Report No: PB1 U100-00-0799

DEPARTMENT OF WATER AFFAIRS
AND FORESTRY

in association with

UMGENI WATER
Corporate Services Division

MKOMAZI/MOOI-MGENI TRANSFER SCHEME PRE-FEASIBILITY STUDY

MKOMAZI-MGENI TRANSFER SCHEME

SUPPORTING REPORT No 3

RECONNAISSANCE BASIN STUDY

Report No 2787C/7856
May 1999

NINHAM SHAND
CONSULTING ENGINEERS

MKOMAZI/MOOI-MGENI TRANSFER SCHEME PRE-FEASIBILITY STUDY
REPORT STRUCTURE

MGENI AUGMENTATION OVERVIEW REPORT

MKOMAZI-MGENI TRANSFER SCHEME MAIN REPORT

- SUPPORTING REPORT No 1
  RECONNAISSANCE INVESTIGATIONS
- SUPPORTING REPORT No 2
  MGENI SYSTEM WATER DEMANDS
- SUPPORTING REPORT No 3
  RECONNAISSANCE BASIN STUDY
- SUPPORTING REPORT No 4
  HYDROLOGY & WATER RESOURCES
- SUPPORTING REPORT No 5
  ENVIRONMENTAL
  - VOLUME 1
  - VOLUME 2: SUPPLEMENTARY DOCUMENTS
    - Environmental Prognosis of Impact of Transfer of Water from Mkomazi River to Mgeni & Mlazi catchments
    - Environmental Scoping for Components of the Conveyance Route
    - Mkomazi Estuarine Freshwater Requirements
  - VOLUME 3: SUPPLEMENTARY DOCUMENTS
    - Mkomazi IFR Study
  - VOLUME 4: SUPPLEMENTARY DOCUMENTS
    - Social Impact Assessment Report
    - Impact on Fauna and Flora of the Impendle and Smithfield Dam Sites
- SUPPORTING REPORT No 6
  ENGINEERING DESIGN & COSTING
  - VOLUME 1
  - VOLUME 2: SUPPLEMENTARY DOCUMENTS
    - Risk Assessment
    - Water Quality Assessment
- SUPPORTING REPORT No 7
  ECONOMICS
  - VOLUME 1
  - VOLUME 2: SUPPLEMENTARY DOCUMENTS
    - Socio-Economic Impact of outcomes relating to the Mkomazi-Mgeni Augmentation Scheme

MOOI-MGENI TRANSFER SCHEME MAIN REPORT

- SUPPORTING REPORT No 1
  WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
- SUPPORTING REPORT No 2
  HYDROLOGY & WATER RESOURCES
- SUPPORTING REPORT No 3
  ENVIRONMENTAL
  - VOLUME 1
  - VOLUME 2: SUPPLEMENTARY DOCUMENTS
    - Spring Grove - Dartington Pre-feasibility Social Impact Assessment
  - VOLUME 3: SUPPLEMENTARY DOCUMENTS
    - Mooi IFR Refinement Study
  - VOLUME 4: SUPPLEMENTARY DOCUMENTS
    - Impact of Fauna and Flora of the Spring Grove & Dartington Dam Sites
- SUPPORTING REPORT No 4
  ENGINEERING DESIGN & COSTING
  - VOLUME 1
  - VOLUME 2: SUPPLEMENTARY DOCUMENTS
    - Engineering Geological Report

MKOMAZI / MOOI-MGENI TRANSFER SCHEME PRE-FEASIBILITY STUDY

PREFACE

In January 1997, the Department of Water Affairs & Forestry: Directorate of Project Planning, in conjunction with Umgeni Water: Corporate Services Division, invited various firms of consulting engineers to submit proposals to undertake a Pre-Feasibility Study for a scheme to transfer water from the upper Mkomazi River to the Mgeni System. In July 1997, a multi-disciplinary team led by Ninham Shand was appointed.

This Study follows on from the Mgeni River System Analysis Study carried out between 1991 and 1994, in which the Mkomazi River was identified as a potentially viable source of water for augmentation of the Mgeni System, and the Mooi-Mgeni Transfer Feasibility Study carried out in 1995, in which the first phase scheme to augment the Mgeni System from the Mooi River was investigated in detail and possible second phase schemes were identified.

This Study comprises two distinct parts; a pre-feasibility investigation of augmentation schemes on the Mkomazi River preceded by scheme identification and reconnaissance investigations, and a pre-feasibility investigation of second phase transfer schemes from the Mooi River. A comparison of the two main augmentation options is made at the culmination of the Study. The report structure is given overleaf.

Sub-consultants employed by Ninham Shand to undertake various aspects of the Study included:

- IWR Environmental: Environmental studies and IEM co-ordination
- Scott Wilson: Social studies
- Keeve Steyn: Engineering aspects of tunnels and pumpstations, and involvement with Basin Studies
- Simmer Biggar and Associates: Infrastructure aspects.

As part of the Study Team, the following Client departments were involved:

- Council for Geoscience: Geological Survey
- Department of Water Affairs & Forestry: Project Planning (East)
- Department of Water Affairs & Forestry: Environment Studies
- Department of Water Affairs & Forestry: Hydrology
- Umgeni Water: Corporate Services Division: Water Resources Planning
- Umgeni Water: Scientific Services Division: Water Quality
- Umgeni Water: Scientific Services Division: Hydro-biology.

EXECUTIVE SUMMARY

This Report describes the Reconnaissance Basin Study, in which water demands within the Mkomazi River basin for the various user sectors are described for present (1995) and future (2040) conditions. Three future scenarios were evaluated, namely a high, middle (most likely) and low road scenario. The impact of the in-basin demands on the yield of proposed transfer schemes was also evaluated. The main objective of this component of the Mkomazi-Mgeni Transfer Scheme Pre-Feasibility Study was to ensure that adequate allowance is made for water demands within the donor catchment before water can be made available for transfer, thus ensuring that inhabitants of the Mkomazi Catchment are not adversely affected by the proposed transfer scheme.

The following user sectors were assessed:

- *Domestic (rural and urban)*
- *Agriculture (irrigation and livestock)*
- *Forestry*
- *Industrial*
- *Environmental.*

Data was gathered from various sources, generally in a processed rather than raw form, with particular assistance from Umgeni Water in the form of GIS data. Assembly of primary data was excluded from the terms of reference based on the current level of study.

By far the largest sectoral demand for future (2040) conditions was found to be the environment, at approximately 25% of the natural MAR for the middle scenario. This was followed by forestry at 8%, and irrigation and industry (SAPPI/SAICCOR) both at 5% of the natural MAR. Livestock and domestic demand combined make up only 1% of the MAR. Both the forestry and irrigation demands are concentrated in the middle reaches of the catchment.

The impacts of the present and future demands on the yield of the proposed transfer schemes were also modelled. The reduction in yield for the middle scenario was less than 10% in all cases. A possible future dam on the lower reaches of the Mkomazi was also evaluated, but its viability is doubtful, as a very large dam would be required in order to achieve a significant yield.

A water balance was carried out, taking into account all future middle scenario demands, as well as the proposed Smithfield Scheme, which appeared to be the more favourable transfer scheme on the basis of the reconnaissance investigations. It was found that all but approximately 18% of the MAR is utilised. This remaining portion would be mainly large floods and could almost certainly not be feasibly harnessed.

The following further studies and actions are recommended for the feasibility phase of investigation:

- *Proceed with the determination of the Ecological and Basic Human Needs Reserves.*
- *Review projected forestry areas and other runoff-reducing activities in the light of catchment management initiatives, possible revisions to limits previously set and changes in policy.*
- *Update hydrological and yield models accordingly.*

MKOMAZI-MGENI TRANSFER SCHEME

SUPPORTING REPORT NO 3: RECONNAISSANCE BASIN STUDY

CONTENTS **Page**

CONTENTS (cont'd) **Page**

LIST OF FIGURES

Figures bound in Report

Figures bound in Appendix F

CONTENTS (cont'd)

Figures bound in Appendix F (cont'd)

APPENDICES: SUPPORTING DEMAND DATA

MKOMAZI-MGENI TRANSFER SCHEME

SUPPORTING REPORT NO 3: RECONNAISSANCE BASIN STUDY

1. BACKGROUND AND INTRODUCTION

During the course of the reconnaissance phase of the Study (Supporting Report No 1: Reconnaissance Investigations), it was noted that to date no attempt had been made to quantify the present and future water demands within the Mkomazi River basin. It has historically been policy of the Department of Water Affairs & Forestry (DWAF) that the demands of a donor catchment should be met before water can be transferred to another catchment, that is, water cannot be transferred to another catchment to the detriment of the inhabitants of the donor catchment.

With this in mind, it was agreed by the Project Management Team that an additional study to determine the present and future water demands within the Mkomazi basin should be carried out. It was agreed that due to time and budget constraints and the level of detail of the main study, this should be carried out at a reconnaissance level, making use as far as possible of existing sources of data. Collection of primary data was specifically excluded. There will be adequate opportunity for refinement of the Basin Study during the feasibility phase of planning, should this be deemed necessary.

This report describes the Reconnaissance Basin Study, in which water demands within the Mkomazi River basin for the various user sectors are described for present (1995) and future (2040) conditions. The locality of the basin is shown in **Figure 1** in **Appendix F**. Three future scenarios were evaluated, namely a high, middle (most likely) and low road scenario. The impact of the in-basin demands on the yield of proposed transfer schemes was also evaluated. The main objective of this component of the Mkomazi-Mgeni Transfer Scheme Pre-Feasibility Study was to ensure that adequate allowance is made for water demands within the donor catchment before water can be made available for transfer, thus ensuring that inhabitants of the Mkomazi Catchment are not adversely affected by the proposed transfer scheme. Economic evaluations of the proposed transfer schemes, described in Supporting Report No 7: Economics, were also based on yields calculated with future in basin demands in place.

It was decided that the study should be carried out at quaternary subcatchment level (Midgley *et al*, 1994a), the localities and extents of which are shown in **Figure 2** in **Appendix F**. Three future demand scenarios were evaluated, with the middle road scenario forming the basis of the current phase of planning and the other two scenarios being evaluated with a view to assessing sensitivity. The following user sectors were assessed:

- Domestic (Rural and urban)
- Agriculture (Irrigation and livestock)
- Forestry
- Industrial
- Environmental.

2. APPROACH AND METHODOLOGY

2.1 General

With the study being carried out at macro level, in support of the Pre-Feasibility Study, data gathering has been at a fairly high level, with only existing information being used. Data has been sourced from, inter alia, studies carried out previously in the region, current investigations into population characteristics, the Umgeni Water GIS database, the Department of Water Affairs & Forestry and KZN Department of Agriculture. Data processing has been confined to corrections to information obtained where errors were detected, and reformatting of data for consistency of reporting.

2.2 Data Gathering and Processing

2.2.1 Population figures and domestic unit demands

Population data

The base data for the determination of domestic demands was taken from a model of the population projections for the Umgeni Water operational area, supplied in electronic format by Umgeni Water, having been developed under a separate appointment by the Scott Wilson Planning and Development division (Umgeni Water, 1998a). This model was based on the 1991 census data, being the most recent information available. A description of the model, the procurement of data and methodology used by Scott Wilson is given in **Appendix A.**

Data for the entire planning area was made available on a quaternary subcatchment basis, with an urban/non-urban breakdown, for the current (1995) level up to future (2040) levels in increments of 4 to 5 years. Four growth scenarios were considered in this population analysis:

Scenario 1 - High Growth
Scenario 2 - Middle Growth
Scenario 3 (i) - Low Growth
Scenario 3 (ii) - Low Growth.

The methodology behind this population model will not be discussed in detail (see description in **Appendix A**), save to say that the two Low Growth scenarios attempt to model the impact of the Aids epidemic on the future population growth, using a percentage reduction applied to the total population.

Summarised population data is illustrated in **Figures 2.1** and **2.2**, showing rural and urban population totals per quaternary subcatchment respectively. **Figure 3** in **Appendix F** shows the projected middle road population in each quaternary subcatchment.

Unit demands

To develop a range of unit demands, reference was made to the National Housing Board (NHB) guidelines, (National Housing Board, 1995). **Table 2.1** shows the typical water usages as given by the NHB, for communal water points, yard and house connections.

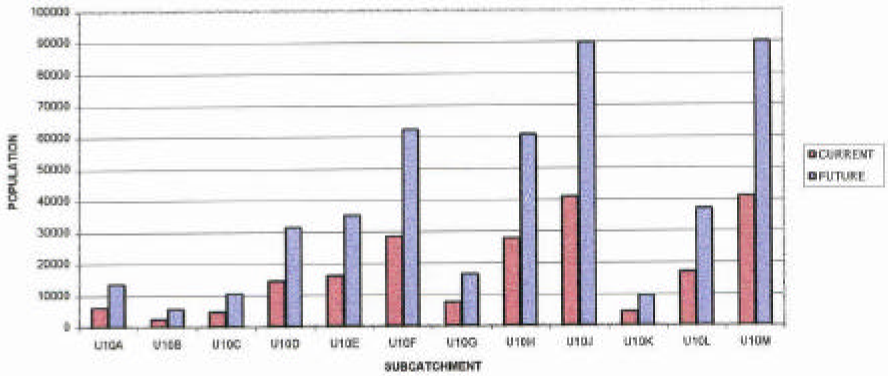
TABLE 2.1: TYPICAL DOMESTIC WATER USAGE (NATIONAL HOUSING BOARD, 1995)

Type of water supply	Typical consumption (litres/capita/day)	Range
Communal water point		
Well or standpipe at considerable distance (> 1000 m)	7	5 - 10
Well or standpipe at medium distance (250 - 1000 m)	12	10 - 15
Well nearby (< 250 m)	20	15 - 25
Standpipe nearby (< 250 m)	30	20 - 50
Yard connection	40	20 - 80
House connection		
Single tap	50	30 - 60
Multiple tap	150	70 - 250

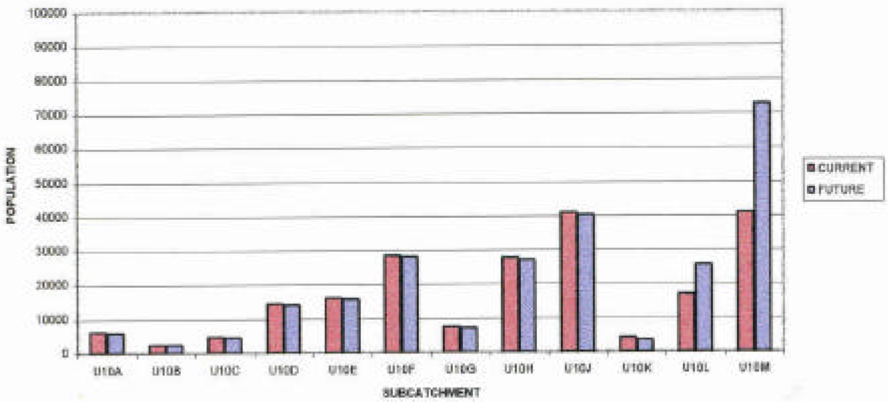
Using the above guidelines, per capita daily water consumption was determined for high, medium and low scenarios for urban and rural (non-urban) populations, (see **Table 2.2**).

FIGURE 2.1 : RURAL POPULATION, CURRENT vs FUTURE

HIGH SCENARIO



MIDDLE SCENARIO



LOW SCENARIO

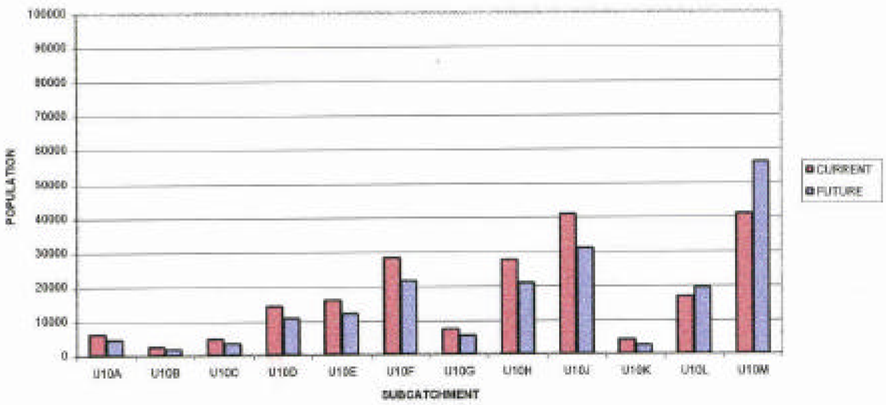
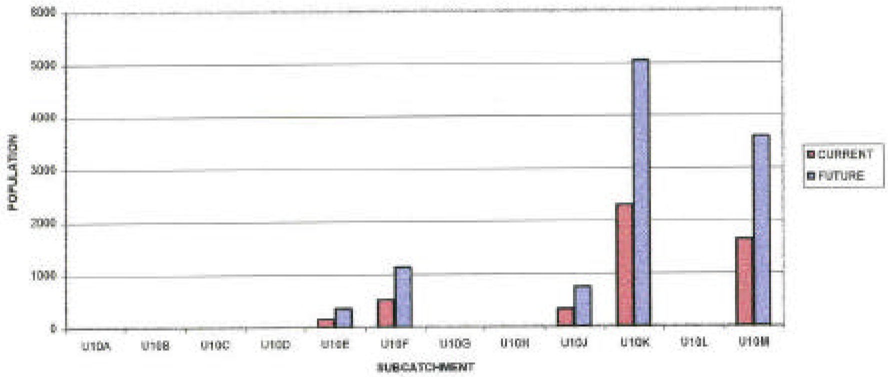
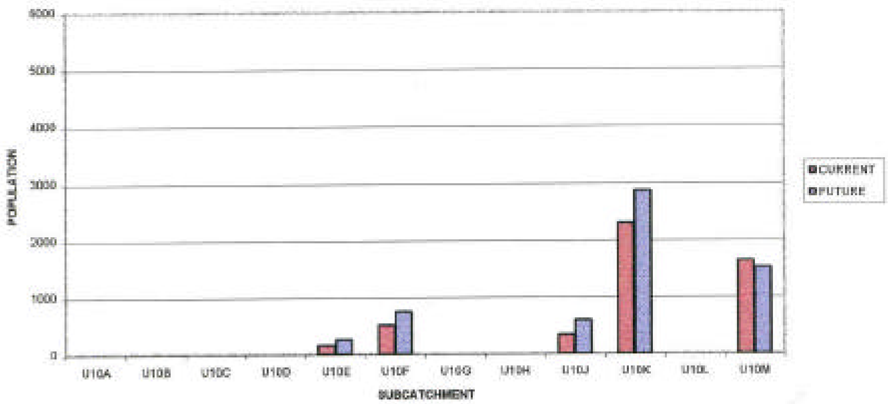


FIGURE 2.2 : URBAN POPULATION, CURRENT vs FUTURE

HIGH SCENARIO



MIDDLE SCENARIO



LOW SCENARIO

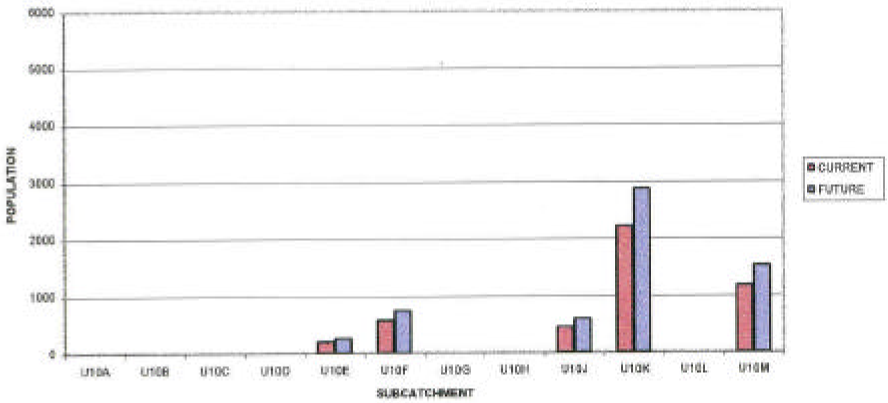


TABLE 2.2: HIGH, MEDIUM AND LOW PER CAPITA DEMANDS FOR URBAN AND RURAL POPULATIONS

Category	Demand (*l*/c/d) for Scenario		
	High	Medium	Low
Urban	200	150	100
Rural (Non-urban)	60	30	8

High scenario

An urban demand of 200 *l*/c/day falls below the upper range of the NHB guidelines for a household connection with multiple taps. This lower figure has been adopted to allow for the mix of urban and peri-urban categories in the urban population data. The rural demand of 60 *l*/c/day lies just short of the upper range for yard connections in rural schemes.

Middle scenario

The urban demand of 150 *l*/c/day reflects the NHB recommended typical consumption for a household connection with multiple taps. The rural figure of 30 *l*/c/day is the typical rate for a standpipe system closer than 250 m. It is assumed here that ultimately all rural communities will have this level of service (bearing in mind that this study is considering only the ultimate future (2040) condition).

Low scenario

An urban figure of 100 *l*/c/day lies in the lower range given in the NHB guidelines for a household connection with multiple taps. A rural demand of 8 *l*/c/day approximates the typical consumption rate for communal water point type schemes with a well or standpipe at a considerable distance (> 1000 m).

Combining the above population growth scenarios and water demand scenarios produces a matrix of possible consumption scenarios, as illustrated in **Table 2.3**.

TABLE 2.3: WATER CONSUMPTION SCENARIOS

Population Scenario	Consumption Scenario		
	High	**Medium**	**Low**
High	**X**	x	x
Medium	x	**X**	x
Low (L1)	x	x	**X**
Low (L2)	x	x	x

Those alternatives shown with shaded blocks have been used in the following analysis of domestic water demands to derive total consumption figures for each quaternary subcatchment. No separate figures have been derived for the Low (L2) scenario, as the population figures for the future (2040) development are similar to those of the Low (L1) scenario, and will thus yield similar overall consumption.

The population base data and unit demands are included in **Appendix A**, along with the calculations of the urban and rural domestic demands, at quaternary subcatchment level for 1995 (current), 2020 and 2040 (future) conditions.

2.2.2 Groundwater potential

The availability of groundwater in the Mkomazi River catchment has been considered as a means of supplying the rural population from an alternative source to surface water.

Data on groundwater was obtained from the Umgeni Water GIS database, in the form of Harvest Potential or Safe Abstraction Levels. **Figure 4** in **Appendix F** shows the Mkomazi River basin with its quaternary subcatchments, indicating the groundwater Harvest Potential, ranging from 13 600 $m^3/km^2/a$ to 89 800 $m^3/km^2/a$.

The method used in determining the feasibility of supplying a community with groundwater can be summarised as follows (Umgeni Water, 1998d):

- establish the demand of the community;
- select an area beyond which the drilling of boreholes is not economically practical due to conveyance costs;

- calculate the abstractable volume according to the area of viability; and
- compare yield with demand, applying a factor of safety of 2 or 3 to the community demand.

In applying this process on a regional (quaternary subcatchment) basis, some assumptions had to be made regarding the area within each catchment in which it will be economically viable to drill boreholes to supply the rural communities. Details of the distribution of rural communities within each subcatchment are not available at the current level of study, hence an arbitrary percentage of total subcatchment area was assumed. In general, 10% of the catchment area has been assumed to be suitable or viable for groundwater sourcing. This lower value, although chosen arbitrarily, takes into account areas that are unsuitable due to sparse population distribution, terrain or groundwater quality.

For each quaternary subcatchment an estimate was made of the relative area of the various Harvest Potential classifications present. Multiplying each subcatchment area by the percentage area which could be a potential source, as discussed above, and then carrying out a pro-rata exercise for the various Harvest Potential classifications produces a safe abstraction total. The results of this analysis are given in **Appendix B**.

2.2.3 Agriculture - Irrigation

High scenario

During the course of the Mgeni River System Analysis Study (MRSAS) carried out by BKS (DWAF and Umgeni Water, 1994), the detailed investigation carried out on the Mooi River basin predicted a maximum potential increase in irrigation in that catchment of approximately 100%. This was based on an estimate of existing cultivated land shown in 1:50 000 topographical maps and aerial photographs, summed with all other areas within 2 km and not more than 60 m above the river, excluding marsh, swamp and vlei areas, very steep and built-up areas (in accordance with DWAF guidelines).

It was established that factors such as availability of water, suitability of soils and market demands were not taken into account in the Mooi River analysis, and that the areas determined were probably somewhat high (Cedara, 1998a), although probably acceptable for the purposes of that study. With the lack of a similar exercise on the Mkomazi River basin, the principle of a 100% increase in irrigation was adopted as the high scenario.

The BKS investigation produced maximum irrigation areas in terms of the then proposed dam subcatchments for the Mooi River. These increases were used to develop individual percentage increases for each quaternary subcatchment on the Mooi River, as part of the current investigation in that basin, (see Mooi-Mgeni Transfer Scheme Supporting Report No 1: Reconnaissance Basin Study). The pertinent details of that analysis, in which data was produced for both irrigation from the main stream and tributaries, are given in **Appendix C** of this report.

To develop similar characteristics for the Mkomazi River basin, a comparison was made of position in the overall catchment, topography, Mean Annual Precipitation (MAP) and status of current irrigation development within each subcatchment. By comparing these parameters with quaternary subcatchments of the Mooi River Basin, similar increases were adopted as and where appropriate.

The result of this more qualitative analysis was a maximum possible area of irrigation (high scenario) of 171,47 km^2 versus a current area of 81,39 km^2, representing an increase of about 110%.

In some subcatchments, no current irrigation has been identified. In these areas, an arbitrary (but limited) value has been assigned as a future area.

Middle Scenario

From discussions with Mr R Bennett of the Bio-Resource Centre (BRC), (Cedara, 1998a), it was agreed that the scenario developed by BKS was in all likelihood an over prediction of future irrigation areas, and that the potential for irrigation in the Mkomazi River basin is somewhat lower. In accordance with this premise, each quaternary subcatchment was considered on its own merits, and probable percentage increases to future full irrigation development were devised.

This was done in conjunction with the Bio-Resource Unit (BRU) map shown in **Figure 5** in **Appendix F**. According to this classification, developed by the BRC, the potential for an area is determined according to an amalgamation of factors such as rainfall, soil types and slope, and applies not only to irrigation but to agriculture as a whole. Approximate areas for each BRU were determined within a subcatchment, and used as an indicator of the overall potential for agriculture within that area. The current area under irrigation was also used as an indicator of the potential - a low current area indicates a probable low suitability for irrigation. Probable ultimate increases in irrigated areas were developed using these indicators, with areas having no current irrigation being assigned an arbitrary value. These calculations are shown in **Appendix C** and yielded an overall increase of approximately 54%.

Low scenario

A low scenario was developed by assuming 50% of the increase proposed for the middle scenario. Again, where no irrigation is shown currently, limited increases were assigned.

Table 2.4 shows the current and future irrigation areas for the three scenarios, at quaternary subcatchment level, with a graphical representation given in **Figure 2.3**.

TABLE 2.4: CURRENT AND FUTURE IRRIGATION AREAS

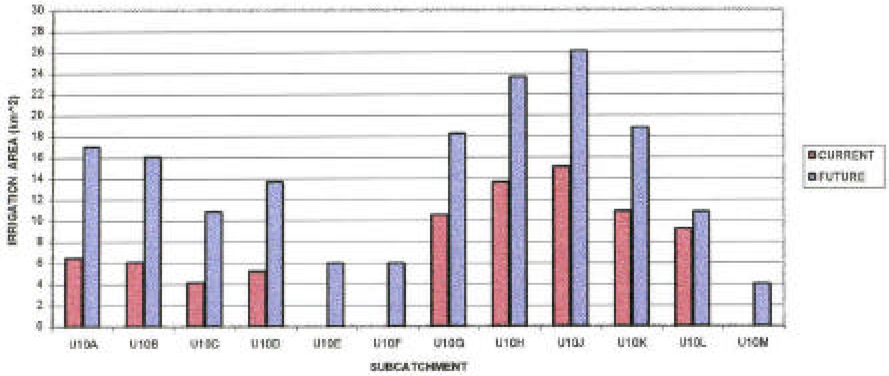
Subcatchment	Catchment Area (km^2)	Current development (km^2)			Future Development (Total) (km^2)		
		Main	Trib's	Total	High	Middle	Low
U10A	418	4,87	1,63	6,50	17,08	8,13	7,31
U10B	392	4,57	1,53	6,10	16,03	7,63	6,86
U10C	267	3,11	1,04	4,15	10,90	5,81	4,98
U10D	337	3,92	1,31	5,23	13,74	8,37	6,80
U10E	327	0,00	0,00	0,00	6,00	4,00	2,00
U10F	379	0,00	0,00	0,00	6,00	4,00	2,00
U10G	353	1,16	9,42	10,58	18,30	15,87	13,23
U10H	458	1,50	12,17	13,67	23,65	20,51	17,09
U10J	505	1,65	13,44	15,09	26,11	22,64	18,86
U10K	364	1,19	9,68	10,87	18,81	15,22	13,04
U10L	307	1,00	8,20	9,20	10,84	11,50	10,35
U10M	280	0,00	0,00	0,00	4,00	2,00	1,00
Total	**4388**	**22,97**	**58,42**	**81,39**	**171,47**	**125,68**	**103,52**

2.2.4 Agriculture - Livestock

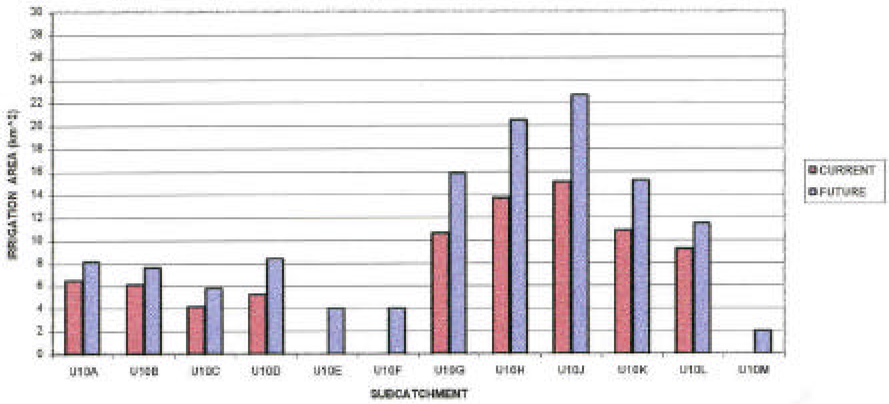
Data pertaining to livestock counts in the Mkomazi River catchment was obtained from the State Veterinary Services (KZN Dept. of Agriculture, 1998). This information was included in the Livestock Census for 1997. Numerical

FIGURE 2.3 : TOTAL IRRIGATION AREAS : CURRENT vs FUTURE

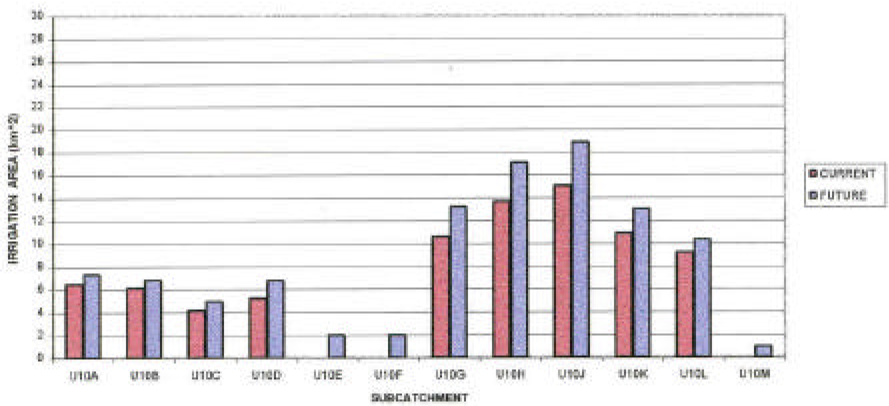
HIGH SCENARIO



MIDDLE SCENARIO



LOW SCENARIO



data was supplied at a magisterial district level, and classified according to cattle, sheep, goats, horses, donkeys/mules, pigs, poultry and dogs. For the purposes of the current analysis only cattle, sheep and goats were considered. Using a graphical representation of the magisterial districts overlaid with the quaternary subcatchment boundaries (see **Figure 6** in **Appendix F**), an estimate was made of the relative proportion of the magisterial district in each subcatchment, and the total livestock count was determined on a pro-rata basis for that area. Unit demands were developed after consultation with Mr R Bennett (Cedara, 1998b), based on daily consumption for a Large Stock Unit (LSU). Cattle were given an average value to account for dairy/beef split.

In order to develop a growth pattern for livestock, it was assumed that the demand for meat and dairy products, and consequently the total livestock population, would grow at the same rate as the population of the Umgeni Water operational area, as determined by Scott Wilson (Umgeni Water, 1998a) using the population model described in Section 2.2.1. This yielded an approximate overall increase of 51% between 1995 and 2020, and 12% between 2020 and 2040. The base data, unit demands and demand calculations are given in **Appendix D**.

2.2.5 Forestry

Details of current forestry areas and permits were obtained from the Department of Water Affairs & Forestry (DWAF, 1998), in the form of data sheets used for permit approval and allocation, showing existing areas and permits applied for and approved to date.

The data currently being used by DWAF to determine existing areas of afforestation is a union of National Landcover (NLC) areas obtained by the Council for Scientific and Industrial Research (CSIR), utilising satellite imagery, and information obtained by Umgeni Water using aerial photography. The CSIR data has apparently not been ground-truthed and is thus considered to be conservative. In addition to this, the union of the two data sets produces high values as areas of natural vegetation are not excluded and any overestimation in either data set is replicated in the final set. The Umgeni Water data, due to its method of procurement, is considered to be more accurate and excludes natural forests. The existing forestry areas according to these two methods are shown in **Table 2.5**.

TABLE 2.5: EXISTING FORESTRY AREAS AS DEFINED BY DWAF AND UMGENI WATER

Subcatchment	Catchment Area (km^2)	Afforested Area (km^2)		
		CSIR 96	Umgeni Water	CSIR 96 *U* Umgeni Water (DWAF)*
U10A	418	2,98	2,35	5,09
U10B	392	10,46	8,74	17,92
U10C	267	12,76	38,86	45,60
U10D	337	5,38	15,53	20,37
U10E	327	33,18	40,76	50,66
U10F	379	47,32	69,31	81,43
U10G	353	54,60	62,87	86,81
U10H	458	132,88	138,25	174,84
U10J	505	146,55	134,37	172,72
U10K	364	80,30	76,90	102,08
U10L	307	15,39	9,82	20,43
U10M	280	0,00	0,24	2,43
Total	**4388**	**541,80**	**598,00**	**780,38**

Note: * DWAF figures are the union of CSIR and Umgeni Water figures.

An apparent error was noted in the DWAF data sheets with the existing forestry area of U10A. This has been adjusted for the current calculations.

The basis of permit allocation by DWAF is an allowable percentage reduction in base flow runoff from the catchment. An additional factor is also applied for sub-optimal catchments (optimal catchments are given a factor of 1). The result is an allowable increase in afforestation up to a point where the base flow runoff is reduced to the level calculated using the above factor.

To develop the various future scenarios, the methods described below were used. Note that it was assumed that other runoff-reducing activities, such as dry land sugar cane cultivation, will, in future, be controlled by Catchment Management Agencies in a similar manner to forestry. Maximum permissible reduction in runoff will be determined and future forestry areas described below were therefore assumed to include other runoff reducing activities. (The data and calculations are given in **Appendix E**).

<u>High scenario</u>

The higher DWAF existing area (CSIR 96 *U* Umgeni Water) was used as a baseline, to which was added all currently registered permit applications, whether approved or not. This was compared with the baseline area plus the allowable additional area calculated on the basis of percentage reduction in runoff, with the maximum of these two being accepted.

Where some sub-optimal catchments have high allowable percentage runoff reduction figures, these were checked against forestry potential maps for Eucalyptus and Pine (see **Figures 7** and **8** in **Appendix F**), and the percentage of suitable or optimal area within each subcatchment. All these subcatchments showed high percentages of suitable or optimal area.

Subcatchments U10A - D, in the upper part of the basin, include large tracts of natural forest and nature reserve. This is shown in **Figure 13** in **Appendix F**, which illustrates environmentally sensitive parts of the Mkomazi River catchment. On the basis that these areas will not be planted with commercial forest, the "available" area for afforestation in these four quaternary subcatchments has been calculated according to the allowable percentage reduction in runoff, as described above, applied to only that portion of the catchment area not covered by indigenous forest or nature reserve.

This analysis is shown in the calculations for the high scenario given in **Appendix E**. The percentage area considered to be unavailable for commercial afforestation in each of these subcatchments can be summarised as follows:

U10A	Loteni Nature Reserve	60%
U10B	Cobham State Forest	60%
U10C	Cobham State Forest	40%
U10D	Mkomazi Forest	20%.

<u>Middle scenario</u>

The Umgeni Water base data, considered to be more accurate, was taken as the existing afforested area. To this was added the areas covered by any permits that have been approved to date, and the probable increment that will be applied by DWAF to achieve the maximum allowable area according to percentage runoff reduction. It was assumed that DWAF would calculate the increment on the basis of their own baseline data described under the High Scenario.

Low scenario

The Umgeni Water existing afforested areas were used as base areas, to which were added all currently approved permits.

The results of the analysis of future areas of afforestation are summarised in **Table 2.6**, and illustrated in **Figure 2.4**.

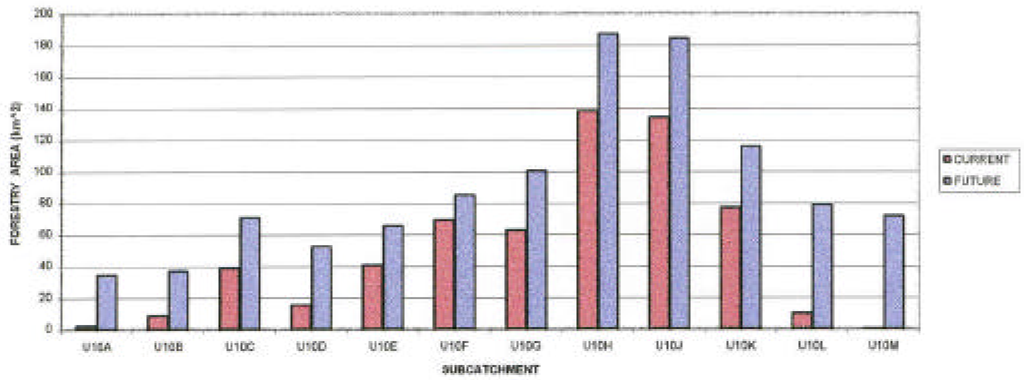
The maximum allowable afforestation in the Mkomazi River catchment was also calculated in the Mkomazi/Mgeni/Mooi River Hydrology and Yield Update (DWAF and Umgeni Water, 1998). This was done using the DWAF method of low flow reduction together with the optimal/suboptimal factor, as described above. **Table 2.7** shows a comparison of the area derived by BKS and that calculated as the "middle" scenario in the current analysis.

TABLE 2.6: FUTURE AFFORESTED AREAS, HIGH, MIDDLE AND LOW SCENARIOS

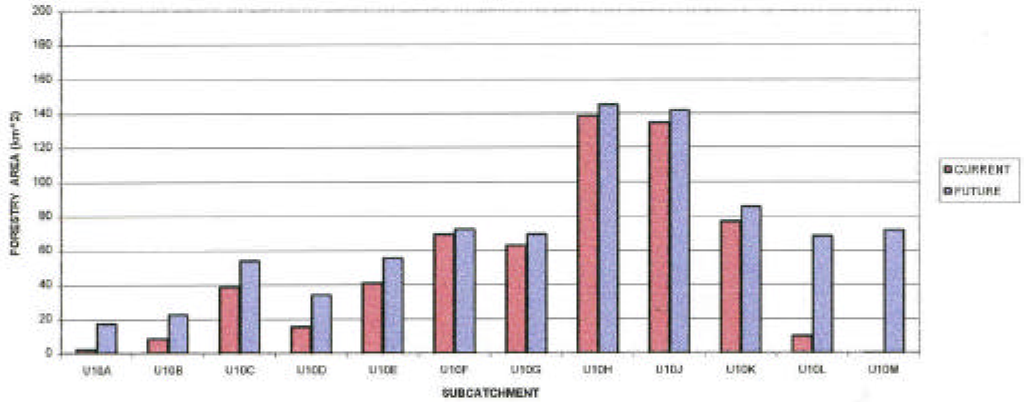
Catchment	Area (km^2)	Afforested area for scenario (km^2)		
		High	Middle	Low
U10A	418	34,38	17,17	17,17
U10B	392	37,20	22,79	22,79
U10C	267	70,94	53,88	53,88
U10D	337	52,46	34,08	34,08
U10E	327	65,44	55,54	41,22
U10F	379	85,16	72,54	72,54
U10G	353	100,27	69,36	69,36
U10H	458	186,97	144,71	144,71
U10J	505	184,32	141,73	141,73
U10K	364	116,04	85,49	85,49
U10L	307	78,77	68,16	9,82
U10M	280	71,80	71,70	0,24
Total	**4387**	**1083,75**	**837,10**	**693,03**

FIGURE 2.4 : FORESTRY AREAS : CURRENT (Umgeni Water) vs FUTURE

HIGH SCENARIO



MIDDLE SCENARIO



LOW SCENARIO

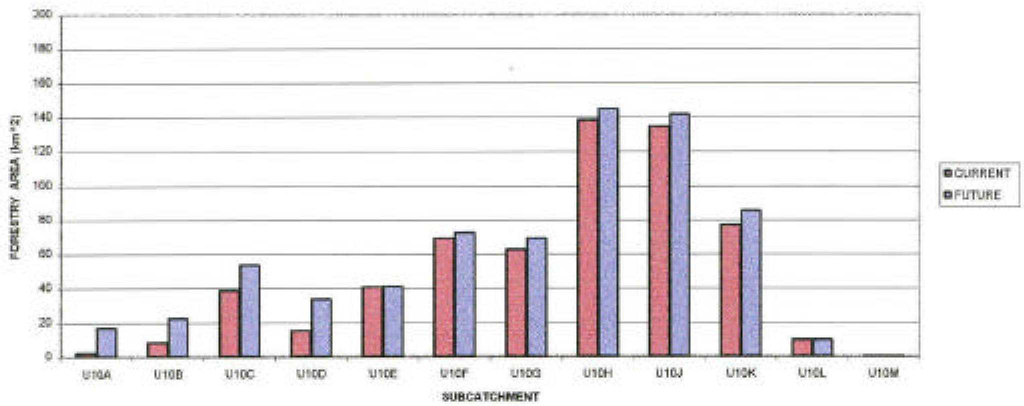


TABLE 2.7: COMPARISON OF MIDDLE FORESTRY SCENARIO WITH BKS DATA (DWAF AND UMGENI WATER, 1998)

Catchment	Afforested area (km^2)		
	Area (km^2)	Current study	BKS
U10A	418	17,17	83,60
U10B	392	22,79	39,20
U10C	267	53,88	53,40
U10D	337	34,08	33,70
U10E	327	55,54	65,40
U10F	379	72,54	75,80
U10G	353	69,36	70,60
U10H	458	144,71	55,85
U10J	505	141,73	123,17
U10K	364	85,49	88,78
U10L	307	68,16	74,88
U10M	280	71,70	68,29
Total	**4387**	**837,15**	**832,67**

Most subcatchments show a reasonable correlation, although U10A, H and J feature greater discrepancies, the reasons for which are not apparent. However, the overall total is in close agreement with that obtained by BKS.

2.2.6 Industrial

Industrial demands in the Mkomazi River catchment are listed in the BKS Hydrology Update Report (DWAF and Umgeni Water, 1998). The only demand that has any significant impact available water in the Mkomazi River is that of SAPPI/SAICCOR, situated near the river mouth in U10M.

From the point of view of growth and future demands, it has been assumed that this demand of approximately 50 million m^3/a will remain constant.

2.2.7 Environmental

Environmental demands are given in the form of Instream Flow Requirements (IFR) and Estuarine Freshwater Requirements (EFR), which have been derived as part of the current pre-feasibility study process. These studies are described in detail in Supporting Report No 4: Environmental, and are therefore only briefly summarised here.

IFR's to maintain the river in a specific Desired Future State were determined at four representative sites along the river (see **Figure 2** in **Appendix F**), the most downstream site (IFR Site 4), with the greatest flow requirements being situated a few kilometres upstream of Goodenough Weir. Downstream of IFR 4 the river becomes significantly more degraded and the EFR becomes dominant. The EFR study found that the ecological health of the estuary is greatly affected by the frequency and duration of mouth closure. Consequently, the derivation of the EFR was based mainly on an assessment of flows required to keep the mouth open during critical times of the year.

The IFR at Site 4 is given in **Table 2.8** and the EFR in **Table 2.9**.

TABLE 2.8: INSTREAM FLOW REQUIREMENTS AT IFR SITE 4

	OCT	NOV		DEC		JAN		FEB			MAR		APR	MAY	JUN	JUL	AUG	SEP
IFR MAINTENANCE LOW FLOWS																		
FLOW (m^3/s)	3,70	6,20		11,00		11,80		12,50			12,50		9,30	6,80	3,00	4,00	3,50	3,50
DEPTH (m)	0,97	1,08		1,22		1,24		1,26			1,26		1,18	1,10	1,03	0,98	0,95	0,95
VOLUME (Mm^3)	9,90	16,10		29,50		31,60		30,20			33,50		24,10	18,20	13,00	10,70	9,40	9,10
IFR MAINTENANCE HIGH FLOWS																		
FLOW (instantaneous peak m^3s)	10,00	15,00	25,00	60,00	28,00	75,00	28,00	400,00	60,00	20,00	90,00	28,00						
DEPTH (m)	1,20	1,31	1,46	1,77	1,50	1,86	1,50	2,67	1,77	1,39	1,93	1,50						
DURATION (days)	2,00	3,00		3,00		3,00		5,00	3,00		3,00	3,00						
VOLUME (Mm^3)	0,76	4,29		10,26		12,35		62,80			14,50							
IFR DROUGHT LOW FLOWS																		
FLOW (m^3/s)	1,80	2,40		3,50		4,70		6,50			6,50		4,70	3,00	2,40	2,10	1,80	1,60
DEPTH (m)	0,83	0,88		0,95		1,02		1,09			1,09		1,07	0,92	0,88	0,85	0,83	0,81
VOLUME (Mm^3)	4,8	6,20		9,40		12,60		15,70			17,40		12,20	8,00	6,20	5,60	4,80	4,10
IFR DROUGHT HIGH FLOWS																		
FLOW (instantaneous peak m^3s)		6,00		20,00		12,00	12,00	75,00	60,00	12,00	12,00							
DEPTH (m)		1,07		1,39		1,25	1,25	1,86		1,25	1,25							
DURATION (days)		2,00		3,00		3,00		5,00	3,00		3,00							
VOLUME (Mm^3)		0,44		2,57		2,27		11,70			0,85							

Note: Volume for high flows is the total for all flood events in the particular month

TABLE 2.9: ESTUARINE FRESHWATER REQUIREMENTS

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
EFR MAINTENANCE FLOWS												
FLOWS (m^3/s)	> 4	> 4	> 4	> 4	> 4	> 4	2 - 4	2 - 4	2 - 4	1 - 2	1 - 2	2 - 4
EFR DROUGHT FLOWS												
FLOW (m^3/s)	2 - 4	2 - 4	> 4	>- 4	> 4	2 - 4	2 - 4	1 - 2	< 1	< 1	< 1	1 - 2

3. HYDROLOGICAL MODELLING

3.1 Introduction

The Mgeni River System Analysis Study (MRSAS) (DWAF and Umgeni Water, 1994) produced hydrology for, amongst others, the Mkomazi and Mooi Rivers. The hydrology of these rivers was updated by BKS (DWAF and Umgeni Water, 1998) as part of the Mkomazi/Mgeni/Mooi River Hydrology and Yield Update. The purpose of the hydrology update was to re-evaluate the available water resources within the Mgeni River System, as well as the adjacent Mooi and Mkomazi River Systems, with consideration of various possible augmentation options.

The study of the Mkomazi River hydrology was previously not carried out to the same level of detail used for the rest of the study area. This was however corrected as part of the hydrology update study by evaluating the hydrology of the Mkomazi River specifically with respect to the catchment developments. The hydrology was also extended to span the period October 1925 to September 1996.

The Mkomazi River catchment was divided into 4 subcatchments for modelling purposes, with catchment sub-division depending on the location of reliable flow gauges and possible future dam sites. BKS then produced present day (1996) hydrology for the four subcatchments. The modelling catchment boundaries are shown in **Figure 2** in **Appendix F**.

3.2 Purpose of this Task

The Mkomazi River hydrological analysis consisted of the following:

- disaggregation of the hydrology of the Mkomazi River into quaternary catchment hydrology, based on the hydrology created for the 4 subcatchments of the Mkomazi River; and
- determining the effect on MAR of forestry and irrigation with revised data for the future 2040 development levels.

3.3 Disaggregation of Present Development Hydrology

The Mkomazi River catchment was previously divided into four subcatchments for modelling purposes. The outlets of the three upper subcatchments were at the proposed Impendle, Smithfield and Ngwadini Dam sites, with the fourth sub-catchment draining into the sea.

3.3.1 Incremental natural runoff sequences

Naturalised runoff sequences were available for the four modelling subcatchments. As agreed by the Project Management Committee, the runoff sequences were disaggregated into quaternary catchment sequences based on the ratios of catchment area and mean annual precipitation (MAP) of the quaternary catchment and modelling subcatchments, rather than by setting up rainfall-runoff models for each quaternary subcatchment. Catchment areas and MAP's for the modelling subcatchments were available from the updated BKS information, while quaternary catchment information for the 12 quaternary catchments of the Mkomazi River were taken from the WR90 information (Midgley *et al*, 1994b). The results of the disaggregation are shown in **Table 3.1**.

3.3.2 Afforestation demand files

Present development forestry demand files, based on CSIR Forestek curves, and a GIS coverage of afforestation areas, for the different modelling subcatchments, were supplied by BKS. Note that these figures included dryland sugarcane in the lower catchments, which would have a similar impact on runoff to afforestation.

The forestry demand files were disaggregated into quaternary demand files using the ratios of forestry per quaternary (determined from the BKS GIS data) and the afforestation area per modelling subcatchment.

Although the rainfall variance between quaternary catchments should ideally also be acknowledged in disaggregating the forestry demands, the above approach was followed as the forestry demands are not significant when compared to the natural runoff in the catchment. For the Mkomazi River catchment as a whole, the forestry demand is only about 5% of the natural runoff. **Table 3.1** summarises the forestry demands for each quaternary catchment.

3.3.3 Irrigation demand files

Irrigation in the Mkomazi River catchment consists of mainstream and diffuse irrigation. Mainstream irrigation is supplied from the main rivers and reservoirs, while diffuse irrigation is located away from the main streams and is supplied from smaller tributaries and farm dams.

There is limited irrigation in the Mkomazi River catchment, with a total present day irrigation demand of 49,7 million m^3/a. As this is only 4,7% of the natural runoff for the Mkomazi River catchment, and considering the level of detail of this Study, it was decided to disaggregate the modelling subcatchment irrigation demands produced by BKS on the ratio of quaternary and modelling subcatchment areas, rather than to source primary data. Proportions of irrigation demand supplied from main streams, smaller tributaries and farm dams were assumed to be the same for the quaternary subcatchments as for the modelling subcatchments. **Table 3.1** summarises the irrigation demands for each quaternary subcatchment.

TABLE 3.1: MKOMAZI RIVER QUATERNARY CATCHMENT INFORMATION PRESENT DEVELOPMENT

Quaternary Catchment				Afforestation		Main Stream Irrigation		Diffuse Irrigation	
Number	**Area (km^2)**	**MAP (mm)**	**Natural Runoff (Mm^3/a)**	**Area (km^2)**	**Demand (Mm^3/a)**	**Area (km^2)**	**Demand (Mm^3/a)**	**Area (km^2)**	**Demand (Mm^3/a)**
U10A	418	1287	186,85	2,35	0,42	4,87	3,07	1,63	1,03
U10B	392	1176	160,16	8,68	1,56	4,57	2,89	1,53	0,96
U10C	267	1091	101,09	39,02	7,03	3,11	1,96	1,04	0,65
U10D	337	999	116,99	15,26	2,74	3,92	2,47	1,31	0,82
U10E	327	1034	88,18	41,59	5,08	0,00	0,00	0,00	0,00
U10F	379	963	88,22	71,42	8,20	0,00	0,00	0,00	0,00
U10G	353	981	57,44	80,71	4,99	1,16	0,70	9,42	5,68
U10H	458	924	70,10	155,63	9,62	1,50	0,90	12,17	7,34
U10J	505	878	73,34	153,07	9,46	1,65	1,00	13,44	8,11
U10K	364	793	47,71	97,21	6,00	1,19	0,72	9,68	5,84
U10L	307	758	38,62	27,79	1,73	1,01	0,61	8,20	4,95
U10M	280	858	38,22	18,92	0,94	0,00	0,00	0,00	0,00
Total	**4387**		**1066,92**	**711,65**	**57,77**	**22,98**	**14,32**	**58,42**	**35,38**

3.4 Determining Effect of Estimated 2040 Forestry and Irrigation on Mean Annual Runoff

In addition to the present development hydrology, estimates were made of possible future 2040 irrigation and forestry areas in the Mkomazi River catchment in order to determine the effect of increasing development on the MAR of the catchment, as described in Sections 2.2.3 and 2.2.5 of this Report.

Estimates of the 2040 irrigation and forestry areas were made for three scenarios, a high, middle and low scenario. Future irrigation areas were essentially based on a comparison with Mooi River catchments with similar position in the basin and similar Mean Annual Precipitation (MAP). Future forestry areas were amongst others based on Umgeni Water existing areas, currently approved permits and maximum allowable areas as determined by DWAF.

The changes in land use were modelled using the WRSM90 model configurations as configured by BKS. In order to be compatible with the previous demands, the afforestation demands were calculated using the BKS AFFDEM program. It should be noted that the same scenarios for afforestation and irrigation were used in the model, i.e. high afforestation with high irrigation, middle afforestation with middle irrigation, etc, as afforestation would impact on runoff and therefore on the water available for irrigation.

3.4.1 Incremental natural runoff sequences

The naturalised runoff remained the same with the present development disaggregation still applicable. **Table 3.1** shows a summary of the quaternary catchment runoff.

3.4.2 2040 afforestation demands

The afforestation demand files for the modelling catchments calculated as described above were disaggregated into quaternary catchment demands. Input to the AFFDEM program included catchment area, natural runoff, evaporation, tree type and area of afforestation. **Table 4.5** (Section 4.4) summarises the afforestation demands for the high, middle and low 2040 scenarios.

3.4.3 2040 irrigation demands

The BKS WRSM90 configurations were used to determine irrigation demands for the three different scenarios. As the 2040 irrigation areas were supplied for the different quaternary catchments, these areas had to be aggregated for each modelling catchment, the irrigation demand calculated for each modelling catchment (using the WRSM90 configuration) and the modelling catchment demand then disaggregated into quaternary catchment demands.

High irrigation demands were calculated using high forestry demands, as for the middle and low scenarios. It should be noted that no re-calibration of the WRSM90 models were attempted. **Table 4.3** (Section 4.2) shows the irrigation demands for the high, middle and low 2040 scenarios.

4. DISCUSSION OF SECTORAL DEMANDS

Sectoral demands are summarised in **Table 4.6** at the end of this Section.

4.1 Population - Domestic Demands

Appendix A shows the results of the calculations to determine the urban and rural domestic demands, for high, medium and low road scenarios at quaternary subcatchment level for 1995 (current), 2020 and 2040 (future) conditions. These results are summarised in **Table 4.1**. Only the 1995 and future (2040) results are indicated.

TABLE 4.1: SUMMARY OF DOMESTIC DEMAND IN THE MKOMAZI RIVER CATCHMENT

Consumer Group and scenario		Demand excluding groundwater supplement to rural demand (Mm^3/a)		Demand including groundwater supplement to rural demand (Mm^3/a)	
		1995	2040	1995	2040
Urban	High	0,362	0,793	0,362	0,793
	Middle	0,271	0,329	0,271	0,329
	Low	0,181	0,169	0,181	0,169
Rural	High	4,628	10,149	4,066	9,812
	Middle	2,314	2,713	1,514	1,844
	Low	0,617	0,556	0,000	0,000
Total	High	4,990	10,942	4,428	10,605
	Middle	2,585	3,042	1,785	2,173
	Low	0,798	0,725	0,181	0,169

The determination of safe groundwater abstraction quantities has been discussed in Section 2.2.2 - Groundwater Potential. This total has been subtracted from the rural demand for each quaternary subcatchment, to determine the net demand that will be required to be met from surface water resources. It has been assumed that as from now all rural demands will be met through groundwater abstractions where possible, but where the groundwater supply is not able to meet the full rural demand, it has not been utilised. This assumes that marginal supplies will not be developed, rather an alternative (surface water) resource will be tapped. The results of the analysis are given in **Appendices A** and **B** along with the rural domestic demand calculations. Groundwater has not been considered as a source for urban supply.

In terms of a percentage of the naturalised Mean Annual Runoff (MAR) of 1 066 million m^3/a, the total domestic demand of the Mkomazi River catchment is very small, as shown in **Table 4.2**.

TABLE 4.2: TOTAL DOMESTIC DEMAND IN THE MKOMAZI RIVER CATCHMENT AS A PERCENTAGE OF NATURAL MAR

Scenario	Percentage Natural MAR MAR = 1066 Mm^3/a	
	1995	2040
High	0,42	0,99
Middle	0,17	0,20
Low	0,02	0,01

4.2 Agriculture - Irrigation

Table 4.3 shows the demands attributable to irrigation in the Mkomazi River catchment, per quaternary subcatchment for the high, middle and low growth scenarios. The percentage of natural MAR (also shown) taken up by this demand sector gives an indication of the impact that irrigation has in the river basin.

TABLE 4.3: IRRIGATION DEMANDS IN THE MKOMAZI RIVER CATCHMENT

Subcatchment	Natural MAR (Mm^3/a)	Irrigation Demand (Current and Future) (Mm^3/a)			
		Current	Future		
			High	Middle	Low
U10A	186,85	4,10	10,66	5,08	4,57
U10B	160,16	3,85	10,01	4,76	4,29
U10C	101,09	2,61	6,81	3,24	2,92
U10D	116,99	3,29	8,58	4,08	3,68
U10E	88,18	0,00	3,72	2,47	1,24
U10F	88,22	0,00	4,97	3,41	2,26
U10G	57,44	6,38	10,92	7,89	7,10
U10H	70,10	8,24	14,11	10,20	9,18
U10J	73,34	9,11	15,58	11,25	10,13
U10K	47,71	6,56	11,22	8,11	7,30
U10L	38,62	5,56	6,47	6,86	6,18
U10M	38,22	0,00	2,30	1,74	0,56
Total	**1066,92**	**49,70**	**105,35**	**69,09**	**59,41**
Total as % MAR		**4,7**	**9,9**	**6,5**	**5,6**

4.3 Agriculture - Livestock

Analysis of current and future livestock numbers along with probable unit consumptions, as discussed in Section 2.2.4 and shown in **Appendix D**, indicates a very low percentage utilisation of the Natural MAR, as shown in **Table 4.4**.

TABLE 4.4: TOTAL LIVESTOCK DEMANDS IN THE MKOMAZI RIVER CATCHMENT

Scenario	Total Demand	
	Mm^3/a	% Natural MAR
Current	5,1	0,48
Future (2040)	8,6	0,81

Disaggregated demands for each quaternary subcatchment are shown in **Appendix D**.

4.4 Forestry

Forestry demands have been calculated using the AFFDEM model as developed by BKS and discussed in Section 3.4. **Table 4.5** shows the current and future demands generated by this sector in terms of each quaternary subcatchment and the total demand as a percentage of the Natural MAR.

TABLE 4.5: FORESTRY DEMANDS IN THE MKOMAZI RIVER CATCHMENT

Subcatchment	Natural MAR (Mm^3/a)	Forestry Demand (Current and Future) (Mm^3/a)			
		Current	Future		
			High	Middle	Low
U10A	186,85	0,42	5,92	2,99	2,81
U10B	160,16	1,56	6,40	3,97	3,73
U10C	101,09	7,03	12,21	9,38	8,82
U10D	116,99	2,74	9,03	5,93	5,58
U10E	88,18	5,08	17,92	14,80	12,57
U10F	88,22	8,20	7,83	6,70	5,59
U10G	57,44	4,99	6,27	4,39	4,12
U10H	70,10	9,62	11,69	9,16	8,60
U10J	73,34	9,46	11,52	8,97	8,43
U10K	47,71	6,00	7,25	5,41	5,08
U10L	38,62	1,73	4,92	4,31	0,58
U10M	38,22	0,94	0,76	0,63	0,38
Total	**1066,92**	**57,77**	**101,72**	**76,64**	**66,29**
Total as % MAR		**5,4**	**9,5**	**7,2**	**6,2**

4.5 Industrial

The SAPPI/SAICCOR factory, situated near the Mkomazi River mouth in U10M, has a permit allocation of 137 Ml/day (50 Mm^3/a). This is the only industrial abstraction of any significance within the catchment.

Although it has been assumed that the permit allocation is being utilised, it should be noted that this is not currently the case and a portion of this abstraction is used to meet local domestic demands on the South Coast, outside the Mkomazi River basin.

There is no indication that there is any intention to apply for any additional water allocations, neither is any other significant industrial development planned within the catchment.

4.6 Environmental

As indicated in Section 2.2.7, the dominant environmental requirement is that at IFR Site 4, details of which are given in **Table 2.8**. The total demand, assuming that drought flows occur once in ten years, equates to 315,5 million m^3/a or 29,8% of the natural MAR at that point in the catchment.

TABLE 4.6: SUMMARY OF CURRENT AND FUTURE SECTORAL DEMANDS IN THE MKOMAZI RIVER CATCHMENTS

Sub-Catch-ment	Natural MAR (Mm^3/a)	Demand (Mm^3/a)										
		Forestry		Irrigation		Livestock		Domestic		Industrial		Environ-mental
		Current	Future	Current	Future	Current	Future	Current	Future	Current	Future	
U10A	186,9	0,42	2,99	4,10	5,08	0,40	0,70	0,00	0,00	0,00	0,00	
U10B	160,2	1,56	3,97	3,85	4,76	0,30	0,60	0,00	0,00	0,00	0,00	
U10C	101,2	7,03	9,38	2,61	3,24	0,40	0,60	0,00	0,00	0,00	0,00	
U10D	117,0	2,74	5,93	3,29	4,08	0,40	0,70	0,00	0,00	0,00	0,00	
U10E	88,2	5,08	14,80	0,00	2,47	0,40	0,70	0,01	0,02	0,00	0,00	
U10F	88,2	8,20	6,70	0,00	3,41	0,50	0,90	0,34	0,35	0,00	0,00	
U10G	57,4	4,99	4,39	6,38	7,89	0,30	0,50	0,00	0,00	0,00	0,00	
U10H	70,1	9,62	9,16	8,24	10,20	0,60	1,00	0,30	0,30	0,00	0,00	
U10J	73,3	9,46	8,97	9,11	11,25	0,50	0,90	0,47	0,47	0,00	0,00	
U10K	47,7	6,00	5,41	6,56	8,11	0,40	0,70	0,13	0,16	0,00	0,00	
U10L	38,6	1,73	4,31	5,56	6,86	0,40	0,60	0,00	0,00	0,00	0,00	
U10M	38,2	0,94	0,63	0,00	1,74	0,30	0,50	0,54	0,88	50,00	50,00	
Total	1066,9	57,77	76,64	49,70	69,09	4,90	8,40	1,79	2,18	50,00	50,00	265,12

Note: Environmental requirements cannot be allocated on subcatchment basis. The total given is the IFR at IFR Site 4.

5. YIELD ANALYSIS

5.1 Introduction

A yield analysis has been carried out to determine the yields of the proposed transfer schemes for natural and present conditions, as well as for the 2040 middle road scenario development levels. In addition, the yield of a possible future dam at the Ngwadini site on the lower Mkomazi River was determined, to assess the viability of such a dam. In order to avoid confusion between this dam and the proposed Ngwadini off-channel dam currently under consideration by Umgeni Water, it is henceforth referred to as the Lower Mkomazi Dam. The yield analysis is covered in more detail in Supporting Report No 4: Hydrology & Water Resources.

The WRYM model had to be configured in order to determine scheme yields for a variety of dam sizes and development conditions.

The following schemes were investigated (see **Figure 12**, **Appendix F**) :

- Impendle Dam (five different capacities)
- Smithfield Dam (one capacity)
- A system of Impendle Dam with Smithfield Dam, assuming a single capacity for Smithfield Dam and two different capacities for Impendle Dam
- A system consisting of the largest Impendle Dam with Smithfield Dam, and with three different capacities for the Lower Mkomazi Dam. (Note that the off-channel Ngwadini Dam is shown in **Figure 12** in **Appendix F.** The Lower Mkomazi site is in the same vicinity).

The first three schemes were analysed for natural conditions, present development, and future 2040 middle scenario development. The WRYM models configured for the different schemes were based on the BKS WRYM models for the Impendle and Smithfield Dam schemes. IFR requirements were included in the yield analysis.

The same basic WRYM model was used for the different schemes, with only minor changes made to accommodate the different schemes. Further scheme details are given with each scheme description discussed hereafter. System diagrams are given in Supporting Report No 4: Hydrology and Water Resources.

5.2 Catchment development

The present development demands in the Mkomazi River catchment are relatively small when compared with the natural MAR (1066 million m^3/a) from the catchment. The major consumers of water are irrigation, afforestation and SAPPI/SAICCOR with present development demands of about 49,7 million m^3/a, 57,8 million m^3/a and 50 million m^3/a, respectively.

The WRYM model configurations for the future 2040 scenarios were adapted to include one additional dummy dam (a single dam used to represent all small dams the subcatchment), in the Ngwadini (Lower Mkomazi) incremental catchment, and mainstream irrigation in the Smithfield, Ngwadini and Mkomazi mouth incremental catchments. The mainstream irrigation was supplied at 70% assurance (in years), introducing different zones in the proposed dams to achieve the required assurances.

The proposed Middle South Coast Scheme involves the transfer of water from the Mkomazi Catchment and these demands should not be considered in basin demands. It will have to be largely supplied from the yield of the proposed Mkomazi-Mgeni Transfer Scheme dams.

5.3 Instream Flow Requirements

IFR's, described in detail in Supporting Report No 5: Environmental, were included in all the scheme analyses. The IFR demands were calculated allowing for IFR drought flows once in every 10 years on average.

Demand files were calculated for IFR sites 1, 2 and 4. IFR site 3 was not included in these analyses, as it was found not to be critical and was indicated as the least reliable site in the IFR study. In order to meet the demands at IFR sites 1, 2 and 4 without support from the dams, the demands for these sites were only supplied from the inflow to Impendle Dam or Smithfield Dam and any other incremental runoff available at that point.

IFR site 4 requirements were modelled with all the scenarios, as IFR site 4 was found to be the critical IFR site of the three included in the analysis.

5.4 Impendle Scheme

The Impendle Scheme, with a single dam from which transfers take place at the Impendle site, was analysed for five different storage capacities, ranging from 0,25 of the natural MAR to 1,5 MAR (135 to 810 million m^3). Development upstream of Impendle Dam catchment included a dummy dam with diffuse irrigation for both the present and future development scenarios, as well as mainstream irrigation. IFR requirements were met only from the inflow to Impendle Dam plus any incremental runoff available at the specific site.

Releases were made for the portion of the SAICCOR demands not met by incremental runoff. The abstraction point is located between IFR site 4 and the estuary.

The results of the yield analysis are shown in **Table 5.1**.

The 2040 scenario included, apart from the increased afforestation demands, additional irrigation to be supplied from both dummy farm dams and mainstream irrigation.

5.5 Smithfield Scheme: Phase 1

The Smithfield Scheme consists of a first phase dam at the Smithfield site, from where water is transferred, followed by a second phase dam at Impendle, from where water is released down river to Smithfield as required. Only one size of Smithfield Dam, with a capacity of 137 million m^3, was considered in the yield analysis, as the topography limits the full supply level to 915 masl. Apart from a dummy dam with irrigation located in the Smithfield incremental catchment, the Smithfield scheme was analysed using the same assumptions used for the Impendle Dam scheme. The results of the yield analysis are shown in **Table 5.1**.

Note that in this case only IFR sites 2 and 4 were considered, as IFR site 1 is located upstream of Smithfield Dam. IFR requirements were again only met from the inflow to Smithfield Dam and the incremental runoff available at the IFR sites. SAICCOR demands were dealt with as per the Impendle Scheme.

5.6 Smithfield Scheme: Phase 2

The system consisting of Smithfield Dam with a dam at the Impendle site was analysed for the one size of Smithfield Dam with two sizes of Impendle, namely a 1 MAR and 1,5 MAR dam. Both these scenarios were analysed for natural, present development and 2040 development conditions. The results of the yield analysis are shown in **Table 5.1**.

IFR requirements were limited to what could previously be met with the individual Impendle and Smithfield schemes. This was done to make sure that the IFR requirements did not receive additional support from the dams.

5.7 Smithfield Dam (137 million m^3), Impendle Dam (810 million m^3) with Lower Mkomazi Dam

The Lower Mkomazi Dam was added to the Smithfield/Impendle system to determine the yield available from the Lower Mkomazi Dam with the system upstream being operated as described in Section 5.6 above.

The 137 million m^3 Smithfield Dam with the 810 million m^3 Impendle Dam was used as base for the model configuration. All demands and operating rules remained the same as for the Impendle/Smithfield Scheme. Three sizes of Lower Mkomazi Dam were then analysed with the above scheme.

It was decided that IFR site 4 requirements should be supplied from the Lower Mkomazi Dam when necessary, in view of the major abstractions from the scheme upstream. The Lower Mkomazi Dam could also, apart from receiving spills, not be supported by any of the upstream dams.

It is clear from the yield results shown in **Table 5.1** that although some additional yield is available at the Lower Mkomazi Dam, large dams would have to be built in order to secure a significant yield.

The Lower Mkomazi Dam was only assessed in combination with the Smithfield Scheme, as this was considered to be the most likely scheme to be implemented on the basis of investigations up to the time of this analysis.

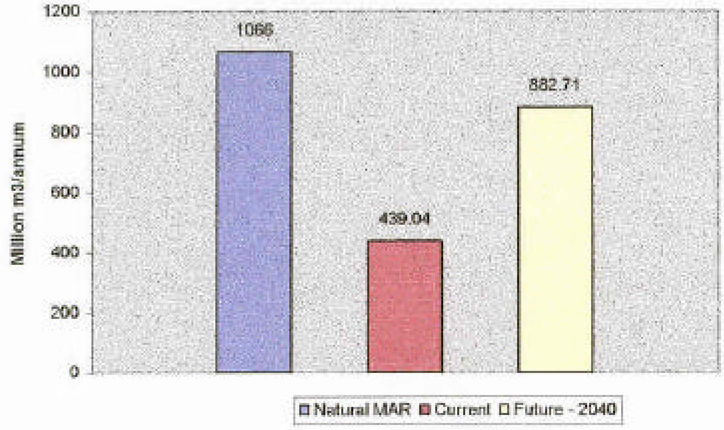
TABLE 5.1: RESULTS OF YIELD ANALYSIS

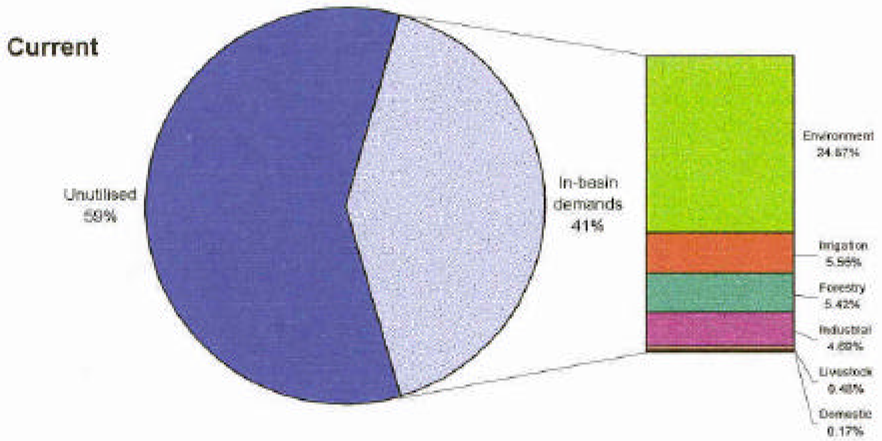
Scheme Name	Dams in Scheme	Dam Volume (Mm^3)	Historical Firm Yield (Mm^3/a) for Development Level		
			Natural Conditions	Present Development	2040 Middle Road Scenario
Impendle	Impendle	135	126	120	
		270	223	204	
		543	314	293	276
		680	341	318	
		810	358	335	304
Smithfield	Smithfield	137	157	135	112
Impendle and Smithfield	Impendle Smithfield	543 137	397	358	331
	Impendle Smithfield	810 137	454	413	385
Lower Mkomazi	Impendle Smithfield Lower Mkomazi	810 137 517		122	
Lower Mkomazi	Impendle Smithfield Lower Mkomazi	810 137 1033		186	
Lower Mkomazi	Impendle Smithfield Lower Mkomazi	810 137 1549		246	

6. WATER BALANCE

To represent the various user groups in the Mkomazi River basin and their impact on available water resources, a water balance calculation has been carried out for the current and future (middle) scenarios. This involves totalling in-basin demands both by volume and as a percentage of the total natural MAR of the Mkomazi System, as shown in **Table 6.1** and represented in **Figure 6.1**. Note that the proposed Smithfield and Ngwadini Schemes are included in the future scenario.

FIGURE 6.1 : ILLUSTRATION OF CURRENT AND FUTURE SECTOR DEMANDS





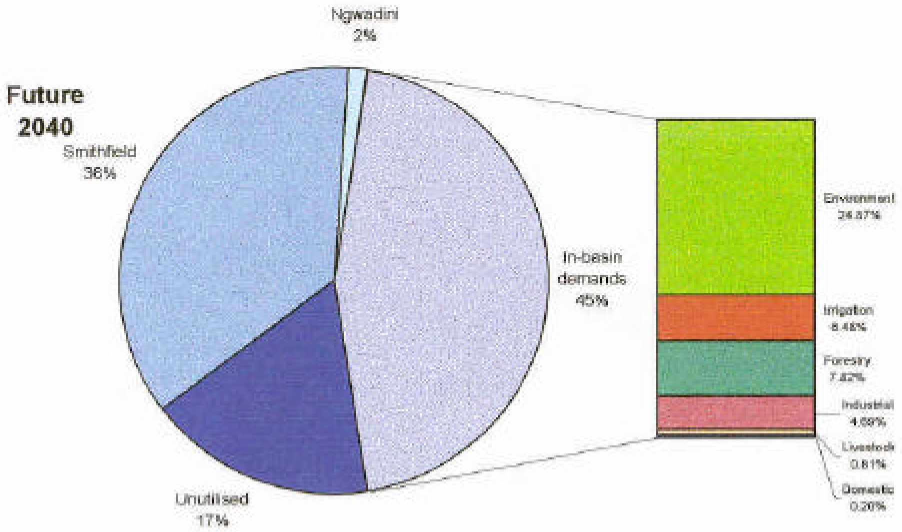


TABLE 6.1: SECTORAL DEMANDS IN RELATION TO NATURAL MAR
(NATURAL MAR = 1 067 Million m³/a)

	Current Demands - 1995		Future Demands - 2040		Comment
	Mm³/a	% Nat MAR	Mm³/a	% Nat MAR	
In-basin demands					
Environment	265,12	24,85	265,12	24,85	IFR 4 demands less SAPPI/SAICCOR
Irrigation	49,70	4,66	69,09	6,48	
Forestry	57,77	5,41	76,64	7,18	
Industrial	50,00	4,69	50,00	4,69	SAICCOR
Livestock	4,90	0,46	8,40	0,79	
Domestic	1,79	0,17	2,18	0,20	Total domestic demand
Subtotal	**429,28**	**40,24**	**471,43**	**44,19**	
Available MAR	*637,72*	*59,76*	*595,57*	*55,81*	
Proposed water transfer schemes					
Ngwadini*			16,40	1,54	Abstraction to off channel storage
Smithfield			119,00	11,15	Phase 1
			335,00	31,40	Phase 2 **
			388,00	36,36	Phase 3 ***
Subtotal (Ngwadini + Phase 3, Smithfield)			**404,40**	**37,90**	
Total utilisation of Natural MAR					
In-basin demands	429,28	40,24	471,43	44,19	
Transfer schemes	0,00	0,00	404,40	37,90	
Total	**429,28**	**40,24**	**875,83**	**82,09**	
Unutilised	*637,72*	*59,76*	*191,17*	*17,91*	

Note: * Data provided by Umgeni Water
** 540 million m³ dam at Impendle
*** Impendle dam raised to 810 million m³

Considering the representation of current conditions in the catchment, shown in **Figure 6.1**, 40% of the natural MAR is required to meet in-basin demands, with the remaining 60% being unutilised.

The future (2040) condition, which includes the increased in-basin demands and the inter-basin transfers of the proposed Ngwadini and Smithfield

(Mkomazi-Mgeni) schemes, shows 45% being required to meet in-basin demands and a total of 38% by transfer schemes, leaving 17% unutilised. This unutilised portion will largely be major flood flows, which could not be practically harnessed.

7. CONCLUSIONS

By far the largest sectoral demand for future (2040) middle scenario conditions was found to be the environment, at approximately 25% of the natural MAR. This was followed by forestry at 8%,and irrigation and industry (SAPPI/SAICCOR) both at 5% of the natural MAR. Livestock and domestic demand combined make up only 1% of the MAR. Both the forestry and irrigation demands are concentrated in the middle reaches of the catchment.

With the above demands and the proposed Mkomazi-Mgeni Transfer Scheme in place, only 17% of the total natural MAR of the Mkomazi will be unutilised. This remaining volume could not be practically harnessed and it can therefore be stated that under these conditions, the Mkomazi River will be effectively fully utilised.

The following further studies and actions are recommended for the feasibility phase of investigation:

- Proceed with the determination of the Ecological and Basic Human Needs Reserves.
- Review projected forestry areas and other runoff-reducing activities in the light of catchment management initiatives, possible revisions to limits previously set and changes in policy.
- Update hydrological and yield models accordingly.

REFERENCES

Cedara (1998a), **IRRIGATION AREAS**, *Personal Communication with Mr R Bennett, Bio-Resource Centre, Cedara College, (April 1998).*

Cedara (1998b), **LIVESTOCK CONSUMPTION RATES***, Personal Communication with Mr R Bennett, Bio-Resource Centre, Cedara College, (June 1998).*

DWAF (1998), **FORESTRY AREAS**, *Personal Communication with Mr N Ward and Mr E Coetzee, DWAF, Durban, (March 1998).*

DWAF and Umgeni Water (1994), **DETAILED MOOI RIVER STUDY (SUPPORTING REPORT TO MGENI SYSTEMS ANALYSIS REPORTS)**, *Report No PB U000/00/2392, BKS, June 1994.*

DWAF and Umgeni Water (1998), **MKOMAZI/MGENI/MOOI RIVER HYDROLOGY AND YIELD UPDATE**, *BKS, January 1998, Draft report.*

KZN Dept. of Agriculture (1998), **LIVESTOCK NUMBERS**, *Personal Communication with Dr R Carter, State Veterinary Services, Cascades, Pietermaritzburg, (June 1998).*

Midgley D C, Pitman W V and Middleton B J (1994a), **SURFACE WATER RESOURCES OF SOUTH AFRICA 1990**, *Volume VI, Book of Maps, WRC Report No 298/6.2/94.*

Midgley D C, Pitman W V and Middleton B J (1994b), **SURFACE WATER RESOURCES OF SOUTH AFRICA 1990**, *Volume VI, Appendices, WRC Report No 298/6.1/94.*

National Housing Board (1995), **GUIDELINES FOR THE PROVISION OF ENGINEERING SERVICES AND AMENITIES IN RESIDENTIAL TOWNSHIP DEVELOPMENT**, *National Housing Board, 1995.*

Umgeni Water (1997), **MGENI SYSTEM WATER DEMANDS: INLAND SYSTEM**, *Table of data provided by Mr R Akerman (22 July 1997)*

Umgeni Water (1998a), **METHODOLOGY FOR REVISED POPULATION PROJECTIONS - UMGENI WATER'S AREA OF OPERATION**, *Scott Wilson Planning and Development Resources, 1998. (Text included in Appendix A1).*

Umgeni Water (1998d), **DETERMINATION OF UTILISABLE GROUNDWATER USING HARVEST POTENTIAL MAPS**, *personal communication with G Metcalfe, June 1998.*

APPENDICES: SUPPORTING DEMAND DATA

Appendix A	Population figures and domestic demand calculations
Appendix B	Calculation of available groundwater abstractions
Appendix C	Calculation of future irrigation areas
Appendix D	Calculation of livestock numbers and demands
Appendix E	Calculation of future forestry areas
Appendix F	GIS Figures

APPENDIX A

Population figures and domestic demand calculations

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Urban and rural domestic demands

Population growth rate	*High*
Urban consumption rate (l/p/day)	*200*
Rural consumption rate (l/p/day)	*60*

Urban demand

Catchment	1995		2020		2040	
	Population No	Demand Mm3/a	Population No	Demand Mm3/a	Population No	Demand Mm3/a
U10A	0	0.000	0	0.000	0	0.000
U10B	0	0.000	0	0.000	0	0.000
U10C	0	0.000	0	0.000	0	0.000
U10D	0	0.000	0	0.000	0	0.000
U10E	161	0.012	249	0.018	353	0.026
U10F	517	0.038	800	0.058	1134	0.083
U10G	0	0.000	0	0.000	0	0.000
U10H	0	0.000	0	0.000	0	0.000
U10J	338	0.025	523	0.038	741	0.054
U10K	2301	0.168	3559	0.260	5045	0.368
U10L	0	0.000	0	0.000	0	0.000
U10M	1640	0.120	2537	0.185	3596	0.263
Total	**4957**	**0.362**	**7668**	**0.560**	**10869**	**0.793**

Rural demand (Gross before groundwater contribution)

Catchment	1995		2020		2040	
	Population No	Demand Mm3/a	Population No	Demand Mm3/a	Population No	Demand Mm3/a
U10A	6262	0.137	9686	0.212	13731	0.301
U10B	2648	0.058	4096	0.090	5806	0.127
U10C	4846	0.106	7495	0.164	10625	0.233
U10D	14371	0.315	22229	0.487	31511	0.690
U10E	16053	0.352	24830	0.544	35198	0.771
U10F	28496	0.624	44077	0.965	62482	1.368
U10G	7554	0.165	11685	0.256	16564	0.363
U10H	27734	0.607	42898	0.939	60811	1.332
U10J	40996	0.898	63411	1.389	89889	1.969
U10K	4371	0.096	6760	0.148	9583	0.210
U10L	16989	0.372	26278	0.575	37251	0.816
U10M	41024	0.898	63455	1.390	89952	1.970
Total	**211344**	**4.628**	**326900**	**7.159**	**463403**	**10.149**

Rural demand (net after groundwater contribution)

Catchment	1995	2020	2040
	Mm3/a		
U10A	0.000	0.000	0.301
U10B	0.000	0.000	0.000
U10C	0.000	0.164	0.233
U10D	0.315	0.487	0.690
U10E	0.352	0.544	0.771
U10F	0.624	0.965	1.368
U10G	0.000	0.256	0.363
U10H	0.607	0.939	1.332
U10J	0.898	1.389	1.969
U10K	0.000	0.000	0.000
U10L	0.372	0.575	0.816
U10M	0.898	1.390	1.970
Total	**4.066**	**6.709**	**9.813**

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Urban and rural domestic demands

Population growth rate	*Middle*
Urban consumption rate (l/p/day)	*150*
Rural consumption rate (l/p/day)	*30*

Urban demand

Catchment	1995		2020		2040	
	Population No	Demand Mm3/a	Population No	Demand Mm3/a	Population No	Demand Mm3/a
U10A	0	0.000	0	0.000	0	0.000
U10B	0	0.000	0	0.000	0	0.000
U10C	0	0.000	0	0.000	0	0.000
U10D	0	0.000	0	0.000	0	0.000
U10E	161	0.009	199	0.011	270	0.015
U10F	517	0.028	595	0.033	748	0.041
U10G	0	0.000	0	0.000	0	0.000
U10H	0	0.000	0	0.000	0	0.000
U10J	338	0.019	423	0.023	593	0.032
U10K	2301	0.126	2510	0.137	2872	0.157
U10L	0	0.000	0	0.000	0	0.000
U10M	1640	0.090	1678	0.092	1522	0.083
Total	4957	0.271	5405	0.296	6005	0.329

Rural demand (Gross before groundwater contribution)

Catchment	1995		2020		2040	
	Population No	Demand Mm3/a	Population No	Demand Mm3/a	Population No	Demand Mm3/a
U10A	6262	0.069	7161	0.078	6021	0.066
U10B	2648	0.029	3002	0.033	2525	0.028
U10C	4846	0.053	5484	0.060	4622	0.051
U10D	14371	0.157	16637	0.182	14039	0.154
U10E	16053	0.176	18698	0.205	15798	0.173
U10F	28495	0.312	33243	0.364	28090	0.308
U10G	7554	0.083	8617	0.094	7263	0.080
U10H	27734	0.304	32134	0.352	27121	0.297
U10J	40995	0.449	47695	0.522	40287	0.441
U10K	4371	0.048	4487	0.049	3623	0.040
U10L	16989	0.186	24680	0.270	25484	0.279
U10M	41024	0.449	65799	0.720	72856	0.798
Total	211344	2.314	267637	2.931	247729	2.713

Rural demand (net after groundwater contribution)

Catchment	1995	2020	2040
	Mm3/a		
U10A	0.000	0.000	0.000
U10B	0.000	0.000	0.000
U10C	0.000	0.000	0.000
U10D	0.000	0.000	0.000
U10E	0.000	0.205	0.000
U10F	0.312	0.364	0.308
U10G	0.000	0.000	0.000
U10H	0.304	0.352	0.297
U10J	0.449	0.522	0.441
U10K	0.000	0.000	0.000
U10L	0.000	0.000	0.000
U10M	0.449	0.720	0.798
Total	1.514	2.163	1.844

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Urban and rural domestic demands

Population growth rate	*Low*
Urban consumption rate (l/p/day)	*100*
Rural consumption rate (l/p/day)	*8*

Urban demand

Catchment	1995		2020		2040	
	Population No	Demand Mm3/a	Population No	Demand Mm3/a	Population No	Demand Mm3/a
U10A	0	0.000	0	0.000	0	0.000
U10B	0	0.000	0	0.000	0	0.000
U10C	0	0.000	0	0.000	0	0.000
U10D	0	0.000	0	0.000	0	0.000
U10E	161	0.006	153	0.006	208	0.008
U10F	517	0.019	458	0.017	575	0.021
U10G	0	0.000	0	0.000	0	0.000
U10H	0	0.000	0	0.000	0	0.000
U10J	338	0.012	325	0.012	456	0.017
U10K	2301	0.084	1931	0.070	2209	0.081
U10L	0	0.000	0	0.000	0	0.000
U10M	1640	0.060	1291	0.047	1170	0.043
Total	**4957**	**0.181**	**4158**	**0.152**	**4618**	**0.169**

Rural demand (Gross before groundwater contribution)

Catchment	1995		2020		2040	
	Population No	Demand Mm3/a	Population No	Demand Mm3/a	Population No	Demand Mm3/a
U10A	6252	0.018	5508	0.016	4632	0.014
U10B	2648	0.008	2309	0.007	1943	0.006
U10C	4846	0.014	4218	0.012	3555	0.010
U10D	14371	0.042	12797	0.037	10798	0.032
U10E	16053	0.047	14382	0.042	12152	0.035
U10F	28496	0.083	25571	0.075	21607	0.063
U10G	7554	0.022	6628	0.019	5587	0.016
U10H	27734	0.081	24718	0.072	20851	0.061
U10J	40996	0.120	36687	0.107	30989	0.090
U10K	4371	0.013	3451	0.010	2787	0.008
U10L	16989	0.050	18984	0.055	19602	0.057
U10M	41024	0.120	50613	0.148	56041	0.164
Total	**211344**	**0.617**	**205866**	**0.601**	**190554**	**0.556**

Rural demand (net after groundwater contribution)

Catchment	1995	2020	2040
	Mm3/a		
U10A	0.000	0.000	0.000
U10B	0.000	0.000	0.000
U10C	0.000	0.000	0.000
U10D	0.000	0.000	0.000
U10E	0.000	0.000	0.000
U10F	0.000	0.000	0.000
U10G	0.000	0.000	0.000
U10H	0.000	0.000	0.000
U10J	0.000	0.000	0.000
U10K	0.000	0.000	0.000
U10L	0.000	0.000	0.000
U10M	0.000	0.000	0.000
Total	**0.000**	**0.000**	**0.000**

METHODOLOGY FOR REVISED POPULATION PROJECTIONS UMGENI WATER'S AREA OF OPERATION

1.0 INTRODUCTION

The objective of this exercise is to provide population projections, under different growth scenarios, for Umgeni Water's operational area to the year 2040.

2.0 PROBLEM STATEMENT

Umgeni Water was provided with population data, including projections, as part of the Umgeni Water Needs Analysis project conducted in 1996. Problems were however encountered by Umgeni Water when attempts were made to model population growth at quaternary catchment level. Aside from problems of allocating figures from one spatial base (EAs) to a different spatial base (quaternary catchments), the growth rates provided (extracted from the [1]Eskom Strategic Plan) were not considered suitable for an extensive (45 year) study period.

In the Eskom Strategic Plan, a single growth rate was applied to the total population in each enumerator area over a 20 year time period. The growth rates were largely drawn from the [2]Urban Foundation's Demographic Projection Model (1990) and additional work conducted by the Development Bank of South Africa. Relevant growth rates were applied to each enumerator area, depending on its "generic region" classification and settlement type. At Eskom's specific request, race was not considered as a factor in any of the required analyses, and as such, the growth rates do not reflect population dynamics within different race groups. In addition, the Eskom study did not call for an in-depth analysis of anticipated future population growth and as such, no changes in growth rates were anticipated over the 20 year period.

When using these growth rates over a 45 year period, however, the resultant figures tend to be unrealistically high. The objective here therefore is, firstly, to adjust these growth rates to provide a more comprehensive set of projections to meet Umgeni Water's modelling needs and to manipulate the resulting figures to provide the data at a quaternary catchment level and planning region level as required by Umgeni's models.

3.0 GROWTH SCENARIOS

Although there are demographic models available, many of these are either highly generalised and/or out-dated. Demographers in general appear to be waiting for the release of 1996 Census before up-dating previous works or embarking on new modelling exercises. In the interim however, existing models will have to suffice. Umgeni Water specifically requested that projections be provided under different growth scenarios and having examined various options available, it was decided that three growth scenarios could be provided. These scenarios are explained in detail hereunder.

[1] Seneque Smit & Maughan-Brown (1994) : Eskom Strategic Plan
[2] The Urban Foundation (1990) : Population Trends : Demographic Projection Model

3.1 Scenario 1 – High Growth

This effectively utillises the growth rates applied in the Eskom Strategic Plan and as such the scenario assumes sustained high growth rates throughout the study period.

Methodology

In the Eskom Strategic Plan, population growth rates were sourced from the Development Bank of South Africa and the Urban Foundation. These were critically appraised and then assigned an urban/rural assignation to enable the growth rates to be linked to each enumerator area within each magisterial district according to the dominant settlement type. As stated previously, no changes in growth rates were anticipated and thus this growth rate remains constant across the study period.

3.2 Scenario 2 – Middle Growth

One of the most recent demographic models is the [3]"Demographic and Income Distribution Model" produced by the Centre for Development Enterprise in 1995. This is effectively a revision of the Urban Foundation's "Demographic Projection Model" of 1990.

The Urban Foundation's Model was based on data drawn from the 1980 Census, the 1985 adjusted Census as well as revised 1985 population estimates produced by the Bureau of Market Research. This model provided population estimates per race group and projections for the entire country on the basis of "Generic Regions". Metropolitan areas were classified as specific generic regions, while other areas were classified according to their function in relation to the nearest metropolitan area. In applying one "generic region" classification across entire districts, the model did not allow for differential population growth between the urban and rural components of the population within each district. It therefore adopted a very "coarse-grained" approach which was really only useful as a first cut analysis.

In addition, the 1991 census in conjunction with the HSRC's study on fertility showed that the population was not growing as rapidly as was previously thought. There was also evidence of more moderate population shifts towards metropolitan and other urban areas than were anticipated under the Urban Foundation's model. By 1994 the Urban Foundation has ceased to exist and the CDE, comprising many of the former employees of the Urban Foundation, undertook to revise the Demographic Projection Model to incorporate the new census data as well as the findings of the HSRC's fertility study.

Further refinements were made to the model in terms of the "generic region" classifications to provide a finer-grained analysis. Metropolitan areas were no longer separated into "homeland" and "non-homeland" regions, but treated as one region, while other urban areas were labelled as "large towns" and "small towns" and non-urban areas were analysed separately. In addition, different growth rates were applied within the "large town" generic region. In KwaZulu-Natal this has resulted in large towns such as those on the North Coast and in Zululand (Lower Tugela, Lower Umfolozi and Mtunzini) being assigned different growth rates to those on the south coast (Port Shepstone and Umzinto) and those in Northern Natal (Newcastle and Klip River).

[3] Centre for Development and Enterprise (1995) : Demographic and Income Distribution Models : Technical Reports

This CDE study is therefore considered to be the most comprehensive analysis of recent population trends presently available and the projections provided are considered a suitable base-line for the revision of future population estimates for Umgeni Water's operational area. One draw-back of the model however is that it does not project population beyond the year 2011. The catchment models devised by Umgeni Water specifically call for population estimates through to 2040, and as such a practical methodology has to be devised to extend the CDE's projections.

Methodology

The methodology proposed for extending the CDE's growth rates involved three levels of analysis, scoping down from the National level through to Provincial level and finally to generic region level. Whilst it may seem irrelevant to begin a fine-grained analysis at the macro-level of national projections, the reason for this is fairly simple. The [4] HSRC produced population growth projections to 2035 (by race group) for the country as a whole in a demographic study produced in 1987. Although the base figures are somewhat suspect and the growth rates employed therein are considered high, the study provides a relatively good yard-stick of anticipated growth trends per race group nationally beyond 2011.

Step 1 : Extending CDE's National Projections to 2040

- As a first step, the HSRC growth rates by race to 2035 for South Africa as a whole are extracted and extended to 2040 using a standard trend line.
- CDE's growth rates by race for South Africa to up to 2011 are extracted.
- The two data sets are plotted on a line graph and the CDE growth projections are extended to follow the curve of the HSRC growth projections.

Step 2 : Extending CDE's Provincial Projections to 2040

- The next step would be to extract CDE's growth rates by race for KwaZulu-Natal to 2011;
- At each milestone year, the total figure for each race group is calculated as a percentage of the total figure for the same race group for South Africa as a whole. These percentages are then applied to the HSRC figures to ascertain the likely Provincial growth under the HSRC growth rates.
- The two data sets are plotted on a line graph and the CDE growth projections are extended to follow the curve of the HSRC growth projections.
- From this it is then possible to derive "first cut" population totals for each race group in KwaZulu-Natal through to 2040, using the CDE model and extensions thereto. These totals will provide a "control" for the finer grained projections.

Step 3 : Extending CDE's Projections by Generic Region to 2040

- As there is considerable variation in the growth rates for different generic regions, it would not be not be acceptable to extend the growth rates to 2040 simply by

[4] HSRC (1987) : Projections of the South African Population 1985 - 2035

following the Provincial trend lines for each race group. The only other option is therefore to plot the growth rates for each race group by generic region, and extend the existing growth curve to the required year.

- These growth rates can then be applied to CDE's base figures to project the population by race to 2040. The growth rates can be tested by comparing these total figures at each five year milestone against the "first cut" totals derived under ***Step 2***.

3.3 Scenario 3(i) and 3(ii) – Low Growth

Scenario 3 comprises two low growth scenarios which attempt to factor in the possible effects of AIDs on future population growth. This scenario draws on work done by [5]Whiteside *et al* in 1995 wherein epidemiological models were used to project the course of the AIDS epidemic and estimate the impact of this epidemic on KwaZulu-Natal. It must be stressed here that the resultant figures must be viewed with considerable caution for the following reasons :

- Whiteside's work examines the Province as a whole, and as such it must be assumed, under both Scenario 3(i) and 3(ii), that the impact of AIDS on population growth will be the same regardless of spatial location;
- The projections provided in Whiteside's study only extend to 2011, and in fact Whiteside himself cautions that "the further into the future the projection is taken, the less reliable it becomes".
- Predicting the course of AIDs is in itself problematic, as Whiteside says, "Any attempt to forecast the course of the HIV epidemic is fraught with many difficulties and uncertainties. These relate primarily to the large number of assumptions that must be made in building forecasting models, often with data that are not completely reliable. The results of models should therefore be treated with caution, and must be used responsibly".

Methodology

Whiteside has applied an integrated approach to modelling the AIDS epidemic firstly using a simple forward projection model to create a baseline seroprevalence curve for adults (ie HIV projection model). The second model is a population projection model which simulates the future course of population growth under different assumptions regarding fertility, mortality and migration to provide a base population projection (not considering the effects of AIDS). This model then draws data from the HIV projection model to create a population projection which reflects the effects of AIDS.

The HIV projection model was manipulated to generate two possible projections:

- In Projection 1 the model generated curve is manipulated to concur with existing (1990 – 1993) antenatal sero-survey data as well as the expected results for the 1994 survey, and shows the prevalence increasing rapidly during the epidemic stage and peaking around the year 2003 at 20.7%. Prevalence levels out at this stage and then gradually begins to decline.
- In Projection 2 the model generated curve also concurs with the antenatal sero-survey data, but thereafter follows a more gentle curve in line with that generated

[5] Whiteside, A & Wilkens, N (1995) : The Impact of HIV / AIDS on Planning Issues in KwaZulu-Natal

by other epidemiological models. Prevalence peaks at 19.9% in the year 2004, again with levelling out at this stage followed by a gradual decline.

From this exercise, it is then possible to determine the anticipated annual number of AIDS deaths under each of the two projections, and this can then be viewed in terms of its likely impact on population growth.

In attempting to apply these assumptions to our projections under Scenario 3, it has been necessary to adopt a very broad-brush approach. This merely involves calculating the percentage impact of AIDS under Whiteside's two projections at each milestone year, and applying these percentages to the baseline population generated under Scenario 2.

Furthermore, as previously stated, Whiteside's projections only extend to 2011. In the absence of any other data sources, it would be futile to attempt any extension of trends in the course of the AIDS epidemic beyond 2011, and as such, for the purposes of this study, it has been assumed that the percentage impact will remain constant after 2011.

4.0 APPLICATION OF GROWTH RATES

It was requested by Umgeni that projections be provided for:

- Enumerator Areas;
- Quaternary Catchments;
- Umgeni's Planning Regions; and
- Regional Councils.

In addition it was requested that the data be provided in the form of a model to allow for further manipulation at a later stage.

4.1 Basic Unit of Analysis

The basic unit of analysis used in the Umgeni Water Needs Analysis, and indeed in all Scott Wilson's projects requiring demographic in-put, is the Enumerator Area and with base population figures derived from the Eskom Strategic Plan. These are largely drawn from the spatial units defined in the 1991 census, although some changes were made to the original base in 1997, under commission from the Department of Local Government and Housing, to accommodate new administrative boundaries.

For this study therefore, the basic unit of analysis is the adjusted enumerator area with base population figures for 1995 drawn from the Eskom database. Under each Scenario therefore, the enumerator areas, and the relevant population projections, provide the base files for the larger spatial units.

In each base file, identifiers are assigned to EAs to allow for the aggregation of the figures to quaternary catchments, planning regions and regional councils.

Quaternary catchments are larger spatial units than Eas, and although it is relatively simple to assign identifiers from these larger regions to those EAs which fall entirely within the region, problems arise where catchment or planning region boundaries dissect EAs. In these instances, it has been necessary to apportion population figures from one EA to two or more catchments. This has been conducted simply as a proportionate analysis, ie, it has been assumed that, if 30% of an EA falls into a particular catchment, then 30% of that EA's population should be assigned to the catchment. A more accurate method of analysis would be to examine aerial photography to determine population distribution within EAs, but this would be a lengthy study in its own right and would go far beyond the scope of this study.

The same procedure was applied in respect of assigning Planning region identifiers to Eas.

The base spreadsheets for quaternary catchments and planning regions therefore reflect the proportions of EAs assigned to the respective catchments and planning regions. As these spreadsheets form the basis of all further calculation, any changes made to the percentages at a later date will carry through to the summary spreadsheets.

With regard to the projections for Regional Councils, as previously stated, the original EAs were adjusted to accommodate administrative boundaries, and as it was simply a matter of aggregating EA data to arrive at the Regional Council summaries.

4.2 Scenario 1

For the purposes of Scenario 1, the growth rates drawn from the Eskom Strategic Plan were simply applied to the EAs in the base spreadsheets to provide projections to 2040. In light of the fact that Scenario 2 is largely based on a model which examines future population growth using the milestone years 1996, 2001, 2006 and 2011, it was decided to adopt, for the purposes of this study, the following milestones:
1995 (base year); 2001; 2006; 2011; 2015; 2020; 2025; 2030; 2035 and 2040.

Projected populations for these years are then calculated at EA level and aggregated up to Regional Councils, Planning Regions and Quaternary Catchments in the relevant "summary" files.

4.3 Scenario 2

Scenario 2 is based on the CDE model, which provides growth rates for each race group within each "generic region". Accordingly, each EA was assigned a "generic region" code which then determined the relevant growth rates for each milestone period. In order to provide a population base line for 1995 by race, it was necessary to extrapolate the racial breakdown from the 1991 census and apply this to the 1995 base.

Projections were then conducted for each race group and summed to provide total anticipated population figures per EA for each milestone year. These figures were then aggregated up to Regional Councils, Planning Regions and Quaternary Catchments in the relevant "summary" files.

4.4 Scenario 3 (L1 & L2)

Scenario 3 attempts to assess the possible impact of AIDS on future population growth. In both instances, a percentage reduction is applied to the total population generated under Scenario 2 for each milestone year. The resulting figures are then aggregated up to Regional Councils, Planning Regions and Quaternary Catchments in the relevant "summary" files.

5.0 DIRECTORY STRUCTURE

The model, set up in Microsoft Excel version 7, comprises separate sub-directories for each of the following units of analysis:

- Regional Councils
- Planning Regions
- Quaternary Catchments

It has not been considered necessary to create a separate directory for Enumerator Areas as the EA forms the basic unit of analysis for all the above units and projections per EA appear in the "Base" spreadsheets for all the above mentioned spatial units.

A fourth sub-directory called "Growth Rates" contains all the growth rates for Scenario 2 and the percentage adjustments for Scenario 3.

Each sub-directory comprises a further three sub-directories:

- Scenario 1
- Scenario 2
- Scenario 3

Each of these sub-directories contain a series of linked base sheets and summaries for the relevant scenarios.

6.0 CONCLUSION

In conclusion, it must be stressed that this study has utilised base figures projected from the 1991 Census. In addition, growth rates applied in the projections are derived from relatively out-dated sources, and adjustments implemented to reflect the impact of AIDS on future population growth, are highly generalised.

In light of this is recommended that these projections be seen simply as possible guidelines to possible future population growth and not as definitive figures. In addition, it may be expedient to revisit the projection exercise after the release of the 1996 Census, as this will provide more a current population base as well as a providing a base for a more comprehensive analysis of past population growth trends.

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY

Rural domestic demands - Summary info

Summary of unmet rural demands after groundwater contribution for low, middle and high scenarios.

Catchment	1995			2020			2040		
	Low	Mid	High	Low	Mid	High	Low	Mid	High
U10A	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.301
U10B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
U10C	0.000	0.000	0.000	0.000	0.000	0.164	0.000	0.000	0.233
U10D	0.000	0.000	0.315	0.000	0.000	0.487	0.000	0.000	0.690
U10E	0.000	0.000	0.352	0.000	0.205	0.544	0.000	0.000	0.771
U10F	0.000	0.312	0.624	0.000	0.364	0.965	0.000	0.308	1.368
U10G	0.000	0.000	0.000	0.000	0.000	0.256	0.000	0.000	0.363
U10H	0.000	0.304	0.607	0.000	0.352	0.939	0.000	0.297	1.332
U10J	0.000	0.449	0.898	0.000	0.522	1.389	0.000	0.441	1.969
U10K	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
U10L	0.000	0.000	0.372	0.000	0.000	0.575	0.000	0.000	0.816
U10M	0.000	0.449	0.898	0.000	0.720	1.390	0.000	0.798	1.970
Total	0.000	1.514	4.066	0.000	2.163	6.709	0.000	1.844	9.813

APPENDIX B

Calculation of available groundwater abstractions

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Domestic demands : Groundwater contribution to rural demand

Current conditions - 1995

Low scenario

Catchment	Area	Supply area	Abstr. area	Safe abstraction: Sa cat.	Pro rata	Total		Rural demand: Basic	Incl FOS	Unmet demand
	km2	%	km2	m3/km2/a	%	m3/a	Mm3/a	Mm3/a	Mm3/a	Mm3/a
U10A	416.00	10	41.60	0 13600 17700	5 5 90	0 28424 665674	0.694	0.018	0.054	0.000
U10B	392.00	10	39.20	0 13600 17700	5 5 90	0 26656 624456	0.651	0.008	0.024	0.000
U10C	267.08	10	26.71	0 13600 17700	5 10 85	0 36323 401822	0.438	0.014	0.042	0.000
U10D	337.09	10	33.71	13600 17700	30 70	137533 417655	0.555	0.042	0.126	0.000
U10E	327.22	10	32.72	13600 17700	30 70	133506 405426	0.539	0.047	0.141	0.000
U10F	379.13	10	37.91	13600 17700	20 80	103123 536848	0.640	0.083	0.249	0.000
U10G	353.12	10	35.31	13600 17700	10 90	48024 562520	0.611	0.022	0.066	0.000
U10H	457.95	10	45.80	13600	100	622812	0.623	0.081	0.243	0.000
U10J	505.09	10	50.51	13600	100	686922	0.687	0.120	0.360	0.000
U10K	364.39	10	36.44	17700	100	894009	0.894	0.013	0.039	0.000
U10L	307.19	10	30.72	13600 36000 80600 89800	10 30 30 30	41778 331765 742785 827570	0.869	0.050	0.150	0.000
U10M	280.02	10	28.00	21800 35000	15 85	91567 855851	0.948	0.120	0.360	0.000
Total	4388.28		438.83				8.150	0.418	1.254	0.000

Middle scenario

Catchment	Area	Supply area	Abstr. area	Safe abstraction: Sa cat.	Pro rata	Total		Rural demand: Basic	Incl FOS	Unmet demand
	km2	%	km2	m3/km2/a	%	m3/a	Mm3/a	Mm3/a	Mm3/a	Mm3/a
U10A	416.00	10	41.60	0 13600 17700	5 5 90	0 28424 665674	0.694	0.069	0.207	0.000
U10B	392.00	10	39.20	0 13600 17700	5 5 90	0 26656 624456	0.651	0.029	0.087	0.000
U10C	267.08	10	26.71	0 13600 17700	5 10 85	0 36323 401822	0.438	0.053	0.159	0.000
U10D	337.09	10	33.71	13600 17700	30 70	137533 417655	0.555	0.157	0.471	0.000
U10E	327.22	10	32.72	13600 17700	30 70	133506 405426	0.539	0.176	0.528	0.000
U10F	379.13	10	37.91	13600 17700	20 80	103123 536848	0.640	0.312	0.936	0.312
U10G	353.12	10	35.31	13600 17700	10 90	48024 562520	0.611	0.083	0.249	0.000
U10H	457.95	10	45.80	13600	100	622812	0.623	0.304	0.912	0.304
U10J	505.09	10	50.51	13600	100	686922	0.687	0.449	1.347	0.449
U10K	364.39	10	36.44	17700	100	894009	0.894	0.048	0.144	0.000
U10L	307.19	10	30.72	13600 36000 80600 89800	10 30 30 30	41778 331765 742785 827570	0.869	0.186	0.558	0.000
U10M	280.02	10	28.00	21800 35000	15 85	91567 855851	0.948	0.449	1.347	0.449
Total	4388.28		438.83				8.150	2.315	6.945	1.514

High scenario

Catchment	Area	Supply area	Abstr. area	Safe abstraction: Sa cat.	Pro rata	Total		Rural demand: Basic	Incl FOS	Unmet demand
	km2	%	km2	m3/km2/a	%	m3/a	Mm3/a	Mm3/a	Mm3/a	Mm3/a
U10A	416.00	10	41.60	0 13600 17700	5 5 90	0 28424 665674	0.694	0.137	0.411	0.000
U10B	392.00	10	39.20	0 13600 17700	5 5 90	0 26656 624456	0.651	0.058	0.174	0.000
U10C	267.08	10	26.71	0 13600 17700	5 10 85	0 36323 401822	0.438	0.106	0.318	0.000
U10D	337.09	10	33.71	13600 17700	30 70	137533 417655	0.555	0.315	0.945	0.315
U10E	327.22	10	32.72	13600 17700	30 70	133506 405426	0.539	0.352	1.056	0.352
U10F	379.13	10	37.91	13600 17700	20 80	103123 536848	0.640	0.624	1.872	0.624
U10G	353.12	10	35.31	13600 17700	10 90	48024 562520	0.611	0.165	0.495	0.000
U10H	457.95	10	45.80	13600	100	622812	0.623	0.607	1.821	0.607
U10J	505.09	10	50.51	13600	100	686922	0.687	0.898	2.694	0.898
U10K	364.39	10	36.44	17700	100	894009	0.894	0.096	0.288	0.000
U10L	307.19	10	30.72	13600 36000 80600 89800	10 30 30 30	41778 331765 742785 827570	0.869	0.372	1.116	0.372
U10M	280.02	10	28.00	21800 35000	15 85	91567 855851	0.948	0.898	2.694	0.898
Total	4388.28		438.83				8.150	4.628	13.884	4.066

NKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Domestic demands : Groundwater contribution to rural demand

2020

Low scenario

Catchment	Area	Supply area	Abstr. area	Safe abstraction				Rural demand		Unmet demand
				Sa cat.	Pro rata	Total		Basic	Incl FOS	
	km2	%	km2	m3/km2/a	%	m3/a	Mm3/a	Mm3/a	Mm3/a	Mm3/a
U10A	418.00	10	41.80	0 13600 17700	5 5 90	0 28424 665674	0.694	0.015	0.046	0.000
U10B	392.00	10	39.20	0 13600 17700	5 5 90	0 26656 624456	0.651	0.007	0.021	0.000
U10C	267.08	10	26.71	0 13600 17700	5 10 85	0 36323 401822	0.438	0.012	0.036	0.000
U10D	337.09	10	33.71	13600 17700	30 70	137533 417655	0.555	0.037	0.111	0.000
U10E	327.22	10	32.72	13600 17700	30 70	133508 405428	0.539	0.042	0.125	0.000
U10F	379.13	10	37.91	13600 17700	20 80	103123 536848	0.640	0.075	0.225	0.000
U10G	353.12	10	35.31	13600 17700	10 90	48024 562520	0.611	0.019	0.057	0.000
U10H	457.95	10	45.80	13600	100	622812	0.623	0.072	0.216	0.000
U10J	505.09	10	50.51	13600	100	686922	0.687	0.107	0.321	0.000
U10K	384.39	10	38.44	17700	100	894008	0.894	0.010	0.030	0.000
U10L	307.19	10	30.72	13600 36000 80600 89800	10 30 30 30	41778 331765 742785 827570	0.889	0.035	0.105	0.000
U10M	280.02	10	28.00	21800 36000	15 85	91567 856861	0.948	0.148	0.444	0.000
Total	4388.28		438.83				8.160	0.600	1.800	0.000

Middle scenario

Catchment	Area	Supply area	Abstr. area	Safe abstraction				Rural demand		Unmet demand
				Sa cat.	Pro rata	Total		Basic	Incl FOS	
	km2	%	km2	m3/km2/a	%	m3/a	Mm3/a	Mm3/a	Mm3/a	Mm3/a
U10A	418.00	10	41.80	0 13600 17700	5 5 90	0 28424 665874	0.694	0.078	0.234	0.000
U10B	392.00	10	39.20	0 13600 17700	5 5 90	0 26656 624456	0.651	0.033	0.099	0.000
U10C	267.08	10	26.71	0 13600 17700	5 10 85	0 36323 401822	0.438	0.050	0.150	0.000
U10D	337.09	10	33.71	13600 17700	30 70	137533 417955	0.555	0.182	0.546	0.000
U10E	327.22	10	32.72	13600 17700	30 70	133506 405426	0.539	0.205	0.615	0.205
U10F	379.13	10	37.91	13600 17700	20 80	103123 536848	0.640	0.364	1.092	0.364
U10G	353.12	10	35.31	13600 17700	10 90	48024 562520	0.611	0.094	0.282	0.000
U10H	457.95	10	45.80	13600	100	622812	0.623	0.352	1.056	0.352
U10J	505.09	10	50.51	13600	100	686922	0.687	0.522	1.566	0.522
U10K	384.39	10	38.44	17700	100	894006	0.894	0.049	0.147	0.000
U10L	307.19	10	30.72	13600 36000 80600 89800	10 30 30 30	41778 331780 742786 827570	0.889	0.270	0.810	0.000
U10M	280.02	10	28.00	21800 36000	15 85	91567 856851	0.948	0.720	2.160	0.720
Total	4388.28		438.83				8.160	2.929	8.707	2.163

High scenario

Catchment	Area	Supply area	Abstr. area	Safe abstraction				Rural demand		Unmet demand
				Sa cat.	Pro rata	Total		Basic	Incl FOS	
	km2	%	km2	m3/km2/a	%	m3/a	Mm3/a	Mm3/a	Mm3/a	Mm3/a
U10A	418.00	10	41.80	0 13600 17700	5 5 90	0 28424 665574	0.694	0.212	0.636	0.000
U10B	392.00	10	39.20	0 13600 17700	5 5 90	0 26656 624456	0.651	0.090	0.270	0.000
U10C	267.08	10	26.71	0 13600 17700	5 10 85	0 36323 401822	0.438	0.154	0.462	0.154
U10D	337.09	10	33.71	13600 17700	30 70	137533 417655	0.555	0.487	1.461	0.487
U10E	327.22	10	32.72	13600 17700	30 70	133508 405428	0.539	0.544	1.632	0.544
U10F	379.13	10	37.91	13600 17700	20 80	103123 536848	0.640	0.965	2.895	0.965
U10G	353.12	10	35.31	13600 17700	10 90	48024 562520	0.611	0.256	0.768	0.256
U10H	457.95	10	45.80	13600	100	622812	0.623	0.839	2.517	0.839
U10J	505.09	10	50.51	13600	100	686922	0.687	1.389	4.167	1.389
U10K	384.39	10	38.44	17700	100	894006	0.894	0.148	0.444	0.000
U10L	307.19	10	30.72	13600 36000 80600 89800	10 30 30 30	41778 331786 742786 827570	0.889	0.575	1.725	0.575
U10M	280.02	10	28.00	21800 36000	15 85	91567 856861	0.948	1.390	4.170	1.390
Total	4388.28		438.83				8.158	7.159	21.477	6.709

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Domestic demands : Groundwater contribution to rural demand

Ultimate conditions - 2040

Low scenario

Catchment	Area	Supply area	Abstr. area	Safe abstraction				Rural demand		Unmet demand
				Sa cat.	Pro rata	Total		Basic	Incl FOS	
	km2	%	km2	m3/km2/a	%	m3/a	Mm3/a	Mm3/a	Mm3/a	Mm3/a
U10A	418.00	10	41.80	0 13600 17700	5 5 90	0 28424 665874	0.694	0.014	0.042	0.000
U10B	392.00	10	39.20	0 13600 17700	5 5 90	0 26656 624456	0.651	0.005	0.015	0.000
U10C	267.08	10	26.71	0 13600 17700	5 10 85	0 36323 401822	0.438	0.010	0.030	0.000
U10D	337.09	10	33.71	13600 17700	30 70	137533 417655	0.555	0.022	0.066	0.000
U10E	327.22	10	32.72	13600 17700	30 70	133506 405426	0.539	0.035	0.105	0.000
U10F	379.13	10	37.91	13600 17700	20 80	103123 536848	0.640	0.063	0.189	0.000
U10G	353.12	10	35.31	13600 17700	10 90	48024 562520	0.611	0.016	0.048	0.000
U10H	457.85	10	45.80	13600	100	622612	0.623	0.061	0.183	0.000
U10J	505.09	10	50.51	13600	100	686922	0.687	0.090	0.270	0.000
U10K	364.39	10	36.44	17700	100	894009	0.894	0.008	0.024	0.000
U10L	307.19	10	30.72	13600 36000 80600 89800	10 30 30 30	41778 331765 742785 827570	0.869	0.057	0.171	0.000
U10M	280.02	10	28.00	21800 36000	15 85	91567 856861	0.948	0.144	0.432	0.000
Total	4388.28		438.83				8.150	0.666	1.658	0.000

Middle scenario

Catchment	Area	Supply area	Abstr. area	Safe abstraction				Rural demand		Unmet demand
				Sa cat.	Pro rata	Total		Basic	Incl FOS	
	km2	%	km2	m3/km2/a	%	m3/a	Mm3/a	Mm3/a	Mm3/a	Mm3/a
U10A	418.00	10	41.80	0 13600 17700	5 5 90	0 28424 665874	0.694	0.066	0.198	0.000
U10B	392.00	10	39.20	0 13600 17700	5 5 90	0 26656 624456	0.651	0.028	0.084	0.000
U10C	267.08	10	26.71	0 13600 17700	5 10 85	0 36323 401822	0.438	0.051	0.153	0.000
U10D	337.09	10	33.71	13600 17700	30 70	137533 417655	0.555	0.154	0.462	0.000
U10E	327.22	10	32.72	13600 17700	30 70	133506 405426	0.539	0.173	0.519	0.000
U10F	379.13	10	37.91	13600 17700	20 80	103123 536848	0.640	0.308	0.924	0.000
U10G	353.12	10	35.31	13600 17700	10 90	48024 562520	0.611	0.080	0.240	0.000
U10H	457.85	10	45.80	13600	100	622612	0.623	0.297	0.891	0.297
U10J	505.09	10	50.51	13600	100	686922	0.687	0.441	1.323	0.441
U10K	364.39	10	36.44	17700	100	894009	0.894	0.040	0.120	0.000
U10L	307.19	10	30.72	13600 36000 80600 89800	10 30 30 30	41778 331765 742785 827570	0.869	0.279	0.837	0.000
U10M	280.02	10	28.00	21800 36000	15 85	91567 856861	0.948	0.798	2.394	0.798
Total	4388.28		438.83				8.150	2.716	8.148	1.844

High scenario

Catchment	Area	Supply area	Abstr. area	Safe abstraction				Rural demand		Unmet demand
				Sa cat.	Pro rata	Total		Basic	Incl FOS	
	km2	%	km2	m3/km2/a	%	m3/a	Mm3/a	Mm3/a	Mm3/a	Mm3/a
U10A	418.00	10	41.80	0 13600 17700	5 5 90	0 28424 665874	0.694	0.301	0.903	0.301
U10B	392.00	10	39.20	0 13600 17700	5 5 90	0 26656 624456	0.651	0.127	0.381	0.000
U10C	267.08	10	26.71	0 13600 17700	5 10 85	0 36323 401822	0.438	0.233	0.699	0.233
U10D	337.09	10	33.71	13600 17700	30 70	137533 417655	0.555	0.690	2.070	0.690
U10E	327.22	10	32.72	13600 17700	30 70	133506 405426	0.539	0.771	2.313	0.771
U10F	379.13	10	37.91	13600 17700	20 80	103123 536848	0.640	1.368	4.104	1.368
U10G	353.12	10	35.31	13600 17700	10 90	48024 562520	0.611	0.363	1.089	0.363
U10H	457.85	10	45.80	13600	100	622612	0.623	1.332	3.996	1.332
U10J	505.09	10	50.51	13600	100	686922	0.687	1.969	5.907	1.969
U10K	364.39	10	36.44	17700	100	894009	0.894	0.210	0.630	0.000
U10L	307.19	10	30.72	13600 36000 80600 89800	10 30 30 30	41778 331765 742785 827570	0.869	0.816	2.448	0.816
U10M	280.02	10	28.00	21800 36000	15 85	91567 856861	0.948	1.970	5.910	1.970
Total	4388.28		438.83				8.150	10.150	30.450	9.813

APPENDIX C

Calculation of future irrigation areas

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY

Development of high scenario increase factors for the Mkomazi River basin

Sub - Catchment	MAP	Current development			Maximum potential development			Increase factors	
		Main	Trib's	Total	Main	Trib's	Total	Main	Trib's
	mm	km^2			km^2			km^2	
V20A	1025	3.80	1.90	5.70	6.19	10.66	16.85	1.63	5.61
V20B	972	5.79	10.32	16.11	12.97	24.15	37.12	2.24	2.34
V20C	953	2.62	4.23	6.85	5.87	9.90	15.77	2.24	2.34
V20D	857	8.97	8.50	17.47	19.02	25.16	44.18	2.12	2.96
V20E	755	11.21	12.08	23.29	22.08	21.99	44.07	1.97	1.82
V20F	867	2.80	0.00	2.80	3.50	0.00	3.50	1.25	
V20G	759	9.22	1.43	10.65	11.71	1.43	13.14	1.27	1.00
V20H	681	16.91	0.00	16.91	20.63	0.00	20.63	1.22	
V20J	670	1.97	0.00	1.97	2.40	0.00	2.40	1.22	
Total		**63.29**	**38.46**	**101.75**	**104.38**	**93.28**	**197.66**		

Relating increase factors to the Mkomazi River catchment :

Catchment	Comment	Factor	
		Main	Trib
U10 A - D	Similar MAP and altitude/position as V20A. Apply same increase	1.63	5.61
U10 E, F	No irrigation currently. Increase to an arbitrary 3 km2 in mainstream and tributaries.		
U10 G - K	Mainstream irrigation - use a factor of 1.0 due to the highly incised nature of the valley and little potential increase in area. Increase tributaries as for V20E.	1.00	1.82
U10 L, M	Mainstream irrigation - use a factor of 1.0 due to the highly incised nature of the valley and little potential increase in area. Increase tributaries by 1.2 assuming some potential.	1.00	1.20

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Irrigation areas

High scenario

Analysis based on increase factors developed from comparison with Mooi River catchments of similar position in basin and similar Mean Annual Precipitation.

Sub - Catchment	Area	Current development (1994)		Total	Increase factors		Maximum potential development		Total
		Main	Trib's		Main	Trib's	Main	Trib's	
	km2	km^2		km^2	km^2		km^2		km^2
U10A	418.00	4.87	1.63	6.50	1.63	5.61	7.94	9.14	17.08
U10B	392.00	4.57	1.53	6.10	1.63	5.61	7.45	8.58	16.03
U10C	267.08	3.11	1.04	4.15	1.63	5.61	5.07	5.83	10.90
U10D	337.09	3.92	1.31	5.23	1.63	5.61	6.39	7.35	13.74
U10E *	327.22	0.00	0.00	0.00			3.00	3.00	6.00
U10F *	379.13	0.00	0.00	0.00			3.00	3.00	6.00
U10G	353.12	1.16	9.42	10.58	1.00	1.82	1.16	17.14	18.30
U10H	457.95	1.50	12.17	13.67	1.00	1.82	1.50	22.15	23.65
U10J	505.09	1.65	13.44	15.09	1.00	1.82	1.65	24.46	26.11
U10K	364.39	1.19	9.68	10.87	1.00	1.82	1.19	17.62	18.81
U10L	307.19	1.00	8.20	9.20	1.00	1.20	1.00	9.84	10.84
U10M *	280.02	0.00	0.00	0.00			2.00	2.00	4.00
Total	4388.28	22.97	58.42	81.39			41.35	130.12	171.47

* U10 E, F and M show no current irrigation, thus arbitrary (limited) values are assigned.

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Irrigation potential development

Middle scenario : Development of probable percentage increase in are based on Bio-Resource Units.

Catchment	Comment	Increase potential
U10A	Cat 3 : 15%. Cat 4 : 20%. Cat 6 : 45%. Cat 8 : 20% Current : 6.5 / 418 = 1.6% Predominantly low potential with low current development. Increase potential is valid.	25
U10B	Cat 3 : 20%. Cat 4 : 20%. Cat 6 : 30%. Cat 8 : 30% Current : 6.1 / 392 = 1.6% Predominantly low potential with low current development. Increase potential is valid.	25
U10C	Cat 3 : 30%. Cat 4 : 30%. Cat 6 : 25%. Cat 8 : 25% Current : 4.15 / 267 = 1.6% Medium potential with low current development. Use slight increase in potential	40
U10D	Cat 3 : 10%. Cat 4 : 60%. Cat 6 : 15%. Cat 9 : 15% Current : 5.23 / 337 = 1.6% High potential with low current development. Use increase in potential	60
U10E	Cat 3 : 20%. Cat 4 : 70%. Cat 5 : 10% Current : 0 / 327 = 0% No current area with high / medium potential. Use increase to 4 km^2	(4 km^2)
U10F	Cat 3 : 20%. Cat 4 : 70%. Cat 5 : 10% Current : 0 / 379 = 0% No current area with high / medium potential. Use increase to 4 km^2	(4 km^2)
U10G	Cat 2 : 50%. Cat 3 : 20%. Cat 4 : 30% Current : 10.58 / 353 = 3.0% Fairly low current area with high potential. Increase potential to 50%	50
U10H	Cat 2 : 10%. Cat 3 : 75%. Cat 5 : 5%. Cat 7 : 10% Current : 13.67 / 458 = 3.0% Fairly low current area with high potential. Increase potential to 50%	50
U10J	Cat 2 : 25%. Cat 3 : 35%. Cat 4 : 10%. Cat 5 : 10%. Cat 7: 20%. Current : 15.09 / 505 = 3.0% Fairly low current area with high potential. Increase potential to 50%	50
U10K	Cat 2 : 10%. Cat 3 : 10%. Cat 4 : 35%. Cat 5 : 10%. Cat 6 : 15%. Cat 7 : 20% Current : 10.87 / 364 = 3.0% Fairly low current area with medium potential. Increase potential to 40%	40
U10L	Cat 2 : 10%. Cat 3 : 10%. Cat 4 : 10%. Cat 5 : 40%. Cat 6 : 10%. Cat 7 : 20% Current : 9.20 / 307 = 3.0% Fairly low current area with medium / low potential. Increase potential is valid.	25
U10M	Cat 2 : 5%. Cat 3 : 25%. Cat 4 : 5%. Cat 5 : 10%. Cat 6 : 55% Current : 0 / 280 = 0.0% No current area with medium / low potential. Use increase to 2 km^2	(2 km^2)

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Irrigation areas

Middle scenario

Analysis using percentages developed from Bio-Resource Units (Cedara)

Sub - Catchment	Area	Current development		Total	Precentag increase	Increase in area	Ultimate evelopment
		Main	Trib's				
	km2	km^2		km^2	%	km^2	km^2
U10A	418.00	4.87	1.63	6.50	25.0	1.6	8.13
U10B	392.00	4.57	1.53	6.10	25.0	1.5	7.63
U10C	267.08	3.11	1.04	4.15	40.0	1.7	5.81
U10D	337.09	3.92	1.31	5.23	60.0	3.1	8.37
U10E *	327.22	0.00	0.00	0.00	-	4.0	4.00
U10F *	379.13	0.00	0.00	0.00	-	4.0	4.00
U10G	353.12	1.16	9.42	10.58	50.0	5.3	15.87
U10H	457.85	1.50	12.17	13.67	50.0	6.8	20.51
U10J	505.09	1.65	13.44	15.09	50.0	7.5	22.64
U10K	364.39	1.19	9.68	10.87	40.0	4.3	15.22
U10L	307.19	1.00	8.20	9.20	25.0	2.3	11.50
U10M *	280.02	0.00	0.00	0.00	-	2.0	2.00
Total	4388.28	22.97	58.42	81.39		44.27	125.66

* U10 E, F and M show no current irrigation, thus arbitrary (limited) values are assigned.

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Irrigation areas

Low scenario

Scenario based on an arbitrary 50 % of the increase developed for the "Middle" scenario.

Sub - Catchment	Area	Current development		Total	Precentag increase	Increase in area	Ultimate evelopment
		Main	Trib's				
	km2	km^2		km^2	%	km^2	km^2
U10A	418.00	4.87	1.63	6.50	12.5	0.8	7.31
U10B	392.00	4.57	1.53	6.10	12.5	0.8	6.86
U10C	267.08	3.11	1.04	4.15	20.0	0.8	4.98
U10D	337.09	3.92	1.31	5.23	30.0	1.6	6.80
U10E *	327.22	0.00	0.00	0.00	-	2.0	2.00
U10F *	379.13	0.00	0.00	0.00	-	2.0	2.00
U10G	353.12	1.16	9.42	10.58	25.0	2.6	13.23
U10H	457.95	1.50	12.17	13.67	25.0	3.4	17.09
U10J	505.09	1.65	13.44	15.09	25.0	3.8	18.86
U10K	364.39	1.19	9.68	10.87	20.0	2.2	13.04
U10L	307.19	1.00	8.20	9.20	12.5	1.2	10.35
U10M *	280.02	0.00	0.00	0.00	-	1.0	1.00
Total	4388.28	22.97	52.91	81.39		22.13	103.52

* U10 E, F and M show no current irrigation, thus arbitrary (limited) values are assigned.

APPENDIX D

Calculation of livestock numbers and demands

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Livestock numbers

Catchment	Magisterial District	%	Cattle		Sheep		Goats	
			Base	No	Base	No	Base	No
U10A	Impendle	30	34154	10246	6610	1983	9646	2894
U10B	Impendle	5	34154	1708	6610	331	9646	482
	Underberg	15	44481	6672	19917	2988	59	9
U10C	Underberg	15	44481	6672	19917	2988	59	9
	Polela	5	44086	2204	10202	510	25366	1268
U10D	Impendle	20	34154	6831	6610	1322	9646	1929
	Underberg	2	44481	890	19917	398	59	1
	Polela	5	44086	2204	10202	510	25366	1268
U10E	Impendle	10	34154	3415	6610	661	9646	965
	Polela	15	44086	6613	10202	1530	25366	3805
U10F	Impendle	8	34154	2732	6610	529	9646	772
	Polela	20	44086	8817	10202	2040	25366	5073
U10G	Impendle	20	34154	6831	6610	1322	9646	1929
	Polela	2	44086	882	10202	204	25366	507
U10H	Richmond	10	26918	2692	2491	249	3252	325
	Ixopo	10	71519	7152	6606	661	8132	813
	Polela	10	44086	4409	10202	1020	25366	2537
	Impendle	2	34154	683	6610	132	9646	193
U10J	Richmond	10	26918	2692	2491	249	3252	325
	Ixopo	15	71519	10728	6606	991	8132	1220
U10K	Ixopo	15	71519	10728	6606	991	8132	1220
U10L	Richmond	10	26918	2692	2491	249	3252	325
	Ixopo	10	71519	7152	6606	661	8132	813
U10M	Richmond	5	26918	1346	2491	125	3252	163
	Umzinto	10	39233	3923	3818	382	8020	802
	Umbumbulu	10	22476	2248	205	21	2260	226
Totals				**123161**		**23045**		**29873**

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Livestock demands

Unit demands (l/day)	Cattle	100
	Sheep	30
	Goats	30

Current demands (1997)

Catchment	Cattle		Sheep		Goats		Total
	No	Demand Mm3/a	No	Demand Mm3/a	No	Demand Mm3/a	Demand Mm3/a
U10A	10246	0.374	1983	0.022	2894	0.032	0.4
U10B	8380	0.306	3318	0.036	491	0.005	0.3
U10C	8876	0.324	3498	0.038	1277	0.014	0.4
U10D	9925	0.362	2230	0.024	3199	0.035	0.4
U10E	10028	0.366	2191	0.024	4770	0.052	0.4
U10F	11550	0.422	2569	0.028	5845	0.064	0.5
U10G	7713	0.282	1526	0.017	2437	0.027	0.3
U10H	14935	0.545	2062	0.023	3868	0.042	0.6
U10J	13420	0.490	1240	0.014	1545	0.017	0.5
U10K	10728	0.392	991	0.011	1220	0.013	0.4
U10L	9844	0.359	910	0.010	1138	0.012	0.4
U10M	7517	0.274	527	0.006	1191	0.013	0.3
Total	123161	4.50	23045	0.25	29873	0.33	5.1

2020 Growth rate 51%

Catchment	Cattle		Sheep		Goats		Total
	No	Demand Mm3/a	No	Demand Mm3/a	No	Demand Mm3/a	Demand Mm3/a
U10A	15472	0.565	2994	0.033	4370	0.048	0.6
U10B	12654	0.462	5010	0.183	742	0.008	0.0
U10C	13403	0.489	5281	0.058	1928	0.021	0.6
U10D	14986	0.547	3368	0.037	4830	0.053	0.6
U10E	15143	0.553	3309	0.036	7202	0.079	0.7
U10F	17440	0.637	3879	0.042	8826	0.097	0.8
U10G	11646	0.425	2304	0.025	3679	0.040	0.5
U10H	22552	0.823	3114	0.034	5841	0.064	0.9
U10J	20264	0.740	1872	0.021	2333	0.026	0.8
U10K	16199	0.591	1496	0.016	1842	0.020	0.6
U10L	14864	0.543	1374	0.015	1719	0.019	0.6
U10M	11350	0.414	796	0.009	1798	0.020	0.4
Total	185973	6.79	34798	0.51	45109	0.49	7.1

2040 Growth rate 12%

Catchment	Cattle		Sheep		Goats		Total
	No	Demand Mm3/a	No	Demand Mm3/a	No	Demand Mm3/a	Demand Mm3/a
U10A	17328	0.632	3354	0.037	4894	0.054	0.7
U10B	14172	0.517	5611	0.061	831	0.009	0.6
U10C	15012	0.548	5915	0.065	2160	0.024	0.6
U10D	16785	0.613	3772	0.041	5410	0.059	0.7
U10E	16960	0.619	3706	0.041	8066	0.088	0.7
U10F	19533	0.713	4345	0.048	9885	0.108	0.9
U10G	13043	0.476	2581	0.028	4121	0.045	0.5
U10H	25259	0.922	3487	0.038	6541	0.072	1.0
U10J	22695	0.828	2097	0.023	2613	0.029	0.9
U10K	18143	0.662	1676	0.018	2063	0.023	0.7
U10L	16648	0.608	1538	0.017	1925	0.021	0.6
U10M	12712	0.464	891	0.010	2014	0.022	0.5
Total	208290	7.60	38974	0.43	50522	0.55	8.6

APPENDIX E

Calculation of future forestry areas

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Forestry areas

Forestry potential data - suboptimal catchments

<u>Mkomazi River catchment</u>

Eucalypt

U10..	Total	Unsuitable		Marginal		Suitable		Optimal		DNA		Total
		No	%	No	%	No	%	No	%	No	%	%
H	150	0	0.0	7	4.7	79	52.7	64	42.7	0	0.0	100.0
J	166	9	5.4	29	17.5	60	36.1	68	41.0	0	0.0	100.0
K	120	7	5.8	32	26.7	59	49.2	22	18.3	0	0.0	100.0
L	101	19	18.8	47	46.5	26	25.7	9	8.9	0	0.0	100.0
M	90	3	3.3	21	23.3	47	52.2	19	21.1	0	0.0	100.0

Pine

U10..	Total	Unsuitable		Marginal		Suitable		Optimal		DNA		Total
		No	%	No	%	No	%	No	%	No	%	%
H	153	0	0.0	5	3.3	56	36.6	92	60.1	0	0.0	100.0
J	165	5	3.0	30	18.2	55	33.0	74	44.8	0	0.0	100.0
K	120	1	0.8	37	30.8	53	44.2	29	24.2	0	0.0	100.0
L	98	13	13.3	50	51.0	26	26.5	9	9.2	0	0.0	100.0
M	89	4	4.5	21	23.6	35	39.3	29	32.6	0	0.0	100.0

V20..	Unsuit. %	Marg. %	Suitable %	Optimal %	DNA %	Suit + Opt
H	0	4	45	51	0	93
J	4	18	35	43	0	78
K	3	29	47	21	0	68
L	16	49	26	9	0	35
M	4	23	46	27	0	73

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Forestry areas

High scenario

Analysis based on maximum of : allowable area (including adjustment for nature reserve and indigenous forest in upper catchment) calculated as a percentage reduction in runoff, adjusted for optimal or suboptimal regions. and current DWAF (CSIR95) areas plus all currently listed permits.

Sub - Catchment No	Catchment area	Available area	Status	Percentage allowable area	Opt/Subopt factor	Max. allowable area	DWAF area plus current permits *	Total area
	km^2	km^2		%		km^2	km^2	km^2
U10A ++	418.00	167.00	Opt	20	1.00	33.40	34.38	34.38
U10B ++	392.00	157.00	Opt	10	1.00	15.70	37.2	37.20
U10C ++	287.08	160.00	Opt	20	1.00	32.00	70.94	70.94
U10D ++	337.09	270.00	Opt	10	1.00	27.00	52.46	52.46
U10E	327.22		Opt	20	1.00	65.44	57.62	65.44
U10F	379.13		Opt	20	1.00	75.83	85.16	85.16
U10G	353.12		Opt	20	1.00	70.62	100.27	100.27
U10H #	457.95		Subopt	20	0.78	117.42	166.97	166.97
U10J #	505.09		Subopt	20	0.78	129.51	164.32	164.32
U10K #	364.39		Subopt	20	0.78	93.43	116.04	116.04
U10L #	307.19		Subopt	20	0.78	78.77	20.42	78.77
U10M #	280.02		Subopt	20	0.78	71.80	0.34	71.80
Total	4,388.3					810.9	946.12	1,083.75
% catch area						18.48	21.56	24.70

* Existing forestry in U10A corrected in accordance with summary sheet obtained from DWAF, shown incorrectly on permit data sheet.

\# U10 H - M : Where high increases are shown in suboptimal areas, these have been checked against forestry potential maps.

++ U10 A - D : Available area for afforestation derived from area in catchment not covered by nature reserve or indigenous forest. Percentage allowable area then applies to this available area.

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Forestry areas

Middle scenario (Most probable)

Analysis based on Umgeni Water existing areas, plus all currently approved permits, plus the remaining increment up to the maximum allowable area based on percentage reduction in runoff, as calculated by DWAF.

Sub - Catchment No	Catchment area	Umgeni Water base area	Currently approved permits	Increment** (Conditional > 0)	Total
	km^2	km^2	km^2		km^2
U10A	418.00	2.35	14.82	0.00	17.17
U10B	392.00	8.74	14.05	0.00	22.79
U10C	267.08	38.86	15.02	0.00	53.88
U10D	337.09	15.53	18.55	0.00	34.08
U10E	327.22	40.76	0.46	14.32	55.54
U10F	379.13	69.31	3.23	0.00	72.54
U10G	363.12	62.87	6.49	0.00	69.36
U10H	467.05	138.26	6.45	0.00	144.71
U10J	505.09	134.37	7.36	0.00	141.73
U10K	364.39	76.90	8.59	0.00	85.49
U10L	307.19	9.82	0.00	58.34	68.16
U10M	280.02	0.24	0.00	71.46	71.70
Total	4,388.3	598.0	95.0	144.1	837.1
% catch area		13.63	2.17	3.28	19.08

Increment calculation

Sub - Catchment No	Max. prob. area	Current DWAF area incl. permits	Increment **
	km^2		
U10A	33.40	54.01	-20.61
U10B	15.70	31.97	-16.27
U10C	32.00	60.62	-28.62
U10D	27.00	38.92	-11.92
U10E	65.44	51.12	14.32
U10F	75.83	84.66	-8.83
U10G	70.62	93.30	-22.68
U10H	117.42	181.29	-63.87
U10J	129.51	180.08	-50.57
U10K	93.43	110.67	-17.24
U10L	78.77	20.43	58.34
U10M	71.80	0.34	71.46
Total	810.9		

** Increment is based on possible increase from current DWAF areas up to maximum allowable areas according to run-off. (Negative increments indicate that the allowable area has already been exceeded).

MKOMAZI WATER DEMANDS AND RECONNAISSANCE BASIN STUDY
Forestry areas

Low scenario

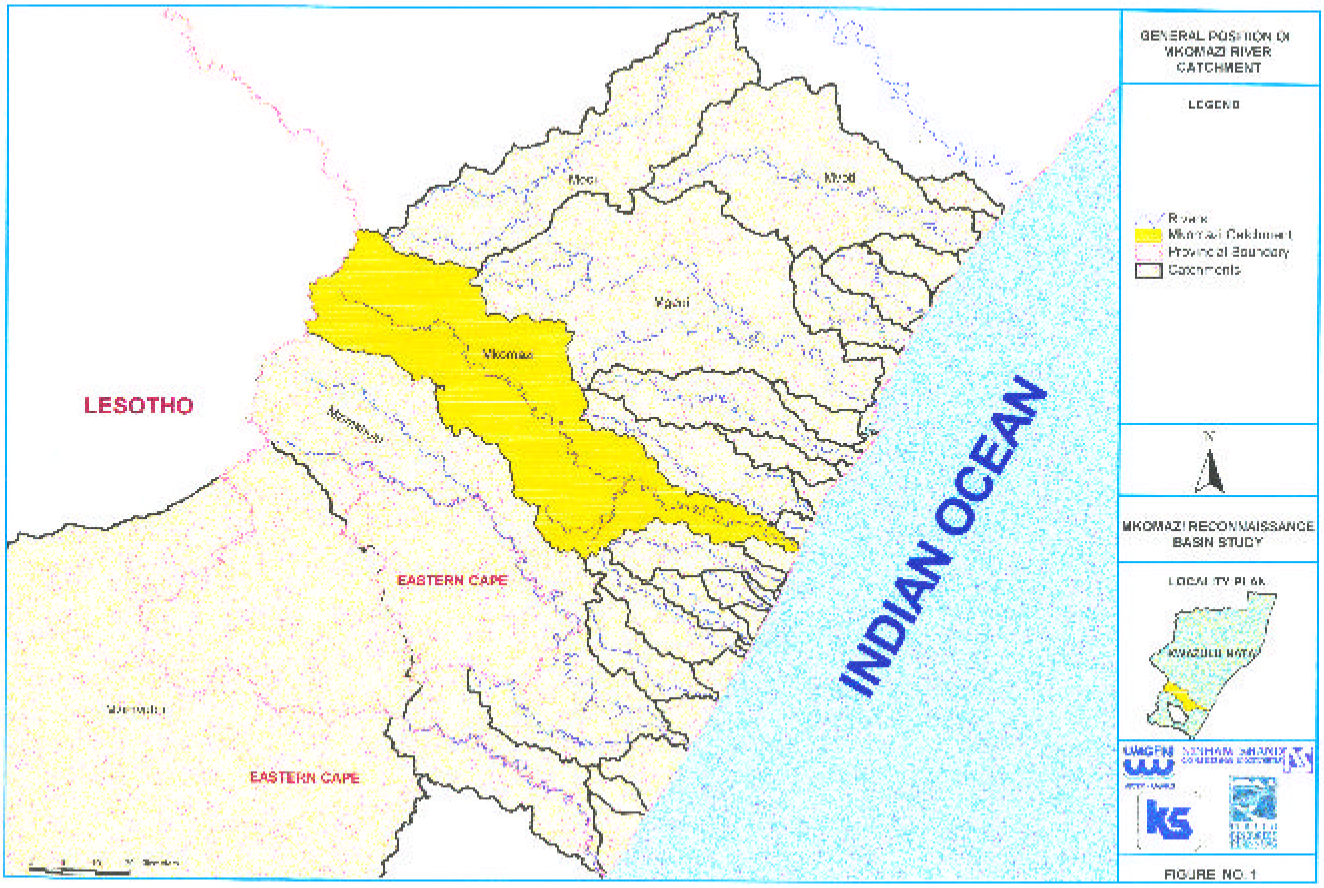
Analysis based on Umgeni Water existing area plus all currently approved permits.

Sub - Catchment	Catchment area	Umgeni Water base area	Permits	Total
	km^2	km^2		
U10A	418.00	2.35	14.82	17.17
U10B	392.00	8.74	14.05	22.79
U10C	267.08	38.86	15.02	53.88
U10D	337.09	15.53	18.55	34.08
U10E	327.22	40.76	0.46	41.22
U10F	379.13	69.31	3.23	72.54
U10G	353.12	62.87	6.49	69.36
U10H	457.95	138.26	6.45	144.71
U10J	505.09	134.37	7.36	141.73
U10K	364.39	76.90	8.59	85.49
U10L	307.19	9.82	0.00	9.82
U10M	280.02	0.24	0.00	0.24
Total	**4,388.3**	**598.0**	**95.0**	**693.0**
% catch area		**13.63**	**2.17**	**15.79**

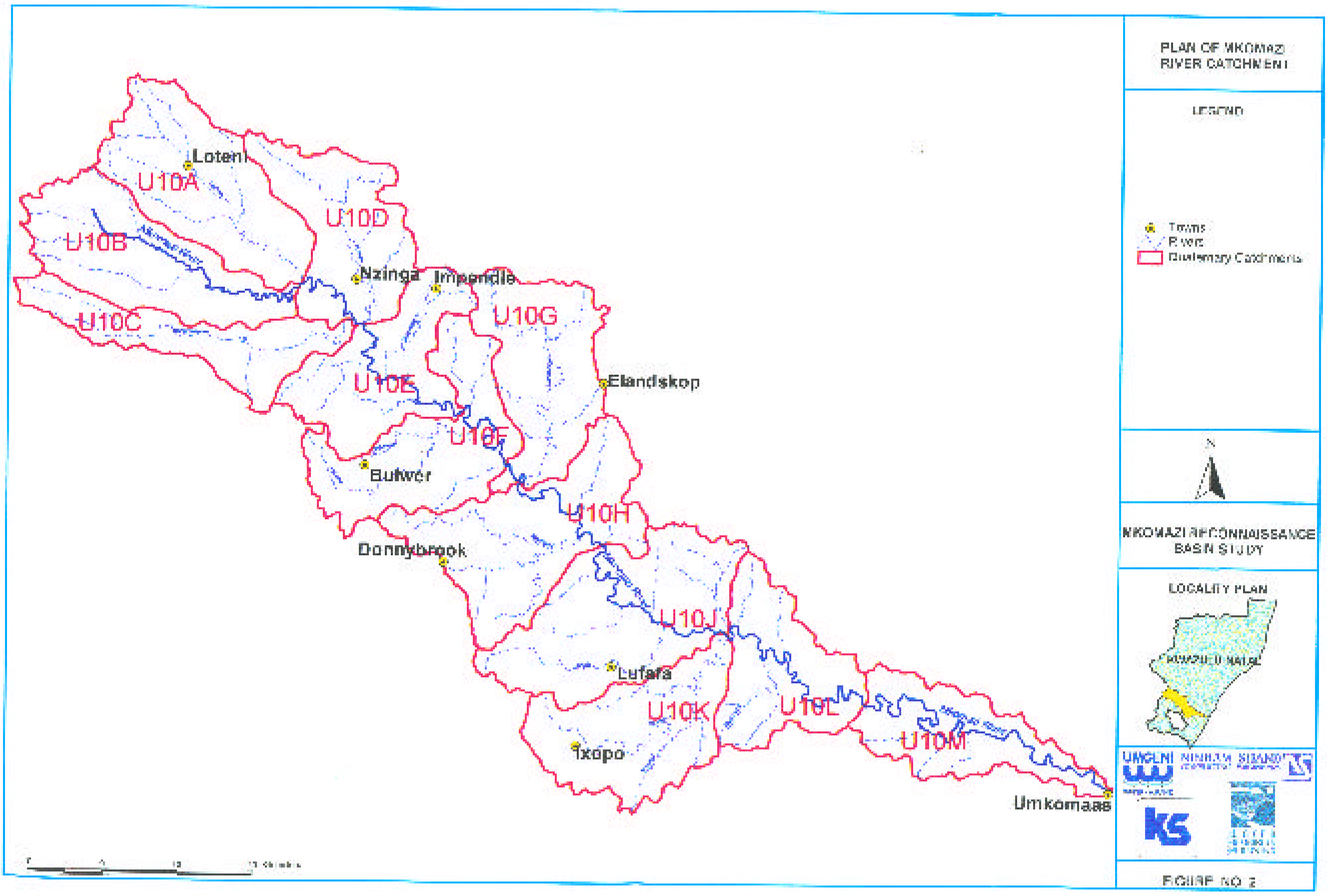
APPENDIX F

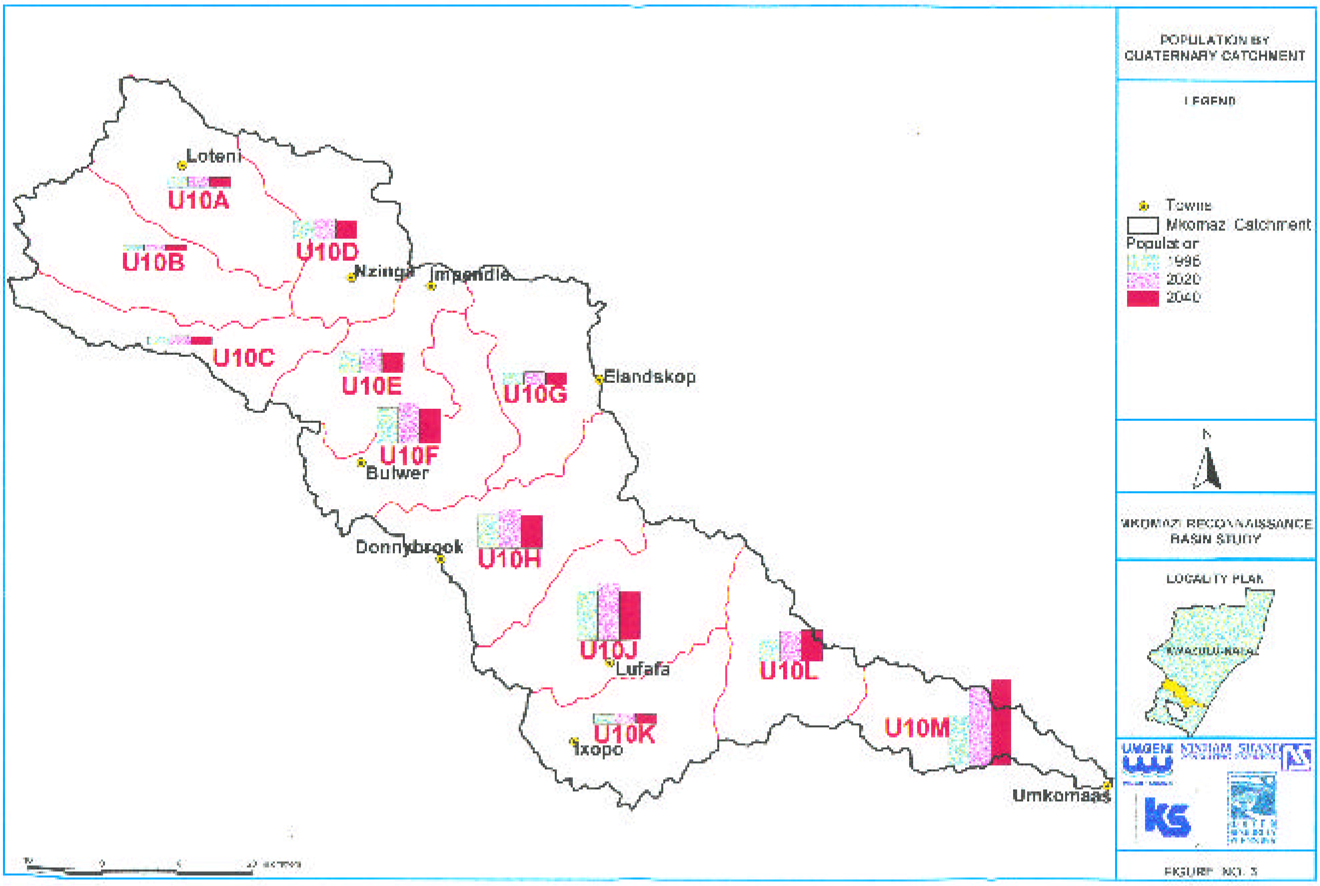
GIS Figures

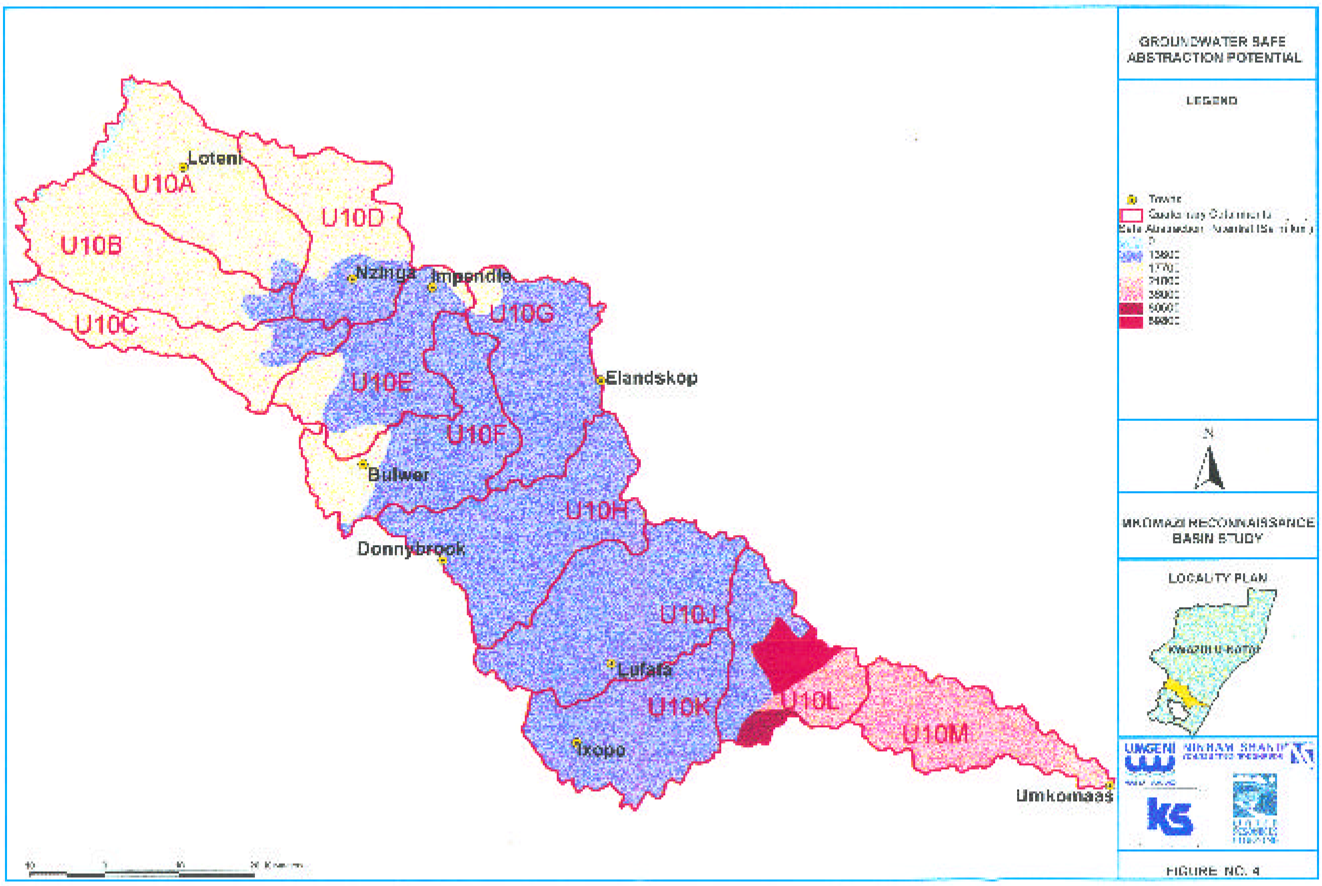
Appendix F : GIS Figures

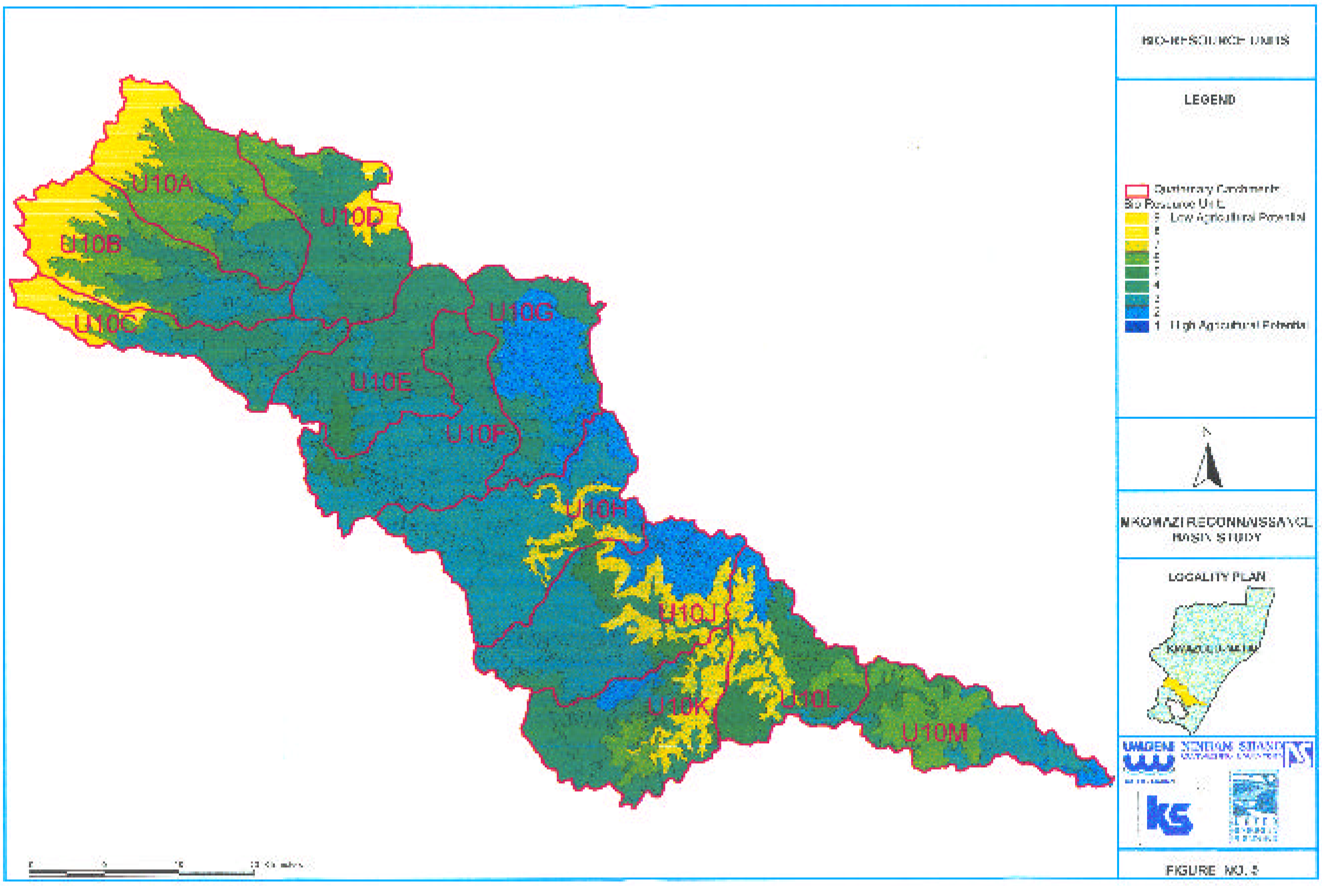


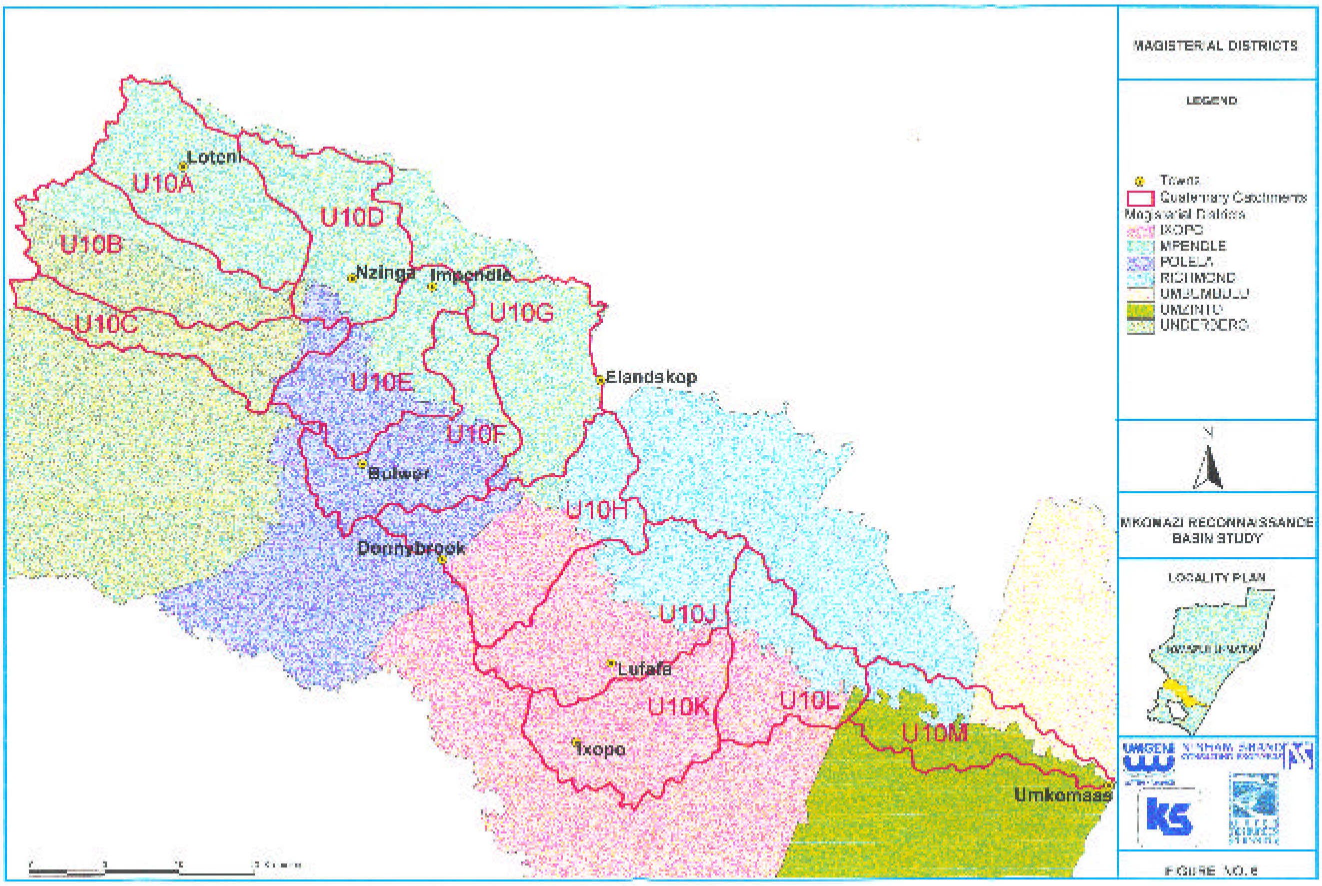
GENERAL POSITION OF MKOMAZI RIVER CATCHMENT
LEGEND
Rivers
Mkomazi Catchment
Provincial Boundary
Catchments
N
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU NATAL
LESOTHO
EASTERN CAPE
EASTERN CAPE
INDIAN OCEAN
Mooi
Mvoti
Mgeni
Mkomazi
FIGURE NO. 1

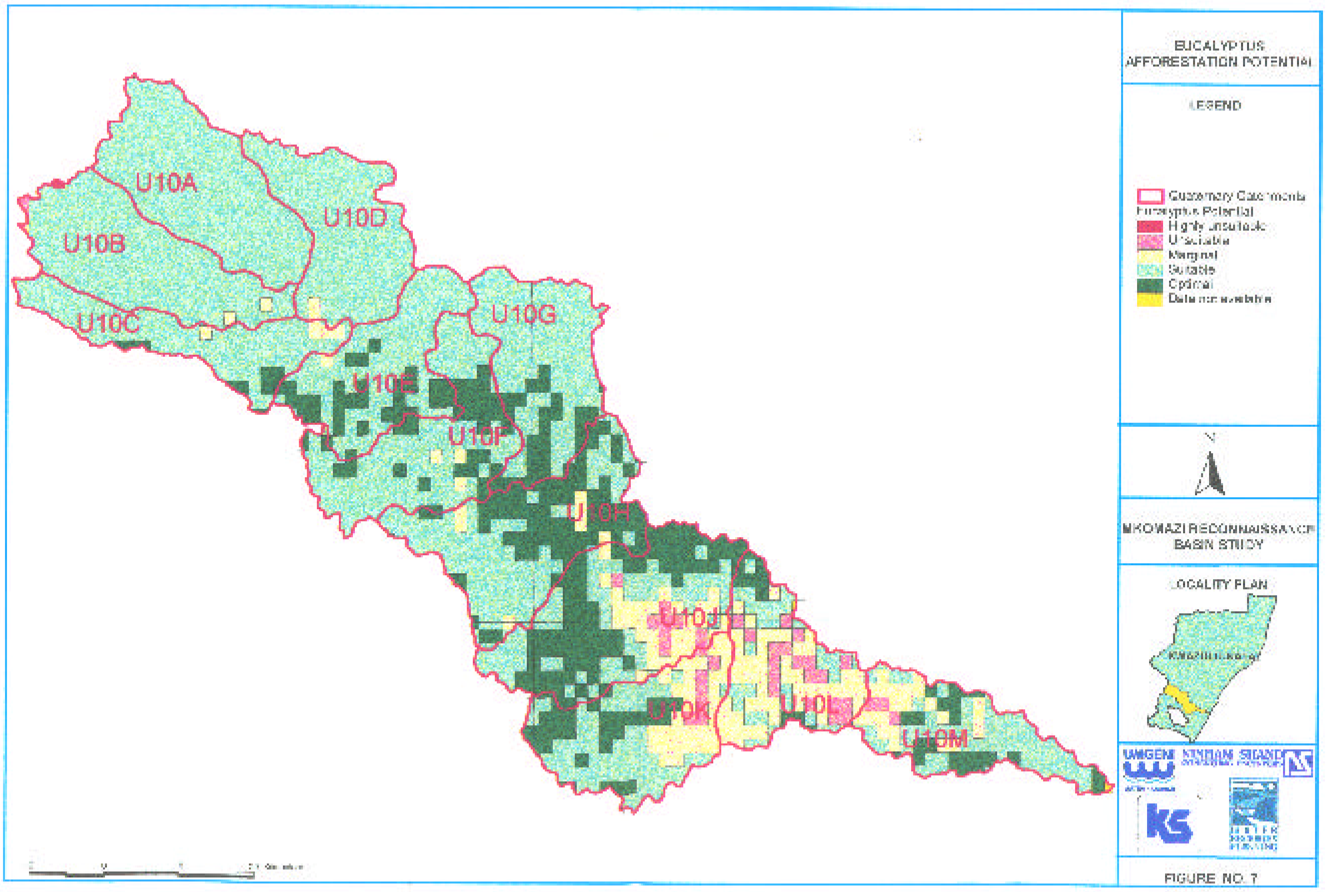

PLAN OF MKOMAZI RIVER CATCHMENT
LEGEND
Towns
Rivers
Quaternary Catchments
N
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU NATAL
UMGENI
NINHAM SHAND
KS
FIGURE NO 2
Loteni
U10A
U10B
U10C
U10D
Nzinga
Impendle
U10G
U10E
Elandskop
U10F
Bulwer
U10H
Donnybrook
U10J
Lufafa
U10K
U10L
Ixopo
U10M
Umkomaas


POPULATION BY QUATERNARY CATCHMENT
LEGEND
Towns
Mkomazi Catchment
Population
1996
2020
2040
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
FIGURE NO. 3
Loteni
U10A
U10B
U10D
Nzinga
Impendle
U10C
U10E
U10G
Elandskop
U10F
Bulwer
Donnybrook
U10H
U10J
Lufafa
U10L
U10K
Ixopo
U10M
Umkomaas


GROUNDWATER SAFE ABSTRACTION POTENTIAL
LEGEND
Towns
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
UMGENI
NINHAM SHAND
FIGURE NO. 4
U10A
U10B
U10C
U10D
U10E
U10F
U10G
U10H
U10J
U10K
U10L
U10M
Loteni
Nzinga
Impendle
Elandskop
Bulwer
Donnybrook
Lufafa
Ixopo
Umkomaas

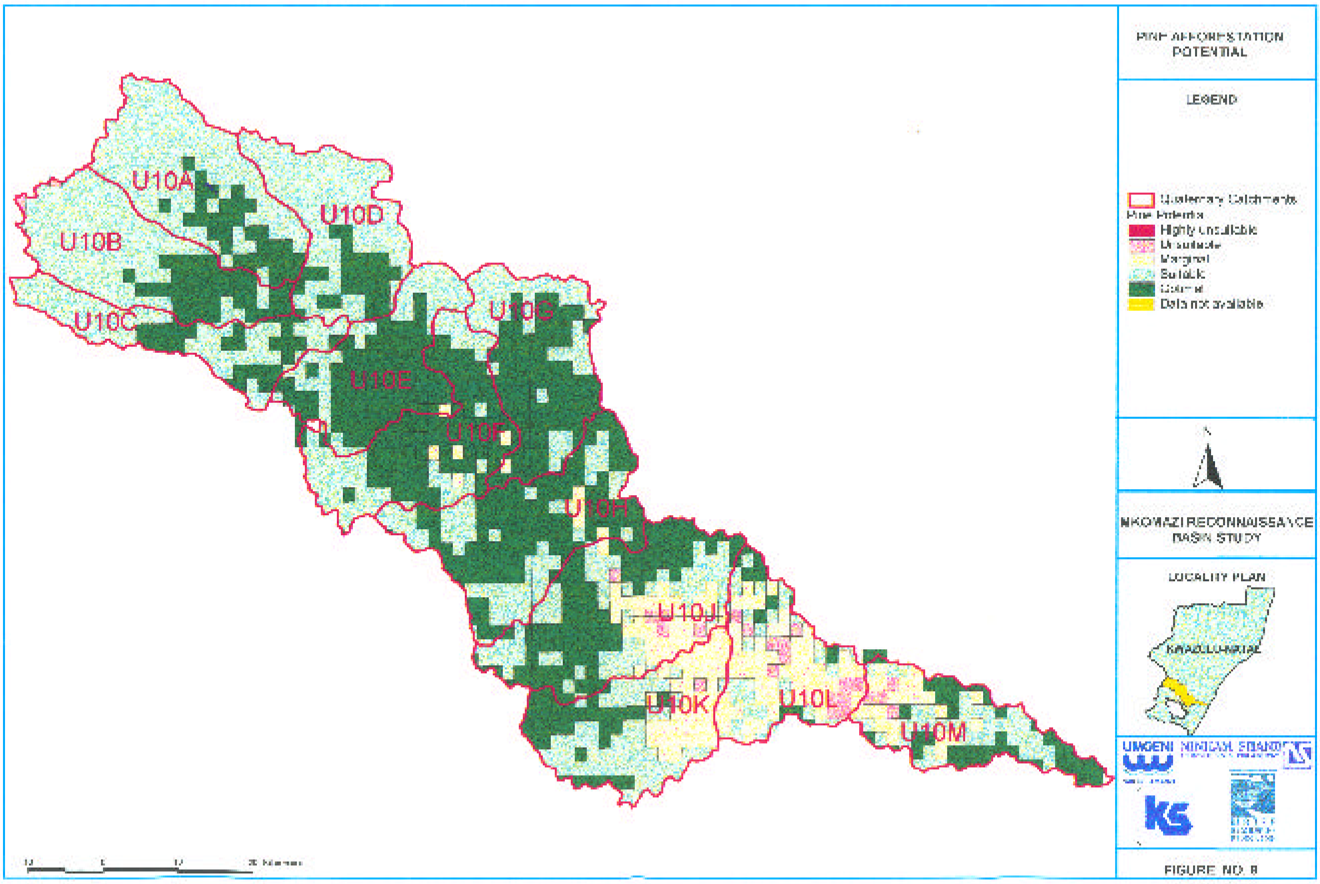

U10A
U10B
U10C
U10D
U10E
U10F
U10G
U10H
U10J
U10K
U10L
U10M
BIO-RESOURCE UNITS
LEGEND
Quaternary Catchments
Bio Resource Unit
9 Low Agricultural Potential
8
4
1 High Agricultural Potential
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
UMGENI
NINHAM SHAND
ks
FIGURE NO. 5


MAGISTERIAL DISTRICTS
LEGEND
Towns
Quaternary Catchments
Magisterial Districts
IXOPO
MPENDLE
POLELA
RICHMOND
UMBUMBULU
UMZINTO
UNDERBERG
N
MKOMAZI RECONNAISSANCE
BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
UMGENI
NINHAM SHAND
KS
FIGURE NO. 6
Loteni
U10A
U10B
U10C
U10D
Nzinga
Impendle
U10G
U10E
Elandskop
U10F
Bulwer
U10H
Donnybrook
U10J
Lufafa
U10K
U10L
U10M
Ixopo
Umkomaas

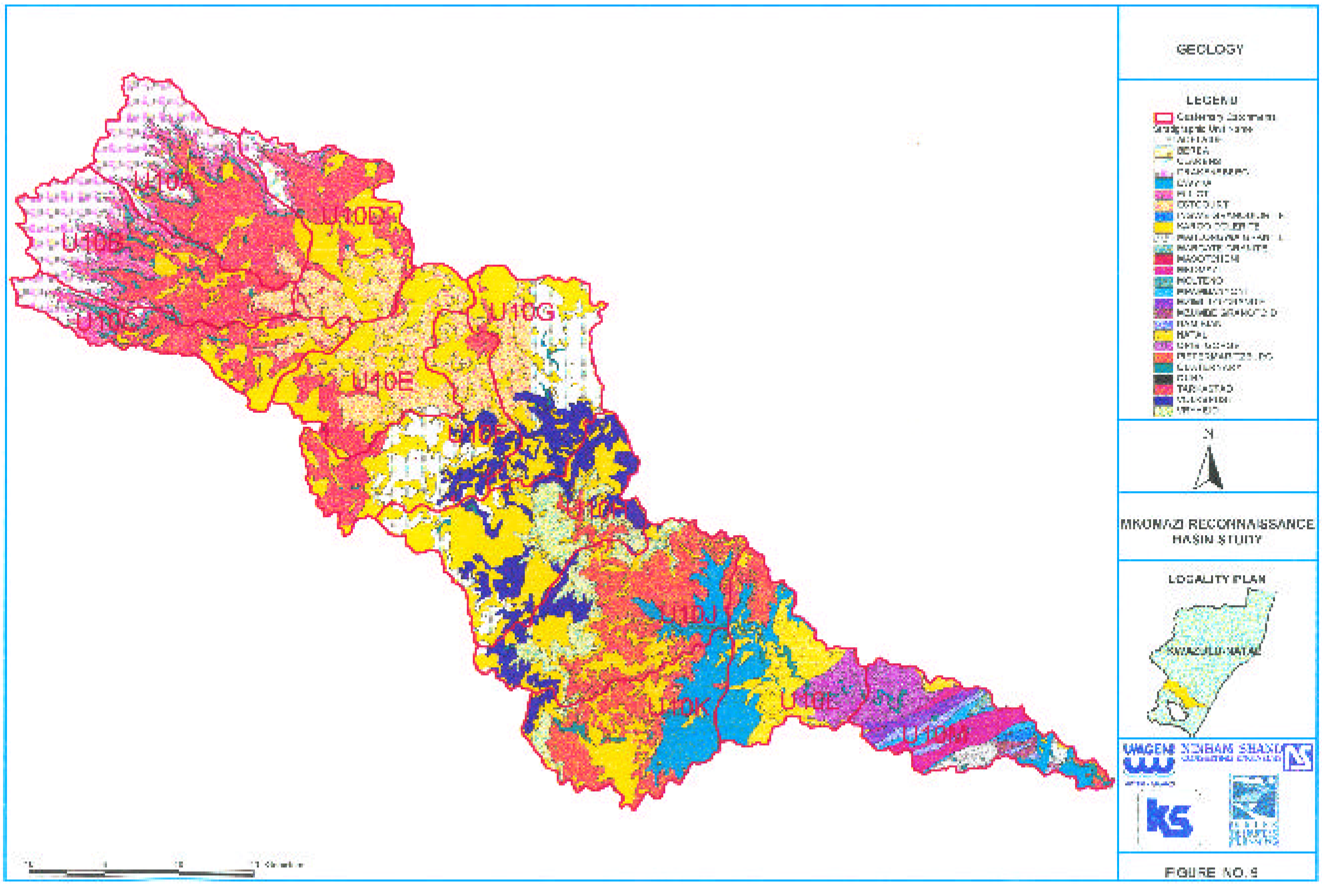


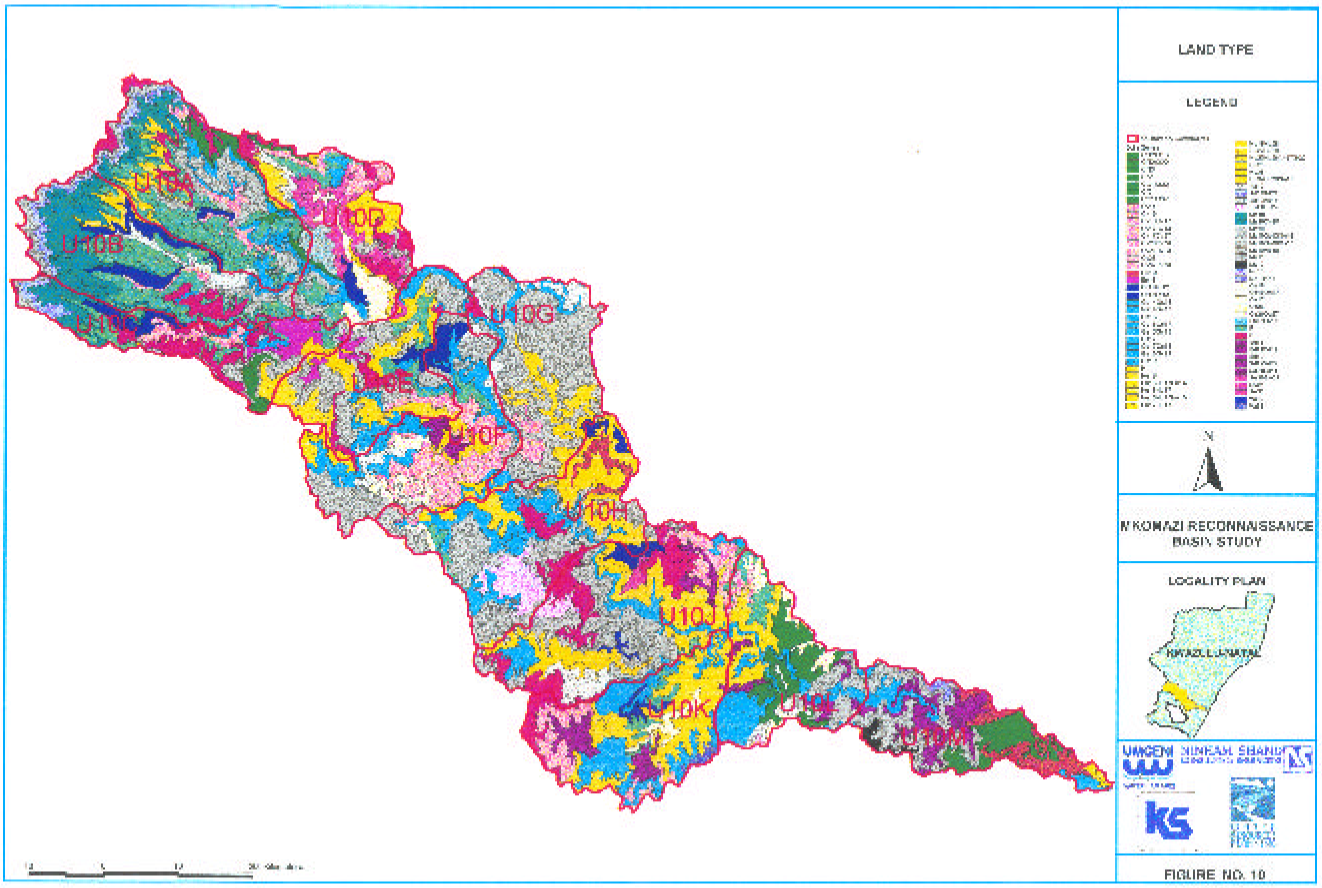
U10A
U10B
U10C
U10D
U10E
U10F
U10G
U10H
U10J
U10K
U10L
U10M
EUCALYPTUS AFFORESTATION POTENTIAL
LEGEND
Quaternary Catchments
Eucalyptus Potential
Highly unsuitable
Unsuitable
Marginal
Suitable
Optimal
Data not available
N
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
UMGENI
NINHAM SHAND
KS
WATER RESOURCES PLANNING

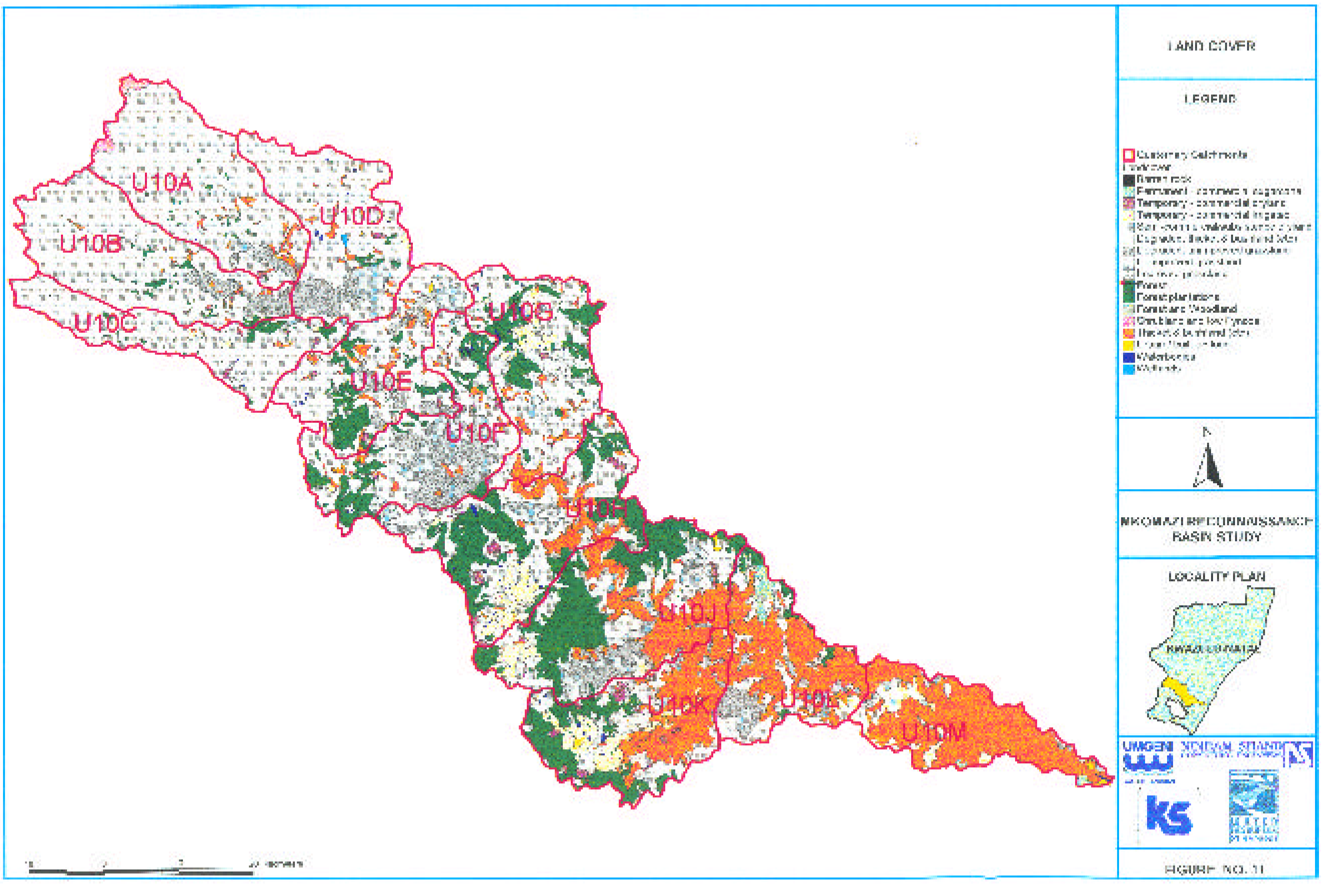
FIGURE NO. 7

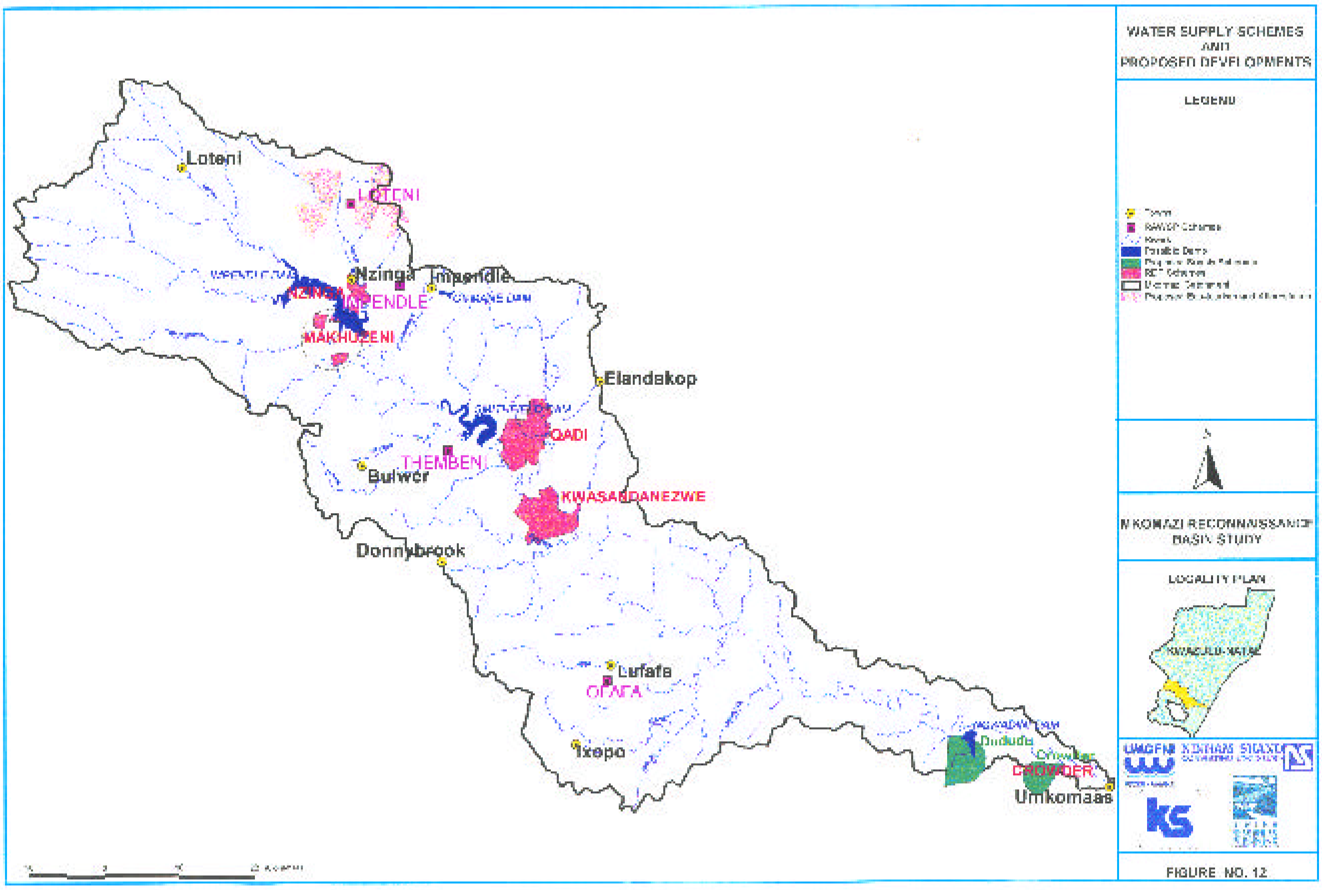


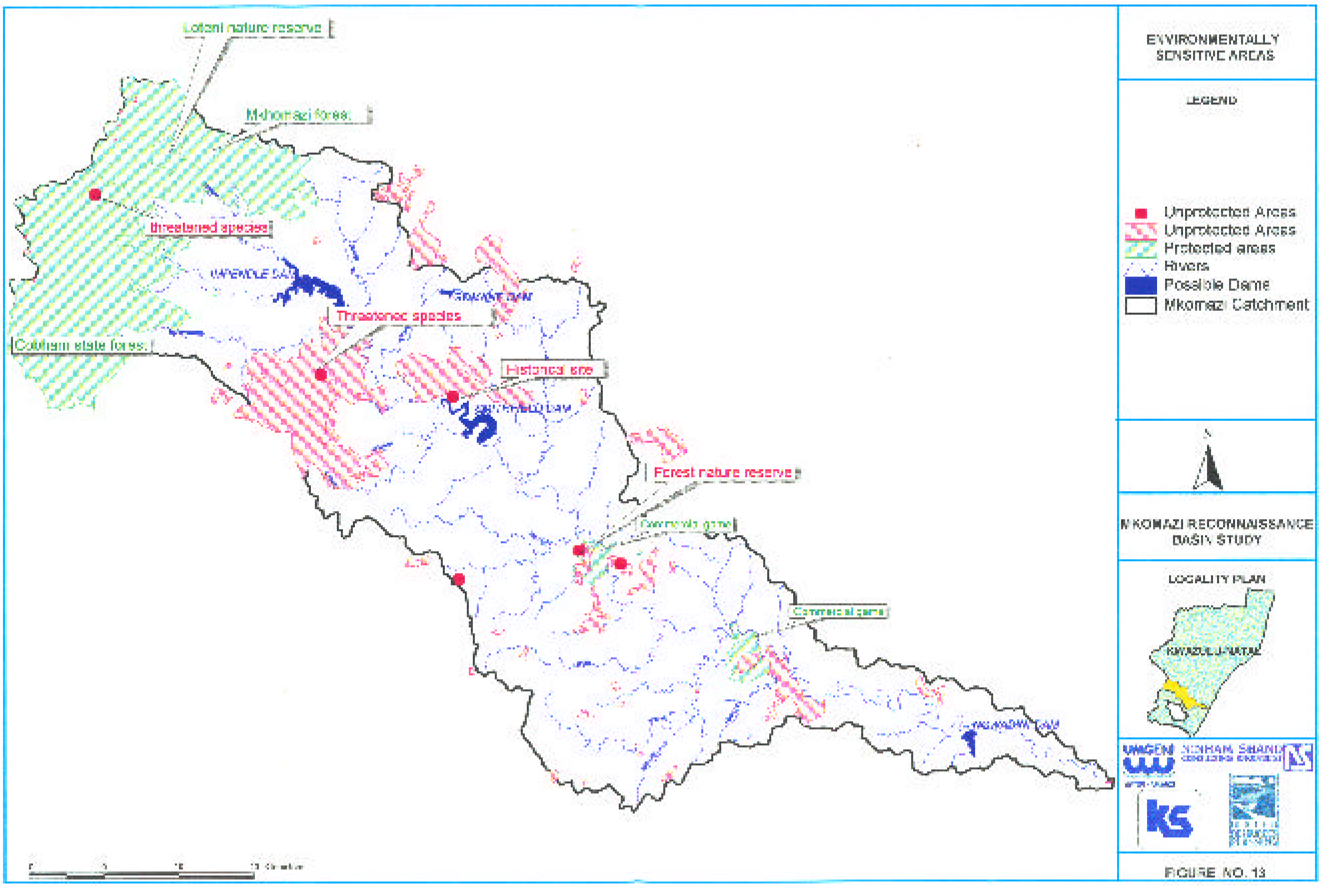
PINE AFFORESTATION POTENTIAL
LEGEND
Quaternary Catchments
Pine Potential
Highly unsuitable
Unsuitable
Marginal
Suitable
Optimal
Data not available
N
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
UMGENI
NINHAM SHAND
KS
FIGURE NO. 8
U10A
U10B
U10C
U10D
U10E
U10F
U10G
U10H
U10J
U10K
U10L
U10M

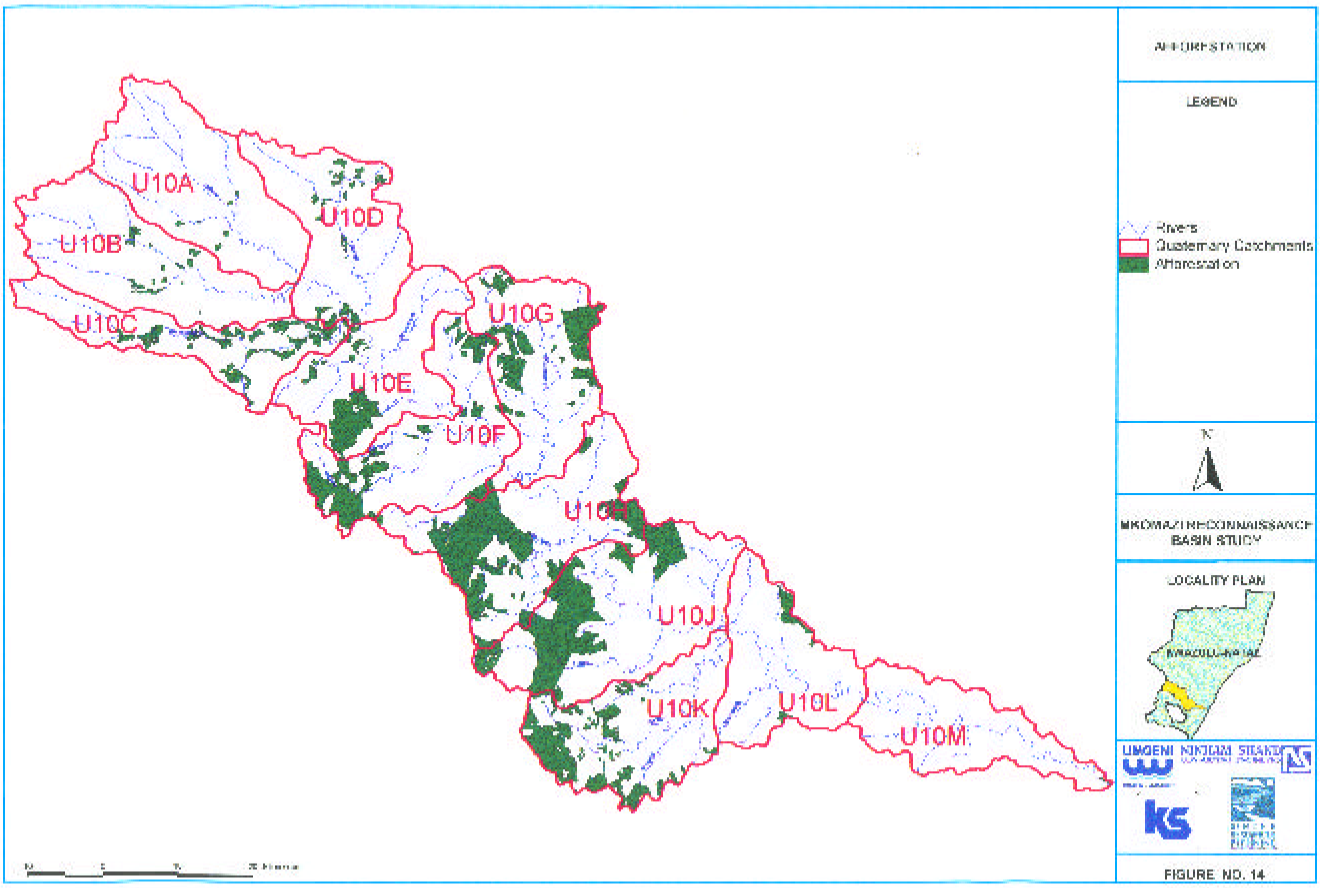

GEOLOGY
LEGEND
BEREA
ESTCOURT
MOLTENO
NATAL
TARKASTAD
U10A
U10B
U10C
U10D
U10E
U10G
U10J
U10K
U10M
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
FIGURE NO. 9


LAND TYPE
LEGEND
U10B
U10G
U10J
U10K
N
MKOMAZI RECONNAISSANCE
BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
UMGENI
NINHAM SHAND
KS
FIGURE NO. 10


U10A
U10B
U10C
U10D
U10E
U10F
U10G
U10H
U10J
U10K
U10L
U10M
LAND COVER
LEGEND
Barren rock
Forest
Forest plantations
Forest and Woodland
Waterbodies
Wetlands
N
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
UMGENI
FIGURE NO. 11


WATER SUPPLY SCHEMES
AND
PROPOSED DEVELOPMENTS
LEGEND
MKOMAZI RECONNAISSANCE
BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
Loteni
LOTENI
Nzinga
Impendle
NZINGA
IMPENDLE
MAKHUZENI
Elandskop
QADI
THEMBENI
Bulwer
KWASANDANEZWE
Donnybrook
Lufafa
Ixopo
Dududu
CROWDER
Umkomaas
FIGURE NO. 12


Lotoni nature reserve
Mkhomazi forest
threatened species
Threatened species
Cobham state forest
Historical site
Forest nature reserve
Commercial game
Commercial game
ENVIRONMENTALLY SENSITIVE AREAS
LEGEND
Unprotected Areas
Unprotected Areas
Protected areas
Rivers
Possible Dams
Mkomazi Catchment
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
UMGENI
NINHAM SHAND
KS
FIGURE NO. 13


AFFORESTATION
LEGEND
Rivers
Quaternary Catchments
Afforestation
N
MKOMAZI RECONNAISSANCE BASIN STUDY
LOCALITY PLAN
KWAZULU-NATAL
U10A
U10B
U10C
U10D
U10E
U10F
U10G
U10H
U10J
U10K
U10L
U10M
UMGENI
NINHAM SHAND
FIGURE NO. 14