NOMENCLATURE

DDDD	Daily Domestic Design Demand
DSS	Decision Support System
DNA	National Directorate for Water Affairs - Mozambique
DUNSS	Domestic Users Not Served by the Scheme
EC	European Community
GMS	Galvanized Mild Steel
GNP	Gross National Product
HDPE	High Density Polyethylene
HC	House Connection
HP	Horse Power
MDA	Maximum Daily Abstraction
O&M	Operation and Maintenance
PEC	Community Education Programme - Mozambique
PRONAR	National Rural Water Programme - Mozambique
PVC	Polyvinyl Chloride
PWSC	Present Water Source Capacity
UDAAS	Water Supply and Sanitation Unit - Mozambique
UFW	Unaccounted-For Water
VLOM	Village Level Operation and Maintenance
WSEDD	Water Source in Excess of Domestic Demand
WSETD	Water Source in Excess of Total Demand
YT	Yard Tap

LIST OF SYMBOLS

°C	Degree Celsius
CAPEX	Capital Expenditure
dia.	Diameter
ha	Hectare
km/h	Kilometres per hour
kl	Kilolitre
kl/d	Kilolitre per day
kW	Kilowatt
l/p/d	Litres per person per day
l/s	Litres per second
m	Metres
mm	millimetres
m^3	Cubic metre
m^3/h	Cubic metre per hour
m^3/day/person	Cubic metres per day per person
m^3/year	Cubic metres per year
MJ/m^2/day	Mega Joule per square metre per day
mg/l	Milligrams per litre
NTU	Nephelometric Turbidity Unit
λ	Darcy friction factor
η	pump versus motor efficiency
π	Ratio of circumference of a circle to diameter

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ACKNOWLEDGEMENTS

I would like to thank Professor David Stephenson, my supervisor, for his support. I would also like to thank the National Directorate for Water Affairs - Mozambique and the Swiss Development Cooperation for the funding of the bursary, and the Department of Water Affairs and Forest - South Africa and the Mvula Trust for their assistance during the preparation of this work. My gratitude extends also to Institutions and individuals, with whom I had discussions on improving the research work for this report.

DEDICATION

To Louis and Nádia for your contribution to the sleepless nights

ABSTRACT

Current practice of the rural water sector in Mozambique does not generally consider all factors that have influence on project sustainability. The urgent need to provide returnees in rural areas with safe water, does not give adequate time to engineers, technicians and those involved in the sector, to conceive and plan a water project properly.

A Decision Support System (DSS) for rural water supply has been proposed to assist the decision making process to be more systematic, fast and comprehensive. It requires a number of input data variables which are not difficult to obtain and these variables have been selected to ensure that most aspects inherent in a successful project are considered. The main achievement of this system is the project report, similar to a project preliminary design, and the financial results which are important for project assessment and ranking.

The Decision Support System is a computational model which uses engineering and economics approach to combine and process input data and information contained in its database. While the calculation method does not need constant updating, the database has to be verified frequently to produce reliable results. South African prices have been used in the database construction but a correction factor facility was incorporated to adjust and make the model useable in Mozambique.

The model has been designed to be used by planners, engineers and technicians, and funding agencies. The model can be used by planners to assess implication of policy decisions on future water supplies and water resources development. For engineers and technicians, the model estimates water demands, project components sizes and quantities, and water source development and reliability. To funding agencies, the model is a tool to determine the best investment scenario of a rural water supply project.

CANDIDATE'S DECLARATION

I declare that this project report is my own work, unaided work. It is being submitted for the Degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

____

5th day of August 1996

A DECISION SUPPORT SYSTEM FOR RURAL WATER SUPPLY IN MOZAMBIQUE

Nelson Hanry de Pena Beete

A project report submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering

Johannesburg, 1996

Zambezi River) the climate is influenced by the subtropical anti-cyclonic zone. Around the Zambezi River and towards the coast (east) there is a transitional zone with high rainfall figures.

The average annual rainfall is 968 mm: it varies between 327 mm at the Limpopo river entrance (south) and 2611 mm in Gurue in the mountainous areas of Zambezia province (north). There is a general decline of recharge index from north to south and from the coast inland. This trend is only modified by altitude influence.

Droughts are common and related to the erratic rainfall distribution during the wet season. Severe ones were recorded in 1949/50, 1959/60, 1969/70, 1979/84 and 89/95. Months of drought can be followed by heavy storms accompanied by high floods. Tropical cyclones occasionally invade the coastal areas. In the past 20 years, 4 out of 8 cyclones caused excessive rainfall followed by floods.

The average annual potential evaporation varies from 1200 mm in the south (Libombos) to 1800 mm in some low areas in the north. The water balance, calculated over monthly averages, shows a surplus resulting in runoff in areas with more than 800 mm of annual rainfall. The annual surplus can be over 400 mm in mountainous areas.

Average annual temperatures varies from 18° C to 26° C, increasing northward and inland. This trend is interrupted by the influence of the altitude in the upland areas with average annual temperatures of 18° C. Average relative humidity at the coast is around 71% falling to 64% inland. The average solar radiation generally lies between 18 and 20 MJ/m^2/day. Average wind speed varies from less than 4 to over 8 km/h.

3.0 MOZAMBIQUE - A DESCRIPTION

3.1 Background

Mozambique lies on the east coast of the Southern Africa, between 10° 27' S and 26° 25' S latitude and 30° 12' E and 40° 51' E longitude, and has a land area of 799 380 km^2.

The 1980 census indicated a population figure of 12.1 million. With an estimated annual average growth rate of 2.3% for rural areas and 4.2% for urban areas, the 1996 population is about 18 million.

The World Bank classifies Mozambique as one of the poorest country in the world. Just before the Independence in 1975, the economy went into a sharp decline. This situation was reverted in the late seventies to reach its post-Independence economic peak in 1981. Since then the economy declined again and in 1987 it slowly started to recover. At the present around 70% of the rural and 50% of the urban households live in absolute poverty i.e. no income at all. This is reflected in the high mortality rate, 273 per 1000 live births for children under five years old, and a GNP of $80 US per capita.

The morphology of the country can be characterized by distinct units: coastal lowlands, middle plateaus, upland plateaus and mountainous areas. This division generally coincides with certain altitudinal intervals: 0 to 200 m (44% of the surface area), 200 to 500 m (29%), 500 to 1000 m (21%), and over 1000 m (6%) respectively.

3.2 Climate

The climate in the north (north of Zambezi River) is under the influence of the equatorial low pressure zone with a NE monsoon during the hot season *(Figure 3.1)*. In the south (south of

v) Surface water treatment and supply

Small and large schemes of this nature can be implemented. This generally implies the construction of a weir or dam, pumping to a reservoir, treatment (e.g. slow sand filtration or flocculation, sedimentation, filtration, and disinfection), then distribution (usually requiring further pumping and storage).

The concept of providing water to a certain community is sometimes misleading as it implies that the community has no water at all. The reality is that within the community, some type of water source exists. It may, however, not be of good quality, enough quantity, within a short distance, or continuously available. These factors determine whether the existing water supply need improvement or not. It is a question of adequacy. Chapter 5 covers these subject with more details.

2.4 Improving water facilities

Some of the typical improved water supply systems found in rural areas are indicated below.

i) Protected springs

Springs can be capped and the water led to a reservoir where it can be collected from a tap.

ii) Shallow wells

Where near-surface water exists shallow wells can be dug, capped and fitted with a low-lift handpump.

iii) Boreholes

Boreholes have been sunk and fitted with one of the following:

- handpump;
- windmill pumping into an adjacent reservoir with taps;
- diesel pump pumping into a reservoir at an elevated position, with some pipeline distribution and streets taps.

iv) Rainwater harvesting

Schools, clinics, and some private homes have been fitted with roof runoff collection and storage systems. This entails the fitting of guttering and downpipes which lead into constructed or prefabricated storage reservoirs.

The upgrading of water facilities may therefore contribute better at improving health if they are part of a general health and development programme.

2.3 Water and economic development

An improvement in the access of poor communities to water can make a substantial contribution to the quality of life of such communities.

In southern Africa people spend substantial time daily collecting water. Usually it is the poorest sections of the community who experience the greatest problems of access to water and who often have to pay most for water.

The saving in costs (whether in terms of time, effort and money) due to an improved system of supply, may be invested in more productive activities such as education, child-care or employment. More specifically, these savings might be used to help pay for the construction and maintenance of the improved water supply systems.

It stands to reason that a healthy labour force is more likely to make a greater contribution to productivity than one which is diseased. While research on the consequences of ill health is limited and in some cases, neither consistent and nor generally applicable, it does nonetheless lend support to the assumption that illness decreases productivity (Emmett et al 1993).

An additional consideration is that improving water supply may, in the long run, also lead to the greater use of water in other productive activities, such as agriculture. Another associated benefit is the creation of employment opportunities related to water vending and the construction of water tanks and pipeline facilities.

The World Health Organisation has been able to show some "demonstrable reductions" in morbidity and mortality due to diarrhea as a result of improved water and sanitation provision (Churchill et al, 1987:11). These reductions were not large but, are adequate enough, to prove the link between good sanitation and reduction of mortality rates.

It has been shown that improvements in community water supplies and modern sanitation can cause reductions in mortality rates due to cholera of up to 70% and for typhoid fever of between 60 and 80% (Sorokin, 1988:79-80). A United Nations study has suggested that the control of water-related diseases would add an average of about ten years to life expectancy in the developing world (Baum and Tolbert, 1985:305).

Heavy investments in upgrading the water and sanitation facilities will not necessarily produce quick and dramatic improvements in health. While the evidence suggests that s. water supplies facilities are necessary for ensuring good health, they may not be sufficient to achieve significant changes in morbidity and mortality in developing communities. This is because the relationship between disease on the one hand and water and sanitation on the other is extremely complicated.

For example, diseases associated with water supply and excreta disposal, may either be "water-borne" (dependent on pathogens in the water supply), or "water-washed" (dependent on the quantity of water used for personal hygiene) or "water-based" (requiring direct contact with the infected water source) (Emmett et al 1993). In addition some diseases depend on vectors that breed in or near water sources. Health problems may also be caused by the presence of minerals or other natural contaminants in the water supply. Aspects such as personal and cultural hygienic practices, contamination during transportation and storage of water, and the physical condition of the population do contribute to the spread of diseases. Some other factors governing susceptibility to diseases are poverty, malnutrition, low levels of education and literacy, and overcrowding. It is apparent that diseases, high morbidity and mortality rates are a result of several factors.

2.0 ASPECTS OF RURAL WATER SUPPLY

2.1 Background

Safe water is not only recognised as one of the basic human needs, but is also intimately related to health and productivity of developing communities. The importance of water as a basic need was given recognition by the United Nations' designation of the 1980s as the International Drinking Water Supply and Sanitation Decade. As result, many small programmes have been developed, surface water sources have been protected and treated where necessary, ground water resources have been developed and protected, and rain water harvesting has been promoted to improve water supplies in rural areas.

2.2 Water and health

Improving water services is a step towards a number of important social needs and functions. The most frequently mentioned is the relationship between the health of a population and the levels of water supply.

Inadequate water and sanitation provision is regarded as a major cause of high mortality and morbidity rates in many developing countries. The most widespread diseases in developing countries are those transmitted by human faeces, and water is a major medium of transmission.

Available evidence suggests that there is usually a relationship between morbidity rates and both the quality and quantities of water to which people have access. For example, empirical studies (e.g. Sorokin 1988:79) have shown that the shorter the distance to safe sources of water, the lower the incidence of diarrhoea. Those households with water inside the dwelling tend to have the lowest rate of diarrhoea, followed by those with water outside the dwelling but nearby, while those who are furthest from water sources have the highest rate of infection.

In Chapter 3, brief descriptions of the water resources and rural water supply situation in Mozambique, is given. This chapter illustrates the context and conditions in which this model will be used.

Chapter 4 deals with the Decision Support System model. This chapter starts by giving a general overview on project planning and then covers issues related to the principles on which the model works.

Chapter 5, the User Manual, starts with general principles of project planning in order to help the user decide on variables input. Then follows a list of the required input information and hints on the efficient use of the model.

A case study is covered in Chapter 6. A real project was selected and its data used to run the model. The results computed by the model were then compared to those of the project to check the reliability of the model performance.

Chapter 7 discusses and summarizes the conclusions drawn from this research work and presents recommendations for further work on the subject.

1.3 When should this model be used?

As with any project, a rural water supply project has a cycle with the following stages (Grover, 1983):

Identification and Preparation: In this stage an overview of the existing water supply, the need for the project, and a brief description of the proposed project, its alternatives and order-of-magnitude of the costs, are provided.

Approval: The stage where the decision makers, including financiers and donors, determine whether the project will be implemented.

Implementation: The stage when detailed designs are completed and the project facilities are built and commissioned

Operation: The stage when the project facilities are used to provide the services.

Evaluation: This is the final stage, when assessment is made to determine the lessons learned to improve on future projects.

This Decision Support System provides the preliminary cost estimates based on considerable data gathering and analysis. It is therefore, a tool to be used during the *Identification and Preparation* stage to predict costs, and during *Evaluation* to compare the preliminary estimates with the final cost and identify the causes if major discrepancies exist.

1.4 Structure of the report

In Chapter 2, the general principles guiding the rural water supply activity are presented. A short discussion based on literature review is also presented therein.

Some of the reasons for the central planning are inheritance of the post-independence practices, shortage of skilled people and structured database at regional and provincial level.

The objective of this study is to develop a Decision Support System for rural water supply that would assist the parties involved (investors, donors, government agencies and the beneficiaries) in planning the investments, and enable them to select options among several cost scenarios depending on the particular conditions of the area, or village under consideration.

The assessed costs are based on the price data gathered from South African manufactures, suppliers, consultants, contractors and other relevant organizations. To enable the use of the model in Mozambique, provision is made for the adjustment of scenarios derived by means of cost indices.

1.2 The contribution of this work

The Decision Support System is a simple computational model which has its strength on database manipulation, quick calculations and easy of use in a simple computer. It can make an important contribution to develop an uniform approach to project planning in general, and capacity building, at provincial and regional level, in particular. The model has been designed to cater for one scheme at a time (adequate for local planning) and the input data format requires the user to plan the proposed project carefully.

Continuous use of this model by the rural water operators will also contribute to improving the sector planning mechanisms. Comments and suggestions from users will in turn contribute to further development of the model in addressing local factors that would improve the accuracy.

1.0 INTRODUCTION

1.1 Background

After two decades of devastating war, Mozambique is now enjoying peace and the main goal is to reconstruct the Country and develop the economy. Displaced people and refugees have been returning to their places of origin. Most of these people come from the rural areas where the infrastructure has been decimated.

Urban areas cannot accommodate any population influx satisfactorily and it has been envisaged that to influence economy growth, rural areas have to be repopulated and in order to start producing goods. An effective rural resettlement programme requires provision of minimum infrastructure satisfying the basic human needs to entice people to those areas. Among the basic infrastructural requirements, provision of safe and reliable water supply has priority. Water is important from the health and survival point of view and is a necessity for establishment of villages and industries.

Factors involved in rural water supply, which are to some extent different from those of urban water supply, make it difficult to estimate in advance the cost of a sustainable rural water supply for any particular village. Some of the factors involved are: population, population density, population migratory trends, service level, type and distance of water sources, distance to the nearest place of procurement. These factors can be combined in different ways, varying from ase to case, and such combinations make the determination of cost of water *per capita* a time consuming and difficult exercise.

Rural water supply in Mozambique has largely been based on emergency relief supplies, usually in the form of wells or small boreholes fitted with hand pumps. Urgency for providing safe water to the rapidly growing rural population, limits the time for adequate project preparation. These projects are currently coordinated with large involvement from the central level institutions.

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YT	Yard Tap

Figure 4.2 Technical calculation flow diagram

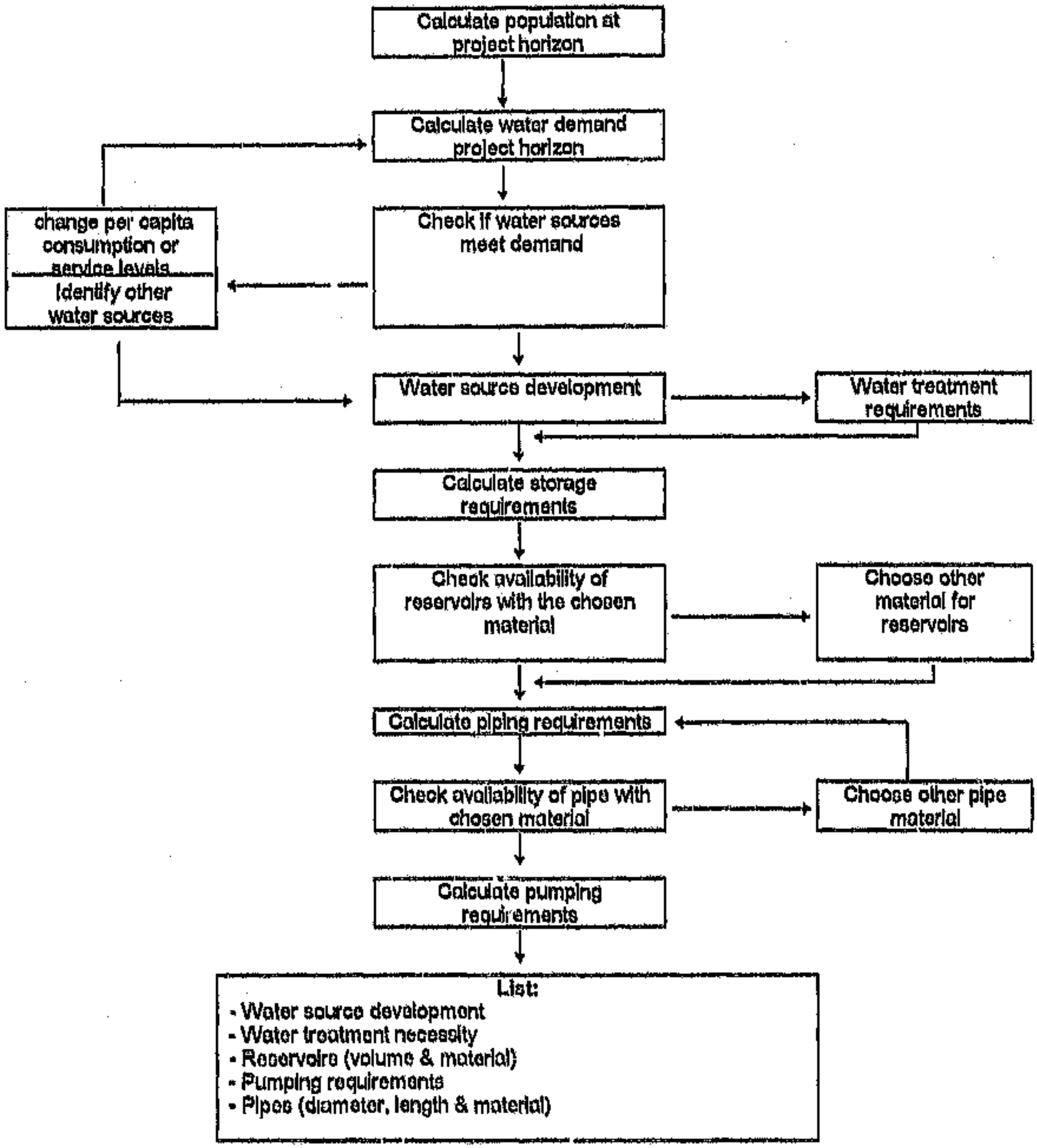
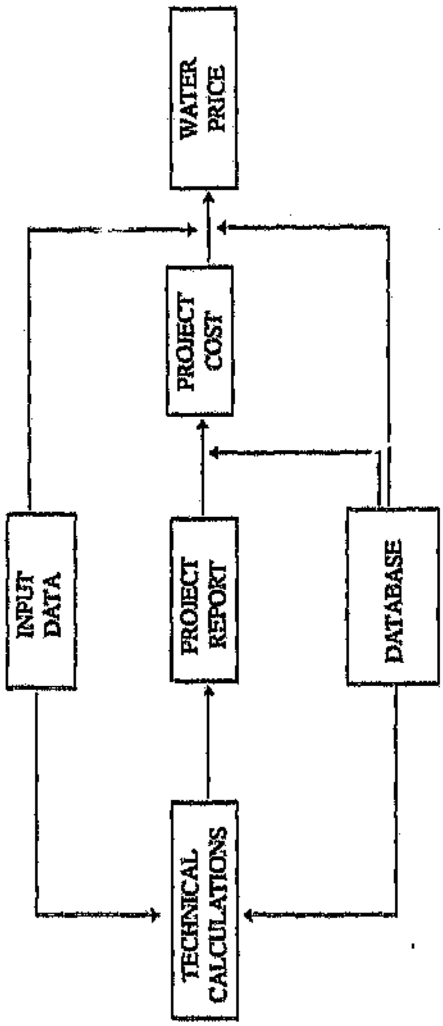


Figure 4.1 Model flow diagram



found. Often in such a case, a simplification of the specifications for the model may overcome the difficulty.

The Decision Support System for rural water supply is essentially a computational model. Most of the relationships governing the technical and financial aspects of a rural water supply project are extensively developed mathematically. The computation may sometimes be repetitive in order to compare different scenarios. This is the fundamental reason to embark in this research.

The model operations, illustrated on Figure 4.4 *Flow diagram*, requires input data from the user describing the existing conditions, the water supply arrangements, the proposed project, and financial and economic factors involved. Guidelines to assist the decision on variables input are discussed on Chapter 5, and data requirements are indicated on the *Appendix B*.

When the data input stage is completed the model then sizes the project components. This stage is called the technical calculations (*Appendix C*). As often the component's size may not be commercially available, the model converts the components into standard sizes.

A project report (*Appendix D*) is then created listing materials and equipments, the unit and total prices, and the total project cost. The project report resembles a summary bill of quantities.

The project report is the instrument that will help the user to decide the scenario fitting better to the existing situation and conditions.

A detailed description of technical calculation, project reporting, financial calculation, and the principles guiding the analysis, is given in the following sections. For clarity, the sections below should be read together with the *Appendices* A to F.

4.0 THEORY OF THE DECISION SUPPORT SYSTEM

4.1 Background

The Decision Support System for rural water supply is a model that should be viewed in the context of general modelling of human and physical systems. Modelling can be considered as the development of a device which can represent a system behaviour. The quality of a model is dependent on how accurately it can reproduce the system response.

A model can be classified in many ways. An example of a model classification by (Langham, 1971) is illustrated below:

Conceptual Model: an idea of the causal relationship between various systems variables is conceived in a qualitative way from observational experience of system behaviour.

Mathematical Model: the ideas underlaying the conceptual model are formalized and written as statistical or exact mathematical relationships.

Computational Model: a procedure is adopted for solving the mathematical model with given system data and boundary conditions.

Physical Model: is a mechanical or electrical model behaving according to the same kind of equations as those describing the mathematical model.

Langham argues that a normal procedure is to devise a conceptual model and to produce a mathematical model for it. If the mathematical model can be solved by computation, then there is a choice between solving the equations analytically or using either analogue or numerical approximations. If the mathematical model cannot be solved in this way, then a physical analogue may be used. The sequence can be interrupted at any stage if the appropriate model cannot be

Figure 3.3. Hydrogeological map of Mozambique

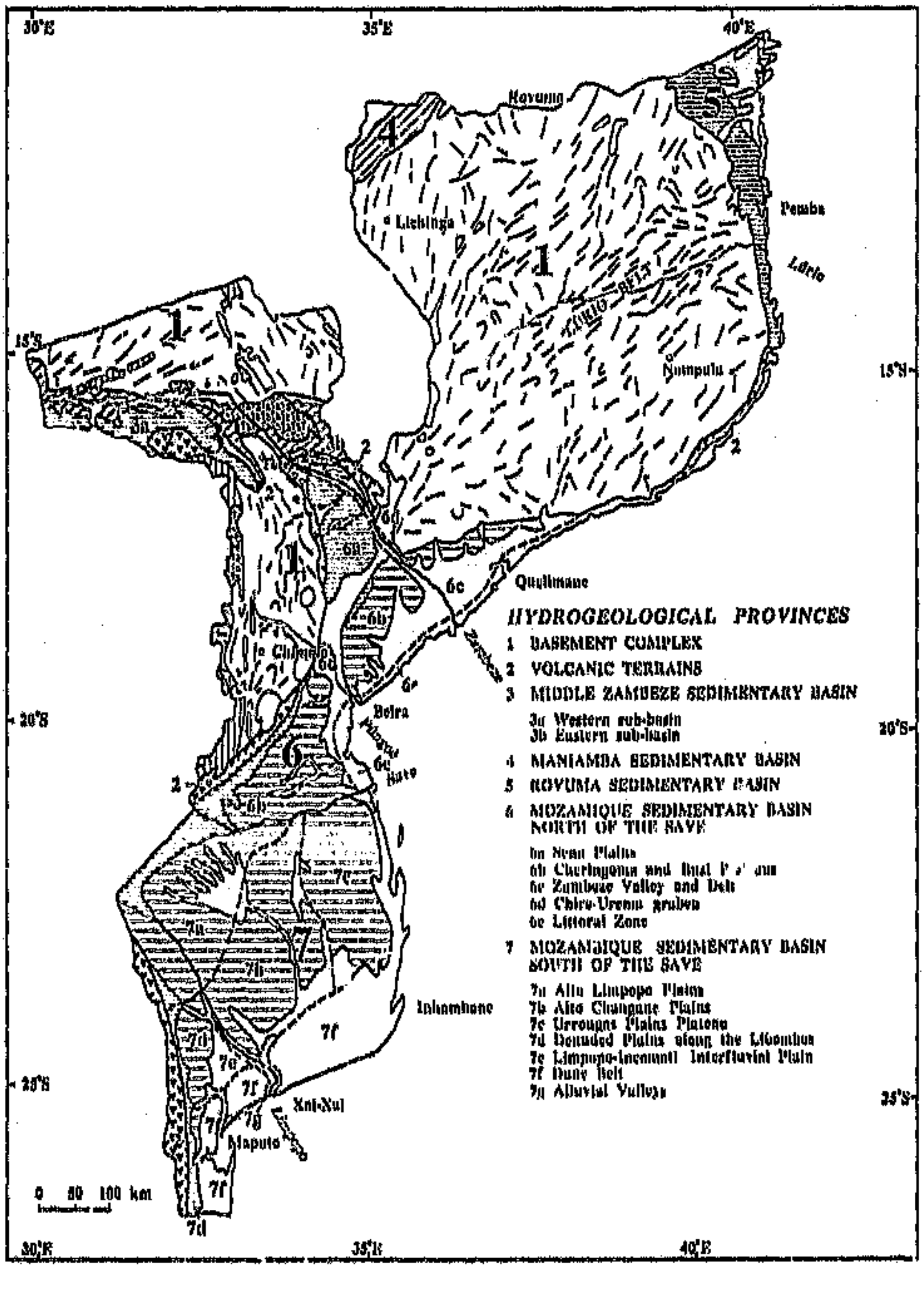
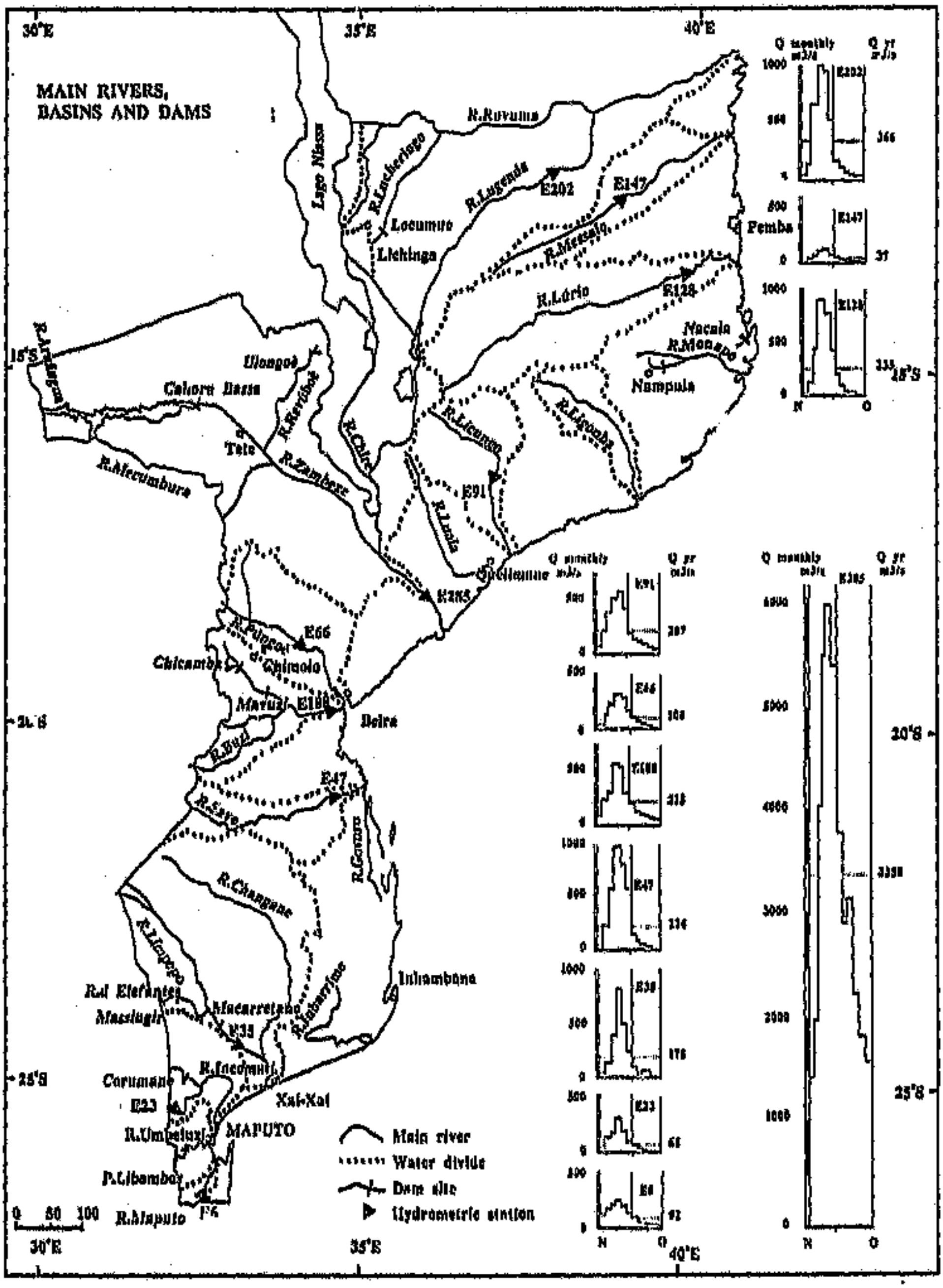


Figure 3.2 Mozambican main rivers, basins and dams



With regard to small piped water supplies, the policy is to keep the coverage level of 5% with a focus on rehabilitation and maintenance. New schemes will only be constructed to assist the population resettlement.

The policy paper also states that priority should be given to labour based construction of wells, springs and boreholes. Drilling machinery should only be used when there is not water near surface within 500 m from the village and able to supply 500 people per water source. The beneficiaries will be responsible for the operation and maintenance of these sources based on Village Level Operation and Maintenance (VLOM) concept, that is technology to be kept extremely simple. Women play an important role in the process as they traditionally are in charge of collecting water for domestic use. Necessary training will be provided by PEC - Programa de Educação Comunitária (Community Education Programme). Although households are quite poor some sort of financial contribution towards operating and maintaining the water supplies will be encouraged.

PRONAR has estimated that they have an annual capacity to implement water projects able to provide 875 000 people with safe water. This can be done through construction of 1600 wells or boreholes, 3 small piped schemes and rehabilitation of 12 small piped schemes. The network of contractors has capacity to construct more but availability of funds is the biggest constraint.

Funding of rural water supply is essentially dependent on external donors. What is specific about rural water supply sector is that there is a large number of small scale donors whose initiatives are sometimes difficult to coordinate.

estimated to be 28 million m^3/year covering 28% of the rural population. For the year 2002 the target is 40% of the rural population with access to improved (protected) sources, and higher per capita consumption (around 20 l/p/d). The rural water demand will increase to 58 million m^3/year.

Industrial and commercial demand in urban areas is now about 12 million m^3/year, of which two-thirds are in the capital city - Maputo. This demand is likely to increase to 20 million m^3/year by 2002.

Present estimates indicate that about 98000 ha of irrigation areas have been constructed, of which about half is currently being used. The annual demand is 540 million m^3/year and this figure is expected to double by 2002 when all irrigation areas have been rehabilitated.

The demands for year 2002 referred above are some of the short term targets listed in the National Water Policy paper.

3.5 Rural water supply

In 1978 less than 5% of rural population were served by formal piped water supply schemes or protected water sources. Within the National Directorate of Water Affairs (DNA) a unit was set up to deal with water supply and sanitation in the country. This unit was called Unidade de Direcção de Abastecimento de Água e Saneamento - Water Supply and Sanitation Unit (UDAAS) and as result in 1987 the level of rural water supply coverage increased to 11.4%. In 1987 UDAAS stopped bearing responsibility for rural water supply and a new department was established to deal only with rural water supply. This is called PRONAR - Programa Nacional de Abastecimento de Água Rural (National Rural Water Supply Programme).

About 28% of the rural population is now provided with water of reasonable quality. In total, 6300 water source were developed (wells, springs and boreholes) serving approximately 23% and 176 small piped schemes are in operation to serve some 5%.

On the Karoo Formations, found mainly in the inland areas on the central areas of the country, little information exists about the aquifers.

The Post-Karoo Formation found on the south of river Save and along the coastal areas in the north, contain highly saline waters unsuitable for consumption.

Near-surface aquifers, suitable for low yield hand-pump extraction, can be found in nearly all parts of the country except in some parts of the Crystalline Complex. The best ground water resources are to be found in the productive alluvial aquifers along the major rivers. These have been developed for water supplies of five cities.

The main constraint in the use of ground water is often the water quality. For example, high population densities and increased use of pit latrines in peri-urban areas brought about severe ground water pollution. In areas with high population density, ground water from shallow wells are therefore unsuitable for human consumption.

3.4 Water demand

The total water consumption in 1985 was estimated at 1612 million m^3, of which only 4% derived from ground water resources. More than 90% of total consumption was used in agriculture, 7.4% for domestic use, and 1.7% in industry.

The consumption of water for urban domestic use is now about 25 million m^3/year. This is far from meeting the demand of the existing population as only about 25% is served by formal systems. It is expected that by the year 2002, 70% of the urban population will be served with potable water supply and this will result in a consumption of 56 million m^3/year.

In rural areas typical water use is 10-12 l/p/d and falls to 4 l/p/d in areas far from a water source. At the present the domestic rural consumption from piped water and protected sources is

Cahora Bassa dam is one of the world's ten largest dams. In 1971, 583 small dams were registered in Mozambique as having an estimated total volume of 60 million m^3. More than 90% were used for agricultural purposes or livestock watering.

Now the total impounded water capacity is 44900 million m^3. The two largest dams are Cahora Bassa (for power generation) with 39200 million m^3 and Massingir (multi-purpose) with 2260 million m^3 volume. The reservoir siltation in the dams have not been monitored.

Mozambique has about 13000 km^2 of inland water. The largest natural lakes are located along the Malawian border. The Mozambican part of the Lake Niassa has a surface area of 7000 km^2. Some smaller lakes and ponds can be found in the north-east, but the majority are situated in the south on the inland plains, in local depressions in the inland dune, area and behind the recent dunes in the littoral zone.

In the short term, the highest priority will be given to establish water sharing agreements on the Incomati, Limpopo, Púngoè, Save and Zambezi rivers. These agreements should also guarantee minimum ecological flows.

3.3.2 Ground water

Ground water resources can be found in three main hydrogeological units *(Figure 3.3)*: the Crystalline Complex, the Karoo Formations, and the Post-Karoo Formations.

The Crystalline Complex covers the north-west region of the country and contain two types of aquifers: those in the saturated zone and those in fractured rock. Typical borehole yields are 1-2 m^3/h and rarely greater than 6 m^3/h. Low uneconomic yields (0.5-0.8 m^3/h) can also be found. The degree of mineralization depends on the water bearing formation and typically lies between 700 mg/l and 1500 mg/l.

3.3 Water resources

3.3.1 Surface water

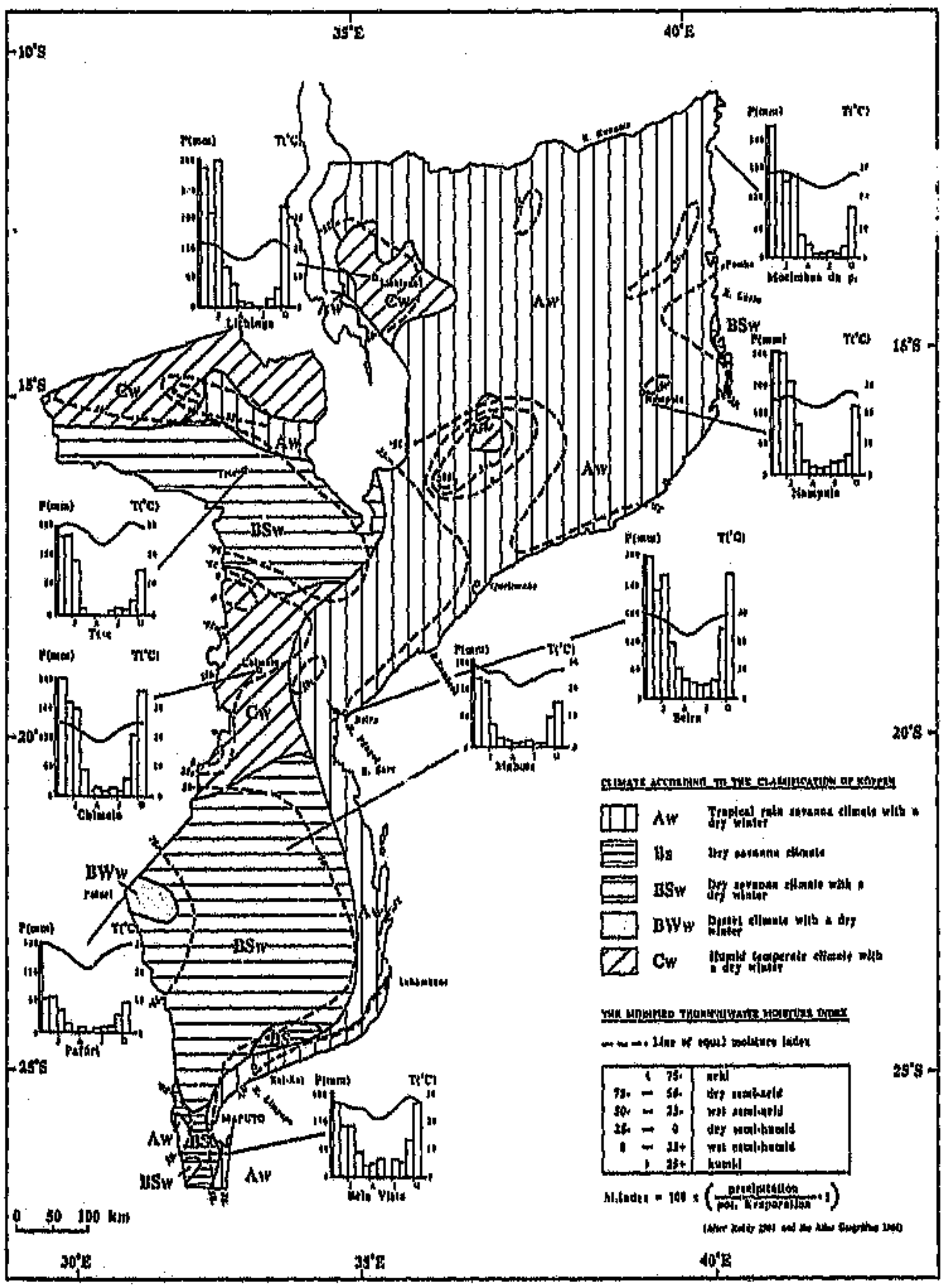
The main source of water in Mozambique is surface water. The average annual run-off amounts to $213*10^9$ m^3/year, of which only $97*10^9$ m^3 /year originates from rainfall on Mozambican territory. The irregular rainfall distribution during the year implies that substantial water storage is required in order to make use of most of the water potentially available: about 10 m^3/day/person compared to world average of 27 m^3/day/person (DNA 1994).

There are over 100 river basins in the country and the majority of the rivers flow into the Indian ocean *(Figure 3.2)*. The rainy season contributes to 70% of the annual run-off. Most rivers have a torrential regime. The rivers are classified as perennial, seasonal or ephemeral streams. Some of the previously perennial rivers have no flow towards the end of the dry season e.g. Incomati, Limpopo, Save, Ligonha, Monapo, Lurio and Messalo. The seasonal rivers have water throughout the wet season but are otherwise dry; frequently these river beds function as underground drain. The ephemeral streams only have water during and immediately after heavy rains.

Almost all major rivers in Mozambique are international rivers and the water consumption by the upstream riparian states reduces the availability of water for the future economic development of the country. South Africa, Swaziland and Zimbabwe now abstract over 50% of the potential border flow. As a result of this consumption by the neighbouring states, the previously perennial rivers in the southern provinces are now dry for s[illegible] months of the year. These rivers are the source of water for the city of Maputo and th[illegible]mically important irrigation areas in Umbeluzi, Incomati and Limpopo basins.

Many dams have been constructed with the aim to guarantee water supply to urban centres and to irrigation schemes, to produce electrical energy or to regulate the torrential regimes. The

Figure 3.1 Climate (after Reddy 1984 and ATLAS Geográfico 1986)



$$D = \sqrt[5]{\frac{\lambda L Q^2}{gH(\frac{\pi}{4})^2}} \tag{31}$$

where,

D = the pipe diameter (m)

λ = the non-dimensional Darcy friction coefficient

L = the pipeline length (m)

Q = the flow (m^3/s)

g = the gravitational acceleration (9.81 m/s^2)

H = head (m)

π = ratio of circumference of a circle to diameter (3.14)

Storage

Storage is calculated as a function of daily water demand. The user specifies how many days demand of storage is appropriate for the scheme taking into account the system reliability and hours per day pumping versus hours per day drawoff.

Storage excess

The model compares the existing storage capacity with the calculated capacity required. If the existing storage is bigger than the calculated capacity, then there is a need for additional storage. If the existing storage is smaller than the calculated capacity, then there is storage capacity in excess which could be used for future demands.

New scheme

Pumping requirements for a new scheme, is assessed using the same approach as used for the existing scheme, and the values of flow and head now correspond to those of future needs.

The power required for the extension of the system is then compared with the installed capacity to determine additional pumping capacity to be installed.

Gravity Scheme

Neglecting minor losses and using Darcy-Weisbach equation

$$H=\frac{\lambda L V^2}{2gD} \tag{28}$$

and continuity equation

$$V=\frac{Q}{\frac{\pi D^2}{4}} \tag{29}$$

the following relationship is obtained

$$H=\frac{\lambda L Q^2}{2gD^5(\frac{\pi}{4})^2} \tag{30}$$

rearranging the above formula diameter D is calculated as follows:

For a new scheme the final velocity is not known at the start. This is because the pipe diameter calculated not always is the pipe diameter commercially available. An interaction is therefore required.

Pipe diameters are based on maximum permissible flow velocities decided for practical reasons. The next larger commercially available pipe size is selected in each case.

Pumping Requirement

Existing Scheme

The power consumed, in *watts*, by a pump when delivering a discharge Q (m^3/s) at a head Hm (m) with combined pump/motor efficiency η, is:

(27)

$$P = \frac{\rho g Q H}{\eta}$$

where,

P = is power (watts)

ρ = is the water density (1000 kg/m^3)

η = is the pump/motor efficiency

g = is the gravitational acceleration (9.81 m/s^2)

Q = is the flow (m^3/s)

H = is the total head (metres)

Comparing the pump requirement of the existing conditions with that of installed pumping capacity, it is possible to determine if the existing equipment is working overloaded, under-loaded or within recommended range. The head H, is the sum of the static head and the friction head loss.

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Comparing the pump requirement of the existing conditions with that of installed pumping capacity, it is possible to determine if the existing equipment is working overloaded, under-loaded or within recommended range. The head H, is the sum of the static head and the friction head loss.

If the proposed project considers only handpumps level of service, i.e. does not include a scheme construction, the demand for users not served by the scheme is equal to the total domestic demand.

The result, demand for users not served by the scheme, is then assessed in relation to water source. Surface water sources are not considered.

Pumping scheme

Under this classification fall all the schemes that involve pumping. The calculation is as follows:

Existing scheme

The head loss due to friction is calculated based on Darcy-Weisbach formula:

$$H=\frac{\lambda L V^2}{2gD} \tag{26}$$

where,

H = the head loss due to friction in metres

λ = the non-dimensional Darcy friction coefficient

L = the pipe length in metres

V = the flow velocity in metres per second

g = the gravity acceleration in metres per second square

D = the pipe diameter in metres

For the existing scheme it is an explicit equation because all the variables are known. However, the rate at which the pipeline is operating can be accessed by comparing the actual velocity and the recommended velocity, set in the model database.

Water source in excess of domestic demand (WSEDD). The importance of this calculation, is to check if the available water sources are adequate to meet the domestic demand, independently if it is through the scheme, or direct collection from the water source. The calculation is as follows:

$$WSEDD = Water\ Source\ Capacity - Total\ Domestic\ Demand \tag{23}$$

For the "current situation", the value of water source capacity is related to the developed sources, and for the proposed scheme, the water source capacity is the water source potential less the developed sources.

Water source in excess of total demand (WSETD):

$$WSETD = Water\ Source\ Capacity - Total\ Demand \tag{24}$$

This is a useful indicator, if plans exist to develop irrigation schemes, fauna, or industrial activities. For the "current situation", it compares the total demand with water sources developed. For future, or under proposed scheme, potential water sources are taken into account

Water source balance for scheme demand. This exercise compares the water demand with the source. It indicates, in percentage, how much can each source contribute to the total demand. It is up to the user to decide how to combine the sources.

Water source balance for **domestic users not served by the scheme** (DUNSS). Since the primary objective is to supply water to rural domestic consumers, consideration is also taken to those consumers not served by the existing or proposed scheme.

$$DUNSS = Total\ Domestic\ Demand - Scheme\ Domestic\ Demand \tag{25}$$

Water source capacity

Present water source capacity is the capacity which has been developed and is in working condition. The calculation is as follows:

Present Water Source Capacity (PWSC):

(20)

$$PWSC = (River + Weir + Spring + Borehole + Wells)\ Daily\ Yields$$

For a gravity system, where pumping is not required and treatment consists only of disinfection, the scheme can operate up to 24 hours a day. However, for pumping schemes in particular when water treatment is involved, the scheme will operate on average not more than 10 hours a day. This aggravates when electricity is not available, or is supplied by a local generator. Number of working hours is fundamental to calculate the water source development, and storage requirements.

Maximum daily abstraction (MDA) for surface water:

(21)

$$Max\ Daily\ Abstraction = PWSC * No\ of\ Operating\ Hours * 3600secs$$

The model repeats this calculation for each source and adds them. This gives the maximum capacity of surface water sources.

Maximum daily abstraction (MDA) for groundwater:

(22)

$$MDA = Av\ Borehole\ Yield * No\ of\ Borehole * No\ Operating\ Hours * 3600secs$$

The model repeats this calculation for each source and adds them. This gives the maximum capacity of groundwater sources.

Number of yard connections:

(16)

$$No\ of\ YT = \frac{Population * \%Population\ With\ YT}{No\ of\ people\ per\ household}$$

The number of standpipes for the existing system should entered by the user. For the proposed scheme, the **number of standpipes** is calculated as follows:

(17)

$$No\ of\ SP = \frac{Population * \%Population\ Using\ SP}{Max\ Design\ No\ of\ people\ Using\ SP}$$

Number of hand pumps:

(18)

$$No\ of\ HPu = \frac{Population * \%Population\ Using\ HPu}{Max\ Design\ No\ of\ people\ Using\ HPu}$$

Number of required water points:

(19)

$$No\ of\ Water\ Points = \frac{Project\ Area}{Max\ Design\ Walking\ Distance} - No\ of\ SP$$

To be accurate, the project area should be divided in smaller areas according to the levels of service. In the above formula, for instance, the 'project area' should not have included areas covered by house connection or yard connection. This model does not take this into account because, in many cases, the areas covered with house connection and yard connection, are almost negligible when compared with the total project area.

Then **Other Demand** is calculated as follows:

(12)

$$Other\ Demand = (Hospital + School + Workers)\ Demands$$

Total Demand:

(13)

$$Total\ Demand = Total\ Domestic\ Demand + Other\ Demand$$

The total demand is then divided into scheme demand, and demand of users not served by the scheme; the scheme demand is the sum of demands of users served by the scheme. This differentiation is important because rural water schemes are generally designed to serve only part of the domestic demand. The computation of **Scheme Design Demand,** taking into account daily peak factor and unaccounted-for water (UFW), is as follows:

(14)

$$Scheme\ Design\ Demand = Scheme\ Demand * Daily\ Peak\ Factor * UFW$$

Once the demands are calculated, the model computes the following numbers of consumer connections.

Number of house connections:

(15)

$$No\ of\ HC = \frac{Population * \%Population\ With\ HC}{No\ of\ people\ per\ household}$$

$$\textit{Wells Demand} = \textit{Population} * \textit{\%Population Using Wells} * \textit{Wells d.p.c.c.} \tag{7}$$

where,

HC = House Connection

YT = Yard Tap

SP = Standpipe

Hpu = Handpump

d.p.c.c = daily *per capita* consumption

Therefore, the **Total Domestic Demand:**

$$\textit{Total Domestic Demand} = (HC + YT + SP + HPu + \textit{Wells})\ \textit{Demands} \tag{8}$$

Hospital demand:

$$\textit{Hospital Demand} = \textit{No. Beds} * \textit{Hospital d.p.c.c.} \tag{9}$$

School demand:

$$\textit{School Demand} = \textit{No. Students} * \textit{Student d.p.c.c.} \tag{10}$$

Office demand:

$$\textit{Workers Demand} = \textit{No. Workers} * \textit{Workers d.p.c.c.} \tag{11}$$

G = population growth ratio

n = number of years

Pn = population in year n

Population density in the project area:

$$Population\ Density = \frac{Population}{Project\ Area} \tag{2}$$

Total domestic water demand is a combination of a series of calculations as follows:

$$HC\ Demand = Population * \%Population\ With\ HC * HC\ d.p.c.c. \tag{3}$$

$$YT\ Demand = Population * \%Population\ With\ YT * YT\ d.p.c.c. \tag{4}$$

$$SP\ Demand = Population * \%Population\ Using\ SP * SP\ d.p.c.c. \tag{5}$$

$$HPu\ Demand = Population * \%Population\ Using\ HPu * HPu\ d.p.c.c. \tag{6}$$

4.2 Model Computation

The standard engineering practice is to let a feasibility study precede the final design, using acceptable simplifications and reasonable estimates. The model uses this principle supported by a database to do the calculations.

A project scenario is computed at the time. In order to compare different scenarios the model has to be run as many times as the number of scenarios.

The calculation is divided into technical and financial calculations. Technical calculation concern sizing the project components, and financial calculation cost the project and provides the related financial information.

4.2.1 Technical computation

The supply capacity of a project is one of the most important variables affecting cost, and cost *per capita* of water. Project horizon and levels of service are the two factors with major influence on the supply capacity. The criteria to select values for these variables are described on Chapter 5. After entering the required information (*Appendix C*), the following parameters are calculated by the model:

The **population figure** at the project horizon is calculated using geometric projection formulae:

(1)

$$Pn = P * (1 + G)^n$$

where,

P = current population

5.0 USER MANUAL

5.1 Background

The Decision Support System for rural water supply in Mozambique is a mathematical tool to assist those involved in the water sector selecting and planning projects.

Entering input data is a process of describing the existing facilities, proposed project, and the conditions where the project is intended to be implemented. Before using the model, the project has to be studied and planned, given that the results can only be as accurate as the input data. Thus, prior to elaborating on the model input data having an overview of project planning, is important.

Project planning notion used in this study, refers to a set of broad guidelines and principles set to help the user conceive a project and estimate the variables.

5.2 Project planning

As highlighted in Section 1.3, a rural water supply project has the following stages:

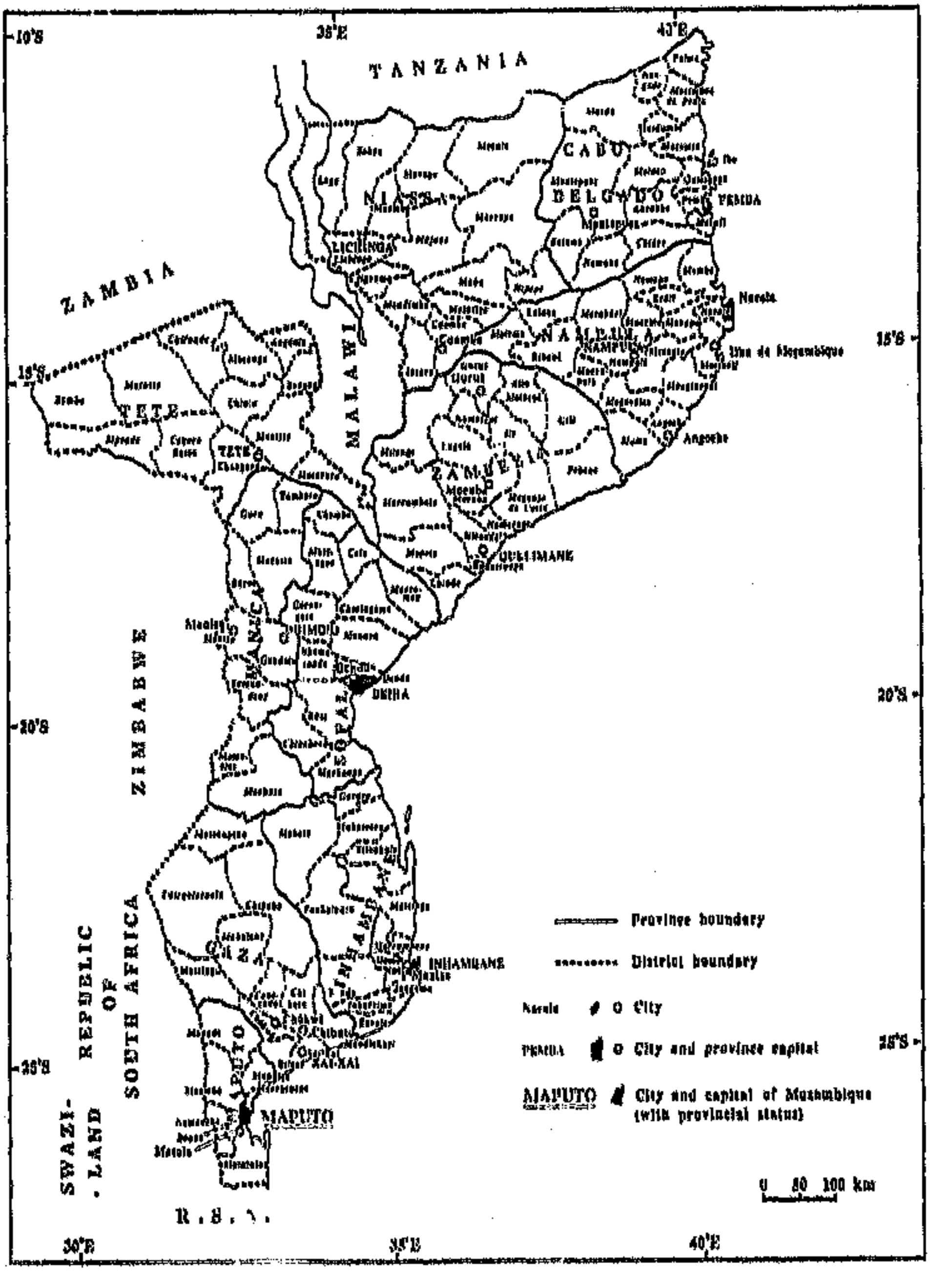
- Identification and Preparation.

- Approval.

- Implementation.

- Operation.

Figure 4.3 Administrative map of Mozambique



These findings confirm the complexity of estimating costs of rural water supplies. The task can certainly be done but it requires skilled and educated judgement which in many cases, are lacking in developing countries.

Each village or community is almost unique on its characteristics and habits. Unless a model can cater for each specific condition, which of course carries a cost, there will be a margin for error. However, with reliable input data, the result calculated by the model would give a good indication of the level of investment required.

- The unit of analysis is the individual project (a scheme serving more than one village and/or the development of local water sources for a village, and the local infrastructure particular to one village). Data is collected and analysed by village and by scheme.

- The model provide for a standardised approach to costing, making all costing assumptions explicit.

Weaknesses:

- The linkage between the village database and the scheme costing sheets is not automated.

- The manner in which unaccounted-for water is treated is simplistic and needs refinement.

- The model does not easily cater for a large number of villages (more than 50) and a large number of schemes (more than 5).

- The allocation of scheme water and scheme costs between villages need refinement.

- The model does not cater adequately for existing infrastructure.

- The data is not stored within a structured database (the model is spreadsheet based).

- The user-interface could be improved. (Not user friendly).

- Error checking could be improved.

on actual project proposal. Instances are when a global per capita figure, e.g. US$ 40 (Singh, 1990) is used to estimate a project cost.

In South Africa until recently no single agency at national level was charged with the responsibility of ensuring that all households are served with adequate water supply and sanitation (Muller 1991a). Because there is a need to reduce the backlog of rural water supply coverage, neglected in the past, the Department of Water Affairs and Forestry has committed itself to the development of a Financial Modelling of rural water supply. The model, developed in 1995/96, had the following objectives:

- To develop capital and operating costs scenarios (at district/area, regional/provincial, and national levels) for rural water supply based on various policy options for service level targets and minimum service level standards.

- To modelling the financial implications of various financing / subsidy / income policies for rural water supply (at the district/area, regional/provincial and national levels) by combining analysis of capital expenditure with operating and maintenance costs, and operating income implications.

The model development has been finalised but no information is yet available about its performance. However, because the prototype was based on five districts of approximately 250 000 people, below are some of the findings summarized by the consultants involved in developing the model:

Strengths:

- The model provides a tool for systematic development of scenarios for both capital and operating costs of rural water supply at the district level, on the basis of key explicit assumptions such as service levels and water demand.

have the major ports, chief components of the Maputo and Beira corridors respectively, and have the highest service providers concentration in the country.

The cost variation among the 10 provinces of the country, shown on *Figure 4.3*, are based on the price indices listed below. Maputo and Sofala provinces have a cost factor of one, and the remainder are as follows:

Gaza 1.2;
Inhambane 1.25;
Manica 1.1;
Tete 1.2;
Zambezia 1.3;
Nampula 1.2;
Cabo Delgado 1.3;
and Niassa 1.4.

The financial computation of the Decision Support System, is currently set to increase by 5% the South African prices if the project is to be implemented in Maputo and Sofala provinces. At this sta this is the main factor for model calibration with regard to its applicability in Mozambique. All variables that affect the cost are either optional, or related to the total project cost by default, or user specified settings. The default settings are based on South Africa current practices and they are similar to those used in Mozambique e.g. ratio between project cost and project design and supervision.

4.5 Financial model for rural water supply in South Africa

Cost estimate of rural water supply has been a complex task particularly when information on water sector demand is scarce or not available. Different countries and organizations use different methods but in many cases they are based on extrapolations from previous projects rather than equipments needed. These goods have to be imported as the country do not manufacture them in quantities enough to meet the market demand. Government generally grants import duties exemption, but the process is lengthy. The delay due to goods clearance, causes project cost to increase out of contro..

In some cases, funds made available are tied funds, meaning that preference may be given to certain suppliers and service providers, usually from the donor country. This may not always be the least cost alternative.

Other factors affecting the project cost stem from the manner in which the project is implemented, and the location of the project. A labour based approach is cheaper but requires a high degree of managerial input. Contractors can deliver in time and require less input from the client. However, their involvement may increase the overall project cost.

Substantial goods imported by Mozambique come from South Africa. After transport, import duties and profit margin, the unit prices can sometimes be as much as the double compared to South African retail prices. It is important, therefore, to verify if materials and equipments to be used in a project are import duty exempted, and if they are purchased directly from the suppliers. Consultants from abroad represent another burden on costs due to travelling and accommodation expenses.

Transport network services are not developed, and some major road routes are not in operational condition; alternative routes, generally more expensive, has to be used to deliver the resources to site. Project location is therefore a variable with large influence on the cost.

4.4 Model Adjustment

Project location has a large influence on costs. In Mozambique, projects carried out near the cities of Maputo and Beira are found to be the least expensive. They are the two biggest cities, asset and the estimated salvage value at the end of its life is divided by the estimated life in years, to give the uniforr 'nstalment of depreciation which is written off every year. The depreciation of the asset is assumed to be directly proportional to its age. The calculation is as follows:

$$\text{Fixed instalment} = \frac{\text{initial cost} - \text{estimated salvage value}}{\text{estimated life (years)}} \tag{33}$$

The cost of water - is the unit cost to be paid to cover the water production. The cost can be expressed as cost per household, cost per capita or cost per kl. These cost can either cover the operation and maintenance, operation maintenance and depreciation, or operation maintenance, depreciation, and annual loan repayment.

The capital cost per capita - is the total project cost divided by the population figure.

4.3 Factors affecting cost of rural water supply in Mozambique

Mozambique considers rural water supply activity a priority due to the need of resettling the population in those areas. The policy is that baric infrastructure, water supply being part thereof, need to be provided to entice people. The cost of providing water in rural areas vary considerably from place to place, and it also depends on how the project is identified and funded.

The National Directorate for Water Affairs (DNA), through PRONAR, identify and rank projects countrywide. These projects are generally co-financed by government and donors, or fully financed by the government budget. Private investors seldom finance such projects.

Cases are when donors, particularly operating in rural areas, find that water supply is a major problem and do make funds available to implement projects to alleviate the problem. The constraint, however, is that donors are not prepared to pay import duties on materials and

The column *amount* has the answer of quantities times rate multiplication.

The information on this worksheet refer only to the proposed project. This is a view tool displaying results. Changes can only be made to "Input Data" (*Appendix B*), to manipulate results.

After calculating the project cost, and operation and maintenance cost, the model computes the unit cost of water and the capital cost per capita. This is the ultimate goal of this model and is described in detail in the next section.

4.2.3.2 Water Price

Water price figures are displayed on a worksheet called "PRICE" (*Appendix F*). The first lines show results imported from the Project Cost worksheet. These are project cost, operation and maintenance cost per annum, and cost sharing between grant, soft loan and commercial loan.

Annual repayments of soft and commercial loans are calculated based on the following formula:

$$\text{Annual repayment} = \frac{i\,(1+i)^n}{(1+i)^n - 1} * C \tag{32}$$

where,

i = interest rate in %;

n = the repayment period in years;

C = the loan capital in Rand.

Depreciation - is calculated based on straight line depreciation sometimes known as the fixed instalment method. The basis of the method is that the difference between the initial cost of the

Besides the material and equipment cost, the model also takes into account other factors that affect the total project cost. These are: community contributions to the project, training, tool's requirement, office equipment, project design, project supervision and contingencies. Three ways are available to the user to specify if the total cost should consider these issues:

i) Not to include in the calculations. Type N (for no) when asked if provision should be made for each item.

ii) To include in the calculations using default percentage values stored as database.

iii) To include in the calculations using lump sum values specified by the user. This is useful when a ceiling budgets exist for each item.

Project costs are shown on "COST" (*Appendix E*) worksheet. On this worksheet, information from "REPORT" (*Appendix D*) worksheet is extracted and listed on a bill of quantities format. Unit rates are imported from the "dBASE" (*Appendix A*) worksheet and used to calculate the costs.

The "COST" worksheet is divided into six columns with the following headings: item number, item description, units, quantities, rate, and amount. The contents of each column are as follows:

The column for *item number* lists pre-set item numbers which could be use for easy reference.

The column *item description* contains brief information on the item.

The column *units* shows the item unit of measurement .

The column *quantities* displays the amount of item required.

The column *rates* indicates the item unit cost.

This model allows the user to specify the components that can be used in the upgrading works and considers them in the calculations.

4.2.2 Project reporting

Project report (*Appendix D*) is a list of selected results and input information describing the existing situation and the proposed project.

The results of calculations are checked through the database for standard dimensions. If the calculated result does not exist, the model assigns the next bigger standard value to the calculations.

Results can also be inspected on the "CALC" (*Appendix C*) worksheet for a more detailed analysis. Inspecting the "CALC" worksheet is useful if the user wants to compare the calculated result and the assigned value.

4.2.3 Financial calculation

Financial calculation are divided into two categories: project costs (*Appendix E*) and the water price (*Appendix F*).

4.2.3.1 Project Costing

The model combines the database information and user's input data to do the calculations. Unit prices of components are stored on the database. Once the technical calculations are completed, the model lists the materials and equipment quantities, the unit cost, and the total cost.

Water treatment

Water purification works form a complex entity. Quality of the influent and the permitted quantities of the several chemical constituents in the effluent determine the size and the sequence of the process facilities. To generalize the cost of these works is a simplistic approach and would violate the truth.

Given that in rural areas water treatment plants are difficult to maintain in operation, this component is to be avoided. Groundwater is the most common water source and simple disinfection is normally sufficient to make the water reasonable safe for domestic consumption.

Based on raw water quality the model only indicates if water treatment is required or not (more details in Section 5.3).

Sharing facilities

In upgrading existing facilities, circumstances are when some of the existing components operating under their capacities and in good working condition, can be used in the new scheme. This occur because when a project is designed, it could be more cost effective to install or build components bigger than the actual needs. For example, by doubling the pipe diameter of a pipe, other factors such as head remaining constant, the capacity increases sixfold, or the capacity of a pipeline can be increased by installing booster pumps (Stephenson 1989). Depending on factors such as rate of growth in demand, operating factor, certainty of future demands, varying cost with time, physical difficulties in the construction of a second pipeline if required, installing a larger diameter main at the outset may be economical.

Decisions of this nature are usually supported by systems analysis techniques such as linear programming and dynamic programming and this implies that different components in a water scheme have different horizons.

Elevation (m) - is the difference in levels from the water source to the highest point along the pipeline for a pumping scheme, and to the end of the pipeline for a gravity scheme.

Source of energy - is the type of energy available to run the pumps and other equipments of the system. The energy can be electricity, or diesel.

Raw water quality - the need to install water treatment facilities is determined by the quality of raw water. For rural water supply only two parameters are being considered: turbidity (NTU) to verify if flocculation, decantation and filtration are required, and *Escherichia Coli* contents to verify the need for disinfection.

For turbidity > 10 NTU the model will indicate that filtration is required. For *Escherichia Coli* > 5 counts/100ml the model will indicate that disinfection is required.

Description of the existing water supply and proposed project

House connection - specify what exist. Options for the proposed project are GMS, PVC, and HDPE.

Yard tap -specify what exist. Options for the proposed project are GMS, PVC, and HDPE.

Standpipe -specify what exist. Options for standpipe connection on the proposed project are GMS, PVC, and HDPE.

Future per capita consumption (litres/person/day) - this information is based on sector policy or the user's judgement. How the consumption trend will vary in the future depends on factors such as economical growth, general development, water availability, and water system reliability.

Storage requirements - considering the reliability of the system, the user should specify how much storage is appropriate as a function of a day demand. The reservoirs are usually sized to meet one to three days demand. This allows for maintenance and repair works without interrupting the supply of water to consumers. For small schemes, a two-day demand is recommended.

Peak factors - are factors used to reflect the increase of consumption in relation to the average line. Although at the end of the day the total consumption is the same, the consumption rates are not uniform during that period, and the system components should be designed to meet peak demands. Default daily peak factor is 2.5.

Unaccounted-for water (%) - is the amount of water which is produced that neither is used by consumers nor is it recorded. It reflects losses due to leakages in the system, and inadequate administrative practices. For small schemes unaccounted-for water figures can be of the order of 10% to 15% depending on how efficiently the system is managed.

Numbers of hours of daily function - is the average number of hours the scheme operates per day. In rural areas, often the water systems only operate during the day due to shortage of electricity or diesel for generators. Ten to 12 hours per day, is a good figure for a well-operated scheme.

Distance from the water source to the highest point (m) - is the distance used in the computation of head losses due to friction. For a pumping scheme, for instance, is the distance to which the water should be pumped, given that from that point the water will flow due to gravity force.

Total pipeline distance (m) - is the distance from the water source to the distribution reticulation. It should also include the total length of the reticulation.

Number of students - is the sum of all schools' capacities within the project area.

Number of hospital beds - is the sum of all hospital capacities within the project area.

Number of workers - is the sum of all working posts within the project area.

Type of scheme - the model only caters for three types of schemes:

Gravity when the water source is at a higher level in relation to distribution, and no pumping is necessary.

Pumping when the water source is at a lower level in relation to the distribution, and pumps are required to provide energy to water to reach water tower, or a distribution reticulation.

Handpump when no scheme is envisaged. Wells and boreholes will only be fitted with handpumps.

Project horizon - number of years from the design to the time the design should cater for, in terms of demand.

Water sources - this information is divided into surface water and groundwater. Surface water consisting of weir, spring, river or lake, requires the maximum abstraction rate (litres/second) for each source.

Groundwater refers to wells and boreholes. Average values of depth (m) and yield (l/s) of both for wells and for boreholes, are required.

Handpump refers to wells or boreholes fitted with handpumps. Average yields (l/s) and depths (m), are the required data.

$$Standpipe = \frac{\text{No of people using standpipes}}{\text{total population}} * 100 \tag{36}$$

$$Handpump = \frac{\text{No of people using handpumps}}{\text{total population}} * 100 \tag{37}$$

$$Others = \frac{\text{No of people with none of the above}}{\text{total population}} * 100 \tag{38}$$

Present number of people served by a water point - this information is related to the user's convenience. Fewer people per water point means less time queueing for water. This figure indicates a level of service and determines the number of water point needs. Values vary from 250 to 500 people per water point. Country policy paper may specify the maximum values.

Present maximum walking distance to a water point - this information is also related to the user's convenience. The shorter the distance to a water point, the shorter the time, and less human energy is spent on water collection. This figure shows a level of service and determines the number of water point needs. Values vary from 250 to 750 metres. Country policy paper may specify the maximum values.

Since both number of people served by a water point and the maximum walking distance to a water point determine the number of water point needs, the model uses the higher number of water points between the two. In doing that both criteria are met.

Yard Tap - household provided with a tap on the yard. Water is collected from the tap to storage in drums and buckets, or for direct use. Per capita consumption can be estimated by dividing the total consumption by the number of people in the household. The average of several households' computation should be used.

Standpipe - a water point with two or four taps where consumers collect their water. *Per capita* consumption can be estimated by recording the total supply, and divide with number of people supplied.

Handpump - refers to wells or boreholes fitted with a handpump for communal water supply. *Per capita* consumption can be estimated recording the total supply and divide with number of people supplied.

Hospital - *per capita* consumption of a hospital, is the total water consumption divided by the number of beds of the hospital.

Workers - consumption figure for this category should be obtained by dividing the total consumption of working places by the number of people employed.

Present percentage of people served by different levels of service - this information is obtained as follows:

$$House\ connection = \frac{No\ of\ people\ with\ house\ connection}{total\ population} * 100 \tag{34}$$

$$Yard\ tap = \frac{No\ of\ people\ with\ yard\ tap}{total\ population} * 100 \tag{35}$$

Project Name - is the name the project is, or will be, known for.

Project Number - is the reference number, the organization assigns to the project.

Project Location - is the province in which the project will be implemented. This information relates to a cost factor which varies province to province due to their particular conditions. Type the first three characters of the province name only, e.g. MAP for MAPUTO.

Population - this refers to current number of people living within the project area, and the population that will be served by the proposed project. This information can be obtained from local authorities and organizations operating in the zone.

Population's Growth Rate - this is a statistical figure calculated by the planning bodies and available in many literatures, and can also be provided by government departments.

Project Area - is the area where the direct beneficiaries of the project live, in hectares. This can be measured out on a map.

Average number of people per household - this is a statistical figure calculated by the planning bodies and available in many literatures, and can also be provided by government departments.

Present per capita consumption (litres/person/day) - value to be calculated based on the current water supply and the consumption. This item is divided into seven categories and each value assessed independently, i.e. they should actually be measured, or if records exist, they should be used to estimate the current *per capita*'s consumption. The categories are:

> *House connection* - household with water running in taps within the house. Per capita consumption can be estimated by dividing the total consumption by the number of people in the household. The average of several households computation should be used.

Training - this is an important component for running the facilities. Provision should always be made to ensure that those who will have the responsibility to operate and maintain the facilities have the knowledge to carry out their duties. This can be achieved through formal, or on-the-job training.

5.3 Input data

The financial model uses the information provided by the user and its database to do the calculations. Database records have been built based technical, financial, and planning procedures used in the civil engineering industry.

Input data structure, however, does not define clearly what variables are related to technical, financial, or planning fields. The model has been designed in this way for two reasons:

i) at regional and provincial levels, most professional are involved one way or the other, in the three fields due to the shortage of specialists in each discipline;

ii) considering that one of the objectives of this model is to develop capacity within the water sector, it is important that prior to entering data, the user goes through the global planning exercise of the project. The results, nevertheless, can be assessed based on area of expertise.

To run the model about 140 input variables are required. Since all the information has the same degree of importance, checking the information source reliability and data accuracy, is advisable.

To enter data, **upper case** has to be used. The model is **case sensitive** and does not recognise information entered in lower case.

The required input information is:

The administration of rural water supplies has features which are different from those characteristics of the water supply and sanitary systems for towns. The size of the administrative area is an important factor leading to communication and travel problems with a central organization. Yet even where self-help and locally run systems are feasible, a central organization will be necessary; there may be a tendency for trained engineers to indulge in design activities rather than to become involved in the vital, but apparently less intellectual demanding, tasks of management, operation, and maintenance of rural water supplies and sanitation.

5.2.7 Financial aspects

There are several financial aspects to be considered when planning a project. Institutional arrangements have influence mainly on the operating costs, but with regard to capital cost, the following items have to be checked:

Community contribution - the beneficiaries can contribute to the project either with funds and/or in kind. This contribution can be up to 50 or 60% of the total project cost and always need to be assessed. The other benefit, is the sense of ownership which is vital for future maintenance of the infrastructures, when the beneficiaries contribute to the project.

Project location - due to the poor conditions of roads in rural areas, transport of goods to site has a considerable influence on the budget.

Office equipment and tools - water tariffs in rural areas are normally not charged according to the real cost. As a result, the undertakings do not usually have enough funds to maintain the scheme properly, and cannot afford to buy office equipment, tools, chemicals, fuel and spare parts. It has been a practice to include these items in capital costs of new projects, or rehabilitation projects.

standards, and on improving economy; normally it is not sensitive to improved quality but is primarily dependent upon the level of service provided.

In rural areas, the larger the community the faster it is likely to grow, as it is more likely to be provided with social infrastructure and may attract population from the surrounding countryside. This has influence on total water demand.

5.2.4 Project horizon

Rural projects will normally have a short future planning period for design purposes. A project horizon figure of ten, or at most 15 years, might be appropriate. This is not to say that future extensions should not be possible beyond the provision made initially. The provision of staging is often important when funds are scarce and needs great, but the design capacity should not be excessive as this leads to waste and inhibits incremental improvements.

5.2.5 Selection of materials and equipments

The selection of materials and equipments has a direct influence on cost, and operation and maintenance of facilities. Preference should be given to local available resources if they meet the standards of quality. Sophisticated equipments always cause problems due to the skill required for maintenance, the high cost, and difficulties in procurement of spare parts.

5.2.6 Institutional aspects

Institutional requirements for rural water supply need to be more community oriented. The level of maintenance skills should not be high and simplicity in the design of facilities is essential. Outside help or remote maintenance organizations cannot always be relied upon.

5.2.2 Water source

For water supply studies, the most important task is to evaluate water resources. Groundwater is the most likely source and the best for rural communities; it is likely to be free from pathogenic bacteria, and generally to be usable without treatment. The aquifer provides natural storage, and wells can be sited close to the users. However, the water may have high mineral contents, or may require pumping if the aquifer is not near surface.

A preferred source will be the one which requires no treatment, and can deliver water to the users by gravity. A source requiring no treatment but which must be pumped would be the next choice. Treatment plants, however simple, are not likely to be maintained properly in rural areas, and failure of the plant poses a public health risk. A failure of a pumping plant can be inconvenient, but is not necessarily dangerous and since the interruption of supply is immediately noticed, it is likely to receive attention.

5.2.3 Water quality

The appropriate standard of water quality is a matter requiring considerable judgement. Published figures are not always relevant, and adherence to them in planning, can lead to unacceptable and unnecessary costs. There are, however, some publications with guidance for minimum water quality parameters suitable for the developing countries conditions; only in extreme cases these publications recommend complex water treatment facilities.

5.2.4 Water demand

The main criterion, apart from population, is water consumption *per capita*. On this, most other parameters will be based. Consumption will rise with increased availability of water, rising living a function of demands. Rural domestic demand is much smaller than that of irrigation for instance. Operation and maintenance of the water supply systems can, nonetheless, be combined with that of the irrigation scheme in order not waste resources when there is shortage of skilled personnel. The management method for the irrigation system may also provide a model for the institutional arrangement needed for water supply and sanitation, or the responsibilities may even be combined.

Socioeconomic and community participation aspects of a project are very important for a successful implementation. Community Education Program (PEC), as the activity is called in Mozambique, should come first to ensure the community acceptance and their contribution towards the project. Community preferences should be taken into account within the availability of funds.

5.2.1 Design criteria

Local factors, such as religion, tribal characteristics, and traditional practices, will be important in determining design criteria for rural projects.

One fundamental criterion is that the provisions, must be more convenient than the existing arrangements. Improved quality of facilities alone is not always sufficient to ensure their use, and the criteria have to be related to existing situation.

Manual lifting of ground water is acceptable for small communities, but in densely populated areas it may be impractical.

Evaluation of previous projects can give valuable confirmation of the accuracy of the design assumptions made. If the total project involves many separate communities, then a pilot project can be useful for this purpose, and as a demonstration to other communities of the benefits to be gained.

- Evaluation.

The success of a project is highly dependent on how the pre-investment planning is carried out. Pre-investment planning comprises the first stage of the project cycle mentioned above: *identification and preparation*. Having a good understanding of the project physical conditions, is important during this stage; economic, social, and technical factors specific to the project location, will influence the needs.

Each project must be related to its locality, both physically and socially. Studies should be as brief as possible and the written report concise. They should be constructed from a standard pattern, so that all relevant data are gathered. Planning for water supply and sanitation components should always allow for upgrading of facilities and the use of more advanced technology when this can be afforded, and the demand arises.

The lower the income level of the target beneficiary groups, the more difficulties any project will encounter on its passage from concept to satisfactory continuous operation. Therefore, and despite their apparent technical simplicity, rural water supply projects can be most difficult for the engineer to bring to a successful conclusion.

To assess the adequacy of an existing supply of water arrangement, the criteria of acceptability should first be stipulated. World Bank (1983) proposed that the following four variables to measure the adequacy of a water supply system:

- amount of water (quantity)
- quality of water
- distance to water supply (accessibility), and
- reliability of the supply.

In the rural sector, domestic water supply is usually considered isolated from other arrangements such as irrigation. This occur because of the imbalance between the installation requirements as

INPUT DATA - 2

Number of:	
Students	
Hospital beds	180
Workers	
Type of existing scheme (G-gravity, P-pumping or HP-handpump)	P
Type of proposed scheme (G-gravity, P-pumping or HP-handpump)	P
Project Horizon	10
Present Water Source - Developed	
Borehole	
Depth (m)	
Yield (l/s)	
Number of boreholes	
Surface	
Weir (max abstraction rate l/s)	
Spring (max abstraction rate l/s)	
River or lake (max abstraction rate l/s)	5
Handpump	
Average Yield (l/s)	1
Number of handpumps	20
Future Water Source for the scheme = (Potential - Developed)	
Borehole	
Depth (m)	
Yield (l/s)	
Number of boreholes	
Surface	
Weir (max abstraction rate l/s)	
Spring (max abstraction rate l/s)	
River or lake (max abstraction rate l/s)	10
Water source for consumers not served by the scheme	
Average well yield (l/s)	
Number of well	
Average borehole yield (l/s)	
Depth (m)	
Number of borehole	
Storage Requirements (No of days' demand)	0.6
Proposed Scheme Will Share Existing Storage? (Y-Yes, N-No)	Y
Peak factors	
Daily	1
Unaccounted-for water (%)	
Present	0
Future	0
Distance from water source to highest point along the pipeline (m)	1778
Total distance of pipeline	5000

Table 6.1 Input Data - Case study

INPUT DATA - 1

Project Name	Caia Water Project
Project Number	1
Province (Only first three characters e.g. NAM for Nampula)	SOF
Population	25000
Population Growth Rate (%)	3.65
Project area (Ha)	355
Average number of people per household	6
Present per capita consumption (l/p/d)	
House connection	120
Yard Connection	60
Standpipe	20
Handpump	15
Student	15
Hospital beds	100
Worker	100
Present percentage of people served by:	
House connection	2.66
Yard connection	27
Standpipe	70.4
Handpump	
Other	
Number of people served by a water point (e.g. standpipe)	500
Maximum walking distance to water point (m)	600
Number of:	
Students	
Hospital beds	150
Workers	250
Future per capita consumption (l/p/d)	
House connection	120
Yard Connection	60
Standpipe	28
Handpump	15
Student	
Hospital beds	100
Worker	100
Future percentage of people served by:	
House connection	3
Yard tap	34
Standpipe	63
Handpump	
Other	
Number of people served by a water point (e.g. standpipe)	500
Maximum walking distance to water point (m)	500

6.2 The Caia project

6.2.1 Introduction

Caia is a small town situated on the right bank of the Zambezi River. The population was estimated to be 25000 inhabitants living in area of about 3550 square kilometres. The town consisted of an Administration Building (Local Authority), one hospital with 150 beds, two garages, a contractor site with 250 workers, and about 80 conventional houses besides the thousands of huts. Electricity power supply system was destroyed during the war.

The existing water supply system consisted of an intake station on the right bank of Nhanzacaia River, tributary to Zambezi River, a water treatment unit, a pipeline feeding a ground reservoir in the town, a water tower, and a distribution reticulation.

The objective of the proposed project is to rehabilitate and expand the existing water system in order to meet the full demand of the town in 10 years. At the project horizon 3.3% of the population will have house connections, 34.3% yard taps, 64.3% will be served by standpipes, and the hospital will have 180 beds. The project is to be financed by a grant from the Government and the European Community (EC).

6.2.2 Description of the existing and proposed schemes

The variables describing the current facilities and the new project are listed below on Table 6.1.

6.0 CASE STUDY

6.1 Background

A rural water supply programme to provide about 260 000 people with adequate water supply and develop institutional capacity for future operation of the facilities, is in progress in the provinces of Sofala, Manica, Tete, and Zambezia. The programme is co-financed by the Government of Mozambique and the European Community (EC).

The programme, comprised of several individual projects, consists of rehabilitating twelve small piped schemes, and construct boreholes and wells equipped with handpumps. The National Directorate for Water Affairs appointed a consulting engineering firm to do the detail design and the respective cost estimate.

The case study is of a project in Caia district, Sofala province. This is one of the biggest projects in the programme, and presently with more information available. The objective of this case study is to verify the advantages and accuracy of the model operation against the consultant calculation methodology and results. The discussion focuses on major differences of approach and consistency; the results are not assessed from a planning or decision making point of view.

The presentation of the case study follows the following sequence: project introduction, description of the existing facilities and proposed scheme, results comparison, and discussion. Description of existing facilities and proposed scheme are summarized by the Decision Support System reports.

- "NA" meaning "not available" or not "not applicable". This is either because the pipe diameter calculated, is bigger than the biggest diameter available in material specified, or the model has no data on specified material. The user has to choose another material. The options are shown in brackets on the input line.

- ERR occurs when no data was typed in, or the data was typed in lowercase. This may lead to a division by zero. It could also be, due to the same reasons as for "NA" message explained above.

- stars across the cell. The information does not fit in the cell. The cell width has to be increased to accommodate the data.

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- stars across the cell. The information does not fit in the cell. The cell width has to be increased to accommodate the data.

5.3.3 Results for funding agencies

Funding agencies may regard the project cost and financial results as the most important source of information to assist the decision making process. Financial results are divided into two categories: project costs and the water price.

Project costs of the proposed scheme are shown on "COST" worksheet (*Appendix E*); the costs are divided in construction costs, and other costs.

Construction costs are, in turn, divided into water source development, pipeline, pumping station, storage and reticulation connections.

Other costs cover items not related to the physical construction but essential for the project implementation. These are project design and implementation, office equipment, tools, training, community participation, and contingencies.

Water price figures are displayed on a worksheet called "Price" (*Appendix F*). It displays information on project cost, operation and maintenance cost per annum, and on the cost sharing between grant, soft loan and commercial loan. It also illustrates the amount of annual repayments on loans, and the annual depreciation values. These figures lead to the final estimate of the price of water per household, per capita and per kilolitre. These prices are listed to include operation and maintenance, operation maintenance and depreciation, and operation maintenance depreciation and annual repayment on loans.

The last line indicates the capital cost per capita if the project is implemented.

5.3.4 Error messages

The Decision Support System model may sometimes display error messages after computation. The most common errors are:

i) Most calculations are carried out on worksheet "CALC" (*Appendix C*) and the results stored on the same worksheet. For instance, the model uses the same information to do calculations for a pumped scheme and a gravity scheme. The difference being that the sources are at opposing ends, i.e. the source is at the lower end for a pumped system and at the higher end for gravity system.

ii) The above arrangement may cause confusion in assessing the results. So to overcome this shortcoming some results of the calculations have been selected and listed on the "REPORT" (*Appendix D*) worksheet. The project report generated, is a summary information of the current situation, and the proposed project.

iii)"CALC" and "dBASE" (*Appendix A*) worksheets are useful for detailed analysis of the results, calculations and factors used. For example, the user can verify on the "CALC" what is the pipe diameter calculated by the model, and the pipe diameter commercially available assigned to the scheme. It could be useful, in certain circumstances, to change some input parameters and obtain a pipe diameter which is closer to a commercially available size.

iv) Users may sometimes be interested in checking the friction factor used in a particular calculation, or to verify where the calculated diameter fit between the next bigger and next smaller standard sizes. Another question could concern all materials, i.e. which one has a standard diameter closer to the calculated diameter? This type of verification can only be done on the "dBASE" worksheet. Users can view the contents of the worksheet but cannot make changes to it, unless they know the password.

v) On the "REPORT", worksheet only the information related to the user's options is displayed. If the user has specified the system as a gravity scheme, the report will show the results related to gravity calculation.

The monies for the project can be in form of grant, soft loan or commercial loan. This information is entered as a percentage of total project cost or a lump sum for each source. Interest rates have also to be entered for soft and commercial loan.

Operating costs (staffing) - these costs are based on time required per year (person-year) and individual salaries. The p ofessions considered are: manager, supervisor, artisan, clerk and labourer.

5.3 Results

The results of the Decision Support System model computation are displayed in 4 worksheets: "CALC" (*Appendix C*) referring to the technical calculations, "REPORT" (*Appendix D*) to project report, "COST" (*Appendix E*) to project cost, and "PRICE" (*Appendix F*) to financial results. This set up helps professionals of different disciplines to inspect the results which are more relevant to their area of expertise. The fields of expertise considered in this study are: planners, engineers and technicians, and funding agencies analysts.

5.3.1 Results for planners

The project report, project cost, and financial results are suitable for planners to assess the technical, and financial implications of policy decisions with regard to the rural water supply sector.

5.3.2 Results for engineers and technicians

Engineers and technicians will find the technical calculations, project report, and project cost, useful to their field of activity. From a technical point of view, it would be important to observe the following:

Office equipment - If no funds are required to pay for office equipment, type N (for no provision required). If a lump figures (ceiling budget) for this activity exists, type N (for no provision) and type the lump sum value. If funds have to be allocated then the user can just type Y (for yes provision required) and the model will allocate 1.5% for office equipment.

Training - If no funds are required to pay for training, type N (for no provision required). If a lump figure (ceiling budget) for this activity exists, type N (for no provision) and type the lump sum value. If funds have to be allocated then the user can just type Y (for yes provision required) and the model will allocate 2% for training.

Community contribution - If the beneficiary community is not contributing to the project implementation, type N (for no provision required). If a lump figure (ceiling budget) will be made available by the community for this activity type N (for no provision), and type the lump sum value. If the community contribution is in the form of labour then the user can type Y (for yes provision required) and the model will allocate 30% as community contribution.

Tools - If no funds are required to buy tools, type N (for no provision required). If a lump figure (ceiling budget) for this item type N (for no provision) and type the lump sum value. If funds have to be allocated then the user can just type Y (for yes provision required) and the model will allocate 1% for tools.

Contingencies - If no funds are required for contingencies, type N (for no provision required). If a lump figure (ceiling budget) for this item exists, type N (for no provision) and type the lump sum value. If funds have to be allocated then the user can just type Y (for yes provision required) and the model will allocate 10% for contingencies.

Project funding - a project can be funded by a single organization or co-financed by several entities. The user will have to enter the information on the funding arrangement either in form of a percentage of the total project cost, lump sum, or both. The data is entered in separate for government and other agencies.

water sources, are also useful to determine the water sources' capacities. Possible water sources are: weir, spring, river, lake or ground water.

Future number of boreholes - is an estimate of the number of boreholes that will be drilled.

Future storage requirements - specified as a function of days demand.

Future unaccounted-for water - for a new scheme this parameter should be smaller than the current figure because leakages can be detected during tests. Values up to 15% are acceptable.

Materials for the proposed projects - advantages exist, in reducing diversity of materials and equipments in a system, to facilitate maintenance and spare parts acquisition. However, consideration should be given to technology development and supply complexities.

Project design - user to specify if provision should be made for project design. If no funds are required to pay for project design, type N (for no provision required). If a lump figure (ceiling budget) for this activity exists, type N (for no provision) and type the lump sum value. If funds have to be allocated for the project design then the user can just type Y (for yes provision required) and the model will allocate 13% for project design.

Project supervision - If no funds are required to pay for project supervision, type N (for no provision required). If a lump figure (ceiling budget) for this activity exists, type N (for no provision) and type the lump sum value. If funds have to be allocated then the user can just type Y (for yes provision required) and the model will allocate 2.5% for project supervision.

Community participation - If no funds are required to pay for community education, type N. If a lump figure for this activity exists, type N (for no provision) and type the lump sum value. If funds have to be allocated then the user can just type Y (for yes provision required) and the model will allocate 1% for community education.

If no guidelines exist, the user will have to forecast the per capita consumption for all categories (house conn... ...rd tap, standpipe, handpump, student, hospital and workers), based on personal experience and comparison with other examples. This a typical data to vary and create different scenarios. However, expecting that the level of service would improve in the future, is common. This implies that future per capita consumption rates should be equal or bigger than the present rate.

Percentage of people served by: house connection, yard tap, standpipe, handpump or others. Considering that improvement is expected in the future, more people will have their water services ameliorated. In such a case, percentage rate should increase for better services and decrease for basic provision. For instance it is acceptable that in the future, everybody should have some kind of safe drinking water. Therefore, there could be a scenario where the percentage of "others" (e.g. people collecting water from stagnant ponds) is zero.

Number of people served by a water point and **maximum walking distance to a water point** - these figures are contained in the sector guidelines and should, in principle, decrease if future improvement is envisaged.

Number of students, hospital beds and workers - information to be verified with the relevant authorities. If no data exist, the users will have to make their own judgement considering the development of the project area.

Type of proposed scheme - this a technical decision based on water source availability and its location. If options exist, run the model with data reflecting the options and compare them. The model caters for pumping or gravity systems combined with handpumps, or handpumps only.

Future water sources - this information is vital for the success of the project. Care and conservative approach should be used when feeding this data into the model. A project should only be carried out, if there is a water source able to meet basic demands. Water resources' studies and investigations reports are the appropriate sources of information. Records on existing

TECHNICAL CALCULATIONS - 3

Water Source Development for scheme demand		313 kl/d	
Availability:			
Boreholes	0%	kl/d	
Weir	0%	kl/d	
Spring	0%	kl/d	
River or lake	276%	864 kl/d	
TOTAL		864 kl/d	

Water Source Development for Users not served by the scheme			
Demand		kl/d	
Boreholes	0%	kl/d	
Wells	0%	kl/d	
Total	*0%*	*kl/d*	
Number of handpumps		0	

Pumping scheme			
Pipeline Requirement			
Present pipeline capacity		.0 l/s	
Required capacity		34.6 l/s	
Flow in excess		34.6 l/s	
Diameter of the new pipeline		171 mm	180 mm
Velocity		1.50 m/s	1.36 m/s
Pumping requirement			
Exist'ng pumping capacity in excess		kW	HP
Head Loss		13 m	
Total Head		13 m	
Required capacity		6 kW	8 HP
Capacity to be installed	kW	6 kW HP	8 HP

Gravity scheme		
Present pipeline capacity	.0 l/s	
Required capacity	34.6 l/s	
Flow in excess	34.6 l/s	
Diameter of the new pipeline	151 mm	160 mm
Velocity	1.93 m/s	1.72 m/s
Storage		
Existing storage	175 kl	
Total required storage	747 kl	
Storage to be constructed	572 kl	

TECHNICAL CALCULATIONS - 2

Installed capacity		kW	HP
Pumping capacity in excess	0%	kW	HP
Gravity scheme			
Present pipeline capacity			
Diameter		125 mm	
Area		0123 m^2	
Actual velocity		22.15 m/s	
Actual flow		272.4 l/s	
Possible flow		36.9 l/s	
Capacity in excess		.0 l/s	0%
Storage			
Existing storage		175 kl	
Required storage		470 kl	
Storage in excess		kl	
Water Treatment			
Existing treatment facilities			
Required treatment facilities			
Treatment facilities in excess			

Proposed Scheme

Population in year	10	will be	35436 people
Future population density			100 people/ha
Future Total Domestic Water Demand			1476 kl/d
Other Future Water Demand			18 kl/d
Future Scheme water demand			1494 kl/d
Total Future Water Demand			1494 kl/d
Future number of house connections			133
Future number of yard connections			1606
Future number of standpipes			45
Number of water point as f:(min walking distance)			14
Future number of handpumps			0
Present Water Source Capacity in Excess			1181 kl/d

Table 6.5 Technical Calculations - Case study

TECHNICAL CALCULATIONS - 1

Current Situation

Existing population			25000 people	
Growth Rate			3.6%	
Project Area			355 ha	
People per household			8	
Current population density			70 people/ha	
Population in year	10	will be	35436 people	
Present Total Domestic Water Demand			939 kl/d	
Present Scheme water demand			939 kl/d	
Other Present Water Demand			40 kl/d	
Total Present Water Demand			979 kl/d	
Current number of house connections			80	
Current number of yard connections			844	
Current number of standpipes			35	
Current number of handpumps				
Present Water Source Capacity			2160 kl/d	
Water Source in excess for Domestic demand			1221 kl/d	57%
Water Source in excess for Total demand			1181 kl/d	55%
Pumping scheme				
Present pipeline capacity				
Diameter			125 mm	
Area			.0123 m^2	
Actual Velocity			1.77 m/s	
Actual flow			21.7 l/s	
Possible flow			36.9 l/s	
Capacity in excess			15.2 l/s	657 kl/d
Present pumping requirement				
Head loss			31.8 m	
Total head			56.8 m	
Pumping requirement			17 kW	22 HP

PROJECT REPORT - 2

Pipeline Diameter and Material		125 mm AC	160 mm HDPE
Pipeline length		6000 m	6000 m
Actual Flow		21.7 l/s	34.0 l/s
Pipeline Capacity		30.9 l/s	
Pipeline Capacity in Excess	41%	1[illegible].2 l/s	
Gravity Scheme			
Pipeline Diameter and Material			
Pipeline Length			
Actual Flow			
Pipeline Capacity			
Pipeline Capacity in Excess			
Storage	Concrete		Concrete
Existing Capacity		175 kl	175 kl
Required Capacity		470 kl	747 kl
Additional Capacity Required		295 kl	572 kl
Capacity in Excess		kl	
Water Treatment			
Filtration - Surface Water			Yes
Filtration - Groundwater			No
Disinfection - Surface Water			Yes
Disinfection - Groundwater			No

Table 6.4 Project Report - Case study

PROJECT REPORT - 1

Description	Current Situation			Proposed Project		
Population		25000 people			35490 people	
Growth Rate		3.6%				
Population Density		70 people/ha			100 people/ha	
Project Horizon					10 years	
Total Domestic Water Demand		939 kl/d			1470 kl/d	
Scheme Water demand		939 kl/d			1494 kl/d	
Other Water demand		40 kl/d			10 kl/d	
Total Demand		979 kl/d			1494 kl/d	
Number of House connection		60			133	
Number of Yard taps		644			1600	
Number of standpipes		35			45	
Number of handpumps		0			0	
Numb· of Water Points (f min walking distance)					14	
Water Source Capacity		2160 kl/d			504 kl/d	
Water Source in Excess for Domestic Demand	57%	1221 kl/d				
Water Source in Excess for Total Demand	55%	1181 kl/d				
Water Source Development for Scheme Demand						
Demand		939 kl/d			913 kl/d	
Water Sources Availability					904 kl/d	
Boreholes				0%	kl/d	
Weir				0%	kl/d	
Spring				0%	kl/d	
River or Lake				270%	904 kl/d	
TOTAL				270%	904 kl/d	
Water Source Development for Users NOT Served by the Schem						
Demand					kl/d	
Boreholes				0%	kl/d	
Wells				0%	kl/d	
Total				0%	kl/d	
Pumping Scheme						
Pumping Requirement		17 kW	22 HP		23 kW	20 HP
Pumping Installed Capacity		kW	HP		kW	HP
Pumping Capacity in Excess	0%	kW	HP			
Pumping to be Installed		17 kW	22 HP		23 kW	20 HP

consultants mentioned some variables which were not used in the calculation (e.g. daily peak factor, UFW, consumers not served by the scheme, and storage requirements). Any assumption made initially is consistently accounted for by the model.

This case study highlights the strength of the Decision Support System on the systematic approach to planning and assurance on including all variables in the calculation. The advantages over manual calculations are consistency, calculation speed, ease of use and accuracy, which allows the user to quickly generate different project scenarios.

Consultant calculated the water treatment requirements. The estimates on water treatment represent almost a third of the total project cost (27%).

The consultant did not consider depreciation on their calculation.

The present model calculation methodology compared to that of the consultant has the following shortcomings:

a) It does not compute network flows. It calculates the main pipeline diameter and assigns that diameter to the full length of the reticulation. This is reasonable for small schemes but overestimates pipe requirements for larger systems.

b) It only indicates the need for water treatment facilities. No cost estimates are provided.

6.2.4.2 Consistency and accuracy

The major difference between the consultant and the present model methodology in this case study, is that the consultant was expected to carry out a detailed design and the respective costing. The present model has been designed to be used at the project preparation stage and does not carry-out detail design.

The total project cost calculated by the model is 11% bigger than the consultant estimates. This is acceptable for the *Identification and Preparation* stage of a project.

The consultant calculation includes water treatment works and detail reticulation analysis. This is a shortcoming in the model design specially for relative large rural water schemes.

The Decision Support System model is consistent on the calculation methodology, comprehensiveness, and also works as a checklist. This is reflected on the fact that the

Table 6.3 Water Costs (cents/kilolitre)

DESCRIPTION	CONSULTANT	MODEL
Operation and maintenance (O&M)	24	21
O&M + Depreciation		39
O&M + depreciation + loan repayment		39

6.2.4 Discussion

The following remarks can be drawn after analysing the results of the consultants ~ainst those of the model:

6.2.4.1 Calculation methodology

The consultant made some initial assumptions which were not reflected in the calculations. These are:

i) All consumers are served by the scheme but only 7 standpipe exist to serve 17 600 people. In the consultant report mention is, however, made that certain proportion of the population currently collect their water directly from the river, and that each standpipe should serve 500 people;

ii) The uncounted-for water (UFW) and daily peak factor are not accounted for;

iii) The system daily operating time is stated as 12 hours, but operation and maintenance calculations were based on 24 hours.

6.2.3 Results

The results obtained by the consultants and the Decision Support System listed below for comparison are divided into costs and water price. Costs results are summarized on Table 6.2 and the water prices on Table 6.3 below. Detail results computed by the model are on Tables 6.4, 6.5, 6.6, and 6.7.

Table 6.2 - Project Costs (Rands)

DESCRIPTION	CONSULTANT	MODEL
Water source development	126 000	50 270
Water treatment works	675 000	
Pipeline and reticulation	1 792 000	3 188 875
Pumping station	231 500	150 800
Storage	679 500	154 657
Construction Cost	3 504 250	3 544 600
Office equipment		53 170
Tools	3 350	35 450
Community participation		35 450
Project design	54 000	54 000
Project supervision	85 000	88 600
Training		70 890
Contingencies	364 660	354 460
Total project	4 011 260	4 448 460
Operation and maintenance per annum	131 457	76 400
Depreciation per annum		63 746
Capital cost per capita	113	125

INPUT DATA - 4

Community Participation	
Provision Required (Y-yes, N-no)	Y
Lump Sum (Amount, N-Not applicable)	
Office Equipment	
Provision Required (Y-yes, N-no)	Y
Lump Sum (Amount, N-Not applicable)	
Tools	
Provision Required (Y-yes, N-no)	Y
Lump Sum (Amount, N-Not applicable)	
Training	
Provision Required (Y-yes, N-no)	Y
Lump Sum (Amount, N-Not applicable)	
Project funding	
Government	
% of Total cost	10
Lump sum	
Other Agencies	
% of Total cost	90
Lump sum	N
Grant	
% of Total cost	100
Lump sum	
Soft Loan	
% of Total cost	0
Lump sum	
Interest rate (%)	0
Period of repayment (years)	0
Commercial Loan	
% of Total cost	0
Lump sum	
Interest rate (%)	0
Period of repayment (years)	0
Operating Costs (Staffing)	
Staffing - number of man years per annum	
Manager	0
Supervisor	2
Artisan	0
Clerk	4
Labourer	2
Staffing - rate (rands per man-year)	
Manager	0
Supervisor	1200
Artisan	0
Clerk	800
Labourer	600

INPUT DATA - 4

Community Participation	
Provision Required (Y-yes, N-no)	Y
Lump Sum (Amount, N-Not applicable)	
Office Equipment	
Provision Required (Y-yes, N-no)	Y
Lump Sum (Amount, N-Not applicable)	
Tools	
Provision Required (Y-yes, N-no)	\
Lump Sum (Amount, N-Not applicable)	
Training	
Provision Required (Y-yes, N-no)	Y
Lump Sum (Amount, N-Not applicable)	
Project funding	
Government	
% of Total cost	10
Lump sum	
Other Agencies	
% of Total cost	90
Lump sum	N
Grant	
% of Total cost	100
Lump sum	
Soft Loan	
% of Total cost	0
Lump sum	
Interest rate (%)	0
Period of repayment (years)	0
Commercial Loan	
% of Total cost	0
Lump sum	
Interest rate (%)	0
Period of repayment (years)	0
Operating Costs (Staffing)	
Staffing - number of man years per annum	
Manager	0
Supervisor	2
Artisan	0
Clerk	4
Labourer	2
Staffing - rate (rands per man-year)	
Manager	0
Supervisor	1200
Artisan	0
Clerk	800
Labourer	600

INPUT DATA - 3

Levels difference between water source and the highest point to pump to (m)	25
Number of hours of daily function	12
Source of energy (E-electricity, D-diesel, O-other)	D
Raw water quality	
Turbidity (NTU)	
Surface Water	15
Groundwater	0
Plate count per 100 ml	
Surface Water	8
Groundwater	0
Existing System	
Pipeline	
Diameter (mm)	125
Elevation (m)	25
Length (m)	1778
Pumping capacity (kW)	0
Storage capacity (Kl)	175
Proposed Scheme Will Share Existing Pipeline? (Y-Yes, N-No)	N
Proposed Scheme Will Share Existing Pumping Capacity? (Y-Yes, N-No)	N
Materials - Existing scheme	
Borehole casing (S-steel, PVC)	
Pipe (CI-Cast Iron, HDPE, PVC, AC-Asbestos)	AC
Reservoir (C-concrete, S-steel, P-plastic)	C
Materials - Proposed scheme	
Borehole casing (S-steel, PVC)	
Pipe (GMS-Galvanized steel, HDPE, PVC, AC-Asbestos)	HDPE
Reservoir (C-concrete, S-steel, P-plastic)	C
Borehole diameter (4,6,8,10 or 12 inches)	
House connection (GMS,PVC,HDPE)	HDPE
Yard Tap (GMS,PVC,HDPE)	HDPE
Standpipe (GMS,PVC,HDPE)	HDPE
Community contribution	
Labour (Y-yes, N-no)	N
Lump Sum (Amount, N-Not applicable)	
Project Design	
Provision Required (Y-yes, N-no)	N
Lump Sum (Amount, N-Not applicable)	54000
Project Supervision	
Provision Required (Y-yes, N-no)	Y
Lump Sum (Amount, N-Not applicable)	
Contingencies	
Provision Required (Y-yes, N-no)	Y
Lump Sum (Amount, N-Not applicable)	

INPUT DATA - 3

Levels difference between water source and the highest point to pump to (m)

Number of hours of daily function

Source of energy (E-electricity, D-diesel, O-other)

Raw water quality
Turbidity (NTU)
Surface Water
Groundwater

Plate count per 100 ml
Surface Water
Groundwater

Existing System
Pipeline
Diameter (mm)
Elevation (m)
Length (m)
Pumping capacity (kW)

Storage capacity (Kl)
Proposed Scheme Will Share Existing Pipeline? (Y-Yes, N-No)
Proposed Scheme Will Share Existing Pumping Capacity? (Y-Yes, N-No)

Materials - Existing scheme
Borehole casing (S-steel, PVC)
Pipe (CI-Cast Iron, HDPE, PVC, AC-Asbestos)
Reservoir (C-concrete, S-steel, P-plastic)

Materials - Proposed scheme
Borehole casing (S-steel, PVC)
Pipe (GMS-Galvanized steel, HDPE, PVC, AC-Asbestos)
Reservoir (C-concrete, S-steel, P-plastic)
Borehole diameter (4,6,8,10 or 12 inches)
House connection (GMS,PVC,HDPE)
Yard Tap (GMS,PVC,HDPE)
Standpipe (GMS,PVC,HDPE)

Community contribution
Labour Y-yes, N-no)
Lump Sum (Amount, N-Not applicable)

Project Design
Provision Required (Y-yes, N-no)
Lump Sum (Amount, N-Not applicable)

Project Supervision
Provision Required (Y-yes, N-no)
Lump Sum (Amount, N-Not applicable)

Contingencies
Provision Required (Y-yes, N-no)
Lump Sum (Amount, N-Not applicable)

INPUT DATA - 2

Number of:
Students
Hospital beds
Workers

Type of existing scheme (G-gravity, P-pumping or HP-handpump)

Type of proposed scheme (G-gravity, P-pumping or HP-handpump)

Project Horizon

Present Water Source - Developed
Borehole
Depth (m)
Yield (l/s)
Number of boreholes

Surface
Weir (max abstraction rate l/s)
Spring (max abstraction rate l/s)
River or lake (max abstraction rate l/s)

Handpump
Average Yield (l/s)
Number of handpumps

Future Water Source for the scheme = (Potential - Developed)
Borehole
Depth (m)
Yield (l/s)
Number of boreholes

Surface
Weir (max abstraction rate l/s)
Spring (max abs ation rate l/s)
River or lake (max abstraction rate l/s)

Water source for consumers not served by the scheme
Average well yield (l/s)
Number of well
Average borehole yield (l/s)
Depth (m)
Number of borehole

Storage Requirements (No of days' demand)
Proposed Scheme Will Share Existing Storage? (Y-Yes, N-No)

Peak factors
Daily

Unaccounted-for water (%)
Present
Future

Distance from water source to highest point along the pipeline (m)
Total distance of pipeline

APPENDIX B - Model Input Data

INPUT DATA - 1

Project Name

Project Number

Province (Only first three characters e.g. NAM for Nampula)

Population

Population Growth Rate (%)

Project area (Ha)

Average number of people per household

Present per capita consumption (l/p/d)
House connection
Yard Connection
Standpipe
Handpump
Student
Hospital beds
Worker

Present percentage of people served by:
House connection
Yard connection
Standpipe
Handpump
Other

Number of people served by a water point (e.g. standpipe)
Maximum walking distance to water point (m)

Number of:
Students
Hospital beds
Workers

Future per capita consumption (l/p/d)
House connection
Yard Connection
Standpipe
Handpump
Student
Hospital beds
Worker

Future percentage of people served by:
House connection
Yard tap
Standpipe
Handpump
Other

Number of people served by a water point (e.g. standpipe)
Maximum walking distance to water point (m)

DATABASE - 4

Depreciation	Asset life (years)
Water source	50
Pipeline	30
Pumping	10
Storage	30

Project Location Cost Factor

MAP	1	MAPUTO
GAZ	1.2	GAZA
INH	1.25	INHAMBANE
SOF	1	SOFALA
MAN	1.1	MANICA
TET	1.25	TETE
ZAM	1.3	ZAMBEZIA
NAM	1.2	NAMPULA
CAB	1.3	CABO DELGADO
NIA	1.4	NIASSA

Province	Factor
ERR	ERR

Project Adjustment Factor 1.05

DATABASE - 3

LEVELS OF SERVICE

Unit Cost

	GMS	PVC	HDPE
House connection	1500	1350	1400
Yard connection	1200	1080	1100
Standpipe	1650	1485	1575

For Calculation

Material	Cost
0	NA
0	NA
0	NA

Darcy Weisbach coefficient

Concrete	GMS	PVC	HDPE	AC
C	GMS	PVC	HDPE	AC
0.02	0.012	0.013	0.011	0.014

Roughness old pipe	***********
Roughness new pipe	***********

ADDITIONAL COSTS

Office Equipment	1.5 %
Tools	1 %
Community Participation	1 %
Training	2 %
Project Design	11 %
Project Supervision	2.5 %
Contingencies	10 %
Community contribution (labour)	30 %
Training	2 %

OPERATION & MAINTENANCE

Water source	
Borehole	5 % of CAPEX
Well	5 % of CAPEX
Spring	5 % of CAPEX
Weir	5 % of CAPEX
Reticulation	2 % of CAPEX
Pipeline	1 % of CAPEX
Pumping - electricity	5 % of CAPEX
Pumping - diesel	10 % of CAPEX
Storage	1 % of CAPEX
Administration	10 % over other O&M costs

DATABASE - 2

For Calculation

	Pumping	Gravity
Diameter	NA	NA
Unit cost	NA	NA

RESERVOIRS

Unit Cost - Rands

Vol. (kl)	Concrete
<100000	1500000
<5000	1100000
<500	155000
<200	90000
<100	60000
<60	45000
<50	38000

Vol. (kl)	Steel
<150	130000
<130	108000
<82	83500
<62	73000

Vol (kl)	Plastic
<200	20000
<150	15000
<100	10000
<80	8000
<50	5000

Data for calculations

Material	Rate	
		Existing
		New

Regression analysis

Concrete	38407
Steel	20
Plastic	30

WATER SOURCE

Well	2000	R/unit including Handpump
Weir	10000	R/kld
Spring	6000	R/kld

Borehole

Unit Cost per meter drilled

Diam	Casing Type		
Inches	Steel	PVC	
4	2000	1750	
6	2250	2100	
8	2500	2350	
10	2750	2600	
12	3000	28[illegible]	

For Calculation

Material	Diam	Unit Cost
0	0	0

	Depth	Cost/Unit
Scheme	0	0
H/pump	0	0

PUMPING

Pumping efficiency (%) 76

Pumping station construction	4000	R/KW
	6200	R/HP

APPENDIX A - Model Database

DATABASE - 1

PIPES

Maximum velocity (m/s)	3
Minimum velocity (m/s)	1
Average velocity (m/s)	1.5

	AC	CI	HDPE	PVC	GMS
Max dia (mm)	1000		850	400	150
Min dia (mm)	150		16	50	15

Unit Cost of pipe per meter - Rands

Dia. (mm)	HDPE
-450	1473.39
-400	1256.48
-300	633.80
-250	496.63
-225	316.06
-200	316.06
-180	265.04
-160	201.42
-160	183.72
-125	126.96
-110	97.33
-100	77.5
-90	61.29
-50	20.86
-40	13.08
-32	8.45
-25	5.39
-20	3.29
-16	2.3

Dia. (mm)	PVC cl24
-400	543
-355	430
-315	338
-250	200
-200	136
-160	88
-140	71
-125	57
-110	45
-90	30
-75	21
-63	15
-50	10

PVC	Pumping	Gravity
Diameter of new pipeline	***********	***********
Unit cost	***********	***********

HDPE	Pumping	Gravity
Diameter of new pipel	***********	***********
Unit cost	***********	***********

Table message Not Applicable	
NA	NA
NA	NA

Dia. (mm)	AC cl24
-1000	910
-900	771
-800	600
-700	512
-600	392
-500	271
-450	236
-400	184
-350	158
-300	116
-250	91
-200	63
-150	38

Dia. (mm)	GMS
-150	112
-100	71
-80	48
-65	38
-50	30
-40	21
-32	18
-25	14
-20	9
-16	7

GMS	Pumping	Gravity
Diameter of new pipeline	***********	***********
Unit cost	***********	***********

AC	Pumping	Gravity
Diameter of new pipeline	***********	***********
Unit cost	***********	***********

projects, however, can be underestimated due to exclusion of treatment works, or overestimated as a result of the overdesign of the reticulation pipes.

The model should not be seen as a replacement of practitioners. Professional judgement and experience are very important on characterising the existing conditions and proposed projects. The computed results can only be as accurate and reliable as the information entered in the model.

7.2 Recommendations for future work

Despite its achievement, room exists for further development. The first step should be to develop a database with Mozambican prices in order to remove the need for the cost adjustment factor.

The Decision Support System model needs to be expanded to compute water treatment works requirements and distribution network with precision, in order to provide accurate results on large rural water projects.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations were drawn from the study of the Decision Support System (DSS) for rural water supply in Mozambique.

7.1 Conclusions

The Decision Support System is a tool to be used primarily during the *Identification and Preparation* stage of a project; it is a computational model designed to assist those involved in the sector, planning and ranking projects. Whilst the calculation methodology does not need constant updating, the database has to be verified frequently to produce sound results.

The advantages of the model over manual calculations are: consistency, calculation speed, ease of use, and accuracy, which allows the user to quickly generate different project scenarios. This is particularly important within the Mozambican context where the need to quickly provide safe water to the population resettling in the rural areas, does not allow sufficient time for drawn out project preparation phases. Highly importantly, the present model has the potential to contribute towards developing a uniform approach to project planning in general, and capacity building at provincial and regional levels, in particular.

The database incorporated in the model was constructed from South African prices. A correction factor facility was inserted to adjust the calculated costs to the Mozambican conditions. Although this procedure is simplistic in need of refinement, it gives good results.

Furthermore calculation methodology does not carry-out network analysis nor estimate the water treatment work requirements. It assigns the diameter of the main pipeline to the full length of the reticulation, and only indicates whether treatment facilities are needed or not. Project cost and financial analysis of small rural schemes may not be substantially affected by this approach. Large

Table 6.7 Financial Results - Case study

FINANCIAL RESULTS - 1

Project cost	R 4,446,458.13
Operation and Maintenance cost (p.a.)	R 76,367.95
Grant	R 4,446,458.13
Soft loan	R 0.00
Commercial Loan	R 0.00

Annual repayment	Interest Rate	Repayment Period	
Soft loan	0.0%	Years	R 0.00
Commercial Loan	0.0%	Years	R 0.00

Depreciation - fixed instalments p.a.	
Water Sources	R 1,006.33
Pipeline	R 42,506.67
Pumping	R 15,080.00
Storage	R 5,155.24

Cost of water	Household p.a.	capita p.a.	kl
To cover O&M only	R 24.40	R 3.10	21.4 c
O&M plus depreciation	R 44.80	R 5.60	39.2 c
O&M+depreciation+ annual repayment	R 44.80	R 5.60	39.2 c

Capital cost per capita	R 125.53

PROJECT COSTS - 2

Contingencies	10.00%	R 354,459.90
Training	2.00%	R 70,891.98
Community contribution	Lump Sum	R 0.00
Project location adjustment		R 0.00
Cost adjustment		R 211,831.34
TOTAL COST		*R 4,448,458.13*

COST SHARING	
Government	R 444,845.81
Other Agencies	R 4,003,612.31
Grant	R 4,448,458.13
Soft loan	R 0.00
Commercial loan	R 0.00

OPERATION & MAINTENANCE p.a.	% of CAPEX	
Water source		R 2,513.33
Borehole	5	R 0.00
Spring	5	R 0.00
Weir	5	R 0.00
River or Lake Intake	5	R 2,513.33
Well + Handpump	5	R 0.00
Borehole + Handpump	5	R 0.00
Reticulation	2	R 38,273.50
Pipeline	1	R 12,752.00
Pumping	10	R 7,540.00
Storage	1	R 1,546.57
Staffing		R 6,800.00
Administration		R 6,942.54
Total p.a.		*R 76,367.95*

Table 6.6 Project Costs - Case study

PROJECT COSTS - 1

Water Source Development					R 50,266.67
River or Lake Intake		kl/d	313		R 50,266.67
Spring		kl/d	0		
Weir		kl/d	0		
Borehole for the scheme		No	0		
Borehole + handpump		No	0		
Well + handpump		No	0		
Pipeline HDPE					
	180 mm	m	5000	R 255.04	R 1,275,200.00
Pumping Station		HP	29	R 5,200.00	R 150,800.00
Storage Concrete		kl	572	R 270.38	R 154,657.31
House Connection		No	133	R 1,400.00	R 186,200.00
Yard Connection		No	1506	R 1,100.00	R 1,656,600.00
Standpipe		No	45	R 1,575.00	R 70,875.00
Construction Cost					*R 3,544,598.97*
Office Equipment				1.50%	R 53,168.98
Tools				1.00%	R 35,445.99
Community Participation				1.00%	R 35,445.99
Project Design				Lump Sum	R 64,000.00
Project Supervision				2.50%	R 88,614.97

DATABASE - 2

dBASE:B29:	-110
dBASE:C29:	97.33
dBASE:F29:	-75
dBASE:G29:	21
dBASE:B30:	-100
dBASE:C30:	77.6
dBASE:F30:	-63
dBASE:G30:	16
dBASE:B31:	-90
dBASE:C31:	61.29
dBASE:F31:	-50
dBASE:G31:	10
dBASE:B32:	-50
dBASE:C32:	20.56
dBASE:B33:	-40
dBASE:C33:	13.06
dBASE:B34:	-32
dBASE:C34:	8.40
dBASE:E34:	PVC
dBASE:H34:	Pumping
dBASE:I34:	Gravity
dBASE:B35:	-25
dBASE:C35:	5.30
dBASE:E35:	Diameter of new pipeline
dBASE:H35:	@VLOOKUP(-1*CALC:$G$123,$F$19..$G$31,0)*-1
dBASE:I35:	@VLOOKUP(-1*CALC:$G$130,$F$19..$G$31,0)*-1
dBASE:B36:	-20
dBASE:C36:	3.20
dBASE:E36:	Unit cost
dBASE:H36:	@VLOOKUP(-1*CALC:$G$123,$F$19..$G$31,1)
dBASE:I36:	@VLOOKUP(-1*CALC:$G$130,$F$19..$G$31,1)
dBASE:B37:	-16
dBASE:C37:	2.3
dBASE:B40:	HDPE
dBASE:D40:	Pumping
dBASE:E40:	Gravity
dBASE:G40:	Table message Not Applicable
dBASE:B41:	Diameter of new pipeline
dBASE:D41:	@VLOOKUP(-1*CALC:$G$123,$B$19..$C$37,0)*-1
dBASE:E41:	@VLOOKUP(-1*CALC:$G$130,$B$19..$C$37,0)*-1
dBASE:G41:	NA
dBASE:H41:	NA
dBASE:B42:	Unit cost
dBASE:D42:	@VLOOKUP(-1*CALC:$G$123,$B$19..$C$37,1)
dBASE:E42:	@VLOOKUP(-1*CALC:$G$130,$B$19..$C$37,1)
dBASE:G42:	NA
dBASE:H42:	NA
dBASE:D45:	^Dia. (mm)
dBASE:E45:	^AC cl24
dBASE:I45:	^Dia. (mm)
dBASE:J45:	^GMS
dBASE:D46:	-1000
dBASE:E46:	910
dBASE:I46:	-150
dBASE:J46:	112
dBASE:D47:	-900
dBASE:E47:	771
dBASE:I47:	-100
dBASE:J47:	71
dBASE:D48:	-800
dBASE:E48:	603
dBASE:I48:	-80
dBASE:J48:	48
dBASE:D49:	-700
dBASE:E49:	612
dBASE:I49:	-60
dBASE:J49:	30
dBASE:D50:	-600
dBASE:E50:	392

APPENDIX G - Formulas On The Model Worksheets

DATABASE - 1

dBASE:B6:	PIPES
dBASE:B7:	'Maximum velocity (m/s)
dBASE:E7:	3
dBASE:[illegible]	'Minimum velocity (m/s)
dBASE:E8:	1
dBASE:B9:	'Average velocity (m/s)
dBASE:E9:	1.5
dBASE:D11:	^AC
dBASE:E11:	^CI
dBASE:F11:	^HDPE
dBASE:G11:	^PVC
dBASE:H11:	^GMS
dBASE:B12:	^Max dia
dBASE:C12:	'(mm)
dBASE:D12:	1000
dBASE:F12:	950
dBASE:G12:	400
dBASE:H12:	150
dBASE:B13:	^Min dia
dBASE:C13:	'(mm)
dBASE:D13:	150
dBASE:F13:	15
dBASE:G13:	50
dBASE:H13:	15
dBASE:B16:	'Unit Cost of pipe per meter - Rands
dBASE:B18:	^Dia. (mm)
dBASE:C18:	^HDPE
dBASE:F18:	^Dia. (mm)
dBASE:G18:	^PVC cl24
dBASE:B19:	-450
dBASE:C19:	1573.39
dBASE:F19:	-400
dBASE:G19:	543
dBASE:B20:	-400
dBASE:C20:	1256.46
dBASE:F20:	-355
dBASE:G20:	430
dBASE:B21:	-300
dBASE:C21:	633.02
dBASE:F21:	-315
dBASE:G21:	330
dBASE:B22:	-250
dBASE:C22:	490.03
dBASE:F22:	250
dBASE:G22:	209
dBASE:B23:	-225
dBASE:C23:	215.00
dBASE:F23:	-200
dBASE:G23:	136
dBASE:B24:	-200
dBASE:C24:	315.00
dBASE:F24:	-160
dBASE:G24:	90
dBASE:B25:	-180
dBASE:C25:	205.04
dBASE:F25:	-140
dBASE:G25:	71
dBASE:B26:	-160
dBASE:C26:	201.42
dBASE:F26:	-125
dBASE:G26:	57
dBASE:B27:	-150
dBASE:C27:	103.72
dBASE:F27:	-110
dBASE:G27:	46
dBASE:B28:	-125
dBASE:C28:	120.00
dBASE:F28:	-90
dBASE:G28:	30

APPENDIX G - Formulas On The Model Worksheets

DATABASE - 1

```
dBASE:B5:    PIPES
dBASE:B7:    'Maximum velocity (m/s)
dBASE:E7:    3
dBASE:B8:    'Minimum velocity (m/s)
dBASE:E8:    1
dBASE:B9:    'Average velocity (m/s)
dBASE:E9:    1.5
dBASE:D11:   ^AC
dBASE:E11:   ^CI
dBASE:F11:   ^HDPE
dBASE:G11:   PVC
dBASE:H11:   ^GMS
dBASE:B12:   ^Max dia
dBASE:C12:   '(mm)
dBASE:D12:   1000
dBASE:F12:   650
dBASE:G12:   400
dBASE:H12:   150
dBASE:B13:   ^Min dia
dBASE:C13:   '(mm)
dBASE:D13:   150
dBASE:F13:   16
dBASE:G13:   50
dBASE:H13:   15
dBASE:B16:   'Unit Cost of pipe per meter - Rands
dBASE:B18:   ^Dia. (mm)
dBASE:C18:   ^HDPE
dBASE:F18:   ^Dia. (mm)
dBASE:G18:   ^PVC cl24
dBASE:B19:   -450
dBASE:C19:   1673.59
dBASE:F19:   -400
dBASE:G19:   543
dBASE:B20:   -400
dBASE:C20:   1256.46
dBASE:F20:   -355
dBASE:G20:   430
dBASE:B21:   -300
dBASE:C21:   833.06
dBASE:F21:   -315
dBASE:G21:   330
dBASE:B22:   -250
dBASE:C22:   496.53
dBASE:F22:   -250
dBASE:G22:   209
dBASE:B23:   -225
dBASE:C23:   316.00
dBASE:F23:   -200
dBASE:G23:   136
dBASE:B24:   -200
dBASE:C24:   316.00
dBASE:F24:   -160
dBASE:G24:   80
dBASE:B25:   -180
dBASE:C25:   205.04
dBASE:F25:   -140
dBASE:G25:   71
dBASE:B26:   -160
dBASE:C26:   201.42
dBASE:F26:   -125
dBASE:G26:   57
dBASE:B27:   -150
dBASE:C27:   103.72
dBASE:F27:   -110
dBASE:G27:   45
dBASE:B28:   -125
dBASE:C28:   120.00
dBASE:F28:   -90
dBASE:G28:   30
```

APPENDIX F - Model Financial Results

FINANCIAL RESULTS - 1

Project cost	******************
Operation and Maintenance cost (p.a.)	R 0.00
Grant	******************
Soft loan	******************
Commercial Loan	******************

Annual repayment	Interest Rate	Repayment Period	
Soft loan	0.0%	Years	R 0.00
Commercial Loan	0.0%	Years	R 0.00

Depreciation - fixed instalments p.a.	
Water Sources	R 0.00
Pipeline	R 0.00
Pumping	R 0.00
Storage	R 0.00

Cost of water	Household p.a.	capita p.a.	kl
To cover O&M only	*****************	ERR<PRICE:E62>	******************
O&M plus depreciation	*****************	ERR<PRICE:E64>	******************
O&M+depreciation+ annual repayment	*****************	ERR<PRICE:E66>	******************

Capital cost per capita	******************

PROJECT COSTS - 2

Contingencies	Lump Sum	R 0.00
Training	Lump Sum	R 0.00
Community contribution	Lump Sum	R 0.00
Project location adjustment		******************
Cost adjustment		R 0.00
TOTAL COST		******************

COST SHARING	
Government	******************
Other Agencies	******************
Grant	******************
Soft loan	******************
Commercial loan	******************

OPERATION & MAINTENANCE p.a.	**% of CAPEX**	
Water source		R 0.00
Borehole	5	R 0.00
Spring	5	R 0.00
Weir	5	R 0.00
River or Lake Intake	5	R 0.00
Well + Handpump	5	R 0.00
Borehole + Handpump	5	R 0.00
Reticulation		
Pipeline	******************	
Pumping	******************	
Storage		
Staffing		R 0.00
Administration		R 0.00
Total p.a.		***R 0.00***

APPENDIX E - Model Project Costs

PROJECT COSTS - 1

Water Source Development					R 0.00
River or Lake Intake	kl/d		0		R 0.00
Spring	kl/d		0		
Weir	kl/d		0		
Borehole for the s^heme	No		0		
Borehole + handpump	No		0		
Well + handpump	No		0		
Pipeline					
	m				
Pumping Station					
			0		
Storage					
	kl			******************	
House Connection	No	NA			R 0.00
Yard Connection	No	NA			R 0.00
Standpipe	No	NA			R 0.00
Construction Cost					*R 0.00*
Office Equipment				Lump Sum	R 0.00
Tools				Lump Sum	R 0.00
Community Participation				Lump Sum	R 0.00
Project Design				Lump Sum	R 0.00
Project Supervision				Lump Sum	R 0.00

PROJECT REPORT - 2

Pipeline Diameter and Material		
Pipeline length		
Actual Flow		
Pipeline Capacity		
Pipeline Capacity in Excess		
Gravity Scheme		
Pipeline Diameter and Material		
Pipeline Length		
Actual Flow		
Pipeline Capacity		
Pipeline Capacity in Excess		
Storage		
Existing Capacity	kl	kl
Required Capacity	kl	kl
Additional Capacity Required	kl	kl
Capacity in Excess	kl	
Water Treatment		
Filtration - Surface Water		No
Filtration - Groundwater		No
Disinfection - Surface Water		No
Disinfection - Groundwater		No

APPENDIX D - Model Project Report

PROJECT REPORT - 1

Description	Current Situation	Proposed Project
Population	people	people
Growth Rate	0.0%	
Population Density	ERR<CALC.G13>	***************
Project Horizon		years
Total Domestic Water Demand	kl/d	kl/d
Scheme Water demand	kl/d	kl/d
Other Water demand	kl/d	kl/d
Total Demand	kl/d	kl/d
Number of House connection	ERR<CALC.G25>	***************
Number of Yard taps	ERR<CALC.G27>	***************
Number of standpipes	ERR<CALC.G29>	***************
Number of handpumps	0	***************
Number of Water Points (I:min walking distance)		***************
Water Source Capacity	kl/d	kl/d
Water Source in Excess for Domestic Demand	********** kl/d	
Water Source in Excess for Total Demand	********** kl/d	
Water Source Development for Scheme Demand		
Demand	kl/d	kl/d
Water Sources Availability		kl/d
Boreholes		0% kl/d
Weir		0% kl/d
Spring		0% kl/d
River or Lake		0% kl/d
TOTAL		0% kl/d
Water Source Development for Users NOT Served by the Schem		
Demand		kl/d
Boreholes		0% kl/d
Wells		0% kl/d
Total		0% kl/d
Pumping Scheme		
Pumping Requirems ..		
Pumping Installed Capacity		
Pumping Capacity in Excess		
Pumping to be Installed		

TECHNICAL CALCULATIONS - 3

Water Source Development for scheme demand		kl/d		
Availability:				
Boreholes	0%	kl/d		
Weir	0%	kl/d		
Spring	0%	kl/d		
River or lake	0%	kl/d		
TOTAL		kl/d		

Water Source Development for Users not served by the scheme				
Demand		kl/d		
Boreholes	0%	kl/d		
Wells	0%	kl/d		
Total	*0%*	*kl/d*		
Number of har ipumps		*0*		

Pumping scheme				
Pipeline Requirement				
Present pipeline capacity		.0 l/s		
Required capacity		****************		
Flow in excess		****************		
Diameter of the new pipeline		****************		NA
Velocity		1.50 m/s		NA

Pumping requirement				
Existing pumping capacity in excess		kW		HP
Head Loss		****************		
Total Head		****************		
Required capacity		****************		************
Capacity to be installed	kW	****************	HP	************

Gravity scheme				
Present pipeline capacity		.0 l/s		
Required capacity		****************		
Flow in excess		****************		
Diameter of the new pipeline		****************		NA
Velocity		****************		NA

Storage				
Existing storage		kl		
Total required storage		kl		
Storage to be constructed		kl		

TECHNICAL CALCULATIONS - 2

Installed capacity		kW	HP
Pumping capacity in excess	**********	****************	************

Gravity scheme		
Present pipeline capacity		
Diameter	mm	
Area	.0000 m^2	
Actual velocity	****************	
Actual flow	****************	
Possible flow	.0 l/s	
Capacity in excess	****************	************

Storage	
Existing storage	kl
Required storage	kl
Storage in excess	kl

Water Treatment
Existing treatment facilities
Required treatment facilities
Treatment facilities in excess

Proposed Scheme

Population in year	J	will be	people
Future population density			****************
Future Total Domestic Water Demand			kl/d
Other Future Water Demand			kl/d
Future Scheme water demand			kl/d
Total Future Water Demand			kl/d
Future number of house connections			****************
Future number of yard connections			****************
Future number of standpipes			****************
Number of water point as f:(min walking distance)			****************
Future number of handpumps			****************
Present Water Source Capacity In Excess			kl/d

APPENDIX C - Model Technical Calculations

TECHNICAL CALCULATIONS - 1

Current Situation

Existing population			people	
Growth Rate			0.0%	
Project Area			ha	
People per household			0	
Current population density			****************	
Population in year	0	will be	people	
Present Total Domestic Water Demand			kl/d	
Present Scheme water demand			kl/d	
Other Present Water Demand			kl/d	
Total Present Water Demand			kl/d	
Current number of house connections			****************	
Current number of yard connections			****************	
Current number of standpipes			****************	
Current number of handpumps				
Present Water Source Capacity			kl/d	
Water Source in excess for Domestic demand			kl/d	************
Water Source in excess for Total demand			kl/d	************
Pumping scheme				
Present pipeline capacity				
Diameter			mm	
Area			.0000 m^2	
Actual Velocity			****************	
Actual flow			****************	
Possible flow			.0 l/s	
Capacity in excess			****************	************
Present pumping requirement				
Head loss			****************	
Total head			****************	
Pumping requirement			****************	************

INPUT DATA - 4

Community Participation
Provision Required (Y-yes, N-no)
Lump Sum (Amount, N-Not applicable)

Office Equipment
Provision Required (Y-yes, N-no)
Lump Sum (Amount, N-Not applicable)

Tools
Provision Required (Y-yes, N-no)
Lump Sum (Amount, N-Not applicable)

Training
Provision Required (Y-yes, N-no)
Lump Sum (Amount, N-Not applicable)

Project funding
Government
% of Total cost
Lump sum

Other Agencies
% of Total cost
Lump sum

Grant
% of Total cost
Lump sum

Soft Loan
% of Total cost
Lump sum
Interest rate (%)
Period of repayment (years)

Commercial Loan
% of Total cost
Lump sum
Interest rate (%)
Period of repayment (years)

Operating Costs (Staffing)
Staffing - number of man years per annum
Manager
Supervisor
Artisan
Clerk
Labourer

Staffing - rate (rands per man-year)
Manager
Supervisor
Artisan
Clerk
Labourer

TECHNICAL CALCULATIONS - 3

```
CALC:E105:   @ROUND(@IF($G$101>0,$G$105/$G$101,@IF($G$105=0,0,0)),2)
CALC:G105:   @ROUND(@IF(INPUT:$C$98=0,0,(INPUT:$C$98*3600*24/$G$101)),0)
CALC:B106:     River or lake
CALC:E106:   @ROUND(@IF($G$101>0,$G$106/$G$101,@IF($G$106=0,0,0)),2)
CALC:G106:   @ROUND(INPUT:$C$99*3600*24/1000,0)
CALC:B107:   TOTAL
CALC:G107:   @SUM($G$103..$G$106)
CALC:B110:   Water Source Development for Users not served by the scheme
CALC:B111:     Demand
CALC:G111:   +$G$80-$G$87
CALC:B112:     Boreholes
CALC:F112:   @IF($G$111>0,$G$112/$G$111,@IF($G$112=0,0,0))
CALC:G112:   +INPUT:$C$104*INPUT:$C$106*3.6
CALC:B113:     Wells
CALC:F113:   @IF($G$111>0,$G$113/$G$111,@IF($G$113=0,0,0))
CALC:G113:   +INPUT:$C$102*INPUT:$C$103*3.6
CALC:B114:       Total
CALC:F114:   +$F$112+$F$113
CALC:G114:   +$G$112+$G$113
CALC:B115:   Number of handpumps
CALC:G115:   +INPUT:$C$103+INPUT:$C$106
CALC:B116:   Pumping scheme
CALC:B119:    Pipeline Requirement
CALC:B120:      Present pipeline capacity
CALC:G120:   @IF(INPUT:$C$148="Y",$G$45,0)
CALC:B121:      Required capacity
CALC:G121:   @ROUND($G$87/3600/INPUT:$C$125*1000,1)
CALC:B122:      Flow in excess
CALC:G122:   @IF($G$121>0,$G$121-$G$120,0)
CALC:B123:      Diameter of the new pipeline
CALC:G123:   @ROUND(($G$122/1000/dBASE:$E$9*4/3.14)^(0.5)*1000,0)
CALC:I123:   @IF(@ISERR(dBASE:$C$69),"NA",dBASE:$C$60)
CALC:B124:      Velocity
CALC:G124:   +dBASE:$E$9
CALC:I124:   @IF($I$123="NA",$I$123,@ROUND(4*$G$122/1000/3.14/($I$123/1000)^2,2))
CALC:B126:    Pumping requirement
CALC:B127:      Existing pumping capacity in excess
CALC:G127:   @IF(INPUT:$C$149="Y",$G$53,0)
CALC:H127:   @ROUND($G$127*1.3404,0)
CALC:B128:      Head Loss
CALC:G128:   @ROUND(@IF($G$123<=0,0,dBASE:$F$143*INPUT:$C$121*(dBASE:$E$9)^2/(19.62*$G$123/1000)),0)
CALC:B129:      Total Head
CALC:G129:   +$G$128+INPUT:$C$128
CALC:B130:      Required capacity
CALC:G130:   @ROUND($G$122/1000*$G$129*10/(dBASE:$E$110/100),0)
CALC:I130:   @ROUND($G$130*1.3404,0)
CALC:B131:      Capacity to be installed
CALC:F131:   kW
CALC:G131:   @IF($G$130-$G$127<0,0,$G$130-$G$127)
CALC:H131:   HP
CALC:I131:   @ROUND($G$131*1.3404,0)
CALC:B134:   Gravity scheme
CALC:B135:     Present pipeline capacity
CALC:G135:   @IF(INPUT:$C$148="Y",$G$45,0)
CALC:B136:     Required capacity
CALC:G136:   @ROUND($G$87/3600/INPUT:$C$125*1000,1)
CALC:B137:     Flow in excess
CALC:G137:   @IF($G$135>=0,0,$G$136-$G$135)
CALC:B138:     Diameter of the new pipeline
CALC:G138:   @ROUND((dBASE:$J$143*INPUT:$C$121*($G$137/1000)^2/(2*INPUT:$C$123*9.81*(3.14/4)^2))^0.2*1000,0)
CALC:I138:   @IF(@ISERR(dBASE:$D$68),"NA",dBASE:$D$68)
CALC:B139:     Velocity
CALC:G139:   @ROUND(@IF($G$137<=0,0,4*$G$137/1000/3.14/($G$138/1000)^2),2)
CALC:I139:   @IF($I$138="NA",$I$138,@ROUND(4*$G$137/1000/3.14/($I$138/1000)^2,2))
CALC:B141:   Storage
CALC:B142:     Existing storage
CALC:G142:   +INPUT:$C$147
CALC:B143:     Total required storage
CALC:G143:   +$G$87*INPUT:$C$109
```

TECHNICAL CALCULATIONS - 2

```
CALC:F53:   @IF($G$53<=0,0,@IF($G52<=0,0,$G$53/$G$52))
CALC:G53:   @IF(INPUT:$C$145-$G$51<0,0,INPUT:$C$145-$G$51)
CALC:I53:   @ROUND(1.3404*$G$53,0)
CALC:B55:   Gravity scheme
CALC:B56:     Present pipeline capacity
CALC:B57:     Diameter
CALC:G57:   +INPUT:$C$142
CALC:B58:     Area
CALC:G58:   @ROUND((INPUT:$C$142/1000)^2*3.14/4,4)
CALC:B59:     Actual velocity
CALC:G59:   @ROUND(((2*9.81*INPUT:$C$143)/(1+(dBASE:$J$141*INPUT:$C$144/(INPUT:$C$142/1000))))^(0.5),2)
CALC:B60:     Actual flow
CALC:G60:   @ROUND($G$59*$G$58*1000,1)
CALC:B61:     Possible flow
CALC:G61:   @ROUND(dBASE:$E$7*$G$58*1000,1)
CALC:B62:     Capacity in excess
CALC:G62:   @IF($G$61-$G$60<0,0,$G$61-$G$60)
CALC:I62:   @IF($G$61<0,0,@IF($G$62<0,0,$G$62/$G$61))
CALC:B64:   Storage
CALC:B65:     Existing storage
CALC:G65:   +INPUT:$C$147
CALC:B66:     Required storage
CALC:G66:   +$G$19*INPUT:$C$109
CALC:B67:     Storage in excess
CALC:G67:   @IF($G$65-$G$66<0,0,$G$65-$G$66)
CALC:B69:   Water Treatment
CALC:B70:     Existing treatment facilities
CALC:B71:     Required treatment facilities
CALC:B72:     Treatment facilities in excess
CALC:A77:   Proposed Scheme
CALC:B79:   Population in year
CALC:D79:   +INPUT:$C$73
CALC:F79:   will be
CALC:G79:   @ROUND(((INPUT:$C$9)*(1+(INPUT:$C$11)/100)^(INPUT:$C$73)),0)
CALC:B81:   Future population density
CALC:G81:   @ROUND($G$79/INPUT:$C$13,0)
CALC:B83:   Future Total Domestic Water Demand
CALC:G83:   @ROUND(($G$79/100*((INPUT:$C$44*INPUT:$C$54)+(INPUT:$C$45*INPUT:$C$55)+(INPUT:$C$46*INPUT:$C$56)+(INPUT
            :$C$47*INPUT:$C$57))*(1+INPUT:$C$119/100))/1000*INPUT:$C$114,0)
CALC:B85:   Other Future Water Demand
CALC:G85:   @ROUND(((INPUT:$C$48*INPUT:$C$64)+(INPUT:$C$49*INPUT:$C$65)+(INPUT:$C$50*INPUT:$C$66))*(1+INPUT:$C$119)
            *INPUT:$C$114/1000,0)
CALC:B87:   Future Scheme water demand
CALC:G87:   @ROUND(($G$79/100*((INPUT:$C$44*INPUT:$C$54)+(INPUT:$C$45*INPUT:$C$55)+(INPUT:$C$46*INPUT:$C$56))*(1+INP
            UT:$C$119/100))/1000*INPUT:$C$114,0)+$G$85
CALC:B89:   Total Future Water Demand
CALC:G89:   +$G$85+$G$83
CALC:B91:   Future number of house connections
CALC:G91:   @ROUND($G$79/100*INPUT:$C$54/INPUT:$C$16,0)
CALC:B93:   Future number of yard connections
CALC:G93:   @ROUND($G$79/100*INPUT:$C$55/INPUT:$C$15,0)
CALC:B95:   Future number of standpipes
CALC:G95:   @ROUND($G$79/100*INPUT:$C$56/INPUT:$C$60,0)
CALC:B96:   Number of water point as f:(min walking distance)
CALC:G96:   @ROUND(INPUT:$C$13*10000/(INPUT:$C$91)^2,0)
CALC:B97:   Future number of handpumps
CALC:G97:   @ROUND($G$79/100*INPUT:$C$57/INPUT:$C$60,0)
CALC:B99:   Present Water Source Capacity in Excess
CALC:G99:   +$G$37
CALC:B101:  Water Source Development for scheme demand
CALC:G101:  @IF($G$89-$G$99<0,0,$G$89-$G$99)
CALC:B102:  Availability:
CALC:B103:    Boreholes
CALC:E103:  @ROUND(@IF($G$101>0,$G$103/$G$101,@IF($G$103=0,0,0)),2)
CALC:G103:  @ROUND(INPUT:$C$93*INPUT:$C$94*3600*24/1000,0)
CALC:B104:    Weir
CALC:E104:  @ROUND(@IF($G$101>0,$G$104/$G$101,@IF($G$104=0,0,0)),2)
CALC:G104:  @ROUND(INPUT:$C$97*3600*24/1000,0)
CALC:B105:    Spring
```

TECHNICAL CALCULATIONS - 1

```
CALC:A3:    Current Situation
CALC:B5:    'Existing population
CALC:G5:    +INPUT:$C$9
CALC:B7:    'Growth Rate
CALC:G7:    +INPUT:$C$11/100
CALC:B9:    Project Area
CALC:G9:    +INPUT:$C$13
CALC:B11:   People per household
CALC:G11:   +INPUT:$C$15
CALC:B13:   Current population density
CALC:G13:   +INPUT:$C$9/INPUT:$C$13
CALC:B15:   Population in year
CALC:D15:   +INPUT:$C$73
CALC:F15:   will be
CALC:G15:   @ROUND(((INPUT:$C$9)*(1+(INPUT:$C$11)/100)^(INPUT:$C$73)),0)
CALC:B17:   Present Total Domestic Water Demand
CALC:G17:   @ROUND(((INPUT:$C$9)/100)*((INPUT:$C$18*INPUT:$C$28)+(INPUT:$C$19*INPUT:$C$29)+(INPUT:$C$20*INPUT:$C$30)
            +(INPUT:$C$21*INPUT:$C$31))*INPUT:$C$114/1000*(1+INPUT:$C$118/100),0)
CALC:B19:   Present Scheme water demand
CALC:G19:   @ROUND(((INPUT:$C$9)/100)*((INPUT:$C$18*INPUT:$C$28)+(INPUT:$C$19*INPUT:$C$29)+(INPUT:$C$20*INPUT:$C$30)
            )*INPUT:$C$114/1000*(1+INPUT:$C$118/100),0)
CALC:B21:   Other Present Water Demand
CALC:G21:   @ROUND((((INPUT:$C$22*INPUT:$C$38)+(INPUT:$C$23*INPUT:$C$39)+(INPUT:$C$24*INPUT:$C$40)+(INPUT:$C$25*INP
            UT:$C$41))*INPUT:$C$114/1000*(1+INPUT:$C$118/100)),0)
CALC:B23:   Total Present Water Demand
CALC:G23:   +$G$17+$G$21
CALC:B25:   Current number of house connections
CALC:G25:   +INPUT:$C$9/INPUT:$C$15*INPUT:$C$28/100
CALC:B27:   Current number of yard connections
CALC:G27:   @ROUND(INPUT:$C$9/INPUT:$C$15*INPUT:$C$29/100,0)
CALC:B29:   Current number of standpipes
CALC:G29:   @ROUND(INPUT:$C$9*INPUT:$C$30/100/INPUT:$C$34,0)
CALC:B31:   Current number of handpumps
CALC:B33:   Present Water Source Capacity
CALC:G33:   @ROUND((((INPUT:$C$78*INPUT:$C$79+INPUT:$C$82+INPUT:$C$83+INPUT:$C$84+(INPUT:$C$87*INPUT:$C$89))*3600*2
            4/1000,0)
CALC:B35:   Water Source in excess for Domestic demand
CALC:G35:   +$G$33-$G$17
CALC:I35:   @ROUND(@IF($G$37<0,0,$G$35/$G$33),2)
CALC:B37:   Water Source in excess for Total demand
CALC:G37:   +$G$33-$G$23
CALC:I37:   @ROUN?(@IF($G$37<0,0,$G$37/$G$33),2)
CALC:B39:   Pumping scheme
CALC:B40:    Present pipeline capacity
CALC:B41:     Diameter
CALC:G41:   +INPUT:$C$142
CALC:B42:     Area
CALC:G42:   @ROUND((INPUT:$C$142/1000)^2*3.14/4,4)
CALC:B43:     Actual Velocity
CALC:G43:   @ROUND($G$19/INPUT:$C$125/3600/G42,2)
CALC:B44:     Actual flow
CALC:G44:   @ROUND($G$19/INPUT:$C$125/3600*1000,1)
CALC:B45:     Possible flow
CALC:G45:   @ROUND($G$42*dBASE:$E$7*1000,1)
CALC:B46:     Capacity in excess
CALC:G46:   @IF($G$45-$G$44<0,0,$G$45-$G$44)
CALC:I46:   @ROUND($G$46*INPUT:$C$125*3600/1000,0)
CALC:B48:    Present p  nping requirement
CALC:B49:     Head loss
CALC:G49:   @ROUND(dBASE:$F$141*INPUT:$C$144*($G$43)^2/2/9.81/(INPUT:$C$142/1000),1)
CALC:B50:     Total head
CALC:G50:   +INPUT:$C$143+$G$49
CALC:B51:     Pumping requirement
CALC:G51:   @ROUND((10*$G$50*$G$19)/(INPUT:$C$125*3600*(dBASE:$E$118/100)),1)
CALC:I51:   @ROUND(1.3404*$G$51,0)
CALC:B52:     Installed capacity
CALC:G52:   +INPUT:$C$145
CALC:I52:   @ROUND(1.3404*$G$52,0)
CALC:B53:     Pumping capacity in excess
```

INPUT DATA - 3

INPUT:B196:	Training
INPUT:B197:	Provision Required (Y-yes, N-no)
INPUT:B198:	Lump Sum (Amount, N-Not applicable)
INPUT:B200:	Project funding
INPUT:B201:	Government
INPUT:B202:	% of Total cost
INPUT:B203:	Lump sum
INPUT:B205:	Other Agencies
INPUT:B206:	% of Total cost
INPUT:B207:	Lump sum
INPUT:B209:	Grant
INPUT:B210:	% of Total cost
INPUT:B211:	Lump sum
INPUT:B213:	Soft Loan
INPUT:B214:	% of Total cost
INPUT:B215:	Lump sum
INPUT:B216:	Interest rate (%)
INPUT:B217:	Period of repayment (years)
INPUT:B219:	Commercial Loan
INPUT:B220:	% of Total cost
INPUT:B221:	Lump sum
INPUT:B222:	Interest rate (%)
INPUT:B223:	Period of repayment (years)
INPUT:B225:	Operating Costs (Staffing)
INPUT:B226:	Staffing - number of man years per annum
INPUT:B227:	Manager
INPUT:B228:	Supervisor
INPUT:B229:	Artisan
INPUT:B230:	Clerk
INPUT:B231:	Labourer
INPUT:B233:	Staffing - rate (rands per man-year)
INPUT:B234:	Manager
INPUT:B235:	Supervisor
INPUT:B236:	Artisan
INPUT:B237:	Clerk
INPUT:B238:	Labourer

INPUT DATA - 2

INPUT:B98:	Spring (max abstraction rate l/s)
INPUT:B99:	River or lake (max abstraction rate l/s)
INPUT:B101:	Water source for consumers not served by the scheme
INPUT:B102:	Average well yield (l/s)
INPUT:B103:	Number of well
INPUT:B104:	Average borehole yield (l/s)
INPUT:B105:	Depth (m)
INPUT:B106:	Number of borehole
INPUT:B109:	'Storage Requirements (No of days' demand)
INPUT:B110:	Proposed Scheme Will Share Existing Storage? (Y-Yes, N-No)
INPUT:B113:	'Peak factors
INPUT:B114:	Daily
INPUT:B117:	'Unaccounted-for water (%)
INPUT:B118:	Present
INPUT:B119:	Future
INPUT:B121:	'Distance from water source to highest point along the pipeline (m)
INPUT:B122:	Total distance of pipeline
INPUT:B123:	'Levels difference between water source and the highest point to pump to (m)
INPUT:B126:	'Number of hours of daily function
INPUT:B127:	'Source of energy (E-electricity, D-diesel, O-other)
INPUT:B130:	'Raw water quality
INPUT:B131:	Turbidity (NTU)
INPUT:B132:	Surface Water
INPUT:B133:	Groundwater
INPUT:B135:	Plate count per 100 ml
INPUT:B136:	Surface Water
INPUT:B137:	Groundwater
INPUT:B140:	'Existing System
INPUT:B141:	Pipeline
INPUT:B142:	Diameter (mm)
INPUT:B143:	Elevation (m)
INPUT:B144:	Length (m)
INPUT:B146:	Pumping capacity (kW)
INPUT:B147:	Storage capacity (Kl)
INPUT:B148:	Proposed Scheme Will Share Existing Pipeline? (Y-Yes, N-No)
INPUT:B149:	Proposed Scheme Will Share Existing Pumping Capacity? (Y-Yes, N-No)
INPUT:B152:	'Materials - Existing scheme
INPUT:B153:	Borehole casing (S-steel, PVC)
INPUT:B154:	Pipe (CI-Cast Iron, HDPE, PVC, AC-Asbestos)
INPUT:B155:	Reservoir (C-concrete, S-steel, P-plastic)
INPUT:B158:	'Materials - Proposed scheme
INPUT:B159:	Borehole casing (S-steel, PVC)
INPUT:B160:	Pipe (GMS-Galvanized steel, HDPE, PVC, AC-Asbestos)
INPUT:B161:	Reservoir (C-concrete, S-steel, P-plastic)
INPUT:B162:	Borehole diameter (4,6,8,10 or 12 inches)
INPUT:B163:	House connection (GMS,PVC,HDPE)
INPUT:B164:	Yard Tap (GMS,PVC,HDPE)
INPUT:B165:	Standpipe (GMS,PVC,HDPE)
INPUT:B168:	Community contribution
INPUT:B169:	Labour (Y-yes, N-no)
INPUT:B170:	Lump Sum (Amount, N-Not applicable)
INPUT:B172:	Project Design
INPUT:B173:	Provision Required (Y-yes, N-no)
INPUT:B174:	Lump Sum (Amount, N-Not applicable)
INPUT:B176:	Project Supervision
INPUT:B177:	Provision Required (Y-yes, N-no)
INPUT:B178:	Lump Sum (Amount, N-Not applicable)
INPUT:B180:	Contingencies
INPUT:B181:	Provision Required (Y-yes, N-no)
INPUT:B182:	Lump Sum (Amount, N-Not applicable)
INPUT:B184:	Community Participation
INPUT:B185:	Provision Required (Y-yes, N-no)
INPUT:B186:	Lump Sum (Amount, N-Not applicable)
INPUT:B188:	Office Equipment
INPUT:B189:	Provision Required (Y-yes, N-no)
INPUT:B190:	Lump Sum (Amount, N-Not applicable)
INPUT:B192:	Tools
INPUT:B193:	Provision Required (Y-yes, N-no)
INPUT:B194:	Lump Sum (Amount, N-Not applicable)

INPUT DATA - 1

INPUT:B3:	Project Name
INPUT:B5:	Project Number
INPUT:B7:	Province (Only first three characters e.g. NAM for Nampula)
INPUT:B9:	'Population
INPUT:B11:	'Population Growth Rate (%)
INPUT:B13:	'Project area (Ha)
INPUT:B15:	'Average number of people per household
INPUT:B17:	'Present per capita consumption (l/p/d)
INPUT:B18:	House connection
INPUT:B19:	Yard Connection
INPUT:B20:	Standpipe
INPUT:B21:	Handpump
INPUT:B22:	Student
INPUT:B23:	Hospital beds
INPUT:B24:	Worker
INPUT:B27:	'Present percentage of people served by:
INPUT:B28:	House connection
INPUT:B29:	Yard connection
INPUT:B30:	Standpipe
INPUT:B31:	Handpump
INPUT:B32:	Other
INPUT:B34:	Number of people served by a water point (e.g. standpipe)
INPUT:B35:	Maximum walking distance to water point (m)
INPUT:B37:	Number of:
INPUT:B38:	Students
INPUT:B39:	Hospital beds
INPUT:B40:	Workers
INPUT:B43:	'Future per capita consumption (l/p/d)
INPUT:B44:	House connection
INPUT:B45:	Yard Connection
INPUT:B46:	Standpipe
INPUT:B47:	Handpump
INPUT:B48:	Student
INPUT:B49:	Hospital beds
INPUT:B50:	Worker
INPUT:B53:	'Future percentage of people served by:
INPUT:B54:	House connection
INPUT:B55:	Yard tap
INPUT:B56:	Standpipe
INPUT:B57:	Handpump
INPUT:B58:	Other
INPUT:B60:	Number of people served by a water point (e.g. standpipe)
INPUT:B61:	Maximum walking distance to water point (m)
INPUT:B63:	Number of:
INPUT:B64:	Students
INPUT:B65:	Hospital beds
INPUT:B66:	Workers
INPUT:B69:	'Type of existing scheme (G-gravity, P-pumping or HP-handpump)
INPUT:B71:	'Type of proposed scheme (G-gravity, P-pumping or HP-handpump)
INPUT:B73:	'Project Horizon
INPUT:B75:	'Present Water Source - Developed
INPUT:B76:	Borehole
INPUT:B77:	Depth (m)
INPUT:B78:	Yield (l/s)
INPUT:B79:	Number of boreholes
INPUT:B81:	Surface
INPUT:B82:	Weir (max abstraction rate l/s)
INPUT:B83:	Spring (max abstraction rate l/s)
INPUT:B84:	River or lake (max abstraction rate l/s)
INPUT:B86:	Handpump
INPUT:B87:	Average Yield (l/s)
INPUT:B88:	Number of handpumps
INPUT:B90:	Future Water Source for the scheme = (Potential - Developed)
INPUT:B91:	Borehole
INPUT:B92:	Depth (m)
INPUT:B93:	Yield (l/s)
INPUT:B94:	Number of boreholes
INPUT:B96:	Surface
INPUT:B97:	Weir (max abstraction rate l/s)

DATABASE - 7

dBASE:B182:	Depreciation
dBASE:D182:	Asset life (years)
dBASE:B183:	Water source
dBASE:D183:	30
dBASE:B184:	Pipeline
dBASE:D184:	30
dBASE:B185:	Pumping
dBASE:D185:	10
dBASE:B186:	Storage
dBASE:D186:	30
dBASE:B189:	Project Location Cost Factor
dBASE:H190:	Province
dBASE:I190:	Factor
dBASE:B191:	MAP
dBASE:C191:	1
dBASE:D191:	MAPUTO
dBASE:H191:	@ARRAY(@VLOOKUP(INPUT:$C$7,$B$191..$D$200,2))
dBASE:I191:	@ARRAY(@VLOOKUP(INPUT:$C$7,$B$191..$D$200,1))
dBASE:B192:	GAZ
dBASE:C192:	1.2
dBASE:D192:	GAZA
dBASE:B193:	INH
dBASE:C193:	1.25
dBASE:D193:	INHAMBANE
dBASE:B194:	SOF
dBASE:C194:	1
dBASE:D194:	SOFALA
dBASE:B195:	MAN
dBASE:C195:	1.1
dBASE:D195:	MANICA
dBASE:B196:	TET
dBASE:C196:	1.25
dBASE:D196:	TETE
dBASE:B197:	ZAM
dBASE:C197:	1.3
dBASE:D197:	ZAMBEZIA
dBASE:B198:	NAM
dBASE:C198:	1.2
dBASE:D198:	NAMPULA
dBASE:B199:	CAB
dBASE:C199:	1.3
dBASE:D199:	CABO DELGADO
dBASE:B200:	NIA
dBASE:C200:	1.4
dBASE:D200:	NIASSA
dBASE:B203:	Project Adjustment Factor
dBASE:C203:	1.05

DATABASE - 6

dBASE:C138:	0.012
dBASE:D138:	0.013
dBASE:E138:	0.011
dBASE:F138:	0.014
dBASE:C141:	Rouganess old pipe
dBASE:F141:	@HLOOKUP(INPUT:C154,B137..F138,1)
dBASE:C143:	Roughness new pipe
dBASE:F143:	@HLOOKUP(INPUT:$C$160,$B$137..$F$138,1)
dBASE:B147:	ADDITIONAL COSTS
dBASE:B149:	Office Equipment
dBASE:F149:	1.5
dBASE:G149:	%
dBASE:B150:	Tools
dBASE:F150:	1
dBASE:G150:	%
dBASE:B151:	Community Participation
dBASE:F151:	1
dBASE:G151:	%
dBASE:B152:	Training
dBASE:F152:	1.5
dBASE:G152:	%
dBASE:B153:	Project Design
dBASE:F153:	11
dBASE:G153:	%
dBASE:B154:	Project Supervision
dBASE:F154:	2.5
dBASE:G154:	%
dBASE:B155:	Contingencies
dBASE:F155:	10
dBASE:G155:	%
dBASE:B156:	Community contribution (labour)
dBASE:F156:	30
dBASE:G156:	%
dBASE:B157:	Training
dBASE:F157:	2
dBASE:G157:	%
dBASE:B160:	OPERATION & MAINTENANCE
dBASE:B161:	Water source
dBASE:B162:	Borehole
dBASE:D162:	5
dBASE:E162:	% of CAPEX
dBASE:B163:	Well
dBASE:D163:	5
dBASE:E163:	% of CAPEX
dBASE:B164:	Spring
dBASE:D164:	5
dBASE:E164:	% of CAPEX
dBASE:B165:	Weir
dBASE:D165:	5
dBASE:E165:	% of CAPEX
dBASE:B167:	Reticulation
dBASE:D167:	2
dBASE:E167:	% of CAPEX
dBASE:B169:	Pipeline
dBASE:D169:	1
dBASE:E169:	% of CAPEX
dBASE:B171:	Pumping - electricity
dBASE:D171:	5
dBASE:E171:	% of CAPEX
dBASE:B173:	Pumping - diesel
dBASE:D173:	10
dBASE:E173:	% of CAPEX
dBASE:B175:	Storage
dBASE:D175:	1
dBASE:E175:	% of CAPEX
dBASE:B177:	Administration
dBASE:D177:	10
dBASE:E177:	% over other O&M costs
dBASE:A179:	[illegible]

DATABASE - 5

dBASE:H110:	+INPUT:$C$162
dBASE:I110:	@IF(INPUT:$C$159="S",@VLOOKUP(INPUT:$C$162,$B$110..$C$114,1),@IF(INPUT:$C$159="PVC",@VLOOKUP(INPUT:$C$162,$B$110..$D$114,2),0))
dBASE:B111:	6
dBASE:C111:	2250
dBASE:D111:	2100
dBASE:B112:	8
dBASE:C112:	2500
dBASE:D112:	2350
dBASE:H112:	Depth
dBASE:I112:	Cost/Unit
dBASE:B113:	10
dBASE:C113:	2750
dBASE:D113:	2500
dBASE:G113:	Scheme
dBASE:H113:	+INPUT:$C$92
dBASE:I113:	+$I$110*$H$113
dBASE:B114:	12
dBASE:C114:	3000
dBASE:D114:	2850
dBASE:G114:	HPump
dBASE:H114:	+INPUT:$C$105
dBASE:I114:	+$I$110*$H$114
dBASE:B117:	PUMPING
dBASE:B118:	Pumping efficiency (%)
dBASE:E118:	75
dBASE:B120:	'Pumping Station -construction
dBASE:E120:	4000
dBASE:F120:	'R/kW
dBASE:E121:	+$E$120*1.3
dBASE:F121:	R/HP
dBASE:B124:	LEVELS OF SERVICE
dBASE:B126:	'Unit Cost
dBASE:I127:	For Calculation
dBASE:D128:	GMS
dBASE:E128:	^PVC
dBASE:F128:	^HDPE
dBASE:I128:	Material
dBASE:J128:	Cost
dBASE:B129:	'House connection
dBASE:D129:	1500
dBASE:E129:	13?0
dBASE:F129:	1400
dBASE:I129:	+INPUT:$C$163
dBASE:J129:	@IF(INPUT:$C$163="GMS",$D$129,@IF(INPUT:$C$163="PVC",$E$129,@IF(INPUT:$C$163="HDPE",$F$129,"NA")))
dBASE:B130:	'Yard connection
dBASE:D130:	1200
dBASE:E130:	1080
dBASE:F130:	1100
dBASE:I130:	+INPUT:$C$164
dBASE:J130:	@IF(INPUT:$C$164="GMS",$D$130,@IF(INPUT:$C$164="PVC",$E$130,@IF(INPUT:$C$164="HDPE",$F$130,"NA")))
dBASE:B131:	'Standpipe
dBASE:D131:	1350
dBASE:E131:	1495
dBASE:F131:	1575
dBASE:I131:	+INPUT:$C$165
dBASE:J131:	@IF(INPUT:$C$165="GMS",$D$131,@IF(INPUT:$C$165="PVC",$E$131,@IF(INPUT:$C$165="HDPE",$F$131,"NA")))
dBASE:B134:	Darcy Weisbach coefficient
dBASE:B136:	Concrete
dBASE:C136:	GMS
dBASE:D136:	PVC
dBASE:E136:	HDPE
dBASE:F136:	AC
dBASE:B137:	C
dBASE:C137:	GMS
dBASE:D137:	PVC
dBASE:E137:	HDPE
dBASE:F137:	AC
dBASE:B139:	0.02

DATABASE - 4

```
dBASE:I78:      -200
dBASE:J78:      20000
dBASE:B79:      -6000
dBASE:C79:      1100000
dBASE:F79:      -130
dBASE:G79:      108000
dBASE:I79:      -150
dBASE:J79:      16000
dBASE:B80:      -600
dBASE:C80:      155000
dBASE:F80:      -82
dBASE:G80:      83500
dBASE:I80:      -100
dBASE:J80:      10000
dBASE:B81:      -200
dBASE:C81:      90000
dBASE:F81:      -62
dBASE:G81:      73000
dBASE:I81:      -80
dBASE:J81:      8000
dBASE:B82:      -160
dBASE:C82:      80000
dBASE:I82:      -60
dBASE:J82:      6000
dBASE:B83:      -60
dBASE:C83:      45000
dBASE:B84:      -60
dBASE:C84:      38000
dBASE:B90:      Data for calculations
dBASE:F90:      Regression analysis
dBASE:B91:      Material
dBASE:C91:      Rate
dBASE:F91:        Concrete
dBASE:H91:      +0.0109*(REPORT:$H$114)^2+197*REPORT:$H$114+38407
dBASE:B92:      @IF(INPUT:$C$161="C","Concrete",@IF(INPUT:$C$161="S","Steel",@IF(INPUT:$C$161="P","Plastic"," ")))
dBASE:C92:      @IF(INPUT:$C$161="C",$H$91,@IF(INPUT:$C$161="S",$H$92,@IF(INPUT:$C$161="P",$H$93," ")))
dBASE:D92:      Existing
dBASE:F92:        Steel
dBASE:H92:      20
dBASE:B93:      @IF(INPUT:$C$155="C","Concrete",@IF(INPUT:$C$155="S","Steel",@IF(INPUT:$C$155="P","Plastic"," ")))
dBASE:C93:      @IF(INPUT:$C$155="C",$H$91,@IF(INPUT:$C$155="S",$H$92,@IF(INPUT:$C$155="P",$H$93," ")))
dBASE:D93:      New
dBASE:F93:        Plastic
dBASE:H93:      30
dBASE:B97:      WATER SOURCE
dBASE:B99:      Well
dBASE:C99:      2000
dBASE:D99:      R/unit including Handpump
dBASE:B100:     'Weir
dBASE:C100:     10000
dBASE:D100:     R/kld
dBASE:B101:     'Spring
dBASE:C101:     6000
dBASE:D101:     R/kld
dBASE:B104:     Borehole
dBASE:B106:     'Unit Cost per meter drilled
dBASE:B108:     ^Diam
dBASE:D108:     ^Casing Type
dBASE:G108:     For Calculation
dBASE:B109:     Inches
dBASE:C109:     ^Steel
dBASE:D109:     ^PVC
dBASE:G109:     Material
dBASE:H109:     Diam
dBASE:I109:     Unit Cost
dBASE:B110:     4
dBASE:C110:     2000
dBASE:D110:     1750
dBASE:G110:     +INPUT:$C$159
```

DATABASE - 3

dBASE:I50:	-50
dBASE:J50:	30
dBASE:D51:	-500
dBASE:E51:	271
dBASE:I51:	-40
dBASE:J51:	21
dBASE:D52:	-450
dBASE:E52:	236
dBASE:I52:	-32
dBASE:J52:	18
dBASE:D53:	-400
dBASE:E53:	194
dBASE:I53:	-25
dBASE:J53:	14
dBASE:D54:	-350
dBASE:E54:	156
dBASE:I54:	-20
dBASE:J54:	9
dBASE:D55:	-300
dBASE:E55:	116
dBASE:I55:	-16
dBASE:J55:	7
dBASE:D56:	-250
dBASE:E56:	91
dBASE:D57:	-200
dBASE:E57:	63
dBASE:D58:	-150
dBASE:E58:	38
dBASE:H58:	GMS
dBASE:K58:	Pumping
dBASE:L58:	Gravity
dBASE:H59:	Diameter of new pipeline
dBASE:K59:	@VLOOKUP(-1*CALC:$G$123,$I$46..$J$55,0)*-1
dBASE:L59:	@VLOOKUP(-1*CALC:$G$138,$I$46..$J$55,0)*-1
dBASE:H60:	Unit cost
dBASE:K60:	@VLOOKUP(-1*CALC:$G$123,$I$46..$J$55,1)
dBASE:L60:	@VLOOKUP(-1*CALC:$G$138,$I$46..$J$55,1)
dBASE:B61:	AC
dBASE:E61:	Pumping
dBASE:F61:	Gravity
dBASE:B62:	Diameter of new pipeline
dBASE:E62:	@VLOOKUP(-1*CALC:$G$123,$D$46..$E$58,0)*-1
dBASE:F62:	@VLOOKUP(-1*CALC:$G$138,$D$46..$E$58,0)*-1
dBASE:B63:	Unit cost
dBASE:E63:	@VLOOKUP(-1*CALC:$G$123,$D$46..$E$58,1)
dBASE:F63:	@VLOOKUP(-1*CALC:$G$138,$D$46..$E$58,1)
dBASE:B66:	For Calculation
dBASE:B67:	
dBASE:C67:	Pumping
dBASE:D67:	Gravity
dBASE:B68:	Diameter
dBASE:C68:	@ARRAY((@IF(INPUT:$C$160="HDPE",$D$41..$E$42,@IF(INPUT:$C$160="PVC",$H$35..$I$36,@IF(INPUT:$C$160="AC",$E$62..$F$63,@IF(INPUT:$C$160="GMS",$G$59..$K$60,$G$41..$H$42)))))
dBASE:D68:	'NA
dBASE:B69:	Unit cost
dBASE:C69:	'NA
dBASE:D69:	'NA
dBASE:B73:	RESERVOIRS
dBASE:B76:	'Unit Cost - Rands
dBASE:B77:	^Vol. (kl)
dBASE:C77:	^Concrete
dBASE:F77:	^Vol. (kl)
dBASE:G77:	^Steel
dBASE:I77:	Vol (kl)
dBASE:J77:	Plastic
dBASE:B78:	-100000
dBASE:C78:	1500000
dBASE:F78:	-150
dBASE:G78:	130000

DATABASE - 2

dBASE:B29:	-110
dBASE:C29:	97.33
dBASE:F29:	-75
dBASE:G29:	21
dBASE:B30:	-100
dBASE:C30:	77.5
dBASE:F30:	-63
dBASE:G30:	15
dBASE:B31:	-90
dBASE:C31:	61.29
dBASE:F31:	-50
dBASE:G31:	10
dBASE:B32:	-50
dBASE:C32:	20.55
dBASE:B33:	-40
dBASE:C33:	13.08
dBASE:B34:	-32
dBASE:C34:	8.46
dBASE:E34:	PVC
dBASE:H34:	Pumping
dBASE:I34:	Gravity
dBASE:B35:	-25
dBASE:C35:	5.39
dBASE:E35:	Diameter of new pipeline
dBASE:H35:	@VLOOKUP(-1*CALC:$G$123,$F$19..$G$31,0)*-1
dBASE:I35:	@VLOOKUP(-1*CALC:$G$138,$F$19..$G$31,0)*-1
dBASE:B36:	-20
dBASE:C36:	3.28
dBASE:E36:	Unit cost
dBASE:H36:	@VLOOKUP(-1*CALC:$G$123,$F$19..$G$31,1)
dBASE:I36:	@VLOOKUP(-1*CALC:$G$138,$F$19..$G$31,1)
dBASE:B37:	-16
dBASE:C37:	2.1
dBASE:B40:	HDPE
dBASE:D40:	Pumping
dBASE:E40:	Gravity
dBASE:G40:	Table message Not Applicable
dBASE:B41:	Diameter of new pipeline
dBASE:D41:	@VLOOKUP(-1*CALC:$G$123,$B$19..$C$37,0)*-1
dBASE:E41:	@VLOOKUP(-1*CALC:$G$138,$B$19..$C$37,0)*-1
dBASE:G41:	NA
dBASE:H41:	NA
dBASE:B42:	Unit cost
dBASE:D42:	@VLOOKUP(-1*CALC:$G$123,$B$19..$C$37,1)
dBASE:E42:	@VLOOKUP(-1*CALC:$G$138,$B$19..$C$37,1)
dBASE:G42:	NA
dBASE:H42:	NA
dBASE:D45:	^Dia. (mm)
dBASE:E45:	^AC cl24
dBASE:I45:	^Dia. (mm)
dBASE:J45:	^GMS
dBASE:D46:	-1000
dBASE:E46:	910
dBASE:I46:	-150
dBASE:J46:	112
dBASE:D47:	-900
dBASE:E47:	771
dBASE:I47:	-100
dBASE:J47:	71
dBASE:D48:	-800
dBASE:E48:	689
dBASE:I48:	-80
dBASE:J48:	48
dBASE:D49:	-700
dBASE:E49:	612
dBASE:I49:	-65
dBASE:J49:	38
dBASE:D50:	-600
dBASE:E50:	392

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FINANCIAL RESULTS - 1

PRICE:C18:	Project cost
PRICE:F18:	+COSTS:$G$77
PRICE:C20:	Operation and Maintenance cost (p.a.)
PRICE:F20:	+COSTS:$G$106
PRICE:C22:	Grant
PRICE:F22:	+COSTS:$G$84
PRICE:C24:	Soft loan
PRICE:F24:	+COSTS:$G$85
PRICE:C26:	Commercial Loan
PRICE:F26:	+COSTS:$G$86
PRICE:C30:	Annual repayment
PRICE:D31:	Interest Rate
PRICE:E31:	Repayment Period
PRICE:C32:	Soft loan
PRICE:D32:	+INPUT:$C$216/100
PRICE:E32:	+INPUT:$C$217
PRICE:F32:	@IF(INPUT:$C$216=0,0,((INPUT:$C$216/100*(1+INPUT:$C$216/100)^INPUT:$C$217))/((1+INPUT:$C$216/100)^(INPUT:$C$217)-1)*$F$24)
PRICE:C34:	Commercial Loan
PRICE:D34:	+INPUT:$C$222/100
PRICE:E34:	+INPUT:$C$223
PRICE:F34:	@IF(INPUT:$C$222=0,0,((INPUT:$C$222/100*(1+INPUT:$C$222/100)^INPUT:$C$223))/((1+INPUT:$C$222/100)^(INPUT:$C$223)-1)*$F$26)
PRICE:C38:	Depreciation - fixed instalments p.a.
PRICE:C40:	Water Sources
PRICE:F40:	+COSTS:$G$20/dBASE:$D$183
PRICE:C42:	Pipeline
PRICE:F42:	+COSTS:$G$37/dBASE:$D$184
PRICE:C44:	Pumping
PRICE:F44:	+COSTS:$G$41/dBASE:$D$185
PRICE:C46:	Storage
PRICE:F46:	+COSTS:$G$44/dBASE:$D$186
PRICE:C50:	Cost of water
PRICE:D50:	Household p.a.
PRICE:E50:	capita p.a.
PRICE:F50:	kl
PRICE:C52:	To cover O&M only
PRICE:D52:	@ROUND(COSTS:$G$106/REPORT:$E$20*CALC:$G$11,1)
PRICE:E52:	@ROUND(COSTS:$G$106/REPORT:$E$20,1)
PRICE:F52:	@ROUND(COSTS:$G$106*100/(REPORT:$E$34*365),1)
PRICE:C54:	O&M plus depreciation
PRICE:D54:	@ROUND((COSTS:$G$106+$F$40+$F$42+$F$44+$F$46)/REPORT:$E$20*CALC:$G$11,1)
PRICE:E54:	@ROUND((COSTS:$G$106+$F$40+$F$42+$F$44+$F$46)/REPORT:$E$20,1)
PRICE:F54:	@ROUND((COSTS:$G$106+$F$40+$F$42+$F$44+$F$46)*100/(REPORT:$E$34*365),1)
PRICE:C56:	O&M+depreciation+ annual repayment
PRICE:D56:	@ROUND((COSTS:$G$106+$F$40+$F$42+$F$44+$F$46+$F$32+$F$34)/REPORT:$E$20*CALC:$G$11,1)
PRICE:E56:	@ROUND((COSTS:$G$106+$F$40+$F$42+$F$44+$F$46+$F$32+$F$34)/REPORT:$E$20,1)
PRICE:F56:	@ROUND((COSTS:$G$106+$F$40+$F$42+$F$44+$F$46+$F$32+$F$34)*100/(REPORT:$E$34*365),1)
PRICE:C60:	Capital cost per capita
PRICE:F60:	+COSTS:$G$77/REPORT:$H$20

PROJECT COSTS - 3

```
COSTS:C102:   Pumping
COSTS:F102:   @IF(INPUT:$C$71="P",@IF(INPUT:$C$127="E",dBASE:$D$171,@IF(INPUT:$C$127="D",dBASE:$D$173,"")),"")
COSTS:G102:   @IF(INPUT:$C$71="P",dBASE:$D$171*$G$41/100,"")
COSTS:C103:   Storage
COSTS:F103:   @IF(INPUT:$C$71="P",dBASE:$D$175,@IF(INPUT:$C$71="G",dBASE:$D$175,""))
COSTS:G103:   @IF(INPUT:$C*71="P",dBASE:$D$175*$G$44/100,@IF(INPUT:$C$71="G",dBASE:$D$175*$G$44/100,""))
COSTS:C104:   Staffing
COSTS:G104:   (INPUT:$C$227*INPUT:$C$234)+(INPUT:$C$228*INPUT:$C$235)+(INPUT:$C$229*INPUT:$C$236)+(INPUT:$C$230*INPU
              T:$C$237)+(INPUT:$C$231*INPUT:$C$238)
COSTS:C105:   Administration
COSTS:G105:   +dBASE:$D$177/100*@SUM($G$92..$G$104)
COSTS:C106:   Total p.a.
COSTS:G106:   @SUM($G$82..$G$105)
```

PROJECT COSTS - 2

```
COSTS:F57:   @IF(INPUT:$C$189="Y",dBASE:$F$149/100,@IF(@ISNUMBER(INPUT:$C$190),"Lump Sum",""))
COSTS:G57:   @IF(INPUT:$C$189="Y",dBASE:$F$149*$G$54/100,@IF(@ISNUMBER(INPUT:$C$190),INPUT:$C$190,""))
COSTS:C59:   Tools
COSTS:F59:   @IF(INPUT:$C$193="Y",dBASE:$F$150/100,@IF(@ISNUMBER(INPUT:$C$194),"Lump Sum",""))
COSTS:G59:   @IF(INPUT:$C$193="Y",dBASE:$F$150*$G$54/100,@IF(@ISNUMBER(INPUT:$C$194),INPUT:$C$194,""))
COSTS:C61:   Community Participation
COSTS:F61:   @IF(INPUT:$C$185="Y",dBASE:$F$151/100,@IF(@ISNUMBER(INPUT:$C$186),"Lump Sum",""))
COSTS:G61:   @IF(INPUT:$C$185="Y",dBASE:$F$151*$G$54/100,@IF(@ISNUMBER(INPUT:$C$186),INPUT:$C$186,""))
COSTS:C63:   Project Design
COSTS:F63:   @IF(INPUT:$C$173="Y",dBASE:$F$153/100,@IF(@ISNUMBER(INPUT:$C$174),"Lump Sum",""))
COSTS:G63:   @IF(INPUT:$C$173="Y",dBASE:$F$153*$G$54/100,@IF(@ISNUMBER(INPUT:$C$174),INPUT:$C$174,""))
COSTS:C65:   Project Supervision
COSTS:F65:   @IF(INPUT:$C$177="Y",dBASE:$F$154/100,@IF(@ISNUMBER(INPUT:$C$178),"Lump Sum",""))
COSTS:G65:   @IF(INPUT:$C$177="Y",dBASE:$F$154*$G$54/100,@IF(@ISNUMBER(INPUT:$C$178),INPUT:$C$178,""))
COSTS:C67:   Contingencies
COSTS:F67:   @IF(INPUT:$C$181="Y",dBASE:$F$155/100,@IF(@ISNUMBER(INPUT:$C$182),"Lump Sum",""))
COSTS:G67:   @IF(INPUT:$C$181="Y",dBASE:$F$155*$G$54/100,@IF(@ISNUMBER(INPUT:$C$182),INPUT:$C$182,""))
COSTS:C69:   Training
COSTS:F69:   @IF(INPUT:$C$197="Y",dBASE:$F$157/100,@IF(@ISNUMBER(INPUT:$C$198),"Lump Sum",""))
COSTS:G69:   @IF(INPUT:$C$197="Y",dBASE:$F$157*$G$54/100,@IF(@ISNUMBER(INPUT:$C$198),INPUT:$C$198,""))
COSTS:C71:   Community contribution
COSTS:F71:   @IF(INPUT:$C$169="Y",dBASE:$F$156/100,@IF(@ISNUMBER(INPUT:$C$170),"Lump Sum",""))
COSTS:G71:   @IF(INPUT:$C$169="Y",dBASE:$F$156*$G$54/100,@IF(@ISNUMBER(INPUT:$C$170),INPUT:$C$170,""))
COSTS:C73:   Project location adjustment
COSTS:G73:   (@SUM($G$54..$G$69)-$G$71)*(dBASE:$I$191-1)
COSTS:C75:   Cost adjustment
COSTS:G75:   @SUM(($G$54..$G$69)-$G$71)*(dBASE:$E$203-1)
COSTS:C77:   TOTAL COST
COSTS:G77:   @SUM($G$54..$G$69)-$G$71+$G$73+$G$75
COSTS:C81:   COST SHARING
COSTS:C82:   Government
COSTS:G82:   ($G$77*INPUT:$C$202/100)+INPUT:$C$203
COSTS:C83:   Other Agencies
COSTS:G83:   ($G$77*INPUT:$C$206/100)+INPUT:$C$207
COSTS:C84:   Grant
COSTS:G84:   ($G$77*INPUT:$C$210/100)+INPUT:$C$211
COSTS:C85:   Soft loan
COSTS:G85:   ($G$77*INPUT:$C$214/100)+INPUT:$C$215
COSTS:C86:   Commercial loan
COSTS:G86:   ($G$77*INPUT:$C$220/100)+INPUT:$C$215
COSTS:C90:   OPERATION & MAINTENANCE p.a.
COSTS:F90:   % of CAPEX
COSTS:C91:   Water source
COSTS:G91:   @SUM($G$92..$G$95)
COSTS:C92:     Borehole
COSTS:F92:   +dBASE:$D$162
COSTS:G92:   +$F$92/100*$G$28
COSTS:C93:     Spring
COSTS:F93:   +dBASE:$D$164
COSTS:G93:   +$F$93/100*$G$26
COSTS:C94:     Weir
COSTS:F94:   +dBASE:$D$165
COSTS:G94:   +$F$94/100*$G$24
COSTS:C95:     River or Lake Intake
COSTS:F95:   +dBASE:$D$166
COSTS:G95:   +$F$94/100*$G$20
COSTS:C97:     Well + Handpump
COSTS:F97:   +dBASE:$D$163
COSTS:G97:   +$F$97/100*$G$32
COSTS:C98:     Borehole + Handpump
COSTS:F98:   +dBASE:$D$162
COSTS:G98:   +$F$92/100*$G$30
COSTS:C100:  Reticulation
COSTS:F100:  @IF(INPUT:$C$71="P",dBASE:$D$167,@IF(INPUT:$C$71="G",dBASE:$D$167,""))
COSTS:G100:  @IF(INPUT:$C$71="P",dBASE:$D$167/100*($G$47+$G$49+$G$51),@IF(INPUT:$C$71="G",dBASE:$D$167/100*($G$47+
             $G$49+$G$51),""))
COSTS:C101:  Pipeline
COSTS:F101:  @IF(INPUT:$C$71="P",dBASE:$D$169,@IF(INPUT:$C$71="G",dBASE:$D$169,""))
COSTS:G101:  @IF(INPUT:$C$71="P",dBASE:$D$169/100*$G$37,@IF(INPUT:$C$71="G",dBASE:$D$169/100*$G$37,""))
```

PROJECT COSTS - 1

```
COSTS:C20:   Water Source Development
COSTS:G20:   +$G$22+$G$24+$G$26+$G$28+$G$30+$G$32
COSTS:C22:   River or Lake Intake
COSTS:D22:   kl/d
COSTS:E22:   +CALC:$G$101
COSTS:G22:   @IF($G$41=0,0,$G$41/8)
COSTS:C24:   Spring
COSTS:D24:   kl/d
COSTS:E24:   +CALC:$G$105
COSTS:F24:   @IF($E$24="","",dBASE:$C$101)
COSTS:G24:   @IF($E$24=""," ",$E$24*$F$24)
COSTS:C26:   Weir
COSTS:D26:   kl/d
COSTS:E26:   +CALC:$G$104
COSTS:F26:   @IF($E$26="","",dBASE:$C$100)
COSTS:G26:   @IF($E$26=""," ",$E$26*$F$26)
COSTS:C28:   Borehole for the scheme
COSTS:D28:   No
COSTS:E28:   +INPUT:$C$94
COSTS:F28:   @IF($E$28="","",dBASE:$I$113)
COSTS:G28:   @IF($E$28=""," ",$E$28*$F$28)
COSTS:C30:   Borehole + handpump
COSTS:D30:   No
COSTS:E30:   +INPUT:$C$106
COSTS:F30:   @IF($E$30="","",dBASE:$I$114)
COSTS:G30:   @IF($E$30=""," ",$E$30*$F$30)
COSTS:C32:   Well + handpump
COSTS:D32:   No
COSTS:E32:   +INPUT:$C$103
COSTS:F32:   @IF($E$32="","",dBASE:$C$99)
COSTS:G32:   @IF($E$32=""," ",$E$32*$F$32)
COSTS:C35:   Pipeline
COSTS:C36:   @IF(INPUT:$C$71="P",REPORT:$I$83,@IF(INPUT:$C$71="G",REPORT:$I$96," "))
COSTS:C37:   @IF(INPUT:$C$71="P",REPORT:$H$83,@IF(INPUT:$C$71="G",REPORT:$H$96," "))
COSTS:D37:   m
COSTS:E37:   @IF(INPUT:$C$71="P",REPORT:$H$86,@IF(INPUT:$C$71="G",REPORT:$H$98,""))
COSTS:F37:   @IF(INPUT:$C$71="P",dBASE:$C$69,@IF(INPUT:$C$71="G",dBASE:$D$69," "))
COSTS:G37:   @IF($E$37="","",$E$37*$F$37)
COSTS:C40:   Pumping Station
COSTS:D41:   @IF(INPUT:$C$127="E",CALC:$F$131,@IF(INPUT:$C$127="D",CALC:$H$131,""))
COSTS:E41:   @ROUND(@IF(INPUT:$C$127="E",REPORT:$H$79,@IF(INPUT:$C$127="D",REPORT:$I$79,"")),0)
COSTS:F41:   @IF(INPUT:$C$127="E",dBASE:$E$120,@IF(INPUT:$C$127="D",dBASE:$E$121,""))
COSTS:G41:   @IF($E$41="","",$E$41*$F$41)
COSTS:C43:   Storage
COSTS:C44:   @IF(REPORT:$H$106=" "," ",REPORT:$H$106)
COSTS:D44:   kl
COSTS:E44:   @IF(INPUT:$C$71="P",REPORT:$H$114,@IF(INPUT:$C$71="G",REPORT:$H$114,""))
COSTS:F44:   @IF($INPUT:$C$155="C",$dBASE:$H$91,@IF($INPUT:$C$155="S",$dBASE:$H$92,@IF($INPUT:$C$155="P",$dBASE:$
             H$93," ")))/$E$44
COSTS:G44:   @IF($INPUT:$C$155="C",$dBASE:$H$91,@IF($INPUT:$C$155="S",$dBASE:$H$92,@IF($INPUT:$C$155="P",$dBASE:$
             H$93," ")))
COSTS:C47:   House Connection
COSTS:D47:   No
COSTS:E47:   @IF(INPUT:$C$71="P",CALC:$G$91,@IF(INPUT:$C$71="G",CALC:$G$91,"NA"))
COSTS:F47:   @IF(INPUT:$C$71="P",dBASE:$J$129,@IF(INPUT:$C$71="G",dBASE:$J$129," "))
COSTS:G47:   @IF($E$47="","",$E$47*$F$47)
COSTS:C49:   Yard Connection
COSTS:D49:   No
COSTS:E49:   @IF(INPUT:$C$71="P",CALC:$G$93,@IF(INPUT:$C$71="G",CALC:$G$93,"NA"))
COSTS:F49:   @IF(INPUT:$C$71="P",dBASE:$J$130,@IF(INPUT:$C$71="G",dBASE:$J$130," "))
COSTS:G49:   @IF($E$49="","",$E$49*$F$49)
COSTS:C51:   Standpipe
COSTS:D51:   No
COSTS:E51:   @IF(INPUT:$C$71="P",CALC:$G$95,@IF(INPUT:$C$71="G",CALC:$G$95,"NA"))
COSTS:F51:   @IF(INPUT:$C$71="P",dBASE:$J$131,@IF(INPUT:$C$71="G",dBASE:$J$131," "))
COSTS:G51:   @IF($E$51="","",$E$51*$F$51)
COSTS:C54:   Construction Cost
COSTS:G54:   @SUM($G$22..$G$51)
COSTS:C57:   Office Equipment
```

PROJECT REPORT - 3

```
REPORT:C110:    Existing Capacity
REPORT:E110:    +CALC:$G$66
REPORT:H110:    @IF(INPUT:$C$110="Y",$E$110,0)
REPORT:C112:    Required Capacity
REPORT:E112:    +CALC:$G$66
REPORT:H112:    +CALC:$G$143
REPORT:C114:    Additional Capacity Required
REPORT:E114:    @IF($E$112>$E$110,$E$112-$E$110,0)
REPORT:H114:    @IF(INPUT:$C$110="Y",CALC:$G$144,CALC:$G$143)
REPORT:C116:    Capacity In Excess
REPORT:E116:    +CALC:$G$67
REPORT:C120:    Water Treatment
REPORT:C121:      Filtration - Surface Water
REPORT:H121:    @IF(INPUT:$C$132>11,"Yes","No")
REPORT:C122:      Filtration - Groundwater
REPORT:H122:    @IF(INPUT:$C$133>11,"Yes","No")
REPORT:C123:      Disinfection - Surface Water
REPORT:H123:    @IF(INPUT:$C$136>6,"Yes","No")
REPORT:C124:      Disinfection - Groundwater
REPORT:H124:    @IF(INPUT:$C$137>6,"Yes","No")
```

PROJECT REPORT - 2

```
REPORT:C64:    Water Source Development for Users NOT Served by the Scheme
REPORT:C65:    Demand
REPORT:H65:    +CALC:$G$111
REPORT:C66:    Boreholes
REPORT:G66:    +CALC:$F$112
REPORT:H66:    +CALC:$G$112
REPORT:C67:    Wells
REPORT:G67:    +CALC:$F$113
REPORT:H67:    +CALC:$G$113
REPORT:C68:    Total
REPORT:G68:    +CALC:$F$114
REPORT:H68:    +CALC:$G$114
REPORT:C71:    Pumping Scheme
REPORT:C73:    Pumping Requirement
REPORT:E73:    @IF(INPUT:$C$69="P",CALC:$G$51," ")
REPORT:F73:    @IF(INPUT:$C$69="P",CALC:$I$51," ")
REPORT:H73:    @IF(INPUT:$C$71="P",CALC:$G$130+$B$79," ")
REPORT:I73:    @IF(INPUT:$C$71="P",$H$73*1.2," ")
REPORT:C75:    Pumping Installed Capacity
REPORT:E75:    @IF(INPUT:$C$69="P",CALC:$G$52," ")
REPORT:F75:    @IF(INPUT:$C$69="P",CALC:$I$52," ")
REPORT:H75:    @IF(INPUT:$C$71="P",CALC:$G$127," ")
REPORT:I75:    @IF(INPUT:$C$71="P",CALC:$I$127," ")
REPORT:C77:    Pumping Capacity In Excess
REPORT:D77:    @IF(INPUT:$C$69="P",CALC:$F$53," ")
REPORT:E77:    @IF(INPUT:$C$69="P",CALC:$G$53," ")
REPORT:F77:    @IF(INPUT:$C$69="P",CALC:$I$53," ")
REPORT:C79:    Pumping to be Installed
REPORT:E79:    @IF($E$73<$E$75,0,@IF(INPUT:$C$69="P",$E$73-$E$75," "))
REPORT:F79:    @IF($F$73<$F$75,0,@IF(INPUT:$C$69="P",$F$73-$F$75," "))
REPORT:H79:    @IF(INPUT:$C$71="P",$H$73-$H$75," ")
REPORT:I79:    @IF(INPUT:$C$71="P",$I$73-$I$75," ")
REPORT:B81:    |::
REPORT:C83:    Pipeline Diameter and Material
REPORT:E83:    @IF(INPUT:$C$69="P",CALC:$G$41," ")
REPORT:F83:    @IF(INPUT:$C$69="P",INPUT:$C$154," ")
REPORT:H83:    @IF(INPUT:$C$71="P",CALC:$I$123," ")
REPORT:I83:    @IF(INPUT:$C$71="P",INPUT:$C$160," ")
REPORT:C85:    Pipeline length
REPORT:E85:    @IF(INPUT:$C$69="P",INPUT:$C$122," ")
REPORT:H85:    @IF(INPUT:$C$71="P",INPUT:$C$122," ")
REPORT:C87:    Actual Flow
REPORT:E87:    @IF(INPUT:$C$69="P",CALC:$G$44," ")
REPORT:H87:    @IF(INPUT:$C$71="P",CALC:$G$121," ")
REPORT:C89:    Pipeline Capacity
REPORT:E89:    @IF(INPUT:$C$69="P",CALC:$G$45," ")
REPORT:C91:    Pipeline Capacity In Excess
REPORT:D91:    @IF(INPUT:$C$69="P",CALC:$J$46," ")
REPORT:E91:    @IF(INPUT:$C$69="P",CALC:$G$46," ")
REPORT:C94:    Gravity Scheme
REPORT:C96:    Pipeline Diameter and Material
REPORT:E96:    @IF(INPUT:$C$69="G",CALC:$G$87," ")
REPORT:F96:    @IF(INPUT:$C$69="G",INPUT:$C$154," ")
REPORT:H96:    @IF(INPUT:$C$71="G",CALC:$I$130," ")
REPORT:I96:    @IF(INPUT:$C$71="G",INPUT:$C$160," ")
REPORT:C98:    Pipeline Length
REPORT:E98:    @IF(INPUT:$C$69="G",INPUT:$C$144," ")
REPORT:H98:    @IF(INPUT:$C$71="G",INPUT:$C$122," ")
REPORT:C100:   Actual Flow
REPORT:E100:   @IF(INPUT:$C$69="G",CALC:$G$60," ")
REPORT:H100:   @IF(INPUT:$C$71="G",CALC:$G$121," ")
REPORT:C102:   Pipeline Capacity
REPORT:E102:   @IF(INPUT:$C$69="G",CALC:$G$61," ")
REPORT:C104:   Pipeline Capacity In Excess
REPORT:D104:   @IF(INPUT:$C$69="G",CALC:$I$62," ")
REPORT:E104:   @IF(INPUT:$C$69="G",CALC:$G$62," ")
REPORT:C106:   Storage
REPORT:E106:   @IF(dBASE:$B$93=" "," ",dBASE:$B$93)
REPORT:H106:   @IF(dBASE:$B$92=" "," ",dBASE:$B$92)
```

PROJECT REPORT - 1

REPORT:C17:	Description
REPORT:D17:	Current Situation
REPORT:G17:	Proposed Project
REPORT:C20:	Population
REPORT:E20:	+CALC:$G$5
REPORT:H20:	+CALC:$G$78
REPORT:C22:	Growth Rate
REPORT:E22:	+CALC:$G$7
REPORT:C24:	Population Density
REPORT:E24:	+CALC:$G$13
REPORT:H24:	+CALC:$G$81
REPORT:C26:	Project Horizon
REPORT:H26:	+INPUT:$C$73
REPORT:C28:	Total Domestic Water Demand
REPORT:E28:	+CALC:$G$17
REPORT:H28:	+CALC:$G$83
REPORT:C30:	Scheme Water demand
REPORT:E30:	+CALC:$G$19
REPORT:H30:	+CALC:$G$87
REPORT:C32:	Other Water demand
REPORT:E32:	+CALC:$G$21
REPORT:H32:	+CALC:$G$85
REPORT:C34:	Total Demand
REPORT:E34:	+CALC:$G$23
REPORT:H34:	+CALC:$G$89
REPORT:C37:	Number of House connection
REPORT:E37:	+CALC:$G$25
REPORT:H37:	+CALC:$G$91
REPORT:C39:	Number of Yard taps
REPORT:E39:	+CALC:$G$27
REPORT:H39:	+CALC:$G$93
REPORT:C41:	Number of standpipes
REPORT:E41:	+CALC:$G$29
REPORT:H41:	+CALC:$G$95
REPORT:C43:	Number of handpumps
REPORT:E43:	+CALC:$G$31
REPORT:H43:	+CALC:$G$97
REPORT:C45:	Number of Water Points (f:min walking distance)
REPORT:H45:	+CALC:$G$98
REPORT:C48:	Water Source Capacity
REPORT:E48:	+CALC:$G$33
REPORT:H48:	+CALC:$G$107
REPORT:C50:	Water Source In Excess for Domestic Demand
REPORT:D50:	+CALC:$I$36
REPORT:E50:	+CALC:$G$36
REPORT:C52:	Water Source In Excess for Total Demand
REPORT:D52:	+CALC:$I$37
REPORT:E52:	+CALC:$G$37
REPORT:C54:	Water Source Development for Scheme Demand
REPORT:C55:	Demand
REPORT:E55:	+CALC:$G$19
REPORT:H55:	+CALC:$G$101
REPORT:C56:	Water Sources Availability
REPORT:H56:	+CALC:$G$107
REPORT:C57:	Boreholes
REPORT:G57:	+CALC:$E$103
REPORT:H57:	+CALC:$G$103
REPORT:C58:	Weir
REPORT:G58:	+CALC:$E$104
REPORT:H58:	+CALC:$G$104
REPORT:C59:	Spring
REPORT:G59:	+CALC:$E$105
REPORT:H59:	+CALC:$G$105
REPORT:C60:	River or Lake
REPORT:G60:	+CALC:$E$106
REPORT:H60:	+CALC:$G$106
REPORT:C61:	TOTAL
REPORT:G61:	@SUM($G$57..$G$60)
REPORT:H61:	@SUM($H$57..$H$60)

TECHNICAL CALCULATIONS - 4

CALC:B144: Storage to be constructed
CALC:G144: @IF($G$143-$G$142<0,0,$G$143-$G$142)

Author: Beete Nelson Hanry de Pena.
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