REPORT TO THE

WATER RESEARCH COMMISSION

GUIDELINES FOR THE ESTIMATION OF DOMESTIC WATER DEMAND OF DEVELOPING COMMUNITIES IN THE NORTHERN TRANSVAAL

by

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WATER SYSTEMS MANAGEMENT

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EXECUTIVE SUMMARY

INTRODUCTION

A large percentage of the population in South Africa has inadequate domestic water supplies and experience critical water shortages. The inadequacy of the service is in terms of the volume of water delivered, inappropriateness of water distribution facilities, excessive walking distance, long queues at water points, poor maintenance and inadequate bulk water development.

It is now generally accepted that appropriate and adequate water supply facilities can only be developed and sustained by fully involving the community. This implies that it is essential to focus on the requirements of the domestic water user and not to use arbitarily fixed design rules. This document gives guidelines for :

- Determining the requirements of the domestic water user
- Estimating present and possible future water demand
- Assessing the parameters applicable for the design of bulk water systems
- Designing appropriate water distribution facilities

GENERAL APPROACH TO WATER DEMAND ESTIMATION

Domestic water users require potable water mainly to satisfy personal needs and only a small quantity of water is required to sustain life. Domestic water demand is therefore essentially related to the character and make up of the domestic water user. Research and available literature suggest that :

Domestic Water Demand = f(Value orientation of the water user, Water tariff)

Value orientation describes the level of living of the community but is however difficult to quantify in view of the large number of intervening variables which determine the values held by individuals. The development, priorities and attitudes of communities has also been significantly influenced by the political and socio-economic situation in South Africa.

VALUE ORIENTATION OF THE DOMESTIC WATER USER

Value orientation is best described and revealed by quantifiable indicators. The indicators may be grouped into two main categories although it is recognised that a degree of overlap occurs. The one category comprises indicators which describes the communities monitory status and the other describes the individual's make up and attitude.

Indicators which relate to the prosperity of the community give insight into the ability of households to add water using facilities such as kitchens and bathrooms to their homes and to purchase water using household equipment and other utensils. It is also argued that households which enjoy more favourable income levels, can afford the pleasure of a garden and would thus require significantly greater volumes of water. The indicators which reveal the prosperity of the water user group include income, education, housing type, gardening activity, agricultural activity, population size and business activity.

Indicators which define the water user group's nature, attitude and general make up, include extent of electricity connections, extent of unauthorised (pirate) yard connections, education level, household size, garden and housing development, agricultural activity, institutional structure and population.

The status level or value orientation of the community described by the indicators reflect the values which the community attaches to personal hygiene, improved gardens, improved access to water (shorter walking distance) and to other services, and the desire for improved sanitation facilities. This would suggest that attempts to categorize communities in terms of rural, urban or semi-urban and to provide services according to these sometimes arbitary classifications has no sound basis.

The various indicators are interelated and cannot be considered in isolation. The value orientation of a community is also dynamic and changes with time. As conditions change in terms of income, employment opportunities, distance to the work place and numerous other factors, so values alter and change. This implies that the level of service required by a community, also changes with time. Indicators which are considered to be most appropriate in determining the value orientation or level of living index of the domestic water user group, are given in the table below

VALUE ORIENTATION (LEVEL OF LIVING INDEX) OF THE COMMUNITY AND WATER DEMAND

LEVEL OF LIVING INDEX	1	2	3	4	5	6	7
VALUE ORIENTATION	VERY LOW	LOW	LOW TO MODERATE	MODERATE	MODERATE TO HIGH	HIGH	VERY HIGH

INDICATOR	RANGE APPLICABLE TO EACH INDEX LEVEL						
Income (R/household/month)	< 300	300 - 600	500 - 1 000	700 - 1 300	1 000 - 1 700	1 300 - 2 500	> 2 500
Education (% with no education)	> 50	45	35	25	15	< 5	0
Dwelling Construction	Limited traditional, untreated cement block, clustered	Untreated cement block	Limited painted cement block	Painted cement block/informal housing	Painted cement block/limited western/ improved informal	Moderate western, small stands	Western, large stands
Gardening activity	None	Limited	Moderate	Moderate	moderate to extensive	Extensive	Extensive
Agricultural activity (LSU/person)	> 0.7	0.6	0.4	0.2	0	0	0
Population	< 1 000	2 000	3 500	5 000	8 000	-	-
Business activity in dormitory residential areas	Extensive	Extensive	Moderate	Moderate	Limited	Limited	Limited
Electricity connections (% households) serviced	0	0	10	35	50	80	100
Pirate connections (% households)	0	20	50	70	90	100	100
Household size (people per household)	> 8	7	6	6	5.5	4.5	4
WATER DEMAND (l/c/d)	25	35	50	80	130	250	450

WATER REQUIRED FOR VARIOUS DOMESTIC ACTIVITIES

Domestic water is required for drinking, cooking, dish washing, house washing, clothes washing, personal hygiene, gardening, sanitation and swimming pool maintenance. The desire to use water and the volumes required is related to the level of living of the water user. This in turn is related to the disposable income, value orientation, enthusiasm for gardening, ability and willingness to pay for water used and an awareness of the scarcity of water. A summary of the volume of water required for each of the domestic activities for the different levels of living is given below. Wastage and excessive loss of water is not reflected in the values given.

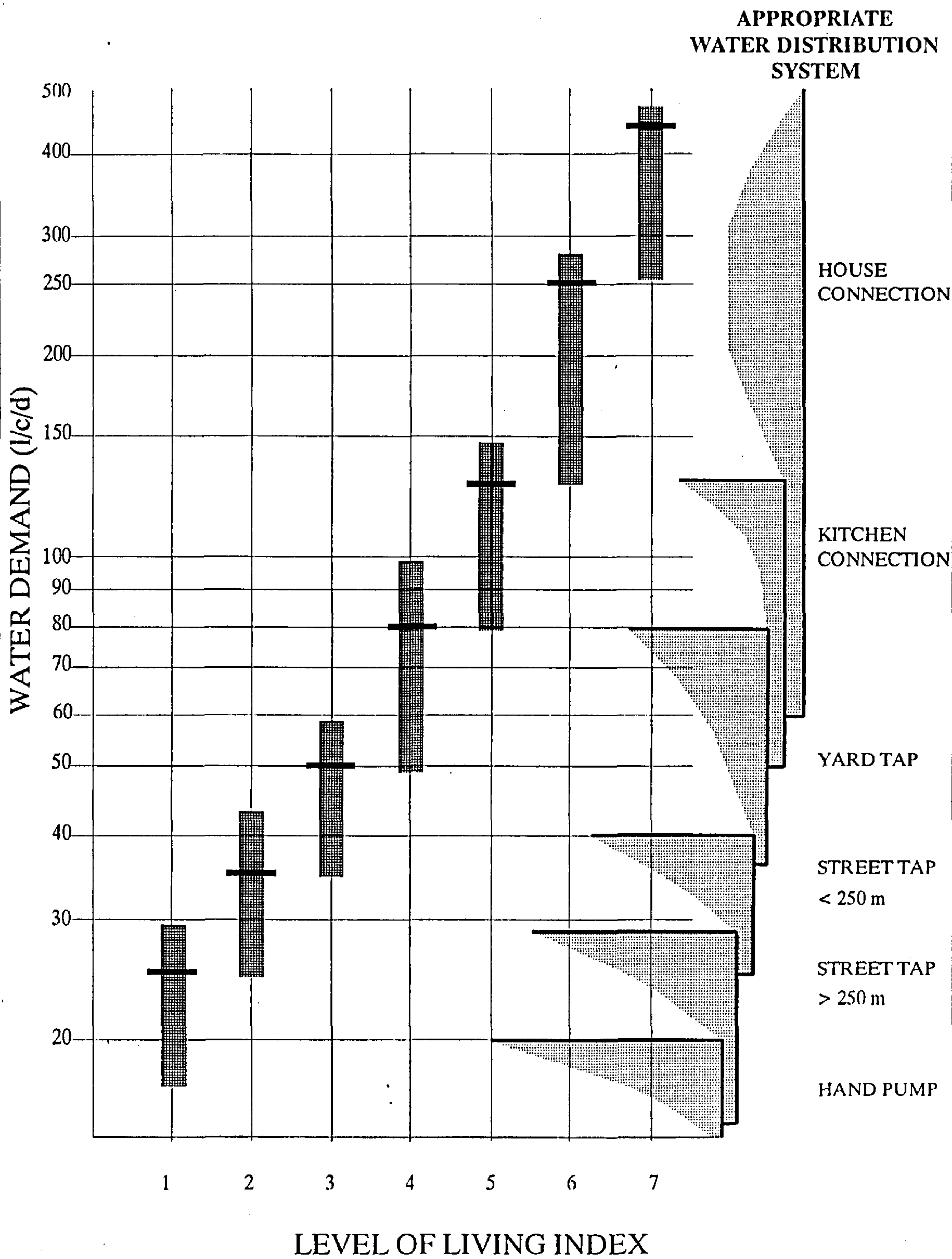
LEVEL OF LIVING INDEX	WATER USE (l/c/d)								
	DRINK/ COOK	DISH WASH	HOUSE WASH	CLOTHES WASH	BATH/ SHOWER	GARDEN	TOILET	POOL	TOTAL
1	3	2	1	3	15	0	0	0	25
2	3	2	1	3	16	10	0	0	35
3	4	3	1	4	20	18	0	0	50
4	4	4	2	4	40	26	0	0	80
5	4	6	2	5	60	48	5	0	130
6	4	10	3	6	92	100	30	5	250
7	4	15	5	8	163	200	40	15	450

The volume of water required for each of the domestic activities is very similar regardless of the level of living excepting in the case of personal hygiene, sanitation and gardening where huge increases in water demand occurs with increasing level of living.

In order to determine the appropriate domestic water demand level of a community, it is necessary to categorize the community in terms of its value orientation and level of living index by quantifing as many of the value orientation indicators as possible. The domestic water demand is then determined from the above table or may be read off from the graph given below. A water demand range is given to emphasize the diverse nature of human needs, conditions and values.

PAYING FOR WATER

Having to pay for water used significantly reduces water demand. Charging for water, is widely used to discourage waste and irresponsible water use, to limit water losses and to promote an awareness of the scarcity of water. Charging for water delivered is indeed also necessary to generate income so as to ensure the sustainability of the water supply facilities.



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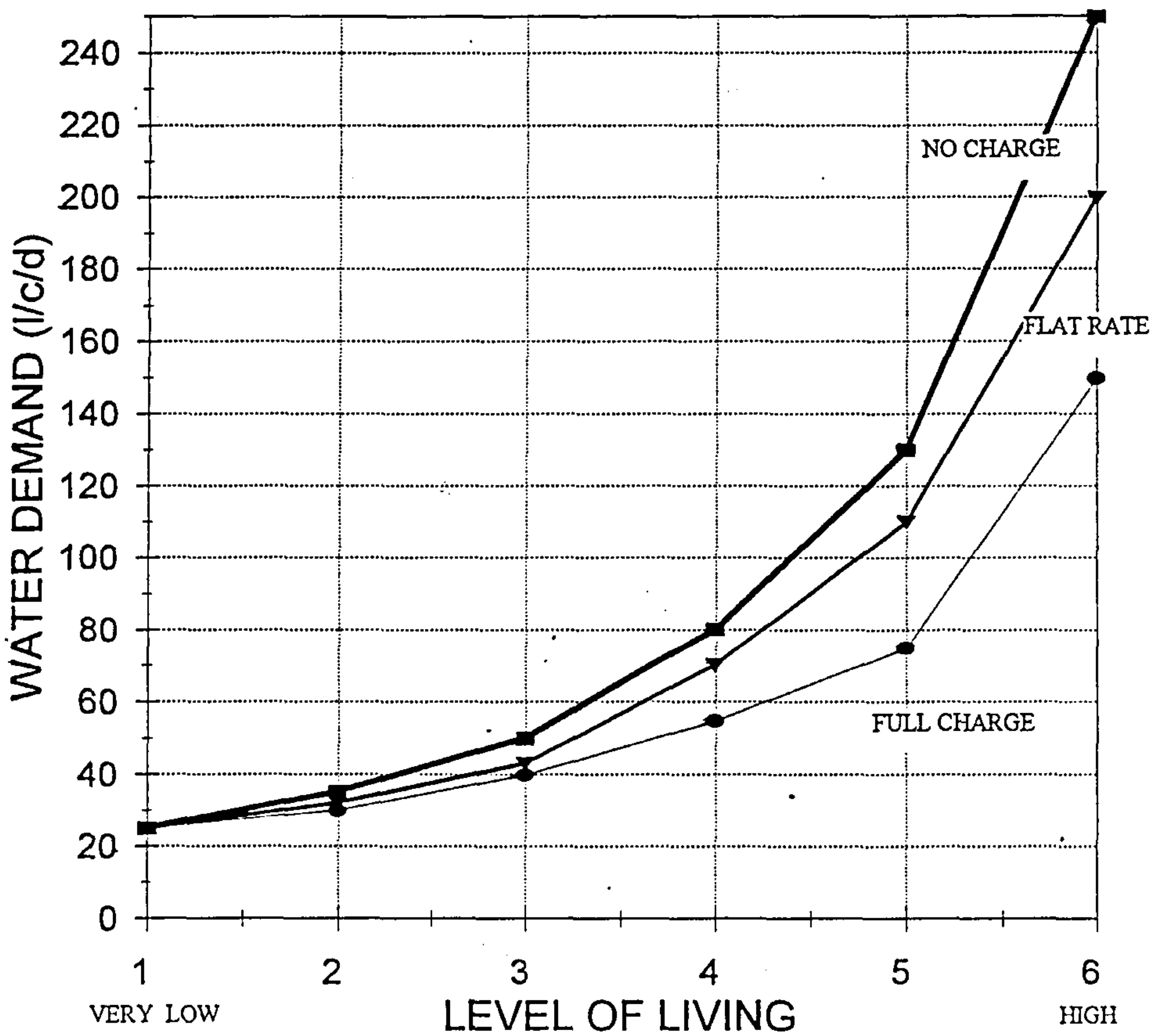
Two basic tariff systems are in general use viz, the flat rate fee whereby households are required to pay a fixed monthly fee regardless of the volume of water used, and the other is based on charging for water in relation to the volume of water used. The latter tariff system is often combined with a sliding scale in which higher rates are charged for use above certain target levels.

The degree of reduction in water demand varies in accordance with the tariff type as well as the level of living of the water user group. Water users which have a relatively low level of living and therefore have a modest water demand, display a small reduction in water demand, should water be charged in relation to the actual volume of water used. The reduction is marginally less should the flat rate system be applied. On the other end of the scale, communities which have a high level of living and therefore enjoy a high water demand, experience a reduction of 30% or more should the sliding tariff system be applied. The reduction is only about 10% to 15% should the flat rate fee be applied.



WATER DISTRIBUTION SYSTEMS

The actual water use is in practice quite often considerably less than the estimated water demand and this may be ascribed to various inhibitors which include inappropriate water distribution system and the unavailability of sufficient quantities of bulk water.

CHARACTERISTICS AND PERFORMANCE OF VARIOUS DOMESTIC WATER DISTRIBUTION SYSTEMS

WATER DISTRIBUTION SYSTEM	GENERAL ACCESS CONDITIONS	WATER DELIVERY RANGE (l/c/d)	NUMBER OF HOUSEHOLDS SERVICED
Scoop water from springs, streams and wells	• limited water • topography • walking distance, > 500 m	< 16	15 - 25
Windpump	• lack of wind • population density • long walking distance > 500 m	< 5 - 16	15 - 25
Handpump	• population density • topography • walking distance, < 500 m	< 10 - 20	25 - 30
Street tap >250 m	• population density • topography • walking distance > 250 m	< 15 - 25	25 - 35
Street tap < 250	• walking distance < 250 m	25 - 40	25 - 35
Yard tap	• on site	35 - 80	1 - 4
Kitchen connection	• on site • bathroom generally not included	40 - 120	1
Fully reticulated	• water borne sewage may be included	50 -> 250	1

The criteria for selecting an appropriate water distribution system should be based on its capability to deliver the required water at an acceptable level of access. General practice to date was however to select a water distribution system (for example a street tap system or handpump system) without taking cognisance of the needs of the domestic water user. This has led to the situation in many instances where the facility is incapable of delivering the required volume of water. Typically there would be insufficient taps which inhibits access to the water and results in long queues at water points. In other cases, walking distances are excessive. Essentially, the design of water supply facilities for developing groups has to date been based on supply driven principles, ie fixed at only 25 to 50 l/c/d with little or no consideration given to the actual needs of the community.

These shortcomings lead to a situation of gross dissatisfaction which gives rise to resistance to paying for water, sabotage of facilities and the construction of unauthorised yard connections with the resulting excessive water loss.

Selection of an appropriate water distribution system is dictated by the volume of water which needs to be delivered. The performance of the various water distribution systems generally used is given in the table above.

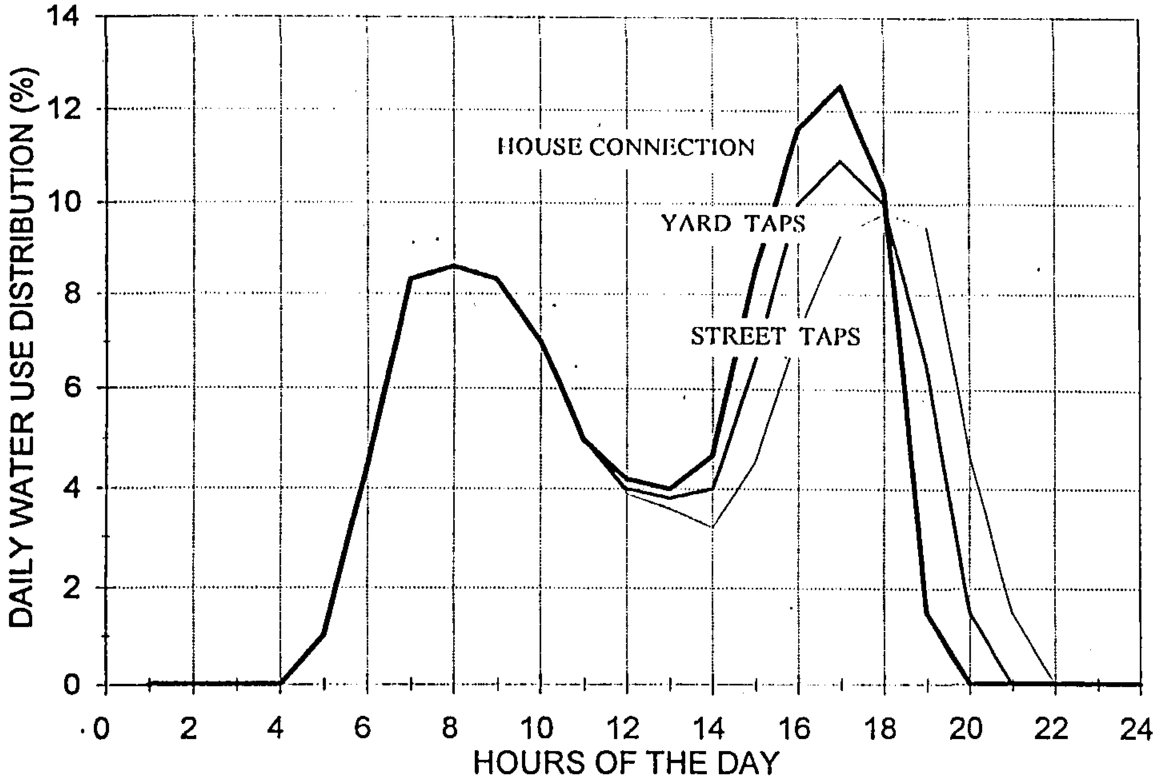
DAILY WATER DEMAND DISTRIBUTION

In the planning and design of bulk water works, cognisance needs to be taken of the daily and seasonal variation in the water demand.

Two distinct peaks occur in the daily distribution of water use. This pattern occurs regardless of the type of water supply system in use and the peaks occur at about 7 - 8 am and 4 - 7 pm. The daily distribution of water use is influenced mainly by the water collection habits of the domestic water user group and the type of water distribution system.

Residents who fetch water from water points located outside their homes, generally make 2 to 3 trips per day, or more frequently should the water point be located close to the dwelling. Generally, other household chores are first undertaken before the first water fetching trip is made. Households without yard or house connections have about 1 days water requirements in storage in the dwelling which is used until water supplies are topped up later in the day.

Garden watering significantly influences the late afternoon water use pattern. The presence of street lighting also tends to flatten the afternoon peak by allowing water fetching after dark. Residents having house connections commence drawing water from about 4.30 am reaching a peak at about 8 am.



Weekend water use may increase, particularly in less developed villages where the number of weekend visitors returning from distant places of work is high. In most instances however, the increased water use is insignificant and it may be assumed that the pattern of daily water use on average remains approximately constant for each day of the week. The distribution of daily water use and suggested daily peak factors are given in the graph below.

SEASONAL WATER DEMAND DISTRIBUTION

Seasonal water demand is influenced mainly by the level of gardening activity. As the level of living and value orientation of the community rises, so the enthusiasm for gardening also increases. The ability to apply water on gardens is only possible for residents who have house or yard connections. The potential for garden watering increases as enthusiasm and desire for gardening increases and the level of sophistication of the water supply service improves. Increased garden watering results in greater variation in water use between summer and winter and induces a higher summer daily demand. Large volumes of water are required to maintain gardens during the summer months when the net evaporation is normally high.

The summer peak factors vary in accordance to the type of water distribution system and the enthusiasm for gardening. The following summer peak factors are suggested :

- House connections 1.5
- Yard connections 1.35
- Street tap systems 1.2

FUTURE WATER DEMAND ESTIMATION

Future water demand estimation is based on estimated per capita water demand and the estimated population for various future time horizons.

Domestic water demand is a function mainly of the value orientation of the domestic water user group. The desire for improved living conditions is a natural tendency observed in communities of all levels of living or levels of development. It is therefore necessary to determine the likely value orientation of the community for the required future time horizons. The complex and interrelated issues which comprise the dynamics of population development make it very difficult to determine value orientation for future time horizons.

The rate of improvement of the level of living or value orientation is likely to vary for the different level of living groupings. The poorer communities, which are assumed to have the lowest level of living, have limited resources and the lowest level of education and is therefore least likely to benefit from opportunities which may arise. The rate of improvement of the level of living of this group is likely to improve at a rate considerably less than the cost of living increase.

Communities having a low to moderate level of living are at the threshold where enthusiasm for gardening becomes important. Improvements of the level of living of these communities, result in a major increase in total water demand.

Communities which enjoy a relatively high level of living are considered to already have improved water supply facilities which includes yard connections or house connections. Continued water demand growth is nevertheless experienced by this group due to improved level of living which amongst other things contributes to increased gardening activities.

It is not possible to forecast accurately future rate of economic growth without having knowledge of other intervening factors such as prevailing political conditions, policy shifts, industrial unrest and other related factors. A scenario approach is therefore suggested for the estimation of future per capita water demand and includes :

- **Scenario 1 (low rate of increase in water demand)**

  Vigorous economic conditions prevail and stable political situation occurs. Level of living is assumed to increase and sufficient funds are available to improve services including water supply. Residents pay for water. The net result is that water demand increases at a low rate.

- **Scenario 2 (moderate rate of increase in water demand)**

  Poor prevailing economic conditions and unstable political situation occurs and is associated with a low level of improvement in the level of living. Limited funds are available for the improvement of water supply systems. Residents do not pay for water and water wastage is high. A moderate increase in water demand occurs

- **Scenario 3 (high rate of increase in water demand)**

  Stable economic and political conditions prevail and a moderate improvement in the level of living occurs. Services are improved at a moderate rate with water. shortages occurring occasionally. Residents in general do not pay for water.

  The anticipated water demand for various future time horizons and the various scenarios considered above, are given in the table below

FUTURE PER CAPITA DOMESTIC WATER DEMAND FOR VARIOUS SCENARIOS

PRESENT WATER DEMAND BASED ON LEVEL OF LIVING	GROWTH IN WATER DEMAND IN ONE YEAR INTERVALS (l/c/d)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	SCENARIO 1: Vibrant economy,level of living improved,water tariff, services improved, stable political situation ... Low water demand growth														
450	405	365	328	295	266	275	285	295	305	316	327	338	350	362	375
250	225	203	182	164	148	154	160	166	173	180	187	194	202	210	219
130	124	117	112	106	101	106	110	116	122	129	134	142	148	156	164
80	77	74	71	68	65	69	73	77	81	85	90	95	100	106	111
50	48	46	44	42	41	43	44	47	49	51	53	55	58	61	63
35	37	39	42	44	47	50	52	54	56	58	60	62	64	67	70
25	26	26	27	28	28	29	30	31	32	33	34	35	37	39	42
	SCENARIO 2: Low economy, low level of living improvement, no tariff, water wastage, unstable political situation ... Moderate water demand growth														
450	455	459	464	468	473	478	482	487	492	497	502	507	512	517	522
250	253	256	259	262	265	269	272	275	278	282	285	288	292	295	299
130	132	135	138	141	143	146	150	153	155	158	161	165	168	171	176
80	82	84	87	89	92	94	97	100	103	105	108	111	115	118	121
50	52	54	56	58	60	62	65	67	70	73	75	78	81	84	86
35	37	39	42	44	47	50	52	54	56	58	60	62	64	67	70
25	26	26	27	28	28	29	30	31	32	33	34	35	37	39	42
	SCENARIO 3: Moderate economic and political situation, water tariff generally applied services mainly improved ... High water demand														
450	460	470	480	491	500	509	518	527	533	538	543	549	554	560	565
250	256	262	268	275	281	288	295	302	309	317	325	332	340	348	357
130	134	139	143	148	153	158	164	169	174	180	186	192	198	205	211
80	83	86	89	92	95	98	102	105	109	113	117	121	125	129	133
50	52	54	56	58	60	62	65	67	70	73	75	78	81	84	86
35	37	39	42	44	47	50	52	54	55	68	60	62	64	67	70
25	26	26	27	28	28	29	30	31	32	33	34	35	37	39	42

GUIDELINES FOR THE ESTIMATION OF DOMESTIC WATER DEMAND OF DEVELOPING COMMUNITIES IN THE NORTHERN TRANSVAAL

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GUIDELINES FOR THE ESTIMATION OF DOMESTIC WATER DEMAND OF DEVELOPING COMMUNITIES IN THE NORTHERN TRANSVAAL

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1 OBJECTIVES OF THE STUDY

This report concerns the factors which influence water demand of developing communities resident in the Northern Transvaal. This community sector, which numbers several million persons, comprises a range of economic, social and cultural groupings. These people reside in towns, villages and settlements in the former Venda, Gazankulu, Lebowa, KwaNdebele, KaNgwane and Bophuthatswana.

There is mounting effort to provide all the communities in South Africa with sufficient quantities of potable water which is within reasonable access. Available resources, particularly water and funds are however scarce, and therefore it is essential that the most equitable, efficient and effective solutions be found which would satisfy social needs and would provide systems acceptable to the consumer. The factors which influence domestic water demand are numerous and interrelated and this project aims to :

- Assess the factors which influence domestic water usage of developing communities
- Determine the parameters which may be applied when estimating water demand of developing communities of different economic, social and cultural groupings
- Set guidelines for the estimation of possible future domestic water demand of the various developing community groups in the Northern Transvaal.

2 BACKGROUND TO THE STUDY

2.1 STATEMENT OF THE DOMESTIC WATER SUPPLY SITUATION

A large percentage of the several million people comprising the developing community have inadequate water supplies. The adequacy of water supply is measured in terms of the volume of water received per person, walking distance, queuing time at the water point and water quality. The disadvantaged group is estimated by various researchers and organizations to exceed 50% of the population. The Department of Water Affairs and Forestry's water supply and sanitation policy document records that some 12 million people are without adequate water supply.

Water supply systems in proclaimed towns are usually more spophisticated and capable of delivering high volumes of water per household.

The reasons for the poor water supply situation are numerous and varied and include inappropriate choice of water supply technology, low levels of community involvement, (Wiseman et al, 1988) ad hoc development, poor maintenance, insufficient supply of water, (Van Tonder et al, 1990), inadequate provision of water abstraction points (Van Schalkwyk, 1992) and lack of wind (Van As et al, 1981). The prolonged drought has further aggravated the situation. Water losses in certain systems also drastically reduces the volume of water available to residents.

A review of the water supply situation in several hundred villages (WSM, 1991, 1993, 1994) and the results of several socio-economic studies undertaken in the Northern Transvaal (Van Tonder et al, 1990; Lebowa Development Corporation, 1992) would suggest that a large percentage of the water supply problems are related to inappropriate design. Designs are usually based on guidelines which do not fully meet the needs and aspirations of the communities.

This points to a lack of understanding of the consumer. The recent increased focus on community participation is aimed at amongst other things, to address this short coming. It is however considered that a complete switch from a top down development process to a bottom up procedure would not ensure effective and efficient provision of sustained water supply. A combination of these processes is considered more appropriate and therefore this research project aims to identify, evaluate and describe indicators which may be used by the planner, designer and developer to more accurately quantify the needs of the consumer.

2.2 DOMESTIC WATER SUPPLY FROM FIRST PRINCIPLES

The drive to alleviate the hardships endured by developing communities has intensified through the initiatives of several governmental organizations and funding agencies. The development of water supply systems to adequately meet the demand of all communities will require huge capital expenditure and may exceed R 10 billion. The manpower requirements to accomplish this task are also enormous. Added to this South Africa is in general a water poor country and water demand in many areas exceeds water availability.

The resources required to alleviate the water supply situation are limited and require prudent and prioritized allocation. In order to achieve this it is necessary to have a thorough understanding of the factors which influence water demand. Information is required amongst other things, regarding the socio-economic status of the consumer, domestic environment, population and the distribution of daily and seasonal water demand. The impact on water demand, also needs to be known, as it has become clear to the authorities that contributions from the communities served is essential in order to ensure the sustainability of the water supply systems. It would also be essential to have the tools to make realistic estimates of possible future water demand so as to ensure the continued effective and efficient operation of the developed water supply systems.

Water demand is related to numerous factors and these are thoroughly investigated and assessed in this report. Water demand is essentially people driven. Water use in the more than 4 000 villages in the Northern Transvaal is in most cases not monitored. It is therefore not possible to determine water use parameters from past trends. Recourse therefore needs to be had to water demand estimation based on per capita water use or water use per family or per dwelling unit.

In order to successfully apply this approach, it is essential to thoroughly understand the human factor and its environment. The relevant literature reveals that a growing awareness for the importance of a more human orientated approach has developed over the past years.

This project is therefore essentially a study to understand the water use consumers in terms of their habits with respect to water use, culture and their social and economic conditions. Other aspects addressed include income/expenditure patterns, family structure, community structure, domestic environment and the daily activities of residents. It is essential to determine people's needs, perceptions, practices, attitudes and expectations if problems related to water supply are to be solved.

2.3 DESCRIPTION OF THE STUDY AREA AND THE DOMESTIC WATER CONSUMER

The study area comprises the northern parts of South Africa. The southern boundary of the study area is defined by an imaginary line drawn through Komati Poort/Nelspruit/Pretoria (refer to Figure 1).

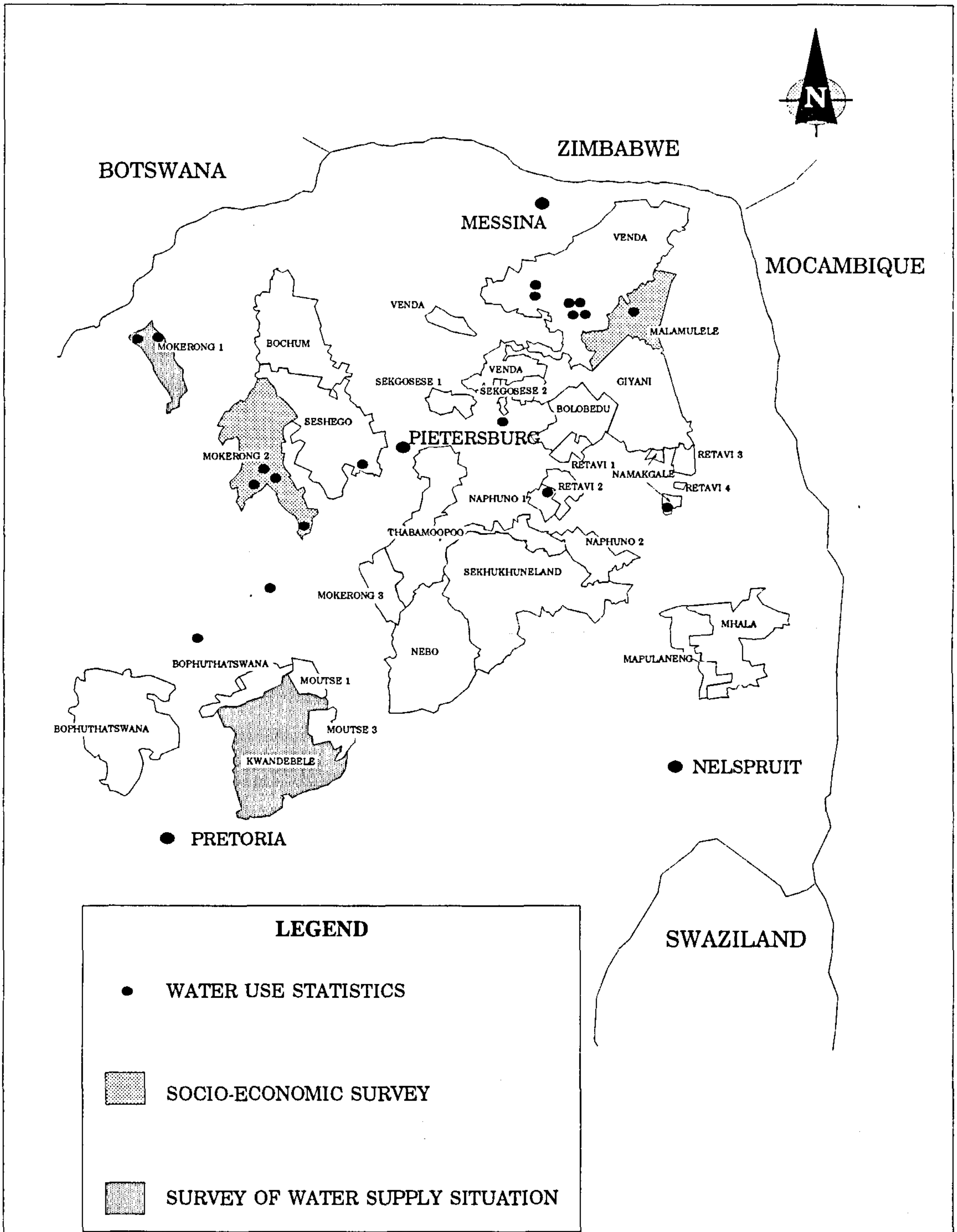
Data collection, surveys and research was concentrated in this area. The research team however communicated extensively with organizations and interested parties throughout Southern Africa and useful sources of data were identified and collected. The literature survey, undertaken as part of this study, also yielded data and information from sites in other parts of Africa, USA, Europe and Asia. The data and information obtained was included in the study where possible.

The developing community comprises the black population group. This group numbers several million persons and are located in more than 4 000 villages, settlements and towns in the former Venda, Lebowa, Gazankulu, KaNgwane, KwaNdebele, Bophuthatswana and RSA. This community comprises a wide range of economic, social and cultural groupings.

Towns, villages and settlements in most instances comprise 1 000 to more than 5 000 residents who reside on stands which have been orderly set out. This applies to most squatter areas as well. Residential areas in rural parts of Natal/ Kwazulu and Lesotho tend to be more dispersed and stands are not arranged in an orderly fashion.

Stands sizes in the more rural and remote environments of the study area generally range from 1 200 m^2 to 2 000 m^2 which offers scope for limited agricultural activity. In the more urban context, where population densities are high and land availability limited, stand sizes vary from about 350 m^2 to 600 m^2.

It is general practice to categorize residential areas in terms of rural, semi-urban, denser settlements and urban areas. The use of this classification system is clouded by inconsistencies in terms of definition as well as other practical considerations as



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LOCALITY MAP: TRANSVAAL

FIG. 1

described below. The international trend of defining urban areas is according to density and economic criteria, ie the absence of agricultural activity and high population densities (Urban Foundation, 1990). The dense, or closer settlements, occur in the former homeland areas only and are essentially considered to be agglomerations of dwellings were people do not derive significant income from agriculture. Most residents from these settlements commute to urban or metropolitan centres for business and work (Van Ryneveldt, 1994). Rural areas are considered according to Koornhof (1982) to include villages and settlements having a population of less than 2 000 people (WSM, 1993). Semi-urban areas would comprise the remainder of the villages and settlements. Many rural and semi-urban settlements and villages are however functionally urban yet lack the institutional structures necessary to address their own technical and financial problems (Hollingworth, 1990). The definition of urban used in the official population census comprise proclaimed towns with some form of local authority. Critics such as Prowth (1986) found this definition too narrow and recommended that it be extended to include settlements from which persons commute to proclaimed towns for employment, shopping and other purposes and would include peri urban, squatter areas or closer settlements normally surrounding the larger proclaimed towns. Settlements with a population greater than 5 000 persons would also be included.

The results of this study showed that it was unnecessary, for the purposes of water supply planning and development, to categorize residents in terms of residential type groupings. Other indicators, such as income, level of living and domestic environment proved to be a convenient and sound basis for ensuring appropriate planning and development of water supply systems. This study shows that it is far more important to provide a level of service appropriate to the level of living and condition of living regardless of whether the residential area is located in a proclaimed town, large concentration of people or in areas distant from large towns. Indeed, the classification in terms of race was also found to be unnecessary. The population race grouping of the domestic water user was also found to be of no importance.

3 METHODOLOGY USED IN THIS STUDY AND DATA COLLECTION

3.1 INTRODUCTION

Water use by the domestic sector is people driven and the consideration of the human factor is therefore of crucial importance in the provision and maintenance of adequate water supply systems. This study was therefore directed at understanding the domestic water consumer and experiencing conditions at grass roots level. This was achieved by identifying and evaluating all the factors which may possibly influence domestic water use, collecting relevant data and information and drafting water demand and water use relationships. The validity of the hypothesis was subsequently examined and assessed.

3.2 LITERATURE SURVEY

An extensive literature survey was undertaken which was commenced by enlisting the assistance of Infotech (CSIR) utilizing the Waterlit facilities. An extensive list of references pertaining to water use, water demand, water supply systems, water sources, water equipment and water demand growth was obtained. The titles were closely scrutinized and a short list of the most promising references was drafted and is given in the bibliography of this report.

The extensive list of references compiled by Alcock (1989) and stored in the Watsnu Literature Database was reviewed and numerous titles were identified for further scrutiny. These are also given in the bibliography.

The library of the now defunct Department of Development Aid was screened for further literature regarding the domestic water use sector. Project reports were also obtained from Transvaal Provincial Administration, Department of Water Affairs and Forestry, Water Research Commission, Human Sciences Research Council and various Consulting Engineering firms. Reports, papers and other material reviewed yielded numerous additional references for review.

The above mentioned literature survey resulted in the drafting of a bibliography related to domestic water use, domestic water demand, estimation of future domestic water demand, planning and design guidelines, water supply systems, water sources and development of sources, water distribution and water tariffs. A list of more than 150 titles was drafted and is given in this report. The review of the literature mentioned yielded some 40 titles which were considered particularly relevant to this research project.

The literature was reviewed with the view of identifying factors which influence domestic water demand, identifying theories regarding domestic water demand estimation as used in the past, sorting information regarding organizations involved with domestic water supply and who may have data and information which could be used to develop and validate a water demand estimation procedure suitable for application in the Northern Transvaal. Data and information contained in the references were from sites throughout South Africa, the remainder of Africa and further abroad.

3.3 DATA COLLECTION

Data and information was obtained essentially from three sources namely, surveys, reports and monitoring of water use at selected sites.

Extensive surveys have been undertaken by WSM on various projects in more than 400 villages throughout the Northern Transvaal (WSM, 1992, 1993, 1994). These surveys were aimed at assessing and evaluating water supply systems in extended areas of Lebowa, Venda, Gazankulu and KwaNdebele. Procedures developed by WSM allowed gathering of information with regard to the character of the residential area, level of living, water supply facilities, water sources developed and other related socio-economic factors. The undertaking of these projects contributed significantly to the research programme in that not only was extensive data collected, but importantly, experience was gained at grass roots level of conditions in a wide range of villages and settlements having varying socio- economic status.

Access was also gained to the results of numerous socio-economic surveys undertaken in the Northern Transvaal and include detailed surveys of water supplies and water collection activities, income and expenditure patterns, demographic information, education, agricultural activities, the extent and use of various fuels such as electricity, wood and coal, transport related information and information regarding services and water supply facilities. The project team also conducted interviews with 100 families resident in villages located throughout the study area.

The most important socio-economic surveys include Van Tonder et al (1990), Steenberg (1992), Urban-Econ (1991), Urban-Econ (1994), Pieterse et al (1993), Lebowa Development Corporation (1991), Geerts et al (1990) and Barendse (1994).

Sources of data and information was also identified by corresponding with more than 200 organizations and individuals who were thought to be involved with the supply of water to developing communities. The organizations included the Departments of Health and Finance, Provincial Administrations, several Departments of the former Independent States and Self Governing Territories, World Bank, United Nations, DBSA, Water Boards, several government Departments in Botswana, Swaziland, Lesotho, Namibia and Zimbabwe, Universities, Municipalities and numerous other interest groups.

Some 60 responses were received with more than half of these responding positively. The bulk of the positive responses was received from Municipalities and Water Supply Authorities who are responsible for the supply of water to communities who mainly have yard tap water supply facilities. Water delivered in these instances is usually metered and therefore information is available with regard to average monthly consumption rates. In a limited number of instances, data loggers are used and therefore information is available with regard to the daily distribution of water use including water losses.

Contact was made with these organizations and the raw data was obtained and processed. The sites where data is available is scattered mainly in the PWV area and at a limited number of sites in the Northern Transvaal.

A review of the available information, revealed shortcomings in the database. Ten sites were identified where monitoring of various water use aspects was conducted.

The sites are located in various residential areas throughout the Northern Transvaal and included monitoring of individual households, water use from handpumps and bulk water supplies to selected residential areas (refer to Figure 1). Water metering at these sites proved particularly difficult. Developing communities have become suspicious and antagonistic towards government. Installing water meters was viewed by residents as a government motivated action as the first step towards making residents pay for water.

The data collected from the various sites were analyzed and processed to yield information with regard to average daily use, distribution of daily water use, water use for various water use purposes, seasonal distribution of water use, impact of payment for water, impact of walking distance, impact of water supply system technology on water use and impact of water quality.

The information was used to validate the water demand relationship developed in this research project. These aspects are discussed in this report below.

A vast amount of data and information was collected during the course of surveys undertaken of the more than 400 villages and settlements. The information is mainly spacial by nature and was therefore compiled and loaded into a geographical information system (GIS) which allowed effective and convenient assessment and processing. The facilities developed have been transferred to the Department of Water Affairs and Forestry and form part of a village domestic water management facility. The data and information may be accessed by contacting the Strategic Planning Directorate.

3.4 DEVELOPMENT OF THE WATER DEMAND MODEL

The development of the water demand model followed several discrete steps which included :

- Conceptualization and systemization and involved classification of the factors into logical and economical categories, sub-classification of broad categories of factors which influence water use, definition of terms such as level of living and conditions of living, conceptualisation of the underlying dynamics that influence water demand and the initial selection of the factors which were considered to influence water demand.

- Design of initial hypothetical model which involved the further selection and prioritization of factors which influence water use and the development of relationships between the various factors.

- Development of appropriate and cost effective indicators. This involved grouping and categorizing the factors into those which may be used for rapid appraisal of the water supply situation, those which may be obtained from existing data sources and those which can only be obtained from expensive, costly and time consuming surveys.

- Testing and evaluating the factors and indicators used in the water demand model. Information gained from literature, existing data sources and from field surveys was imputed in the model. This allowed assessment of the various factors in terms of relevance and efficiency, ie. in terms of effort to obtain versus accuracy of results. Final adjustments could then be made to the model.

4 DEFINITIONS AND TERMINOLOGY

Several of the terms used in the water - supply/water demand context may be misleading and could lead to misinterpretation. This section therefore lists the important terms which occur in this report and are defined in the context in which they are used. The definitions were taken from various sources and are considered to be in general use in the water industry. The references include Department of Water Affairs, 1998; Horne Glasson, 1989; Bekker, 1982 and WSM, 1993.

Use : the volume of water supplied to the end user including distribution losses. This term is specifically used when dealing with historical data, especially when the purpose to which water is put to, is categorized, for example domestic water use. Usage is sometimes adopted when the emphasis is mainly on purpose.

Water consumption : Often loosely applied to water use or demand but does not necessary imply consumptive use.

Consumptive use : The volume of water used by the end consumer and not returned as effluent for return flow. This water is therefore converted to another phase of the hydrological cycle and is therefore not available for reuse. Consumptive use includes water used for gardening.

Non-consumptive use : The portion of water abstracted form source and delivered to the user, but which becomes available for reuse. Examples include water used for toilet flushing, dish washing and personal hygiene.

Water Demand : The theoretical volume of water required by the end user under conditions where no constraints occur in terms of, for example, access and water availability. Water demand is especially applicable when considering future water requirements and should therefore include allowance for all losses between source and consumer. The water losses would include losses at the head works, raw water treatment works, distribution losses and unaccounted for water.

Forecast : Estimate of possible future water demand based on empirical equations.

Projections : Estimates based on historical and/ or current trends

Water need or requirement : The reasonable quantity of water required for basic domestic purposes and ecological protection to maintain an acceptable quality of life. Water requirement may therefore be equated to water demand.

Water reuse : Water collected from one or more sites, treated and redistributed to different sites for reuse. Direct reuse of water may also occur for example water used for bathing is subsequently reused in the garden.

Water source : Raw water sources acting in combination with one or more water works to produce a water supply.

Stream supply : Water drawn directly from streams and pools.

Hand pump supply : Water drawn from a borehole using a hand pump.

Wind pump supply : Water drawn from a borehole using a wind pump. The water is usually discharged into a reservoir from where it is drawn by means of a tap.

Well supply : Water drawn from a hand dug well which is located in or near a residential area where the water table is 2 to 3 m below surface level. Temporary rudimentary wells are also constructed by residents in sand beds of rivers during dry winter months from which water is scooped using basins or buckets.

Street tap : Water piped to points within the village and the average walking distance is usually less the 250 m. In many instances however, only a limited number of street taps are installed on the system and therefore walking distances may be considerably greater than 250 m.

Yard taps : Water piped to individual stands, with a stand pipe located on the stand. The recent development of certain stands, includes a tap located adjacent to the toilet to facilitate and improve hygienic practices.

Kitchen supply : Water piped to individual stands but with the provision of a kitchen connection. Houses in these developments usually do not have a separate bathroom and washing facilities are restricted to activities in the kitchen. Most of these installations are metered.

Full reticulation : Water piped to individual dwellings having full reticulation. Water is therefore available in the kitchen, bathroom and toilet of such dwellings. Taps are also available in the garden for watering and maintaining the garden.

Dwelling unit : A suite of rooms which may be interconnected or which may be located in several individual structures, but forming an independent living unit and may comprise a kitchen, living area and sleeping areas.

Household : A group of people living in a dwelling unit an may consist of a single family together with or without their servants and with or without boarders, but with a maximum of 3 paying boarders.

Unaccounted for water : The volume of water lost from the water supply systems through leakage, apparent loss through under-registration of consumer meters and unmetered water used for municipal purposes such as street washing, fire fighting, sewer-flushing and watering of parks and gardens. The loss, usually excessive, which occours from unauthorized pirate connections, is also regarded as unaccounted for water.

Level of Living :

Describes the economic status and value orientation of the community as a whole or of individual households. Standard of living on the other hand is a normative concept and refers to the level of living to which the community or household aspires to.

5 FACTORS WHICH INFLUENCE WATER USE

5.1 INTRODUCTION

Information gleamed from the literature reviewed, personal communication, experience from field visits and other sources of data and information, were used to draft a list of all possible factors, and indicators of factors identified, which may influence water demand. More than 100 factors and related indicators were identified and the comprehensive list is given in Appendix A. It is recognized that many of the factors and indicators are interrelated and certain of the factors have a lesser to negligible impact on the water demand. This research project is aimed at identifying those factors which have a major impact on water demand and which therefore need to be included in the water demand estimation model.

In reviewing the factors identified, it was found that these may be grouped into 4 main categories viz :

- People related factors (level or condition of living)

- Access to the water (technology related)
- Water availability (physical environment)
- Factors which inhibit water use

It is appreciated that there is a certain degree of overlap between these categories. It is also noted that water demand implies the volume of water which will be used under conditions where water use is not restricted. In practice however, numerous limiting factors occur which restrict actual water use and these may include inadequate infrastructure, unauthorized water connections, interrupted water supplies and poorly maintained water distribution systems.

Information with regard to certain of the factors which influence water demand is readily available or may be obtained easily from field visits. This information is classed transparent. Information related to some of the other factors needs to be sorted from databases, reports and other not so accessible sources. A further category of factors which influence water demand include those where information can only be obtained by means of expensive and time consuming surveys.

5.2 PEOPLE RELATED FACTORS (Level of Living)

As already mentioned, water demand estimation is primarily an exercise pertaining to the assessment of the level of living of the residents. The developing communities in the Northern Transvaal comprise the full range of level of living conditions varying from the least developed communities, which are located in remote areas and which are mainly involved with agricultural pursuits, to the most sophisticated groups. The former group essentially uses water only for drinking, cooking and personal hygiene.

Further up the level of living scale are communities which enjoy a modest level of living and reside in improved housing units and derive much of their income from more distant sources where improved job opportunities occur. Electricity reticulation and access to improved transport is usually available in such centres. Limited gardening activity occurs which results in increased water use.

The upper end of the level of living scale is characterised by communities which enjoy modern housing facilities, often with reticulated water supply systems which include water borne sewage. Electricity reticulation and telephone connections are extensive. A large percentage of the residents have a high level of enthusiasm for gardening. However, in many instances, the stand size is limited and therefore gardens are of moderate size. Water is used for the full spectrum of activities of the domestic environment.

5.3 ACCESS TO AVAILABLEWATER SUPPLIES

Access to available water supplies is mainly a function of the type of water supply system installed, number of water abstraction points developed and the population density.

Several water supply system types are in common use and include fully reticulated systems with water borne sewage, yard tap systems, street tap systems, wind pumps, handpumps and direct abstraction from springs, streams and shallow wells.

The water use at home is limited by the ease with which the water is obtained from the water supply system. In the case of a rudimentary water supply system where water is scooped from streams, springs and shallow wells, it is required that the water user carry the water over long distances, and in addition, the water is quite often not readily available at the collection point. In such cases, water use activities such as washing of laundry, and to a limited extent, bathing, tends to be transferred from the house to the source. The volume of water used in such cases is therefore relatively low.

Hand pump, wind pump systems and particularly street tap systems require considerably less effort to draw the water, but access may be impeded by long walking distances.

Improving access to available water by providing yard tap systems or house connection systems results in a considerable increase in water use. Water is readily available for high water use activities such as bathing, sanitation and garden water use.

5.4 AVAILABILITY OF WATER

The availability of water significantly influences the actual volume of water used as opposed to the water demand. Water used is in numerous instances considerably lower than the demand due to water shortages. This occurs particularly in areas which are ravaged by prolonged droughts.

The availability of water is a function of the mean annual precipitation, ground water potential, borehole success rate, the presence of regional schemes with adequate capacity, the presence of well structured maintenance programmes and the availability of funds for development of water resources and water supply infrastructure.

Ground water, which is a widely dispersed source, is drawn from boreholes drilled in close proximity to the residential areas. This is the most commonly used source to meet water demands in the areas located distant from the major towns. Certain areas of the Northern Transvaal, however, have a poor ground water potential and field surveys have indicated that the volume of water made available to residents in these areas is low and water shortages often occur. Regional schemes have been proposed in these areas, but prohibitive costs of construction has delayed the development of most of these schemes.

5.5 FACTORS WHICH INHIBIT WATER USE

There are several barriers which limit water usage, assuming that adequate quantities of water are available. These include water tariff, topography and water quality.

Water tariff has a significant and restrictive influence on the volume of water used by households. Charges are generally however only made for water used in areas where fully reticulated water supply distribution systems have been developed or where site connections have been provided.

Several examples of the impact of water metering and the charging for water used have been recorded. These are discussed in this report.

The tariff type is also of considerable importance and essentially two tariff types are used, viz a flat rate tariff and volume based. A flat rate tariff is generally applied in the more rudimentary systems or in high density developments such as flats. In these cases, the volume used by the household is not individually metered. A charge related to the volume of water used is usually applied in cases where site connections have been made and individually metering of water used occurs.

Steep topography limits the volume of water that can be carried to the individuals home from the water abstraction point. This is particularly the case where gradients steeper than about 1 : 15 occur and would be applicable in the rough terrain of the eastern escapement in the Northern Transvaal.

Water quality has a limiting influence on the water usage per person. The impact of water quality on water use is related to the distance between the source and the home as well as the particular use of that water.

The influence of many of the factors which impact on water use has not been researched at all. The information available in the literature together with the data and information obtained from reports and field surveys allowed initial selection of the factors considered to be the most important indicators of possible water demand. These were classified into logical and economical categories. This selected list formed the basis for the initial design of the water demand model. A brief overview is given of the major groupings of factors and there relative impact on domestic water demand. A detailed analysis and investigation of the various factors and their related indicators is given in section 6 of this report.

6. THE WATER DEMAND RELATIONSHIP

6.1 THEORIES DEVELOPED IN THE PAST

The literature reviewed contained several water demand estimation and water demand forecasting procedures. None of the methods reviewed however, provide a means of estimating current water use, considering the various limiting factors. The methods proposed by various researchers could not readily be applied in the developing community environment as found in South Africa, and in particular, in the Northern Transvaal. The importance of several of the factors and parameters assumed to have an influence on the water demand, are not applicable in the South African context and therefore made direct application of the methods doubtful.

A brief overview of the various methods of estimating water demand and making forecasts of possible future water demand are given below. This discussion is taken mainly from extensive work undertaken by a Technical Committee commissioned by the Department of Water Affairs (1988) in this regard. The methods described below rely mainly on having a long historical record available of water use. This is however not the case for the largest percentage of communities in the Northern Transvaal. Recourse therefore has to be had to estimating per capita water demand.

Extrapolation. Proponents of extrapolation methods presume inertial evolution of certain elements of the process and argue that the future is an extension of the present in a general direction and can be estimated from the evolution of the past. Among others, analytical extrapolation, phenomenological extrapolation and vectorial extrapolation can be distinguished. Extrapolation methods are based on a long historical record and can therefore only be applied in a limited number of cases since metering of water use is presently seldom undertaken in developing areas.

Analytical extrapolation is based on predication theory - the least square fitting of a function to the time series. The mathematical form of the water demand forecasting model using analytical extrapolation procedures is determined by statistical methods.

Phenomenological extrapolation requires that the trend be described by some other means, for example, the use of empirical experience or identification of some variation law in the phenomenon under study. An example is the logistic model in which the phenomenon cannot pass a saturation level and the variation rate at any moment is proportionate to the level at that moment and the difference between that level and the saturation level. The resulting equations are known as Gompertz functions. Another similar example is the exponential model, namely an exponential equation expressing the phenomenon as a function of time. For the evolution stage, the function follows a concave-up curve, but in the course of time, the exponent gradually decreases to create a concave-down curve, which ultimately levels as saturation is reached asymptotically.

Vectorial extrapolation involves the regression curve and correlation of trends. The regression curve expresses the future variation of the factor depending on another factor having a known evolution, and the assumption is that the structure of the correlation does not change.

The above procedures are all based on historical data, but in the case of the developing communities, very little data is available. Recourse has to be had to the development of water demand estimation techniques which rely on econometric modelling procedures. A trend followed during recent times is to base estimates of present and future water demands on various development scenarios which cover a range of possibilities and attempt to anticipate changes in technology, socio-economic factors and political considerations.

The method of water demand estimation based on unit water use takes account only indirectly of the historical effect of economic growth, which has been proved to be an important explanatory variable of water demand. There are difficulties however, of estimating the future economic growth rate or the rate of change of the level of living of a community.

In view of the limited historical water use data available for developing communities, water demand estimation for this water user group would of necessity be based on econometric methods of water demand estimation. This procedure was followed by several researchers and include Mu et al (1990), Department of Water Affairs (1988), Arimah et al (1993) and Horne Glasson (1989).

6.2 THE WATER DEMAND ESTIMATION RELATIONSHIP

6.2.1 Factors which influence water demand

In the water demand estimation model, water demand is the dependent variable and the factors which are thought to influence water use include socio-economic parameters, access to water, water availability and inhibitors and are used as independent variables. The water demand model is thus based on the theory that water demand is a function of the various factors which define consumer behaviour and that variations in domestic water demand can be accounted for by differences in :

- Population density
- Household size
- Family structure
- Housing type
- Gardening activity
- Electricity use
- Income
- Business activity
- Education
- Expenditure pattern
- Motor vehicle and other fixed asset ownership
- Agricultural activity
- Water supply system type
- Sanitation facilities
- Water tariff
- Water quality
- People per abstraction point
- Water user type

The results of several studies and review of available information has shown that there is a strong relationship between the volume of water required for domestic purposes and the economic and level of living status of the consumer (Horne Glasson, 1989; Department of Water Affairs, 1988 and Jackson, 1989). This is readily apparent from water use statistics in numerous proclaimed towns throughout South Africa, where there are in general no contraints on the volume of water used, apart from the water use tariff which is usually applicable.

The tendency is for per capita water use to increase substantially as level of living improves. Data provided by Van Duuren (1974) confirms this observation. The major differences in water use of communities having varying socio-economic status is mainly in terms of dish washing, personal hygiene, sanitation and gardening activities.

It is thus hypothesized that the desire to use water is related to disposable income, value orientation, enthusiasm for gardening, ability and willingness to pay for water used and an awareness of water scarcity. Factors and indicators which describe the consumer and its immediate living environment, are crucial to the estimation of the level of water demand of the particular domestic water consumer in question.

It is therefore hypothesized that :

Water Use = f (living conditions, access, tariff, inhibitors)

Since water demand is the volume of water which would be used, should access to the water not be restrictive and assuming other inhibitors are not present then it follows that :

Water Demand = f(living conditions, tariff)

From the above therefore, it is necessary to assess and describe the profile of the water consumer, in terms of level of living, prosperity, habits and attitude towards water use.

6.2.2 Description of the domestic water consumer

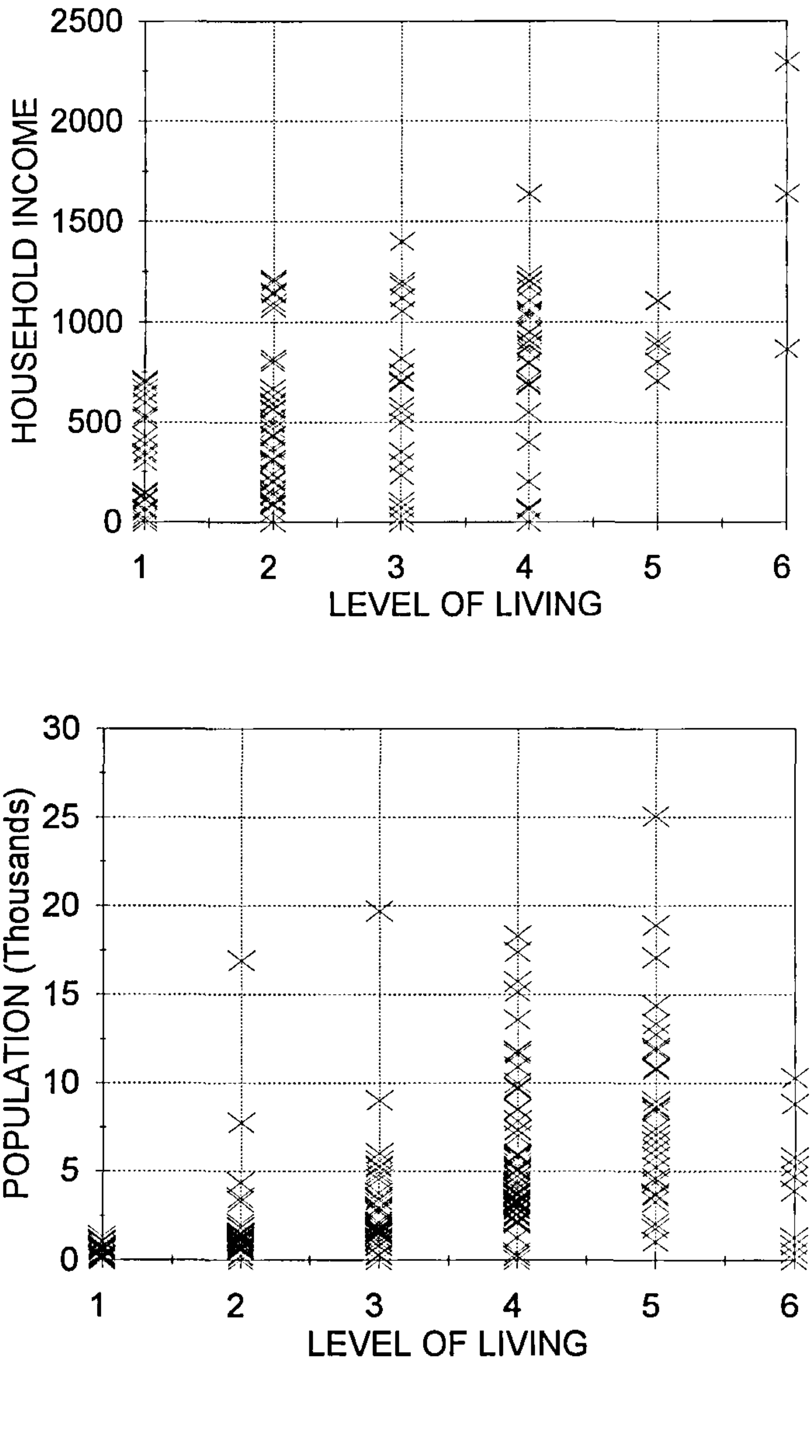
Population

The developing communities, which have varying socio-economic status, are found in villages, settlements and towns located throughout the Northern Transvaal. The villages and towns are however concentrated mainly in the former Independent States and Self-governing Territories. The population of settlements vary from less than 500 to more 10 000. In general however, the population of the settlements numbers approximately 1 300 (WSM, 1992,1993,1994).

Residents usually reside on stands which have been orderly set out in a rectangular grid. Stand sizes in general measure about 1 200 m^2 to 2 000 m^2. The larger stands offer a limited potential for agricultural activity. In most instances however, residents in rural areas who have a particular interest in agricultural pursuits, undertake dryland farming on large communal dryland areas located near the settlements. Grazing of cattle occurs on communal grazing areas. In the more developed areas, particularly as found adjacent to major towns and urban centres where low cost housing developments have occurred, stand sizes are generally about 375 m^2 ranging from about 350 m^2 to 600 m^2.

Indications are that village size, ie village population, may be used to obtain an indication of the average level of living of the residents of the village. A survey undertaken of some 250 villages in the Mokerong 1 and 2 districts of the former Lebowa (WSM, 1992) shows a correlation between population and a subjective (based on work undertaken in 1991/1992 on a drought relief project) index of level of living. This index was related to housing type, gardening activity and electricity connections (refer to Figure 2).

A demographic analysis undertaken of the Nzhelele River valley located north of the Soutpansberg mountains in Venda (WSM, 1993), showed that villages and settlements located closest to major towns and centres of employment and



WATER RESEARCH COMMISSION

POPULATION VERSUS SOCIO-ECONOMIC STATUS

FIG 2

business had a growth rate in excess of 4%/annum for the period 1985 to 1991. A survey of these villages, which numbered more than 50, revealed that residents enjoyed a relatively high level of living. The perception was that improved conditions occurred in these villages in terms of employment opportunities and access to services such as water supply and health care. Significant numbers of people therefore migrated from the less developed and remote villages located in the northern part of the Nzhelele River valley. Indeed, certain of the remote villages experienced a decrease in population for the period 1985 to 1991.

A spontaneous, mushroom growth of towns and large villages is considered to be a 20th century phenomenon. The magnet of prosperity, so often illusionary, draws dwellers from remote areas away from the villages and farms to more developed centres. The movement is accelerated with drought and other disasters (Antoniou, 1980). The extraordinary growth is evident in KwaNdebele, which is located close to the Gauteng area. An average growth of nearly 6 %/a was experienced during the past decade.

It is therefore postulated that level of living or socio-economic status of a community, is related to the population size.

Income

A description of the consumer in terms of his/her living conditions and socio-economic status is pursued by considering and evaluating various indicators. The indicators may be used to qualitatively define the personal development of the consumer and his living conditions. Income is an important indicator as it reflects the capacity of the domestic water user to improve his dwelling, to having ultimately, access to kitchen and bathroom facilities, developed gardens and to acquire material items and appliances which all result in increased water demand.

Information with regard to income is difficult to obtain in view of the fact that it requires extensive, time consuming and expensive field surveys using interview techniques. The political unrest in recent times also seriously hampered this method of data collection. The data collected also suffers from potential gross inaccuracies due to the fact that the respondents with high income levels usually report lower levels of income and the converse applies to respondents with a low level of income.

Two sets of data were available for examining the relationship between income and water use. One set includes average values for some 40 villages in KwaNdebele and the other set comprises data of some 100 families interviewed as part of this project. The results showed the expected general increase in water use with increased income level (See figure 7). There was, however a wide scatter which reflects the diversity of human conditions and choices. Choice gives rise to individual prioritization of expenditure.

Other measures of income are obtained from statistics relating to Gross National Product, Gross Domestic Product and Gross Geographical Product. GNP or GDP provide a good measure of the monetary value of goods and services produced annually in a given country. The measure lends itself to time series analysis. GDP per capita is the standard measure of welfare of the individual, but however, says nothing about the distribution of income (Eckert, 1986). It was further noted by Eckert that the association between GDP per capita and the supply of basic human needs is quite weak. The GDT measures the value of final output of a region's economy over a certain period. It includes all final goods produced and services rendered within the territory by residents and non residents without regard to its allocations among domestic and foreign claims. This information cannot be disaggregated to village level and is therefore of relatively little importance when planning and developing water supply systems of village level. The status of the domestic water consumer in a regional area, when considering the planning and development of regional water supply systems, may be had by referring to GDT figures.

Household size

The demarcation of households as static units of analysis is problematic.

Qualitative research has shown that 90 % of households change even over a short period of time. The reasons for the changes of household size and structure could include the following :

- dividing up of households
- new members to the households
- moving of households
- movement of children

The movement of children between households has to do with the insecure economic position members find themselves in as a result of migration of parents/dependants, change of the household head, boys needed as shepherds, girls needed to help with household tasks, and poverty.

A de jure (all absent household members, ie. members not present but who consider themselves as members of the household and make some type of contribution to the household, or make use of the resources available to the household) / de facto (members present at the household at time of census) relationship could be considered useful in providing an indication of labour migration and its effect on age/gender distribution, but is otherwise fraught with methodological limitations. Application of the concept "de jure" to the household suggests a normative definition of the household, ie. whom should a household consist of, who ought to belong to a household. It implies static household boundaries and consequently does not take cognisance of the processional nature of intra - and inter-household relations as they manifest in fluctuating household composition and the movement of people between households.

As a result of these considerations, a number of recent anthropological studies in rural areas of Southern Africa have made use of the residential site as the primary unit of observation. In the context of "betterment" areas and closer settlements, the residential site as unit of investigation is easily identifiable and more "stable", producing data which is "more reflective of on-the-ground experiences, such as the fluidity of sociologically important units, such as domestic groups and residential units" (Speigel, 1986).

Available information would suggest that defining a household as a functional unit revolving around income is not accurate. The relationship between the linkage of households as an unit reflects the strategies to maximise control of income and pensions. Functional use and income relations are common principles used for this linkage. Definitive borders for households fail to expose the dynamic nature of households.

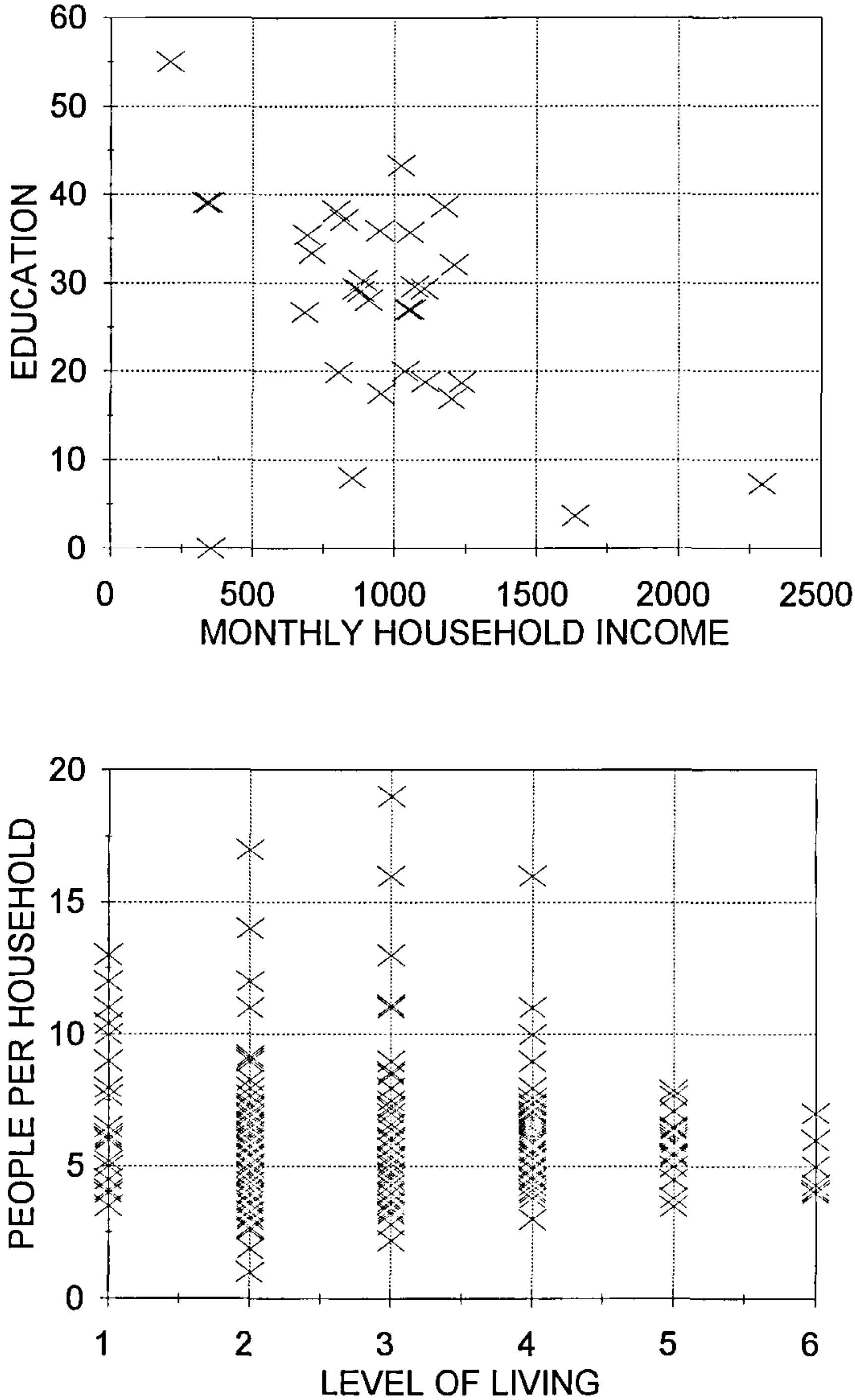
Information regarding household size was available for some 40 villages in KwaNdebele and of 100 households surveyed during the course of this study. Household size varies from less than 4 to more than 20 but in general the range is between 5 and 7.

Indications are however that households having a high or very high level of living, generally have a household size varing from 4 to about 3.6 persons. Darr et al (1975) showed that per capita water use of communities in these levels of living is significantly influenced by household size.

A plot of household size versus income using the KwaNdebele data produced a wide scatter (refer to Figure 3). The individual household data however reflects a trend which indicates that average household size reduces marginally with increased average monthly household income. On a village level, this indicator cannot however be used with confidence to determine level of income.

Education

Education is considered to be an indicator of the potential to generate income. Without education, it is generally only possible to obtain unskilled positions. With higher levels of education, better employment opportunities are presented and consequently higher levels of income may be achieved. It is also considered that education may be a good indicator of the value orientation of the communities. With increased levels of education,



WSM	WATER RESEARCH COMMISSION INCOME VERSUS EDUCATION AND HOUSEHOLD SIZE	FIG 3

expectations and the desire for improved living conditions is thought to increase.

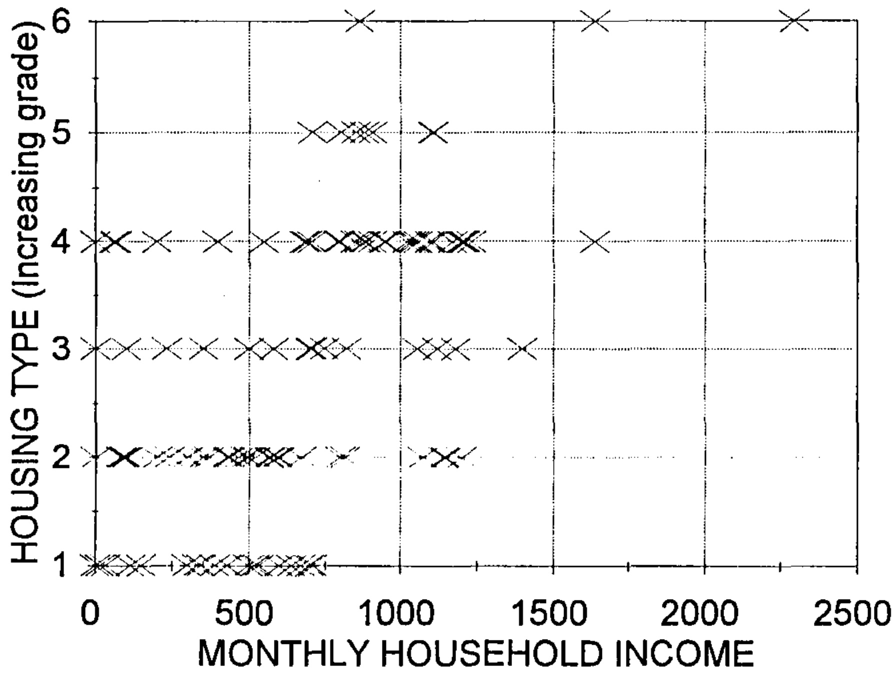
Information regarding education is available for the communities in each of the villages in KwaNdebele. A plot of education (% of the economically active community which has no education) versus average monthly household income shows a wide degree of scatter (refer to Figure 3). This is due to the fact that various other mediating variables play a role, eg. age, experience and political influences. The small data set is considered insufficient to validate the statements made. A general trend is however decernable from the available information.

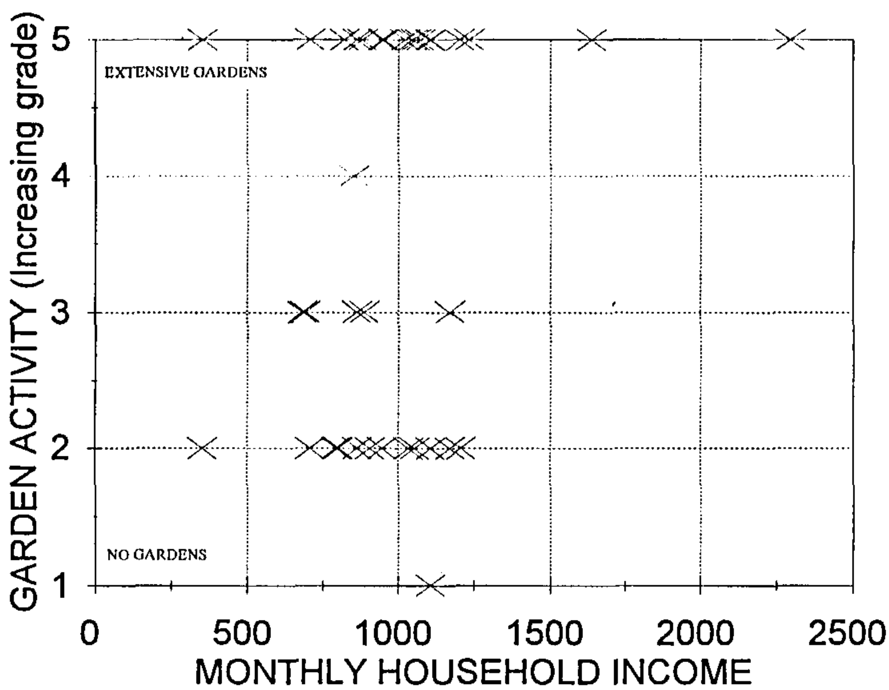
Housing type

The predominant housing type, which occurs in the villages is considered a suitable and effective indicator of the prosperity and value orientation of the community. Credit facilities are usually not available to most households in view of the current land tenure arrangement and other economic factors. Improvements to dwellings are therefore a reflection of the economic status of the community and is readily determined by making a cursory visit to the village or town.

The type of housing also readily yields information with regard to the potential water use of the community. The presence of facilities which would include kitchens and bathrooms may be readily determined.

Information regarding housing type was obtained for 40 villages in KwaNdebele (WSM, 1994) and this was plotted against income obtained from a survey undertaken by Urban-Econ (1994). The dataset is small and the results produced a wide scatter (refer to Figure 4). The general trend which reflects improved house type at higher income levels is however noted. This trend is also reflected in a plot of expenditure on housing (% of income) versus household income (refer to figure 8).





WSM	**WATER RESEARCH COMMISSION** **LEVEL OF LIVING VERSUS HOUSE TYPE AND GARDEN ACTIVITY**	**FIG 4**

Gardening Activity

Gardening activity is considered an important indicator to reflect value orientation and potential water use. Garden activity is a manifestation of the household's drive to improve and beautify its environment. Material wealth is in most instances required to achieve the above as it involves purchasing fencing, gates, plants and making a water connection. Water is essential to maintain a wet garden, ie. a garden which includes a lawn. Most communities do not have yard connections and residents therefore take it upon themselves to make unauthorised yard connections. This practice results in excessive water loss and therefore results in increased water use.

An advantage of using gardening activity as an indicator is that the information is readily obtainable at nominal cost by making a cursory visit to the village or town. This information also identifies villages having the potential of high water demand. Garden water use amounts to 20% or more of the total water demand of communities having a low to moderate or higher level of living.

Information related to gardening activity was obtained for 40 villages in KwaNdebele and was plotted against the income levels for the villages in question. A wide scatter was obtained due to the small data set (refer to Figure 4). The scatter is also a reflection of the preferences and choice expressed by communities.

Electricity Connections

Electricity connections are considered to be an indicator of the economic status of the community. Electricity is one of the few services, which until recently, was only provided on request and payment had to be made for services rendered. Households therefore had to have the economic means in order to derive the benefit of electrification. Electricity connections also reveal the communities' desire for comfort and convenience offered by the service.

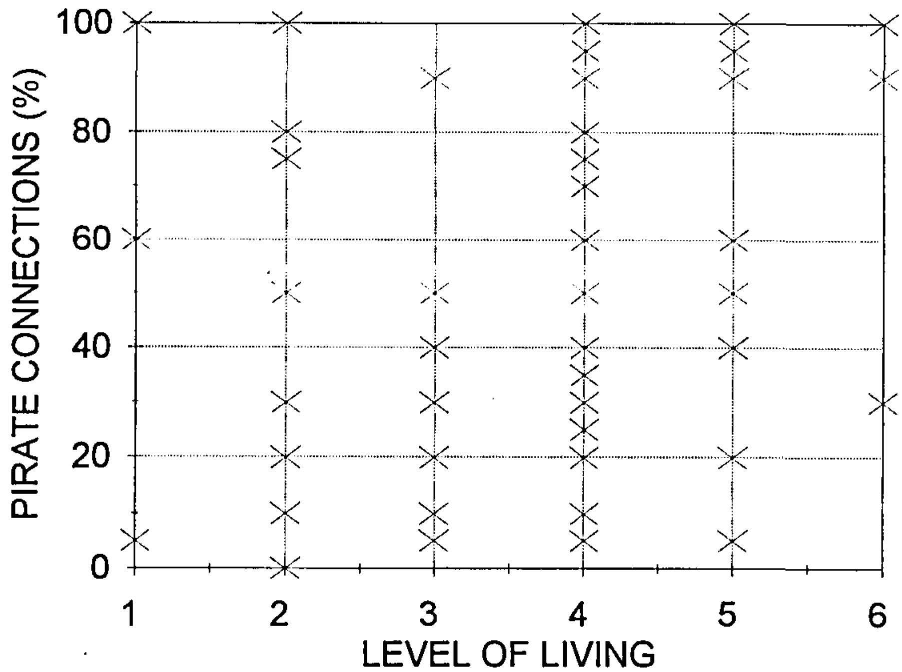
Fuel switching is a complicated process which takes place over time since appliances need to be acquired in order to benefit from the switch. It is of importance to note that it is the utility, ie the stove or light etc, and not the fuel which is desirable. The cost of the fuel is therefore not the major consideration. Effective savings of the community is an important factor as it determines the amount of money which can be use as a deposit for the purchase of larger appliances. Income alone is therefore not the major indicator (Viljoen, 1994).

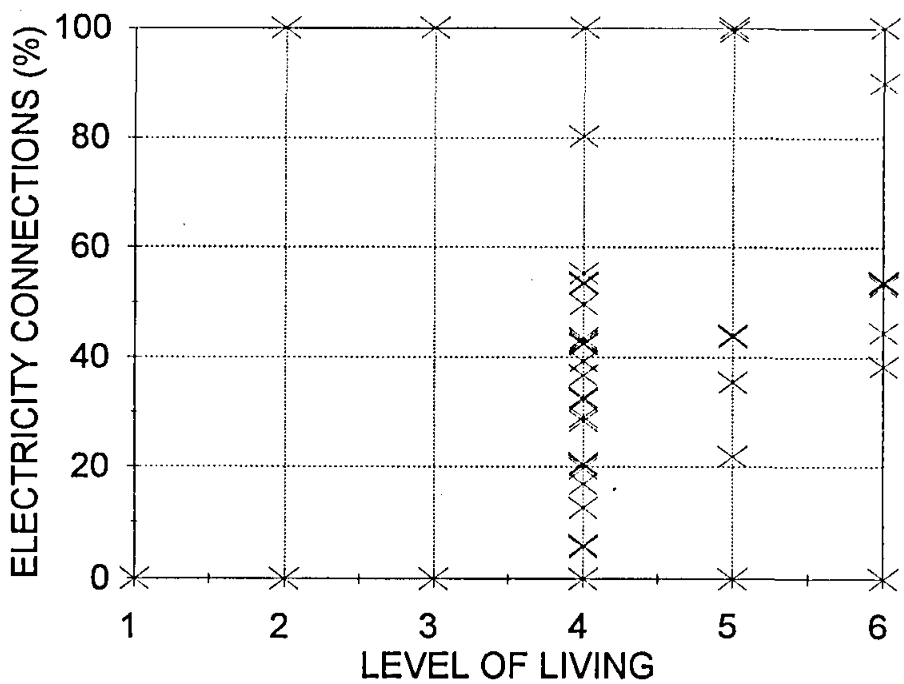
It is relatively easy to obtain information with regard to electricity connections from Eskom databases, and a graph was plotted using income statistics for 40 villages in KwaNdebele (refer to Figure 5). The scatter is considered to reflect the diversity of human beings in terms of setting priorities and making choices regarding expenditure of available funds. The general trend which reflects increasing income level is however noted.

Unauthorised yard connections (Pirate connections)

The practice of making pirate connections is motivated by numerous factors and include the perception of obtaining a more secure water supply, avoiding the need to queue for long periods at water points, drastically reducing walking distance and the desire for convenience and comfort. There is the added benefit in some instances, where water available from a yard tap is sold to other members of the community who are left without water. Knowledge of the occurrence of pirate connections is also important to identify communities where exceptionally high water use and high water losses may occur.

Information regarding pirate connections was obtained from a field survey of some 250 villages in the Mokerong 1 & 2 districts of Lebowa (WSM, 1992). In a significant number of villages, more than 70% of households have made their own yard connections. The plot revealed that pirate connections occurred even in communities having a low level of living (refer to Figure 5). This may be ascribed to the critical water shortages which occur in many of the villages in the area, and as mentioned earlier, residents regard a yard





WSM

WATER RESEARCH COMMISSION

LEVEL OF LIVING VERSUS PIRATE CONNECTIONS AND ELECTRICITY CONNECTIONS

FIG 5

connection as a more reliable and assured source of water. Many residents leave taps open and therefore automatically obtain a share of the water in the middle of the night when water demand is usually practically zero. This naturally only occurs where pumps run 24 hours per day.

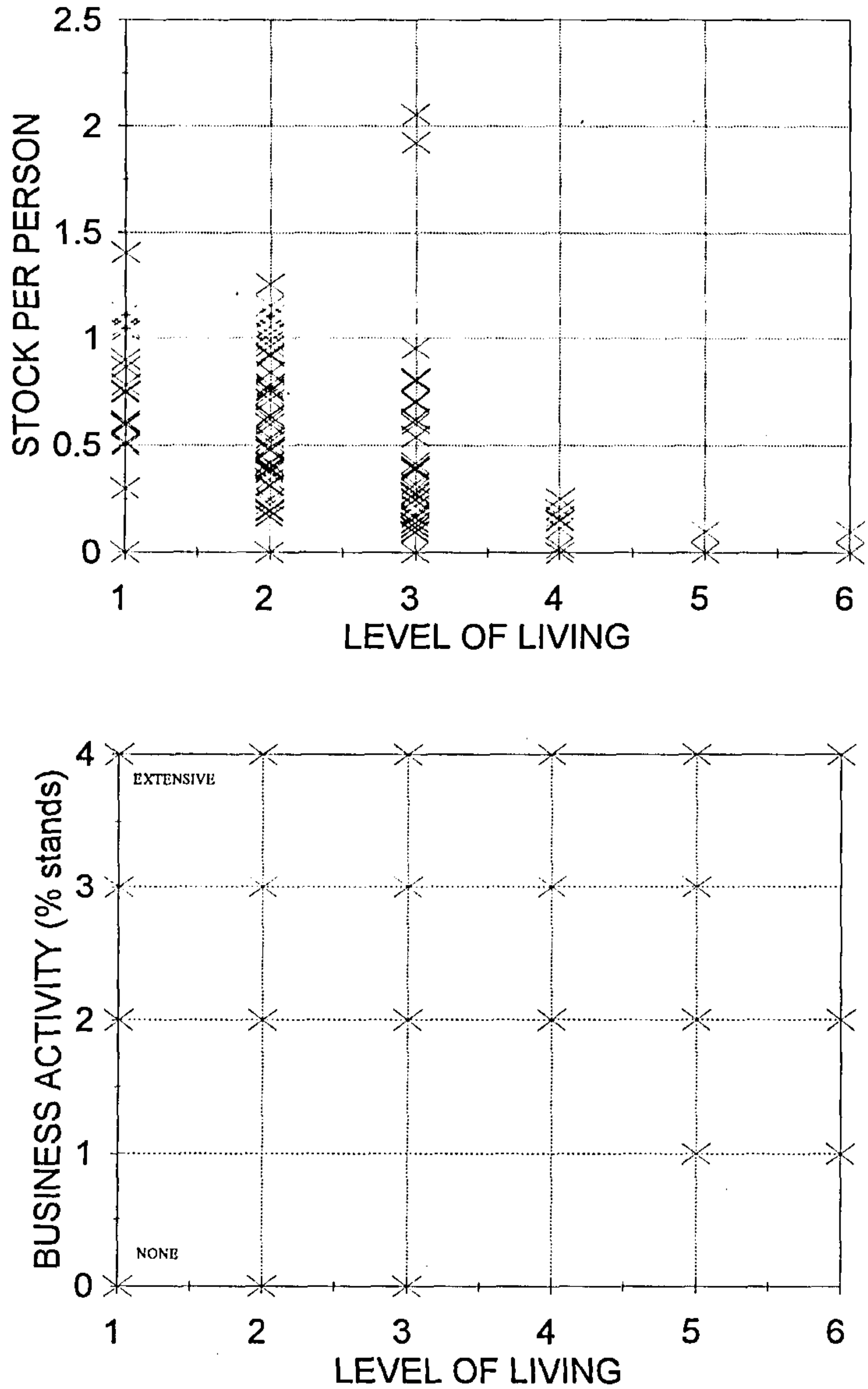
Agricultural activities

Communities which rely mainly on agriculture for subsistence, in general have low cash incomes. These communities therefore have a low potential to acquire material goods, undertake home improvements which would also include improved bathing and washing facilities, and to acquire water using household appliances.

Data with regard to the numbers of stock owned by each community is relatively easy to obtain and is found to be a good indicator of the level of farming activity. Information regarding stock ownership and level of living was obtained for some 250 villages in the Mokerong 1 & 2 districts of Lebowa (refer to Figure 6). The general trend, as discussed above, is shown although there is significant scatter about the mean.

Business Activity

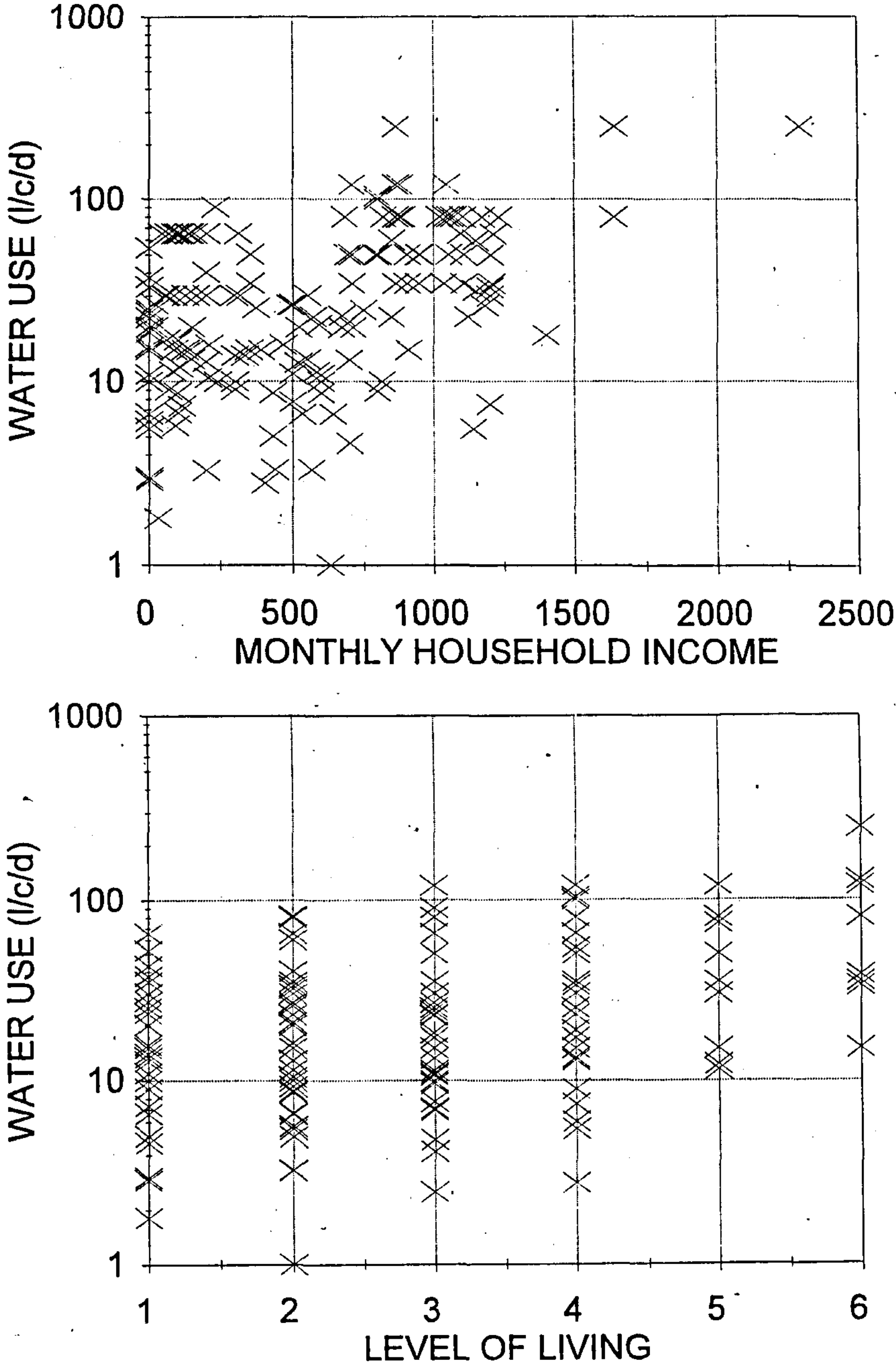
The level of business activity in a village is readily obtained by making a cursory visit to the village. The businesses in general comprise small grocery stores, cafes and bottle stores. Contrary to general expectation, a high level of business activity (high number of businesses) in general indicates a low level of living. Communities who have a low income level have fewer people travelling to distant places of work and therefore do not have the advantage of doing their monthly grocery shopping in the larger commercial centres. These communities are therefore forced to obtain their domestic requirements from shops located in the village. A plot of the number of businesses in some 30 villages in Mokerong 1 district of Lebowa against level of income displays this trend (refer to Figure 6).



WATER RESEARCH COMMISSION

LEVEL OF LIVING VERSUS AGRICULTURAL AND BUSINESS ACTIVITY

FIG 6



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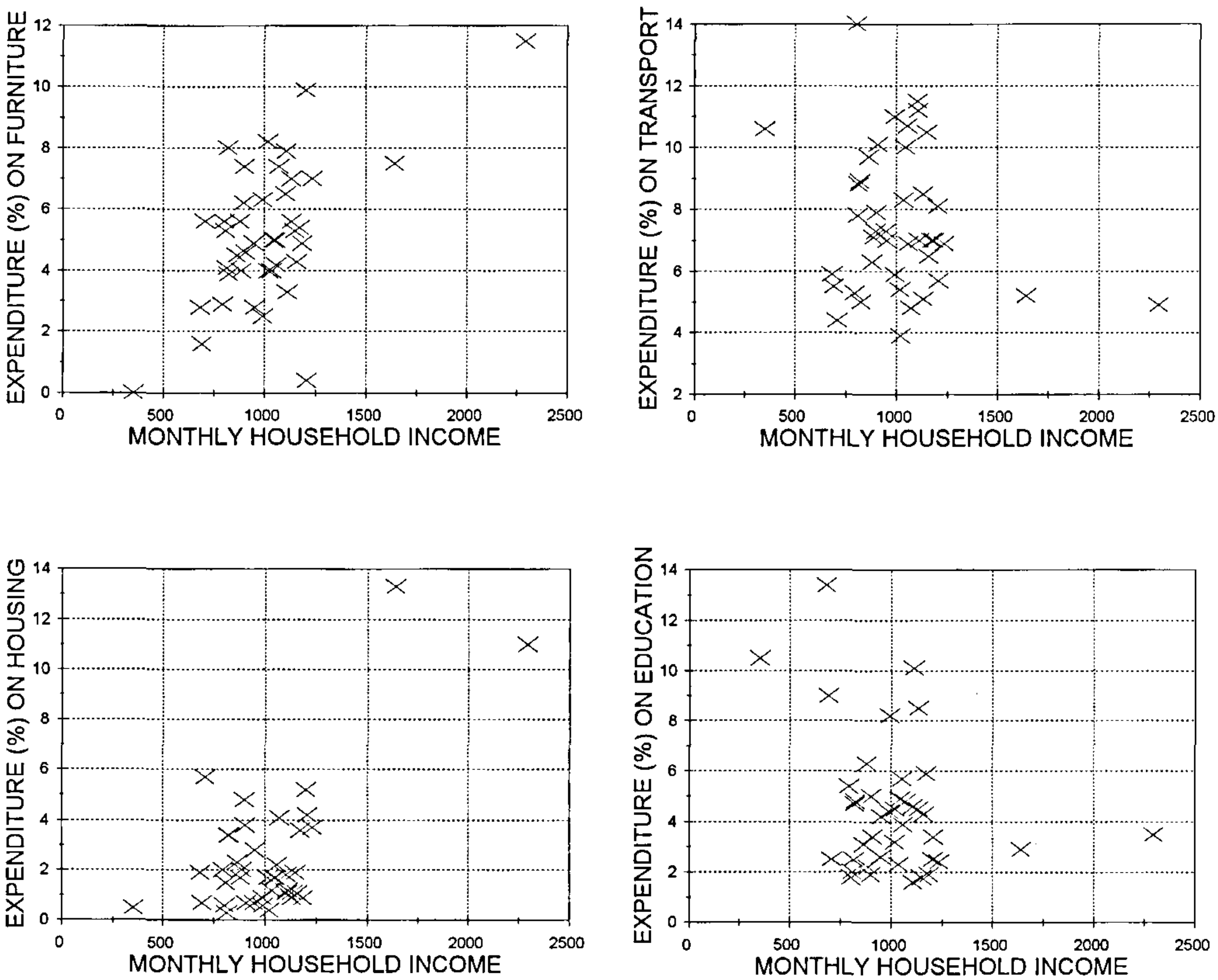
INCOME AND STANDARD OF LIVING VERSUS WATER USE

FIG 7



WSM

WATER RESEARCH COMMISSION

EXPENDITURE PATTERNS

FIG 8

Expenditure

Surveys of expenditure have been conducted by various organizations (Urban-Econ, 1994; DBSA, 1993) and provides insight into the average expenditure pattern of communities of various socio-economic status. Surveys were conducted in more than 40 villages and settlements in KwaNdebele and aggregated survey results are available for all the districts of the Northern Transvaal.

The results of the surveys revealed that household expenditure is mainly in terms of food, clothing, housing and transport. A significant sum of money is also saved each month which is used to purchase appliances and other non essentials. The priorities of households change with income level, household headship, education level of household head, modernity and the type of dwelling (Viljoen et al, 1994). There is evidence that dwelling type strongly influences priorities, with many purchases differed until a certain standard of dwelling is obtained. Expenditure patterns are important as these indicate the propensity of the household to buy certain goods and articles (refer to figure 8). Households spend proportionally more on furniture and housing at higher levels of living but the oppisite holds for expenditure on education and transport.

6.2.2 Access to water

Access to the water is one of the main limiting factors which inhibits the domestic water user from obtaining the full water requirement. In most villages and settlements throughout the Northern Transvaal, domestic unit water use is low and in many cases, this may be ascribed to poor access.

Access to water is a function of :

- Source of water
- Systems type
- Queuing time at the water point, and is a function of the number of

water points and population

- Walking distance

From the above, it may be deduced that access may be interpreted as the effort to obtain the required water. As effort increases, so the volume of water used per capita decreases.

Water Source

The sources of water from which domestic water may be obtained include streams, rivers, dams, springs, shallow wells, boreholes and rainwater harvested from roofs. In many villages and settlements, residents have access to more than one water source and in such cases, the water drawn from the various sources is used for specific purposes. Spring water, would in such cases for example be used for cooking and drinking, whilst river water would be used for personal hygiene and clothes washing.

Several perennial **rivers** occur in the Northern Transvaal and include Nzhelele River in Venda, Upper Klein Letaba River in Gazankulu and the numerous rivers and streams which drain the eastern escapement. Perennial rivers generally occur in areas where the mean annual precipitation exceeds 700 mm. Water is drawn directly from these rivers by residents who live in close proximity to the rivers.

In the case of seasonal rivers, which traverse most of the Northern Transvaal, water abstraction from the river is restricted to the rainy season which occurs during the summer months. The rivers usually cease to flow during the winter months, but because of the considerable depth of alluvium which in many cases is 3 to 5 m deep, significant volumes of water are trapped in the sand. Residents of villages adjacent to such rivers make extensive use of hand dug wells in the river bed during periods of no flow. The water is scooped from the wells using buckets or basins and requires considerable effort and the process is time consuming. Water drawn from rivers and streams in this manner is quite often polluted and is usually not treated. This situation is aggravated in instances where residents wash their clothes at the river.

In a limited number of cases, reticulated water supply systems have been developed which rely on direct river abstraction for their water source. In such cases, efforts are made to treat the water before it is conveyed to the residential areas. Access to this water is a function of the water distribution type in use and is usually not inhibited by the river abstraction works.

Dams have in many instances been constructed on rivers to improve the reliability and extent of water supply. Dams provide storage which improves the reliability of water supply during periods of low flow or zero flow. Water drawn from dams is usually treated before being conveyed and distributed to the domestic water user. Access to such water is usually good.

Springs occur in the mountainous areas of the Northern Transvaal where rainfall usually exceeds 700 mm/a. Such areas occur along the Soutpansberg mountain range in the northern part of the Transvaal and in the Drakensberg mountain range which forms the Eastern Escarpement. The number of villages which have access to this water source is limited in view of the fact that springs occur only in limited areas in the Northern Transvaal.

The yield of springs vary from less than 1 l/s to more that than 3 l/s. Certain springs however, have high salt content and relatively high temperature and are not used for domestic purposes. Examples of these occur north of the Soutpansberg in Venda.

Water is scooped from springs using basins or other similar utensils and used to fill larger containers. This is a time consuming process and limits the number of households which may be serviced by the spring. In certain cases, the springs have been protected to prevent access by stock and other animals and measures have also been taken to offer limited storage and improve water withdrawals. In such cases, the number of households which may be served is restricted by the yield of the spring. A spring which has a reliable yield of 1 l/s, may meet the domestic water demand of some 400 households assuming adequate storage has been provided.

Wells are usually hand dug and normally do not exceed 3 m in depth. Wells are usually developed in the sandy beds of the many seasonal rivers in the Northern Transvaal and are cased using metal drums or other similar supporting materials. As mentioned earlier, water is scooped from wells using basins or buckets which makes access difficult. The considerable walking distance from the village to the wells in the river alluvium, which occurs in most cases, further negates use from this source.

Wells are also developed on private property, ie. on individual stands of home owners, in areas where a shallow water table occurs. This situation arises for eg. in Sekgakgapeng in the vicinity of Potgietersrus. In most instances no lining material is used. A bucket and rope or chain system is used to hoist the water to the surface. Access to this water is relatively easy but it was noted that when water was reticulated in this settlement making water available via street taps, virtually all residents made unauthorised connections to the water distribution system in order to have tap water on site.

Boreholes allow water abstraction from underground sources and is the most common and widespread water source used throughout the Northern Transvaal. Boreholes are easy to develop and the capital cost of developing a borehole scheme is low. The time involved in developing a borehole scheme is nominal and may involve two weeks to three months development time depending on the scale of the project.

Water availability from boreholes however varies significantly depending on the ground water potential. Certain areas, due to the geological conditions, have a particularly low groundwater potential and poor drilling success rate. Such areas include the Nebo district of Lebowa located in the Marble Hall, Burgersfort area and numerous other smaller areas of local extent. In such areas, vast numbers of boreholes have been drilled with limited success. The successful boreholes, usually have low yield normally less than 0.5 l/s and is only suitable for equipping with hand pump or wind pump facilities. The volume of water which may be drawn from such facilities severely limits the number of households which may be served. Residents served from groundwater sources in such areas are severely restricted.

In yet other areas, high groundwater potential occur and a favourable drilling success rate is achieved. Boreholes yielding 3 l/s to more than 10 l/s are found in such instances. Boreholes of this nature are usually equipped with diesel or electric driven pumps and may serve a community of 3 000 to more than 30 000 people.

Borehole schemes involve mechanical equipment which have in many instances been neglected. In other cases, the remoteness of the site makes regular maintenance difficult. The reliability of the borehole schemes has therefore been questioned by many residents and indeed, by certain of the former homeland administrations as well. Policy decisions have accordingly been taken by certain authorities not to develop groundwater resources.

The development of groundwater sources, is also subject to consideration of the quality of the groundwater. Salinity, nitrate and fluoride levels are excessive in many areas of the Northern Transvaal and this aspect is discussed later in the report.

The groundwater potential and other important groundwater parameters are currently being mapped for the whole of South Africa. The Pietersburg 1:500 000 map sheet has been mapped as part of a pilot project funded by the WRC (Haupt et al, 1994) and demarcate areas of varying groundwater potential, drilling success rate, water quality hazard and approximate water table level.

The effort to draw water from groundwater is related to the equipment on the borehole and this aspect is discussed below.

Water distribution system type

A wide range of water distribution types are in common use. Access to the water from the various systems improves with the sophistication and level of distribution coverage, ie as the number of taps or abstraction points on the reticulation increases, so access improves and water use increases. In general, the water supply systems used include scooping directly from the water source where essentially no steps have been taken to provide abstraction facilities, through to the most sophisticated water supply systems where houses are fully reticulated with multiple taps provided in the kitchen, bathroom and garden.

Scooping water from the water source occurs where water is abstracted directly from springs, streams and shallow wells. These sources are in many instances unprotected and therefore prone to pollution. Walking distances in excess of 500 m to 1 000 m are common. These sources also usually occur in undulating or steep topography which makes the transport of the water difficult and arduous.

Sources of water where scooping occurs can usually only serve less than about 25 families assuming the yield of the source can sustain demand. The volume of water which can be made available to households restricted to scooping domestic water requirements is limited to about 5 l/c/d to 10 l/c/d.

Wind pump facilities are usually erected on boreholes having a yield of about 0.5 l/s or more. Wind pumps are also quite often erected at sites distant from the villages and in such instances, the water is intended mainly for stock water use. The lack of other developed sources however results in such schemes also being used for domestic purposes.

Wind pump systems typically pump water into a reservoir located adjacent or near to the windpump having a capacity of less than 100 m^3. Wind pumps on average deliver about 16 m^3/d depending on wind speed and duration.

Access to the available water requires little effort not considering the walking distance. Water is drawn from the reservoir by means of a tap. In many areas however, particularly in the central and western parts of the Northern Transvaal, no or very little wind occurs during June and July and then water shortages occur. Long queues of containers at wind pump sites is evidence of this situation and in certain cases, particularly where no other water sources are available, residents have taken to manually turning the wind pump wheel so as to abstract limited quantities of water. The volume of water available to residents from wind pump schemes is varied and is limited mainly by the average delivery of the wind pump and the walking distance. The range may be in the order 5 l/c/d to 16 l/c/d.

Extensive use is made of wind pumps in the Transkei and Ciskei areas, but very few wind pumps occur in the lowveld areas.

Handpump equipped boreholes are commonly used throughout the Northern Transvaal and indeed, world wide. Hand pump development involves low capital expenditure usually costing less than R 6 000 per development and may take less than one week to commission. A vast number of private hand pump developments have also been undertaken by residents on their individual stands in villages and settlements throughout the Northern Transvaal. This development occurred in response to the poor water supply situation and there is the added incentive to derive considerable revenue from the sale of water.

A wide range of hand pump types are in common use and these can essentially be divided into two categories viz :

- Positive displacement piston pumps which are the most common form used. A wide range of designs and makes are available including home made units installed on private boreholes and on certain community operated schemes. The efficiency and ease of operation varies, and the rate of filling a 25 l container is usually less than 1 minute.

- Rotary spiral screw pumps, which operates on the principal of increasing the pressure on the water by creating a progressive cavity, which then screws the water in the direction of flow. Water delivery is in a steady stream although the flow rate is usually low. It takes approximately 1.5 minutes to fill a 25 l container. The horizontal operating mechanism of the pump is tiring to the user and needs to be rotated at considerable speed in order to maintain reasonable flow. The advantage of this pump is that water may be drawn from levels exceeding 80 m, a level which makes the operation of the positive displacement piston pump types difficult, if not impossible, particularly for children and the aged.

Handpumps are usually located in or close to the settlement and therefore walking distances are 500 m or less. The rate of water delivery, usually less than 4 m^3/d, is restricted by the time distribution of visits made to water points by residents. Two peaks, as fully discussed later in the report, occur during the day. These occur mainly during the early morning and late afternoon. Very little water is abstracted during the period 10h00 to 15h00. After nightfall, no further water collection is generally made. The number of families which may therefore be served by a hand pump is usually less than 25. A hand pump effectively operates for only about 6 hours per day delivering 10 to 12 l/m. This is equal to a delivery of 4 m^3/d.

A study undertaken by Alcock (1989) in KwaZulu/Natal showed that the average time taken to fill 20 or 25 l containers varied from about 1.5 min to more than 4 min with the average being about 3 min. Filling time includes time to rinse the container, time to fill the container, changing of operators and changing of vessels. Water withdrawal usually occurs in a relaxed atmosphere even when queues have formed. This experience was confirmed by monitoring at numerous sites throughout the Northern Transvaal (WSM, 1992, 1993). '

The volume of water made available from handpumps is in the range of 10 l/c/d to 20 l/c/d. The volume of water available to users reduces significantly in cases where low borehole yields occur and pump delivery rate exceeds borehole yield, where the number of households which are forced to draw water from the hand pump exceeds 30, and where walking distance is in excess of 500m.

It will be shown later in the report that hand pump developments are only appropriate in villages where level of living conditions are low and where sufficient handpumps have been provided so that the number of households per hand pump is less than 30. This situation rarely occurs where the hand pump option has been implemented.

Street tap developments occur on systems where water from a bulk water source is reticulated in the streets of the village or settlement. Street taps are spaced such that domestic water users need walk not more than 200 m to 250 m. In numerous street tap water distribution systems, too few taps were installed. These are sometimes located on the bulk water pipeline which conveys the water from the source to the holding reservoir or on the pipeline en route to other more distant villages. Walking distances are therefore quite often in excess of 250 m and in addition, the number of people served per tap exceeds 150 which makes it impossible for residents to draw sufficient quantities of water during daylight hours, making allowance for daily peak withdrawal habits.

The volume of water drawn from stand pipes varies from about 15 l/c/d to 25 l/c/d depending on the average walking distance and population density. Under favourable conditions as much as 35 l/c/d may be drawn from the street tap. Walking distances usually vary from about 100 m to more than 500 m. The number of people served per street tap varies from less than 50 to more than 1 000 (Van Schalkwyk, 1992). In the latter extreme cases, the volume of water which can be drawn is severely limited and is less than 10 l/c/d (Stone,1984). The water drawn from street taps is usually not monitored excepting in cases where residents are required to pay for water in relation to the volume drawn.

Water losses from street taps were estimated by Musetshu (1994) and found to be in the order of 10%. The losses include the water used to rinse the containers and spillage while filling the container. Further losses, which may exceed 10%, also occur due to poorly maintained taps or taps that have not been closed properly. This is particularly the case where water supplies are intermittent and water shortages often occur. Taps are left open by residents in order to be alerted when water is again available in the system.

Yard taps have been made available in numerous villages and settlements in Venda and Bophuthatswana. Residents who wish to have water on their stands made application to the former homeland water authorities and after having paid a fixed fee, the site connection was made from the reticulation system. Water delivered in this manner is usually metered and residents are expected to pay a fee in accordance with the volume of water used.

In such instances, the water is used for domestic purposes as well as gardening. Water used in the house is in general restricted to the volume of water carried into the house from the outside taps. Formal kitchen facilities are not available in such circumstances.

In Lebowa, Gazankulu and KwaNdebele, no procedures and facilities are available to have yard connections officially made. Residents are frustrated by this situation and vast numbers of households have taken it upon themselves to make their own unauthorised yard connections. The connections are in most cases crudely made and excessive water losses occur. The losses were estimated in various settlements and may exceed 100% in certain cases (WSM, 1992; WSM, 1994).

The practice of unauthorised yard connections negatively influences pressures in the distribution system and also results in excessive withdrawal in certain areas of the village with the remaining parts of the village often receiving no water at all. Large numbers of people are therefore forced to purchase water at exorbitant prices from vendors of water.

Households having yard connections usually have a high level of enthusiasm for gardening. A well maintained lawn is normally evident and requires large volumes of running water. Considerable wastage occurs in villages where the water supply is intermittent and where short falls often occur. Residents tend to leave their taps open and excessive amounts of water are applied to the lawn when water is once more available in the system, which usually occurs at night.

Residents having access to water on their stands normally draw water more evenly during a 24 hour period. Two peaks however still occur mainly in the early morning and late afternoon. Water abstraction distribution is discussed in more detail later in the report.

The volume of water drawn by residents having yard tap facilities varies from about 35 l/c/d to 80 l/c/d. Access to the water is good and little effort is required to fetch water.

Kitchen connections have in many cases been made by residents who have yard connections. In most cases, residents who have made such connections have formal kitchen areas with a built in sink. Bathroom facilities usually do not occur in these homes. Access to the water is greatly improved and water use for all household purposes increases significantly particularly for personal hygiene. The burden and effort of carrying the water is greatly reduced.

The volume of water used by households having kitchen tap facilities is in the order of 40 l/c/d to 120 l/c/d. The greatest percentage of the water is used for gardening and personal hygiene purposes.

Fully reticulated water supply systems occur in villages, settlements and towns having western type housing developments. The dwellings normally have kitchens and full bathroom facilities which include wash basin, bath or shower and quite often water borne sewage facilities. Access to the water is greatly improved and is drawn through a system of multiple taps.

The volume of water used by such families varies from about 50 l/c/d to more than 250 l/c/d. The bulk of the water is used for personal hygiene, sanitation and gardening.

The potential water loss from fully reticulated water supply systems is significant. Losses occur through wasteful gardening practices and poorly maintained facilities such as valves on taps and toilet systems. The Soweto Urban Council recorded that losses due to poorly maintained facilities may exceed 30% (Davis, 1994).

Walking distance

Walking distance may significantly increase the effort of drawing water for domestic purposes in terms of time taken to fetch water and energy expended in conveying the water. Evidence of excessive walking distance include washing being done at the source rather than at home and the extensive use of wheelbarrows which is aimed at reducing the burden of fetching water. It also needs to be borne in mind that a walking distance of less than 100 m may be classed as excessive should the gradient exceed 1 : 8 to 1 : 12.

The walking distance is primarily a function of the water distribution system (refer to Table 1). Undeveloped springs,streams and wells are usually located relatively far from the villages and therefore systems where water is scooped directly from the source usually involves walking distances in excess of 500 m.

Borehole systems comprise boreholes which are normally sited at a location where the percentage for strike success is the highest. The location of these sites is therefore governed by geological features rather than distance from the village. Boreholes equipped with windpumps and handpumps are therefore located at distances which vary from within the village to more than 1 km from the village. In the case of privately developed handpumps, residents are restricted to drilling boreholes on their private individual stands with no consideration given to geological features. A successful private borehole development is soon followed by attempts by numerous other neighbours. This occurs particularly in villages which experience extreme water shortages and where the level of living is moderate or better.

Walking distances on street tap reticulation systems vary from less than 100 m

TABLE 1 : CHARACTERISTICS OF VARIOUS DOMESTIC WATER DISTRIBUTION SYSTEMS

WATER DISTRIBUTION SYSTEM	GENERAL ACCESS CONDITIONS	WATER DELIVERY RANGE (l/c/d)	POSSIBLE WATER LOSS (%)	NUMBER OF HOUSEHOLDS SERVICED
Scoop water from springs, streams and wells	• limited water • topography • walking distance, > 500 m	< 16	-	15 - 25
Handpump	• population density • topography • moderate walking distance, < 500 m	< 10 - 20	10	25 - 30
Windpump	• lack of wind • population density • long walking distance > 500 m	< 5 - 16	10	15 - 25
Street tap > 250m	• population density • topography • walking distance > 250 m	< 15 - 25	> 20	25 - 35
Street tap < 250m	• walking distance < 250 m	25 - 50	> 20	25 - 35
Yard tap	• on site	35 - 80	15 - > 100	1 - 4
Kitchen connection	• on site • bathroom generally not included	40 - 120	15 - > 100	1
Fully reticulated	• water borne sewage may be included	50 -> 250	15 - > 100	1

in developments were extensive street taps have been installed to more than 500 m in cases where only a limited number of street taps were commissioned. In the latter cases, the number of people served by the street taps is also excessive and further restricts water use.

Yard tap systems usually have one tap on each stand whether it is an authorized or unauthorized development. In isolated cases, one yard tap is provided for blocks of four stnads. The water is within easy reach of the consumer and may be accessed at any time assuming water availability is adequate. Walking distance is usually less than 20m.

Dwelling units with kitchen connections or which are fully reticulated make use of multiple tap systems and walking distance is therefore negligible and has no negative impact on the volume of water used. Indeed consumers having access to such facilities may draw water at any time during the day or night and this further contributes to the relatively high unit water use.

Population Density

Population density has an influence on the water demand in several ways. In the less developed areas, where stands are relatively large, densities may be low and walking distances may be relatively long. This may result in lower water use. As densification occurs, walking distances reduce but the number of people per abstraction point increases, limiting the volume of water used. In the more developed environments, where gardening activity occurs, densification results in smaller gardens and therefore a reduction in water demand.

In the less developed settlements, the average stand size is 1 200 m^2 to 2 000 m^2 and the stands are set out in an ordered fashion. The average number of stands per hectare equals approximately 3 stands/ha and this translates to approximately 20 people/ha. In Natal, rural settlements, which comprise dwelling units which are haphazardly sited, population density are in the order of 5 people/ha. With densification of the residential area, settlements with clusters of dwellings occur and population densities of up to 30 people/ha are experienced (Olivier et al, 1990). In these environments, taps are usually spaced at walking distances considerably greater than 250 m.

With stand sizes in the order of 1 200 m^2, the average number of stands/ha equals approximately 7, which translates to a population density of about 45 people/ha. Experience in the field, revealed that in most villages, street taps are sited such that walking distances are 250 m or more. In villages having a population density of 45 people/ha or more, the above street tap arrangement would result in high ratios of people per tap and would limit the water use. It is essential that in settlements of this nature, street taps should be spaced at not more than 200 m walking distance and at least 2 taps should be provided at each site.

In the low cost housing developments which are generally undertaken in the more developed environment, stand sizes usually range from 350 m^2 to 600 m^2. In these instances, population densities vary from about 50 people/ha to 90 people/ha. In these developments, yard connections are generally provided and therefore walking distances are less than 20 m.

Informal settlements, such as found on the fringes of the developed commercial and industrial centres, consist largely from make shift dwellings erected in a haphazard manner and these occupy small sites. Population densities of up to 250 people/ha occur (Olivier, 1990). Stand pipes are usually erected in these settlements or water is supplied from tankers. Walking distance is usually not the factor which limits water use. The excessively high population density and concentrations at the taps in terms of people/tap results in very low water use rates. This aspect is discussed in greater detail below.

In developments where households have a high level of living and the stand size is large, the area used for gardening is also accordingly large and therefore water demand increases significantly bearing in mind that the volume of water used for gardening may be as much as 20% of the total unit domestic water demand.

Indicators of excessive walking distances include washing done at the source and the extensive use of wheelbarrows. Interviews with household members in the Northern Transvaal during the course of this study, revealed that clothes washing occurred 2 to 3 times a week. The volume of water used to do the family washing amounts to about 40 litres per week. In cases where the effort involved in fetching water is excessive, families prefer to carry the laundry, which is considerably lighter than the water required to wash the clothes, to the water source. This is particularly the case where the water source includes a stream or river which is not highly turbid. Sufficient volumes of water are thus available to thoroughly rinse the clothes. Certain families however prefer not to do washing at the water source in view of the lack of privacy (Alcock, 1986).

Wheelbarrows are extensively used in areas where water abstraction points are located far from the home and therefore the burden of fetching water very high. A socio-economic survey undertaken in all the villages of the Thabamoopo district of Lebowa (Van Tonder et al, 1989), it was revealed that residents generally use about 90 l/household per day. As the walking distance increases, so the number of families owning a wheelbarrow also increases. About 60 % of families owned a wheelbarrow where the walking distance was in the order of 500m, but nearly 80% of families owned a wheelbarrow where the walking distance exceeded 1 000 m.

In general, water was previously collected by women or the younger female members of the household (El Kasha, 1989; Wiseman et a, 1988) however this situation has changed with changing socio-economic status, education and other cultural transformations. In certain societies however, the status quo has been maintained and water fetching is exclusively the task of the females of the household. A survey undertaken during the course of this project, by interviewing 100 households throughout the Northern Transvaal including KaNgwane revealed that water fetching occurs mainly in the morning and late afternoon. In more than 60 instances, water was fetched by women and girls of the household. Boys were responsible for water fetching in about 20% of the cases whilst men only fetched water in 9% of the cases. The survey also revealed that in cases where men fetched water, this occurred mainly in the Winterveld and other parts of Lebowa. In Gazankulu and KaNgwane men virtually never fetched water and the task is left to the female group. Children of school going age usually fetch water during the afternoon fetch when schools have closed for the day. In the Zulu society, it is the task of the women of the household to collect water (Alcock, 1989; Wiseman et al, 1988).

Water fetching trips per day

Water is usually fetched in the early morning and late afternoon and this gives rise to the characteristic double peak which is experienced in the daily water use distribution. Surveys conducted during the course of this project and the extensive socio-economic survey undertaken throughout the Thabamoopo district of Lebowa (Van Tonder et al, 1989) revealed that an average of 2 to 3 trips are made per day to fetch water. In the WSM survey undertaken for this project, more than 40% of the respondents indicated that 2 trips are made per day.

The number of trips made per day is related to the walking distance, water availability and queuing time at the water point. In the situation where the water is readily accessible, Alcock (1989) found that accessibility tended to reduce the need for home storage with frequent trips made to collect water as required. With long walking distances, several family members are involved in the main water fetching trip of the day and usually in such cases only 1 or 2 trips are made per day. (Antoniou) found that in Kahartoun and El Obeid in central Sudan a family living in an unplanned area located adjacent to low cost housing development, would make 5 or 6 journeys per day to fetch water. This would occupy a large percentage of the water fetchers daylight time. In general, as the effort to fetch water increases, so the number of trips made decreases.

People per water abstraction point

The number of people per water abstraction point has a major impact on the volume of water which the householder is physically able to draw from the tap in any one day and therefore significantly influences the unit water use. If it is considered that street tap water supply facilities deliver approximately 15 l/m, then it would take approximately 2 minutes to fill a 20l or 25l container allowing time for rinsing the container. As already mentioned, water collection does not occur for the full 12 hour (on average) daylight hours of the day but is restricted to an average abstraction period of 6 to 7 hours. The volume of water which may thus be drawn from the system is about 4 500 litre per day. One street tap can therefore adequately serve about 150 to 200 people and this implies about 25 to 35 households. The effort involved in drawing water from a hand pump or distant wind pumps is considerably greater than from a street tap and therefore these installation should only serve less than 30 households.

Wiseman et al (1988) found that in KwaZulu one hand pump was installed in each village regardless of whether 20 or 200 families were to be served. In a survey undertaken in more than 300 villages in the Mokerong and Bochum districts of Lebowa, WSM (1992, 1993) found that the average number of people per abstraction point exceeded 500 with a significant percentage of the villages having concentrations of more than 1 000 people/water abstraction point.

As the concentration of people per tap increases, so there is a rapid increase in the volume of water which can be made available to residents. Evidence of excessively high concentrations of people per tap are long queues of people waiting to draw water.

Stone (1984) showed that where the concentration was about 200 people per tap, water use equalled approximately 20l/c/d and this reduced to less than 10 l/c/d where concentrations in excess of 400 people/tap occurred.

The time people have to spend in queues at water abstraction points is directly related to the concentration of people/water abstraction point. Where concentration of persons per water abstraction point is excessive, ie. greater than 400 people/abstraction point, queues of more than 10 users occurs for prolonged periods even during off peak water collection periods. Queues may also be formed at water points were water shortages occur for extended periods. Here long queues occur but often only the water containers are seen lined up at the water point with the water fetchers not in attendance.

The number of families served by a street tap is also related to the population density assuming that street taps are installed such that walking distance does not exceed 200 m to 250 m as is now common policy throughout South Africa. Where stand sizes equal about 1 200 m^2, the number of stands located in the area described by a circle having radius 250 m would equal about 75 stands. This translates to more than 400 people. This is the average size stand in most villages and settlements and therefore the policy of establishing street pipes having maximum walking distance of 200 m would only be appropriate should two taps be provided at each water point, otherwise excessively high concentrations of people per abstraction point would occur. With decreased stand size, the walking distance needs to be reduced in order to ensure acceptable concentration of people per abstraction point.

Time to fetch water

The time to fetch water is related to the walking distance and the queuing time. The latter was discussed above and the topography is only significant in areas where gradients steeper than 1:10 to 1:15 occur. Indications are that time to fetch water per day with households making 2 to 3 trips per day equals about 40 minutes to 60 minutes assuming an average walking distance of 250 m. The average walking speed is about 40 m/min to 50 m/min (El kasha, 1989; Alcock, 1986). In certain instances, it has been reported that households would spend several hours per day collecting water. This situation occurs in villages and settlements where water supply facilities are exceptionally poor.

Rainwater harvesting

Rainwater collected from roofs and used for domestic purposes occurs in villages and settlements throughout the Northern Transvaal. This practice however only occurs in areas where other sources of water are not reliable and water shortages frequently occur. Rainwater collection also occurs in areas where the walking distance to alternative sources is excessive.

Collecting rainwater is only possible where residents have a dwelling unit with a flat corrugated iron roof. It is also necessary to have a gutter system which would intercept run-off from the roof and direct the water to the storage unit. Water is usually stored in one or more 200 l drums. Facilities to discard the initial run-off, which is usually polluted with dust and other debris, do not occur in most instances. The quality of water collected from roofs is therefore usually less than desirable.

Developing rainwater harvesting facilities is in general uncommon in view of the high cost involved. Limited storage is usually available due to the exhorbitant cost of providing storage in excess of 200l to 600l. Only a limited volume of water can be made available. Stone (1984) found that less than 2% of residents in villages surveyed trapped rainwater giving high cost of development as the limiting factor.

Water trapped from roofs is intermittent in view of the variability of rainfall in the Northern Transvaal and is therefore very unreliable. The volume of water trapped per rainfall event further negates development of this water source. Rainwater is sufficient to meet the need of the average family for about 3 days per rainfall event.

The average roof area of dwellings having corrugated iron roofs measures 60 - 80 m^2. 400 l storage implies a run-off of about 6mm. A rainfall event of at least 2 mm is required to initialise run-off in view of losses which occur in terms of roof wetting and storage in depressions in the roof. It is therefore evident that a rainfall event of some 8 mm is required to yield sufficient water to meet the needs of a family for 3 to 4 days. Review of typical rainfall statistics in the Northern Transvaal suggests that on average there are 5 - 7 rain days per summer season which exceed 2 mm and some 3 - 4 rain days which exceed 10 mm. During the winter months, the rain days which exceed 2 mm reduces to about 2 events per month. It was also noted that the rain days are concentrated in about 7 day intervals which would imply that every 10 - 14 days, an extended period of some 7 days occurs where no rain falls.

Rainwater harvesting therefore requires very large storage to improve the reliability and this makes the cost prohibitive when compared to the cost of developing a private borehole equipped with a hand pump. The latter option has been pursued by many households throughout the Northern Transvaal and this practice is gaining increasing popularity which supports the argument.

Rainwater is however considered to be a bonus by families experiencing extreme hardship in terms of fetching water from great distances or having to rely on a poor water supply system which suffers from frequent shortages.

The construction of dwelling units with corrugated iron roofs occurs in villages and settlements having a low/moderate level of living or better. Very few households however go to the expense of providing gutters. Alcock (1989) found that the mean percentage of households having gutters amounted to 35% in the Ximba ward of KwaZulu. Uys (1980) showed that in Mafikeng, which has a rainfall similar to many areas in the Northern Transvaal, a storage of some 9 000l to 13 500l would yield some 25 l/day to 40l/day. The cost of delivering this water amounts to about R 5.00 /m^3 (1980 prices). A privately developed borehole would yield significantly greater quantities of water at considerably less total cost and this is confirmed by the preference of water source development pursued by individuals.

6.2.3 Limiting Factors

Water Tariff

Paying for water significantly inhibits the volume of water used by households. This is borne out by the widespread use of a punitive water tariff structure, or sliding scale, to restrict water use in towns throughout South Africa, notwithstanding the fact that the percentage income expended on water by households enjoying sophisticated water supply facilities, is only about 2% or less. It must be noted that some communities are willing to pay considerably more for an improved water supply facility. Mu et al (1990) found that villages in certain parts of Thailand were unwilling to pay small amounts for the maintenance of either hand pumps or street tap systems, but were willing and did pay 8 to 9 % of their income for yard taps. The primary concern was to have water on the stands thereby eliminating the need to fetch water.

In a study of water consumption in 17 western states of the USA in 1980 it was found that the average per capita water consumption of unmetered water users was 50% higher than in the case of metered supplies (Department of Water Affairs, 1988). Several examples of the reduction in water use as a result of metering are available in South Africa. Typically reductions of 25% or more have occurred. The greatest reduction occurred where water wastage and a disregard or lack of appreciation of the value and scarcity of water prevails.

In Namakgale township located close to Phalaborwa, water use in 1977/1978 reduced by 51%, and in Seshego located adjacent to Pietersburg, a reduction of some 50% occurred in 1978 after meters had been installed. Several examples of the influence of water metering in large towns in South Africa such as Pietermaritzburg and Port Elizabeth are sited by the committee which reported on water demands in the Vaal River supply area (Department of Water Affairs, 1988). Reductions of more than 27% were noted. In Umlazi during the late 1970s, the effect of metering, but with poor administration in terms of reading meters and timeously sending out accounts on a regular basis, showed a less dramatic reduction in water use. It is therefore the payment of water which significantly reduces water use and not only the installation of water meters.

Assessment of water supply facilities throughout the Northern Transvaal revealed that water metering only generally occurs in the proclaimed towns in Lebowa, Gazankulu and KwaNdebele and on all stands having yard connections in Venda. Reading of the meters and sending out regular accounts is very erratic and has little or no influence on the water use rate.

The purpose of charging for water used, is to discourage waste and high water losses, irresponsible use and to promote an awareness of the scarcity of water. Charging for water delivered is also necessary in order to generate income so as to ensure the sustainability of the water supply facilities. In determining the water tariffs, political and social considerations however frequently overruled economic and financial principles in the past.

Several tariff systems are available for consideration and include the flat rate fee whereby households are required to pay a fixed monthly fee regardless of the volume of water used. This system is favoured in areas where stand pipes or hand pump facilities are in place. Dissatisfaction however sometime prevails because residents who live closest to the water point, have better access and consequently use more water than families who reside further away. A system of progressive tariffs with higher rates payable for use above a certain level is the general practice in areas having yard or house connections.

Tariffs should be realistic and not be heavily subsidized as is currently the case in Lebowa and Gazankulu where residents having house connections are charged only 18 c/m^3.

Accounts are seldom payed in most instances, due to the poor level of service offered, ie. water shortages frequently occur, and due to the fact that meters are infrequently read and accounts are sent out at irregular intervals. In some cases, households only receive 1 or 2 accounts per year.

In areas where the officially developed water supply system is very poor, private water sellers perform a vital function, although charges for the water delivered is exhorbitant. The charges are in relation to the availability of water but vary from 20c to 40c for a 25 l container and R 3 to R10 for a 200l drum. Numerous households have developed private boreholes on their stands which are employed for private use as well as selling water to neighbours. In areas where many private boreholes occur, charges are in the order of R 5/family per month and may increase to R 10 /family per month where water is scarce. The water is in many cases also sold in accordance with the actual volume of water drawn. In areas where alternative but polluted sources of water are available, households usually elect to use bought water for high grade purposes such as cooking, drinking and dish washing and the alternative source is used for clothes washing and personal hygiene. The volume of bought water in these instances would be in the order of 5 l/c/d.

A key element of water tariffing to ensure its successful implementation and sustained practice is that the service must be reliable and that administration in terms of metering and sending out accounts should be faultless. Affordability and willingness to pay is of lesser importance. This is borne out by the fact that numerous communities pay 10 times or more for water than would residents in metropolitan areas having treated water delivered in several rooms of their houses.

Water sellers not only charge exhorbitant fees for water delivered, but also risk contaminating the water delivered. It is further noted that water sold is drawn from sources used by other communities. These communities therefore have to compete for the limited available water and often find themselves standing in long queues whilst the water seller is filling large containers.

The elasticity of water use varies with the volume of water used by the household and the tariff. There is high elasticity in the case of high water user groups. A significant reduction of water use occurs with a relatively small increase in the charge for water used. The water users which use small quantities of water, that is less than 20 l/c/d show little elasticity. This especially applies to households using less than 10 l/c/d. People require a minimum basic amount of water per day to sustain life. This volume of water will be obtained regardless of the cost or effort. Large increases in the price paid for the water is accompanied by little or no decrease in the volume of water used (Kinnear, 1987).

A study in Mozambique (Katko, 1991) revealed that the higher the number of persons per household, the smaller the per capita water consumption. The concept of supply and demand is fundamental and applicable to water and the charge made for the water delivered. When the price of the commodity (water) increases, so the volume bought decreases. The rate of decrease of the volume bought however diminishes until the minimum cutoff point is reached where no further decrease occurs regardless of the amount paid for that volume.

Topography

Steep topography may significantly inhibit water use. Considerably more effort is required where water fetchers need to traverse areas having steep gradients particularly when the full containers need to be transported in the uphill direction. This situation is often the case in view of the fact that residents prefer to construct dwellings at mid slope or higher. The water source which often includes rivers and springs, is usually located at lower elevations. In the case of street tap developments, these are usually located close to the bulk water supply line which is normally constructed at the base of the hill slope.

Interviews with residents in areas where topography is steep showed that gradients in excess of 1:15 result in increased water fetching effort. Grades steeper than 1:8 are problematic. Observation has shown that in areas where grades are particularly steep (1:8), a walking distance of only 100m would be considered excessive. In these instances residents mostly elect to reduce water fetching effort by doing clothes washing at the source. Street tap spacing in these areas should therefore preferably be less than 100 m.

Water Quality

Excessively high salinity, measured as total dissolved solids (TDS) or electrical conductivity (EC), in domestic water would significantly reduce the actual water use. In areas where TDS exceeds 1 500mg/l residents would prefer to purchase water for cooking and drinking from a water seller and use the salty water for other purposes. In many cases the hardness of the water is a problem and water for clothes washing is obtained at high cost from other sources in view of the difficulties of forming a suitable lather with salty water.

High nitrates, which cause methaemoglobinaemia (blue babies) in young children, is seldom recognised by communities as a problem and therefore does not affect water use. Similarly high fluorides, which cause staining of teeth and crumbling of bone, is seldom recognised by communities as a problem and therefore does not affect water use.

Ground water containing excessive levels of salts and which is considered unsuitable for domestic use by residents, occurs throughout the Northern Transvaal for example in parts of Mokerong, Nebo, Sekgosese, districts of Lebowa and in certain parts of Venda and Gazankulu to name but a few (refer to several River Basin Studies undertaken by the Department of Water Affairs and Forestry). As salinity increases, so unit water use reduces.

High nitrates and fluorides occur mainly in the Nebo district of Lebowa and the Kutama Sinthumule district of Venda.

The SABS drinking water standards specify an upper limit of 2 000 mg/l, for TDS, 44 mg/l for Nitrate (as NO_3-) and 1.5 mg/l for fluoride.

6.2.4 Water Availability

The water availability, ie the frequency of water shortfalls or level of water supply assurance, significantly influences the actual volume of water used by the domestic water consumer. Clearly, in areas having limited water supplies, competition for the available water is high and therefore the volume available to individual households is limited. Sources of water generally used for domestic purposes include ground water and surface water.

Ground Water

Water supplies for domestic purposes for most residents in the Northern Transvaal is drawn from ground water. This source is favoured in view of the relatively low capital expenditure required to develop the source, short planning period required and limited time required to develop and implement the scheme. It is also possible to equip boreholes with low technology equipment.

Ground water is a dispersed water resource and occurs in varying quantities in each village and settlement. The volume of water available for abstraction however varies significantly and extensive areas of the Northern Transvaal have proved to have a low ground water potential (Haupt, 1994). Examples of areas which in general have a low ground water potential include Nebo, Sekukuneland, Sekgosese and Bolebedu, Mokerong 1 & 2 districts of Lebowa and KwaNdebele in general.

Areas which have a low ground water potential also generally have a poor drilling success rate. Boreholes found in these areas can invariable only be equipped with hand pumps. The development of this resource is not only expensive, but in many cases the hand pump facilities are inappropriate and do not meet the needs of the communities. In Thailand for example, (Mu et al, 1990) residents undertook to pay for yard connections, but were unwilling to pay for supplies drawn from hand pumps. In the Mokerong 1 & 2 districts of Lebowa, wind pump and hand pump facilities were sabotaged in protest and agitation for improved water supply facilities (WSM, 1992).

In other areas, where boreholes have been equipped with diesel or electric driven pumps, many instances occur where the volume of water abstracted exceeds the yield of the borehole. In such cases, the pumps suck air and are incapable of meeting the water demand of the community. As a result, long queues form at water abstraction points and residents are forced to share the limited water available. The actual water use is considerably less than the water demand.

Surface Water

Rivers, streams and springs are fed from rainfall induced surface run-off processes, and water availability fluctuates in accordance with climatic conditions. Water shortages occur when the total demand exceeds water availability. As described above, water shortages then frequently occurs and negatively influences the volume of water available for actual use. The Northern Transvaal is a water scarce area and stream and river flow is highly variable due to the high variability of the rainfall. Water supplies from surface water are therefore limited.

In a limited number of cases, large regional schemes have been developed where water is drawn from a bulk source such as a major dam or river abstraction works. The water is distributed from these works through extensive pipe networks to numerous villages and settlements. Apart from the fluctuating water availability due to climatic conditions, excessive wastage and problems due to operation and management of the scheme, results in water shortages occurring in villages which are not favourably located in the scheme. Limited quantities of water reach these villages or parts of these villages due to inadequate pressure or low volume of supply. Residents in these areas suffer frequent water shortages for extended periods. The volume of water available for domestic use is therefore significantly less than actual demand in these areas.

6.2.5 Water loss

Water losses varying from 20% to more than 3 times the volume of water delivered to a community for domestic use, has been recorded. Water is extremely scarce and limited in most areas of South Africa and high losses deprive needy communities or individual households who presently receive little or no water. Water losses are therefore responsible for reducing the volume of water made available to individuals.

Water losses are caused by poor maintenance of water distribution facilities and a disregard of the value and scarcity of the water by communities or individual households who have the benefit of excess water. This situation is aggravated in areas where water distribution facilities are in poor condition and where pressures are excessive. Consumer meter malfunction also contributes significantly to the uncounted for water.

The extent of water losses in the less developed areas, has only been measured and reported on in a limited number of instances (Schmidt, 1989; WSM, 1992) due to the inadequacy or nonexistence of water metering facilities.

Water losses occur, although at varying degrees, on all the water distribution systems which include street tap facilities, unauthorized yard connections, yard and house connections and on bulk distribution systems.

Street tap systems

Water losses at street taps occur due to spillage and splashing whilst filling containers and also includes discard water used for rinsing containers. Musetshu (1994) measured the volume of water lost at several street tap points in Venda and found that the loss amounted to about 10%, ie about 2 l/c/d.

A much greater loss occurs at street taps however, includes wasteful practices such as taps which are not closed properly or taps which are poorly maintained. In areas where water shortages often occur, taps are left open so as to alert residents when the service is restored and water is available in the system once again. Huge losses occur and may amount to more than 10% of the volume delivered in the system.

Pirate connections

In a large number of villages and settlements, residents have become dissatisfied with having to fetch water from a street tap. In these instances, no procedures are available, excepting in Venda, for residents to apply and have a yard connection installed. Residents have thus taken it upon themselves to make their own unauthorised connections to the bulk water reticulation. These connections are usually crudely made and generally comprise a pvc pipe inserted in a hole punched in the bulk water pipeline using a pick or similar tool. The joint is usually sealed by using car tubing tied with wire. Losses in excess of 100% of the volume of water delivered has been noted (WSM, 1992).

Yard and house connections

Water losses occur as a result of wasteful and indiscriminate water use practices and poor maintenance of facilities such as taps and toilet valves. In areas which experience frequent water shortages, taps are usually left open in order to alert the household when the service is resumed. It is usual in these areas, that water shortages occur for most of the daylight hours and that flow of water in the pipes occurs only after dark.

Residents having lawns usually leave their sprinklers on at night in order to benefit from the water availability during night hours. Garden watering is therefore totally uncontrolled and excessive quantities of water are applied. Residents which follow this practice do not pay for water and therefore there appears to be no incentive to be mindful of the scarcity of water.

In areas where water metering does however occur, inaccurate meters may account for 15% or more of the total unaccounted for water (Schmidt, 1989).

Bulk water distribution networks

These networks may suffer from excessive water losses which may exceed 60%

(Schmidt, 1989). Water losses occur from pipe bursts, invisible leaks from small breaks in bulk water pipelines particularly in sandy areas, leakage from minor reticulation and leakage from poorly maintained air valves, pump stations, break pressure tanks and other storage units. Disciplined house keeping and regular maintenance should reduce these losses to less than 10% of the total volume of water conveyed.

6.2.6 Health considerations

It is generally considered that a volume of water ranging for 10 l/c/d to 25 l/c/d is required to reduce infant mortality and reduce the risk of water borne diseases (Wiseman, 1988; Van As et al, 1981; Horne Glasson, 1989). It has however also been shown that provision of clean water in adequate quantities alone, does not significantly improve the health status of a community (Van As, 1981; Hall et al, 1991).

Several studies have shown that pollution of the water occurs at the dwelling rather than at the source. Water amounting to approximately one days use per household is generally stored in the home. Water is scooped from the storage units, which are often open, using a cup or similar vessel when required. Dogs and other animals are also known to drink from these containers.

In order to improve the health status of a community, it is essential that the provision of adequate quantities of water be accompanied by an extensive and thorough training programme concering basic hygienic practices. This practice is extensively followed in Lesotho amongst other places (Hall et al,1991).

Provision of significant quantities of water should also be accompanied by adequate means of disposing of the waste water. This is particularly the case where large volumes of water are used for sanitation and personal hygiene. In several villages in Egypt, El Katsha (1989) reports that residents, although mostly having washing machines, prefer to do their clothes washing in the nearby irrigation canal. Population densities are high and no facilities or sites are available for the disposing of dirty water from the washing machines.

7 VALIDATING THE DOMESTIC WATER DEMAND MODEL

7.1 INTRODUCTION

Based on the assessment of the various factors which influence domestic water demand and the discussions above, it was hypothesized that :

- Water demand = f (value orientation, tariff)

The actual water use is however quite often considerably less than the estimated water demand. This is due to certain factors which inhibit water use and include access and other limiting factors discussed earlier.

Value orientation describes the prosperity and self esteem of the community. Prosperity gives an indication of the capacity of the community to aquire or develop dwellings having facilities which use increased volumes of water such as kitchens and bathrooms, or to buy water using household equipment and to develop gardens. Self esteem and the desire for comfort and convenience results in more attention paid to personal hygiene, aquisition of clothes and clothes washing, desire for improved house and garden, insistence on reduced water fetching distance and the need for improved toilet facilities.

Value orientation is complex as it encompasses the diversity of human needs and conditions and is further obscured and distorted by political and socio-economic influences. Consequently, a large data set is required to validate relationships which describe water demand in relation to value orientation. The data required includes mainly socio-economic related information. The collection of this type of data is labour intensive, time consuming and very expensive. Obtaining accurate information with regard to income level is also made difficult by inaccurate responses. The data sets available for use in this project were limited and made interpretation of the results to a high level of confidence difficult, if not impossible in certain cases. The results were nevertheless revealing, informative and useful.

Factors which inhibit water use are physical and can be measured and monitored. These factors include type of water supply system, water metering, water shortages, water availability, topography and water quality. Relationships which include these factors show little scatter and the data collected for this project proved to be adequate to obtain results of reasonable confidence level.

7.2 VALUE ORIENTATION OF THE DOMESTIC WATER USER

Value orientation is considered to be of primary importance in understanding the domestic water user in that it determines the actual volume of water required by individuals and ultimately by the community. Value orientation is difficult to quantify in view of the large number of intervening variables which determine the values held by individuals. The political and socio-economic situation in South Africa has also had a major impact on the community in terms of its development, priorities and attitudes regarding the use of water.

Value orientation is best described by quantifiable indicators which may reveal the value orientation of the water user group. A large number of indicators were identified during the course of this investigation. The validity and usefulness of the indicators were examined by reviewing and assessing data and information available which describes these indicators in terms of income level and other key factors.

The indicators may be grouped into two main categories although it is recognised that a degree of overlap occurs between the two categories. The one category comprises indicators which describe monetary values and the other describes the individual's makeup and attitudes.

The indicators which reveal the prosperity of the water user group include income, education, housing type, gardening activity, agricultural activity, population size and density and business activity. Indicators which may be used to determine the nature, make up and attitudes of the water user include extent of electricity connections, extent of pirate connections, education level, child mortality, household size, garden and housing development, agricultural activity, institutional structure and population.

Housing types include the following groupings :

Level of Development	Status index	Building Layout	Wall construction	Roof Construction
Mostly limited traditional dwellings ranging to cement block dwellings	1	clustered	traditional materials, untreated cement blocks	thatch, corrugated iron
Untreated cement block	2	Single	Untreated cement block	Corrugated iron, flat
Limited painted cement block	3	Single	Limited dwellings with plastered and painted surface	Corrugated iron, flat
Painted cement block, informal housing	4	Single	Most dwellings plastered and painted, temporary informal structures	Corrugated iron, flat
Painted cement block, limited western, improved informal	5	Single	Surfaces plastered and painted, limited brick.	Corrugated iron (flat), limited tile (pitched)
Moderate western, small stands	6	Single	Plastered and painted cement block, brick	Corrugated iron (flat), mostly tile (pitched)
Western, large stands	7	Single	Brick	Mostly tile, pitched

Indicators which relate to the prosperity of the community are considered important because these indicate the ability to improve the home in terms of including increased water use facilities such as kitchens and bathrooms. Indication of the ability of the household to purchase water using household equipment and other utensils which would require the use of additional water may also be had. Furthermore, it is argued that households enjoying more favourable income levels, could afford the benefit of a garden which naturally requires increased water use.

Indicators which define the water user group's identity, nature, attitude and general make up are all related to the average status or condition of individuals which make up the community. The status described by these indicators concern values attached to personal hygiene, improved clothing and therefore a need for increased clothes washing activity, elaborate entertainment, improved gardens, reduced effort in terms of fetching water and including access to other services, and the desire for improved toilet facilities. As the values of individuals change, so the various desires and needs mentioned above increase, which in turn is accompanied by increased water demand.

The interrelationship between the various indicators of the two groupings is in several cases fused. For example, attaching greater value to clothing and appearance can only be realized in practice if sufficient funds are available to acquire clothes and other material acquisitions. It is further noted that the value criteria is dynamic and shifts with time. As conditions change in terms of family structures, employment opportunities, distance to work place and numerous other factors, so values alter and change.

Most of the indicators which are prosperity or material orientated, are influenced by prevailing political and socio-economic conditions. The value systems are in accordance with personal taste and are therefore choice related. The mind set and attitudes which have evolved as a result of political developments in South Africa has significantly influenced the attitude, approach and values of developing communities. These conditions are likely to change rapidly with the enormous political changes which have occurred during recent times. Values can therefore be considered to be in a state of flux and this complicates quantifying indicator

In order to understand the influence of value orientation, and consequently the freedom of choice in terms of water use, it is necessary to consider the use to which water is put.

7.3 USES OF WATER

Water is said to be essential for life, but in reality only a small percentage of our daily water needs are essential for our survival. Water required for dishwashing, clothes washing, personal hygiene and garden watering are not seen as essential human needs, but rather as satisfiers of fundamental human needs.

The various uses to which water is put therefore varies from one community to another dependant on the general values held by that community. The uses include cooking, drinking, dish washing, house cleaning, clothes washing, personal hygiene, sanitation and garden use. Domestic water users, which have a very high level of living, would also require water for, amongst other things, pool maintenance.

7.3.1 Drinking water

Various studies have been undertaken to determine the volume of water used for drinking (Horne et al 1989; Bourne et al, 1992; Alcock, 1989). Indications are that some 1 to 2 l/c/d is used regardless of level of living, value orientation or home environment.

Naturally, communities which extensively entertain, or which rely significantly on beer brewing as an income, would show increased drinking water use rates. The possible increased drinking water in excess of 2 l/c/d would have a negligible impact in terms of the total water demand.

7.3.2 Cooking

The volume of water required for cooking is related to the cooking facilities available and the number of meals prepared per day. Generally, communities having a low level of living, would be limited by cooking facilities and utensils and therefore a low water use amounting to about 1 l/c/d is recorded (Van Tonder et al, 1990). With improved living conditions, an increase to about 2 l/c/d occurs. El Katsha (1989) reported that women cooked once a day and baking was done once a week. In this case water was used sparingly in cooking and often vegetable wash water was reused to wash cups or other utensils. Interviews in the Seshego district of Lebowa during the course of this study revealed that in general, two meals were prepared per day.

7.3.3 Dish washing

Available information would suggest that water required for dish washing increases significantly as the level of living improves.

The volume of water required for dish washing is related to the available cooking facilities and number of pots used, number of meals prepared per day, cutlery and utensils available and the extent of entertaining guests. Indications are that communities having a low to moderate level of living used about

2 l/c/d (Van Tonder et al, 1990). Water users in the high level of living group use about 10 - 15 l/c/d. The use of dish washers would be included in the latter category (Emmett, 1990).

Interviews undertaken in the Seshego district of Lebowa during the course of this study revealed that dish washing occurred more frequently in the morning and afternoon with fewer families washing dishes at night. The average volume of water used by a family having a moderate level of living, amounted to about 2 l/c/d with the largest volume of water used during the afternoon wash. Similar results were obtained from a socio-economic survey undertaken in the Thabamoopo district of Lebowa (Van Tonder et al, 1989).

7.3.4 House cleaning

The volume of water used for house cleaning including floor and window washing is limited and shows moderate variation as level of living improves. Indications are that in communities where water availability is limited, much of the water required for house cleaning, was first used for other purposes. Alcock (1986) noted that water may first be used to wash clothes and other household items before it is used to clean the floor. This water may then ultimately be used in the garden.

7.3.5 Clothes washing

As the level of living improves, so the extent of the wardrobe of the water consumer improves and the value for improved appearance in general increases. There is a positive relationship between income level and expenditure on clothing. Note that expenditure data showed that the lower income groups spend proportionately more on clothing than the higher income groups (Urban Econ, 1991). Increased volumes of water are required to wash clothes and indications are that the frequency of washing the clothes increases.

Clothes are usually washed twice a week (Alcock, 1986) and this is supported by interviews conducted in the Seshego district of Lebowa during the course of this study. The latter survey showed that Saturdays appeared to be the most popular day for washing clothes in the area surveyed.

The survey mentioned above and a socio-economic survey undertaken in the Thabamoopo district of Lebowa, (Van Tonder et al, 1990) revealed that communities having a low to moderate level of living, used about 120 l/household per week on washing clothes which equals about 3 l/c/d.

In areas where the effort involved in fetching water for washing clothes exceeds the acceptance level of the water user, persons responsible for washing clothes, which are usually the women of the household, would elect to wash clothes at the water source. Typically this would include rivers, streams or distant hand pumps or wind pumps. In a number of cases, street taps are also very widely dispersed and therefore clothes washing may be undertaken at the street tap.

7.3.6 Personal hygiene

Water is required for personal hygiene which would include washing of hands and face at various times during the day, cleaning teeth and bathing or showering. As the level of living improves, so households are able to afford improved washing facilities which would ultimately include a bath and/or shower.

Water used for personal hygiene is one of the largest water use components in the total domestic water use spectrum and overshadows all other uses except in cases where large gardens are watered. The volume of water used for personal hygiene shows a rapid and huge increase as the level of living improves. As income levels increase, level of living improves and the importance attached to personal hygiene increases, so the desire to have improved washing facilities also increases. The increased level of living is accompanied by a dramatic increase in the volume of water required for personal hygiene.

Domestic water users having a relatively low level of living would use less than about 14 l/c/d. In areas where water shortages frequently occur, a significant percentage of this water would be reused and personal washing would of necessity occur less frequently.

The percentage water required for personal hygiene amounts to more than 50% of the total water demand. In the case of the high level of living water user group, a nearly 10 fold increase in water required for personal hygiene occurs. Water demand for bathing and washing amounts to about 90 l/c/d which equals some 40% of the total water demand of this group.

7.3.7 Sanitation water

Sanitation facilities using water as a medium for disposal is only available to consumers enjoying a moderate to high and better level of living. Consumers in the lesser income levels, use pit latrines and no water is required excepting for hand washing. This water use is included in the personal hygiene component.

The increased water use for sanitation purposes as level of living improves as shown in table 2, is as a result of improved access to toilets. In many of the low cost housing developments, toilets are erected outside the dwelling. Indeed in many cases, toilets with water borne facilities are installed in toilets previously having buckets or other disposal facilities. The very high income group is assumed to have several bathrooms. Entertainment also contributes to increased water use for sanitation for this latter sector.

7.3.8 Garden water use

Gardens are a major contributor towards the total volume of water required for domestic purposes. Indications are that humans have a natural desire to improve and beautify their home environment. Field surveys undertaken in more than 400 villages in the Mokerong district of Lebowa, parts of Venda and the whole of KwaNdebele; revealed that garden activities were evident in all villages having a moderate and higher level of living. In areas where extreme water shortages occurred, indigenous plants which use very little water were selected and used in the garden. The enthusiasm for gardening is therefore apparent.

As the level of living, income level and value orientation changes, so the desire for an improved garden and the enthusiasm for gardening increases. The maintenance of vegetation requires enormous amounts of water, and the volume required increases significantly in the hotter climates. In the Northern Transvaal, active plant growth commences in August/September when temperatures have increased after the moderate winters. The first rains however, only occur in late September and early October. Furthermore, the exceptionally high average temperatures which occur during the months December, January and February and the relatively low rainfall, necessitates exceptionally high water application rates in order to prevent wilting of plants and lawns.

A study by Van Duuren (1974) showed a good correlation between total water use and values of properties in Pretoria. The increased water use of the higher property cost level suburbs, may be ascribed mainly, but not exclusively, to increased gardening use. This trend is reflected in Table 2 and analysis of the relationship between volumes of water used for domestic purposes in several towns of the Northern Transvaal compared to the volume of sewage return flows (WSM, 1990), would suggest that the volume of water required for gardening activities by the high level of living water user groups amounts to about 100 l/c/d. A study of the water use in various flats and residential homes in Pretoria (Malan, 1988) and research into the volumes of water abstracted from ground water sources for gardening purposes (Simpson, 1990) indicated that as much as 200 l/c/d may be used for gardening purposes by the very high income group. Households having a borehole used an average of about 470 l/c/d from the borehole (Simpson, 1990). Garden watering in USA amounts to about 3 000 l/d/ha and this equals about 100 l/c/d used on 1 000 m^2 garden based on a 3 person household (Thwart et al, 1976).

TABLE 2 : UNIT WATER USE FOR VARIOUS DOMESTIC ACTIVITIES

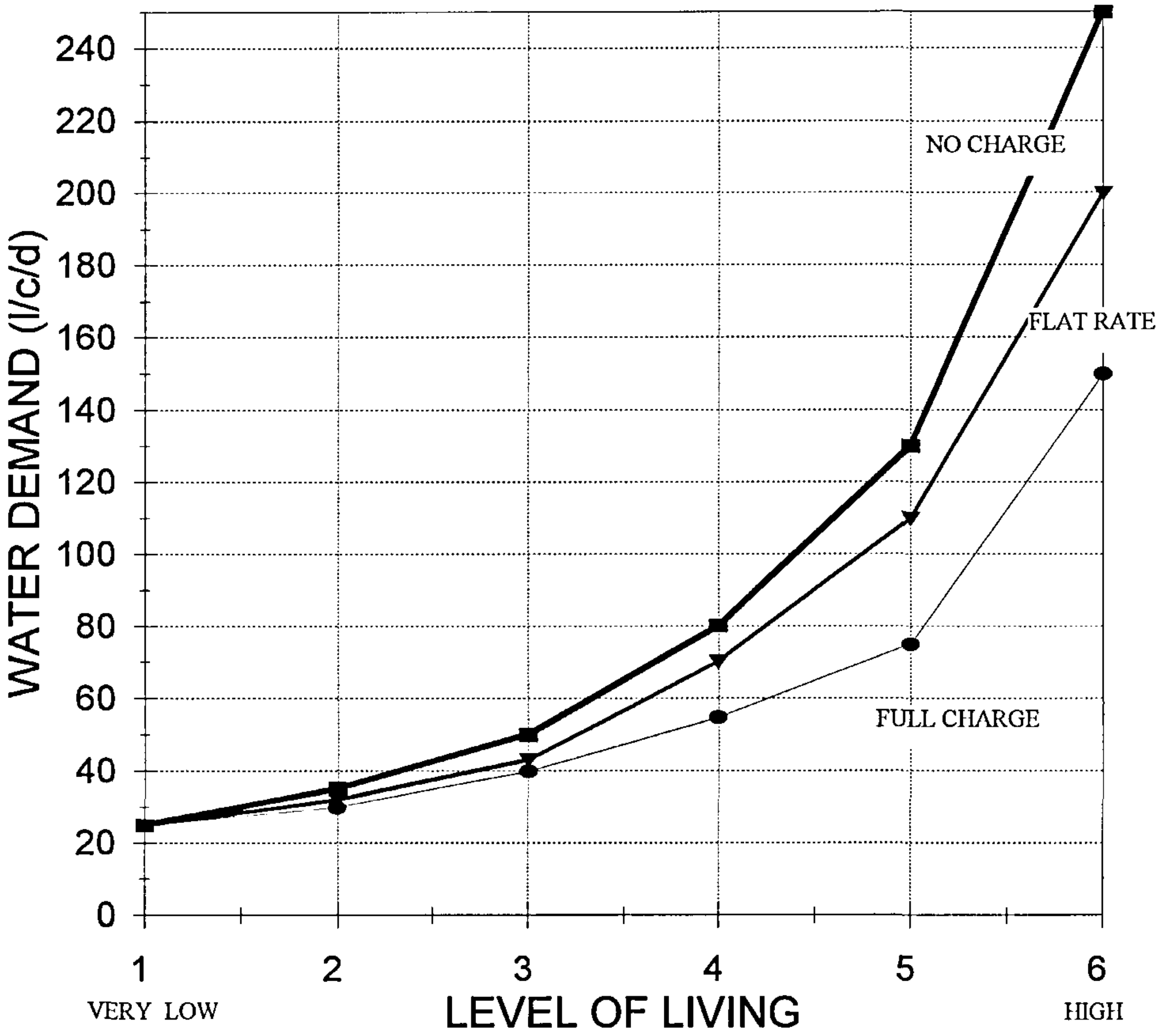
DEVELOPMENT LEVEL		UNIT WATER USE (l/c/d)									
		DRINK	COOK	DISH WASH	HOUSE WASH	CLOTHES WASH	BATH/SHOWER	GARDEN	TOILET	POOL	TOTAL
Subsistence • Traditional dwellings • Limited mud/cement block walls • Clustered		2	1	2	1	2	7	0	0	0	15
Very Low • Limited traditional dwellings • Cement block walls • Clustered	1	2	1	2	1	3	15	0	0		25
Low • Cement block walls • Limited garden	2	2	1	2	1	3	16	10	0	0	35
Low to moderate • Limited painted cement block walls • Moderate gardens	3	2	2	3	1	4	20	18	0	0	50
Moderate • Painted cement block walls • Extensive gardens	4	2	2	4	2	4	40	26	0		80
Moderate to high • Limited western housing • Painted cement block • Extensive gardens	5	2	2	6	2	5	60	48	5	0	130
High • Extensive western housing • Small stands • Extensive gardens • Moderate flush toilet	6	2	2	10	3	6	92	100	30	5	250
Very high • Western housing • Large stands • Extensive gardens • Fully reticulated	7	2	2	15	5	8	163	200	40	15	450
Flat dwellings : Low • Low development level • High density development		2	2	10	3	6	90	5	30	0	148
Flat dwellings : High • High development level • Low density development		2	2	15	5	8	160	10	40	0	242

7.4 WATER TARIFF

Having to pay for water significantly reduces the water demand and consequently the volume of water used by households. It is generally agreed that pricing mechanisms are an effective means of conserving water (Kreutzwiser et al, 1989). A policy decision has recently been made by the Department of Water Affairs and Forestry to recover at least the operating and maintenance costs of delivering water. The purpose of charging for water is therefore two fold viz, to discourage waste, irresponsible water use, limit water losses and to promote an awareness of the scarcity of water. Secondly, charging for water delivered is required in order to generate income so as to ensure the sustainability of the water supply facilities.

Two basic tariff systems are in general use and include the flat rate fee whereby households are required to pay a fixed monthly fee regardless of the volume of water used and the other is based on charging for water in relation to the volume of water used. Quite often, the latter tariff systems is combined with a sliding scale which makes provision to charge higher rates for use above certain cutoff levels. This tariff system is particularly effective in terms of curbing wasteful and irresponsible water use practices.

Charging for water significantly reduces the water demand. The degree of reduction varies in accordance with the tariff type as well as the level of living or in other words, the water demand level. Water users which have a relatively low level of living, and therefore have a modest water demand, display a small reduction in water demand should water be charged in relation to the actual volume of water used. The reduction is marginally less should the flat rate system be applied. On the other end of the scale, communities which have a high level of living and therefore have a high water demand, experience a reduction of 30% or more, should the sliding tariff system be applied. The reduction is only about 10 to 15% should the flat rate fee be applied (see figure 9).



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EFFECTS OF WATER TARIFF ON WATER DEMAND

FIG 9

8 GUIDELINES FOR THE ESTIMATION OF PRESENT DOMESTIC WATER DEMAND

8.1 INTRODUCTION

Domestic water requirement, varies not only in accordance with level of living and value orientation as discussed above, but also diurnally, weekly and seasonally. In order to ensure effective delivery of potable water to domestic water users, it is therefore necessary that procedures and guidelines be given which would facilitate planning and design of water resources development, abstraction works, treatment works, bulk water conveyance system and distribution facilities.

The average annual daily demand is the total volume of water required by the domestic water user in a year divided by the number of days in a year. Water losses from the system are excluded from this value. During the summer months, water demand may be significantly higher than the average daily demand value and the difference is expressed as the average daily demand multiplied by a summer peak factor. Variations in water demand however also occur during the course of the day and therefore the flow capacity of the system should be adequate to cater for the instantaneous peak water demand. The design peak flow rate is determined by multiplying the summer daily demand value by a daily peak factor.

8.2 AVERAGE DAILY WATER DEMAND

Domestic water users require water for several different household purposes but the main water usage is for personal hygiene, sanitation and garden use. The volume of water required varies in accordance with the value orientation of the user. As values change and the level of living of the community rises, so water demand increases. Communities which have a relatively low level of living would require less than 25 l/c/d. Rapid increases in water demand occur with rising level of living and reaches more than 200 l/c/d for communities having a high level of living.

In order to estimate water demand it is therefore necessary to determine the value orientations of the community. The value orientation of individual households which comprise a community, varies widely in view of the diverse nature of human beings.

It is therefore difficult to conclusively define the value orientation of a community. A number of indicators are therefore provided which may guide the planner, designer and developer to determine the approximate value orientation and level of living of the community.

The indicators vary in nature. Certain of the indicators are transparent and information may readily be obtained from cursory field visits. Data and information for yet other indicators is obtainable from existing databases such as the census statistics. Information of the third category of indicators can only be obtained by undertaking extensive, time consuming and expensive surveys. The indicators include income level, education and population.

The characteristics of the community, based on as many of the indicators as possible, should be determined. The average plot of the values against value orientation index would yield the approximate status of the community (refer to Table 3). The approximate estimated unit water demand may then be determined from Table 2 or Figure 10.

The confidence placed on the estimate of the value orientation of the community would be based on the extent of information available of the various indicators. Confidence levels diminish with fewer indicator values known. With limited information available of the indicators, it would be prudent to err on the conservative side by assuming upper levels of development.

The estimated water demand would be significantly reduced should it be known that the domestic water user has to, or will have to pay for water used. In such instances, wastage and indiscriminate usage of water is lessened. The volume of water used for personal hygiene, sanitation and gardening is considerably reduced. The degree to which water use is limited is related to the type of tariff and level of subsidy applied. The greatest impact on water demand occurs where residents pay the full rate and payment is based on the volume of water used. Residents are also charged increased rates, based on a sliding scale, for exceptionally high water usage. A lesser impact is experienced where water users, who draw water from hand pumps or street taps, are charged a flat fee regardless of the volume of water used.

TABLE 3 : VALUE ORIENTATION (LEVEL OF LIVING INDEX) OF THE COMMUNITY

LEVEL OF LIVING INDEX	1	2	3	4	5	6	7
VALUE ORIENTATION	VERY LOW	LOW	LOW TO MODERATE	MODERATE	MODERATE TO HIGH	HIGH	VERY HIGH

INDICATOR	INDEX						
Income (R/household/m)	< 300	300 - 600	500 - 1 000	700 - 1 300	1 000 - 1 700	1 300 - 2 500	> 2 500
Education (% with no education)	> 50	45	35	25	15	< 5	0
Housing type	Limited traditional, untreated cement block, clustered	Untreated cement block	Limited painted cement block	Painted cement block/informal housing	Painted cement block/limited western/ improved informal	Moderate western, small stands	Western, large stands
Gardening activity	None	Limited	Moderate	Moderate	moderate to extensive	Extensive	Extensive
Agricultural activity (LSU/person)	> 0.7	0.6	0.4	0.2	0	0	0
Population	< 1 000	2 000	3 500	5 000	8 000		
Business activity in dormitory towns	Extensive	Extensive	Moderate	Moderate	Limited	Limited	Limited
Electricity connections (% household)	0	0	10	35	50	80	100
Pirate connections (% household)	0	20	50	70	90	100	100
Household size (people per household)	> 8	7	6	6	5.5	4.5	4

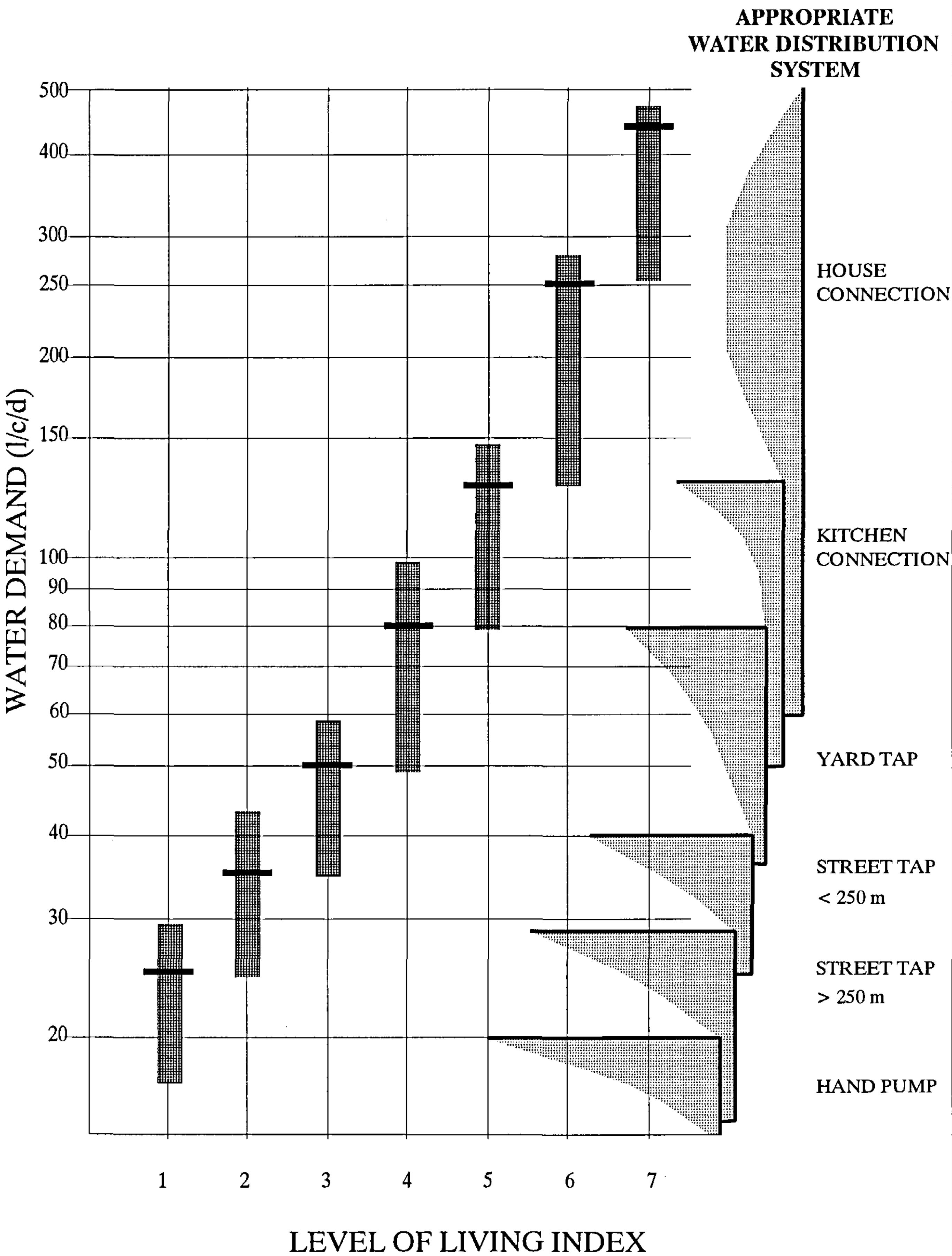

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FIG. 10

The impact of payment for water used, on the estimated water demand is given in Figure 9.

8.3 DAILY PEAK WATER DEMAND

8.3.1 Overview

A review of information obtained from data loggers located on bulk water pipelines which deliver water to several towns in the Goldfield Water supply area (Lottering, 1994), Naboomspruit, villages in the Mooketsi area and Umlazi (Schmidt, 1989), revealed that two distinct peaks in the daily distribution of water use occurs. This pattern of daily distribution of water use occurs regardless of the type of water supply system in use and the peak occurs at about 7-8 am and 4-7 pm. This observation was also made by Alcock (1989) whilst monitoring water use in the Ximba ward of KwaZulu.

The daily distribution of water use is influenced mainly by the water collection habits of the domestic water user group. As reported earlier, residents who have to fetch water from water points located outside their homes, generally make 2 to 3 trips per day, or more frequently should the water point be located close to the dwelling. Generally other household chores are first undertaken before the first water fetching trip is made. This accounts for the relatively late morning peak considering that residents generally rise early, ie. between 4 am and 5 am, to travel to distant places of work and to undertake the early morning household chores. Garden watering significantly influences the late afternoon water use distribution. The availability of street lighting, extends water fetching activity to relatively late at night, which for users having such services, tends to flatten the afternoon peak. High water losses is manifested by night flow which occurs when no domestic water use abstraction takes place.

8.3.2 House connection water distribution

Residents have to rise early so as to travel to distant places for work and business and therefore water use occurs from 4.30 am onwards with a peak occurring at about 8 am. A gradual decrease occurs until a low demand is reached at about 2 pm after which a relatively sharp increase occurs as a result of gardening activity and household water use until a peak is reached at about 6 pm when most residents reach home. Water withdrawals from the system continues until about 10 pm in view of the easy access to water withdrawal points. Water users having house connections draw water from multiple taps located in kitchens and bathrooms.

The daily peak factor, ie the value by which the summer daily demand should be multiplied to obtain the flow required in a pipeline to cater for the instantaneous peak demand of the community, amounts to about 2.4. Daily peak factors measured by Schmidt (1989) was about 2.5. Du Plessis (1980) suggested a daily peak factor of 3.0 for general use in Soweto. Daily distribution of water use of consumers having house connections is given in Table 4 and Figure 11.

8.3.3 Yard Connection water distribution

Residents, which have yard connections, draw water from about 4.30 am in view of the early rise required to reach distant places of work. A peak is reached at about 7-9 am after which a decline in the water use occurs until a low is reached at about 1 pm. A sharp increase occurs in the early afternoon as water for gardening and household use is drawn with a peak reached at about 5 pm. Zero water use occurs at about 9 pm. The decline in water use occurs more rapidly in view of the necessity that water has to be fetched from outside the dwelling.

The daily peak factor is about 2.6 and the distribution of daily water use is given in Table 4 and Figure 11.

8.3.4 Street tap distribution systems

In general, no street lighting is available in villages and settlements where residents are confined to using street taps. Households, particularly those who live distant from the water point, usually have about one days water use in storage in the dwelling. Nevertheless, this domestic water user group makes an early start to collect water to top up home storage in view of the generally perceived unreliability of water supplies. On average 2 to 3 water fetching trips are made per day by each household. The closer the water point is located to the dwelling, the more frequent water fetching trips, and the less storage is provided. (Alcock, 1989; Van Tonder et al, 1990).

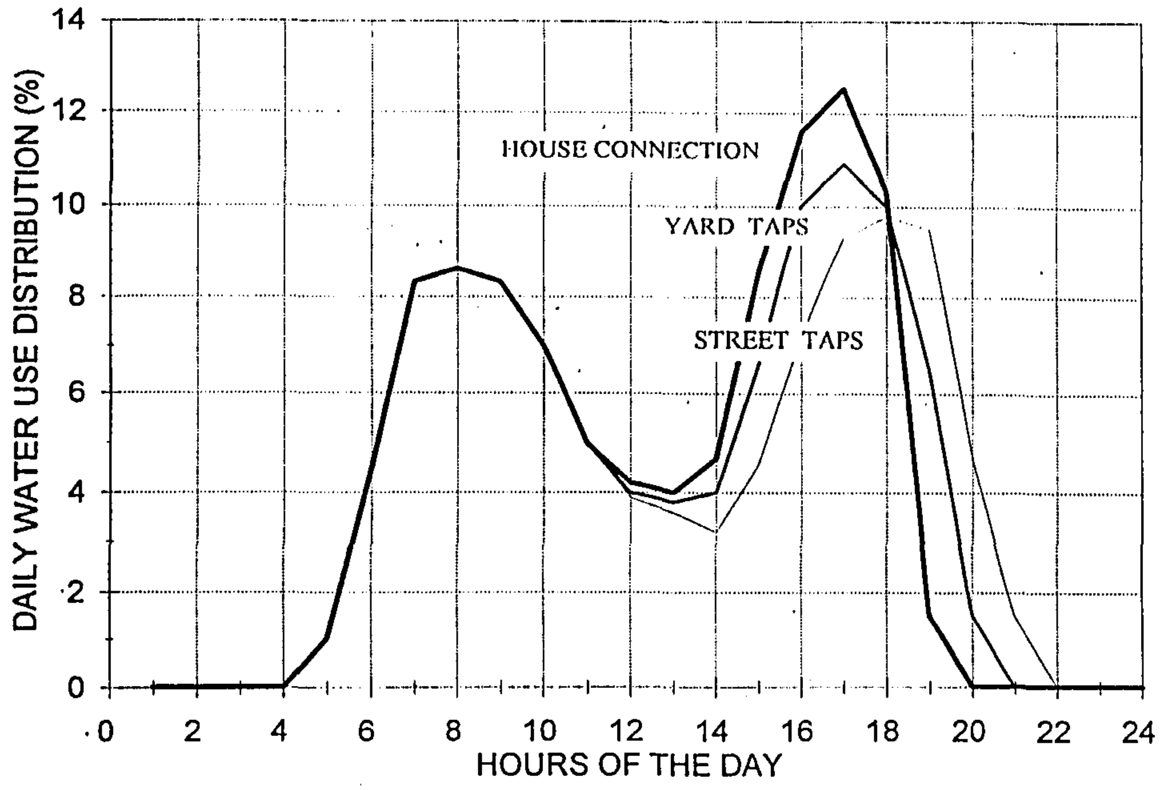
Water is collected from about 5 am and a peak is reached at about 8 am after which a steady decline occurs and a low is reached at about midday. The rate of water withdrawals rapidly increases in the early afternoon as water is collected before nightfall. No water collection occurs after about 8 pm during the summer months and about 7 pm during winter months. The fetching of water after nightfall is extended in villages which have electric street lighting.

The daily peak factor equals about 3.0 and the daily distribution of water use is given in Table 4 and Figure 11.

Although weekend water use may increase, particularly in less developed villages and where the number of weekend visitors returning from distant places of work is high, no discernable differences in the daily distribution of water use during weekends was noted from available records obtained from data logging. It is therefore considered that the pattern of daily water use remains approximately constant on average. In practice however, major differences occur from one day to the next depending on climate, power failure, pipe bursts and other disruptive factors.

TABLE 4 : DISTRIBUTION OF DAILY WATER USE (% OF TOTAL DAILY USE)

HOUR OF THE DAY	WATER USE DISTRIBUTION (%)		
	STREET TAP SYSTEM	YARD CONNECTION	HOUSE CONNECTION
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	1	1	1
6	4.5	4.5	4.5
7	8.3	8.3	8.3
8	8.6	8.6	8.6
9	8.3	8.3	8.3
10	7	7	7
11	5	5	5
12	4.2	4	3.9
13	4	3.8	3.6
14	4.7	4	3.2
15	8.5	6.6	4.6
16	11.6	10	7.2
17	12.5	10.9	9.3
18	10.3	10	9.8
19	1.5	6.5	9.5
20	0	1.5	4.7
21	0	0	1.5
22	0	0	0
23	0	0	0
24	0	0	0
DAILY PEAK FACTOR	3.0	2.6	2.4



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DISTRUBTION OF DAILY WATER USE (% OF TOTAL DAILY USE)

FIG 11

8.4 AVERAGE SUMMER DAILY DEMAND

Seasonal water demands are influenced mainly by gardening activities. This in turn is a function of the value orientation of the community. The ability to apply water on gardens is only possible for residents who have house connections or yard connections.

Based on information obtained during the course of this study, indications are that as the level of living and value orientation rises, so the level of gardening enthusiasm also increases. With an increased desire to pursue gardening activities and improvement in the sophistication and level of service of the water supply facility, so the potential for gardening increases. Increased gardening water use results in greater variation in water use between summer and winter which induces a higher summer daily demand.

The monthly distribution of water demand, which reflects increased water use during the summer months, is induced by climatic changes which include temperature, rainfall and evaporation. These changes result in increased water demand for gardening maintenance. During the summer months, particularly September and October, temperatures are relatively high but no rain generally occurs. Gardens usually revive at this time after the winter dormancy and considerable volumes of water are used for plant growth and maintenance. During the later summer months, namely January and February, exceptionally high temperatures are experienced in the Northern Transvaal and are accompanied by exceptionally high evaporation rates. Rainfall is generally insufficient to maintain gardens and large volumes of water are required during this period to maintain gardens. Increased summer water demand is therefore experienced throughout the area.

From the above therefore, it is postulated that summer peak factors vary in accordance to the type of water distribution systems and the enthusiasm for gardening. A review and analysis of the water use for each of the domestic water use activities as given in Table 2, suggests the following summer peak factors :

- House connections 1.5
- Yard connections 1.35
- Street tap systems 1.2

8.5 PLANNING AND DESIGN PHILOSOPHY

Water supply authorities strive to provide a safe and assured water supply to the domestic water user group. However, the limited funds and scarce water resources makes it difficult to achieve this goal. This has led to a philosophy where only a limited volume of water is provided, which is generally aimed at meeting basic human needs. Planning and design is in general therefore directed at delivering some 25 l/c/d. This is based on directives from the World Bank, World Health Organisation and other interested groups who maintain that this volume of water should be adequate to maintain acceptable health and quality of life standards. Future water demand levels are often arbitarily set at 50 l/c/d to 100 l/c/d.

The above approach makes no allowance for the actual needs of the community which is to be serviced and as a consequence, many systems fail shortly after being commissioned. Members of the community simply draw more than the designed 25 l/c/d. In yet other cases, unauthorized connections are made which disrupt pressures and/or allow high water withdrawal rates.

As mentioned earlier, the needs of the community vary in accordance with level of living, value orientation, aspirations, gardening activities and other socio-economic factors. Communities vary greatly and it is therefore possible to find communities which have a relatively low level of living and are happy with 25 l/c/d, but many other communities may have high levels of living status and are very dissatisfied with even 50 l/c/d. It is therefore clear that a rigid planning and design approach, which aims to supply only a basic service, is unlikely to meet the requirements of the community at large.

A community profile should be compiled of the needs, expectations, perceptions and life styles of the inhabitants, and in additon, aspects such as the existing infrastructure, cultural values of the community and traditions, should also be taken into account.

It is interesting to note that the limiting planning and design approach mentioned above is not followed when planning and designing services for proclaimed towns. Here the design is characterized by high standards and house connections are provided throughout with the capacity to allow water use in excess of 120 l/c/d (Department of National Housing, 1994). Only a small percentage of the population therefore has access to facilities which meet their expectations and by far the *greatest majority of the population have inadequate water supplies* (WSM, 1992; Van Schalkwyk, 1992).

The above mentioned planning and design philosophy has resulted in large numbers of people having a water supply facility which does not meet their needs. This has resulted in amongst other things :

- The extensive practice of making pirate connections which results in excessive water loss, disruptive influences on pressures in the system and water shortages to a large percentage of households in such villages

- Vandalising of water supply facilities such as hand pumps and wind pumps, in protest

- Reluctance to pay for the perceived inferior service

There is a need for a fresh approach to the planning and design of domestic water supply facilities. It is necessary to determine what level of service is adequate, acceptable and affordable. Furthermore the need to maintain and operate the system also needs to be considered. Several organisation, notably Umgeni Water and Bophuthatswana Department of Water Affairs, have identified this need and accordingly developed more appropriate planning and design procedures (Olivier, 1990). The now generally accepted principle of extensive community participation is indeed aimed at understanding the community, identifying actual water requirements, capacity building, empowerment and other issues aimed at ensuring sustainable water supply.

Based on the findings of this study therefore, it is suggested that, particularly for planning purposes, present water demand be determined in accordance with the determined value orientation status of the community. The indicators given in Table 2 and 3, may be used to determine the value orientation status of the community. The list of indicators may also be used as a guideline when drafting socio-economic survey questionnaires, the result of which would ultimately be used to design the appropriate water supply facility. The above information would yield the estimated present water demand (refer to Figure 10).

The appropriate type of water distribution system which should be provided for the community in question is accordingly self evident (refer to Figure 10). The capacity of the various water distribution systems is limited and therefore the selection of the appropriate water distribution type should be in accordance with the volume of water which needs to be delivered to the domestic water user group.

It is pointless, and indeed wasteful, to develop hand pump facilities for communities which require 50 l/c/d. Similarly, a community which is perfectly satisfied with 25 l/c/d, should not be provided with systems having yard connections. Obviously the rate of development of the community needs to be considered when designing the water supply facility which is generally good for 10 - 15 years.

Daily peak factors vary in accordance with the value orientation of the community served and therefore the type of water distribution facility provided viz :

- House connection 2.4
- Yard connections 2.6
- Street tap systems 3.0

Summer peak factors vary in accordance to the level of gardening activity pursued by the community. The enthusiasm for gardening in general only occurs in communities having a moderate to high level of living and therefore implies communities having yard and house connections. The summer peak factor varies in accordance with the water supply facility viz :

- House connections 1.5
- Yard connections 1.35
- Street tap systems 1.2

Estimates of future water demand is discussed below.

Typical planning and design guidelines generally imply providing a limited volume of water per household and are based on the goals set by the United Nations in the Water and Sanitation decade programme aimed at delivering 50 l/c/d in rural areas, but has now been modified as the realities of meeting these general standards become apparent. In the former Lebowa, Venda and Transkei, a design criteria of 35 l/c/d to 50 l/c/d was adopted for rural villages (Transkei Department of Agriculture and Forestry, 1981; WSM, 1992, Musetsho, 1983). In rural villages of Malawi, a design water use rate of 27 l/c/d was used for planning purposes. Many of these schemes failed shortly after being commissioned in view of the fact that the actual water demand exceeded the volume of water delivered. Numerous households in the newly serviced community were consequently left without water.

9. ESTIMATING FUTURE WATER DEMAND

9.1 INTRODUCTION

The volume of water delivered to most villages, settlements and towns where developing communities reside is not metered. In addition, as previously mentioned, a large percentage of the communities served experience water shortages and therefore the actual water use is not a true reflection of the water demand. It is therefore not possible to forecast future water demand based on historical records. Extrapolation and trend analysis procedures are also generally not applicable. In a limited number of instances, metered information is available and may serve as a guideline of possible future water demand.

In general therefore, recourse has to be had to applying an estimated per capita water demand rate to the estimated population. Both these parameters are related to characteristics of the domestic water user group and as seen previously.

Water demand = f(value orientation, tariff)

The change of the value orientation of a community with time and estimation of the population growth rate is extremely difficult. These issues are discussed below.

9.2 POPULATION GROWTH

Population growth is a function of mortality, fertility and migration. The quantification of mortality and fertility is reasonably well understood and can be determined by various models. Nevertheless, a relatively wide range of rates of change in terms of mortality and fertility may be experienced depending on various socio-economic factors. Estimation of migration is particularly difficult as it is significantly influenced by political and economic factors as well as perceptions which residents have with regard to access to services such as transport, health facilities and other infrastructure. The rapid urbanisation which is being experienced throughout South Africa illustrates the point.

A review of population census statistics of the Dzanani district of Venda (WSM, 1993) revealed that remote villages located some distance from business centres had a low and sometimes negative growth rate during the period 1985 - 1991. Yet other villages and settlements located close to commercial centres or major access routes, had growth rates in excess of 4% and in certain places exceeding 6% /annum. The current severe drought experienced throughout the region may also contribute to the movement of people.

An accurate estimate of the future population is crucial to the realistic estimation of possible future water demand. It is therefore essential, particularly in the case of large schemes with high capital cost, that detailed demographic analysis be undertaken. Migration however remains an important unknown and it is therefore suggested that research be undertaken to understand and quantify the dynamics of population movement.

9.3 ESTIMATION OF FUTURE PER CAPITA WATER DEMAND

Unit domestic water demand is, as previously discussed, a function mainly of the value orientation of the domestic water user group. In order to estimate the future per capita water demand of a community, it is necessary to determine what the value orientation of the community would likely be at various future time horizons.

Value orientation is related to the prosperity and welfare of the community as well as the community's values in terms of self esteem, education, hygiene, convenience and comfort. These are complex and interrelated issues which comprise the dynamics of population development. Only limited information is available in terms of growth and improvement of the economic status and welfare of communities in the Northern Transvaal. No information is available regarding the growth and change in the value orientation of the communities. The factors which influence the future per capita water demand are therefore discussed qualitatively and further research would be required to validate assumptions made.

The desire for improved living conditions is a natural tendency observed in communities of all development levels which include the most undeveloped communities varying through the full spectrum to the most sophisticated domestic water user groups. This argument is supported by amongst other things, the expenditure of a significant percentage of the household income on home improvement, education and furniture (see Figure 8). The poorest communities spend 2 - 3 % on housing, up to 10 % on education and 5 - 8 % on furniture. Communities having a moderate to high level of living spend approximately 5 % on housing, 5 - 10 % on education and up to 10% on furniture (Urban Econ, 1994). It has also been noted that in areas where water use is monitored, the annual average growth rate of the total volume of water used, is considerably higher than the annual population growth rate (Department of Water Affairs, 1989; De Wet Shand, 1991). Pietersburg and Louis Trichardt for example, have experienced annual domestic water supply increases of more than 6% /annum and KwaNdebele (WSM, 1994) experienced an annual increase in water use of nearly 20%/annum in the past 10 years. The population growth rate in the latter example was about 6%/a.

GGP, although having certain limitations (Department of Water Affairs, 1988), may be used as an indicator to trace the historical improvement of welfare of the region. Estimates are also regularly made of possible future GGP values for various time horizons. Experience in the past has indicated that there is a correlation between water use growth rate and growth of the GGP. The estimated GGP growth rate for the period 1990 to 2000 is 3.5%/a (DBSA, 1990).

The rate of improvement of the level of living is likely to vary for each of the population development levels. The poorer communities, which are assumed to have the lowest level of living, have limited resources which may be employed to grasp opportunities. This group also has the lowest level of education and would have difficulty competing for the limited job opportunities. The rate of improvement of the level of living of this group is likely to improve at a rate considerably less than the growth of income of this group in real terms.

Communities having a low level of living are at the threshold where enthusiasm for gardening becomes important. Garden water use, is one of the major water uses in the domestic water use spectrum. Water demand for gardens significantly increases the total volume of water used for domestic purposes. Gardening can however only effectively be undertaken in cases where water is made available on individual stands. Yard connections significantly improves access to the available water and therefore rapid increases occur in the use of water for other household activities, particularly for personal hygiene. Entry of the domestic water user into this category, results in a major increase in total water demand.

The desire for change-over from stand pipe water distribution facilities to individual yard connections, once initiated is very rapid. Data from numerous villages and settlements in Venda would suggest that the number of house connections made annually in the various villages reflects a growth in the total number of house connections in excess of 10% in many instances. Venda, unlike Lebowa and Gazankulu, have procedures in place whereby residents wishing to have a yard connection, may make application to the Venda Department of Water Affairs (now defunct) and a fixed fee was payable to effect the connection.

Apart from the natural growth in the number of yard connections made in the various villages, numerous other households were induced by their peers to also enjoy the comfort and convenience offered by a yard connection. Priorities are thus reconsidered by the households and funds are consequently made available for the house connections. This perceived benefit offered by the improved water supply facility results in increased rate of development.

Communities which enjoy a relatively high level of living are considered to already have improved water supply facilities which include yard connections and house connections. Continued growth in water demand is nevertheless experienced by this group. The growth in water demand can be ascribed to improvements in the level of living which contributes to increased gardening activity, improvement to dwellings which would include the addition of bathrooms and other additions which result in increased water demand, acquisition of water using appliances and increased entertainment. This population group has the highest level of education and income and therefore are well equipped to benefit from opportunities which may present themselves.

At high levels of development, the scope for further development is however limited in view of the fact that the greatest percentage of the water is used for personal hygiene, sanitation and gardening. These uses ultimately reach a ceiling and no further growth occurs.

The various population groupings, in terms of level of living, are mixed and do not comprise only one grouping. Each community comprises households from virtually all levels of development. A community which has a low level of living is considered to comprise households mainly from this development level, but this community also has a significant number of households which have a low level of living as well. Households from the low to moderate, moderate, etc level of living categories would also occur in this group. This community may also have households which are desperately poor.

With time, there is a shift in the status of most households and ultimately the community in question as a whole, find themselves in the next up level of level of living.

The very high level of living group comprises predominantly households which have moderate to extensive gardening activity on stands which exceed 1 000 m^2. There are however a significant number of households in these communities who have yet to develop to the very high level of living. It is the improvement of the level of living of this group, although small, which contributes to the ever increasing per capita water use rate.

It is not possible to forecast accurately future rate of economic growth without having knowledge of other intervening factors such as prevailing political conditions, policy shift, industrial unrest and other related factors. The sensitivity of combinations of the above conditions offers the planner and developer a means of making a more sound decision. A scenario approach in the estimation of future per capita water demand is therefore suggested. The scenarios are based on optimistic, moderate and pessimistic assumptions of prevailing political and economic conditions namely :

- **Scenario 1 (low rate of increase in water demand)**

  Vigorous economic conditions prevail and stable political situation occurs. Level of living is assumed to increase and sufficient funds are available to improve services including water supply. Residents pay for water. The net result is that water demand increases at a low rate.

- **Scenario 2 (moderate rate of increase in water demand)**

  Poor prevailing economic conditions and unstable political situation occurs and is associated with a low level of improvement in the level of living. Limited funds are available for the improvement of water supply systems. Residents do not pay for water and water wastage is high. A moderate increase in water demand occurs

- **Scenario 3 (high rate of increase in water demand)**

  Stable economic and political conditions prevail and a moderate improvement in the level of living occurs. Services are improved at a moderate rate with water shortages occurring occasionally. Residents in general do not pay for water.

The rate of increase in water demand with time is not only dependant on the

TABLE 5 : BASIS FOR ESTIMATING FUTURE PER CAPITA DOMESTIC WATER DEMAND

PRESENT WATER DEMAND BASED ON LEVEL OF LIVING	GROWTH IN WATER DEMAND IN ONE YEAR INTERVALS (l/c/d)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	SCENARIO 1: Vibrant economy,level of living improved,water tariff, services improved, stable political situation ... Low water demand growth														
450	405	365	328	295	266	275	285	295	305	316	327	338	350	362	375
250	225	203	182	164	148	154	160	166	173	180	187	194	202	210	219
130	124	117	112	106	101	106	110	116	122	129	134	142	148	156	164
80	77	74	71	68	65	69	73	77	81	85	90	95	100	106	111
50	48	46	44	42	41	43	44	47	49	51	53	55	58	61	63
35	37	39	42	44	47	50	52	54	56	58	60	62	64	67	70
25	26	26	27	28	28	29	30	31	32	33	34	35	37	39	42
	SCENARIO 2: Low economy, low level of living improvement, no tariff, water wastage, unstable political situation ... Moderate water demand growth														
450	455	459	464	468	473	478	482	487	492	497	502	507	512	517	522
250	253	256	259	262	265	269	272	275	278	282	285	288	292	295	299
130	132	135	138	141	143	146	150	153	155	158	161	165	168	171	176
80	82	84	87	89	92	94	97	100	103	105	108	111	115	118	121
50	52	54	56	58	60	62	65	67	70	73	75	78	81	84	86
35	37	39	42	44	47	50	52	54	56	58	60	62	64	67	70
25	26	26	27	28	28	29	30	31	32	33	34	35	37	39	42
	SCENARIO 3: Moderate economic and political situation, water tariff generally applied services mainly improved ... High water demand														
450	460	470	480	491	500	509	518	527	533	538	543	549	554	560	565
250	256	262	268	275	281	288	295	302	309	317	325	332	340	348	357
130	134	139	143	148	153	158	164	169	174	180	186	192	198	205	211
80	83	86	89	92	95	98	102	105	109	113	117	121	125	129	133
50	52	54	56	58	60	62	65	67	70	73	75	78	81	84	86
35	37	39	42	44	47	50	52	54	55	68	60	62	64	67	70
25	26	26	27	28	28	29	30	31	32	33	34	35	37	39	42

scenarios considered, but also varies for each of the water user groups. Water users which have access to house connections in general will experience a lower increase in water demand than would residents having access only to street pipes. Street pipe systems are readily improved and it is also possible for residents to make unauthorised connections. Due consideration was given to the possible rate of improvement to the water distribution systems, ie, the rate at which street tap systems would be upgraded to yard connections and the rate of improvement from yard connections to house connections and eventually to fully reticulated water systems with water borne sewage.

The anticipated water demand for various time horizons and the various scenarios considered are given in Table 5.

10. SUMMARY AND CONCLUSIONS

From the results of this study, the following points are noted and conclusions drawn :

- The study was concentrated in the Northern Transvaal Region but also made extensive use of data and information obtained from other parts of Southern Africa and world wide.

- Domestic Water demand is considered to be a function of the value orientation of the community and is tempered by metering and paying for water.

- Indicators which reveal the value orientation of a community include income, population, household size, education, housing type, gardening activities, electricity connections, pirate connections, agricultural activity and business activity.

- Water demand varies from 15 - 25 l/c/d for communities which have a very low level of living to some 50 l/c/d for communities having a low to moderate level of living and may exceed 250 l/c/d in the case of high level of living.

- Water use may significantly, and often negatively influenced by the type of water distribution system available to the community, walking distance, queuing time at the water point, topography and water quality.

- The actual volume of water used for domestic purposes is also imfluenced by the number of people per tap, topography and water availability

- Paying for water reduces the household water demand by as much as 30%. The reduction is however considerably less for communities which have a low water demand.

- Estimation of possible future water demand is based on assumptions regarding the improvement of the value orientation of the community and is considered to be in the range 2.2%/a to some 4%/a. The lower rate of increase is applicable to communities having a very low or high level of living. High increases in water demand are applicable to communities who are at the threshold where enthusiasm for gardening becomes important.

11. RECOMMENDATIONS

Based on the findings of this study, it is recommended that research be undertaken which would lead to improved understanding of the dynamics of population development. Population development in this context is understood to include improved living conditions and access to services such as water supply, electricity, health and schooling as well as access to job opportunities and commercial centres.

The result of this research would allow more accurate quantification of the value orientation of communities, rate of improvement of communities, factors which define the movement of people and refinement of population growth in terms of fertility and mortality. A more accurate estimate of population growth rate and value orientation is vital for the planning, design and development of not only water supply, but all other services.

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APPENDIX A : FACTORS AND INDICATORS WHICH ARE RELATED TO DOMESTIC WATER USE

A.1 Level of living

A.1.1 Information obtained from surveys

- Income level
- People per household
- Employment level
- Household expenditure
- Child washing interval
- Household possessions
  - Fridge
  - T.V's
  - Gas appliances
- Number of rooms per housing unit
- Average travel time
- Time spent collecting water
- Uses of water
- Private boreholes
- Age of shepherds
- Informal home industries
- Average garden size
- Main income earner
  - Away husband
  - Home husband
  - Wife
- Age of the head of the household
- Washing facilities
- Age of water carriers
- Number of dwellings per household unit
- Household composition - Several families
  - Nucleated

A.1.2 Transparent information

- Housing type
- Garden activity
  - Wet gardens
  - Dry gardens
- Creche
- Business activity
- Proximity to employment/Business centre (Remoteness of village)
- Grave stone style
- Mountain/communication barriers
- Sanitation system type
- Clinics
- Agricultural activity
- T.V installations
- Industrial activity
- Electricity connections

A.1.3 Information obtained from Database

- Population
- Education Level
- Average stand size
- Services and stands
- Price of stands
- Electricity connections
- Electricity use
- Telephone connections
- Road network
- Level of unemployment
- Child mortality
- Stock per person
- Vehicle ownership
- Literacy levels (%people having 6 years schooling)

- *Migration levels*
- Town size
- Number of teachers
- Gross domestic product - GDP
- Number of children
- Life expectancy

A.2 ACCESS TO WATER

A.2.1 Physical Aspects

- Topography
- Average hours of sunshine per day
- Number of guests or non permanent visitors
- Schooling time
- Rainwater collection tanks
- Walking distance (function of systems type)
- Time spent at work
- Water loss (function of system type)
- Container size
- Storage capacity
- Water transport system (function of affordability, demography, system)
- Water quality
- System capacity (function of design specifications)
- Scheme operating hours
- Water metering
- Ease of water withdrawal from system
- Population density
- Town size
- Temperature
- Water distribution system types

  Fully reticulated

  Full bathroom

  Kitchen

- Flush toilet
- Kitchen connections
- Yard taps
- Street pipes < 200 m
- Street pipes > 200 m
- Windmill
- Hand pump
- Springs, streams and small dams

- Water pressure problems
- Type of transport
- Design specifications
- Diesel engine
- Electric motors
- Scheme operating hours
- Motive energy

A.2.2 Social Aspects

- Number of carriers per household
- Time spent in queue's (function of number of people per tap equals function of system type, population)
- Number of people per abstraction point
- Time spent on other tasks
- Number of villages served
- Number of illegal connections
- Number of trips/day
- Public attitude
  - Historical availability of water
  - Historical cost of water

A.2.3 Financial Aspects

- Money spent on water system development by state
- Affordability of water

- Water tariff
  - Water price
  - Charge structure
- Private vendors
- Pay system in use

A.3 AVAILABILITYOF WATER

A.3.1 Surface Water

- Unit run-off per catchment
- Perennial streams
- Pollution level
- TDS level
- MAP
- Average monthly rainfall
- Number of rain days per year
- Area where MAP greater than 700 mm
- Mean annual evaporation
- Mean monthly evaporation
- Net monthly evaporation
- Water restrictions

A.3.2 Ground Water

- Ground water potential
- Average borehole success rate
- Average borehole delivery (l/s)
- Water quality
  - Surface pollution
  - Surface TDS
  - Ground water TDS

A.3.3 Fountains

- Existence of fountains
- Permanency of fountains
- Areas where MAP greater 700 mm

A.3.4 Physical Aspects

- Regional schemes with adequate capacity
- Effectiveness of maintenance programmes
- Money spent on water projects (Development expenditure /district / person / year).