.55	1.12
U70E	1.18	0	0	0	0.85	15.95
U70F	0	0	0	0	0	0
U80A	14.19	26	0	0	0.6	9.01
U80B	2.9	13	25	0.6297	0	0
U80C	4.83	30	1.075	0.9833	0.4	0
U80D	4.41	20	0	0	3	3.55
U80E	3.74	42	79.55	2.024	5	0
U80F	1.65	22	1.642	0	2	0.03
U80G	2.84	91	43.84	0	2	0
U80H	2.19	85	30.16	4.448	0	6.1
U80J	3.7	19	36.32	0	0.4	0
U80K	1.74	32	0.7764	6.167	0	4.48
U80L	1.48	19	0	0	0	1.89
TOTAL	851.4	2954.5	2735.3462	402.5437	432.416	595.8258

HYDROLOGY

Areas	aMTCi Cactment area km2	oMAPi Mean annual precipitation mm/a	oMAEi Mean annual evaporation mm/a	oMARi Natual mean annual runoff (incremental) million m3/a	eMRTo Natual mean annual runoff (accumulative) million m3/a
T40A	208	995	1200	54.92	54.92
T40B	278	979	1200	75.04	75.04
T40C	237	829	1200	38.1	168.1
T40D	372	814	1150	39.26	207.3
T40E	486	823	1150	57.85	265.2
T40F	335	1070	1200	86.51	86.51
T40G	300	1055	1200	74.49	74.49
T51A	328	1260	1300	149.6	149.6
T51B	210	1180	1300	83.48	233.1
T51C	462	952	1300	95.6	444.9
T51D	142	1234	1300	62.26	62.26
T51E	256	957	1300	53.9	116.2
T51F	307	1142	1350	109	109
T51G	256	1087	1350	81.36	81.36
T51H	520	947	1300	105.7	105.7
T51J	265	912	1300	49.65	345.6
T52A	382	906	1200	76.94	867.5
T52B	256	881	1200	47.33	47.33
T52C	261	836	1200	40.39	955.2
T52D	531	791	1200	49.56	1005
T52E	233	903	1200	44.89	44.89
T52F	418	908	1200	81.37	81.37
T52G	221	903	1200	44.82	171.1
T52H	344	778	1200	31.23	202.3
T52J	368	826	1200	44.02	1251
T52K	426	803	1200	45.44	45.44
T52L	179	893	1150	27.41	72.85
T52M	313	901	1150	49.25	1373
U10A	418	1287	1300	209.9	209.9
U10B	392	1176	1300	164.4	164.4
U10C	267	1091	1300	95.63	95.63
U10D	337	999	1300	99.76	474.1
U10E	327	1034	1300	106.4	676.1
U10F	379	963	1300	79.74	755.8
U10G	353	981	1250	83.51	839.3
U10H	458	924	1200	100.4	939.8
U10J	505	878	1200	62.32	1002
U10K	364	793	1200	30.72	30.72
U10L	307	758	1200	19.48	1052
U10M	280	858	1200	27.3	1080
U20A	293	1010	1300	82.58	82.58
U20B	353	988	1300	70.01	70.01
U20C	279	932	1250	49.02	201.6
U20D	338	1040	1300	67.15	67.15
U20E	390	975	1200	64.04	332.8
U20F	435	983	1200	75.26	75.26
U20G	494	895	1200	64.57	472.6
U20H	220	943	1200	39.99	39.99
U20J	678	840	1200	60.09	100.1
U20K	271	949	1200	37.25	37.25
U20L	328	809	1200	22.77	632.7
U20M	360	926	1200	41.52	674.3

U30A	376	967	1200	71.23	71.23
U30B	221	982	1200	24.15	95.38
U30C	242	999	1200	41.53	41.53
U30D	181	986	1200	29.99	71.52
U30E	290	1019	1200	46.66	46.66
U40A	317	919	1250	44.98	44.98
U40B	388	868	1250	37.71	82.69
U40C	264	879	1200	30.62	30.62
U40D	267	865	1200	29.28	142.6
U40E	318	842	1200	32.46	175.1
U40F	290	841	1250	24.06	24.06
U40G	253	898	1250	29.52	53.58
U40H	361	924	1200	49.89	278.5
U40J	279	996	1250	44.96	323.5
U50A	298	1056	1250	57.72	57.72
U60A	105	981	1200	19.96	19.96
U60B	316	822	1200	29.75	49.71
U60C	365	773	1200	34.99	84.7
U60D	185	888	1200	26.2	110.9
U60E	280	907	1200	39.28	39.28
U60F	272	967	1200	33.91	33.91
U70A	114	1040	1200	17.53	17.53
U70B	272	849	1200	26.02	43.55
U70C	350	859	1200	35.87	79.42
U70D	208	938	1200	29.44	108.9
U70E	87	999	1200	15.18	15.18
U70F	59	997	1200	9.98	9.98
U80A	158	1037	1200	30.7	30.7
U80B	339	801	1200	28.27	28.27
U80C	202	962	1200	30.84	59.11
U80D	120	1048	1200	24.07	24.07
U80E	415	831	1200	38.07	38.07
U80F	137	935	1200	19.06	57.13
U80G	261	939	1200	36.89	36.89
U80H	243	1013	1200	43.85	43.85
U80J	371	840	1200	35.23	35.23
U80K	184	950	1200	27	62.23
U80L	107	983	1200	17.53	17.53
TOTAL+A83	27215	84997	110100	4797.56	21388.12

URBAN

	Direct urban use	Indirect urban use	Bulk loss factor	Distribution loss factor	Total losses	Total urban water use	Total return flows	Increased runoff due to urban areas	Return flows generated in the catchment	Urban population
	million m3/a	million m3/a	Factor	Factor	million m3/a	million m3/a	million m3/a	million m3/a	million m3/a	Number
Areas	oUDRo	gUIRo	fUBLi	fNUIi	oUTLo	gUTRo	oURFo	oNUQo	oUTFo	oPOPi
T40A	0	0	0.05	0.125	0	0	0	0	0	0
T40B	0	0	0.05	0.125	0	0	0	0	0	0
T40C	0	0	0.05	0.125	0	0	0	0	0	0
T40D	0	0	0.05	0.125	0	0	0	0.03439	0	0
T40E	0	0	0.05	0.125	0	0	0	0	0	0
T40F	0.3894	0.2181	0.05	0.125	0.2025	0.8099	0.3847	0.3835	0.3847	4650
T40G	5.009	2.685	0.05	0.125	2.565	10.26	4.753	1.419	4.753	6.86E+04
T51A	0	0	0.05	0.125	0	0	0	0	0	0
T51B	0	0	0.05	0.125	0	0	0	0	0	0
T51C	0.05552	0.02118	0.05	0.125	0.02557	0.1023	0.04213	0	0.04213	800
T51D	0.06611	0.0252	0.05	0.125	0.03044	0.1217	0.05809	0.1555	0.05809	650
T51E	0	0	0.05	0.125	0	0	0	0	0	0
T51F	0	0	0.05	0.125	0	0	0	0	0	0
T51G	0	0	0.05	0.125	0	0	0	0	0	0
T51H	0	0	0.05	0.125	0	0	0	0	0	0
T51J	0	0	0.05	0.125	0	0	0	0	0	0
T52A	0.03178	0.01205	0.05	0.125	0.01461	0.05844	0.02379	0	0.02379	400
T52B	0	0	0.05	0.125	0	0	0	0	0	0
T52C	0.1618	0.06136	0.05	0.125	0.07439	0.2975	0.105	0	0.105	5350
T52D	0	0	0.05	0.125	0	0	0	0	0	0
T52E	0	0	0.05	0.125	0	0	0	0	0	0
T52F	0	0	0.05	0.125	0	0	0	0	0	0
T52G	0	0	0.05	0.125	0	0	0	0	0	0
T52H	0	0	0.05	0.125	0	0	0	0	0	0
T52J	0	0	0.05	0.125	0	0	0	0	0	0
T52K	0.2911	0.1107	0.05	0.125	0.1339	0.5357	0.2369	0.1484	0.2369	3750
T52L	0	0	0.05	0.125	0	0	0	0	0	0
T52M	0	0	0.05	0.125	0	0	0	0.3177	0	0
U10A	0.00877	0.00329	0.05	0.125	0.004019	0.01607	0.003892	0	0.003892	350
U10B	0	0	0.05	0.125	0	0	0	0	0	0

U10C	0	0	0.05	0.125	0	0	0	0	0	0
U10D	0	0	0.05	0.125	0	0	0	0	0	0
U10E	0	0	0.05	0.125	0	0	0	0	0	0
U10F	0.04493	0.01717	0.05	0.125	0.0207	0.08279	0.03424	0	0.03424	650
U10G	0	0	0.05	0.125	0	0	0	0	0	0
U10H	0	0	0.05	0.125	0	0	0	0	0	0
U10J	0	0	0.05	0.125	0	0	0	0.3239	0	0
U10K	0.1841	0.07159	0.05	0.125	0.08522	0.3409	0.1482	0.2021	0.1482	3050
U10L	0	0	0.05	0.125	0	0	0	0	0	0
U10M	0	0	0.05	0.125	0	0	0	0.01402	0	0
U20A	0	0	0.05	0.125	0	0	0	0	0	0
U20B	0.01169	0.00475	0.05	0.125	0.005479	0.02192	0.009991	0	0.009991	150
U20C	0	0	0.05	0.125	0	0	0	0.2565	0	0
U20D	0	0	0.05	0.125	0	0	0	0	0	0
U20E	1.039	0.3948	0.05	0.125	0.4779	1.911	0.8753	0.6744	0.8753	1.52E+04
U20F	0.1947	0.07561	0.05	0.125	0.0901	0.3604	0.1633	0.06119	0.1633	2850
U20G	0.0767	0.03068	0.05	0.125	0.03579	0.1432	0.06496	0.02873	0.06496	1050
U20H	0	0	0.05	0.125	0	0	0	0	0	0
U20J	21.03	15.25	0.05	0.125	12.09	48.38	22.19	6.569	22.19	3.98E+05
U20K	0	0	0.05	0.125	0	0	0	0	0	0
U20L	0	0	0.05	0.125	0	0	0	0.01144	0	0
U20M	0	0	0.05	0.125	0	0	21.68	10.8	0	0
U30A	0	0	0.05	0.125	0	0	0	0	0	0
U30B	0	0	0.05	0.125	0	0	0	0.5152	0	0
U30C	0	0	0.05	0.125	0	0	0	0	0	0
U30D	0	0	0.05	0.125	0	0	0	0.7768	0	0
U30E	1.009	0.565	0.05	0.125	0.2777	1.852	0.9915	0.1972	0.9915	1.83E+04
U40A	0	0	0.05	0.125	0	0	0	0	0	0
U40B	0.8236	0.6016	0.05	0.125	0.3563	1.782	0.891	0.4416	0.891	1.14E+04
U40C	0.06794	0.02593	0.05	0.125	0.02347	0.1173	0.04803	0	0.04803	1400
U40D	0	0	0.05	0.125	0	0	0	0	0	0
U40E	0	0	0.05	0.125	0	0	0	0	0	0
U40F	0.02812	0.01059	0.05	0.125	0.009679	0.04839	0.02372	0	0.02372	500
U40G	0	0	0.05	0.125	0	0	0	0	0	0
U40H	0	0	0.05	0.125	0	0	0	0	0	0
U40J	1.788	1.305	0.05	0.125	0.7731	3.865	2.003	0.6704	2.003	2.90E+04
U50A	0.2758	0.1048	0.05	0.125	0.1269	0.5075	0.2649	0.07887	0.2649	2800
U60A	0	0	0.05	0.125	0	0	0	0	0	0
U60B	0	0	0.05	0.125	0	0	0	0.008945	0	0
U60C	0	0	0.05	0.125	0	0	4.468	0.9139	0	0
U60D	0	0	0.05	0.125	0	0	0.7884	4.038	0	0
U60E	0	0	0.05	0.125	0	0	0	1.709	0	0
U60F	97.8	80	0.1	0.125	109	286.8	87.62	13.58	114.6	2.50E+06
U70A	0	0	0.05	0.125	0	0	0	0	0	0
U70B	0	0	0.05	0.125	0	0	0	0.6136	0	0
U70C	0	0	0.05	0.125	0	0	0	0	0	0
U70D	0	0	0.05	0.125	0	0	0	0.09049	0	0
U70E	0	0	0.05	0.125	0	0	0	1.325	0	0
U70F	0	0	0.05	0.125	0	0	0	0	0	0
U80A	0	0	0.05	0.125	0	0	0	0.7622	0	0
U80B	0	0	0.05	0.125	0	0	0	0	0	0
U80C	0	0	0.05	0.125	0	0	0	0	0	0
U80D	0.2959	0.1655	0.05	0.125	0.1538	0.6151	0.2634	0.3016	0.2634	5000
U80E	0	0	0.05	0.125	0	0	0	0	0	0
U80F	0	0	0.05	0.125	0	0	0	0.002424	0	0
U80G	0	0	0.05	0.125	0	0	0	0	0	0
U80H	0.3459	0.1936	0.05	0.125	0.1798	0.7193	0.3482	0.5112	0.3482	4050
U80J	0	0	0.05	0.125	0	0	0	0	0	0
U80K	1.435	0.8036	0.05	0.125	0.7462	2.985	1.42	0.3647	1.42	1.81E+04
U80L	1.342	0.7517	0.05	0.125	0.6979	2.791	1.305	0.1564	1.305	1.80E+04
TOTAL	133.806	103.5088	4.55	11.25	128.200467	365.52441	151.20864	48.457299	151.252243	3114200

RURAL

Areas	Rural population oPORi	Number of large stock units oRSUi	Rural water consumption rate gRCRo	Large stock units comsumption rate gRSRo	Subsistance irrigation gRIRo	Total rural water use gRURo	Rural loss factor oRTLi	Rural return flow oRRFo
T40A	7612	5801	30	45	0	0.2234	0.2	0
T40B	1.83E+04	4.35E+04	30	45	0	1.145	0.2	0
T40C	2.25E+04	1.60E+04	30	45	0	0.6358	0.2	0
T40D	4.63E+04	0	30	45	0	0.6344	0.2	0
T40E	5.62E+04	0	30	45	0	0.7696	0.2	0
T40F	5.75E+04	2808	25	45	0	0.7139	0.2	0
T40G	4.35E+04	2095	25	45	0	0.5399	0.2	0
T51A	699.4	9035	25	45	0	0.1936	0.2	0
T51B	1147	5824	25	45	0	0.1328	0.2	0
T51C	1.41E+04	1.80E+04	25	45	0	0.5299	0.2	0
T51D	767	3916	25	45	0	0.08921	0.2	0
T51E	5571	1.02E+04	25	45	0	0.2737	0.2	0
T51F	1056	8444	25	45	0	0.1855	0.2	0
T51G	3192	9516	25	45	0	0.2319	0.2	0
T51H	2.86E+04	2937	25	45	0	0.3873	0.2	0
T51J	1.73E+04	7498	25	45	0	0.3513	0.2	0
T52A	1.98E+04	1.31E+04	25	45	0	0.4955	0.2	0
T52B	1.33E+04	0	25	45	0	0.1517	0.2	0
T52C	1.45E+04	4674	25	45	0	0.2612	0.2	0
T52D	4.09E+04	1.24E+04	25	45	0	0.721	0.2	0
T52E	1.06E+04	0	25	45	0	0.1214	0.2	0
T52F	2.02E+04	571	25	45	0	0.2417	0.2	0
T52G	1.08E+04	16	25	45	0	0.1231	0.2	0
T52H	3.32E+04	65	25	45	0	0.3805	0.2	0
T52J	2.76E+04	1.29E+04	25	45	0	0.5795	0.2	0
T52K	1.86E+04	1.52E+04	25	45	0	0.5242	0.2	0
T52L	7077	2185	25	45	0	0.1257	0.2	0
T52M	1.65E+04	4710	25	45	0	0.2846	0.2	0
U10A	4343	1.17E+04	25	45	0	0.2904	0.2	0
U10B	6381	1.09E+04	25	45	0	0.2967	0.2	0
U10C	3865	8108	25	45	0	0.2107	0.2	0
U10D	1.01E+04	1.01E+04	25	45	0	0.3225	0.2	0
U10E	1.96E+04	1.40E+04	25	45	0	0.5105	0.2	0
U10F	2.28E+04	1.75E+04	25	45	0	0.6194	0.2	0
U10G	6092	1.04E+04	25	45	0	0.2827	0.2	0
U10H	1.54E+04	1.71E+04	25	45	0	0.5277	0.2	0
U10J	1.75E+04	1.69E+04	25	45	0	0.5463	0.2	0
U10K	4699	1.27E+04	25	45	0	0.3144	0.2	0
U10L	1.25E+04	1.01E+04	25	45	0	0.3513	0.2	0
U10M	2.39E+04	9376	25	45	0	0.465	0.2	0
U20A	3651	1.35E+04	25	45	0	0.3187	0.2	0
U20B	9370	2.20E+04	25	45	0	0.5581	0.2	0
U20C	6733	1.71E+04	25	45	0	0.4288	0.2	0
U20D	5906	2.03E+04	25	45	0	0.4835	0.2	0
U20E	1.36E+04	2.04E+04	25	45	0	0.5737	0.2	0
U20F	1.10E+04	6294	25	45	0	0.2544	0.2	0
U20G	3.13E+04	1.16E+04	25	45	0	0.5948	0.2	0
U20H	9.51E+04	8461	25	45	0	1.26	0.2	0
U20J	6.40E+04	2.51E+04	25	45	0	1.245	0.2	0
U20K	2.31E+04	5153	25	45	0	0.3697	0.2	0
U20L	4.62E+04	9222	25	45	0	0.7162	0.2	0
U20M	4.90E+04	5224	25	45	0	0.6671	0.2	0
U30A	7.27E+04	1.46E+04	25	45	0	1.13	0.2	0
U30B	3.68E+04	656	25	45	0	0.4336	0.2	0
U30C	3.14E+04	1.16E+04	25	45	0	0.5967	0.2	0
U30D	1.68E+04	754	25	45	0	0.2071	0.2	0
U30E	1.90E+04	1723	25	45	0	0.2524	0.2	0
U40A	4013	5269	25	45	0	0.1541	0.2	0
U40B	3006	6035	25	45	0	0.1583	0.2	0
U40C	5159	3673	25	45	0	0.1343	0.2	0
U40D	3.71E+04	4049	25	45	0	0.5067	0.2	0
U40E	4.48E+04	7664	25	45	0	0.6683	0.2	0
U40F	1.28E+04	2861	25	45	0	0.2044	0.2	0
U40G	4.00E+04	1.09E+04	25	45	0	0.6795	0.2	0
U40H	6.84E+04	3.41E+04	25	45	0	1.481	0.2	0
U40J	3.83E+04	1190	25	45	0	0.4616	0.2	0
U50A	3.88E+04	1168	25	45	0	0.4673	0.2	0
U60A	2902	3500	25	45	0	0.105	0.2	0
U60B	1.21E+04	1.03E+04	25	45	0	0.349	0.2	0
U60C	1.95E+04	1.10E+04	25	45	0	0.4493	0.2	0
U60D	6338	2727	25	45	0	0.1284	0.2	0
U60E	3.47E+04	9167	25	45	0	0.5848	0.2	0
U60F	281.2	1947	25	45	0	0.04321	0.2	0
U70A	426.6	3564	25	45	0	0.07809	0.2	0

U70B	1.74E+04	8470	25	45	0	0.3723	0.2	0
U70C	1.11E+04	1.17E+04	25	45	0	0.3673	0.2	0
U70D	1.14E+04	8571	25	45	0	0.3056	0.2	0
U70E	9994	3702	25	45	0	0.1901	0.2	0
U70F	6705	1616	25	45	0	0.1097	0.2	0
U80A	1.73E+04	1100	25	45	0	0.2198	0.2	0
U80B	4.25E+04	1.02E+04	25	45	0	0.6946	0.2	0
U80C	3.33E+04	4355	25	45	0	0.4692	0.2	0
U80D	2.54E+04	3735	25	45	0	0.3667	0.2	0
U80E	3.64E+04	1.36E+04	25	45	0	0.6944	0.2	0
U80F	1.56E+04	4268	25	45	0	0.2661	0.2	0
U80G	1.01E+04	8143	25	45	0	0.2826	0.2	0
U80H	1.62E+04	7559	25	45	0	0.3405	0.2	0
U80J	3.55E+04	1.24E+04	25	45	0	0.659	0.2	0
U80K	1.33E+04	5706	25	45	0	0.2686	0.2	0
U80L	1.75E+04	3337	25	45	0	0.268	0.2	0
TOTAL	1928106	781222	2275	4050	0	38.40251	18	0

ULK

Areas	1 On-site water use (strategic) million m3/a oBSRi	2 On-site water use (mining) million m3/a oBMRi	3 On-site water use (other) million m3/a oBOOi	4 Loss factor (strategic) Factor fBSLi	5 Loss factor (mining) Factor fBMLi	6 Loss factor (other) Factor fBOLi	7 Strategic water use million m3/a gBSRo	8 Mining water use million m3/a gBMRo	9 Other water use million m3/a gBORo	10 Return flow (strategic) million m3/a oBSFo	11 Return flow (mining) million m3/a oBMFo	12 Return flow (other) million m3/a oBOFo	13 Return flow factor (mining) Factor fBMFi	14 Return flow factor (other) Factor fBOFi	15 Retrun flow factor (strategic) Factor fBSFi	16 Groundwater decant/mine dewatering million m3/a oBMGi
40A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40D	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40E	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40F	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40G	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
51A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
51B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
51C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
51D	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
51E	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
51F	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
51G	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
51H	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
51J	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52D	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52E	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52F	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52G	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52H	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52J	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52K	0	0	1.5	0.05	0.1	0.1	0	0	1.65	0	0	0.3	0.2	0.2	0	0
52L	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
52M	0	0	2.23	0.05	0.1	0.1	0	0	2.453	0	0	0.446	0.2	0.2	0	0
10A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10D	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10E	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10F	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10G	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10H	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10J	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10K	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10L	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
10M	0	0	47.6	0.05	0.1	0.1	0	0	52.36	0	0	37.08	0.2	0.779	0	0

20A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
20B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
20C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
20D	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
20E	0	0	0.594	0.05	0.1	0.1	0	0	0.6534	0	0	0.1188	0.2	0.2	0	0
20F	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
20G	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
20H	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
20J	0	0	0.29	0.05	0.1	0.1	0	0	0.319	0	0	0.194	0.2	0.669	0	0
20K	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
20L	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
20M	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
30A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
30B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
30C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
30D	0	0	5.84	0.05	0.1	0.1	0	0	6.424	0	0	3.037	0.2	0.52	0	0
30E	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40D	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40E	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40F	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40G	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40H	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
40J	0	0	3.8	0.05	0.1	0.1	0	0	4.18	0	0	0.76	0.2	0.2	0	0
50A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.391	0	0
60A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
60B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
60C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
60D	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
60E	0	0	2.701	0.05	0.1	0.1	0	0	2.971	0	0	0.1918	0.2	0.071	0	0
60F	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
70A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
70B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
70C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
70D	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.236	0	0
70E	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
70F	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80A	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80B	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80C	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80D	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80E	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80F	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80G	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80H	0	0	1.21	0.05	0.1	0.1	0	0	1.331	0	0	0.3497	0.2	0.289	0	0
80J	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80K	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
80L	0	0	0	0.05	0.1	0.1	0	0	0	0	0	0	0.2	0.2	0	0
TOTAL	0	0	65.765	4.5	9	9	0	0	72.341	0	0	42.4773	18	19.555	0	0

IRRIGATION

	Area under high category crops	Area under low category crops	Area under medium category crops	Green cover area	Conveyance losses for high category crops	Conveyance losses for low category crops	Conveyance losses for medium category crops	Total water use by irrigators	Application efficiency for high category crops	Application efficiency for low category crops	Application efficiency for medium category crops
	km2	km2	km2	km2	Factor	Factor	Factor	million m3/a	Factor	Factor	Factor
Quaternary catchment	aIHAi	aILAi	aIMAi	aISAi	fIHCi	fILCi	fIMCi	gIARo	fIPHi	fIPLi	fIPMi
T40A	0	0	0.37	0.37	0	0	0.15	0.113	0	0	0.75
T40B	0	0	0.55	0.55	0	0	0.15	0.1645	0	0	0.75
T40C	0	0	0.43	0.43	0	0	0.15	0.1379	0	0	0.75
T40D	0	0	0.8	0.8	0	0	0.15	0.2565	0	0	0.75
T40E	0	0	0.98	0.98	0	0	0.15	0.3227	0	0	0.75
T40F	0.105	0.105	1.89	2.047	0.1	0.1	0.1	0.7925	0.65	0.65	0.65
T40G	0.09	0.09	1.62	1.755	0.1	0.1	0.1	0.7317	0.65	0.65	0.65
T51A	0	1.19	2.21	2.805	0	0.1	0.1	1.34	0	0.65	0.65
T51B	0	0.735	1.365	1.732	0	0.1	0.1	0.864	0	0.65	0.65
T51C	0	1.54	2.86	3.63	0	0.1	0.1	1.733	0	0.65	0.65
T51D	0	0.525	0.975	1.237	0	0.1	0.1	0.6143	0	0.65	0.65
T51E	0	0.84	1.56	1.98	0	0.1	0.1	0.995	0	0.65	0.65
T51F	0	0.805	1.495	1.897	0	0.1	0.1	0.9463	0	0.65	0.65
T51G	0	0.665	1.235	1.567	0	0.1	0.1	0.8491	0	0.65	0.65
T51H	0	1.715	3.185	4.042	0	0.1	0.1	1.89	0	0.65	0.65
T51J	0	0.875	1.625	2.063	0	0.1	0.1	0.9555	0	0.65	0.65
T52A	0	1.11	6.29	6.845	0	0.1	0.1	3.159	0	0.65	0.65
T52B	0	0.735	4.165	4.532	0	0.1	0.1	1.818	0	0.65	0.65
T52C	0	0.75	4.25	4.625	0	0.1	0.1	1.946	0	0.65	0.65
T52D	0	1.86	10.54	11.47	0	0.1	0.1	5.261	0	0.65	0.65
T52E	0	0.105	0.195	0.247	0	0.1	0.1	0.09611	0	0.65	0.65
T52F	0	0.21	0.39	0.495	0	0.1	0.1	0.2496	0	0.65	0.65
T52G	0	0.075	0.225	0.262	0	0.1	0.1	0.111	0	0.65	0.65
T52H	0	0.09	0.51	0.555	0	0.1	0.1	0.3162	0	0.65	0.65
T52J	0	0.45	2.55	2.775	0	0.1	0.1	1.691	0	0.65	0.65
T52K	0	0.525	2.975	3.237	0	0.1	0.1	2.116	0	0.65	0.65
T52L	0	0.225	1.275	1.387	0	0.1	0.1	0.8363	0	0.65	0.65
T52M	0	0.375	2.125	2.313	0	0.1	0.1	1.319	0	0.65	0.65
U10A	0	2.6	3.9	5.2	0	0.1	0.1	2.412	0	0.65	0.65
U10B	0	2.135	3.965	5.032	0	0.1	0.1	2.372	0	0.65	0.65
U10C	0	1.038	3.112	3.631	0	0.1	0.1	1.791	0	0.65	0.65
U10D	0	1.308	3.922	4.576	0	0.1	0.1	2.115	0	0.65	0.65
U10E	0	0	0	0	0	0	0	0	0	0	0
U10F	0	0	0	0	0	0	0	0	0	0	0
U10G	0	0	8.993	8.993	0	0	0.1	3.931	0	0	0.65
U10H	0	0	13.67	13.67	0	0	0.1	6.368	0	0	0.65
U10J	0	0	15.09	15.09	0	0	0.1	7.8	0	0	0.65
U10K	0	0	10.87	10.87	0	0	0.1	4.917	0	0	0.65
U10L	0	0	9.2	9.2	0	0	0.1	4.969	0	0	0.65
U10M	0	0	0	0	0	0	0	0	0	0	0
U20A	0	0	25.46	25.46	0	0	0.1	11.27	0	0	0.65
U20B	0	0	7.79	7.79	0	0	0.1	3.09	0	0	0.65
U20C	0	0	9.31	9.31	0	0	0.1	5.022	0	0	0.65
U20D	0	0.385	7.315	7.507	0	0.1	0.1	2.082	0	0.65	0.65
U20E	0	4.635	5.665	7.982	0	0.1	0.1	3.237	0	0.65	0.65
U20F	0	0.585	11.11	11.41	0	0.1	0.1	5.792	0	0.65	0.65
U20G	0	0.665	12.64	12.97	0	0.1	0.1	5.415	0	0.65	0.65
U20H	0	0	0.8	0.8	0	0	0.1	0.4085	0	0	0.65
U20J	0	0	1.43	1.43	0	0	0.1	0.8298	0	0	0.65
U20K	2	0	8	10	0.1	0	0.1	4.878	0.65	0	0.65
U20L	0	0	0	0	0	0	0	0	0	0	0
U20M	0	0	0	0	0	0	0	0	0	0	0
U30A	0	0	0	0	0	0	0	0	0	0	0
U30B	1.5	0	28.5	30	0.1	0	0.1	20.43	0.65	0	0.65
U30C	0.36	0	6.84	7.2	0.1	0	0.1	3.976	0.65	0	0.65
U30D	0.27	0	5.13	5.4	0.1	0	0.1	3.068	0.65	0	0.65
U30E	0.415	0	7.885	8.3	0.1	0	0.1	4.704	0.65	0	0.65
U40A	0	0.38	7.22	7.41	0	0.1	0.1	5.53	0	0.65	0.65
U40B	0	0.67	12.73	13.06	0	0.1	0.1	11.56	0	0.65	0.65
U40C	0	0.35	6.65	6.825	0	0.1	0.1	4.304	0	0.65	0.65
U40D	0	0	0	0	0	0	0	0	0	0	0
U40E	0	0.135	2.565	2.632	0	0.1	0.1	1.823	0	0.65	0.65
U40F	0.67	0	12.73	13.4	0.1	0	0.1	13.17	0.65	0	0.65
U40G	0	0	0	0	0	0	0	0	0	0	0
U40H	0.2945	0	5.595	5.89	0.1	0	0.1	4.081	0.65	0	0.65
U40J	1.135	0	21.57	22.7	0.1	0	0.1	15.29	0.65	0	0.65
U50A	0	0	0	0	0	0	0	0	0	0	0
U60A	0	0	4.1	4.1	0	0	0.1	1.761	0	0	0.65

U60B	0	0	19.2	19.2	0	0	0.1	9.104	0	0	0.65
U60C	0	0	19.2	19.2	0	0	0.1	9.596	0	0	0.65
U60D	0	0	0	0	0	0	0	0	0	0	0
U60E	0	0	0	0	0	0	0	0	0	0	0
U60F	0	0	0	0	0	0	0	0	0	0	0
U70A	0	1.5	3.5	4.25	0	0.1	0.1	2.66	0	0.65	0.65
U70B	0	1.5	3.5	4.25	0	0.1	0.1	2.687	0	0.65	0.65
U70C	0	1.5	3.5	4.25	0	0.1	0.1	2.734	0	0.65	0.65
U70D	0	0.9	2.1	2.55	0	0.1	0.1	1.672	0	0.65	0.65
U70E	0	0.3	0.7	0.85	0	0.1	0.1	0.5756	0	0.65	0.65
U70F	0	0	0	0	0	0	0	0	0	0	0
U80A	0.12	0	0.48	0.6	0.1	0	0.1	0.2866	0.65	0	0.65
U80B	0	0	0	0	0	0	0	0	0	0	0
U80C	0.08	0	0.32	0.4	0.1	0	0.1	0.2339	0.65	0	0.65
U80D	0.6	0	2.4	3	0.1	0	0.1	1.899	0.65	0	0.65
U80E	1	0	4	5	0.1	0	0.1	3.814	0.65	0	0.65
U80F	0.4	0	1.6	2	0.1	0	0.1	1.472	0.65	0	0.65
U80G	0.4	0	1.6	2	0.1	0	0.1	1.557	0.65	0	0.65
U80H	0	0	0	0	0	0	0	0	0	0	0
U80J	0.08	0	0.32	0.4	0.1	0	0.1	0.2773	0.65	0	0.65
U80K	0	0	0	0	0	0	0	0	0	0	0
U80L	0	0	0	0	0	0	0	0	0	0	0
TOTAL	9.5195	36.181	404.817	432.42	1.7	4	7.55	238.58991	11.05	26	47.95

SFRA

	Area under alien vegetation	Area under dryland sugar cane	Area under afforestation	Area of indigenous forests	Reduction in runoff due to alien vegetation	Reduction in runoff due to dryland sugar cane	Reduction in runoff due to afforestation	River losses
	km2	km2	km2	km2	million m3/annum	million m3/annum	million m3/annum	million m3/annum
Quaternary catchment	aAAAi	aCAUi	aFCAi	aFINi	oARDo	oCRDo	oFRDo	vRTLi
T40A	12.77	0	9.027	22.93	3.01	0	1.222	0
T40B	79.68	0	123.6	8.437	13.78	0	14.18	0
T40C	3.99	0	5.08	2.429	0.6643	0	0.3596	0
T40D	11.12	0	9.646	9.4	1.437	0	0.5195	0
T40E	6.04	0	1.519	11.94	0.7611	0	0.08285	0
T40F	7.56	43	2.761	3.701	1.44	1.854	0.1587	0
T40G	12.38	188	0	9.293	2.21	8.105	0	0
T51A	1.97	0	0	0	0.74	0	0	0
T51B	1.76	0	2.786	0	0.65	0	0.3435	0
T51C	3.33	0	26.82	11.9	0.7502	0	2.788	0
T51D	1.12	0	8.06	0	0.44	0	0.9937	0
T51E	1.69	0	12.36	0	0.3862	0	1.401	0
T51F	1.86	0	0	0	0.6622	0	0	0
T51G	1.78	0	2.029	0	0.5701	0	0.1944	0
T51H	8.44	0	17.94	13.95	1.879	0	1.715	0
T51J	1.8	0	3.017	9.591	0.3655	0	0.289	0
T52A	3.07	0	62.26	6.413	0.6625	0	8.264	0
T52B	2.99	0	6.846	7.221	0.5925	0	0.6125	0
T52C	3.36	0	53.54	0.7849	0.593	0	3.796	0
T52D	4.83	0	67.93	0	0.5527	0	3.706	0
T52E	13.07	0	66.49	9.018	2.41	0	6.37	0
T52F	83.73	0	113.8	20.45	17.84	0	10.84	0
T52G	7.75	0	25.48	15.71	1.46	0	2.44	0
T52H	10.1	0	5.151	0	1.221	0	0.2683	0
T52J	7.36	37	10.39	0	0.9894	1.513	0.5543	0
T52K	63.63	64	98.86	0	7.717	2.832	5.401	0
T52L	14.11	27	0	20.49	2.191	1.15	0	0
T52M	15.68	51	0	7.427	2.493	2.171	0	0
U10A	1.41	0	0	0	0.61	0	0	0
U10B	6.49	0	0	0	2.733	0	0	0
U10C	4.08	0	0	0	1.495	0	0	0
U10D	4.46	0	0.745	0	1.338	0	0.1534	0
U10E	3.71	0	25.97	11.31	1.24	0	5.059	0
U10F	3.04	0	24.21	13.4	0.6947	0	2.163	0
U10G	2.91	0	26.19	7.957	0.7186	0	2.668	0
U10H	3.66	0	112.5	1.194	0.8412	0	10.82	0
U10J	4.21	26	99.61	19.05	0.6026	1.288	6.748	0
U10K	4.42	19	62.8	0	0.4867	0.8407	3.419	0
U10L	2.67	16	12.49	0	0.2255	0.6357	0.7075	0
U10M	2.7	14.6	0	0	0.3019	0.6847	0	0
U20A	6.76	0	45.81	4.693	1.965	0	5.882	0
U20B	7.67	0	42.74	9.618	1.649	0	5.188	0
U20C	6.33	0	36.18	10.4	1.234	0	3.629	0
U20D	2.92	9.7	72.3	41.8	0.6161	0.7284	9.14	0

U20E	2.17	49.59	101.4	10.57	0.3907	3.223	10.39	0
U20F	9.36	224.9	160.8	17.18	1.668	14.07	13.32	0
U20G	10.49	200.6	38.05	0	1.446	10.08	1.947	0
U20H	1.57	0	5.556	1.61	0.3058	0	0.521	0
U20J	5.88	2.35	20.56	10.15	0.639	0.1312	1.443	0
U20K	2.16	86.97	5.632	0.8684	0.3282	3.859	0.2593	0
U20L	1.89	0.97	0	0	0.1701	0.05709	0	0
U20M	24.13	5.4	0	0	3.069	0.3178	0	0
U30A	3.46	26.15	2.475	7.896	0.6819	1.16	0.1458	0
U30B	37.58	84.07	0	0	4.547	3.802	0	0
U30C	2.35	42.48	1.552	1.658	0.425	1.958	0.09688	0
U30D	26.52	112.3	0	0	4.555	5.078	0	0
U30E	6.6	241.8	0	0	1.103	10.94	0	0
U40A	66	37.8	178.6	3.496	10.51	2.556	13.5	0
U40B	47.18	46.4	170.7	0	5.298	1.871	8.508	0
U40C	5.53	31.6	75.92	0	0.6963	1.388	3.839	0
U40D	9.49	15.2	24.2	0	1.114	0.6675	1.127	0
U40E	2.35	30.5	4.812	4.146	0.2829	1.339	0.3232	0
U40F	15.07	27.9	116.1	0	1.389	1.076	5.555	0
U40G	2.52	10.5	0	0	0.3276	0.5824	0	0
U40H	2.96	42.83	0	0	0.4492	2.376	0	0
U40J	2.17	127	2.584	0	0.3637	8.198	0.2224	0
U50A	3.06	0	3.468	2.422	0.6024	0	0.3747	0
U60A	0.56	10.89	47.47	7.143	0.1118	0.5073	3.91	0
U60B	3.09	204.9	48.26	1.083	0.3578	10.67	2.589	0
U60C	10.72	71.99	0.5192	0	1.315	3.094	0.02976	0
U60D	4.51	0	0	0.7524	0.6968	0	0	0
U60E	3.18	48.65	4.52	0	0.4785	2.091	0.259	0
U60F	18.52	2.13	0.5976	0	2.607	0.07127	0.02666	0
U70A	9.39	0.41	72.97	8.81	1.655	0.03599	8.15	0
U70B	6.34	110.4	110.5	0	0.7618	4.267	6.099	0
U70C	2.73	145.5	22.8	0	0.3248	5.562	1.198	0
U70D	2.61	18.02	0	0	0.3925	0.989	0	0
U70E	1.18	0	0	0	0.2103	0	0	0
U70F	0	0	0	0	0	0	0	0
U80A	14.19	26	0	0	2.767	1.058	0	0
U80B	2.9	13	25	0.6297	0.2886	0.5317	1.364	0
U80C	4.83	30	1.075	0.9833	0.7637	1.227	0.05864	0
U80D	4.41	20	0	0	0.8851	0.8136	0	0
U80E	3.74	42	79.55	2.024	0.3978	1.625	4.334	0
U80F	1.65	22	1.642	0	0.2416	0.8998	0.08956	0
U80G	2.84	91	43.84	0	0.4243	3.722	2.391	0
U80H	2.19	85	30.16	4.448	0.4027	3.477	1.645	0
U80J	3.7	19	36.32	0	0.4182	0.7352	1.954	0
U80K	1.74	32	0.7764	6.167	0.2678	1.309	0.04234	0
U80L	1.48	19	0	0	0.2492	0.7729	0	0
TOTAL	851.4	2954.5	2735.3462	402.5437	141.5981	139.99125	217.78849	0

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

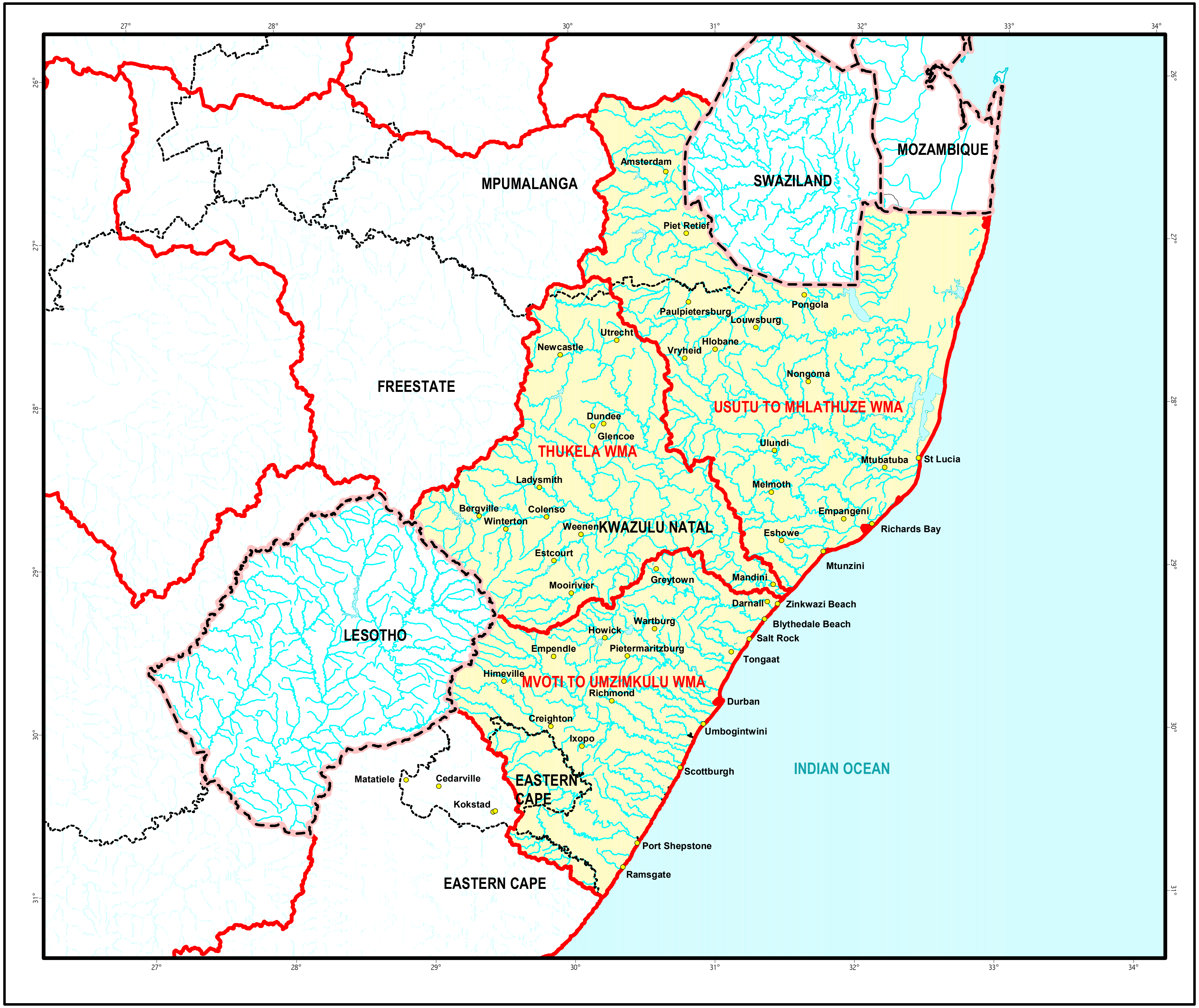
Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D16J	374	374	7	10	203	75922	0.0761	0.1584	255	95551	0.0957	0.1993
D16K	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

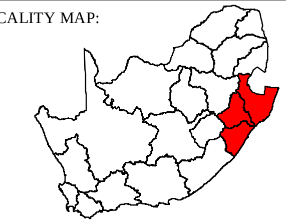
Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
0	**5507**	**5507**				**1627012**	**1.6303**	**0.6465**		**2047654.1**	**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



LOCALITY MAP:



BASE MAP LEGEND:

	GIS COV:
WMA Boundaries	Watermang
International Border	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

N

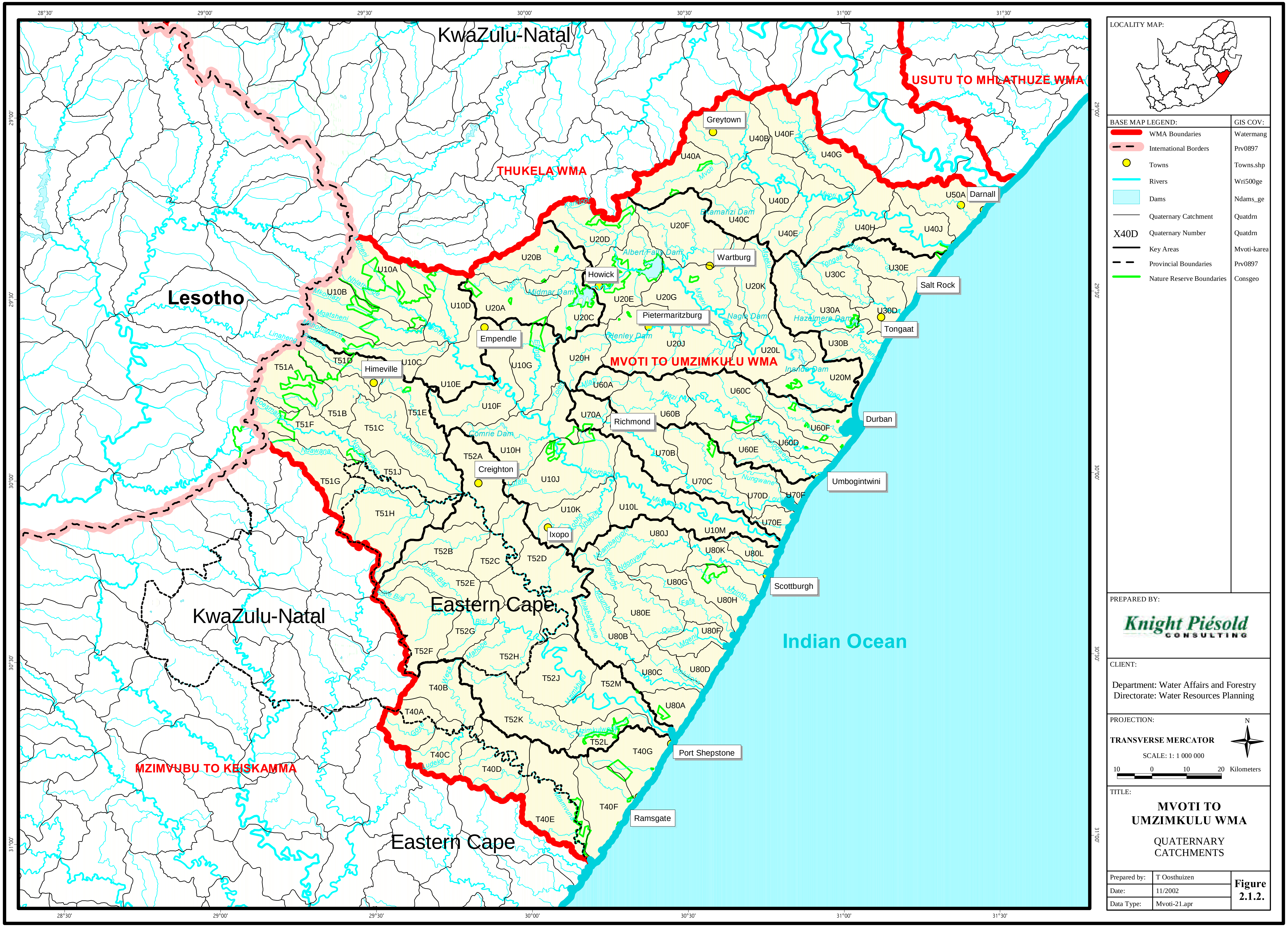
SCALE: 1: 2 500 000

TITLE:

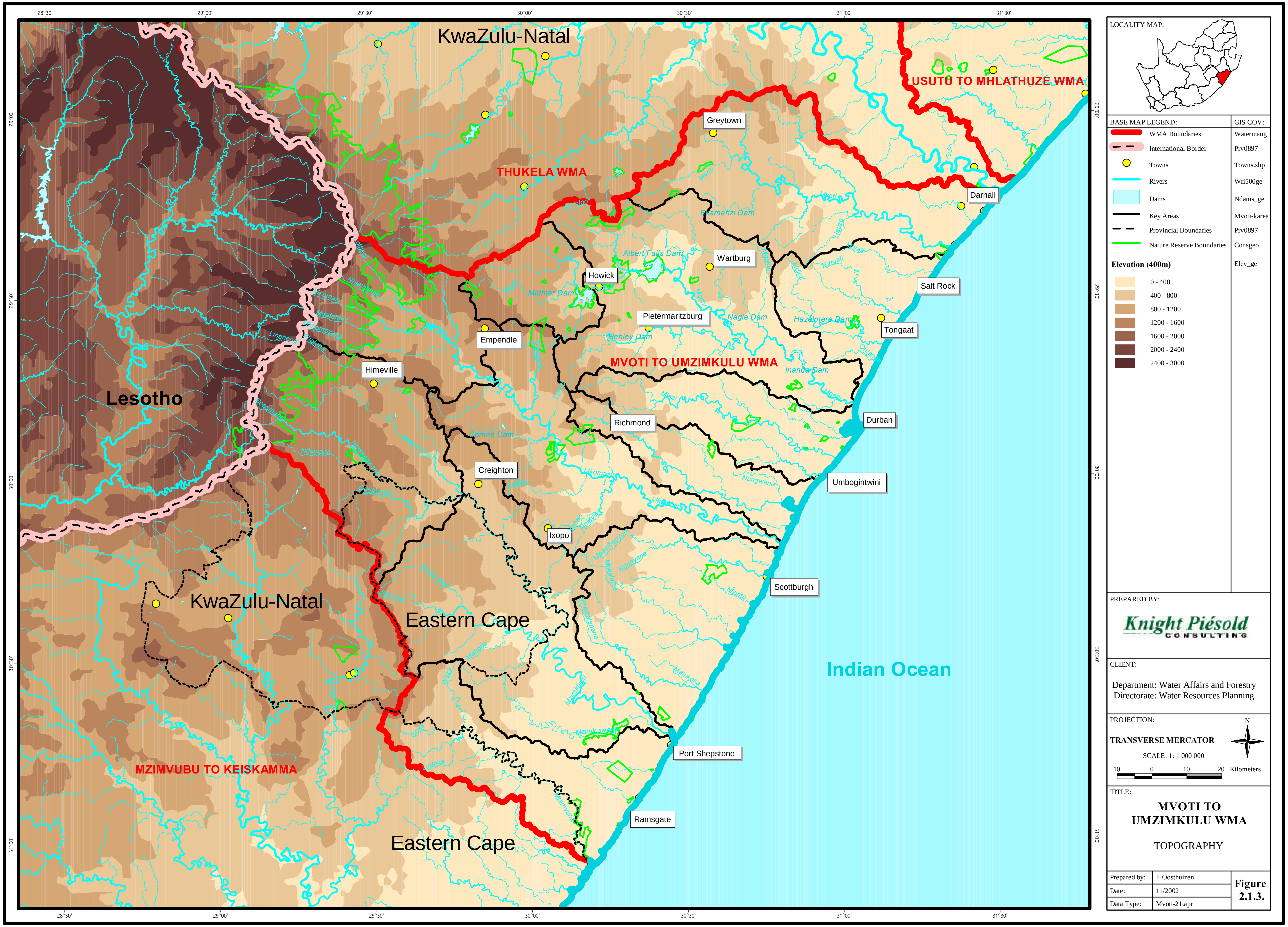
USUTHU TO MHLATHUZE WMA
THUKELA WMA
MVOTI TO UMZIMKULU WMA

LOCALITY PLAN

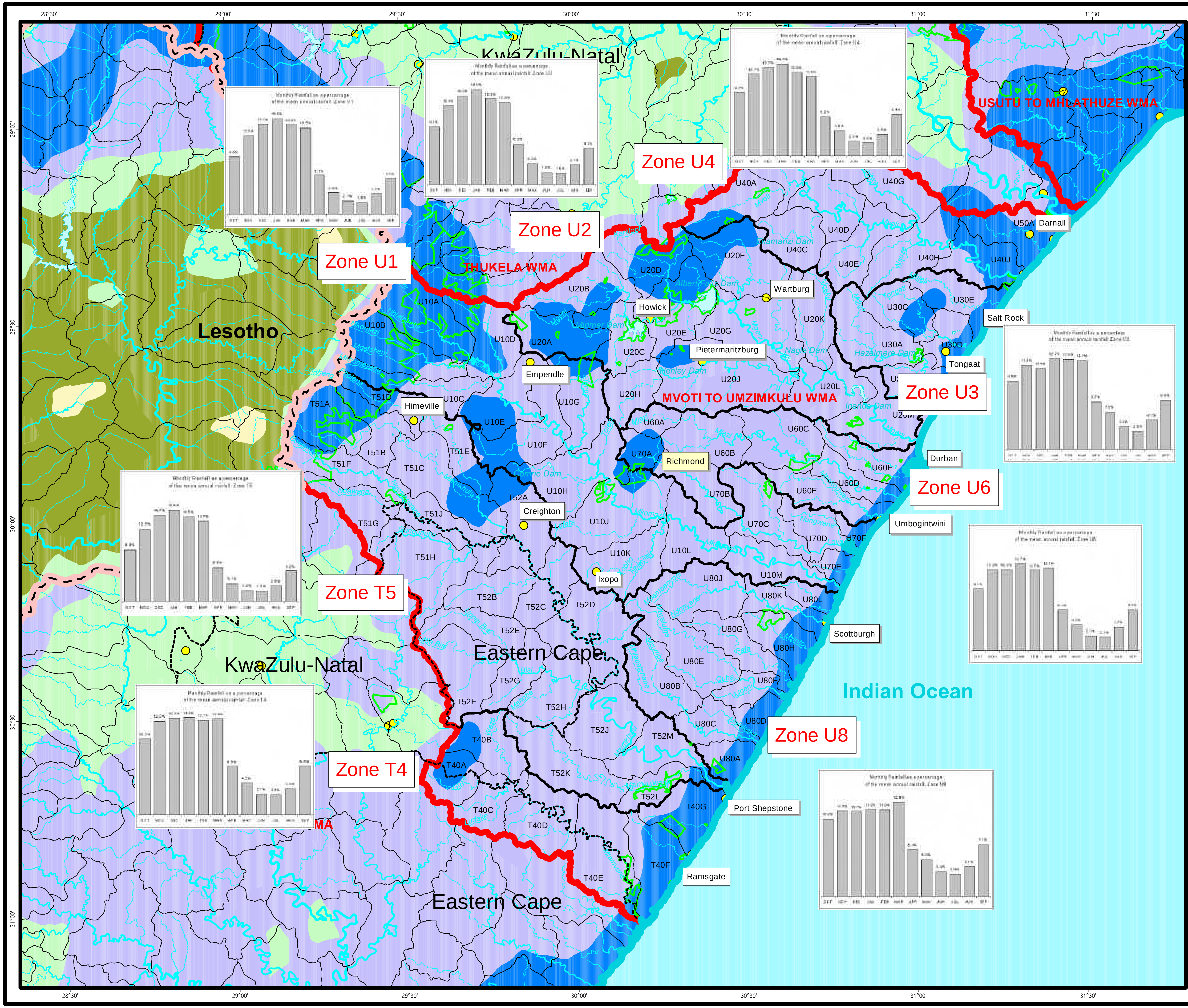
Prepared by:	T Oosthuizen	**Figure 2.1.1**
Date:	02/2002	
Data Type:	mvoti-11.apr	



KwaZulu-Natal
Lesotho
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
Eastern Cape
Indian Ocean
Greytown
Darnall
Wartburg
Howick
Salt Rock
Pietermaritzburg
Tongaat
Empendle
Himeville
Durban
Richmond
Umbogintwini
Creighton
Ixopo
Scottburgh
Port Shepstone
Ramsgate
LOCALITY MAP:
BASE MAP LEGEND:
WMA Boundaries
International Borders
Towns
Rivers
Dams
Quaternary Catchment
X40D Quaternary Number
Key Areas
Provincial Boundaries
Nature Reserve Boundaries
GIS COV:
Watermang
Prv0897
Towns.shp
Wri500ge
Ndams_ge
Quatdm
Quatdm
Mvoti-karea
Prv0897
Consgeo
PREPARED BY:
Knight Piésold CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
TITLE:
MVOTI TO UMZIMKULU WMA
QUATERNARY CATCHMENTS
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-21.apr
Figure 2.1.2.



KwaZulu-Natal
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
Lesotho
Eastern Cape
Indian Ocean
Greytown
Darnall
Wartburg
Howick
Salt Rock
Pietermaritzburg
Tongaat
Empendle
Himeville
Richmond
Durban
Creighton
Umbogintwini
Ixopo
Scottburgh
Port Shepstone
Ramsgate
Albert Falls Dam
Midmar Dam
Nagle Dam
Henley Dam
Hazelmere Dam
Inanda Dam
Comrie Dam
LOCALITY MAP:
BASE MAP LEGEND:
WMA Boundaries
International Border
Towns
Rivers
Dams
Key Areas
Provincial Boundaries
Nature Reserve Boundaries
Elevation (400m)
0 - 400
400 - 800
800 - 1200
1200 - 1600
1600 - 2000
2000 - 2400
2400 - 3000
GIS COV:
Watermang
Prv0897
Towns.shp
Wri500ge
Ndams_ge
Mvoti-karea
Prv0897
Consgeo
Elev_ge
PREPARED BY:
Knight Piésold
CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
N
TITLE:
MVOTI TO UMZIMKULU WMA
TOPOGRAPHY
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-21.apr
Figure 2.1.3.



LOCALITY MAP:

BASE MAP LEGEND: | GIS COV:

		GIS COV
	WMA Boundaries	Watermang
	International Border	Prv0897
	Towns	Towns.shp
	Rivers	Wri500ge
	Dams	Ndams_ge
	Quaternary Catchment	Quatdrn
X40D	Quaternary Number	Quatdrn
	Rainfall Zones	secdrn
	Provincial Boundaries	Prv0897
	Nature Reserve Boundaries	Consgeo

Mean Annual Precipitation RIP

- 500 - 600 mm
- 600 - 700 mm
- 700 - 800 mm
- 800 - 1000 mm
- 1000 - 1500 mm
- > 1500 mm

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

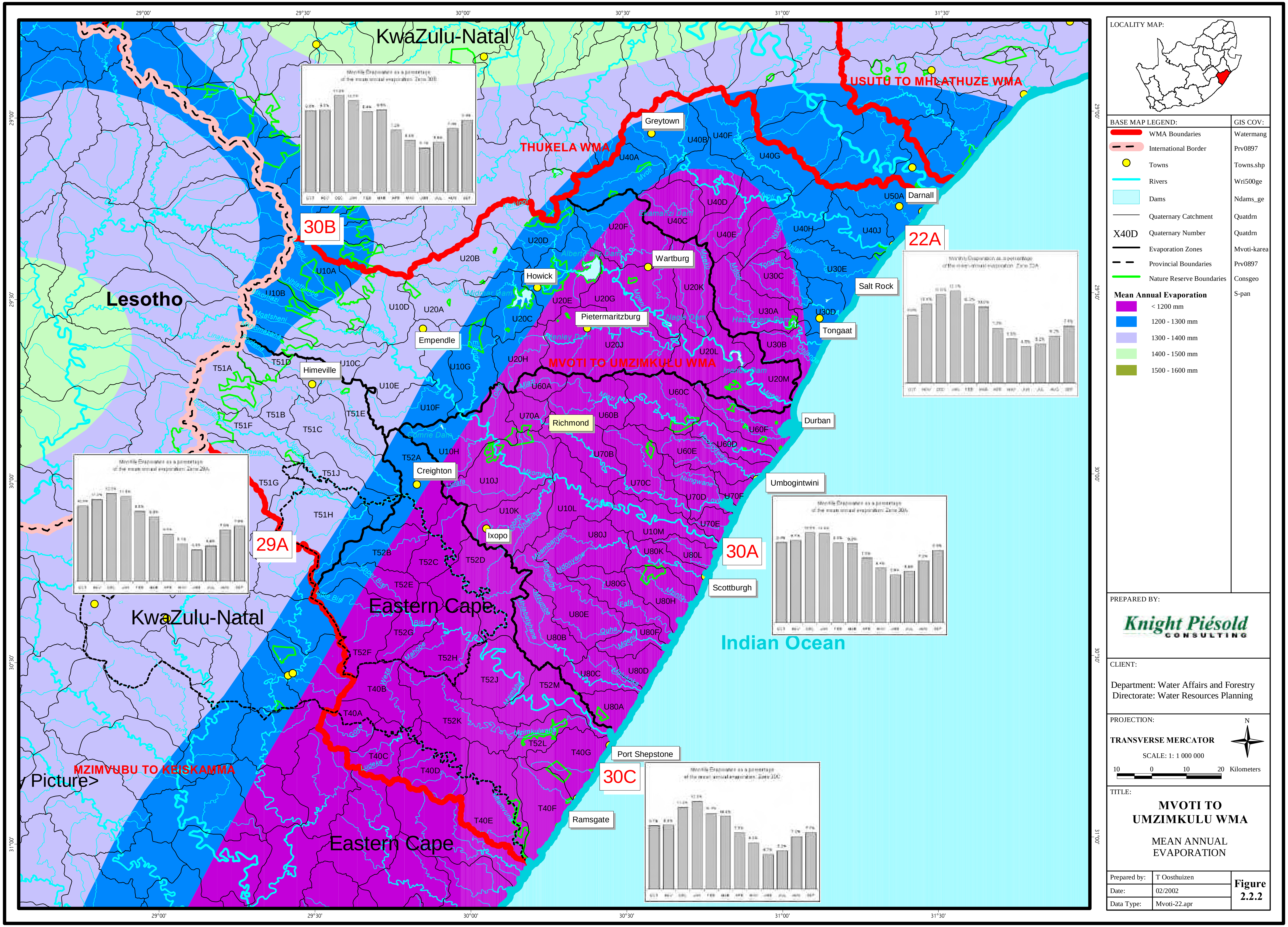
10 0 10 20 Kilometers

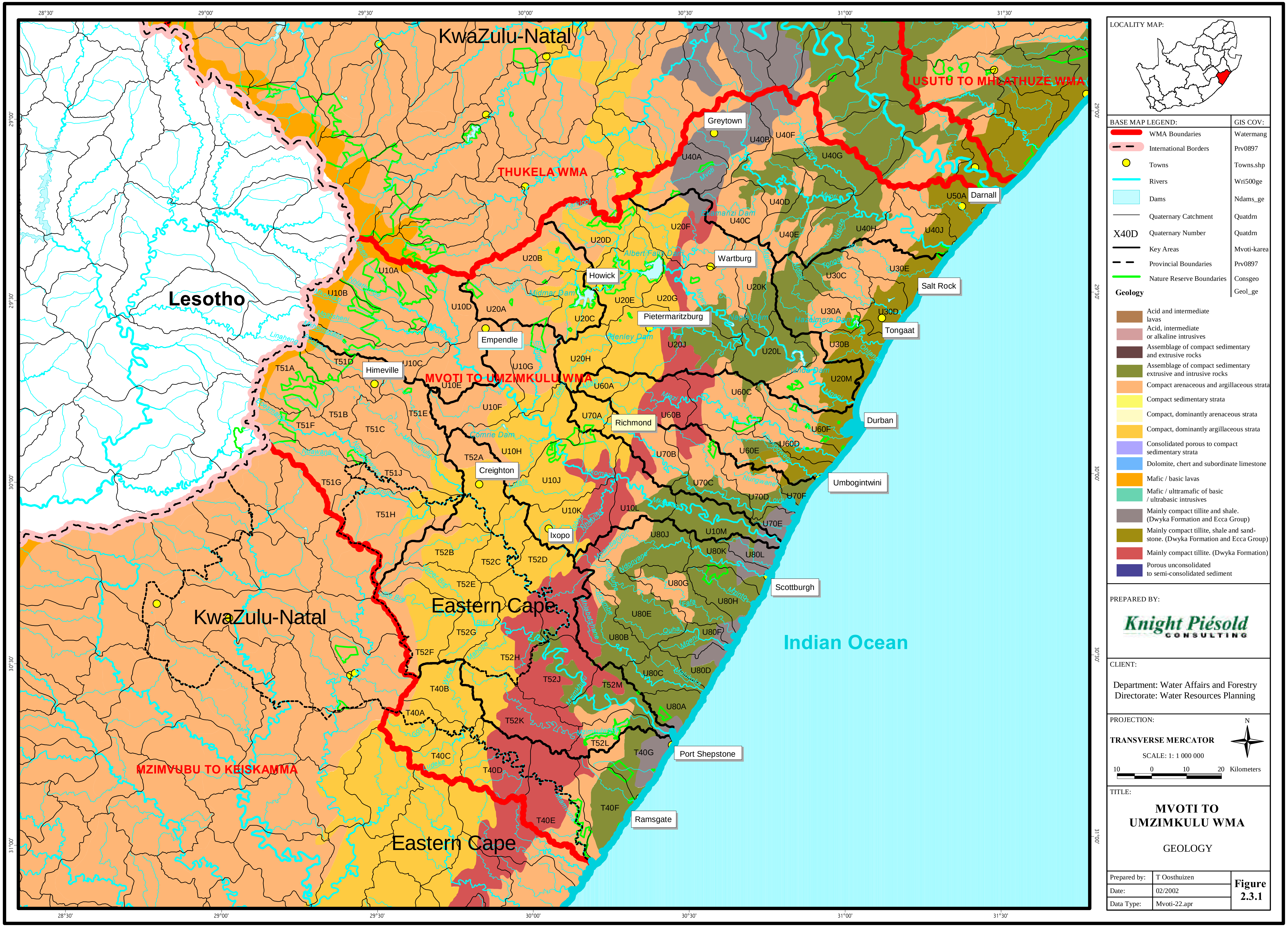
TITLE:

MVOTI TO UMZIMKULU WMA

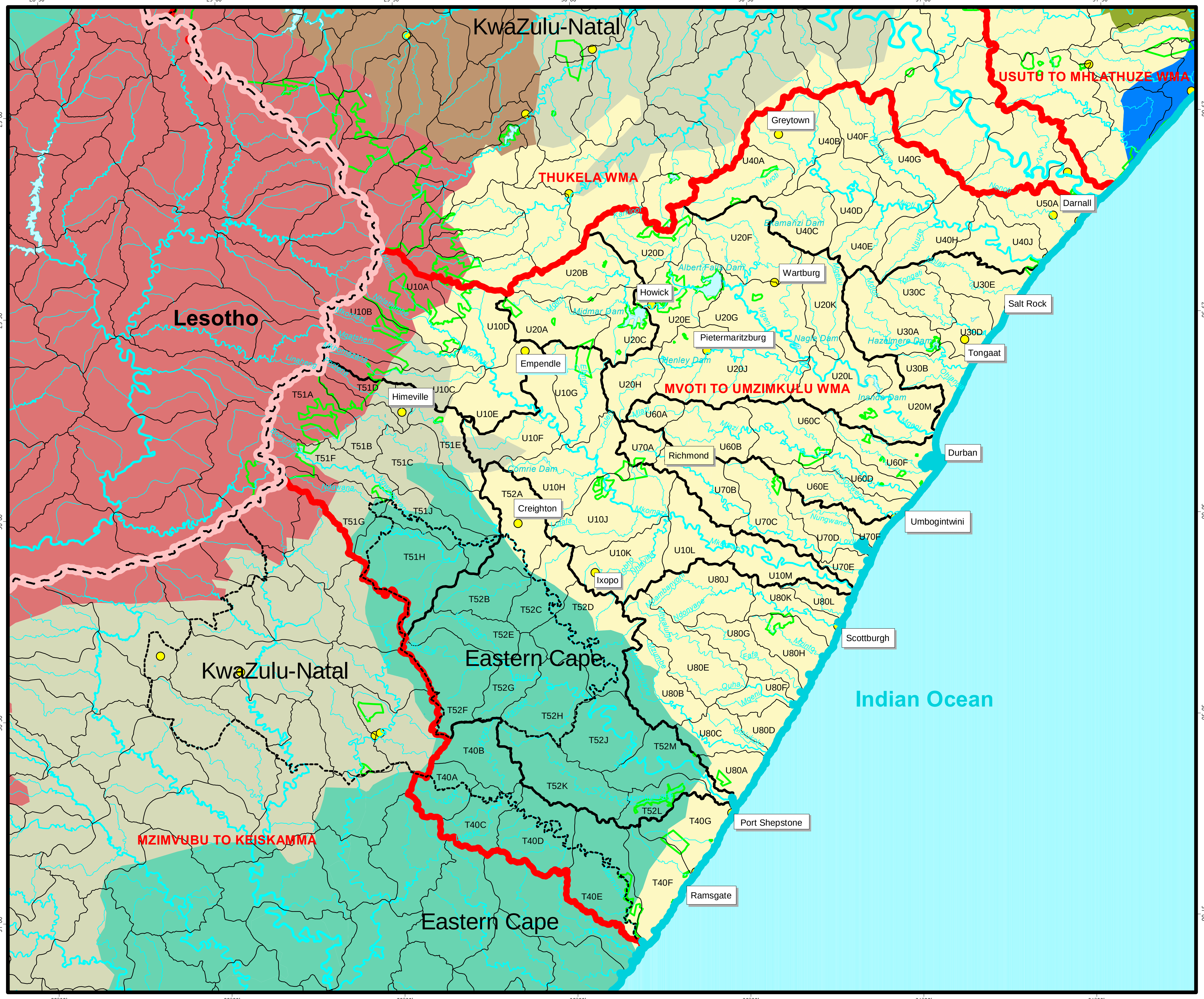
MEAN ANNUAL PRECIPITATION

Prepared by:	T Oosthuizen	**Figure 2.2.1**
Date:	02/2002	
Data Type:	Mvoti-22.apr	


KwaZulu-Natal
Lesotho
Eastern Cape
KwaZulu-Natal
Eastern Cape
Indian Ocean
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
30B
22A
29A
30A
30C
Greytown
Darnall
Wartburg
Howick
Salt Rock
Pietermaritzburg
Tongaat
Empendle
Himeville
Richmond
Durban
Creighton
Umbogintwini
Ixopo
Scottburgh
Port Shepstone
Ramsgate
Monthly Evaporation as a percentage of the mean annual evaporation: Zone 30B
Monthly Evaporation as a percentage of the mean annual evaporation: Zone 22A
Monthly Evaporation as a percentage of the mean annual evaporation: Zone 29A
Monthly Evaporation as a percentage of the mean annual evaporation: Zone 30A
Monthly Evaporation as a percentage of the mean annual evaporation: Zone 30C
LOCALITY MAP:
BASE MAP LEGEND:
WMA Boundaries
International Border
Towns
Rivers
Dams
Quaternary Catchment
X40D Quaternary Number
Evaporation Zones
Provincial Boundaries
Nature Reserve Boundaries
GIS COV:
Watermang
Prv0897
Towns.shp
Wri500ge
Ndams_ge
Quatdrn
Quatdrn
Mvoti-karea
Prv0897
Consgeo
S-pan
Mean Annual Evaporation
< 1200 mm
1200 - 1300 mm
1300 - 1400 mm
1400 - 1500 mm
1500 - 1600 mm
PREPARED BY:
Knight Piésold
CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
N
TITLE:
MVOTI TO UMZIMKULU WMA
MEAN ANNUAL EVAPORATION
Prepared by: T Oosthuizen
Date: 02/2002
Data Type: Mvoti-22.apr
Figure 2.2.2



KwaZulu-Natal
Lesotho
Eastern Cape
KwaZulu-Natal
Eastern Cape
Indian Ocean
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
Greytown
Wartburg
Howick
Pietermaritzburg
Empendle
Himeville
Richmond
Creighton
Ixopo
Darnall
Salt Rock
Tongaat
Durban
Umbogintwini
Scottburgh
Port Shepstone
Ramsgate
LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
WMA Boundaries | Watermang
International Borders | Prv0897
Towns | Towns.shp
Rivers | Wri500ge
Dams | Ndams_ge
Quaternary Catchment | Quatdm
X40D Quaternary Number | Quatdm
Key Areas | Mvoti-karea
Provincial Boundaries | Prv0897
Nature Reserve Boundaries | Consgeo
Geology | Geol_ge
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. (Dwyka Formation and Ecca Group)
Mainly compact tillite, shale and sand-stone. (Dwyka Formation and Ecca Group)
Mainly compact tillite. (Dwyka Formation)
Porous unconsolidated to semi-consolidated sediment
PREPARED BY:
Knight Piésold CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
N
TITLE:
MVOTI TO UMZIMKULU WMA
GEOLOGY
Prepared by: T Oosthuizen
Date: 02/2002
Data Type: Mvoti-22.apr
Figure 2.3.1



LOCALITY MAP:

BASE MAP LEGEND:

		GIS COV:
	WMA Boundaries	Watermang
	International Borders	Prv0897
	Towns	Towns.shp
	Rivers	Wri500ge
	Dams	Ndams_ge
	Quaternary Catchment	Quatdm
X40D	Quaternary Number	Quatdm
	Key Areas	Mvoti-karea
	Provincial Boundaries	Prv0897
	Nature Reserve Boundaries	Consgeo
Soils		Soi

Texture	Relief	Depth
Moderate to Deep	Steep	Clay Soil
Moderate to Deep	Undulating	Clay Soil
Moderate to Deep	Steep	Clay Loam
Moderate to Deep	Undulating	Clay Loam
Moderate to Deep	Steep	Sandy Loam
Moderate to Deep	Undulating	Sandy Loam
Moderate to Deep	Flat	Sandy Soil

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

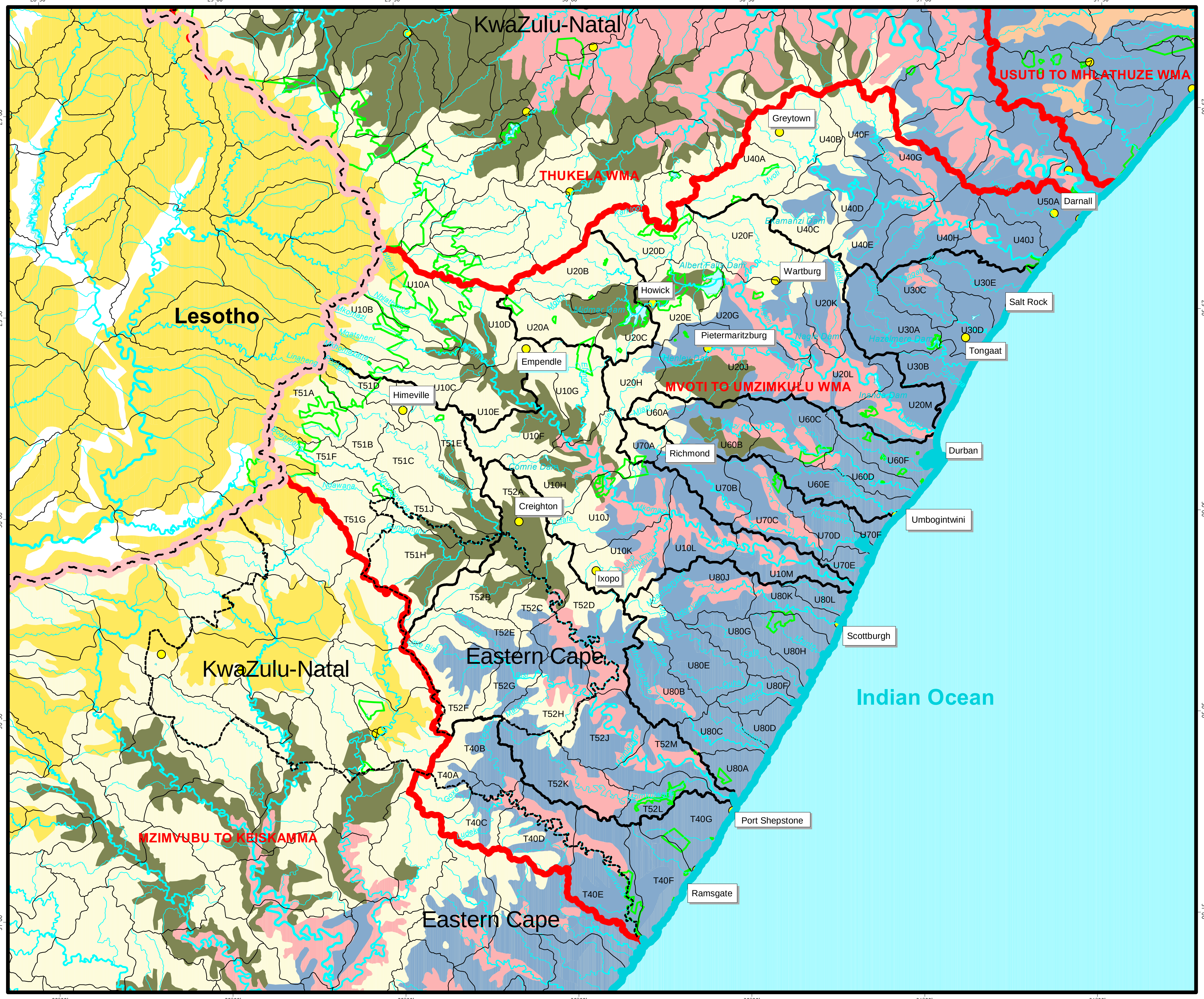
N

TITLE:

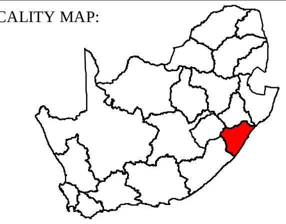
MVOTI TO UMZIMKULU WMA

SOILS

Prepared by:	T Oosthuizen	Figure 2.4.1
Date:	02/2002	
Data Type:	Mvoti-22.apr	



LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Areas	Mvoti-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Natural Vegetation	Acocks

- Coastal Tropical Forest
- Inland Tropical Forest
- Tropical Bush and Savanna
- False Bushveld
- Karoo and Karroid
- False Karoo
- Temperate and Transitional Forest and Scrub
- Pure Grassveld
- False Grassveld
- Sclerophyllous Bush
- False Sclerophyllous Bush

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

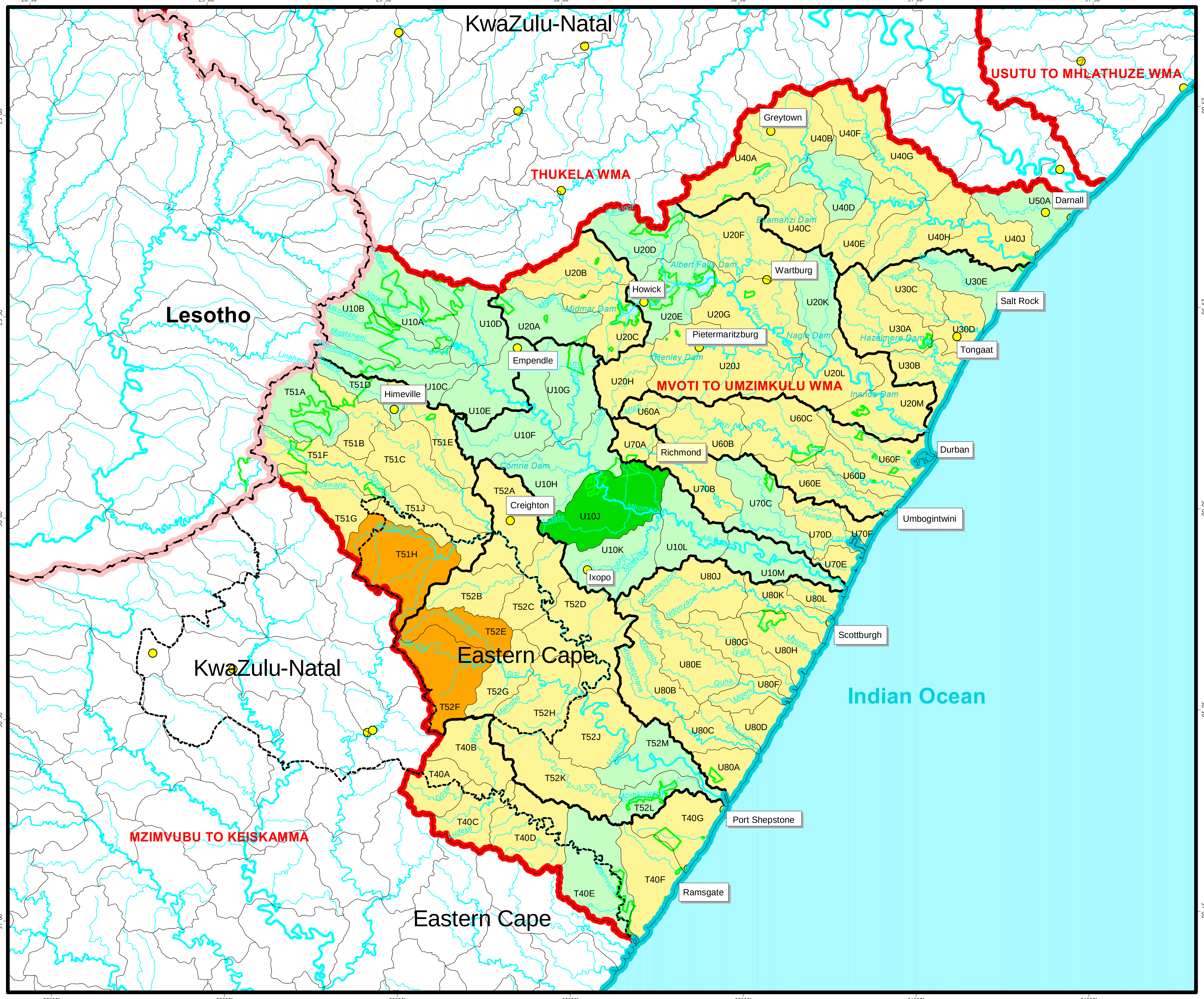
N

TITLE:

MVOTI TO UMZIMKULU WMA

NATURAL VEGETATION

Prepared by:	T Oosthuizen	Figure 2.5.2.1
Date:	02/2002	
Data Type:	Mvoti-22.apr	



LOCALITY MAP:

BASE MAP LEGEND:

		GIS COV:
	WMA Boundaries	Watermang
	International Borders	Prv0897
	Towns	Towns.shp
	Rivers	Wri500ge
	Dams	Ndams_ge
	Quaternary Catchment	Quatdrn
X40D	Quaternary Number	Quatdrn
	Key Areas	Mvoti-karea
	Provincial Boundaries	Prv0897
	Nature Reserve Boundaries	Consgeo

Default Ecological Management Classes — Quatdrn

- 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:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

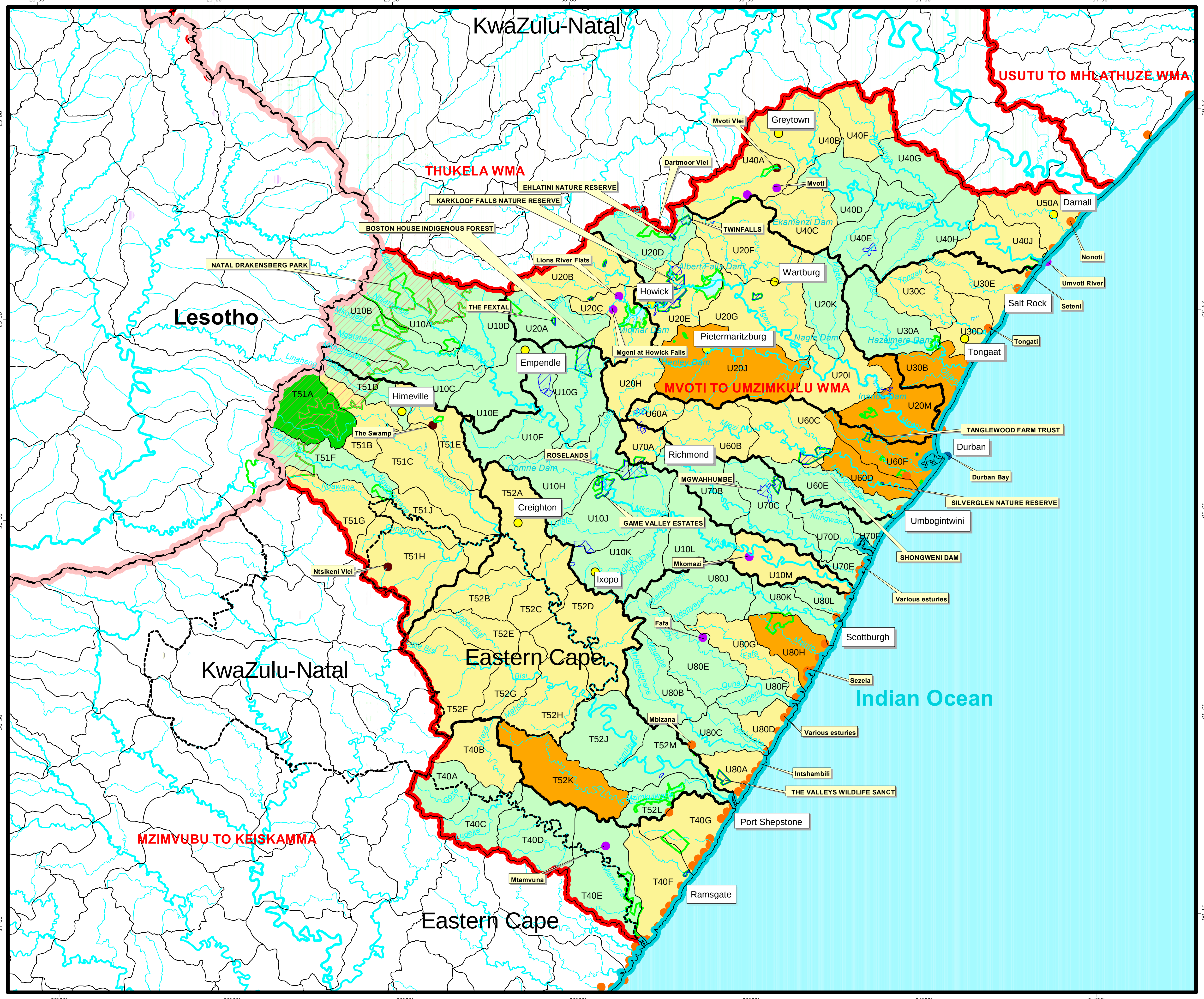
TITLE:

MVOTI TO UMZIMKULU WMA

DEFAULT ECOLOGICAL MANAGEMENT CLASSES

Prepared by:	T Oosthuizen
Date:	11/2002
Data Type:	Mvoti-26.apr

Figure 2.6.3.1



LOCALITY MAP:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Areas	Mvoti-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Present Ecological Status Classes	Quatdm
Class A: Unmodified, Natural	
Class B: Largely Natural	
Class C: Moderately Modified	
Class D: Largely Modified	
Ecologically Sensitive Sites	
Lacustrine wetlands	wetllacu
Riverine wetlands	wetlrive
Palustrine wetlands	wetlpalu
Marine wetlands	wetlmari
Esturine wetlands	wetlestu
Heritage Sites	heritage.shp
RAMSAR Sites	ramsar

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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Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

N

SCALE: 1: 1 000 000

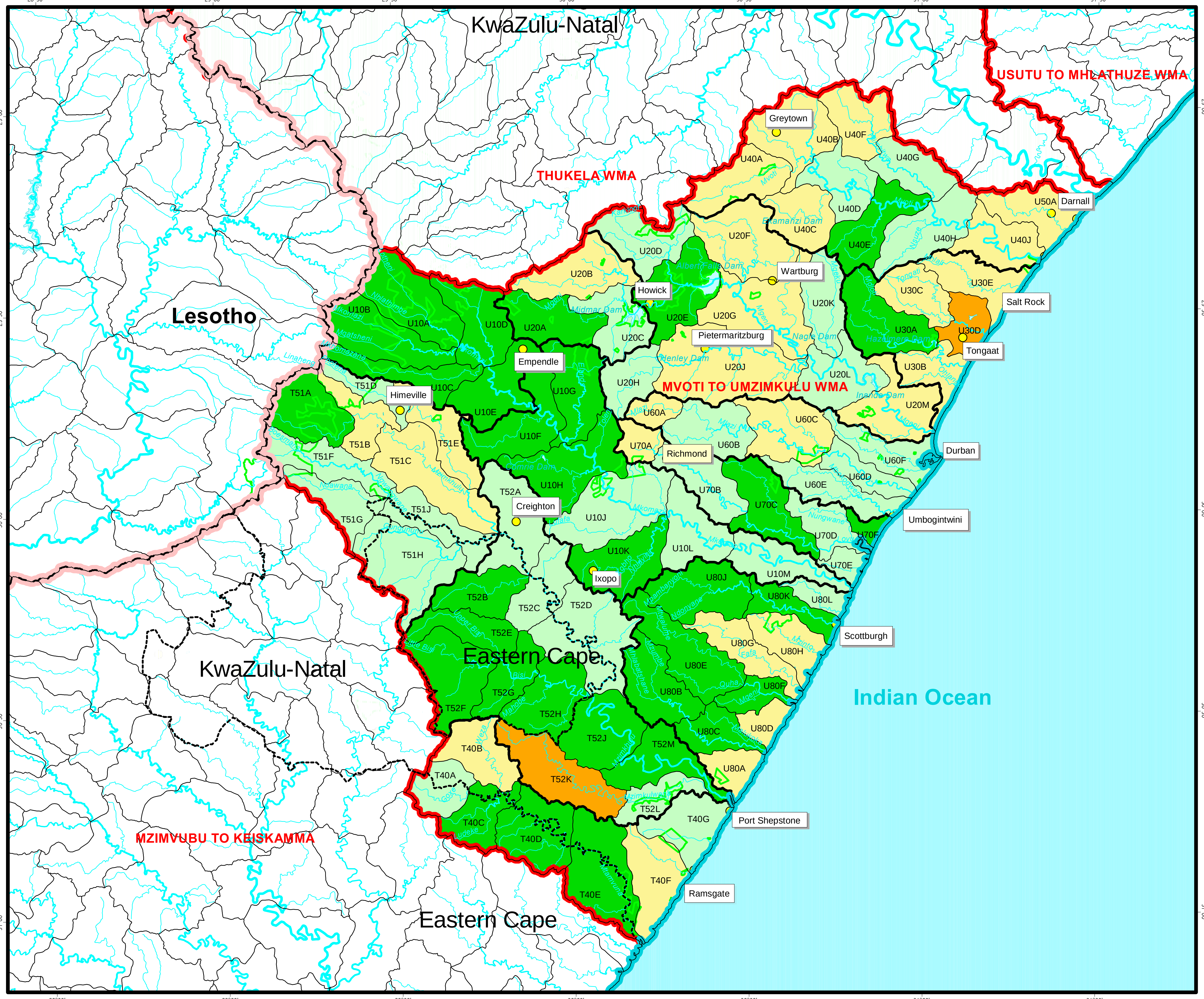
10 0 10 20 Kilometers

TITLE:

MVOTI TO UMZIMKULU WMA
PRESENT ECOLOGICAL STATUS CLASS AND ECOLOGICALLY SENSITIVE SITES

Prepared by:	T Oosthuizen
Date:	11/2002
Data Type:	Mvoti-26.apr

Figure 2.6.3.2



LOCALITY MAP:

BASE MAP LEGEND:

		GIS COV:
	WMA Boundaries	Watermang
	International Borders	Prv0897
	Towns	Towns.shp
	Rivers	Wri500ge
	Dams	Ndams_ge
	Quaternary Catchment	Quatdm
X40D	Quaternary Number	Quatdm
	Key Areas	Mvoti-karea
	Provincial Boundaries	Prv0897
	Nature Reserve Boundaries	Consgeo

Suggested Future Ecological Management Classes — Quatdm

- 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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Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

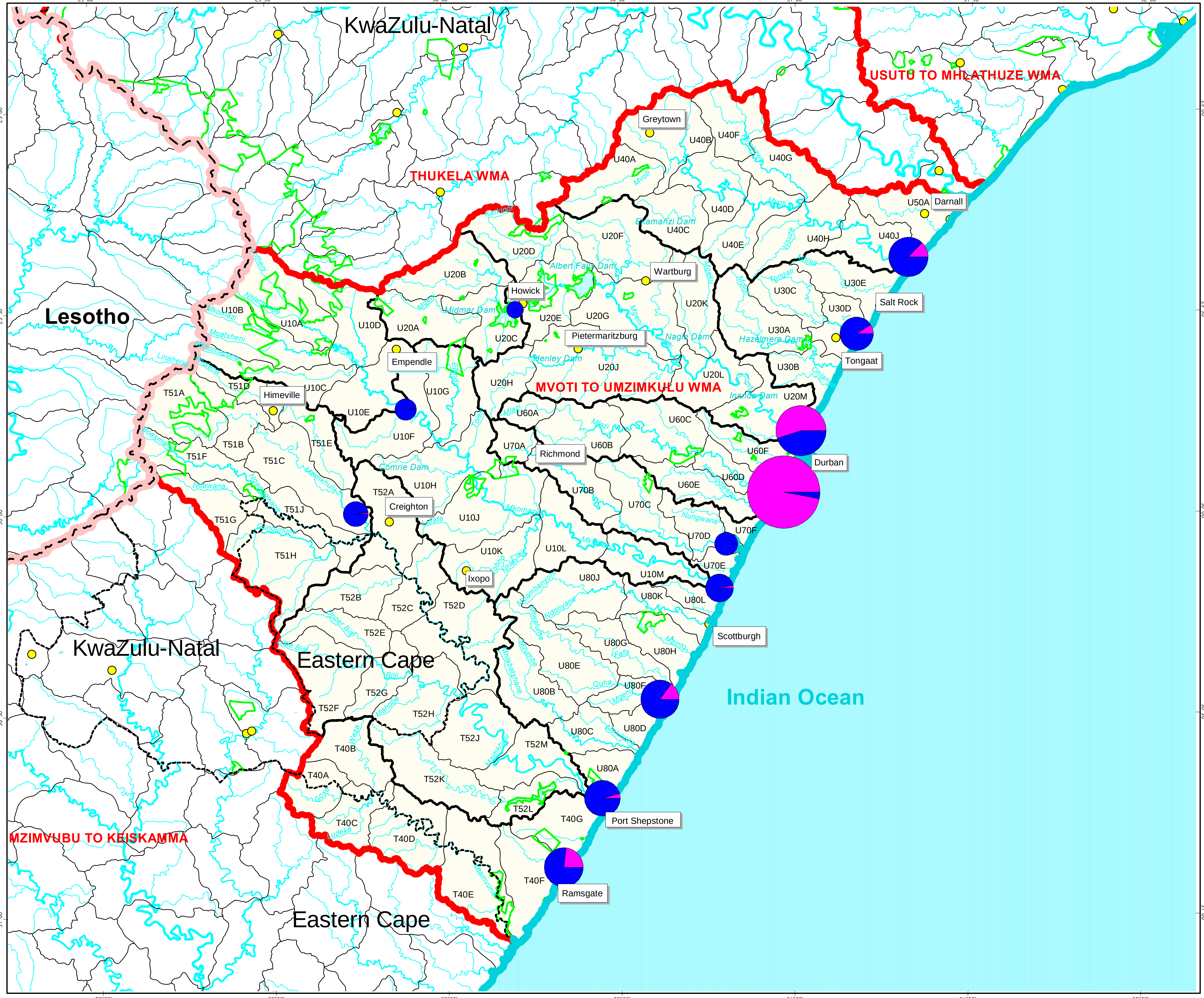
N

TITLE:

MVOTI TO UMZIMKULU WMA

SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASSES

Prepared by:	T Oosthuizen	**Figure 2.6.3.3**
Date:	11/2002	
Data Type:	Mvoti-26.apr	



LOCALITY MAP:

BASE MAP LEGEND:

		GIS COV:
	WMA Boundaries	Watermang
	International Borders	Prv0897
	Towns	Towns.shp
	Rivers	Wri500ge
	Dams	Ndams_ge
	Quaternary Catchment	Quatdrn
X40D	Quaternary Number	Quatdrn
	Key Areas	Mvo-karea
	Provincial Boundaries	Prv0897
	Nature Reserve Boundaries	Consgeo

Population — WSAM

Rural

Urban

Population Quantity

25 000

250 000

2 575 000

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

N

TITLE:

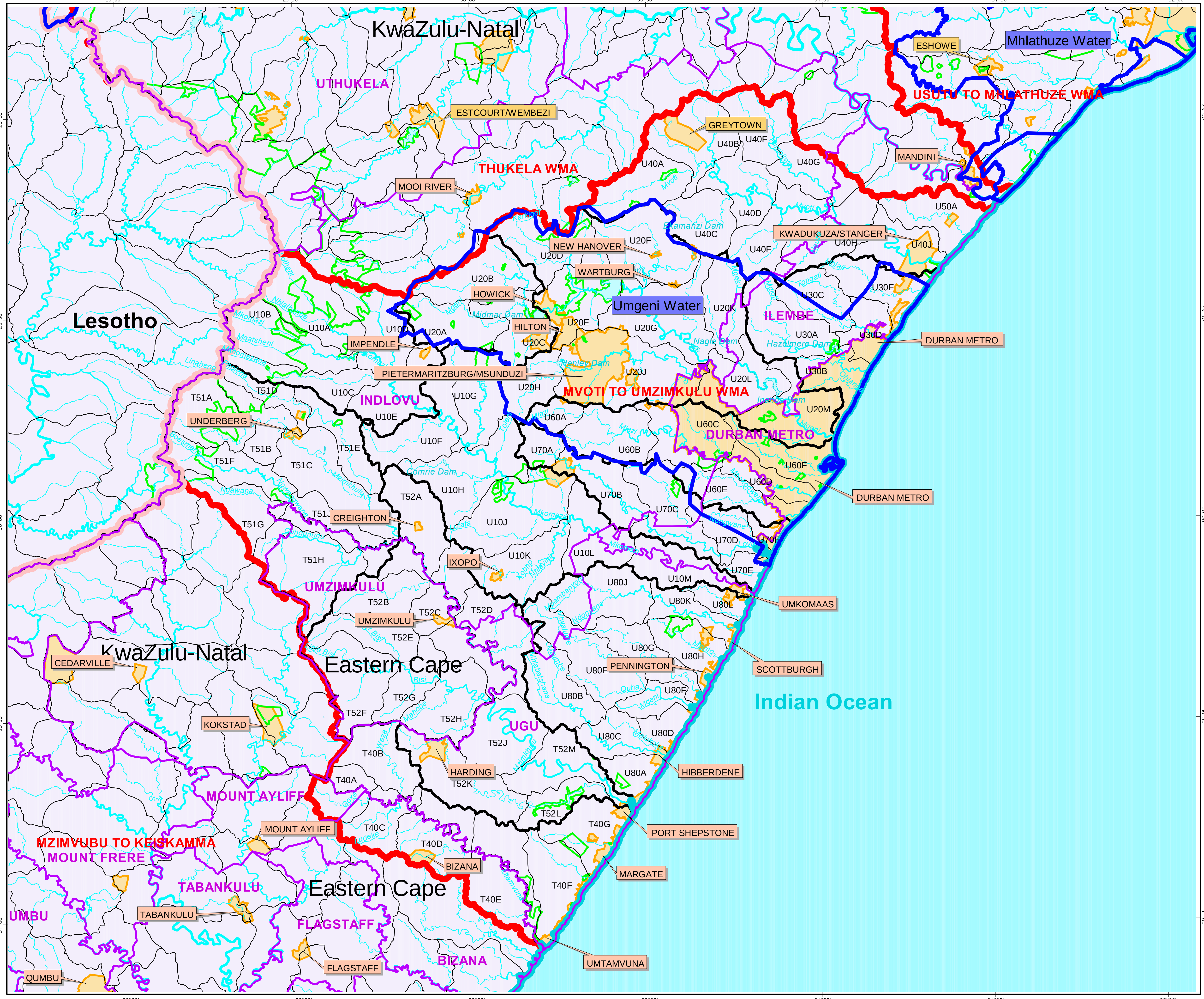
MVOTI TO UMZIMKULU WMA

POPULATION DISTRIBUTION

Prepared by:	T Oosthuizen
Date:	11/2002
Data Type:	Mvoti-32.apr

Figure 3.2.4.1


LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
WMA Boundaries
Watermang
International Borders
Prv0897
Towns
Towns.shp
Rivers
Wri500ge
Dams
Ndams_ge
Quaternary Catchment
Quatdrn
X40D
Quaternary Number
Quatdrn
Key Areas
Mvo-karea
Provincial Boundaries
Prv0897
Nature Reserve Boundaries
Consgeo
Magisterial Districts
Mag96_ge
District Councils
SADC
RC1 uThungulu
RC3 uMzinyathi
RC4 uThukela
RC5 iNdlovu
RC6 Ilembe
RC7 Ugu
Durban Metro
Wild Coast
PREPARED BY:
Knight Piésold
CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
N
SCALE: 1: 1 000 000
10
0
10
20
Kilometers
TITLE:
MVOTI TO UMZIMKULU WMA
DISTRICT COUNCILS AND MAGISTERIAL DISTRICTS
Prepared by:
T Oosthuizen
Date:
11/2002
Data Type:
Mvoti-32.apr
Figure 3.4.8.1
RC1 UTHUNGULU
USUTU TO MHLATHUZE WMA
THUKELA WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
RC6 ILEMBE
DURBAN METRO
RC5 INDLOVU
RC7 UGU
WILD COAST
Lesotho
KwaZulu-Natal
Eastern Cape
Indian Ocean
Weenen
Estcourt
Mooirivier
Greytown
Umvoti
Kranskop
Eshowe
Mtunzini
Mapumulo
Darnall
Lower Tugela
Salt Rock
Tongaat
Ndwedwe
Inanda
Pinetown
Chatsworth
Durban
Umlazi
Umbogintwini
Umbumbulu
Wartburg
New Hanover
Howick
Lions River
Pietermaritzburg
Empendle
Polela
Himeville
Underberg
Richmond
Camperdown
Creighton
Impendle
Ixopo
Transkei
Mount Currie
Umzinto
Scottburgh
Alfred
Port Shepstone
Ramsgate
Mount Ayliff
Mount Frere
Bizana
Flagstaff
Tabankulu
Qumbu



LOCALITY MAP:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Areas	Mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Waterboard Boundaries	Waterbrd

Local/Regional Councils

Transitional Local Council	Salc
Transitional Regional Councils	Sarc

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Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

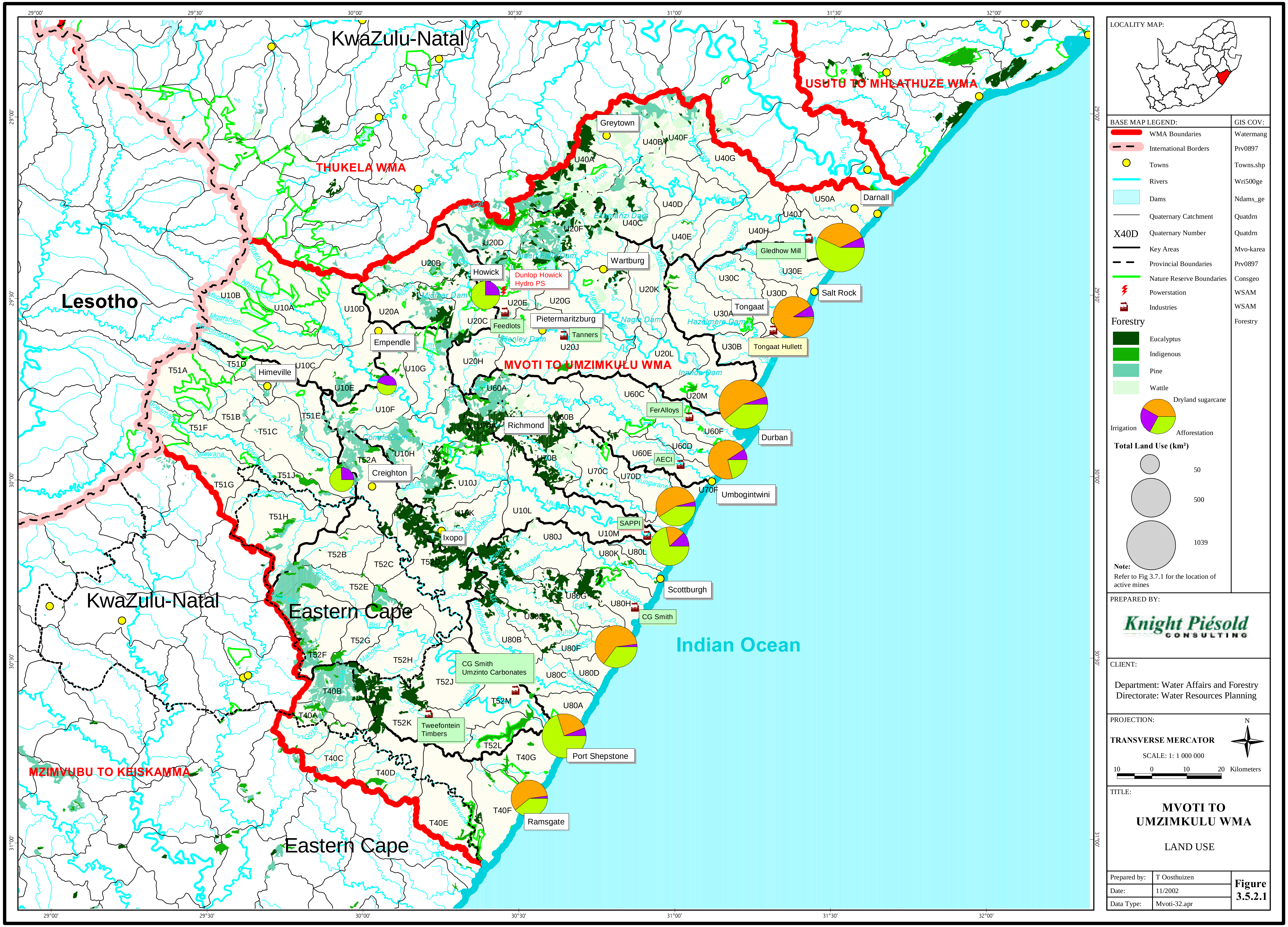
N

TITLE:

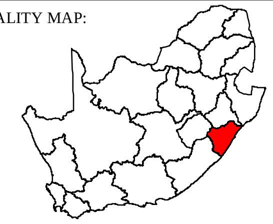
MVOTI TO UMZIMKULU WMA

INSTITUTIONAL BOUNDARIES RELATED TO WATER SUPPLY

Prepared by:	T Oosthuizen	Figure 3.4.8.2
Date:	11/2002	
Data Type:	Mvoti-32.apr	


KwaZulu-Natal
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
Lesotho
KwaZulu-Natal
Eastern Cape
Eastern Cape
Indian Ocean
Greytown
Darnall
Wartburg
Howick
Dunlop Howick Hydro PS
Gledhow Mill
Salt Rock
Tongaat
Tongaat Hullett
Pietermaritzburg
Feedlots
Tanners
Empendle
Himeville
Richmond
FerAlloys
Durban
AECI
Creighton
Umbogintwini
SAPPI
Ixopo
Scottburgh
CG Smith
CG Smith Umzinto Carbonates
Tweefontein Timbers
Port Shepstone
Ramsgate
LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
WMA Boundaries — Watermang
International Borders — Prv0897
Towns — Towns.shp
Rivers — Wri500ge
Dams — Ndams_ge
Quaternary Catchment — Quatdm
X40D Quaternary Number — Quatdm
Key Areas — Mvo-karea
Provincial Boundaries — Prv0897
Nature Reserve Boundaries — Consgeo
Powerstation — WSAM
Industries — WSAM
Forestry — Forestry
Eucalyptus
Indigenous
Pine
Wattle
Dryland sugarcane
Irrigation
Afforestation
Total Land Use (km²)
50
500
1039
Note:
Refer to Fig 3.7.1 for the location of active mines
PREPARED BY:
Knight Piésold CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
TITLE:
MVOTI TO UMZIMKULU WMA
LAND USE
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-32.apr
Figure 3.5.2.1

LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Areas	Mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Livestock & Game	WSAM

Livestock & Game Quantity (ELSU's)

10 000

50 000

110 000

Note: Game populations could not be established and are not shown

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

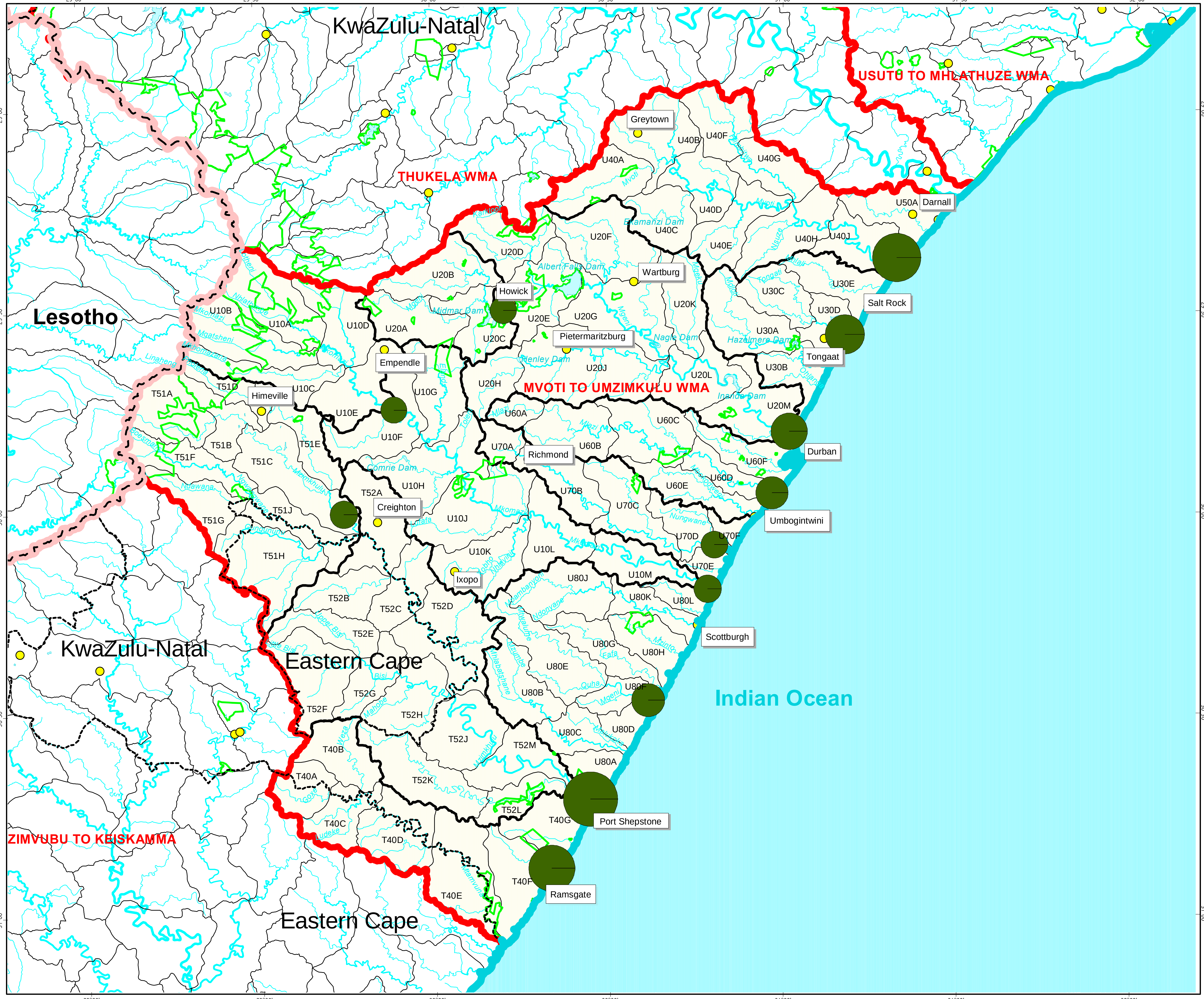
10 0 10 20 Kilometers

TITLE:

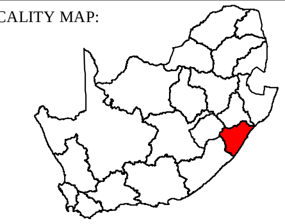
MVOTI TO UMZIMKULU WMA

LIVESTOCK AND GAME NUMBERS

Prepared by:	T Oosthuizen	Figure 3.5.4.1
Date:	11/2002	
Data Type:	Mvoti-35.apr	



LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Areas	Mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Condensed Area of Alien Vegetation (km²)	CSIR

30
100
230

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

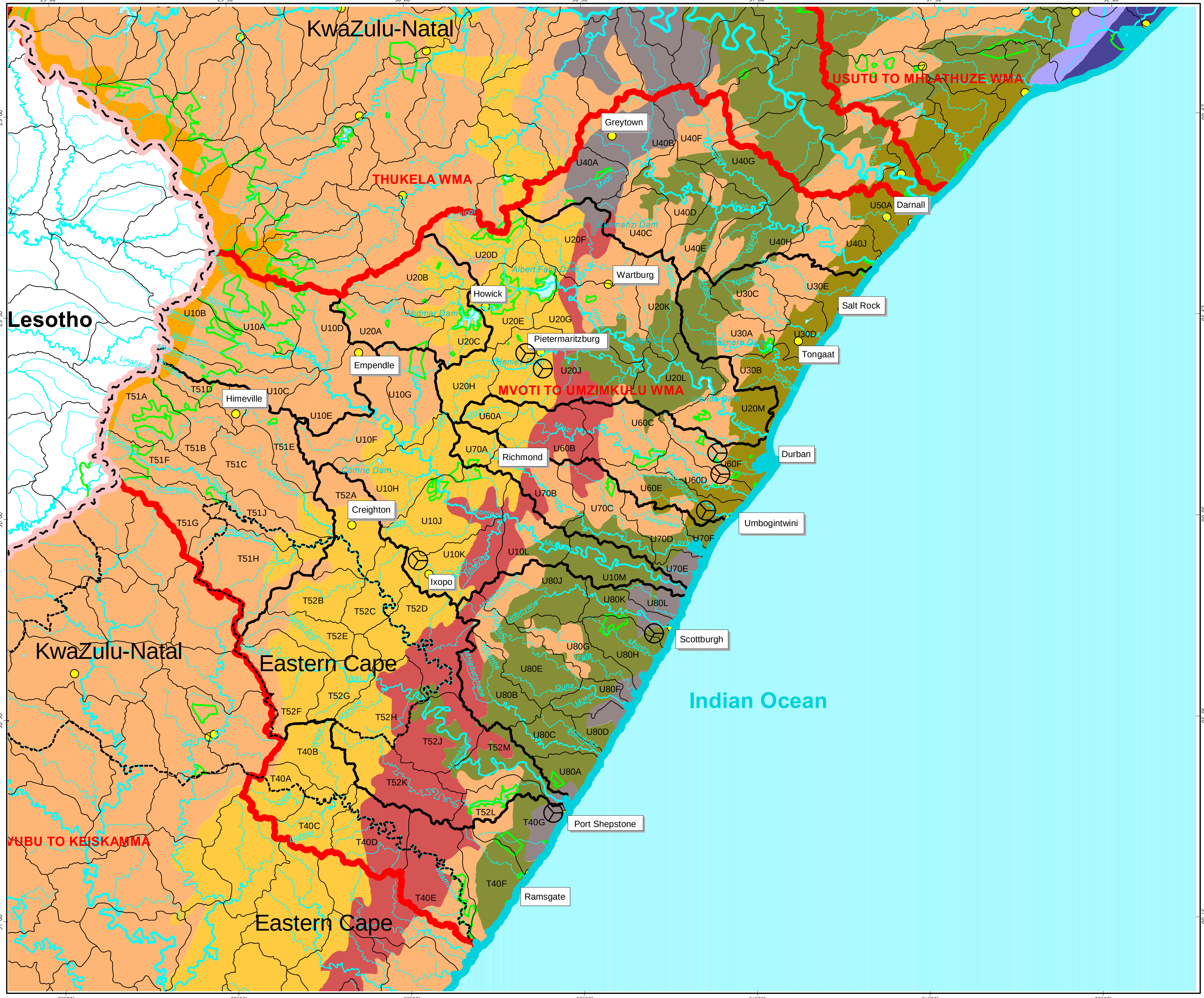
N

TITLE:

MVOTI TO UMZIMKULU WMA

ALIEN VEGETATION INFESTATION

Prepared by:	T Oosthuizen	Figure 3.5.6.1
Date:	11/2002	
Data Type:	Mvoti-35.apr	



LOCALITY MAP:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	Mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Geology	Geol_ge

- 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. (Dwyka Formation and Ecca Group)
- Mainly compact tillite, shale and sandstone. (Dwyka Formation and Ecca Group)
- Mainly compact tillite. (Dwyka Formation)
- Porous unconsolidated to semi-consolidated sediment

Active Mines — Affects Hydrology; Affects Water Quality; Important for Local and Regional Economy; Data not available — Mines

PREPARED BY: Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

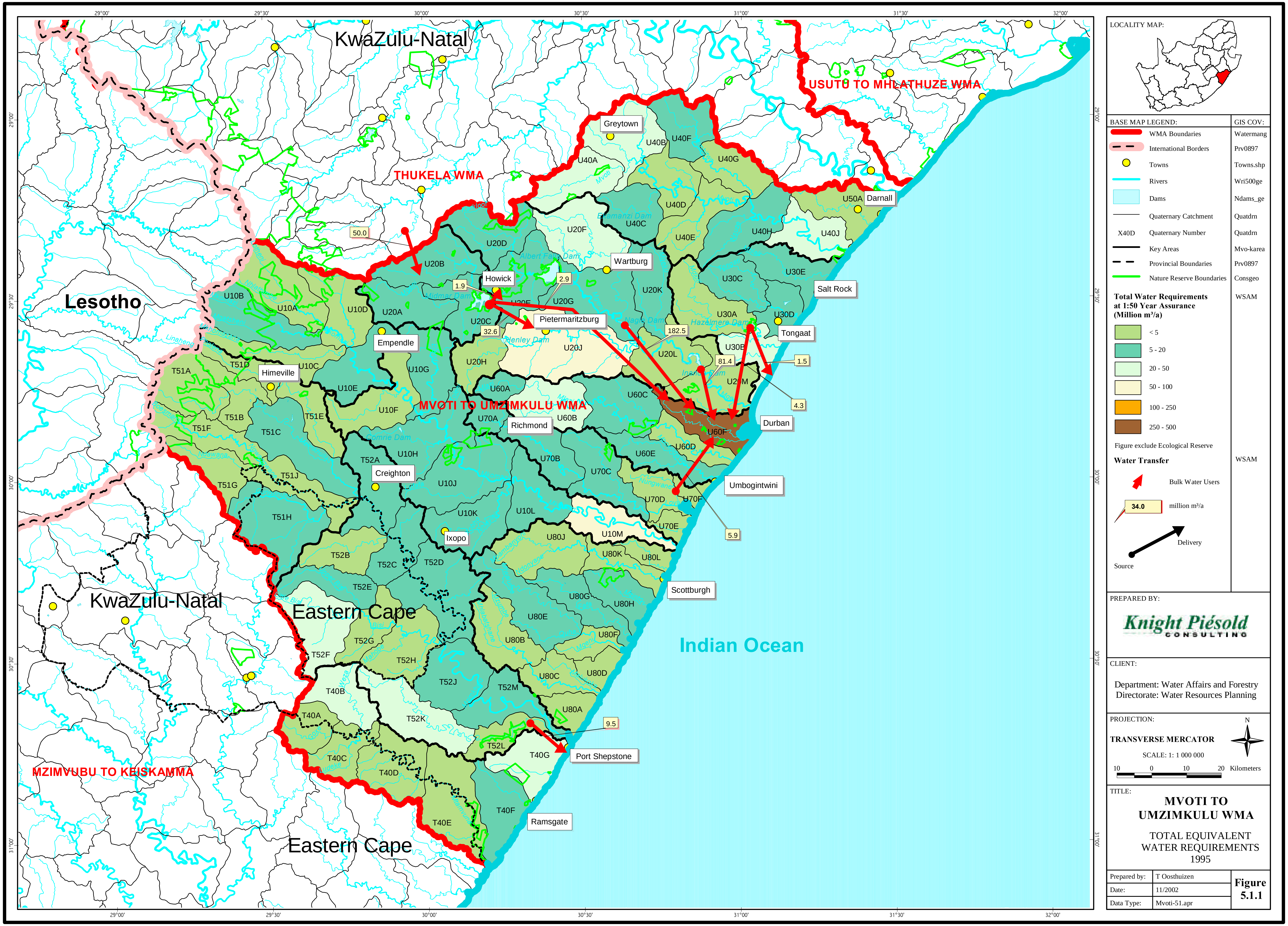
10 0 10 20 Kilometers

TITLE:

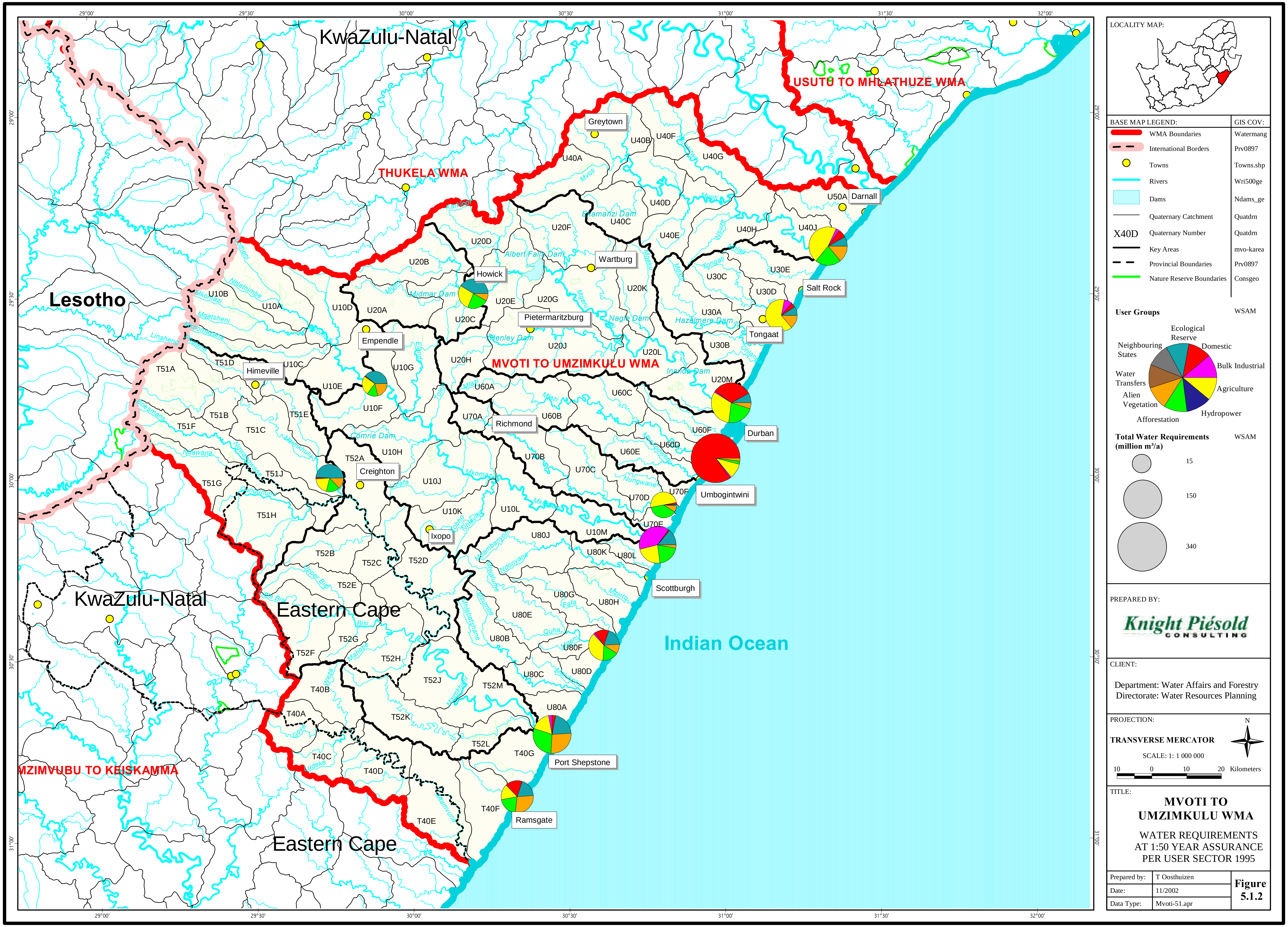
MVOTI TO UMZIMKULU WMA

MINES

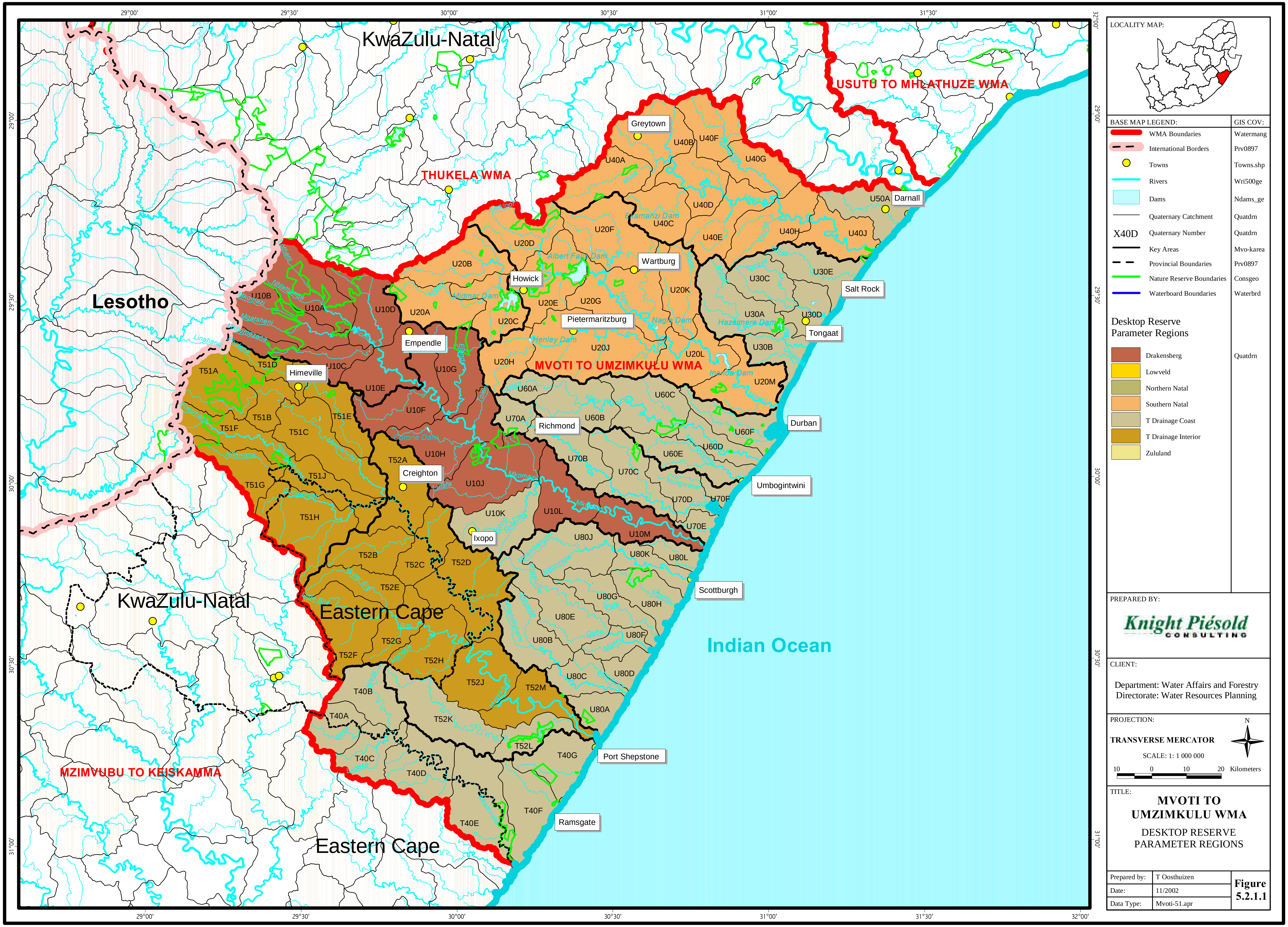
Prepared by:	T Oosthuizen	**Figure 3.7.1**
Date:	11/2002	
Data Type:	Thukela-35.apr	



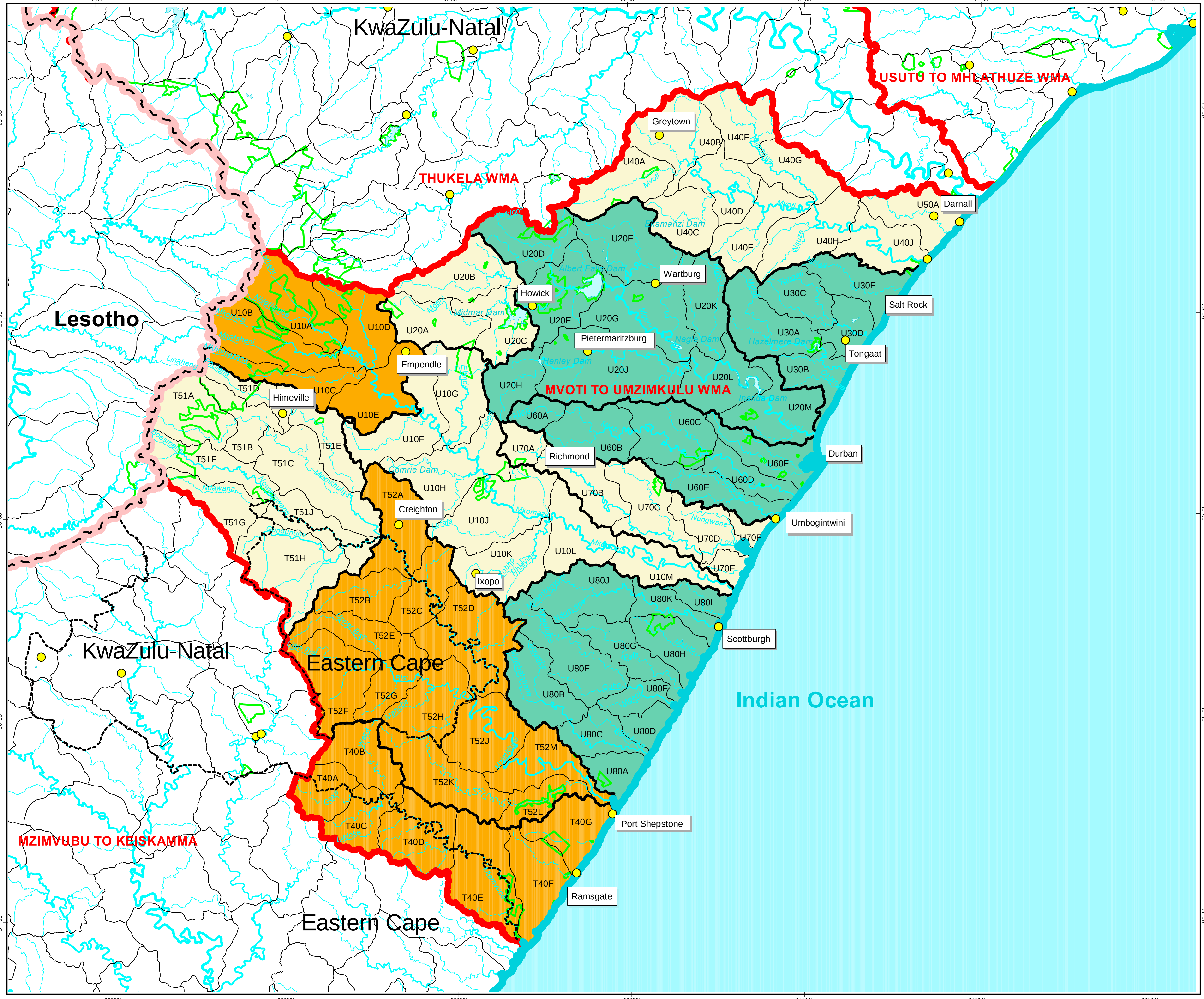
KwaZulu-Natal
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
Lesotho
Eastern Cape
Indian Ocean
Greytown
Darnall
Wartburg
Howick
Pietermaritzburg
Salt Rock
Tongaat
Empendle
Himeville
Richmond
Durban
Creighton
Umbogintwini
Ixopo
Scottburgh
Port Shepstone
Ramsgate
50.0
1.9
2.9
32.6
182.5
81.4
1.5
4.3
5.9
9.5
LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
WMA Boundaries | Watermang
International Borders | Prv0897
Towns | Towns.shp
Rivers | Wri500ge
Dams | Ndams_ge
Quaternary Catchment | Quatdrn
X40D Quaternary Number | Quatdrn
Key Areas | Mvo-karea
Provincial Boundaries | Prv0897
Nature Reserve Boundaries | Consgeo
Total Water Requirements at 1:50 Year Assurance (Million m³/a) | WSAM
< 5
5 - 20
20 - 50
50 - 100
100 - 250
250 - 500
Figure exclude Ecological Reserve
Water Transfer | WSAM
Bulk Water Users
34.0 million m³/a
Delivery
Source
PREPARED BY:
Knight Piésold CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
N
TITLE:
MVOTI TO UMZIMKULU WMA
TOTAL EQUIVALENT WATER REQUIREMENTS 1995
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-51.apr
Figure 5.1.1



LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
WMA Boundaries | Watermang
International Borders | Prv0897
Towns | Towns.shp
Rivers | Wri500ge
Dams | Ndams_ge
Quaternary Catchment | Quatdm
X40D Quaternary Number | Quatdm
Key Areas | mvo-karea
Provincial Boundaries | Prv0897
Nature Reserve Boundaries | Consgeo
User Groups
WSAM
Ecological Reserve
Domestic
Bulk Industrial
Agriculture
Hydropower
Afforestation
Alien Vegetation
Water Transfers
Neighbouring States
Total Water Requirements (million m³/a)
WSAM
15
150
340
PREPARED BY:
Knight Piésold CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
N
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
TITLE:
MVOTI TO UMZIMKULU WMA
WATER REQUIREMENTS AT 1:50 YEAR ASSURANCE PER USER SECTOR 1995
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-51.apr
Figure 5.1.2
KwaZulu-Natal
Lesotho
Eastern Cape
Indian Ocean
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
Greytown
Darnall
Salt Rock
Tongaat
Wartburg
Howick
Pietermaritzburg
Empendle
Himeville
Richmond
Durban
Umbogintwini
Creighton
Ixopo
Scottburgh
Port Shepstone
Ramsgate
Midmar Dam
Albert Falls Dam
Henley Dam
Nagle Dam
Hazelmere Dam
Inanda Dam
Comrie Dam
Bamanzi Dam



KwaZulu-Natal
Lesotho
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
KwaZulu-Natal
Eastern Cape
Eastern Cape
Indian Ocean
Greytown
Darnall
Wartburg
Howick
Pietermaritzburg
Salt Rock
Tongaat
Empendle
Himeville
Richmond
Durban
Creighton
Umbogintwini
Ixopo
Scottburgh
Port Shepstone
Ramsgate
Albert Falls Dam
Midmar Dam
Hazelmere Dam
Henley Dam
Nagle Dam
Inanda Dam
Bhamanzi Dam
U10A
U10B
U10C
U10D
U10E
U10F
U10G
U10H
U10J
U10K
U10L
U10M
U20A
U20B
U20C
U20D
U20E
U20F
U20G
U20H
U20J
U20K
U20L
U20M
U30A
U30B
U30C
U30D
U30E
U40A
U40B
U40C
U40D
U40E
U40F
U40G
U40H
U40J
U50A
U60A
U60B
U60C
U60D
U60E
U60F
U70A
U70B
U70C
U70D
U70E
U70F
U80A
U80B
U80C
U80D
U80E
U80F
U80G
U80H
U80J
U80K
U80L
T51A
T51B
T51C
T51D
T51E
T51F
T51G
T51H
T51J
T52A
T52B
T52C
T52D
T52E
T52F
T52G
T52H
T52J
T52K
T52L
T52M
T40A
T40B
T40C
T40D
T40E
T40F
T40G
29°00'
29°30'
30°00'
30°30'
31°00'
31°30'
32°00'
LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
WMA Boundaries
Watermang
International Borders
Prv0897
Towns
Towns.shp
Rivers
Wri500ge
Dams
Ndams_ge
Quaternary Catchment
Quatdm
X40D
Quaternary Number
Quatdm
Key Areas
Mvo-karea
Provincial Boundaries
Prv0897
Nature Reserve Boundaries
Consgeo
Waterboard Boundaries
Waterbrd
Desktop Reserve
Parameter Regions
Drakensberg
Quatdm
Lowveld
Northern Natal
Southern Natal
T Drainage Coast
T Drainage Interior
Zululand
PREPARED BY:
Knight Piésold
CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
N
SCALE: 1: 1 000 000
10
0
10
20
Kilometers
TITLE:
MVOTI TO
UMZIMKULU WMA
DESKTOP RESERVE
PARAMETER REGIONS
Prepared by:
T Oosthuizen
Date:
11/2002
Data Type:
Mvoti-51.apr
Figure
5.2.1.1



LOCALITY MAP:

BASE MAP LEGEND: | GIS COV:

	WMA Boundaries	Watermang
	International Borders	Prv0897
	Towns	Towns.shp
	Rivers	Wri500ge
	Dams	Ndams_ge
	Quaternary Catchment	Quatdm
X40D	Quaternary Number	Quatdm
	Key Areas	Mvo-karea
	Provincial Boundaries	Prv0897
	Nature Reserve Boundaries	Consgeo
	Waterboard Boundaries	Waterbrd

Ecological Reserve Requirements (% of MAR)

	< 10%	WSAM
	10% - 20%	
	20% - 30%	
	30% - 40%	
	40% - 50%	
	50% - 100%	

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

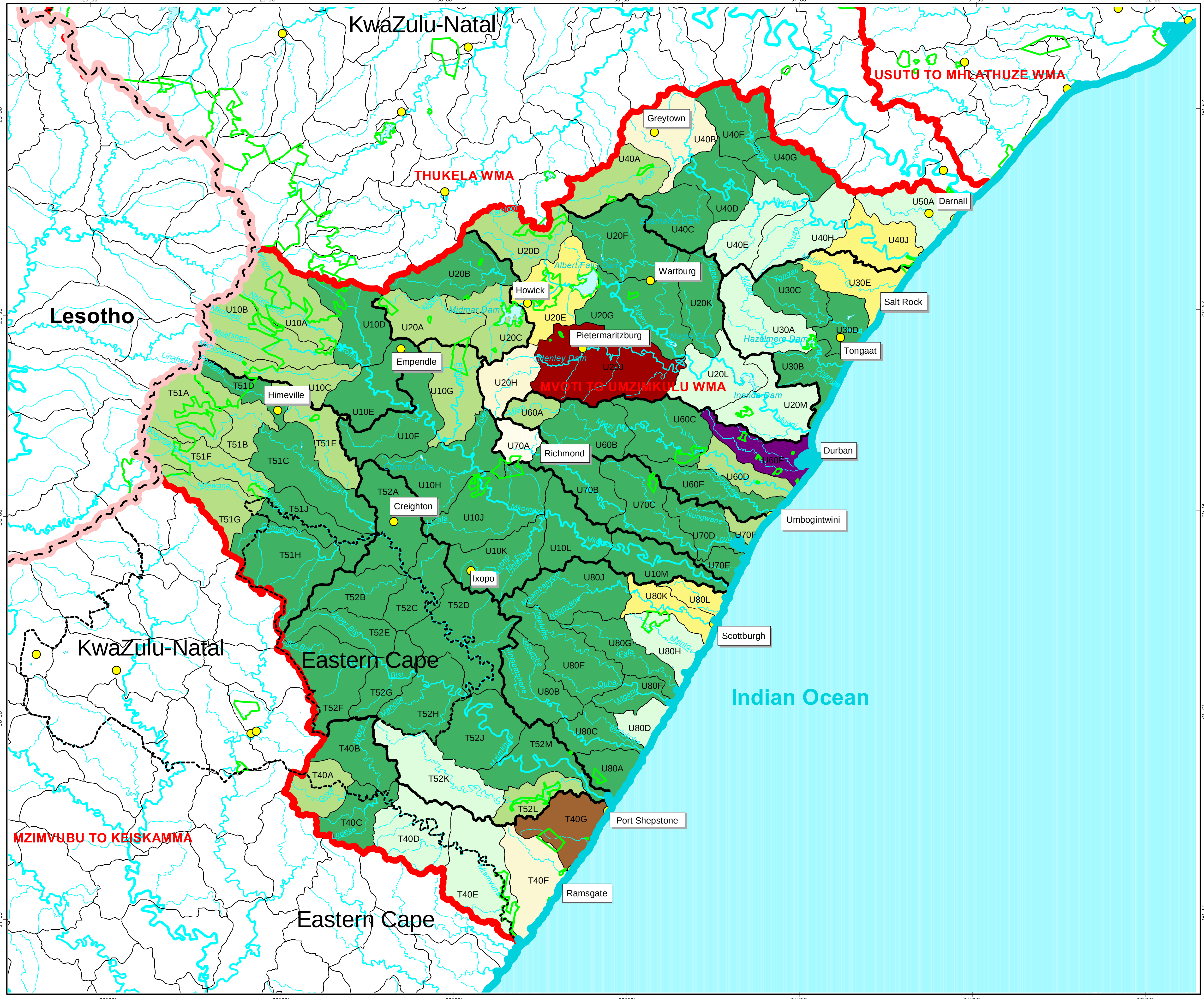
10 0 10 20 Kilometers

TITLE: MVOTI TO UMZIMKULU WMA

WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE

Prepared by:	T Oosthuizen
Date:	11/2002
Data Type:	Mvoti-51.apr

Figure 5.2.4.1



LOCALITY MAP:

BASE MAP LEGEND:

	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	Mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Urban & Rural Total Water Requirements (million m³/a)	WSAM

- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 30
- 30 - 100
- 100 - 300

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

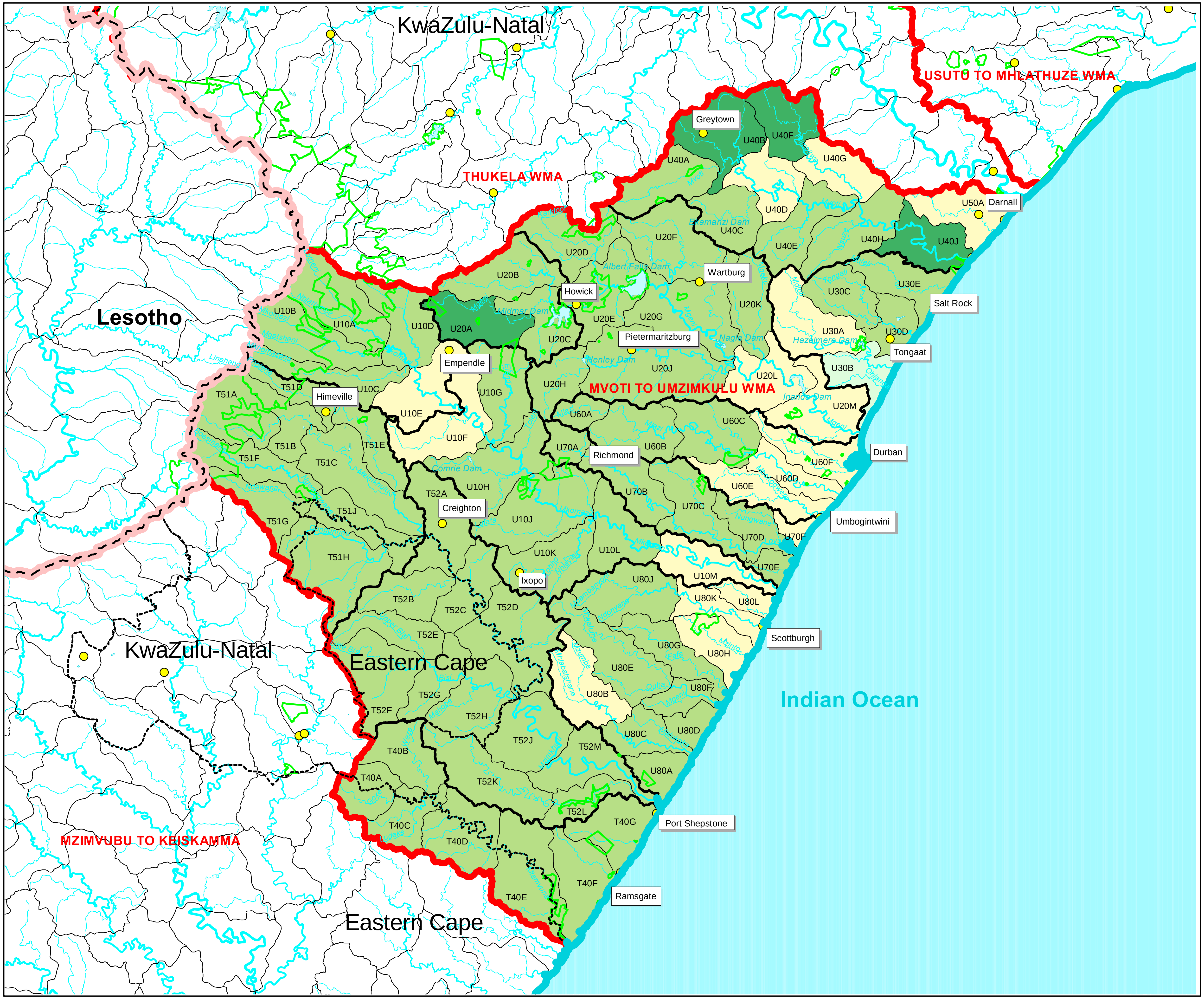
10 0 10 20 Kilometers

TITLE:

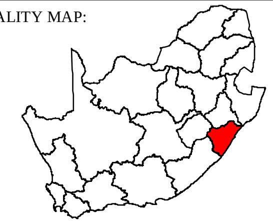
MVOTI TO UMZIMKULU WMA

URBAN & RURAL DOMESTIC WATER REQUIREMENTS IN 1995

Prepared by:	T Oosthuizen	Figure 5.3.1.1
Date:	11/2002	
Data Type:	Mvoti-51.apr	



LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	Mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo

Irrigation Water Requirements (million m³/a) — WSAM

- No requirement
- 0 - 10
- 10 - 20
- 20 - 50
- 50 - 80
- 80 - 130

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

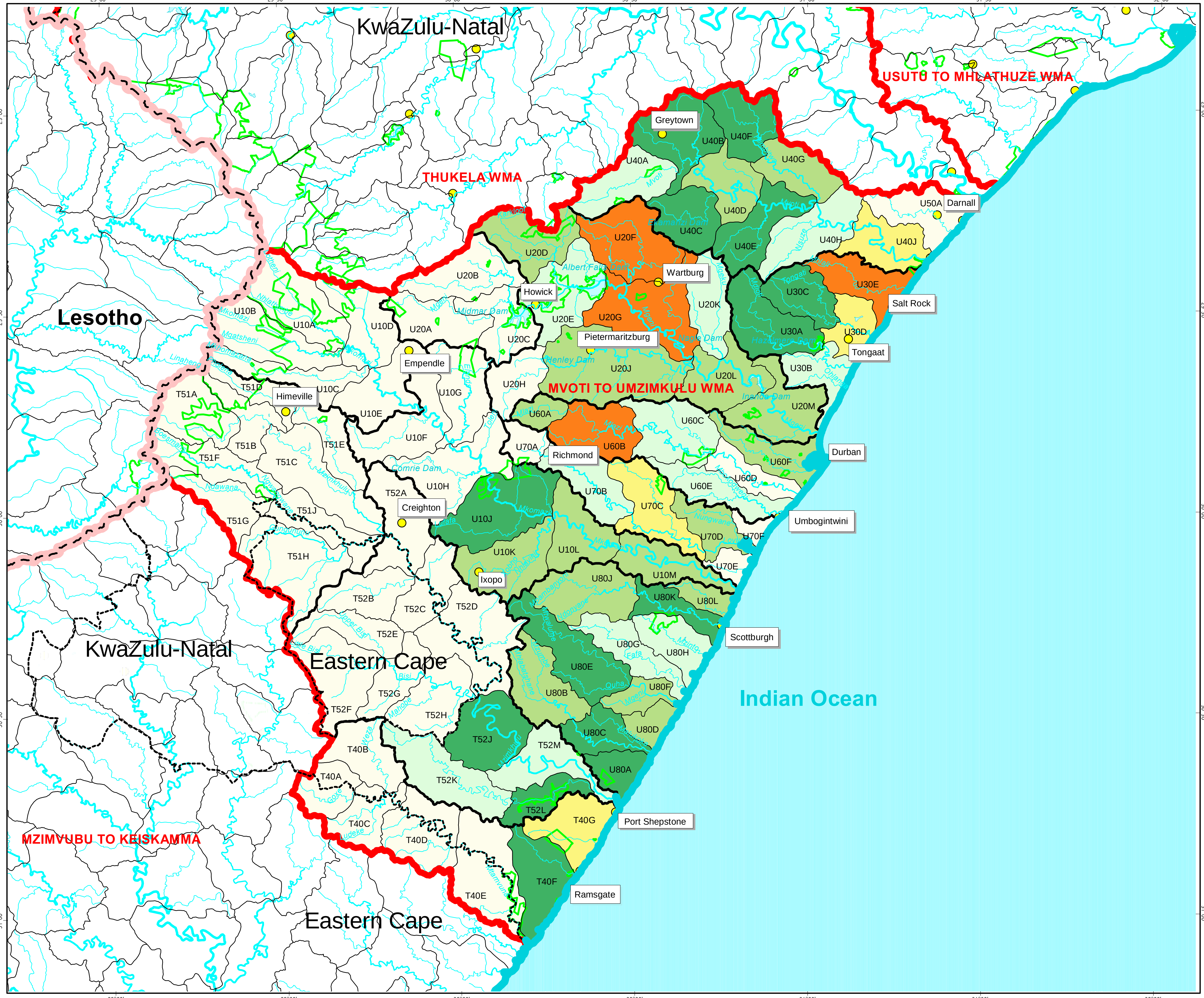
10 0 10 20 Kilometers

TITLE:

MVOTI TO UMZIMKULU WMA

IRRIGATION WATER REQUIREMENTS 1995

Prepared by:	T Oosthuizen	Figure 5.6.2.1
Date:	11/2002	
Data Type:	Mvoti-51.apr	



LOCALITY MAP:

BASE MAP LEGEND:

		GIS COV:
	WMA Boundaries	Watermang
	International Borders	Prv0897
	Towns	Towns.shp
	Rivers	Wri500ge
	Dams	Ndams_ge
	Quaternary Catchment	Quatdm
X40D	Quaternary Number	Quatdm
	Key Areas	mvo-karea
	Provincial Boundaries	Prv0897
	Nature Reserve Boundaries	Consgeo

Water Requirements for Dryland Sugarcane (million m³/a) — WSAM

- No requirement
- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 15

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

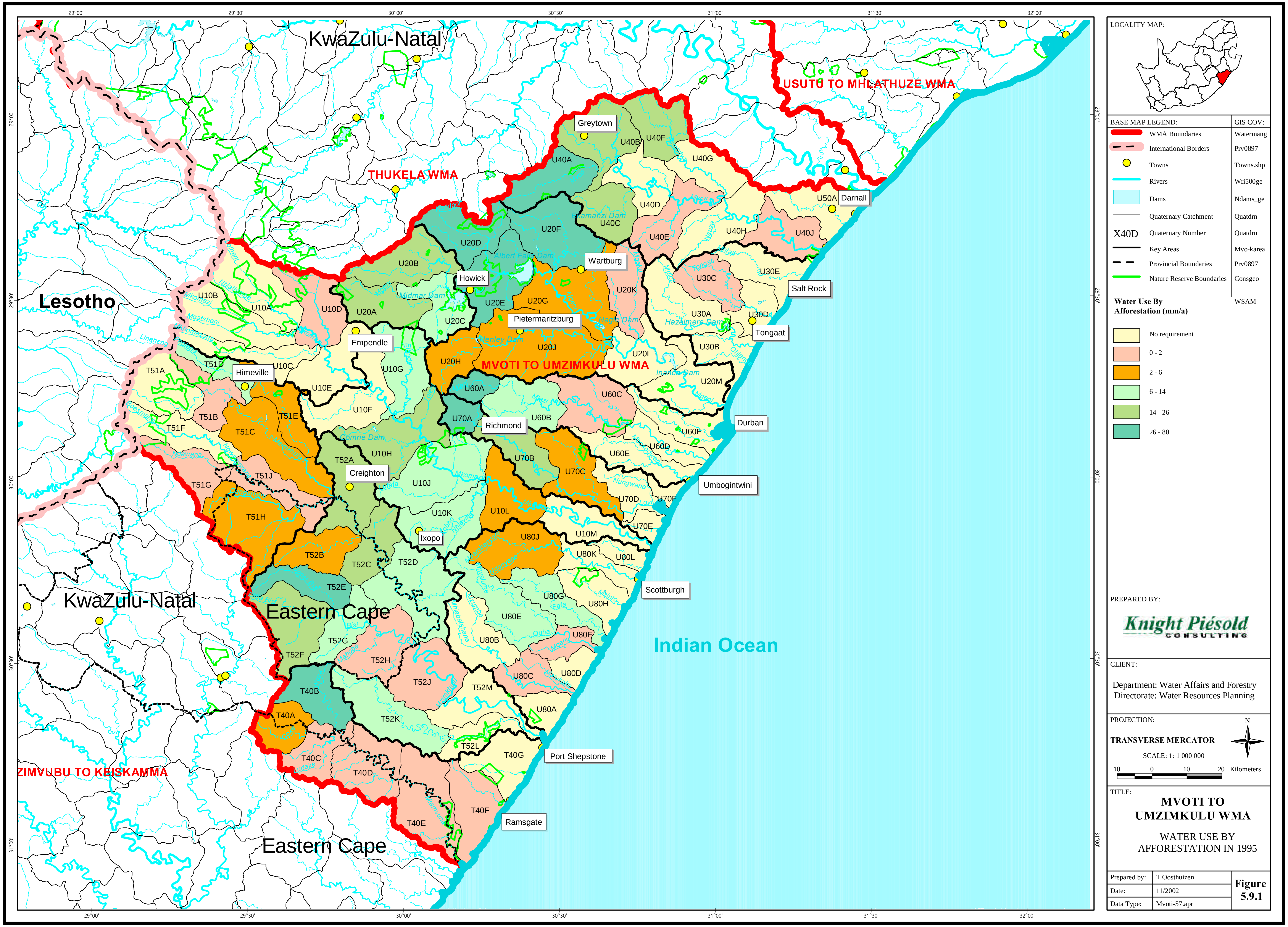
N

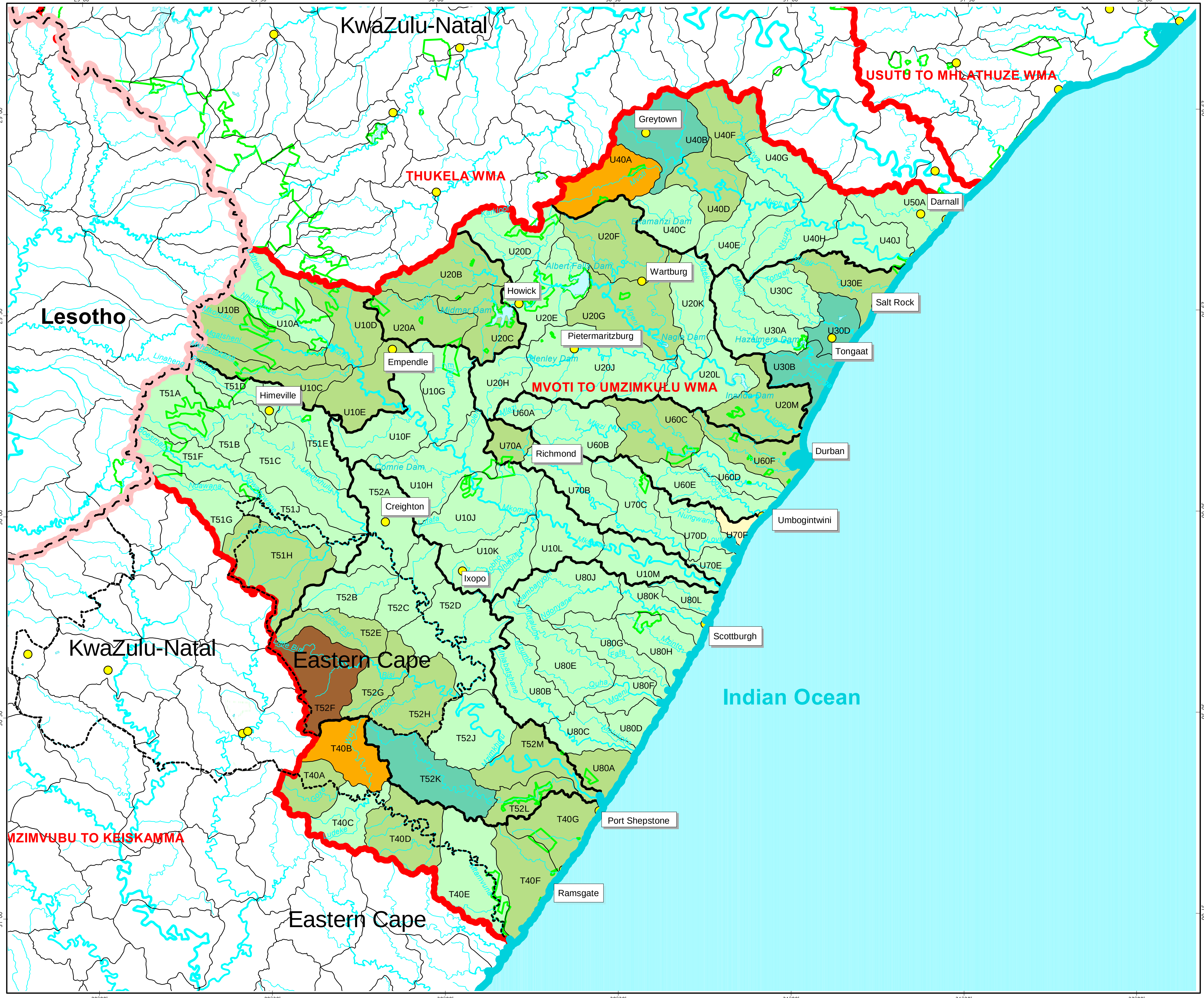
TITLE:

MVOTI TO UMZIMKULU WMA

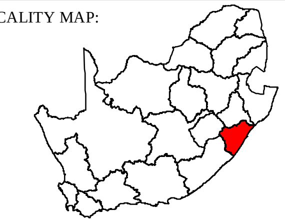
WATER REQUIREMENTS FOR DRYLAND SUGARCANE

Prepared by:	T Oosthuizen	**Figure 5.7.1**
Date:	11/2002	
Data Type:	Mvoti-57.apr	


KwaZulu-Natal
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
ZIMVUBU TO KEISKAMMA
Lesotho
Eastern Cape
Indian Ocean
Greytown
Darnall
Wartburg
Howick
Salt Rock
Pietermaritzburg
Tongaat
Empendle
Himeville
Richmond
Durban
Creighton
Umbogintwini
Ixopo
Scottburgh
Port Shepstone
Ramsgate
LOCALITY MAP:
BASE MAP LEGEND:
WMA Boundaries
International Borders
Towns
Rivers
Dams
Quaternary Catchment
X40D Quaternary Number
Key Areas
Provincial Boundaries
Nature Reserve Boundaries
GIS COV:
Watermang
Prv0897
Towns.shp
Wri500ge
Ndams_ge
Quatdm
Quatdm
Mvo-karea
Prv0897
Consgeo
Water Use By Afforestation (mm/a)
WSAM
No requirement
0 - 2
2 - 6
6 - 14
14 - 26
26 - 80
PREPARED BY:
Knight Piésold CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
N
TITLE:
MVOTI TO UMZIMKULU WMA
WATER USE BY AFFORESTATION IN 1995
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-57.apr
Figure 5.9.1



LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
	WSAM

Water Use By Alien Vegetation (million m³/a)

- No requirement
- 0 - 1
- 1 - 4
- 4 - 9
- 9 - 16
- 16 - 25

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

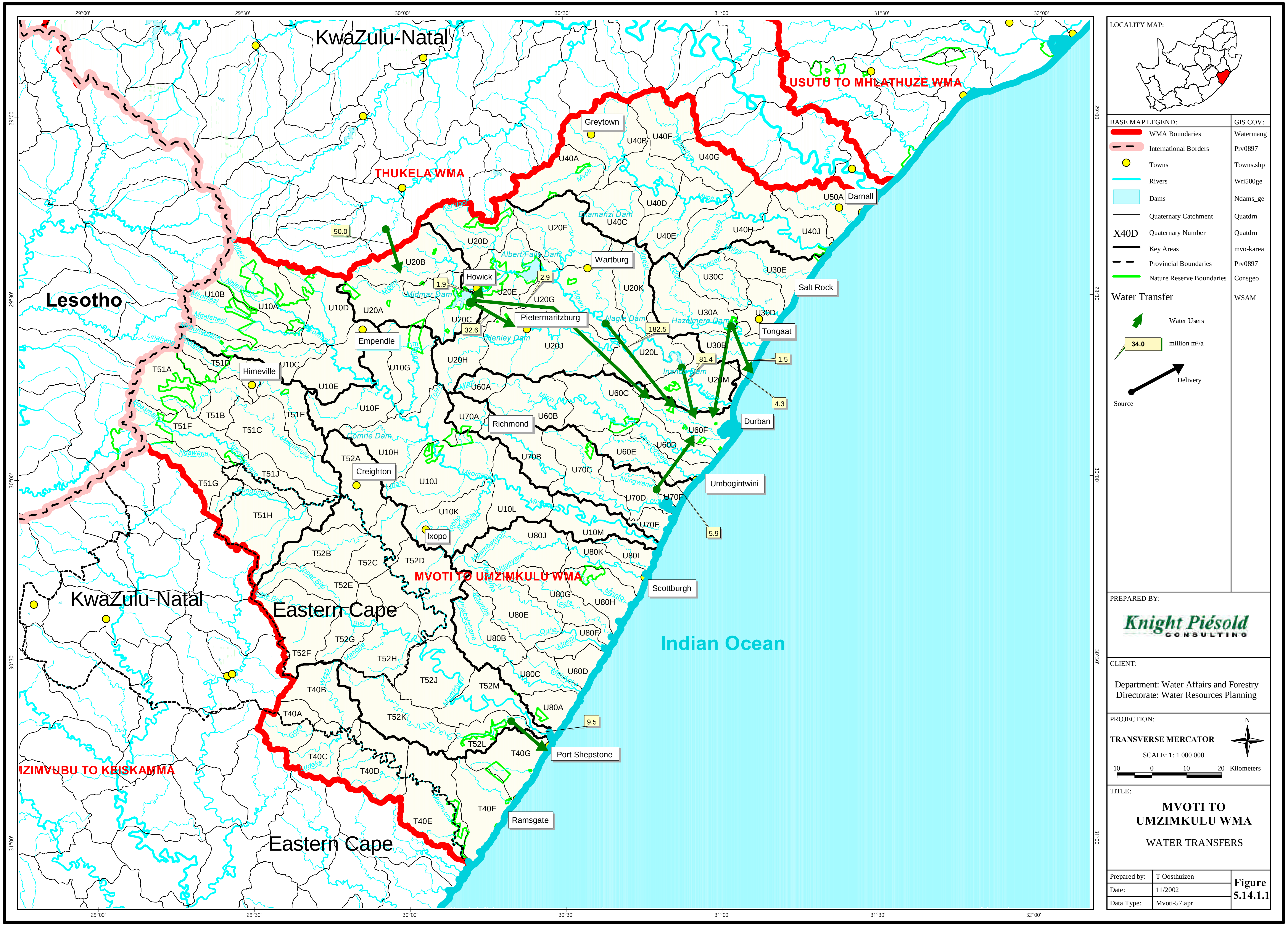
N

TITLE:

MVOTI TO UMZIMKULU WMA

WATER USE BY ALIEN VEGETATION

Prepared by:	T Oosthuizen	Figure 5.11.1
Date:	11/2002	
Data Type:	Mvoti-57.apr	


LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
WMA Boundaries
Watermang
International Borders
Prv0897
Towns
Towns.shp
Rivers
Wri500ge
Dams
Ndams_ge
Quaternary Catchment
Quatdm
X40D
Quaternary Number
Quatdm
Key Areas
mvo-karea
Provincial Boundaries
Prv0897
Nature Reserve Boundaries
Consgeo
Water Transfer
WSAM
Water Users
34.0
million m³/a
Delivery
Source
PREPARED BY:
Knight Piésold
CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
TITLE:
MVOTI TO UMZIMKULU WMA
WATER TRANSFERS
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-57.apr
Figure 5.14.1.1
KwaZulu-Natal
THUKELA WMA
USUTU TO MHLATHUZE WMA
Lesotho
MVOTI TO UMZIMKULU WMA
Eastern Cape
MZIMVUBU TO KEISKAMMA
Indian Ocean
Greytown
Wartburg
Howick
Pietermaritzburg
Empendle
Himeville
Richmond
Creighton
Ixopo
Darnall
Salt Rock
Tongaat
Durban
Umbogintwini
Scottburgh
Port Shepstone
Ramsgate
Albert Falls Dam
Midmar Dam
Henley Dam
Nagle Dam
Hazelmere Dam
Inanda Dam
Comrie Dam
Bloemendal Dam
50.0
1.9
2.9
32.6
182.5
81.4
1.5
4.3
5.9
9.5
U10A
U10B
U10C
U10D
U10E
U10F
U10G
U10H
U10J
U10K
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U70C
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T51F
T51G
T51H
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T52C
T52D
T52E
T52F
T52G
T52H
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T52K
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T40A
T40B
T40C
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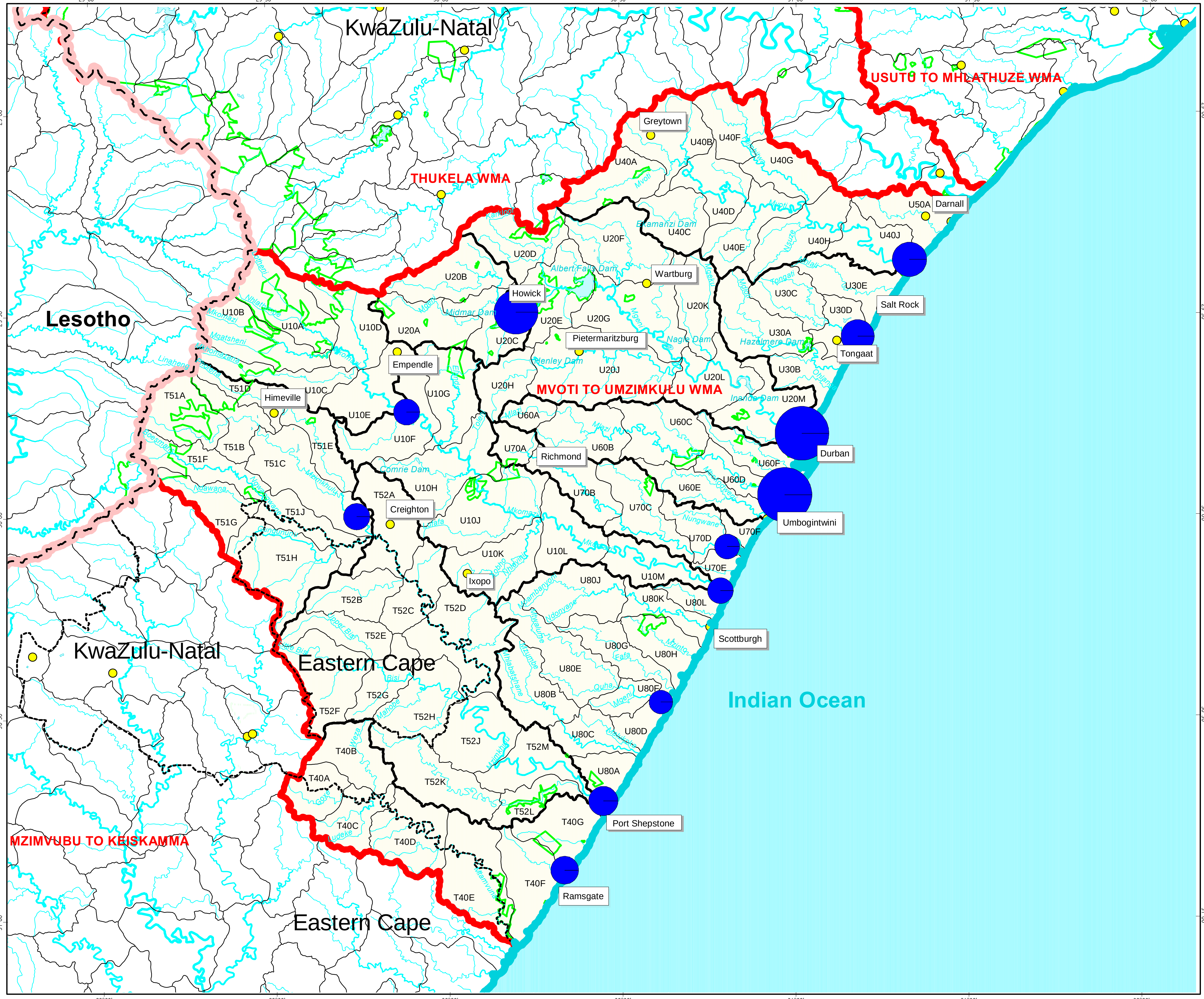
30°00'
30°30'
31°00'
31°30'
32°00'



LOCALITY MAP:

BASE MAP LEGEND:

	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	Mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Total Water Resource (million m³/a)	WSAM

20
120
240

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

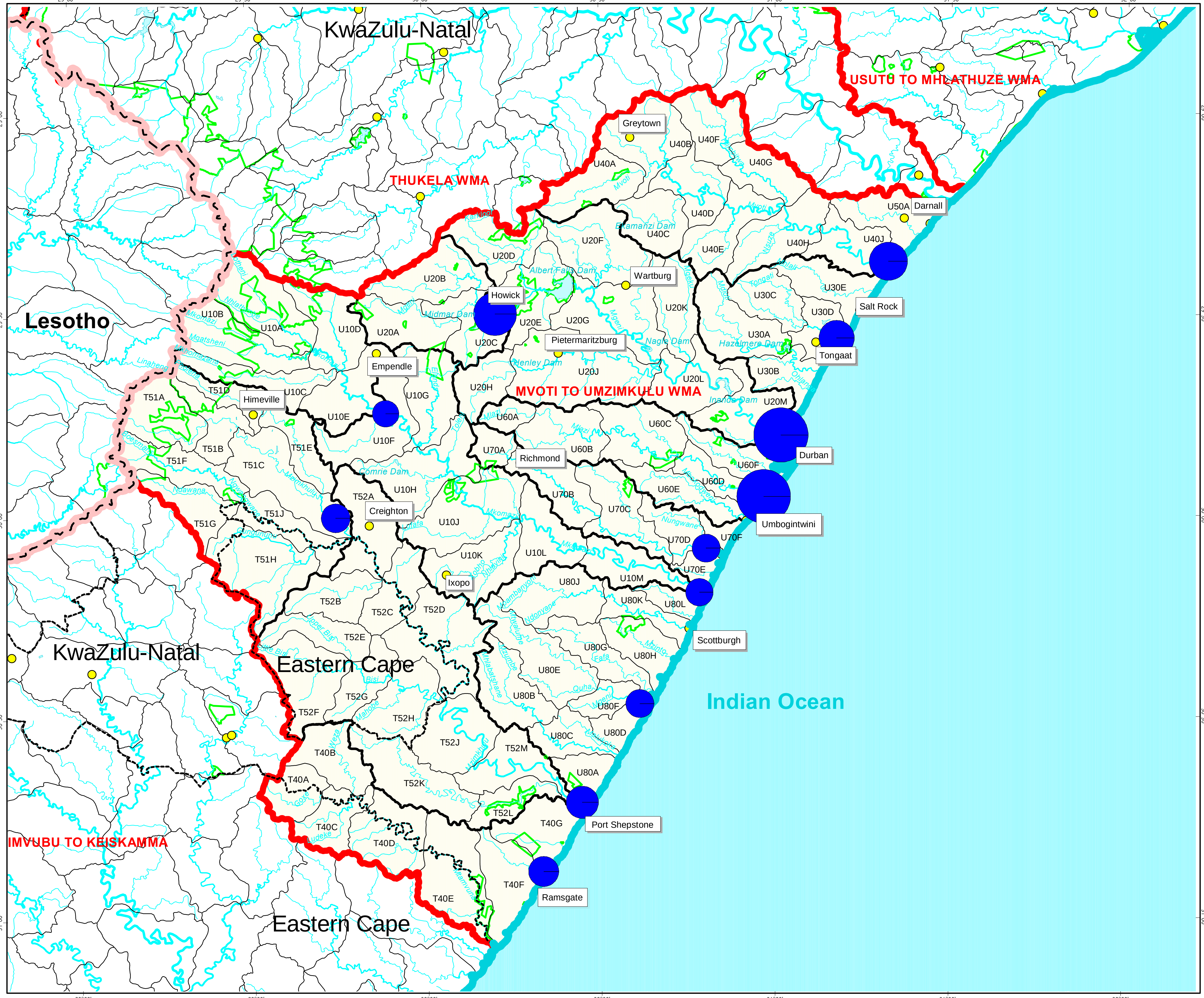
10 0 10 20 Kilometers

TITLE:

MVOTI TO UMZIMKULU WMA

NET 1:50 YEAR YIELD
OF THE TOTAL
WATER RESOURCE
AS DEVELOPED IN 1995

Prepared by:	T Oosthuizen	**Figure 6.1.1**
Date:	11/2002	
Data Type:	Mvoti-61.apr	



LOCALITY MAP:

BASE MAP LEGEND:

		GIS COV:
	WMA Boundaries	Watermang
	International Borders	Prv0897
	Towns	Towns.shp
	Rivers	Wri500ge
	Dams	Ndams_ge
	Quaternary Catchment	Quatdm
X40D	Quaternary Number	Quatdm
	Key Areas	mvo-karea
	Provincial Boundaries	Prv0897
	Nature Reserve Boundaries	Consgeo
		WSAM

Total Water Resource (million m³/a)

20

120

270

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

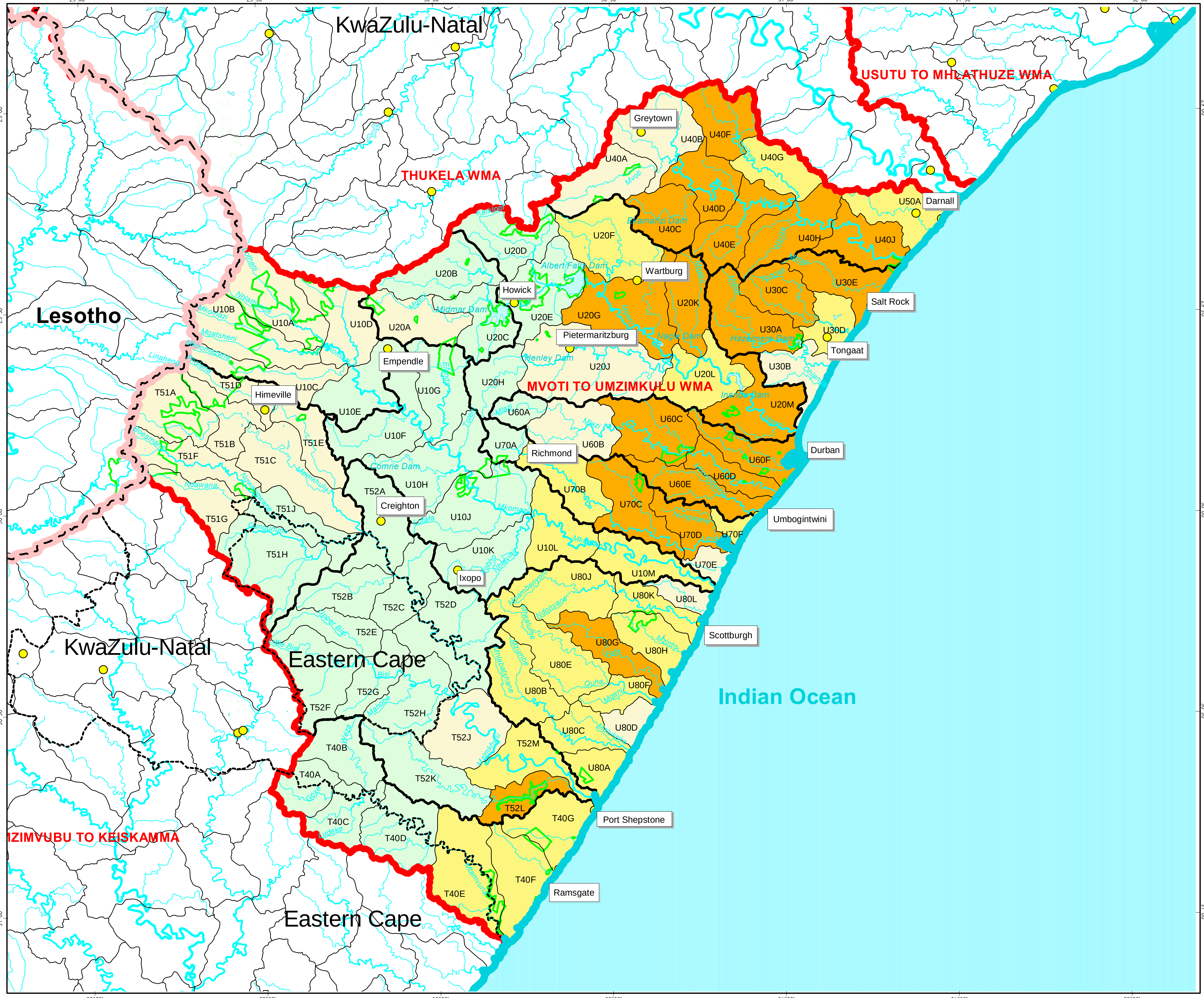
TITLE:

MVOTI TO UMZIMKULU WMA

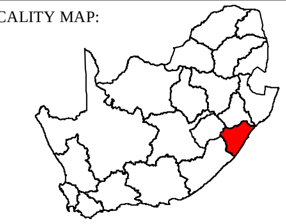
NET 1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE IF DEVELOPED TO FULL POTENTIAL

Prepared by:	T Oosthuizen
Date:	11/2002
Data Type:	Mvoti-61.apr

Figure 6.1.2



LOCALITY MAP:



BASE MAP LEGEND:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Harvest potential (mm/a)	WSAM

Harvest potential (mm/a)

- 0 - 10
- 10 - 15
- 15 - 30
- 30 - 50
- 50 - 100
- 100 - 200
- 200 - 500

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

N

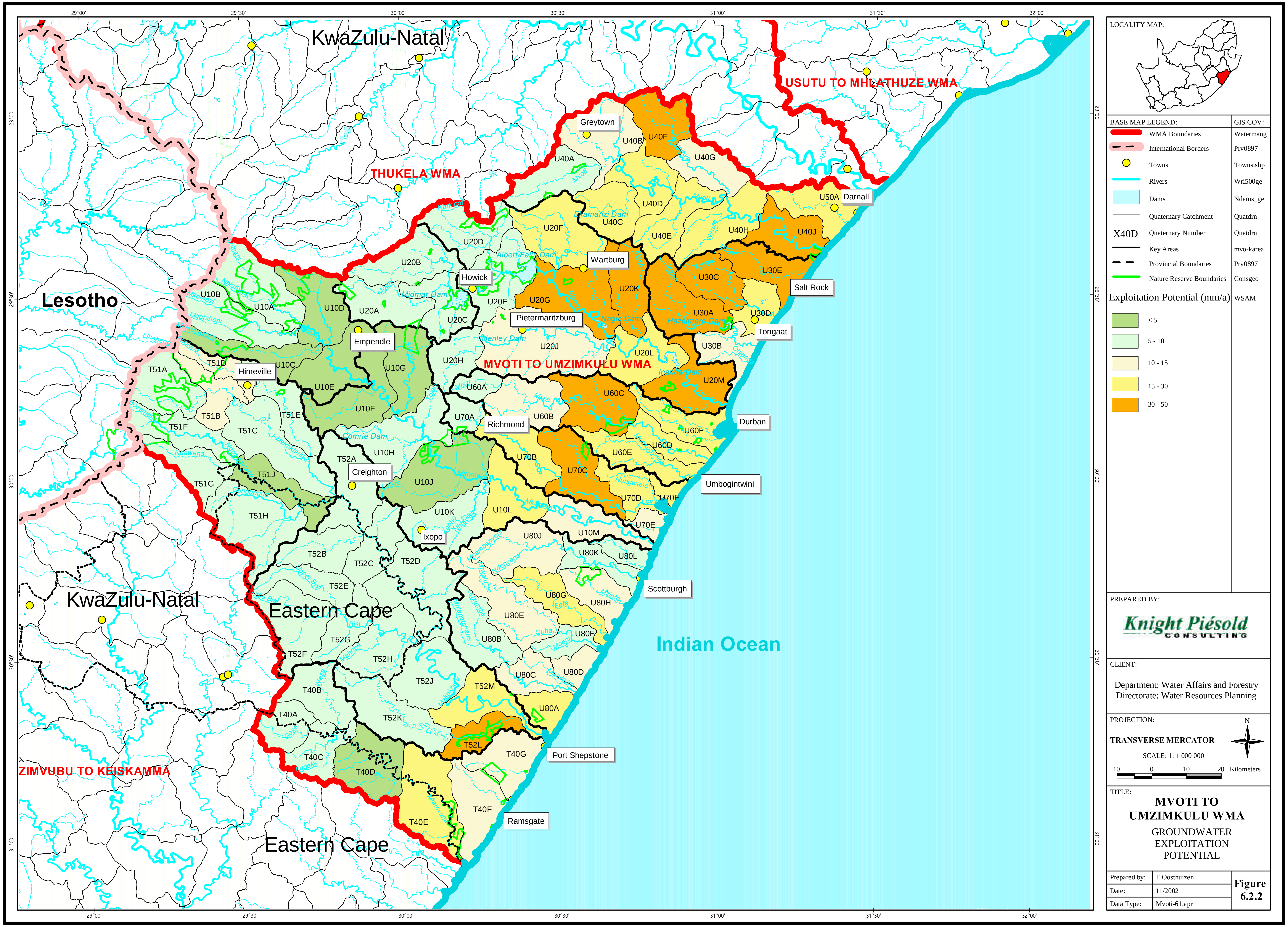
TITLE:

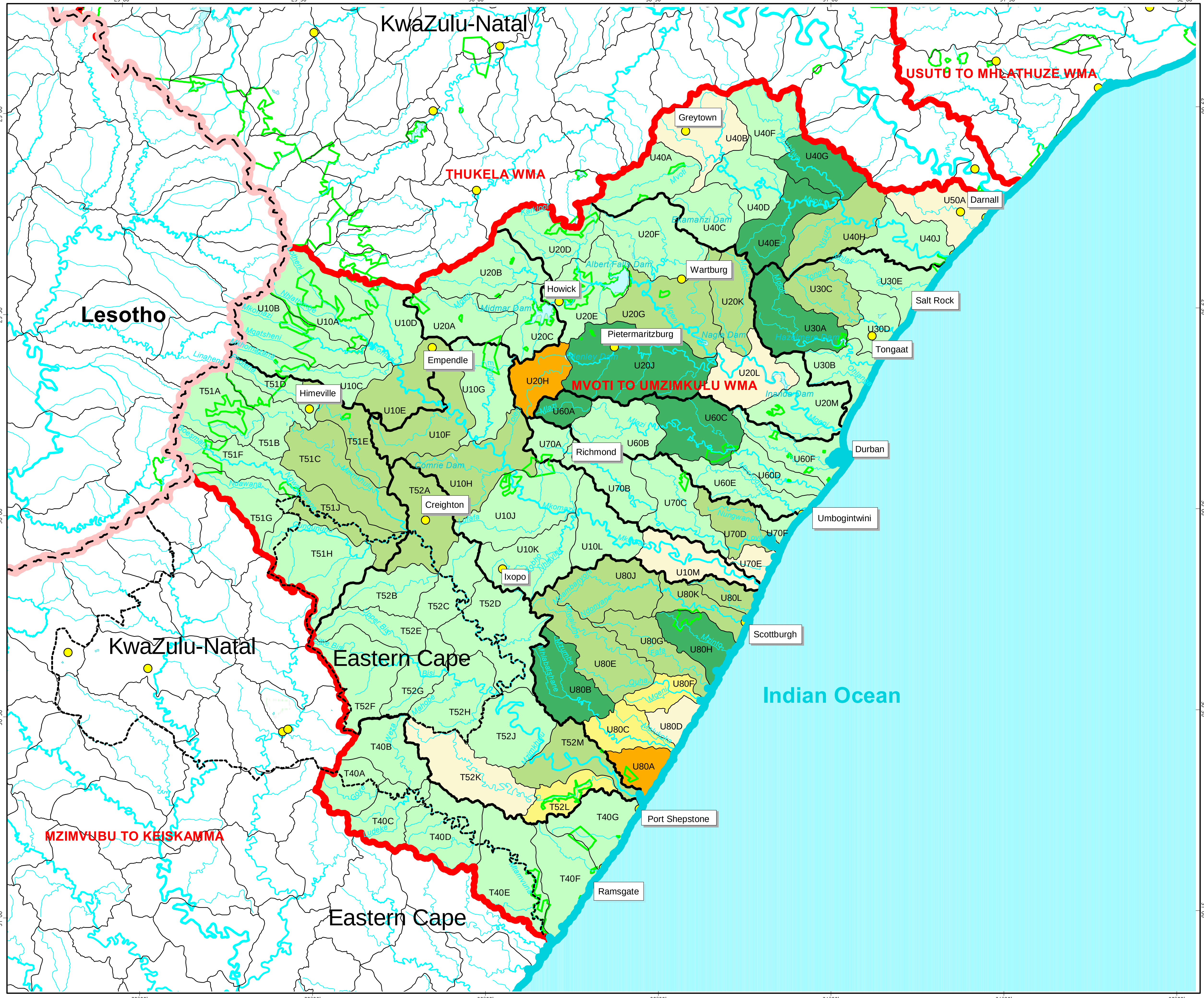
MVOTI TO UMZIMKULU WMA

GROUNDWATER HARVEST POTENTIAL

Prepared by:	T Oosthuizen
Date:	11/2002
Data Type:	Mvoti-61.apr

Figure 6.2.1


KwaZulu-Natal
USUTU TO MHLATHUZE WMA
THUKELA WMA
Lesotho
MVOTI TO UMZIMKULU WMA
KwaZulu-Natal
Eastern Cape
ZIMVUBU TO KEISKAMMA
Eastern Cape
Indian Ocean
Greytown
Darnall
Wartburg
Howick
Salt Rock
Pietermaritzburg
Tongaat
Empendle
Himeville
Durban
Richmond
Creighton
Umbogintwi
Ixopo
Scottburgh
Port Shepstone
Ramsgate
Albert Falls Dam
Midmar Dam
Henley Dam
Inanda Dam
Hazelmere Dam
Nagle Dam
Comrie Dam
LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
WMA Boundaries — Watermang
International Borders — Prv0897
Towns — Towns.shp
Rivers — Wri500ge
Dams — Ndams_ge
Quaternary Catchment — Quatdrn
X40D Quaternary Number — Quatdrn
Key Areas — mvo-karea
Provincial Boundaries — Prv0897
Nature Reserve Boundaries — Consgeo
Exploitation Potential (mm/a) — WSAM
< 5
5 - 10
10 - 15
15 - 30
30 - 50
PREPARED BY:
Knight Piésold CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
N
TITLE:
MVOTI TO UMZIMKULU WMA
GROUNDWATER EXPLOITATION POTENTIAL
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-61.apr
Figure 6.2.2



LOCALITY MAP:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Groundwater Use (mm/a)	WSAM
0 - 0.1	
0.1 - 0.2	
0.2 - 0.5	
0.5 - 1	
1 - 2	
2 - 5	
5 - 10	

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

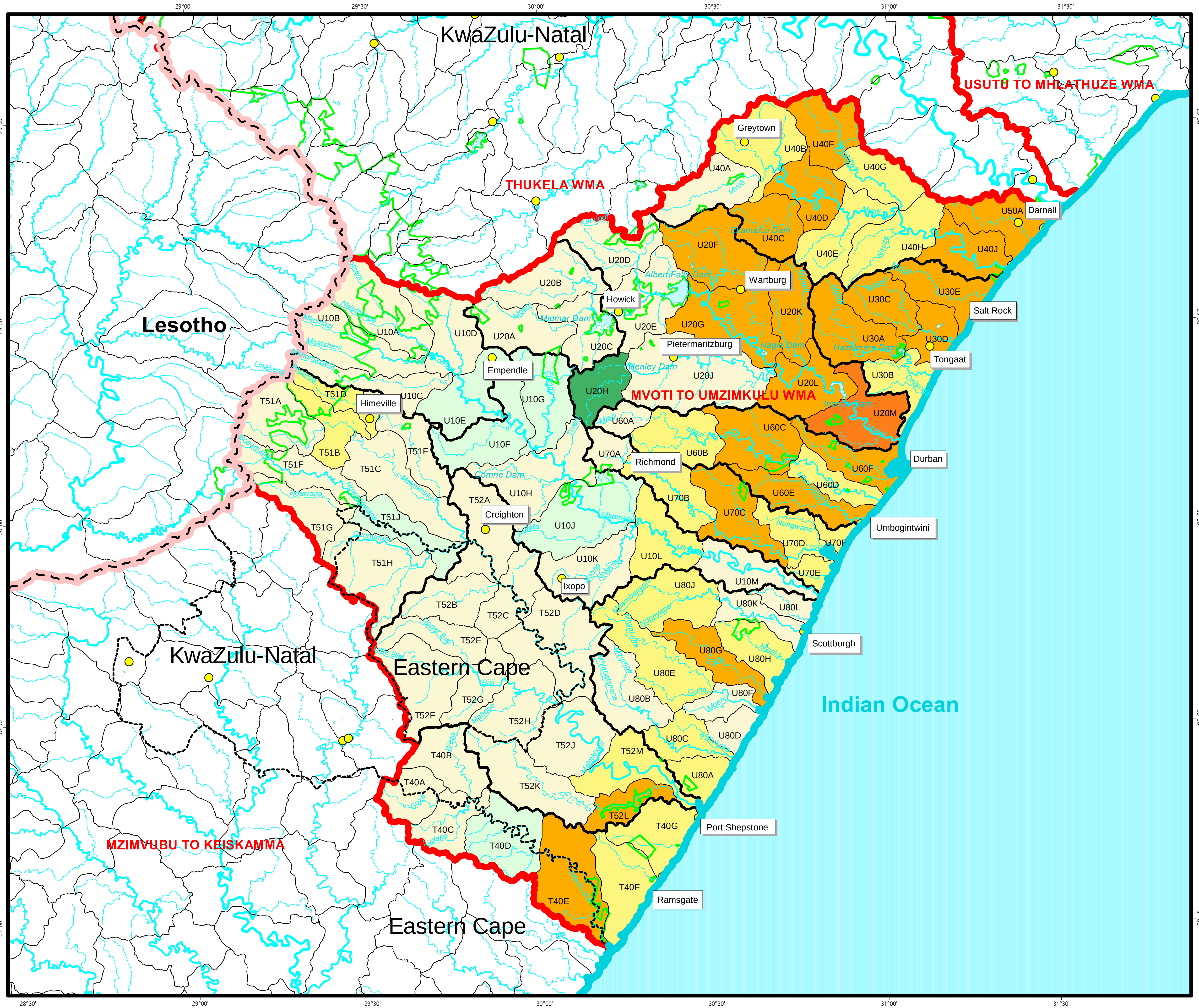
N

TITLE:

MVOTI TO UMZIMKULU WMA

GROUNDWATER USE IN 1995

Prepared by:	T Oosthuizen	Figure 6.2.3
Date:	11/2002	
Data Type:	Mvoti-61.apr	



LOCALITY MAP:

BASE MAP LEGEND:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Remaining Exploitation Potential (mm/a)	WSAM
< 1	
1 - 2	
2 - 5	
5 - 10	
10 - 20	
20 - 50	

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

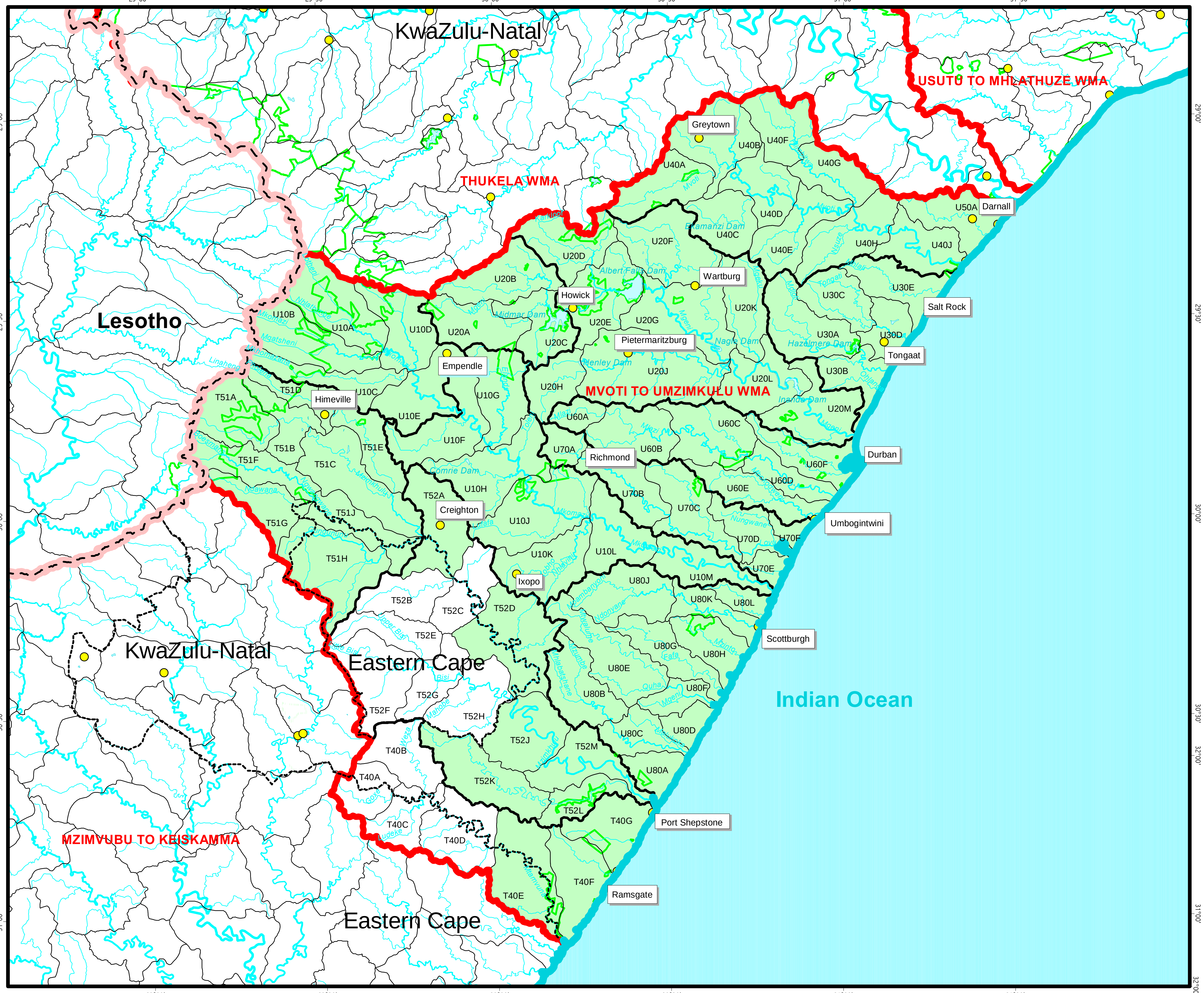
N

TITLE:

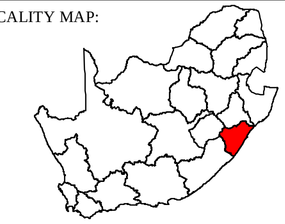
MVOTI TO UMZIMKULU WMA

REMAINING GROUNDWATER EXPLOITATION POTENTIAL IN 1995

Prepared by:	T Oosthuizen	Figure 6.2.4
Date:	11/2002	
Data Type:	Mvoti-62.apr	



LOCALITY MAP:



BASE MAP LEGEND:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Groundwater Balance	WSAM

OVER-UTILISED
HEAVILY-UTILISED
MODERATELY-UTILISED
UNDER-UTILISED
No Info

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

N

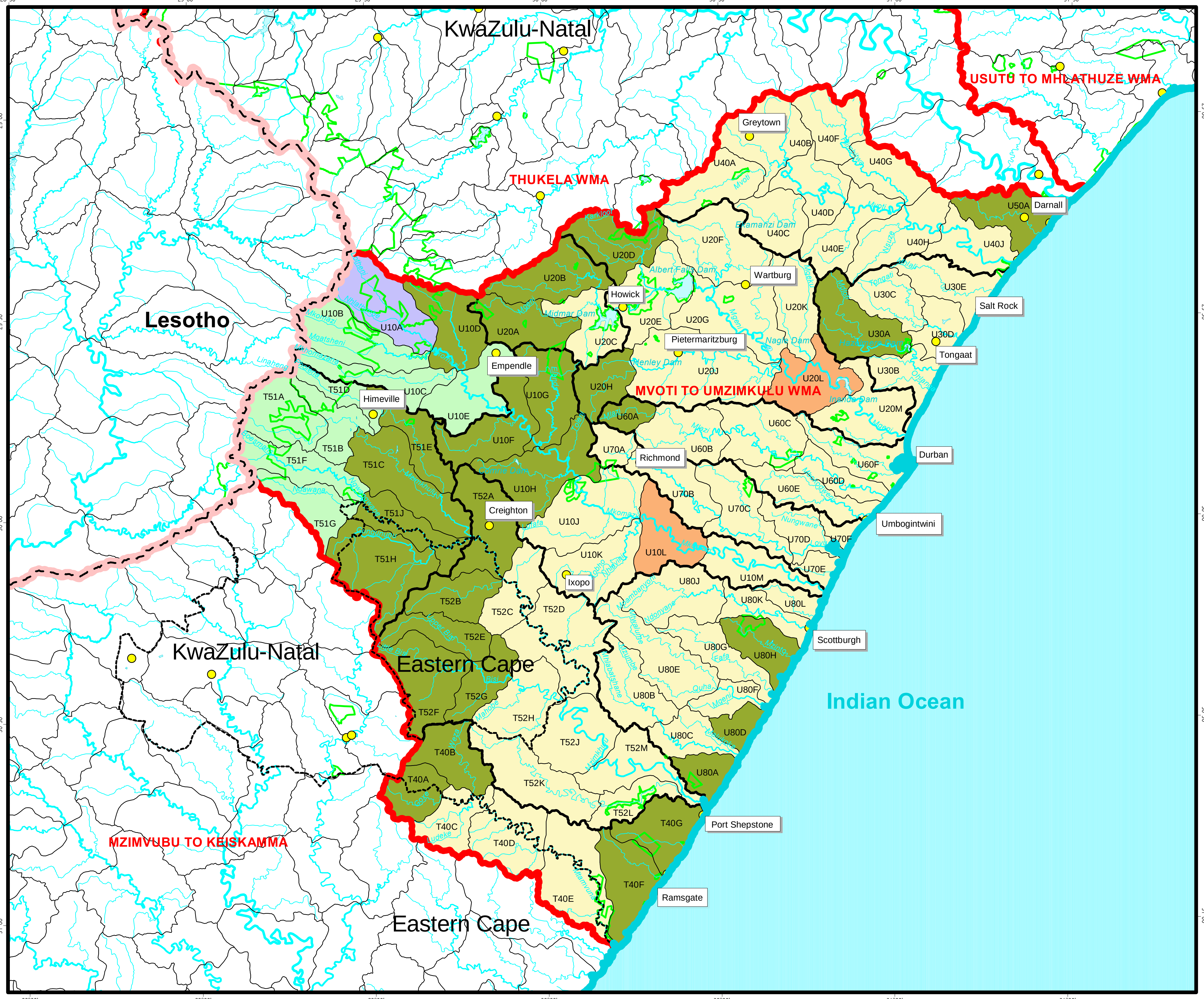
TITLE:

MVOTI TO UMZIMKULU WMA

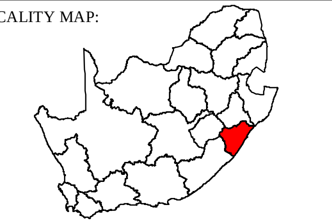
GROUNDWATER BALANCE

Prepared by:	T Oosthuizen
Date:	11/2002
Data Type:	Mvoti-62.apr

Figure 6.2.5



LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
MAR (mm)	WSAM
0 - 20	
20 - 80	
80 - 180	
180 - 310	
310 - 490	
490 - 700	

PREPARED BY:

Knight Piésold
CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

N

SCALE: 1: 1 000 000

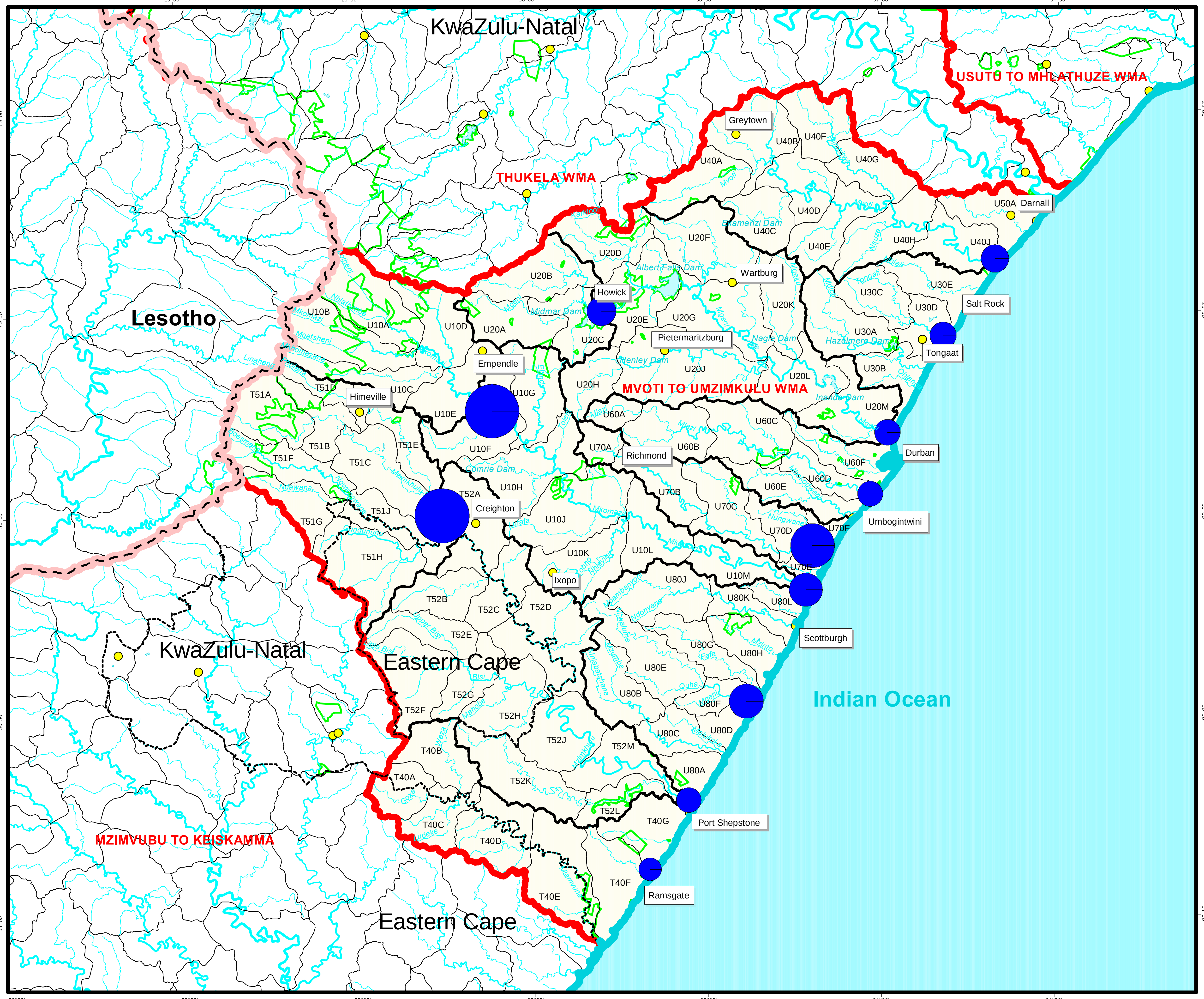
10 0 10 20 Kilometers

TITLE:

MVOTI TO UMZIMKULU WMA

MEAN ANNUAL NATURALISED SURFACE RUNOFF

Prepared by:	T Oosthuizen	**Figure 6.3.1.1**
Date:	11/2002	
Data Type:	Mvoti-62.apr	



LOCALITY MAP:

BASE MAP LEGEND:

	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Yield Possible to Secure (million m³/a)	WSAM

20

120

240

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

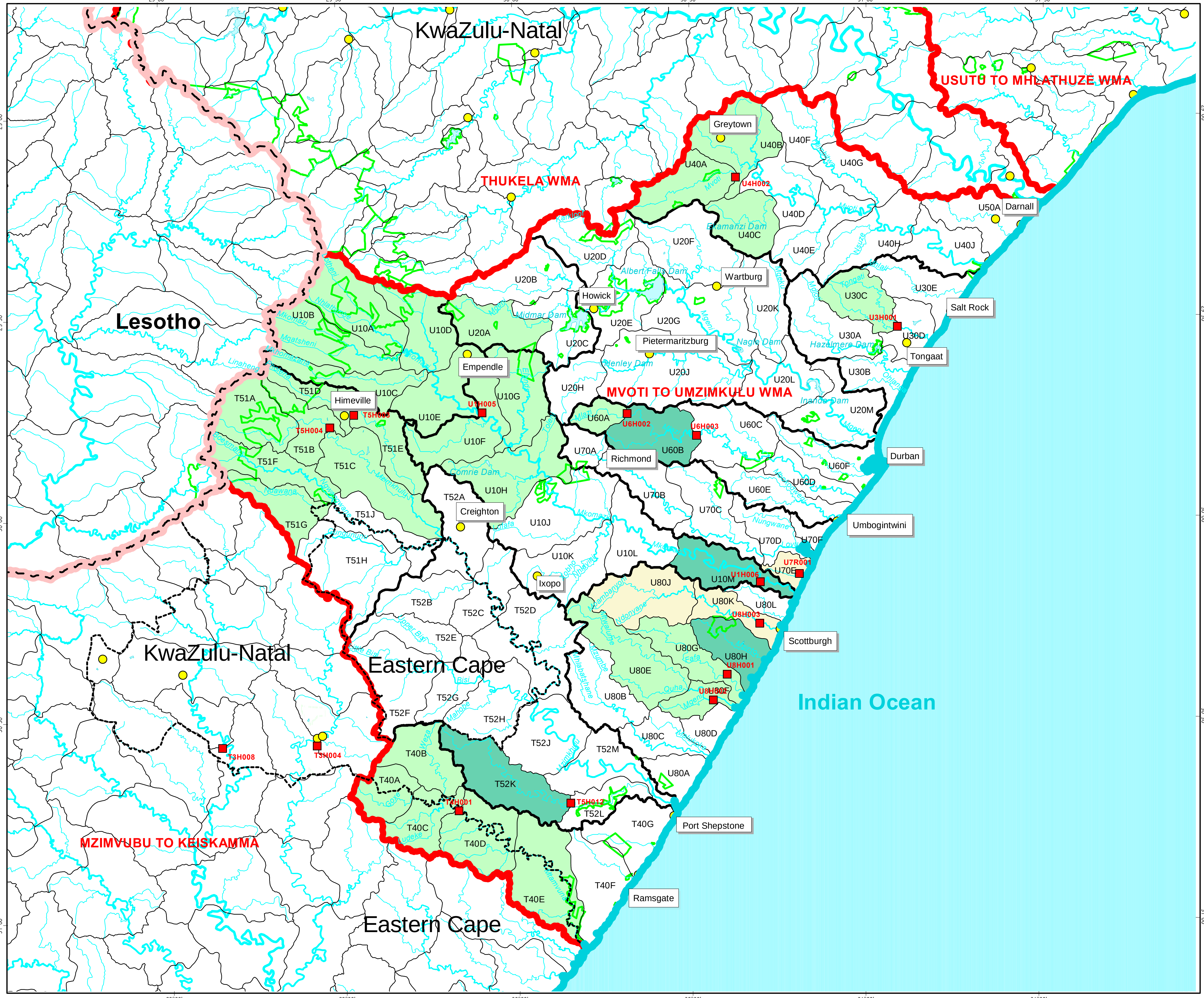
10 0 10 20 Kilometers

TITLE:

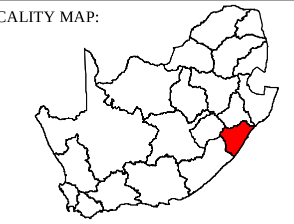
MVOTI TO UMZIMKULU WMA

SURFACE WATER RESOURCE DEVELOPMENT

Prepared by:	T Oosthuizen	Figure 6.3.2.1
Date:	11/2002	
Data Type:	Mvoti-62.apr	



LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Mineralogical Surface Water Quality Class	WSAM

No Data
Ideal
Good
Marginal
Poor
Completely Unacceptable

Gauging Stations

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

N

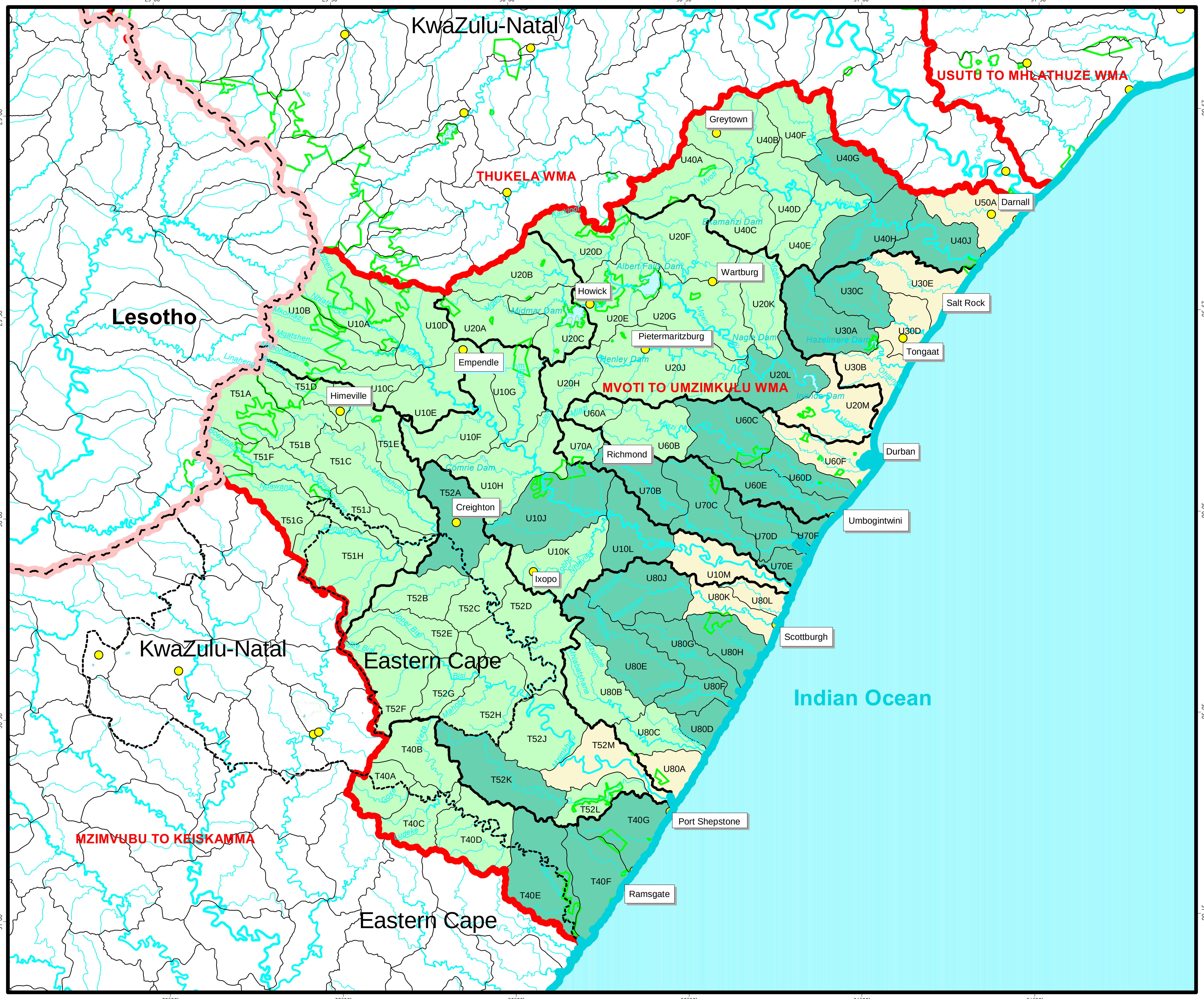
TITLE:

MVOTI TO UMZIMKULU WMA

MINERALOGICAL SURFACE WATER QUALITY

Prepared by:	T Oosthuizen
Date:	11/2002
Data Type:	Mvoti-62.apr

Figure 6.4.1.1



LOCALITY MAP:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Area	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
Mineralogical Ground Water Quality Class	WSAM

- No Data
- Ideal
- Good
- Marginal
- Poor
- Completely Unacceptable

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

10 0 10 20 Kilometers

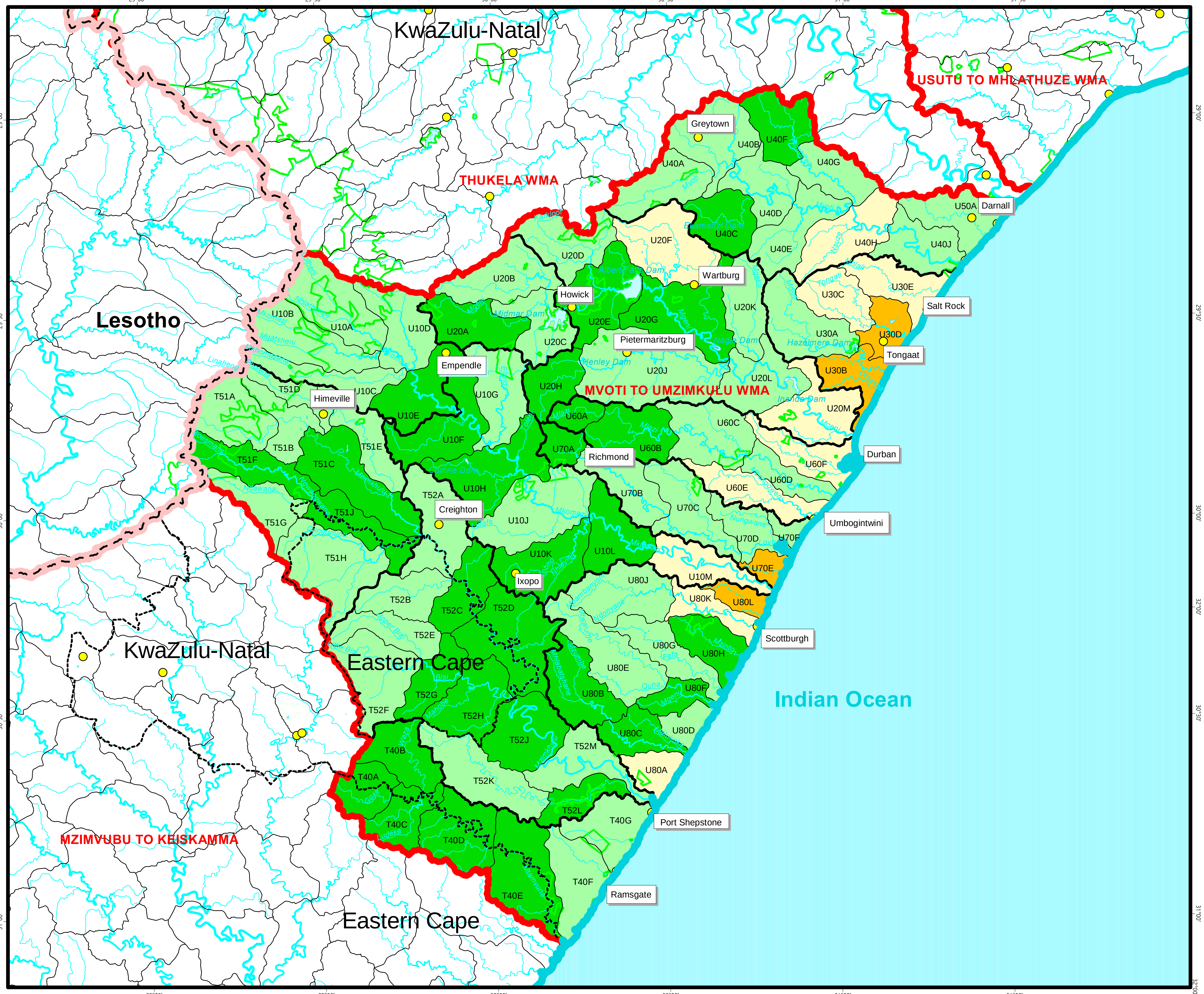
N

TITLE:

MVOTI TO UMZIMKULU WMA

MEAN TOTAL DISSOLVED SOLIDS (TDS)

Prepared by:	T Oosthuizen	Figure 6.4.2.1
Date:	11/2002	
Data Type:	Mvoti-62.apr	



LOCALITY MAP:

BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdrn
X40D Quaternary Number	Quatdrn
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
Nature Reserve Boundaries	Consgeo
PERCENTAGE POTABLE WATER	WSAM

- > 90 %
- 70 - 90 %
- 50 - 70 %
- 30 - 50 %
- < 30 %

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

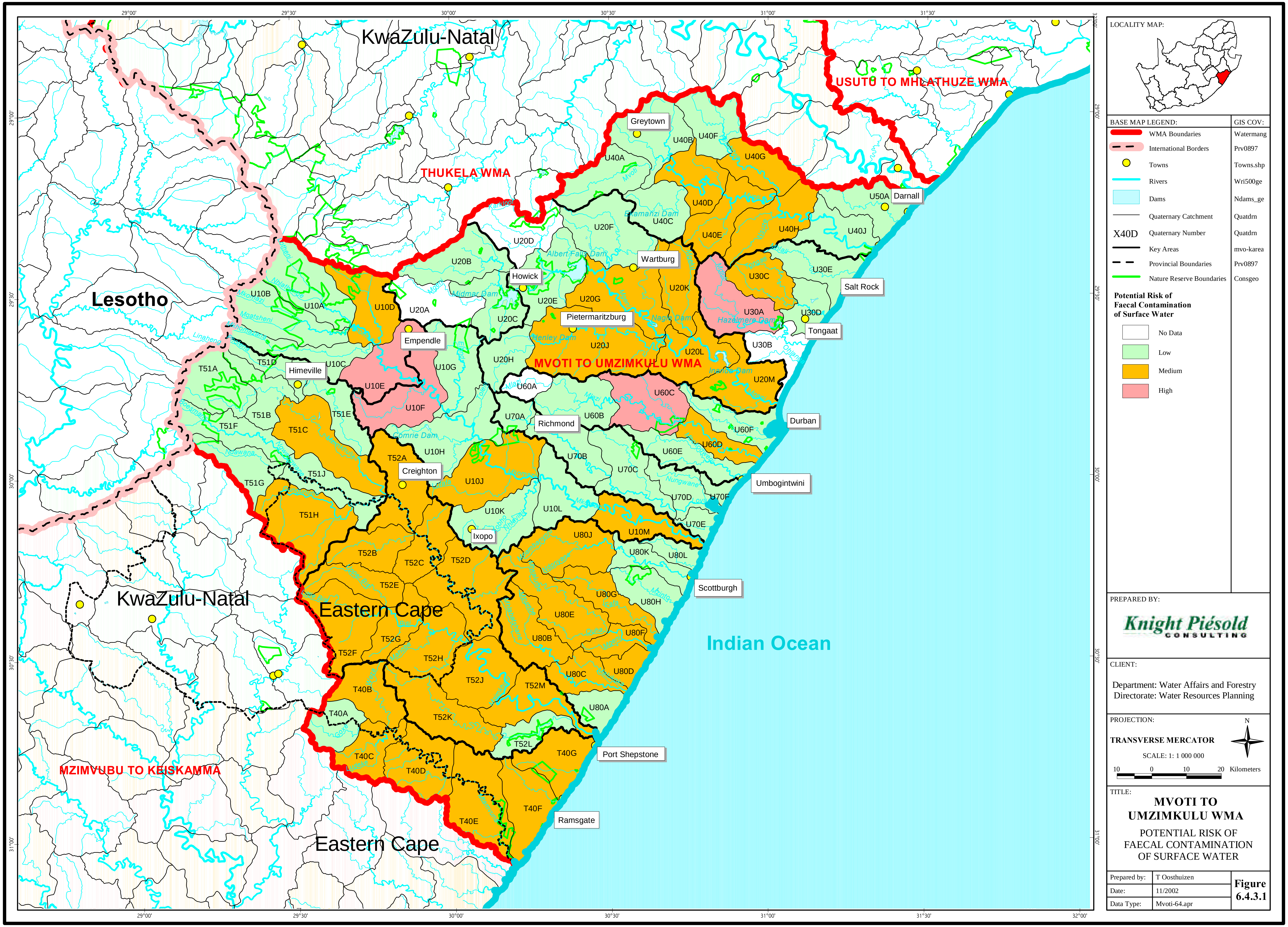
10 0 10 20 Kilometers

TITLE:

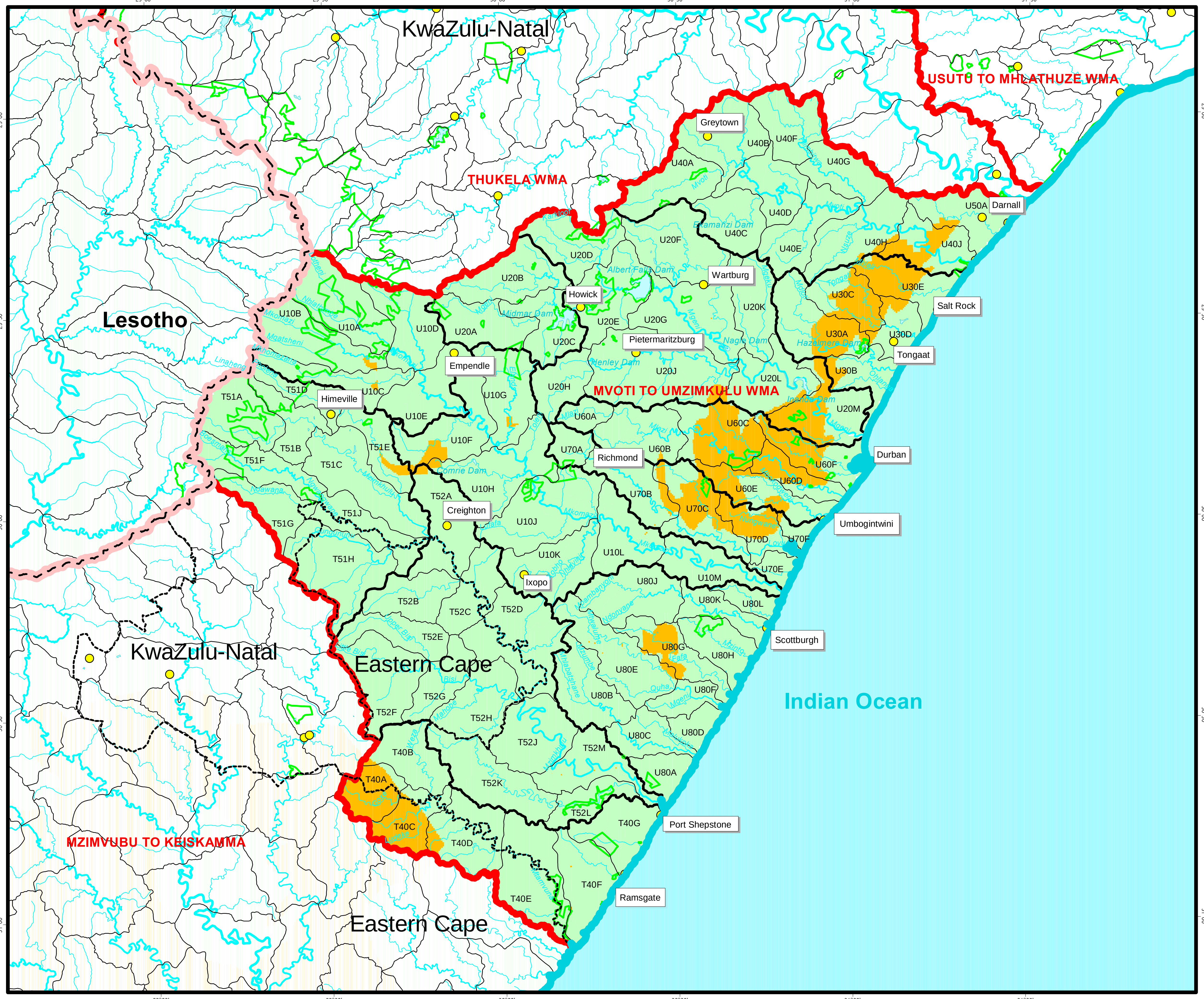
MVOTI TO UMZIMKULU WMA

PERCENTAGE POTABLE WATER

Prepared by:	T Oosthuizen	Figure 6.4.2.2
Date:	11/2002	
Data Type:	Mvoti-62.apr	



KwaZulu-Natal
Lesotho
Eastern Cape
Indian Ocean
THUKELA WMA
USUTU TO MHLATHUZE WMA
MVOTI TO UMZIMKULU WMA
MZIMVUBU TO KEISKAMMA
Greytown
Darnall
Wartburg
Howick
Salt Rock
Pietermaritzburg
Tongaat
Empendle
Himeville
Richmond
Durban
Creighton
Umbogintwini
Ixopo
Scottburgh
Port Shepstone
Ramsgate
LOCALITY MAP:
BASE MAP LEGEND:
WMA Boundaries
International Borders
Towns
Rivers
Dams
Quaternary Catchment
X40D Quaternary Number
Key Areas
Provincial Boundaries
Nature Reserve Boundaries
GIS COV:
Watermang
Prv0897
Towns.shp
Wri500ge
Ndams_ge
Quatdrn
Quatdrn
mvo-karea
Prv0897
Consgeo
Potential Risk of Faecal Contamination of Surface Water
No Data
Low
Medium
High
PREPARED BY:
Knight Piésold CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
TITLE:
MVOTI TO UMZIMKULU WMA
POTENTIAL RISK OF FAECAL CONTAMINATION OF SURFACE WATER
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-64.apr
Figure 6.4.3.1



LOCALITY MAP:

BASE MAP LEGEND:

		GIS COV:
	WMA Boundaries	Watermang
	International Borders	Prv0897
	Towns	Towns.shp
	Rivers	Wri500ge
	Dams	Ndams_ge
	Quaternary Catchment	Quatdm
X40D	Quaternary Number	Quatdm
	Key Areas	mvo-karea
	Provincial Boundaries	Prv0897
	Nature Reserve Boundaries	Consgeo

Groundwater Faecal Contamination Risk

- Low
- Medium
- High

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

N

SCALE: 1: 1 000 000

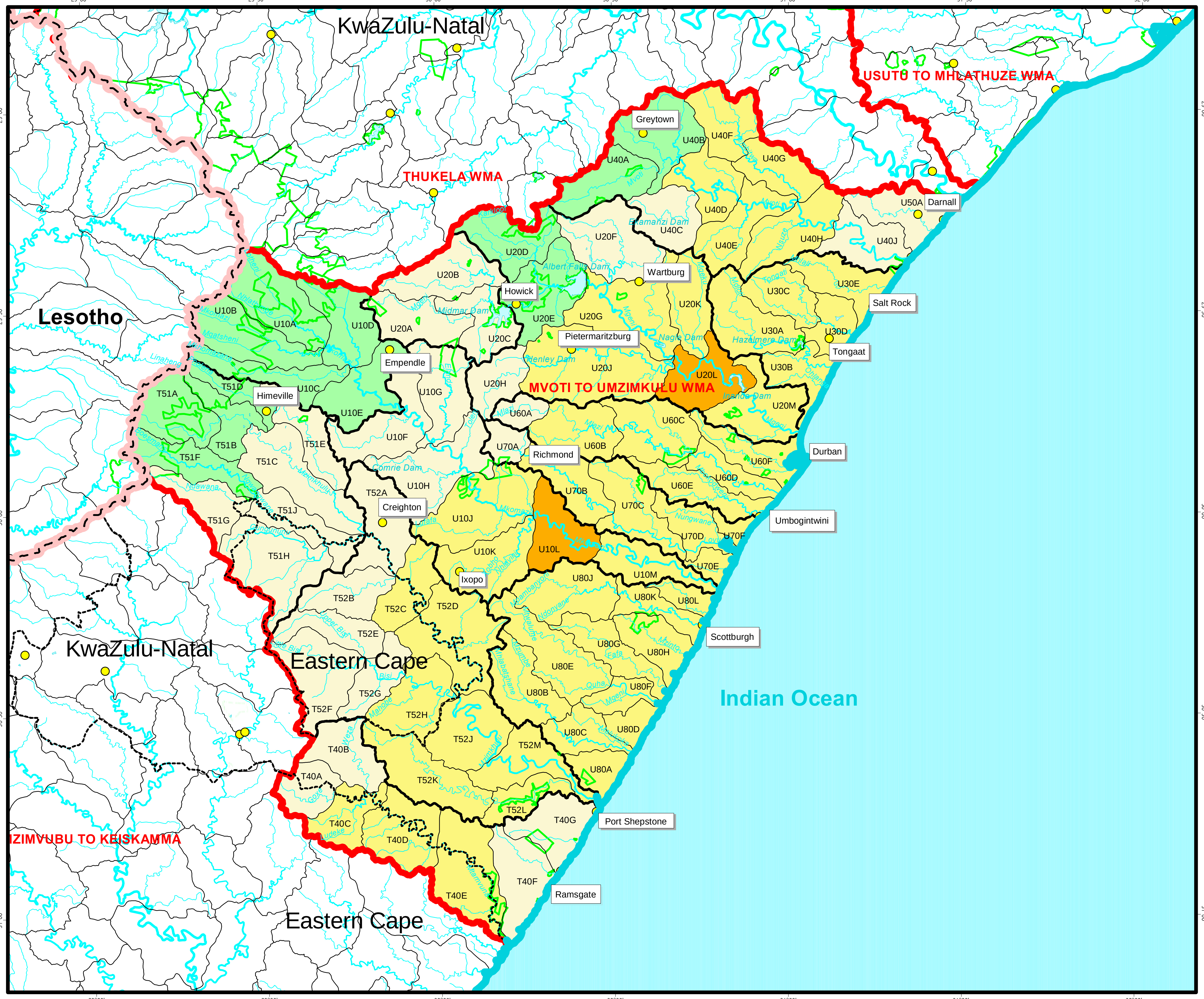
10 0 10 20 Kilometers

TITLE:

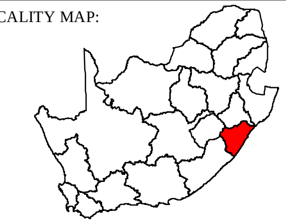
MVOTI TO UMZIMKULU WMA

RISK OF FAECAL CONTAMINATION OF GROUNDWATER

Prepared by:	T Oosthuizen	**Figure 6.4.3.2**
Date:	11/2002	
Data Type:	Mvoti-64.apr	



LOCALITY MAP:



BASE MAP LEGEND:	GIS COV:
WMA Boundaries	Watermang
International Borders	Prv0897
Towns	Towns.shp
Rivers	Wri500ge
Dams	Ndams_ge
Quaternary Catchment	Quatdm
X40D Quaternary Number	Quatdm
Key Areas	mvo-karea
Provincial Boundaries	Prv0897
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%

PREPARED BY:

Knight Piésold CONSULTING

CLIENT:

Department: Water Affairs and Forestry
Directorate: Water Resources Planning

PROJECTION:

TRANSVERSE MERCATOR

SCALE: 1: 1 000 000

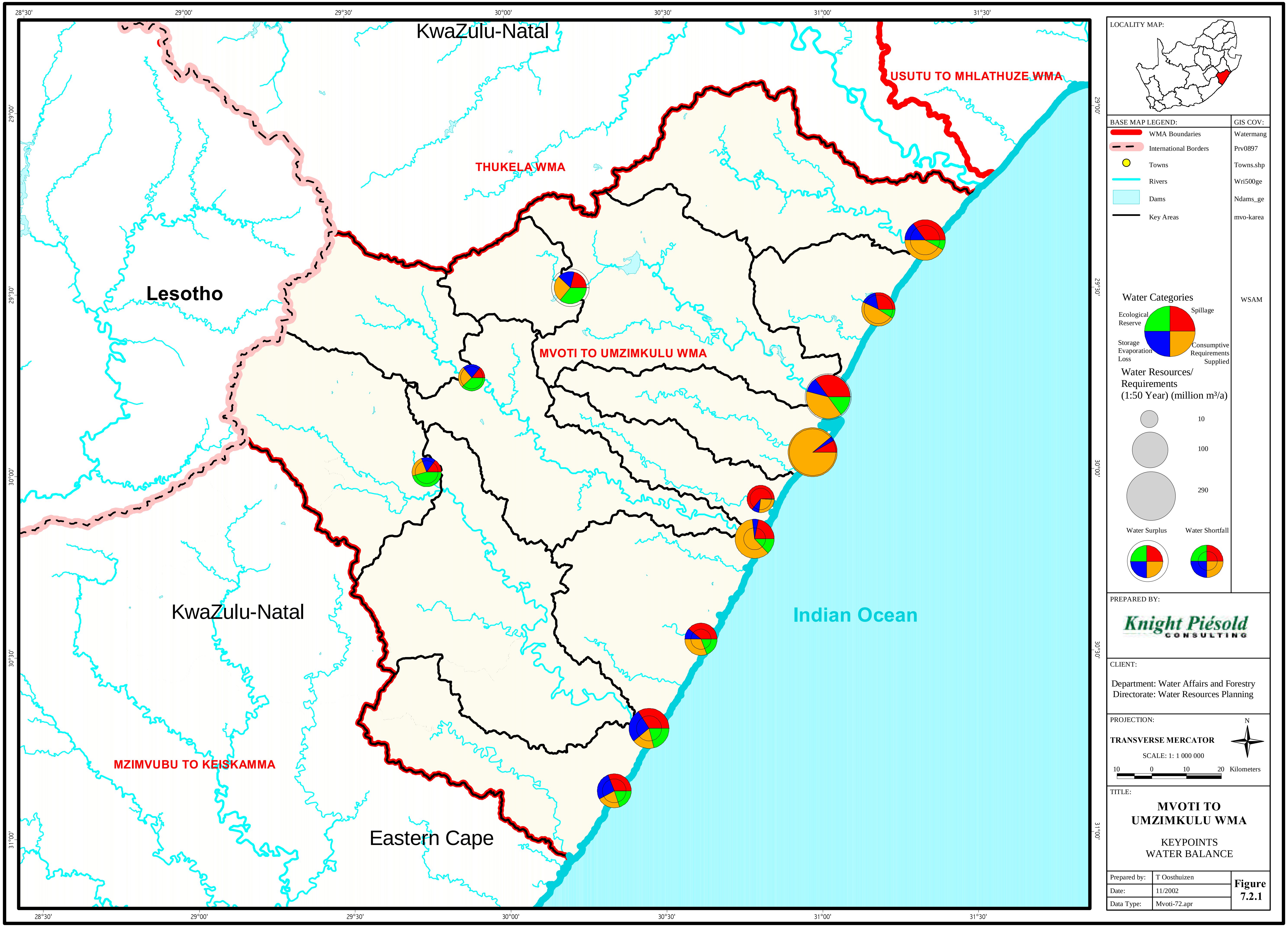
10 0 10 20 Kilometers

TITLE:

MVOTI TO UMZIMKULU WMA

POTENTIAL FOR SEDIMENT ACCUMULATION IN RESERVOIRS

Prepared by:	T Oosthuizen	Figure 6.5.1
Date:	11/2002	
Data Type:	Mvoti-64.apr	


28°30'
29°00'
29°30'
30°00'
30°30'
31°00'
31°30'
KwaZulu-Natal
USUTU TO MHLATHUZE WMA
THUKELA WMA
Lesotho
MVOTI TO UMZIMKULU WMA
KwaZulu-Natal
Indian Ocean
MZIMVUBU TO KEISKAMMA
Eastern Cape
LOCALITY MAP:
BASE MAP LEGEND:
WMA Boundaries
International Borders
Towns
Rivers
Dams
Key Areas
GIS COV:
Watermang
Prv0897
Towns.shp
Wri500ge
Ndams_ge
mvo-karea
WSAM
Water Categories
Ecological Reserve
Spillage
Storage Evaporation Loss
Consumptive Requirements Supplied
Water Resources/ Requirements (1:50 Year) (million m³/a)
10
100
290
Water Surplus
Water Shortfall
PREPARED BY:
Knight Piésold CONSULTING
CLIENT:
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION:
TRANSVERSE MERCATOR
SCALE: 1: 1 000 000
10 0 10 20 Kilometers
N
TITLE:
MVOTI TO UMZIMKULU WMA
KEYPOINTS WATER BALANCE
Prepared by: T Oosthuizen
Date: 11/2002
Data Type: Mvoti-72.apr
Figure 7.2.1