United Republic of Tanzania
Ministry of Water, Energy
and Minerals

Kingdom of the Netherlands
Ministry of Foreign Affairs
DGIS

Morogoro Domestic Water Supply Plan

Volume V

Water Supply Development

Final Report

August 1980

DHV

DHV Consulting Engineers

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PART E - WATER SUPPLY DEVELOPMENT

TABLE OF CONTENTS PAGE

TABLE OF CONTENTS (continued) PAGE

TABLE OF CONTENTS (continued) PAGE

Tables

Tables (continued) PAGE

Tables (continued) PAGE

Figures

<u>Figures</u> (continued) PAGE

ANNEXES

1. INTRODUCTION

1.1. General

At the beginning of 1977, following the "Administrative Arrangement" between the Governments of Tanzania and The Netherlands, the International Technical Assistance Department of the Ministry of Foreign Affairs of the Netherlands charged DHV Consulting Engineers with the execution of the Morogoro Domestic Water Supply Plan (MDWSP). The Tanzanian Government appointed the Ministry of Water, Energy and Minerals as executive authority for the implementation of the project.

The aim of the MDWSP was to study the possibilities for improvement of the rural water supply in the northern part of the Morogoro Region.
Carrying out a Domestic Water Supply Plan, instead of a Water Master Plan, implied that the study had to be focused on the supply of drinking water for the villagers only. During the discussion with the Tanzanian and Netherlands Governments on the determination of the Terms of Reference, the need was felt to incorporate an implementation component in the study. Based on information derived from earlier studies in the Morogoro Region it was decided to incorporate a drilling programme, for exploration and exploitation of deep ground water, in the survey.

A first report "Identification of the present conditions and problems of rural water supply in the northern part of Morogoro Region" was issued in December 1977.

In September 1978 a Progress Report was presented, dealing with the surveys and studies carried out during the period May - August 1978, and including the plan of operations of the team for the succeeding months.
A first review of available and collected data concerning existing water supply systems, water quality aspects, hydrology and hydrogeology was presented in the interim report, which was submitted in April 1979.

The domestic water supply plan is presented in this final report. The report consists of six volumes:

volume I	Main Report
volume II	Water Supply Conditions
volume III	Hydrology
volume IV	Hydrogeology
volume V	Water Supply Development
volume VI	Village Data Handbook.

1.2. Aim

The Terms of Reference of the MDWSP study call for the definition of village water supply development programmes for those villages in the survey area which experience serious problems in regard of their domestic water supply conditions. Such programmes should be based on detailed studies of existing water supply conditions, domestic water demand, and hydrological and hydrogeological conditions prevailing in the survey area.

2. APPROACH

2.1. Introduction

An inventory of the existing rural water supply facilities, in terms of the types of facilities, general quality, and population served, was carried out in 1977 by two of the Consultant's geographers. This geographical survey also included a demographical survey, and mapping of the (new) location of villages which had resulted from the national resettlement programme. Data from this survey are given in Part A (Volume II).

The water supply section started its activities on October 1st, 1978. As a first activity the data on the quality of the existing supplies were complemented with a survey of the physical-chemical and the bacteriological water quality. Furthermore a general appraisal of the technical quality of the improved water supply facilities was executed. Water demand studies were carried out on the basis of design water consumption figures and census data for population and livestock.
All studies and surveys reported above are described in Part B (Volume II).

This volume (Part E) comprises a comprehensive description of the current objectives, policies, and the present design and construction practice for the rural water supply sector. Alternative construction methods for water works structures are described, and costs estimates for various waterworks components are given.
The collection and processing of all relevant data has resulted in:

- a phased rural water supply development programme for the problem villages in the survey area with detailed estimates of time, manpower and financial resources required for its implementation and exploitation
- a concrete implementation programme aimed at the fullest possible realisation of the national targets, especially the short-term 1981 target, for the identified problem villages

A maximum incorporation of the locally available knowledge, experience and assets in the recommended development programmes has been the essence of the approach. The strategy followed to select problem areas, priority schemes and technical solutions constituted another important aspect of the general approach.

The approach is discussed in the following paragraphs. The actual procedures followed are discussed in Chapter E 3, and the water supply development programmes are described in Chapter E 4.

2.2. Data collection and evaluation

Data collection has been geared to an inventory of the current Government policies, and the Maji Department's methods, criteria and assets for the design and construction of rural water supply systems. Data were obtained from numerous publications such as Government and Maji documents, research papers from the University of Dar es Salaam (BRALUP) and International Agencies (WHO, World Bank), Water Master Plans of other Regions in Tanzania, and some earlier studies in the survey area. These publications are listed in the reference list in par. E 2.4.

The most relevant documents are briefly described below.

2.2.1. Earlier studies in the survey area and the rural water supply sector in Tanzania

Earlier studies relevant to the future water supply development in the survey area, include:

- Integrated Development Plan for Morogoro Region.
  Annex II: Water resources and development, DITH (Directorate for International Technical Assistance), the Netherlands, 1975;
- Rural water supply sector study, World Health Organization/World Bank Cooperative Programme, 1977.

The Integrated Development Plan suggests a phased implementation programme for some priority areas, and includes estimates of the capital and recurrent costs involved for each year of the third five-year plan development period.
During the last three years, prices for water supply facilities have continued to rise, and the resettlement programme has had a significant impact on the location and size of villages. Therefore the suggestions and estimates mentioned above are merely to be considered as a first indication of the works to be done and budgets to be secured.

The "Rural water supply sector study" contains a tremendous amount of information on Government aims, institutional arrangements, constraints in resources and organisation, and a cost evaluation of rural water supply facilities. It has been consulted frequently during the execution of this study.

2.2.2. General description of the rural water supply sector

The present study is part of the Government's efforts to speed up the development of the rural water supply sector, in strong support of its villagization programme which was virtually completed in 1977. Tanzania has formulated its own national targets for domestic water supply to rural dwellers. These targets are comparable to, but more advanced than, the rural water supply targets which were formulated during the Habitat Conference in Vancouver (1977).

This study was aimed to operate within the general framework of the national targets and the current development programmes geared towards the attainment of these targets. Paragraph E 3.1 describes in greater detail issues related to the targets and development programmes. It contains a summary of the objectives of the third five-year development plan [4], the budget allocations for capital expenditures in that period [4] and the annual budgets and votes for recurrent expenditures in Morogoro Region for the period 1978/1979 [5,6]. The ministerial organization and the institutional arrangements are also described [2,7].

Full attention should also be given to the various constraints in rural water supply programmes which hamper the implementation and future developments. These constraints occur particularly in the fields of productivity, operation and maintenance, man-power requirements and financial resources [2,7]. See par. E 3.1.

2.2.3. Design criteria and construction methods for improved water supply systems

The design criteria and construction methods currently applied by the Maji Department were obtained from Ministerial Notes [8,9], technical documentation, and standard drawings of elements of water supply systems [7]. Furthermore, numerous discussions were held with engineers and technicians of both the Regional Maji Office in Morogoro and the Maji Headquarters in Dar es Salaam. The data obtained will be discussed briefly below and more comprehensively in par. E 3.2.

The approach towards design criteria for East-African countries, in the period 1969 - 1971, is described by Warner in a BRALUP publication, entitled "Design criteria for Water Supply Systems in East-Africa", [10]. Another document which highlights the various design criteria for rural water supply in East-African conditions is a publication by the Research and Training Division of the Ministry of Water Development and Power, containing the lecture notes of Lundman [11].
In February 1975, the Ministry issued a manual entitled "A Note on Design of Water Supply Projects" [8], which contains the currently applied design criteria.

The Ministerial design parameters and guidelines for the design of domestic water supply systems are mainly geared to the attainment of the 1991 targets. The Note does not contain guidelines for the introduction of phased levels of service to accommodate the 1981 targets, e.g. a gradual and phased reduction of the walking distance to a suitable water source, or a gradual reduction of the number of consumers depending on one water source. The lack of such directives may explain why in most cases the distribution components of existing piped water supply systems already comply with the 1991 targets.
The budgets consumed by such "relatively advanced" distribution systems cause financial constraints to the attainment of the 1981 targets in other problem areas.

The Consultant has in principle adopted the Maji design criteria, but has introduced some alterations whenever this was required for phased implementation programmes which allow for an optimum realisation of the 1981 targets without obstructing the further development towards the 1991 targets.

The construction elements involved in the Maji-built water supply systems in the survey area are:

- shallow wells, with or without a hand pump or a suction line for an engine-driven pump as part of a piped water supply
- boreholes, complete with casings, screens and water lifting equipment
- water intake structures for gravity supplies
- pumphouses, complete with pumps and engines
- transmission and distribution works, including storage tanks and domestic water points

During the last 10 - 15 years, various water supply components have been largely standardized. The data obtained on current construction methods are listed below and will be discussed more comprehensively in par. E 3.2.

Shallow wells

Shallow wells are nowadays constructed in blockwork and have a diameter of 2.4 m (8 ft). This shallow well is normally fed by bottom recharge; its constructional details are described on Maji Drawing No. HQ 488. In earlier days shallow wells were also made with precast reinforced concrete rings. These wells, with a diameter of 4 ft and a recharge from the bottom are no longer constructed, however, due to the low recharge rate.

Boreholes

The Maji Department has percussion and rotary drilling rigs at its disposal for the construction of deep boreholes. In general these rigs are in poor condition. The average footage per rig/year in the period 1974/1975 was reported to be 1740 ft for rotary rigs and 363 ft for percussion rigs. The most frequently used rigs are the Schramm rotary rig and the Ruston Bucyrus percussion rig. The RWE of Morogoro Region has two Ruston Bucyrus (22 W) percussion rigs at his disposal.

The procedures and techniques followed for the exploitation of newly drilled boreholes are of low standard, and this may explain why a large percentage of boreholes are taken out of operation relatively soon after construction. Data on borehole construction in the survey area during the last decennia were obtained from the files of the Regional Maji Office in Morogoro and the Geophysics and Exploration Section at Dodoma. A detailed description of existing boreholes is given in Part D, Hydrogeology (Volume IV).

Other water intake structures

Water intake structures for gravity water supply systems from rivers, streams and springs are normally tailor made, and no standard drawings exist for these construction works. Small dams, the major intake works for gravity supplies from rivers and streams, are constructed of masonry or reinforced concrete. Spring locations are developed and protected by means of blockwork structures.

Pumphouses and pumping equipment

Pumphouses are constructed in blockwork in a simple rectangular shape of 4 m x 6 m or 4 m x 3 m. Two types of pumphouses have been standardized, one for boreholes, Maji Drawing No. TY/ST/34/2, and one for pumped supplies from rivers or shallow wells, Maji Drawing No. TY/ST/49.

Various types of pumps and engines have been installed during the past decennium. The wide range in manufacture and quality is mainly caused by lack of standardization, tendering procedures and conditions of bilateral aid programmes. An inventory of the installed equipment was made on the basis of data in the Maji - Morogoro files and field visits to several improved water supplies.

Recently the Maji headquarters (Maintenance Unit) has been making a great effort to standardize a selection of pumps and engines, but this procedure has not yet been finalized.

The variation in hand pumps is rather limited. Some older shallow wells are equipped with the locally manufactured "Ubungo" hand pump, whereas the more recently constructed shallow wells are provided with the Kenyan made Intersigma pump.

Transmission and distribution works

Instructions and data on pipework are contained in a document of the Maji Department's Supply division [12]. This document describes a great deal of standardization on selection of pipe material, pipeline design, application of fittings and valves. The appendices to the document contain data on the prices of piping materials from Kurasini stores.

Storage reservoirs are standardized for capacities from 22.5 m^3 to 337.5 m^3 (5,000 to 75,000 G). The tanks are circular with reinforced concrete bottom and top slabs and blockwork walls. For capacities ranging between 22.5 m^3 and 135 m^3 (5,000 - 30,000 G) designs are available for ground level tanks or elevated tanks (e.g. on a 20 ft raiser). Larger tanks are constructed as ground level tanks.
The constructional drawings of storage tanks available are summarized in Table E 2.2-1.

Table E 2.2-1 Inventory of Maji Standard drawings for Storage tanks

capacity		Drawing No.			
5,000 G	22.5 m^3	TY/TA/7	(ground level);	TY/TA/56	(elevated level)
10,000 G	45 m^3	TY/TA/12	" ;	TY/TA/39/a	"
20,000 G	90 m^3	TY/TA/13	" ;	TY/TA/40	"
30,000 G	135 m^3	TY/TA/14	" ;	TY/TA/41	"
50,000 G	225 m^3	TY/TA/46	" ;	-	
75,000 G	337.5 m^3	TY/TA/44	" ;	-	

The Ministry has also standardized the design of the public water taps. Three types of so-called domestic water points are available, with the codes IA, IB and IC. Their constructional details are given in the Maji Drawing No. TY/WS/23.

Standardization has been carried out on some other constructional elements, such as cattle troughs. Standard drawings exist for two types of cattle troughs, viz. the short cattle trough, Drawing No. TY/TA/5, and the long cattle trough, Drawing No. TY/TA/6. Such cattle troughs may be part of a piped water supply.

2.2.4. Cost criteria

A first review of the costs of rural water supply systems in Tanzania was produced by BRALUP in 1974 [13]. Other documents which provide useful data on this subject are Regional Water Master Plans [14, 15], the Shallow Wells Handbook of the Shinyanga Shallow Wells Project [16], and the Rural Water Supply Sector Study [2].

The evaluation of these estimates suffers from the lack of data on the breakdown in cost components, and the lack of information about what is included in the cost estimates.

The estimates obtained describe price levels in different periods. Some comparative price analyses using data such as the consumer indices and price increases of some major items involved in rural water supply schemes (pipes, cement, transport) were carried out, to allow for the extrapolation of these figures to the 1978 price level. Such data were collected from the Bureau of Statistics in Dar-es-Salaam.

Other methods used to estimate the present costs of waterworks include cost analyses of newly designed and costed schemes for future implementation. Furthermore, some local contractors were requested to quote for a number of the standardized waterworks components.

Cost estimates for the various structural aspects involved in rural water supply schemes are given comprehensive consideration in par. E 3.3.
The adopted cost estimates have been used to calculate unit costs of typical rural water supply schemes, and total costs of schemes proposed for implementation.

2.2.5. Water resources in the survey area

The feasibility of future water supply projects is mainly determined by the relation between the water resources potential and the domestic water demand.

The water demand studies were described in Part B. The water resources potential and water quality surveys were described in Parts C and D.

Paragraph E 3.4 will process these data within the context of future rural water supply programmes.

2.3. Proposed strategy for future domestic water supply development

The Consultant is required to produce rather detailed short-term implementation programmes for problem villages, on the basis of the outcomes of the water demand and the water resources potential studies.
The set up of such recommendations requires a clear-cut strategy which will serve as a general guideline in all stages of the project execution.

The strategy selected by the Consultant is focused on the following five aspects:

1. The water quality/water quantity dilemma:

In most, if not in all, low-income communities in hot climates infections which are non-waterborne, faecal-oral or water-washed will be major causes of morbidity and mortality. These disease problems will respond to improvements in water quantity, accessibility and reliability and therefore these improvements should always be a major aim of the design of new water supplies [3].
Water treatment is always preferable when the raw water source does not provide clear water or is not protected against the risk of pollution. However, water treatment plants are often expensive and difficult to maintain and to operate. In situations where treatment is deemed to be infeasible owing to financial or maintenance constraints, a choice must be made between supplying water without treatment or abandoning plans for supply from that particular source.

2. Standardization:

Whereas urban water supply systems are generally characterized by a tailor-made design to achieve the greatest practicable efficiency within the project, for designs of rural water supplies it is considered legitimate - indeed in many cases desirable - to sacrifice some degree of efficiency within a particular project in favour of a general standard design which is applicable to various situations in rural areas and may contribute to a more effective working of the rural programme as a whole. Design must be based on simply but rapid and effective construction techniques, such as repetitive work by relatively unskilled artizans, pre-fabrication, standardized equipment and similar devices. Unit designing constitutes an almost essential feature of any such programme. The savings in planning and supervision costs by building village water supply systems for several communities with comparable conditions (e.g. water source, population, topography) to a single design plan will almost certainly outweigh any slight inefficiency of such a design.
It is possible to devise a very simple investigation which will enable a sanitarian to collect in a day or less sufficient basic information to classify a village project as suitable for a certain type of design.
Finally, it should be noted that standardization is not on all occasions the optimal solution to rural water supply design operations. Standardization may be contradictory to elements of appropriate technologies which are available and suitable in a particular area and sufficient allowance should be given to incorporate such appropriate technology methods in the standard designs.

The Ministry has standardized several unit elements of rural waterworks, such as pumphouses, storage tanks, and domestic water points. Extensive experience has been gathered with these standard elements, and they therefore will be fully incorporated in the future development programmes to be set up by the Consultant.

3. Planning stages:

Improved water supplies are normally constructed in one single phase for a design period of 20 years. In other words, schemes which are implemented have an over-capacity of about 100% and consume considerable amounts of capital and man-power which could have been allocated to other problem areas. The attainment of the Government's objectives puts a heavy burden on resources of money, man-power and administrative capacity that can be made available, and there should be no stone left unturned in the effort to arrive at an optimum allocation of these resources.
The Consultant has opted for a division of future programmes into three more or less distinct phases of which phase one and part of phase two fit into the Consultant's assignment to design short term improvements programmes for problem villages.

Phase one: crash programme and source development

Emphasis is put on source development, i.e. development of shallow wells, boreholes, pumped and gravity water supplies up to a level that water is conveyed to a point at a reasonable distance from the village. For the piped systems this phase includes a pumphouse, transmission main and storage tank for a design period of 20 years.
Distribution works are limited to an absolute minimum, e.g. a communal water distribution facility with a number of taps, located close to the storage tank for a design period of 10 years.

Phase two: extension or scheme development

Emphasis is put on scheme development, i.e. up-grading of the basic facilities provided in phase one up to a level which makes the waterworks comply with the long-term targets.
This phase will primarily involve the construction of more shallow wells with handpump, or, for piped water supplies, the development of distribution systems, so as to provide domestic water points within an average walking distance of 400 m (in accordance with the 1991 targets).
Alternative sources, such as boreholes, and piped water supply systems from nearby suitable river intakes, can be developed for larger villages and for common water supply system to a group of villages (e.g. gravity schemes).

Phase three: water treatment

Once all villages are provided with a water supply system which has sufficient standards in quantity, accessibility and reliability, available resources can be allocated to essential water quality improvements. Suitable water treatment techniques for rural water supplies include storage, plain sedimentation and chemical disinfection. More advanced treatment techniques are flocculation/ coagulation and sand filtration. Slow sand filtration is an especially suitable technique, as it combines physical, chemical and bacteriological improvements of the raw water or pre-treated water. Although it involves rather complicated purification mechanisms, slow sand filtration allows for relatively simple operation and maintenance operations at low recurrent costs, provided a suitable design has been made and no extensive pre-treatment is necessary.

4. Resources:

Resources of money, manpower and administrative capacity are seriously limiting factors for a large scale implementation of the required water supply programmes. The budget allocation to the survey area for the third five year development plan does not offer much room for a rural water supply development which approaches the Government's targets. It is however most likely that foreign donors will assist the Goverment with financial and manpower resources. The future programmes, as recommended by the Consultant, have therefore been focused on the full implementation of the national targets.

5. General

The analysis of data regarding water resources potential, water demand and present water supply conditions has revealed two types of problem areas:

- areas were resources are underdeveloped
- areas were resources are very limited

Once the problem areas had been coded in accordance with the typology described above, a start could be made with the development of recommendations for the short-term and long-term improvement of the domestic water supply facilities.

In areas where the resources are underdeveloped, a comparative technical and economic evaluation of various alternative solutions was carried out, using data on the water resources potential, the various technical systems and the cost estimates of these technical systems.

In areas were resources are very limited, a choice had to be made between alternative recommendations such as installation of a very expensive system, provision of a system which is not in accordance with the current policies in domestic water supply development or resettlement of the village at a more suitable location.

Another important topic was the rehabilitation and extension of existing schemes. Recommended programmes have been subject to criteria such as the present level of service in relation to the general policies and the costs involved.

The outcomes of this strategy is discussed in detail in par. E 3.4 and in Chapter E 4.

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3. DATA COLLECTION AND EVALUATION

3.1. General description of the rural water supply sector

The MDWSP study is part of the Government's efforts to speed up the development of the rural water supply sector, in strong support of its villagization programme which was virtually completed in 1977.
The national objectives, current programmes and constraints in the rural water supply sector will each have a direct impact on the methodology and outcome of the present survey.

3.1.1. Government objectives and current development programmes

The Tanzanian Government has established the following objectives for the development of the rural water supply sector:

- to provide a source of clean, potable and dependable water within a reasonable distance of every village by 1981 as a free basic service
- to provide a reliable water supply with clean potable water to the rural areas by 1991, so that all people will have ease of access (i.e a distance of 400 m) to a public domestic water point. This supply should preferably consist of a piped system with communal water points, but a shallow well with handpump also complies with the requirements.

The short-term objective allows rather subjective interpretation of the types of facilities which should be catered for. Sometimes the "reasonable" distance mentioned in the 1981 target is defined at some 4 km, but this largely depends on the geographical, hydrological and hydrogeological conditions of the area. The current practice in internationally sponsored crash-programmes, which are undertaken to relieve the immediate needs for water supply in less favoured areas and villages, is to adopt a walking distance of 1.5 km (1 mile) to the newly constructed water sources. Examples of such programmes are the Shallow Wells Construction Projects in Shinyanga, Lindi - Mtwara and Morogoro.

The majority of the villages in the survey area comply with the 1981 target as far as the distance of 4 km to the water source is concerned, but there is a lot of room for improvement in regard to the qualifications clean, potable and dependable.
Within the identified problem areas the 1981 target is still far away, and improvements will have to be focused on the criteria of dependibility (quality of the water source, water availability, and reliability), and reasonable walking distance (accessibility).

The long term objective has undergone some changes in recent years. Originally it was contemplated to provide the rural areas with piped water supplies by the year 1991, but later the objective was adjusted to the formulation given above [7]. The inclusion of shallow wells with handpumps in the technical solutions which comply with the long term objective considerably increases the feasibility of the implementation of this objective.

Rural water supply development programmes are divided into national and regional components. Programmes are established for an annual or five year planning period.
The Government has formulated the following general guidelines for the development of the rural water supply sector during the Third Five Year Development Plan Period (1976 - 1981):

- village water supply systems should consist of small and simple schemes, at low costs;
- various methods of water collection should be used, e.g. rainwater harvesting and charcos;
  Suitable water lifting devices are hand pumps and wind mills.
- the development of water sources in the villages should be such that by 1981 all villages are provided with at least one dependable water source;
- the village water supply programme is not primarily aimed at piped water. First of all, water should be made available at places where there is shortage of water. Methods to be used are construction of shallow wells, and diversions from rivers and dams using a gravity transmission system;
- water for livestock and irrigation should be collected from rainwater reservoirs which are constructed by small dams. The villagers should be assisted with technical expertise to carry out such programmes [4].

The Consultant would like to comment on a few items out of these guidelines. First of all, the implementation of a dependable water source for each and every village may put a heavy burden on the national and regional budgets for rural water supply development programmes during the Third Five Year Development Plan Period. Situations will occur were villages can only be supplied with a dependable water source at rather elevated costs, e.g. a pumped water supply with a transmission main length of some 10 km. For small villages such solution will require high investment costs per capita, and it then deserves serious consideration to study the alternative of re-settlement of the village at a more suitable location in regard of water resources potential.
The Consultant is aware of the psychological, sociological, and possibly political problems this may cause, but in terms of a proper allocation of financial resources it is considered appropriate to fully analyse alternative solutions.

Another issue is cattle watering. Some areas of the Morogoro Region, e.g. the North-Western Part of Kilosa District, practise extensive stock herding programmes. More and more villages apply for cattle troughs as part of an improved water supply system.
Cattle watering by means of rainwater reservoirs may be rather difficult if the annual precipitation or topographical conditions are not favourable, and such solutions may be more expensive than an extension to an improved piped water supply system. The Consultant suggests including such considerations in the future development programmes for rural water supply facilities. The eventual decision whether or not to provide a village with cattle watering facilities connected to a piped supply, should be based on considerations of costs and water potential.

3.1.2. Budget allocations and current Maji implementations programmes

Budget allocations can be distinguished in development budgets and recurrent budgets for both the national and regional levels. Development budgets are used to finance the implementation of new water supply programmes. The recurrent budgets cover the regular staff (managerial, technical, administrative) and labour force for the day to day running of the Maji Departments, and include the costs of operation and maintenance of implemented programmes.

The budget allocations to the water supply sector for development expenditure in Morogoro Region during the Third Five Year Development Period are summarized in Table E 3.1-1. The table also mentions the total Government budget for the Morogoro Region in that period.

Table E 3.1-1 Budget allocations to the water supply sector for development expenditure in the Morogoro Region during the Third Five Year Development Plan Period

Budget items	TShs
Rural water supply	11,138,000
Urban water supply	6,660,000
Total budget for water supply	17,798,000
Total budget for Morogoro Region	121,831,000

Source: [4]

About 15% of the total Government budget for the Morogoro Region will be allocated to water supply. Rural water supply will obtain 9%, and urban water supply 6%.

The budget estimates for annual development and recurrent expenditure to the domestic water supply sector in the Morogoro Region, for the period 1976 - 1980, are summarized in Table E 3.1-2.
The figures given are the provisional actual expenditure for 1976/1977, revised estimates for 1977/1978, estimates for 1978/1979, and tentative projections for 1979/1980.

Table E 3.1-2 Budget estimates for annual development and recurrent expenditure to the domestic water supply sector in the Morogoro Region for the period 1976/1980

	Estimated budgets (TShs)			Estimated allocation (TShs)
	1976/77	1977/78	1978/79	1979/80
Development expenditure				
- rural	1,859,073	2,155,000	3,090,000	
- urban	485,353	800,000	1,100,000	
Recurrent expenditure				
- rural	2,067,710	4,320,000	4,242,900	5,447,400
- urban	1,164,283	2,019,900	1,921,500	3,070,600
Total expenditure for water supply	5,576,419	9,294,900	10,354,400	8,518,000
Total development expenditure		18,280,000	27,175,000	
Total recurrent expenditure	73,057,447	98,674,173	102,808,300	111,306,300
Total expenditure for Morogoro Region	-	116,954,173	129,983,300	-

Source: United Republic of Tanzania, Public expenditure supply votes [6]

From Table E 3.1-2 it can be concluded that for the period 1978/1979 the total estimated budget for water supply amounts to 8% of the total development and recurrent budgets voted for the Morogoro Region. The allocation to rural water supply is 6%, and that to urban water supply 2%. The distribution between development budget and recurrent budget for rural water supply amounts to 42% and 58% respectively for the period 1978/1979.
For the budget year 1978/79, the RWE'S governmental budget for water supply development projects in Morogoro Region amounts to Tshs 4,190,000. The distribution is as follows: Tshs 1,350,000 for Morogoro District, Tshs 650,000 for Kilosa District, Tshs 1,100,000 for Kilombero District, Tshs 890,000 for Ulanga District, and Tshs 200,000 for surveys and investigations.

The table does not include estimates for the development and recurrent expenditure financed by the national budgets, e.g. the Morogoro Wells Construction Project (estimated development budget of TShs 32,000,000 for the period 1978/1980, mainly financed by the Government of The Netherlands), and the Mindu Dam project for urban water supply provision to Morogoro Town and its industrial area (estimated development budget of TShs 200,000,000 for the period 1978/1980, mainly financed by the World Bank).

Budgets for development expenditure may also be obtained from other sources. Capital expenditure for projects most likely to be sponsored by UNICEF, CDTF, and the Britain-Tanzania Society amount to TShs 2.4 million. See Table E 3.1-3. The donations from UNICEF only cover the material costs of the projects (about 60% of the total investment costs).

Table E 3.1-3 Summary of development projects, in the survey area, sponsored by various institutions.

Projects	Recipient	Source of Finance or Donation		Estimated costs (Tshs)
Morogoro Wells Constr. Progr.	Villages in the Morogoro Region	The Netherlands	D	32,000,000
Mindu Dam project incl. treatment works	Morogoro town, and its industrial area	World Bank	F	200,000,000
Gravity supply schemes	- Konga/Vikenge, Sangasanga	UNICEF	D	606,000
	- Misongeni	UNICEF	D	405,000
Shallow Wells with handpumps	Lubungo, Milengwelengwe Kunke, Madudu, Mamoyo, Mwasa, Magomeni, Ulaya, Nyali	CDTF	D	128,950*
Pumped supply schemes:				
- surface water	Kibati	UNICEF	D	1,107,000
	Lukobe	B.T.S.	D	553,000
- borehole	Chanzuru	UNICEF	D	770,000

* Vote

The implementation programme contemplated by the RWE'S office for the budget year 1978/79 includes the following projects in the survey area:

- Melela water supply: completion of the construction programme which was started in 1976. Surveys are underway for the construction of a borehole to replace the existing water sources (two shallow wells).
- Kibati water supply: construction of a piped water supply from a shallow well. Part of the materials have been purchased, but construction has not started yet.
- Mkuyuni water supply: construction of a piped water supply from a shallow well. Project has not started yet.
- Water supply for Ulaya village and Mnaga sugar factory: Construction of a piped water supply from River Miyombo. The project has not started yet, and it may be transferred to the national programme.
- Muhenda/Ilakala water supply: construction of a piped water supply from a shallow well. Project not yet started, as the Vote on the 1978/79 budget has been withdrawn.

- Shallow Well Programme: construction of one shallow well with handpump in the villages Kidudwe, Luale, Doma, Msongozi, Mikese, Muhenda, Ilakala, Nyali, Magomeni and Manzeze (part of Kilosa township). The shallow wells in Muhenda, Ilakala, Nyali, and Magomeni have not been constructed yet.
  Two additional shallow wells were constructed in Madoto, due to the regular cholera outbreaks in that village.

The budget for surveys and investigations, amounting to Tshs 200,000, is being mainly spent on the topographical survey for the proposed "Kitange" gravity scheme. This scheme is aimed at providing some 50 villages and subvillages in the Gairo and Mamboya divisions with a gravity piped water supply using the Kitange river as water source. The Consultant attributes a very low feasibility to the scheme as the low flows of the sources are far too small to cater for the supply area. Moreover, part of the projected supply area can be provided with considerably cheaper water supply systems (See Chapter 4).

At present, the budget proposals for the budget year 1979/80 are under discussion at the Treasury, and still require approval by Parliament. The tentative implementation programme proposed by the RWE'S office in Morogoro Region includes for the survey area:

- Melela water supply: construction of a borehole to serve as a water source for the existing water supply.
  The hydrogeological survey of the Consultant indicates that no suitable sites for borehole construction may be expected in the whole Melela area. It is recommended to improve the existing shallow well structures, and to replace the pumping units by smaller units (See also subpar. B 3.1.3.).
- Mkuyuni water supply: construction of phase 1 of the proposed piped water supply, consisting of intake well, pumphouse, storage tank and some rudimentary distribution facilities.
- Mikese water supply: construction of a pumphouse at the newly constructed borehole, and some replacements of pipes in the existing transmission and distribution lines.
- Mbamba water supply: construction of a borehole for a future piped water supply.

The construction of shallow wells has not been included in the proposed programmes for the budget year 1979/80, as the Morogoro Wells Construction Project will take care of this type of water supply.

In recent years the design section of the Project Preparation Division of the RWE'S office in Morogoro has completed various designs of piped water supplies for villages in the survey area. The majority of these designs has not been implemented due to lack of financial resources. An inventory of the designs which were completed during the years 1977 and 1978 is given in Table E 3.1-4.

The Consultant is of the opinion that for several villages the solution applied in the completed designs has not been the least costly. Various villages listed in the table have suitable hydrogeological conditions for

Table E 3.1-4 Inventory of designs of the RWE'S design section during the years 1977 and 1978 (for survey area)

Village	Year of Design	Design capacity (l/s)	Technical Description of Design	Estimated costs (Tshs)	Present status of project/remarks
Chanzuru	1977	2.74	BH + 0.3 km + SED (5.4 km)	770,000	BH completed; UNICEF financing
Magole	1977	1.88	BH + 0.77 km + SED (2.2 km)	500,000	BH completed; reservoir under construction
Malolo	1977	2.88	SWP + 1.53 km + SED (3.2 km)	659,000	not constructed (lack of funds)
Kiduhi	1977	10.5	RSWP + 9.1 km + (SRD)[1])	981,000	completed in 1978; [1]) existing
Matuli	1977	5.25	SWP + 1.32 km + SED (6.7 km)	994,000	not constructed (lack of funds)
Mkulazi, Chanyumbu	1977	1.46	RSWP + 9.6 km + SED (6.9 km)	1,450,000	not constructed (lack of funds)
Mzembe	1977	1.15	RSWP + 8.9 km + SED (2.6 km)	874,000	not constructed (lack of funds)
Melela	1976/77	13.81	SWP + 3.25 km + SED (17.9 km)	1,988,000	constructed completed
Kidunda	1977	1.30	RSWP + 0.12 km + SED (1.3 km)	490,000	not constructed (lack of funds)
Kisungusi gravity scheme	1977	23.79	G + TSED (240 km)	27,300,000	not constructed (lack of funds)
Konga/Vikenge, Sangasanga	1978	1.75	G + TSED (1.5 km)	606,000	not started; UNICEF finance
Dakawa Wami, Luhindo	1978	3.78	BH + 4.6 km + SED (2.9 km)	820,000	not constructed (lack of funds)
Kibati	1978	7.60	SWP + TSED (9.3 km)	1,107,000	project started; UNICEF finance
Lukobe	1976/78	0.70	RSWP + 6.6 km + SED	553,000	not started; B.T.S. finance
Misongeni	1978	1.17	G + TSED (5.6 km)	405,000	under construction; UNICEF finance
Mikese	1978	3.76	BH + TSED (4.5 km)	540,000	BH completed; on 1979/80 budget
Tungi	1978		RD (1 km) from Sisal estate[2])	62,000	completed; [2]) temporary system
Mkonowamara	1978	1.41	RSWP + TSED (1.9 km)	390,000	not constructed (lack of funds)
Ulaya, Mnaga sugar estate	1978	18.66	RSWP + TSED (22.1km)	2,180,000	not constructed; Vote deferred
Dumila	1978	3.00	BH + TSED (7.3 km)	760,000	BH completed; lack of funds
Muhenda, Ilakala	1978	7.21	SWP + TSED (26.4 km)	2,670,000	not constructed (lack of funds)
Msowero	1978	0.58	BH + 0.9 km + (SRD)[3])	141,000	BH completed; [3]) existing

LEGEND : BH = borehole ; RSWP = pumped supply from riverside well
ED = extensive distribution system ; S = storage tank
G = Gravity ; SWP = pumped supply from shallow well
RD = rudimentary distribution system ; T = transmission main
BH + 0.3 km + SED (5.4 km): borehole with transmission main of 0.3 km, storage tank and extensive distribution system with distribution lines of 5.4 km length in total

the constructions of shallow wells with handpumps. This water supply system complies with both the 1981 and 1991 targets, and should therefore be considered as an alternative to the proposed piped water supply systems. This issue is discussed in more detail in paragraph E 3.4.

3.1.3. The organization of the Maji Department and institutional arrangements

In 1972 the responsibilities of the Ministries were regionally decentralized and the direct control of the majority of the rural and urban water supply programmes was handed over to the regional authorities. From 1975 the Ministry of Water, Energy and Minerals has been the principal Government agency responsible for the domestic water supply sector.
Annual development programmes are divided into national and regional components. Maji Headquarters plays a principal role in the planning of the national programme, but is not necessarily formally involved in the planning of regional programmes, which evolve from the village level by way of the District and Regional Administrations, and the Prime Minister's Office.

The highest officer for the Maji Department is the Principal Secretary who is directly responsible to the Minister for Water, Energy and Minerals. The Maji Department is divided into four divisions, and four units. The divisions are responsible for activities closely related with water development, i.e. programme and man-power planning, construction, operation and maintenance etc. They are split up into a number of different sections. The units deal with administrative and financial matters.

The following divisions, sections, and units exist:

- the project preparation division.
  This division is split up into the hydrological section, the geological section, the geophysical section, the project research section and the design section.
  The division is headed by the Commissioner of project planning.
- the construction and maintenance division.
  This division is divided into a construction section and a maintenance section. The division is headed by the Commissioner for construction and maintenance.
- the supply division
- the planning division
- the manpower development division
- the internal audit unit
- the finance unit
- the Administrative Unit

A similar organization structure has been set up at regional level. Some of the divisions, sections, or units mentioned above are combined in new groups, or are represented by the Regional Water Engineer (RWE).
Figure E 3.1-1 shows the current organization structure of the Regional Maji Department in Morogoro Region.

In 1978, the total number of employees of the Morogoro Maji Department amounted to 435 persons. The designation of the employees is given in Table E 3.1-5.

Table E 3.1-5 Designation of employees of Maji Department, Morogoro Region

	RWE'S Office	Morogoro District	Kilosa District	Kilombero District	Ulanga District	Total
Regional Water Engineer	1	-	-	-	-	1
District Water Engineer	-	1	1	1	1	4
Planning and Project Preparation Division:						
- hydrology	12	-	-	-	-	12
- hydrogeology	5	-	-	-	-	5
- surveying	22	-	2	2	-	26
- design	4	-	-	-	-	4
- drawing office	18	-	-	-	-	18
Construction Division	37	6	8	7	9	67
Finance Unit	7	1	4	2	1	15
Aministration Unit	8	2	11	1	7	29
Urban Water supply	69	9	23	12	15	128
Regional Maintenance Unit	49	14	38	12	13	126
Total Enrolment	231	33	87	37	46	435

All construction works involved in domestic water supply systems are accomplished under the responsibility of the Regional Water Engineer (RWE). This functional manager has to report to the Principal Secretary on all matters and deals directly with regional and district officials on matters in their respective areas. The RWEs are not responsible for the construction works carried out by rotary drilling rigs and heavy dam construction units, which come under the direct supervision of Maji Headquarters as part of the national development programme.
This national programme includes projects which cover more than one Region, large projects which would effect the even distribution of funds within the Regions, and projects which utilize heavy equipment. Staff engaged in the construction of national projects are normally directly employed and controlled by Regional Water Engineers, with the exception of drilling and dam construction unit crews who are attached to Maji Headquarters. The labour force of shallow wells construction programmes, e.g. Shinyanga Shallow Wells Programme and Morogoro Wells Construction Project, is formally not employed or controlled by the RWE, but he may be given the task of representing Maji Headquarters in such matters.

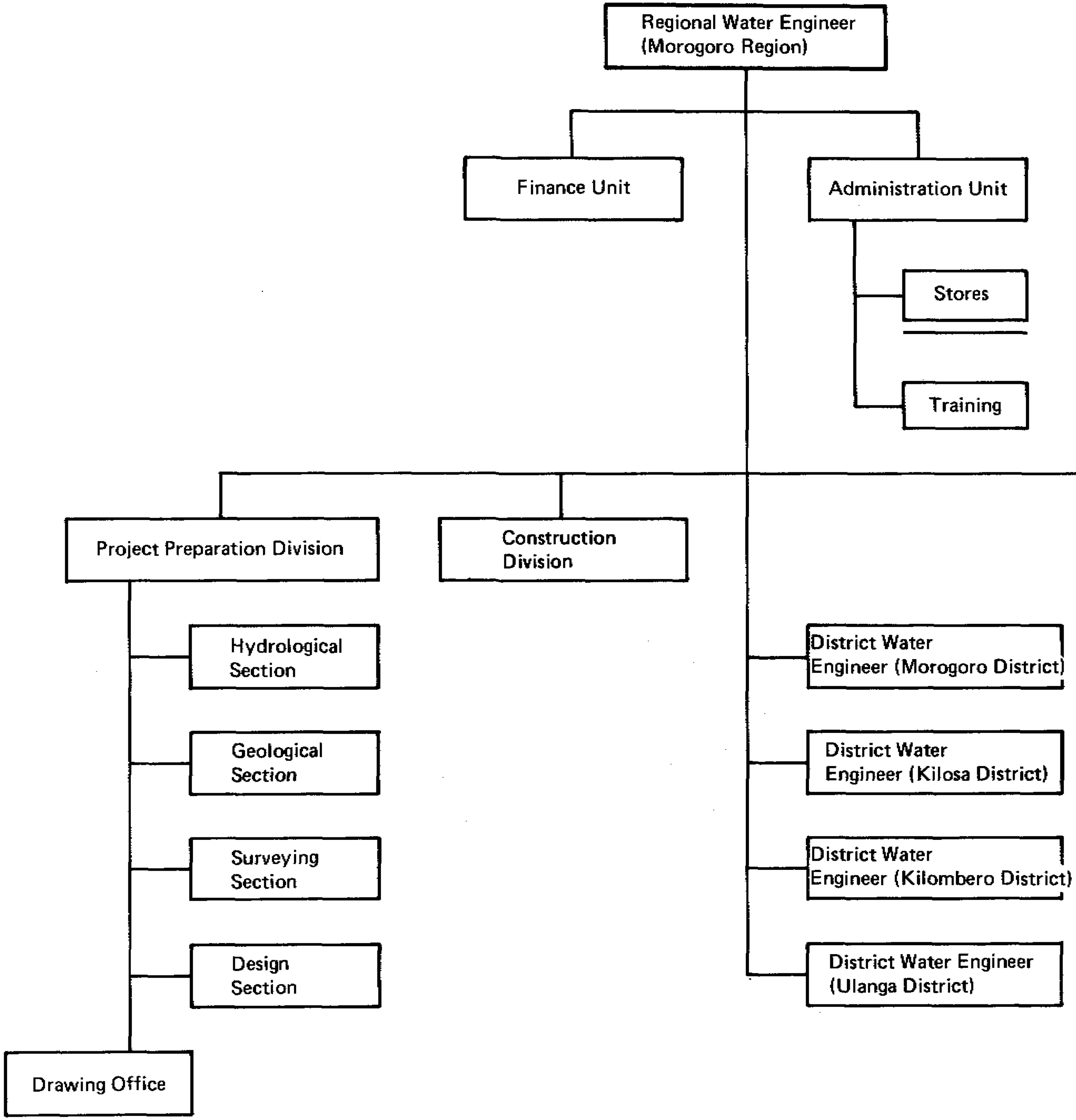


Figure E 3.1–1

Organization of Maji Department Morgoro Region

Regional Water Engineers are technically responsible for the operation and maintenance of schemes completed by them. Recurrent funds for operation and maintenance are issued by the Ministry of Finance and Planning (Treasury) to the Regional and District Administrations (RDDs and DDDs) as the accounting officers. Funds are not allocated to the RWEs but they are advised of a Vote by the accounting officer who is responsible for the actual payment of expenses incurred by the RWE.

One of the other institutions which takes initiative in rural water supply is the Ministry of Agriculture, which organizes the provision of watering points along stock routes and so contributes to water supply for domestic purposes. Furthermore, the Prime Minister's Office and the Community Development Trust Fund (CDTF) both provide funds on a limited scale at the regional level for the development or improvement of village supplies.

3.1.4. Problems and constraints in the rural water supply sector

It is estimated that at present in Tanzania a total of some 5 million people or approximately one third of the present rural population can be considered to have access to acceptable water supply facilities. In other words, a tremendous amount of work remains to be done to attain of the 1981 target.

One of the main constraints in the development of the rural water supply sector is the present level of Maji output. This output falls far short of that required to meet the official target of providing every village with an adequate water supply by 1981. The Rural Water Supply Sector Study of WHO/IBRD [2] reported that in the period 1975/1976 outputs on the national level were just about keeping pace with the annual population growth rate of about 0.4 million. During that period, new schemes having a design population of some 0.5 million but serving a present population of slightly more than 0.3 million were constructed by the Maji Department. In the sector paper it was stated that on the national level new schemes should be constructed at a rate to serve some 2 million people per annum, after allowing for population growth, if the 1981 targets are to be reached.

For the survey area the number of rural dwellers who have, at present, access to an acceptable water source (1981 targets), are estimated at some 325,000 or about 55% of the total rural population. From this group only 110,000 people or 20% of the total rural population are served with an improved water supply.
In the period 1975 up to and including 1977, Maji Morogoro has constructed improved water supplies for some 27,000 people in the survey area, or about 9,000 people annually.
The average annual population increase of the 232,000 rural dwellers, having no access to an acceptable water source, amounts to about 7,000 people. In other words the total implementation capacity of the present programme can just keep pace with the population increase, and in fact no significant improvements are being made. If the people in the less favoured areas are to be provided with a water source in accordance with the 1981 targets, a construction programme should be drawn up for new schemes at a rate to serve some 84,000 people per annum.

The construction capacity required for such a programme is tenfold the present capacity.

Another serious problem area is the operation and maintenance sector.
A considerable number of supplies in the survey area are not operating at all or subject to temporary standstills because of the inadequate provision of manpower, or of operation and maintenance funds. Lack of spares and/or fuel are very often the cause of such standstills.

Finally, it is obvious that the available development and recurrent budgets (See Tables E 3.1-1 and E 3.1-2) are by far too small to fulfil the financial resources requirements imposed by the 1981 and 1991 targets. Estimates of cost aspects of implementation programmes aimed at the realization of the 1981 targets in the survey area are discussed in subpar. E 4.4.4.

In Tanzania, domestic water supply is considered to be a basic commodity, which should be available free of charge for those who make use of communal facilities. Therefore, in general, no funds are generated at the village level to support operation and maintenance activities, although efforts are being made to stimulate villages to cater for their own waterworks operators.
It is estimated that the funds required to operate and maintain existing improved schemes in the survey area in a satisfactory manner amount to about TShs 2,500,000 annually, which is about 30% more than the 1978/1979 allocation of some TShs 1,900,000 for the Morogoro Region as a whole. Assuming that 65% of this budget is allocated to schemes in the survey area, the estimated budget requirements demand a 100% increase of the budget allocation to schemes in the survey area.

3.2. Design criteria and construction method of rural water supply systems

This paragraph discusses in more detail the design criteria and construction methods followed by the Ministry. It contains comments by the Consultant on the current practice, and suggestions for alternative design and construction procedures.
These suggestions aim at an improvement of the quality of the waterworks, or application of procedures more appropriate for the implementation of the short-term and long-term Government policy.

3.2.1. Design criteria

The design criteria contained in the Ministerial Note [8] and the Consultant's suggestions for alterations and additions are summarized in Table E 3.2-1.
Some further comments on the design criteria by the Consultant are listed below:

- it is clearly a Government policy to formulate a criterion for water allowance per head instead of water demand per head. This is done within the context of water resources management and financial implications of water development programmes. This criterion for a maximum daily water allowance makes a criterion for a peak factor between the maximum daily demand and the average daily demand superfluous (must be equal to 1, in accordance with the policy)

- an allowance for losses due to leakage and wastage is not mentioned in the design criteria of the Maji Department. The Consultant suggests that for such losses an allowance of 25% of the total amount of water distributed should be incorporated in designs for piped water supplies. Similar allowances are nowadays adopted in other regions in Tanzania e.g. Kilimanjaro Region.
- the design period is subject to a number of factors such as financial resources, investment criteria as part of phased implementation programmes, demographical considerations, etc. The Consultant's suggestions are based on the assumption that funds and technical assistance from bilateral or multilateral aid programmes will be made available for the development of the major components of the waterworks. Additional provisions, such as extensions of distribution systems, require fewer technical and financial imputs and could be carried out by the regional authorities in phased programmes
- gravity water supply systems with long transmission mains may require above-standard diameters of the transmission lines to arrive at appropriate hydraulic conditions in respect of friction losses. However, as a consequence flowrates will be below the standard values normally adopted, which may cause unwelcome sedimentation of suspended matter, and subsequent clogging of pipes. If the topography of the area requires such a transmission system, special attention should be given to the design of the intake works.
  The intake structure should prevent any sand and coarse suspended matter from entering the transmission system. See also subpar. E 3.2.2.1.
- water treatment is a very valuable contribution to the overall improvement of water supply facilities. It is, however, suggested to limit such activities to a minimum during the coming decennium, e.g. disinfection should only be considered for those supplies which provide water to a community of more than 5000 people.
  The relation between water supply and health has already been discussed in Part B, and it may be concluded that the available budgets should preferably be spent on the improvement of the availability and reliability of water supplies rather than increase of the water quality. Budgets and manpower should be allocated to programmes aimed at the gradual increase of water quality only after sufficient dependable water sources have been made available in all problem areas.

3.2.2. Construction works

This paragraph describes in some detail the construction works which are included in the standardization programme of the Ministry. Comments are given on the various units, and where appropriate, alternative solutions are described.

Table E 3.2-1 Design criteria for rural water supply systems

Items	Design criteria Maji Department (1975)		Design criteria MDWSP-project (1978)
Water allowance per day:	Present	Future	
population	10 GPD (45 l/c/d)	30 l/c/d (6.67 GPD)	30 l/c/d
school: pupils	5 GPD (22.5 l/c/d)	22.5 l/c/d (5 GPD)	5 l/c/d
staff	10 GPD (45 l/c/d)	30 l/c/d (6.67 GPD)	30 l/c/d
dispensary: patients	10 GPD (45 l/c/d)	30 l/c/d (6.67 GPD)	30 l/c/d
staff	10 GPD (45 l/c/d)	30 l/c/d (6.67 GPD)	30 l/c/d
Livestock (1 livestock-unit)	5 GPD (22.5 l/L.U/d)	22.5 l/L.U/d (5 GPD)	22.5 l/L.U/d
Allowance for water losses due to leakage and wastage:	None		25% of water carried through distribution system
Maximum demands:			
maximum hourly demand	4x average hourly demand		4x average hourly demand
maximum daily demand	-		-
Design Period:			
shallow wells with handpump	-		5 years
piped water supplies	20 years		20 years, for all works except distribution lines and domestic water points, which are implemented in phased programmes (phase I, design period 10 years)

Table E 3.2-1 Design criteria for rural water supply systems (continued)

Items	Design criteria Maji Department (1975)	Design criteria MDWSP-project (1978)
Design Population: yearly population growth rate	2.7%	2.7%
Special assumptions for population increase in areas with piped water supply systems	50% increase after 10 years 100% increase after 20 years	50% increase after 10 years 100% increase 20 years
Livestock increase	25% increase after 10 years 50% increase after 20 years	25% increase after 10 years 50% increase after 20 years
Pumping Schedule:	Variable between 8 - 12 hours	Boreholes, shallow wells and riverside wells (or other surface water intake structures): 12 hours 3 a.m. - 9 a.m. 12 a.m. - 6 p.m.
Utilization of gravity supply mains:	24 hours/day	24 hours/day
Storage capacity:	in general about 50% of daily demand	if Q = daily demand (m^3) then storage capacity = Q/2 for gravity supply Q/4 for boreholes, shallow wells, and riverside wells (or other surface water systems)
Pressure in pipelines:		
Transmission lines		
maximum	50% of test pressure	50% of test pressure
minimum	-	10 m.w.h.
Distribution lines		
maximum	-	50% of test pressure
minimum	6 m.w.h.	3 m.w.h.

Table E 3.2-1 Design criteria for rural water supply systems (concluded)

Items	Design criteria Maji Department (1975)	Design criteria MDWSP-project (1978)
Pipe diameter:		
Transmission		
maximum	200 mm (8")	400 mm (16")
minimum	50 mm (2")	40 mm (1½")
Distribution		
maximum	-	-
minimum	12.5 mm (½")	25 mm (1")
Velocities in pipes:	0.9 - 1.8 m/s	0.3 - 2 m/s
Number of people per water supply point:		
- shallow wells with handpump	-	250
- domestic water points of a piped water supply	200	250

3.2.2.1. Water source structures

The Ministry has standardized water source structures for shallow wells, riverside wells, and boreholes. Intake structures for springs, gravity supplies and pumped supplies from rivers are designed individually.

Shallow wells

Nowadays shallow wells are entirely constructed of blockwork. They are circular with a diameter of 2.4 m (8 ft) and a wall thickness of 0.15 m (6 in). The blockwork wall is supported by a tapered reinforced concrete foundation ring, and constructed stepwise during the well sinking process. These lined shallow wells are constructed by continuously digging out the inner part of the circular wall, down to the bottom of the aquifer. After completion of the well digging, a layer of 0.15 m (6") coarse graded gravel (0.5" - 1.5") is cast below the foundation ring. The recharge of the well normally takes place through the bottom of the well, unless the transmissivity of the aquifer is low, in which case some openings in the blockwork wall will be provided. These 2" x 2" openings are screened with wiremesh.
Such shallow wells are constructed up to a maximum depth of 10.7 m (35 ft). Petroldriven pumping units are used to keep the well dry during the construction process. After completion of the construction works, the well may be equipped with a handpump. Nowadays, Intersigma pumps (types 3, 4 and 5), with yields between 0.2 and 0.5 l/s are being installed. Some older shallow wells are equipped with the locally made "Ubungo" handpump, which has a similar yield. Wells of a similar type may also serve as intake wells for a pumped water supply.

The construction of a shallow well is carried out by a group of about 10 people, 3 of whom are Maji-employees, the others being daily paid labourers from the village.

Although such shallow wells may serve their purpose, they are not considered very suitable for a highly productive crash programme aimed at providing problem villages with sufficient water sources by the year 1981. The construction period may last from 4 to 8 months, and during the last year only 6 of these shallow wells were constructed in the survey area.

The Consultant has had extensive experience in Tanzania with the construction of shallow wells in the Shinyanga Shallow Wells Project. At present a similar project is being conducted in the Morogoro Region, again as part of the Dutch bilateral aid programme. Initially, this "Morogoro Wells Construction Project" aims at the construction of some 550 shallow wells in the Morogoro Region, and it is anticipated that double this amount may be required in the survey area. (See Chapter E 4).
Some layouts of shallow wells constructed in the projects mentioned above, are given in Figure E 3.2-1.
The figure represents typical cross-sections of a hand dug well and a hand-drilled well. The hand-dug well has a diameter of 1.25 m and is made of prefabricated concrete rings. Special porous filter rings are provided in the aquifer zone. The well rings are extended some distance below the aquifer to provide storage for periods of low recharge.

Hand-drilled wells are constructed by means of special drilling tools such as riverside, stone, screw, and combination bits. The shallow boreholes have a diameter of 0.3 m, and are provided with a PVC-casing of 0.15 m, which contains slots in the aquifer zone. Suitable gravelpack and seals allow easy entrance of aquifer water into the well.
Hand-drilled wells may be constructed to a depth of about 15 m, and have some advantages over dug wells:

- dewatering the pit is not necessary, thus saving on time, pumps, etc.
- water pressure inside the borehole can be maintained, reducing the danger of caving in or washing out of the aquifer into the borehole
- drilling generally takes less time than excavation by hand

On the other hand, a drilled well will have a much smaller diameter than a dug well and thus hardly possess any storage capacity. Thus the transmissivity of the aquifer should meet certain minimum requirements.
Hand-dug wells allow an easier penetration of hard layers by means of chisel and hammer, or motor-driven jack hammers. Therefore, if hard layers are encountered during the surveying, hand drilling should be replaced by hand digging, or otherwise by hand-operated light duty motor-powered drills, and small rotary or percussion rigs. In both the projects mentioned, the Mobile Drills B 30 S and B 80 are used for this purpose.

Experience has taught that on the average some 20 shallow wells can be constructed monthly. Hand-drilled shallow wells are constructed if aquifer conditions provide yields of $1m^3/h$ or more. At less favourable aquifer conditions, hand-dug wells are a more appropriate solution.

The shallow wells are equipped with a so-called "Shinyanga pump" or "Kangaroo pump", both of which are constructed locally in Shinyanga and in Morogoro, except for the pump cylinder which is still a Dutch product.

Shallow wells with high yields may in future serve as intake wells for a pumped water supply. Shallow wells located in the river bed should preferably be of the hand-dug type. Along the river bed either hand-dug or hand-drilled shallow wells may be used, depending on the yield required and the recharge.

Boreholes

The Regional Maji Office in Morogoro has two Ruston Bucyrus 22 W percussion drilling rigs at its disposal for the construction of deep boreholes. Each of the rigs has a permanent crew of 6 people, and some additional labourers are recruited from the village where drilling takes place.
The boreholes have a diameter of 0.3 m, and normally 6" or 8" steel pipes are applied for casing and screens. The screens are made by cutting 0.3 m x 0.01 m slots in the steel pipes. The gravelpack normally consists of crushed stones of various diameters (1¼" - 1"). After completion of a borehole a pump test is carried out during a period of 24 hours.
From 1950 onwards some 102 boreholes have been constructed in the survey area, or about 4 each year. Percussion rigs were used for about 98% of these boreholes. In the last 5 years some 20 boreholes were constructed with the use of the two Ruston percussion rigs. Average construction time amounts to some three months, but in some cases may take up to six months.

The Maji boreholes have a relatively short lifetime. Many boreholes are abandoned a few years after construction. The reasons for this are an increase of salinity or a decrease of yield due to clogging. The former may be attributed to poor siting activities, the latter to the construction techniques applied. It is observed that the standard of construction techniques used by the Maji Department is not sufficient to ensure a successful borehole operation over a reasonable period of time.
The main shortcomings are:

- the gravelpack is very coarse and consists of sharp and irregular crushed stones. Such material has very poor filtering and screening characteristics. Small sand particles will be able to penetrate deeply and subsequently clog the filter bed
- the screen is manufactured by cutting slots in ordinary casing pipes. This results in a low inflow area per metre of pipe length (<4%) and most likely in poor hydraulic conditions in the gravelpack. The combination of these types of gravelpack and slotted casing pipes makes it most likely that the slots themselves will get clogged by sand particles. Moreover, the slotted steel pipes are very susceptible to incrustation

The Terms of Reference of the MDWSP-Project included a 5,000 ft drilling programme, and the Consultant started this drilling in September, 1978. The drilling sites were selected on the basis of a comprehensive geo-electrical survey which was part of the hydrogeological studies. The programme aimed at exploration as well as exploitation, in other words successful boreholes

were completed so as to serve as an intake for a pumped water supply. The boreholes were drilled with a Schramm TH 64 B rotary rig, which had been made available to the Consultant by Maji Headquarters as part of the administrative agreement between the Governments of Tanzania and The Netherlands. During the period September 1978 - March 1979, some 3,840 ft were drilled. Eight out of seventeen drillings at eleven locations were successful and these boreholes have been completed for exploitation purposes.
The casing material and screens applied have a diameter of 0.15 m (6") and consist of steel and galvanised steel respectively. They were purchased from the Maji Drilling section in Dodoma. The Consultant would have preferred to install stainless steel screens (6") because of the rather elevated aggressivity of the deep groundwater, but such screens were not available in Tanzania.
Much attention has been paid to the proper selection of gravelpack. Natural rounded fine gravel from certain river beds was selected by means of graded sieves. The gravelpack used had diameters between 2 - 3.2 mm.
The pump-test yields varied between 1 - 12 l/s, allowing for a water supply to about 1,000 - 12,000 people, with only limited drawdowns.

The drilling programme has shown that rotary drilling is a very suitable technique in the survey area. The average period required for the production of one exploitation borehole amounted to about 2½ weeks. This can easily be reduced to 2 weeks if all equipment is in good condition. More details about the drilling programme and the prospects for medium depth and deep ground water can be found in Part D, Hydrogeology (Volume IV).

Other water intake structures

The survey area contains some gravity water supply systems which are fed by springs, or streams and rivers at elevated height.
Springs are normally protected by means of blockwork walls and reinforced concrete slabs. Small dams constructed in rivers or streams to create a small intake reservoir for a gravity piped water supply system, are either made of reinforced concrete or of masonry work with natural stones. The reservoir normally contains a wash-out, an overflow, and a small sandtrap with a screened inlet for the transmission main. Only a few sandtraps are provided with a wash-out.

The Consultant has observed that in most cases the intake reservoirs are completely filled with sediment, and that no regular flushings or cleaning of intake reservoirs and sandtraps are carried out. This may seriously reduce the inflow rate of the gravity system, and hence cause water shortage in the supply area. On the other hand, the sediment in the intake reservoir may occasionally form a suitable filter bed, so that the quality of the water is considerably improved before it enters the inlet to the transmission main.
It is not very likely, however, that deposits built up from the natural sediment load of a river will comply with the technical requirements, in terms of grain size and uniformity coefficient, of an appropriate filter bed. The river sediment will include small clay particles which will be

built in between the interstices of larger particles and subsequently clog the natural deposit layer. To function soundly, filter beds for such water intake structures should be manmade and comply with specific filter bed characteristics (see below).

Some of the Consultant's suggestions for the design and construction of river intake structures in regard to conditions prevailing in the survey area will be discussed below. Reference is made to various technical publications which deal with similar subjects [18, 19, 20, 21].

Water intake structures for surface water supplies, both gravity systems and pumped systems, have to be constructed in such a way that the capacity required can be withdrawn under all flow conditions.
On the one hand the intake structures may not be washed away at high flows, on the other hand inflow rates and construction levels have to be considered very carefully so that the withdrawal capacity can be guaranteed even at low flows of the river or stream.
Another essential design criterion is the prevention of sediment entering the transmission systems.

No standard construction details are available or can be given because in each situation many other crucial factors may be present, such as the relation low flow - maximum flow, flow velocities and bottom slope, water quality (suspended solids), soil properties of the river bed and the type of supply (gravity or pumped). Some intake structures are briefly described below:

- river bed and river bank infiltration systems

In cases where sandy or gravelly river beds and river banks as well as sufficient aquifer thickness are available, the system shown in Figure E 3.2-2 can be applied.

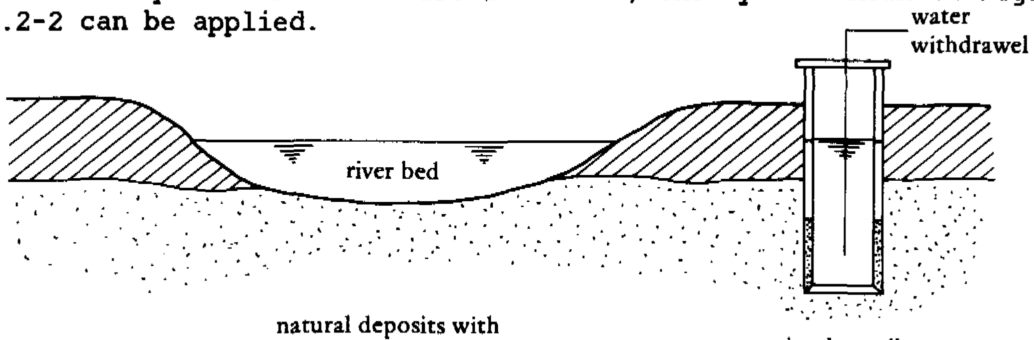


Figure E 3.2-2 Infiltration well along river bed.

The well consists of one or more solid well rings, and one or two filter-rings. Infiltration wells in the river bed should be of a rigid construction and located at a place where the least hydraulic forces of the river may be expected e.g. a shallow inner bend of the river.
Systems which require elevated withdrawal capacities should be provided with two or more infiltration wells. In each and every case the number of infiltration wells and the spacing between the wells has to be based on site investigations, including pump tests and recharge measurements.

- rivers and streams without suitable alluvial deposits

For small rivers and streams having a low sediment load an intake structure can be designed which makes use of a similar but artificial infiltration system. A low weir is constructed over the full width of the river or stream, and the small reservoir upstream of the weir is filled with selected filter material which is supported by a graded underdrainage layer of coarse sand and gravel. Part of the river water percolates through the filter medium and is withdrawn by means of perforated pipes which are buried horizontally in the underdrainage layer. The design of the reservoir should be such that the free flow of the river limits the sedimentation of suspended matter upstream of the weir. The filter material may be anchored by a cover of medium duty wiremesh to prevent it from being washed out during peak flow conditions. See Figure E 3.2-3.

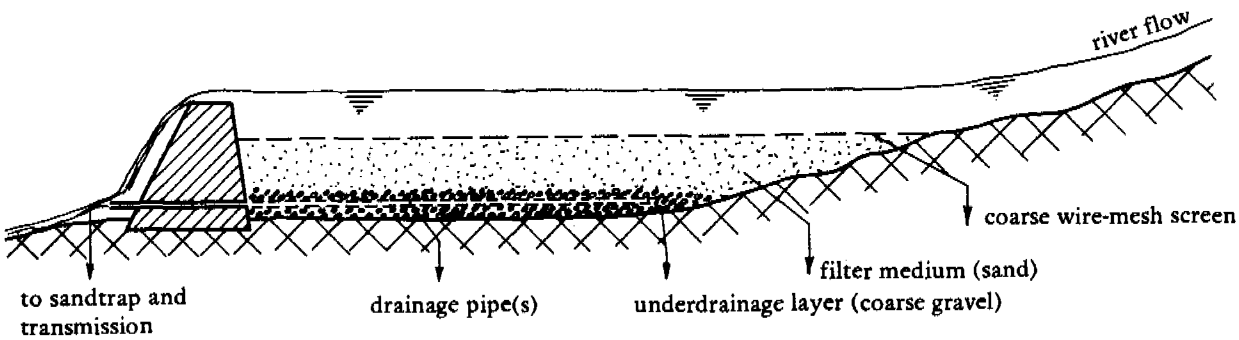


Figure E 3.2-3 Intake structure for surface water withdrawal.

The perforated pipes in the underdrainage system are connected to a main outlet which conveys the water into a sandtrap with overflow to the pump sump or the inlet to the gravity transmission main.
Regular operation and maintenance activities include the removal of sediment and organic matter (due to biological growth) from the reservoir and the sandtrap.
The system is not recommended for rivers with a high sediment load. In such cases, it is appropriate to withdraw the water directly from the river and subject it to a conventional treatment process such as plain sedimentation (see subpar. E 3.2-3).

Another system which may be applied for intake structures is the "Cansdale" filter box [22]. The filter box is buried in a suitable alluvial deposit, under the bed of a river or stream (see Figure E 3.2-4). Under certain conditions also a manmade sandy bed in a quiet zone of the river may be applied for this purpose.
The system consists basically of a reinforced box with a slotted plate in it. The slots in the plate are specially made to taper towards the outside to prevent them from clogging with silt as water enters from below. When

the filter has been buried, heavy pumping is then used to build up a graded bed of soil underneath it. It then works in a way similar to an infiltration gallery when an ordinary pump is fitted.
This kind of device can be used permanantly under a stream bed, but if used under a body of still water such as a dam or a lake, there is danger that the bed may become clogged from time to time, so that the filter has to be moved to another position. If installed under a briskly flowing stream, it may get washed out after heavy rain, and appropriate precautions should be taken to prevent this.

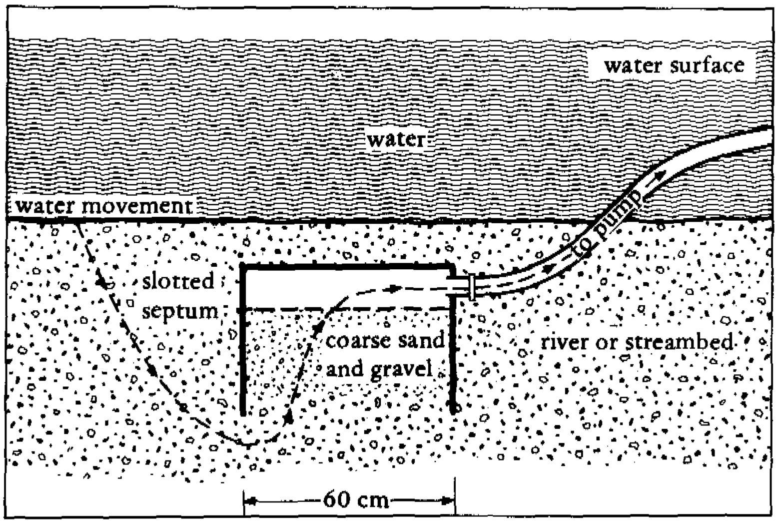


Figure E 3.2-4 Cansdale filtration unit

Special attention is to be given to the intake structure for gravity water supplies. It has been mentioned earlier that topographical conditions may require oversized pipe diameters to keep the friction losses below certain limits. Such oversized pipe diameters will result in relatively low velocities in the transmission main which may aggravate the deposit of suspended matter. Clogging will then occur sooner or later, especially if the capacity of the water source or the topographical conditions do not allow adequate flushing in essential stretches of the transmission main. Some intake structures for surface water withdrawal have been discussed above and are also applicable to gravity water supply systems. In case none of these alternatives are selected due to technical or financial objections than at least a sandtrap should be constructed at the inlet of the transmission main. This sandtrap should be designed for a horizontal flowrate not exceeding 0.15 m/s, have a length of at least 4 m, a length to width ratio not less than 4 and a depth not less than 1 m. A surface loading of 20 m/h is acceptable for such a sandtrap.

Springs in the survey area can possibly be improved and produce a higher yield if the outflow area is enlarged. This will decrease the effect of material which tends to prevent the free outflow of the water. Attention should be paid to the protection of a sufficiently large area around the well against surface pollution by waste products of human and animal origin. A typical technical layout for spring exploitation is given in Figure E 3.2-5.

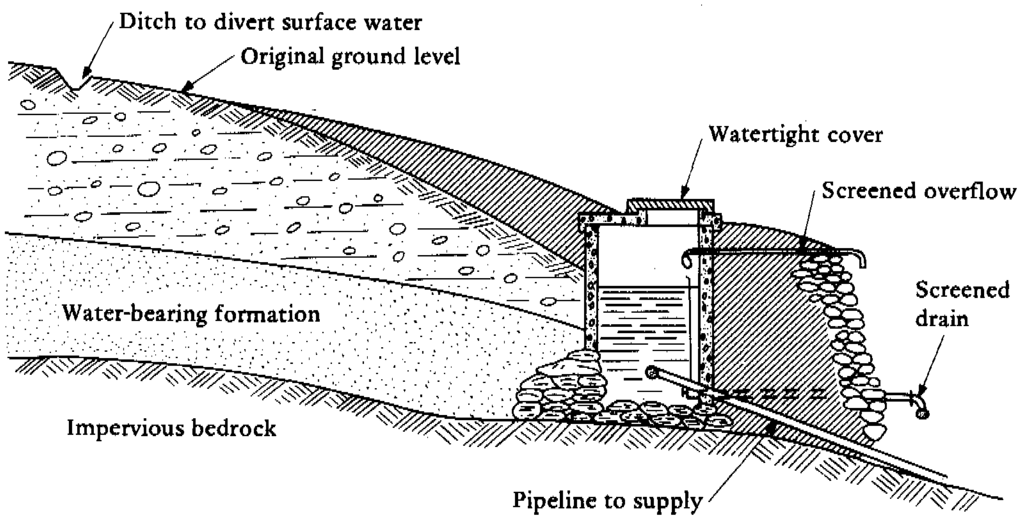


Figure E 3.2-5 Typical layout for spring development (after ref. 3)

3.2.2.2. Water transmission and distribution

Water transmission and distribution works include pumphouses and pumping equipment, pipelines, storage reservoirs and domestic water points.
The Ministry has standardized several of these items, and the Consultant considers most of the designs to be quite suitable for their purpose.

Pumphouse and pumping equipment

The Ministry has standardized two types of pumphouses, one for boreholes (Drawing No. TY/ST/34/2) and one for other pumped supplies (Drawing No. TY/ST/49).
The buildings are rectangular, the sizes being 4 x 3 m for the borehole pumphouse, and 4 x 6 m for the general duty pumphouse. The walls are blockwork structures and all frames, including the roof trusses, are made of wood. Corrugated iron sheets serve as roofing material. The concrete floor is supported by a layer of hardcore and contains special foundation slabs for the pumping units.

Pumping units (engine/pump) present in the survey area comprise those summarized in Table E 3.2-2.

Table E 3.2-2 Pumping units applied in the survey area at present

General Duty	Lister/KSB Kiloskar/Mather & Platt Bukh/Grundfos	Lister/Climax Lister/Godwin
Borehole-units	Lister/Mono Lombardini/Mono Peter/Climax	Lister/Seha Lister/Climax

The Maintenance Unit of the Maji Department is now studying the possibilities of standardizing a very limited number of pumps and engines.

It is most likely that the following pumps and engines will be selected for further scrutiny:

Engines : Lister - Peter - Ruston
Pumps : KSB - Mather & Platt (General duty) - Mono (Boreholes)

The Lister engines used include the LT, ST and HR series. From the Kiloskar engines, the TA and CA series are the most generally used. Both types of engines are diesel-driven and air-cooled.
Suitable KSB pumps for general duties in water supply are the high pressure, multi-stage centrifugal pumps, series WKL and Movi. For light duty, KSB offers the Etanorm series.
The Mather & Platt pumps are also high pressure, multi-stage centrifugal pumps (HS Plurovane series), or single-stage centrifugal pumps (Uniblock series).
The manufacturer of Monopumps (Australia) has, in cooperation with his agent in Tanzania, suggested a standardization programme of Lister/Mono combinations for various borehole conditions. This programme, currently used by the Maji Department, is summarized in Table E 3.2-3.

Table E 3.2-3 Summary of standardized Lister/Mono combinations for borehole pumping units, as suggested by the manufacturer of Monopumps (Australia)

Capacity (m^3/h)	Total head (m)	Engine and speed (r.p.m.)		Pump type and speed (r.p.m.)	
3.5 - 6.0	30 - 120	LT1	2200	8620	435 - 750
3.5 - 8.0	30 - 120	LT1	2200	8620	435 - 1080
6.0 - 10.5	30 - 120	ST1	2200	8620	620 - 1250
8.5 - 13.5	30 - 120	ST2	2200	8620	900 - 1470
11.5 - 24.0	30 - 120	HR2	2200	C820	400 - 835
16.0 - 32.0	30 - 120	HR3	2200	C820	434 - 1000
14.0 - 28.0	120 - 150	HR2	2200	C2520	390 - 700
25.0 - 50.0	30 - 150	HR3	2200	C2520	590 - 1120
1.8 - 5.0	120 - 180	ST1	2200	8640	390 - 770
4.0 - 9.0	120 - 180	ST2	2200	8640	680 - 1200
8.5 - 11.0	120 - 180	ST2	2200	8640	1150 - 1420

No clear-cut conclusions from the Maintenance Unit are available as yet on the performance of the various pumping units. The majority of the breakdowns involves the engines, due to poor operation and maintenance, and poor design and construction of intake wells (See Volume II, subpar. B 3.2.3). Such breakdowns, and shortage of spare parts, apart from fuel, are the main causes of frequent interruptions in water delivery to the consumers.
In general the pumps seem to be quite satisfactory.

On the basis of discussions with various people involved in operation and maintenance of rural piped water supply facilities, the Consultant has selected the following pumping units for the cost estimates of typical village water supply systems as described in the subparagraphs E 3.3.2 and E 3.3.4:

- general duty : Lister engines + KSB pumps
- boreholes : Lister engines + Mono pumps

The Consultant would like to remark that this selection is made for costing purposes only. The selection of pumping units for a standardization programme is considered to be a policy decision of the Maji Maintenance Unit. It is observed that a nation wide standardization of pumping units is not recommendable for reasons of market mechanisms, but a regional standardization limited to a small number of manufactures is believed to be quite appropriate for the improvement of O & M activities.

Transmission and distribution lines

In 1977, the Ministry published a note [12] on pipes, fittings and valves, which describes quite comprehensively the current policies and directives in pipeline construction. Moreover, it provides an inventory of materials which are normally available from the Maji stores at Kurasini (Dar-es-Salaam). A summary of available pipes is given in Table E 3.3-8. The pipe materials most frequently applied are:

- PVC (polyvinylchloride), for medium and large diameters
- PE (polyethylene), for small diameters
- GS (galvanised steel), for small, medium and large diameters

The use of ductile iron is increasing for application in gravity water supplies, where relatively high pressures may be applied.

The construction of transmission and distribution lines is in general quite satisfactory. Problems occur in the handling of pipes and fittings during storage and transport. These materials are sometimes seriously damaged during loading or unloading, and ultraviolet sunlight causes a quick aging of plastic pipes which are not properly protected against it during storage. The latter problem also occurs in some gravity water supply systems where PVC-pipes are not properly covered with a suitable toplayer.

Storage reservoirs

The Ministry has realized an extensive standardization programme of storage tanks for rural water supply systems. The capacities of these tanks vary between 22.5 - 337.5 m^3 (5 - 75 thousand gallons). The structure consists of a circular reinforced concrete tank bottom, a blockwork sidewall and a reinforced concrete cover, except for the 75,000 G tank which is completely made of reinforced concrete. The 9" blockwork wall contains some reinforcement bars over the whole height. The raiser is made of a closed circular blockwork wall. (See Figure E 3.2-6).
The storage tanks are also fitted with provisions such as an overflow and a wash-out, and a float extended above the cover of the storage tank to allow for a remote check of the water level in the storage tank.

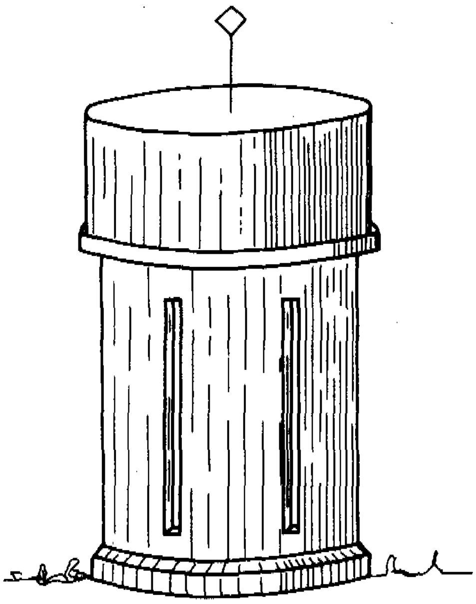


Figure E 3.2-6 Storage tank of Maji Department

Some of the characteristic data of the standardized storage tanks are summarized in Table E 3.2-4.

Table E 3.2-4 Some characteristic constructional data of Maji storage tanks

Capacity		Drawing Nr.	Diameter (m)	Height (m)
5,000 G	22,5 m^3	TY/TA/7 *	4.42	1.80
10,000 G	45.0 m^3	TY/TA/12*	5.49	2.13
20,000 G	90.0 m^3	TY/TA/13*	7.32	2.44
30,000 G	135.0 m^3	TY/TA/14*	7.46/7.90	1.10/1.90
50,000 G	225.0 m^3	TY/TA/46*	8.68/9.15	1.32/2.33
75,000 G	337.5 m^3	TY/TA/44*	10.97	4.10

* ground level tanks

The Consultant considers these storage tanks to be a suitable element in a standardization programme. A disadvantage of the Maji storage tanks is the long construction period they require.
Another problem, which may seriously delay the construction of a tank, is shortage of building materials. For this reason, the Consultant has studied the technical possibilities and economic feasibility of constructing steel or aluminium tanks locally from imported materials, as part of a short-term crash programme for rural water supply. These metal tanks could later be replaced by a blockwork storage tank, or remain part of a larger future water supply system. It seems that a local Dar es Salaam based contractor has been approached for the importation of prefabricated aluminium storage tanks from Australia for some piped water supply schemes in Singida Region. No final conformation on this issue could be obtained before the completion of the MDWSP survey.

Domestic water points

Design drawings exist for three types of public water points. They can be distinguished in the following types (see also Figure E 3.2-7):

- IA: DWP with one tap
- IB: DWP with two taps, low pressure
- IC: DWP with two taps, high pressure

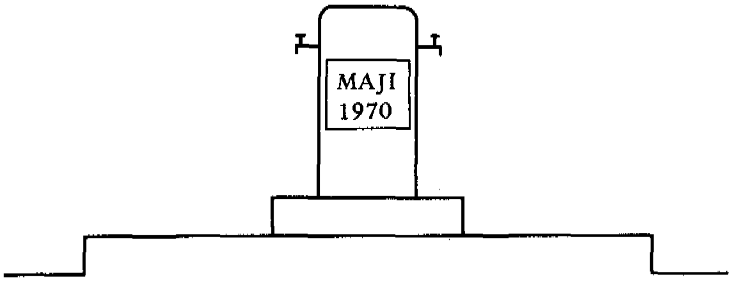


Figure E 3.2-7 Domestic water point (Type IC) of the Maji Department

The superstructure of the storage tank and the layout of the distribution system should be designed in such a way that a minimum pressure of 3 m.w.h. is guaranteed for all domestic water points in the distribution system. The maximum pressure normally recommended at domestic points is 20 m.w.h. At places were the pressure is very high, this can be reduced by introducing simple pressure reducing valves or break pressure tanks. At some locations the domestic water points have been provided with constant flow valves, but often these are not available on the local market.

3.2.3. Water treatment

In accordance with the planning stages as described in par. E 2.3, extensive water treatment has not been envisaged before all villages have been provided with a water supply system which has a sufficient standard of reliability and in water availability and accessibility.
Improved water supplies using ground water sources will in general not require any additional treatment since the sources of this type of supply will be selected and accepted only if they meet the quality standards [24]. The only exception is a simple aeration process for water abstracted from boreholes, in case this water is aggressive towards some of the materials used in the transmission and distribution system. The method suggested for this purpose is a combination of a simple sprayer (e.g. perforated plastic pipe) and a waterfall aerator made of wooden planks. See Figure E 3.2-8. The structure can be placed on top of the storage tank and should be provided with dust and vermin proof ventilation channels. Natural ventilation will provide for sufficient aeration of the relatively small water flows of rural water supply systems.
The aeration will most likely result in deposits of ferric-hydroxides on the wooden planks, and to prevent unwelcome biological growth on the trays intermittent cleaning of those wooden planks will be required. The iron-compounds may be present in the ground water or enter into the water as a result of the corrosion of the casing pipes and screens of the borehole.

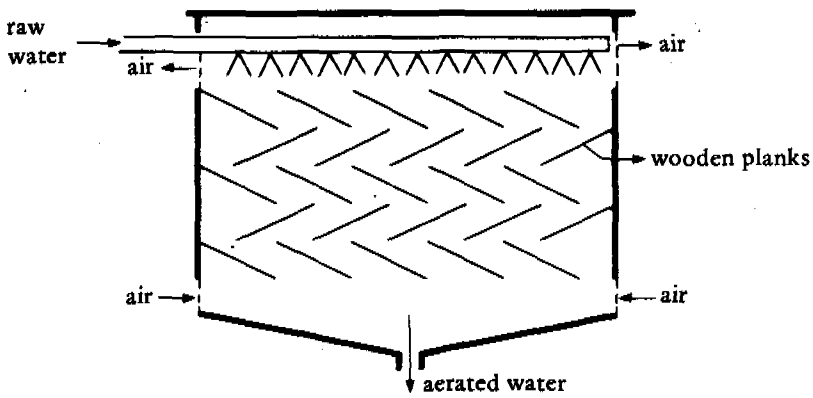


Figure E 3.2-8 Simple aerator

A more complicated situation will occur for improved supplies depending on surface water sources. These sources often contain high levels of turbidity, suspended matter and bacteriological contamination. In some areas bilharzia, causing schistosomiasis is found. Another unwelcome constituent which may be found in surface waters is mica, an inert and insoluble material. Mica may enter into surface water bodies when rivers and streams cut through mica deposits due to eroding activities. The mica will be degraded into small flat but sharp particles. These particles remain suspended in the water and may cause continuous destruction of the flora in the human intestines if mica containing water is consumed regularly.
The simplest way to remove a significant part of the turbidity, suspended matter (e.g. mica), and microflora contained by the water is the construction of appropriate intake structures as described in subpar. E 3.2.2.1. During the current and succeeding phase of rural water supply development (see par. E 2.3) no additional treatment facilities will be required for the majority of small village water supplies, provided that such intake structures are properly operated and maintained.
Occasionally situations will occur where the suggested intake structures cannot be applied for various technical reasons, e.g. inappropriate topographical or hydrogeological conditions or extremely poor water quality. It may than become imperative to provide more elaborate and costly treatment facilities. Treatment processes which may be considered under such conditions are extended storage, plain sedimentation, horizontal-flow pre-filtration, slow sand filtration, and chemical disinfection. These possible units are briefly discussed below:

- extended storage
  A storage basin for extended storage may serve a threefold purpose. It may improve the reliability of the water supply during periods of short supply of raw water, it reduces turbidity by sedimentation and finally it improves the quality of the water because a substantial reduction of pathogenic bacteria may be achieved through the activity of algae, protozoa and other predatory organism on the one hand and the germicidal effect of ultraviolet rays in sunlight on the other hand.

A storage basin designed for a detention time of not less than 48 hours will result in a complete die-off of schistosomiasis cercariae if the basin is free from snails which are an essential host in the life cycle of these pathogenic organisms.
A comprehensive study of the technical and economic feasibility of basins for extended storage has been carried out by SIDA [25].

- plain sedimentation
  A plain sedimentation basin mainly serves the purpose of reduction of turbidity and removal of suspended matter. The detention time (normally 4 - 12 hours) is short in comparison with that of a storage reservoir, but should be long enough to allow the suspended solids to settle (particles with a density higher than water) or to float (particles with a density lower than water). The designed detention time should be based on samples typical of all regimes of the river. A sedimentation tank may have a batchwise or a continuous operation. The most common configuration of a sedimentation basin is a rectangular box made of concrete or masonry, or a dug basin with protected sloping walls.
  More details about plain sedimentation basins can be found in various technical manuals [18, 19, 21]. The SIDA-report [25] also contained a feasibility study on the application of plain sedimentation tanks.

- horizontal-flow prefiltration
  Horizontal flow prefiltration may be carried out in a rectangular box similar to a basin used for plain sedimentation. The raw water inlet is situated at one side of the box, the outlet at the opposite side. In the main direction of flow the water passes through various layers of graded, coarse material (in the sequence coarse-fine-coarse). The vertical depth of the filter bed may be designed at about 1 m (range 0.8 - 1.5 m) and suitable filtration rates are in the range of 0.4 - 1 m/h (horizontal flow).
  The total length of the filter bed, run through by the water, may vary between 4 and 10 metres. A typical layout of a horizontal flow prefiltration unit is given in Figure E 3.2-9.

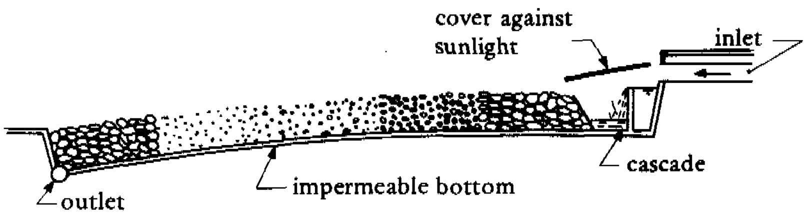


Figure E 3.2-9 Typical layout of a horizontal flow prefiltration

This filtration unit was first developed in Thailand and technical details may be found in a publication of Thanh [23].

- slow sand filtration
  Slow sand filtration is a purification process in which the water to be treated is passed through a porous bed of filter medium. During this passage the water quality improves considerably by reduction of

the number of micro-organism (bacteria, viruses, cysts), by removal of suspended and colloidal material, and by changes in its chemical composition. In a mature bed a thin layer called the Schmutzdecke forms on the surface of the bed. This Schmutzdecke consists of a great variety of biologically very active micro-organisms which break down organic matter, while a great deal of suspended inorganic matter is retained by straining.
Slow sand filters are cleaned by the relatively simple periodical removal of the top of the filter bed, including the Schmutzdecke.

Basically, a slow sand filtration unit consists of a box, containing a supernatant raw water layer, a bed of filter medium, a system of underdrains and a set of filter regulation and control devices (see Figure E 3.2-10).

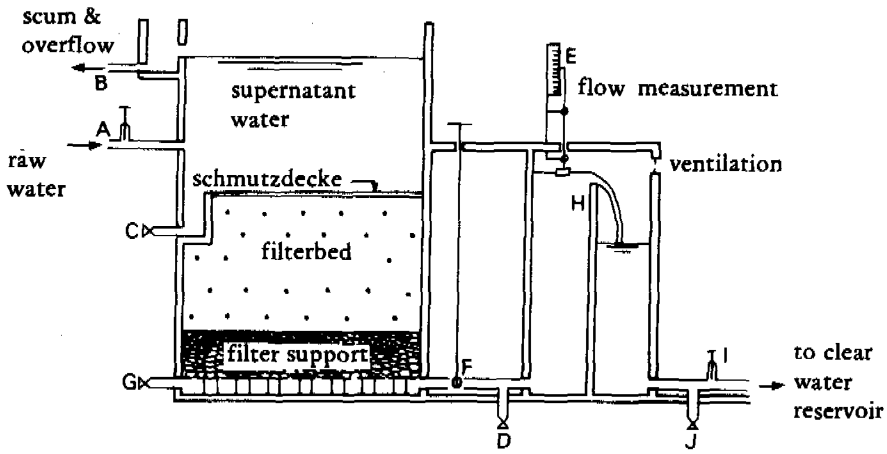


Figure E 3.2-10 Basic elements of a slow sand filter

Slow sand filtration is an efficient method for the removal of organic matter and pathogenic organisms. It is therefore a particularly appropriate treatment method for surface water containing unwelcome quantities of such impurities. The turbidity of surface waters may, however, limit the performance of slow sand filters, so that quite often some pretreatment will have to be applied.
The theory of slow sand filtration has been described comprehensively in a WHO-publication [20], and the International Reference Centre for Community Water Supply (IRC) has issued a detailed manual on design and construction of slow sand filters [21].

- chemical disinfection
Disinfection serves to destroy pathogenic organisms which may cause various types of waterborne diseases. Safety chlorination provides a precautionary measure against future contamination of bacteriologically safe water (e.g. in a distribution system).
Disinfection and/or safety chlorination are recommendable for those systems which depend on surface waters highly contaminated by pathogenic organisms, or systems which provide water to a large group of consumers. Such provision will prevent an epidemic outbreak in the supply area after serious contamination of the water source.

For rural areas in developing countries the most suitable chemicals for these processes are bleaching powder and high-test-hypochlorite materials, the choice being determined mainly by availability and costs in the particular country or area.
The chemicals are characterised by a certain content of "available chlorine" which is the active disinfecting component.
Various suitable dosing systems exist for the application of such chemicals in small village water supply systems. A good example is the so-called floating-platform hypochlorinator, as presented in Figure E 3.2-11.
A glass tube inlet fixed below a float allows for a constant flow of solution to the dosing point while the liquid level falls in the container.

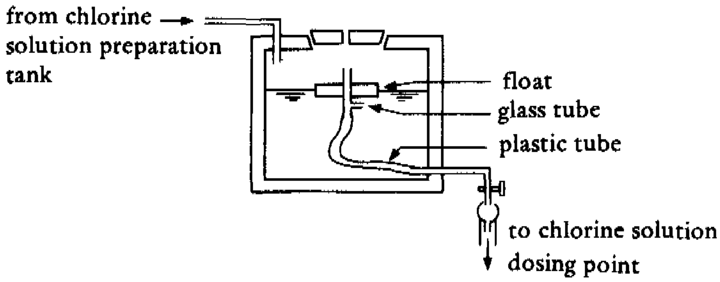


Figure E 3.2-11 Floating-platform hypochlorinator

Depending on the quality of the water to be disinfected, between 0.5 and 2 mg available chlorine are added to each litre of water.
The effectiveness of the disinfection process is expressed as the chlorine content ("residual chlorine") which remains after a certain contact-time.
In general a residual chlorine content of 0.5 mg/l after 30 minutes contact is recommended for rural supplies.
Technical documentation on chemical disinfection for rural water supplies can be found in various publications [18, 19, 21, 25, 26].

3.3. Cost estimates for rural water supply systems

Cost estimating of rural water supply facilities is an extremely difficult issue. In recent years several documents have been published discussing these costs [2, 13, 15, 27]. The valuation of such cost estimates often suffers from a lack of sufficent data on the breakdown of these estimates, no mention of the year for which the prices are applicable nor specifications of price components which are or are not included in the estimates.

The Consultant has opted for the establishment of new cost estimates and cost functions for typical village water supply schemes which may be part of the Consultant's recommendations for short-term and medium/long-term implementation programmes.
Cost estimates for water source structures, transmission and distribibution systems, and water treatment facilities are described in the subparagraphs E 3.3.1 - 3.3.3.

These cost estimates are based on recent estimates by the technical staff of the Regional Maji Office in Morogoro Town, and estimates from local contractors. In some cases, the cost estimates are the result of own judgement or recent experience of the Consultant, obtained from the implementation of some waterworks as part of the MDWSP-programme. (i.e. borehole programme).

The cost estimates have served to make cost functions for some typical village water supply schemes of various capacities and layouts of transmission and distribution systems. These typical rural water supply systems and the cost functions derived from them are described in subpar. E 3.3.4 and Annex EA 1.
The cost estimates and cost functions include costs of materials, equipment, labour, transport and administrative overhead (1%). They represent the 1978 price level.
One point which deserves special attention is the impact of technical overhead costs on the total implementation costs. The Maji Department has traditionally calculated with an overhead component of 20%. Recently many rural water supply projects were implemented with the assistance of bilateral or multilateral aid organizations and cost analyses of such projects indicate that the overhead costs incurred by expatriate assistance may add 50 - 200% to the direct construction costs. The WHO/World Bank study suggests an average overhead component of 60%. The Consultant advises applying this figure for general estimates of overall overhead costs.
The costs of technical overheads, local or expatriate, are not included in the cost-estimates and cost-functions as they largely depend on the extent on which such assistance is introduced.

3.3.1. Water source structures

Cost estimates are given for water source structure for which standardized construction methods exist. These were discussed in subpar. E 3.2.1.

Shallow wells

The Shallow Well Handbook of the Shinyanga Shallow Wells Programme (SSWP) provides comprehensive data on the construction costs of hand-dug and hand-drilled shallow wells.
These cost figures are summarized in Table E 3.3-1.

Table E 3.3-1 Average costs of well construction (without pump) per linear metre of depth

	Depth up to 7 m	Depth from 7 to 15 m
Hand-drilled well	TShs 900/m	TShs 900 - 1,100/m
Hand-dug well	TShs 1,300/m	TShs 1,300 - 3,000*/m
Percussion-rig well	TShs 1,700/m	TShs 1,700 - 2,200/m

* approximate figure. Depending on difficulties encountered, desired speed of progress, hand chisels vs. jack hammers, amount of drainage required etc., the cost may be higher or even much higher.

It is normally assumed that one shallow well with hand pump can serve some 250 people. Table E 3.3-2 summarizes the total capital costs and the per capita investment costs for various shallow wells with a depth of 10 m. The table includes the cost estimate for the shallow wells as constructed by the Maji Department.

Table E 3.3-2 Capital costs of various shallow wells (10 m depth) for locations at 100 km distance from Morogoro depot (1978 price level)

Type of shallow well	Costs (TShs)	
	Total	Per capita
Hand-dug well (SSWP ; 10 m)	20,000	80
Hand-drilled well (SSWP ; 10 m)	10,000	40
Hand-dug well (Maji ; 10 m)	35,000	140

Source: SSWP [16]; Regional Maji Office Morogoro.

The given costs do not include the depreciation of investments such as workshop equipment, and transport equipment, nor does it include salaries of expatriate and governmental technical staff (overhead component).

Boreholes

The cost estimates for boreholes seem to have increased considerably during the last years. The WHO/World Bank study suggests much higher costs than the original Maji-estimates, and recently, the Maji Department revised its calculations on the basis of the experience during the last few years.

The Consultant has carried out a drilling programme as part of the MDWSP survey. During a period of 6 months, some 1170 m (3,840 ft) have been drilled by means of the Maji Schramm rig No. 42. This drilling programme was aimed at exploration as well as exploitation. Therefore the drilling period mentioned included the completion of successful boreholes up to a level required for subsequent construction of a pumphouse, and transmission and distribution facilities.
Table E 3.3-3 summarizes the cost estimates of various sources, and includes data on the amount of feet per rig/year for which these cost estimates are applicable.

Table E 3.3-3 Cost estimates for drilling and construction of deep boreholes - review

Source of estimate	Year	Estimated costs per m/per ft (TShs)		Estimated drilling capacity per rig/year
		Drilling costs	Completion costs	
WHO/World Bank survey	1976	1130/345	-	530 m (1740 ft)
Maji estimate	1978	920/280	1970/600	915 m (3000 ft)
MDWSP drilling programme	1978	575/175	1020/320	2440 m (8000 ft)

The table shows that the cost price per unit length largely depends on the productivity of a rig per rig-year. The first two estimates are based on the current experience with the Maji rigs which are generally speaking in relatively poor condition. Although Rig 42 and corresponding lorry had several serious breakdowns and weather conditions were very unfavourable during most of the drilling period, the MDWSP drilling crew maintained a production of about 200 m/month. Therefore the cost figures of the MDWSP drilling programme are considered to be quite appropriate and realistic for the estimate of costs of boreholes constructed within a properly organized drilling programme.
The costs were calculated from the running costs of the drilling programme with drilling sites at about 60 km from Morogoro. The cost estimates for borehole construction for an average distance of 100 km between depot and site are given in Table E 3.3-4. These figures will be used for further costing operations.

Table E 3.3-4 MDWSP cost estimate for construction of boreholes (100 m depth) for locations at 100 km distance from Morogoro depot (1978 price level)

Source of estimate	Year	Costs (TShs/m)	
		Drilling	Completion
MDWSP drilling programme	1978	600	1,070

This cost price includes all costs for materials, tools, equipment, transport, labour and administrative overheads. Technical overheads, local or expatriate, are not included.
It is expected that the given costs will decrease if a new, and possible lighter, rotary drilling rig is used instead of the poorly maintained Schramm Rig.

Subparagraph E 3.2.2. also described the application of the light duty mobile B80 drilling rig for the construction of shallow boreholes provided with handpumps.
It is estimated that the cost price per unit-length of such a borehole will be 80% of the comparable costs for deep borehole construction, mainly due to differences in depreciation costs for the drilling rig. In other words, drilling costs are estimated at 500 TShs/m, and completion costs at 880 TShs/m, for locations at 100 km from depot.

3.3.2. Water transmission and distribution

Pumphouses and Pumping Units

Cost estimates for the two types of pumphouses were obtained from the technical staff of the Regional Maji Office in Morogoro. See Table E 3.3-5. This cost estimate does not include extra work, such as access road and fencing.

Table E 3.3-5 Cost estimates for pumphouses, for locations at 100 km from Morogoro Depot (1978 price level)

Type of pumphouse	Estimated costs (TShs)
Borehole pumphouse	30,000
General duty pumphouse	40,000

Table E 3.3-6 lists cost estimates for a number of pumping units, which were discussed in subpar. E 3.2.2. These estimates are based on data from local suppliers.

Table E 3.3-6 Cost estimates for pumping unit (net prices, 1978 price level)

Manufacture		Estimated costs (TShs)		
Pump	Engine	Pump	Engine	Pumping unit
	Lister LT1		9,950	
	ST1		13,000	
	ST2		21,250	
	ST3		29,700	
	HR2		35,000	
	HR3		47,800	
KSB-MOVI				
40/8-12		13 -18,000		
65/5- 7		13.6-16,800		
WKL 80/6-10		25.4-33,800		
MONO B620	Lister ST2			38,000
C820	HR2			55,000
C2520	HR3			63,000

For planning purposes, it is desirable to select a limited number of pumping units of which the costs are representative for all applicable possibilities.
The Consultant has selected pumping equipment with capacities of 5 - 10 l/s (100 m total head) for both general duty and borehole pumping units.
The estimated total costs of these pumping units, including labour, transport and administrative overheads are given in Table E 3.3-7.

Table E 3.3-7 Cost estimates for selected pumping units for locations at 100 km from Morogoro Depot (1978 price level)

Pumping unit		Estimated costs (TShs)	
		one unit	including spare unit
General duty	5 l/s	50,000	90,000
	10 l/s	75,000	140,000
Borehole	5 l/s	60,000	-
	10 l/s	80,000	-

An alternative to pumping units using diesel engines as prime movers is the application of electromotors in those villages where nearby overhead power lines are available. An inventory of all power lines at present available in the survey area is presented in Figure E 3.3-1.
Cost-estimates for installation works involved in the application of electric power were obtained from the regional Tanesco Office.
These costs are summarized in Table E 3.3-8. The table also includes estimates for some of the electromotors and submersible motor pumps available from the local market.

Table E 3.3-8 Cost-estimates of equipment and works involved in the utilization of electric power (1979 price level)

Item	Description	Estimated Costs (Tshs)
Power-substation	Under-line substation (50 kVA)	70,000
Powerline	1 km of 11 kV line; 5 MeW	90,000
	1 km of 33 kV line; 8 MeW	110,000
Electromotors		
Crompton/	2 - 8 kW; 1500-3000 rpm	2,500 - 5,500
Brook	10 - 30 kW; 1000-1500 rpm	5,000 - 12,000
Submersible motor pumps KSB	URD 212/6-7; 5.5 kW; 0-6 l/s	32,000 - 34,000

Electromotors have considerable advantages in regard to operation and maintenance, and reliability of the prime mover.
The problems often involved in fuel supply can be eliminated. On the other hand, introduction of a new type of pumping unit, such as a submersible

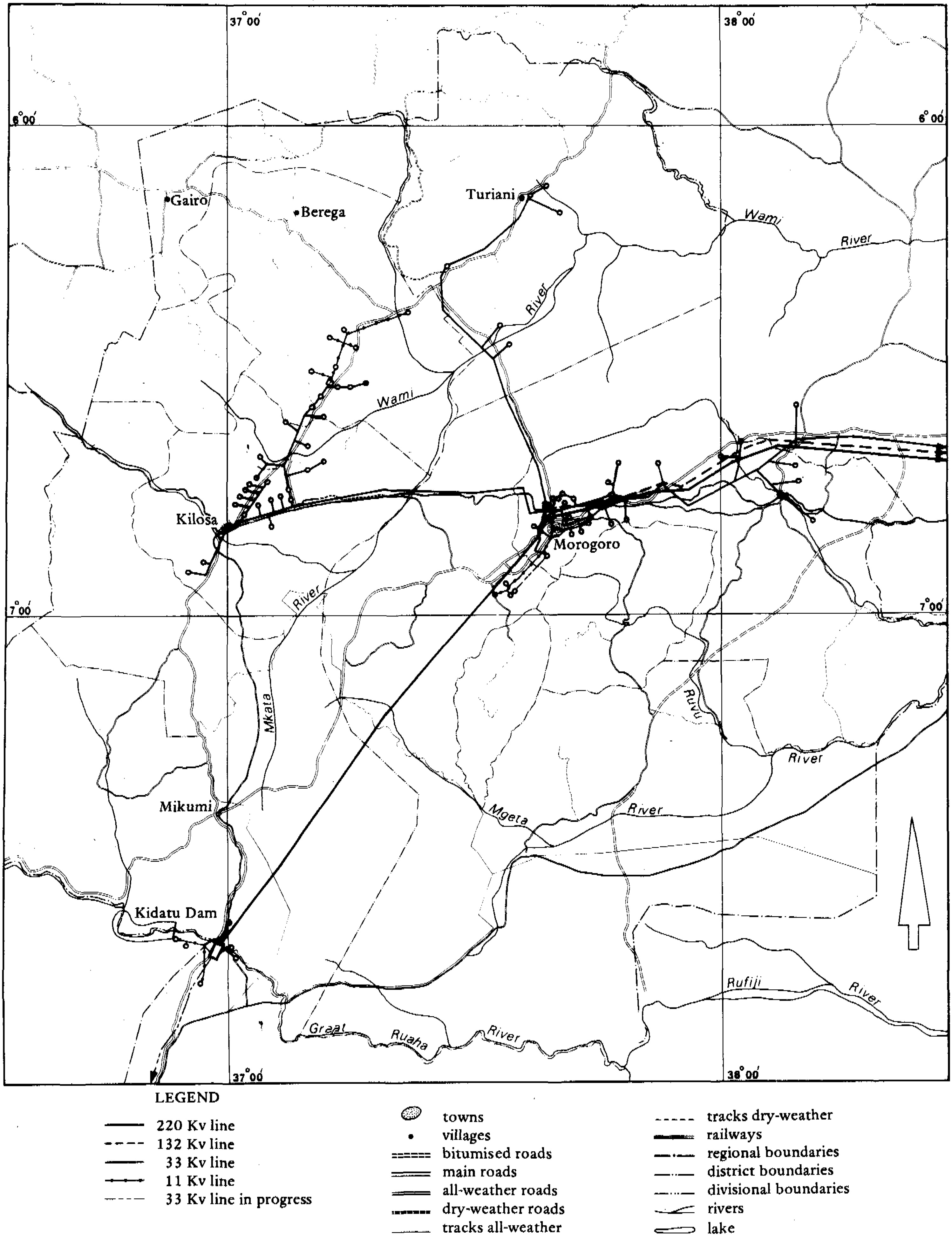


Figure E 3.3-1 Inventory of overhead power lines in the survey area

motor pump (for boreholes), may cause some specific technical problems in regard to the maintenance and repairs of such pumps. For the present conditions, the combination of an electromotor with a conventional borehole pump is probably the most appropriate solution.
The selection between diesel-driven pumps and power-driven pumps depends in each case on local conditions and financial implications. A first estimate of the difference in costs of the two alternative systems can be made on the basis of the data given in Table E 3.3-8.

Transmission and distribution lines

The estimated costs of transmission and distribution lines are built up of the following cost components:

- costs of pipes from Kurasini Stores in Dar-es-Salaam
- costs of joints and accessories: 5%
- transport costs: 10%
- labour costs: 6 - 15 TShs/m
  From data obtained from the technical staff of the Regional Maji Office in Morogoro Town, the labour costs are estimated to be as follows:
  - pipes of 1" - 2": 6 TShs/m
  - pipes of 3" - 4": 10 TShs/m
  - pipes of 6" - 8": 15 TShs/m

  These costs include bush-clearing, excavation, pipe-laying and fitting, testing and repairs, and back-filling
- administrative overheads: 1%

The material costs and total construction costs (TShs/m) of pipelines are summarized in Table E 3.3-9 for some common pipe materials and diameters.

Table E 3.3-9 Cost estimates for pipeline materials and total construction costs of pipelines, for locations at 100 km from Morogoro Depot (1978 price level)

Pipe material	Net costs (TShs/m)	Total construction costs (TShs/m)	Pipe material	Net costs (TShs/m)	Total construction costs (TShs/m)
PVC 3" Class B	23.20	37.20	GS 1" Class C	18.00	27.10
4" B	33.65	49.40	1½" C	23.00	32.90
6" B	72.10	99.30	2" C	32.00	43.40
8" B	141.20	179.90	3" C	54.00	73.10
PVC 3" C	35.65	51.70	4" C	78.10	101.20
4" C	53.45	72.50	6" C	130.00	166.80
6" C	113.10	147.10			
8" C	224.10	276.60	GS 2" D	49.20	63.20
PVC 3" D	41.20	58.20	3" D	68.00	89.40
4" D	62.60	83.10	4" D	95.00	120.90
6" D	132.65	169.90	6" D	150.00	190.10
8" D	253.45	310.80	DI 3" NP 10	100.00	126.00
PE 1" B	4.30	11.10	4" NP 10	120.00	150.00
1½" B	8.60	16.10	6" NP 16	180.00	225.00
2" B	13.75	22.10	8" NP 16	240.00	360.00
PE 1" C	5.45	12.40	10" NP 25	300.00	
1½" C	13.00	21.20	12" NP 25	468.00	
2" C	20.40	29.20	16" NP 40	670.00	
PE 1" D	6.50	13.60			
1½" D	16.80	25.60			
2" D	25.50	35.80			

Storage reservoirs

Cost estimates for storage reservoirs were obtained from the technical staff of the Regional Maji Office in Morogoro Town. These estimates include materials, labour, transport, equipment, administrative overheads. See Table E 3.3-10.

Table E 3.3-10 Cost estimates for storage tanks, at locations 100 km from Morogoro Depot (1978 price level)

Capacity		Standard drawing	Estimated total costs (TShs)
m^3	gallons		
22.5	5,000	TY/TA/7 (ground level)	65,000
22.5	5,000	TY/TA/56 (on raiser)	105,000
45.0	10,000	TY/TA/12 (ground level)	85,000
45.0	10,000	TY/TA/39 (on raiser)	140,000
90.0	20,000	TY/TA/13 (ground level)	110,000
90.0	20,000	TY/TA/40 (on raiser)	185,000
135.0	30,000	TY/TA/14 (ground level)	140,000
135.0	30,000	TY/TA/41 (on raiser)	240,000
225.0	50,000	TY/TA/46 (ground level)	175,000
337.5	75,000	TY/TA/44 (ground level)	375,000 *)

*) completely reinforced concrete structure

Domestic water points

Costs for the three types of domestic water points are estimated to be the same. Data for these estimates were obtained from the technical staff of the Regional Maji Office in Morogoro Town. See Table E 3.3-11.

Table E 3.3-11 Cost estimates for domestic water points, for locations at 100 km from Morogoro Depot (1978 price level)

Types	Estimated total costs (TShs)
IA, IB and IC	3,000

Cattle troughs

Cost estimates for cattle troughs were obtained from the technical staff of the Regional Maji Office in Morogoro Town. The estimates again include materials, labour, transport, equipment and administrative overheads. See Table E 3.3-12.

Table E 3.3-12 Cost estimates for cattle troughs for locations at 100 km from Morogoro Depot (1978 price level)

Type of trough	Estimated costs (TShs)
Short cattle trough	60,000
Long cattle trough	80,000

3.3.3. Water treatment

At present, no water treatment facilities exist for village water supply schemes in the survey area. Moreover, no treatment works are envisaged for the large majority of the village water supply schemes included in the proposed short-term implementation programme. The Consultant considers that the recent SIDA paper, entitled "Rural Water Quality Programme in Tanzania" [25] provides sufficient up to date information on costs of simple treatment systems for village water supply schemes. Therefore, no additional investigations on this topic have been carried out. The SIDA report discusses in detail treatment processes such as extended storage, chlorination, flocculation/coagulation, settling and filtration, and slow sand filtration. For further details reference is made to this report.

3.3.4. Unit costs of typical rural water supply systems

Cost estimates for capital investment costs of various waterworks components, such as water source structures, pumphouses and pumping equipment, transmission mains, storage tanks, distribution lines and domestic water points, were discussed in detail in the subparagraphs E 3.3.1.- 3.3.3. A summary of the cost estimates which has been used for costing operations is given in Table E 3.3-13.

All estimates given include the following cost components:
- material costs
- labour costs
- transport costs
- administrative overheads (1%)

Technical overhead costs for design and construction are not included in the estimates (see also par. E 3.3).

This paragraph will discuss investment costs, annual costs and operation and maintenance costs of some typical rural water supply schemes. A layout of these schemes is presented in Figure E 3.3-2.

Table E 3.3-13 Summary of cost estimates for various waterworks components, at locations 100 km from Morogoro Depot (1978 price level)

Item	Cost estimates (Tshs)	Source
WATER SOURCE STRUCTURES		
- river intake (gravity) - small	40,000- 60,000	MDWSP estimate
- large	80,000-100,000	MDWSP estimate
- shallow well (hand dug; 10 m)	20,000[1]	SSWP, MWCP
- shallow well (hand drilled; 10 m)	10,000[1]	SSWP, MWCP
- shallow well (hand dug; 10 m)	35,000[1]	RWE's Off. Morogoro
- borehole (100 m depth)	107,000	MDWSP field experience
WATER TRANSMISSION STRUCTURES		
- pumphouse (borehole)	30,000	RWE's Off. Morogoro
(general duty)	40,000	RWE's Off. Morogoro
- pumping equipment		
borehole ($Q \leq 5$ l/s)	60,000	Mehta & Sons
($Q \leq 10$ l/s)	80,000	Mehta & Sons
general duty ($Q \leq 5$ l/s)	50,000	Jos Hansen und Soehne
($Q \leq 10$ l/s)	75,000	Jos Hansen und Soehne
- transmission mains	see Table E 3.3-9	Kurasini Stores, T.T.P. RWE's Office
WATER DISTRIBUTION STRUCTURES		
- storage tanks 22.5 m^3, G/R	65,000/105,000	RWE's Off. Morogoro
45 m^3, G/R	85,000/140,000	"
90 m^3, G/R	110,000/185,000	"
135 m^3, G/R	140,000/240,000	"
225 m^3, G	175,000	"
337.5 m^3 G	375,000[2]	"
- distribution lines	see Table E 3.3-9	Kurasini Stores, T.T.P., RWE's Office
- domestic water points (IB/IC)	3,000	RWE's Off. Morogoro
- cattle troughs - short	60,000	"
- long	70,000	"
FUEL FOR PUMPED SUPPLIES		
- diesel consumption	0.31 l/kWh	Jos Hansen und Soehne
- costs diesel	2.03 Tshs/l	Market price
- total energy costs	0.88 Tshs/kWh[3]	MDWSP estimate

[1] including handpump
[2] RCC structure
[3] including transport costs

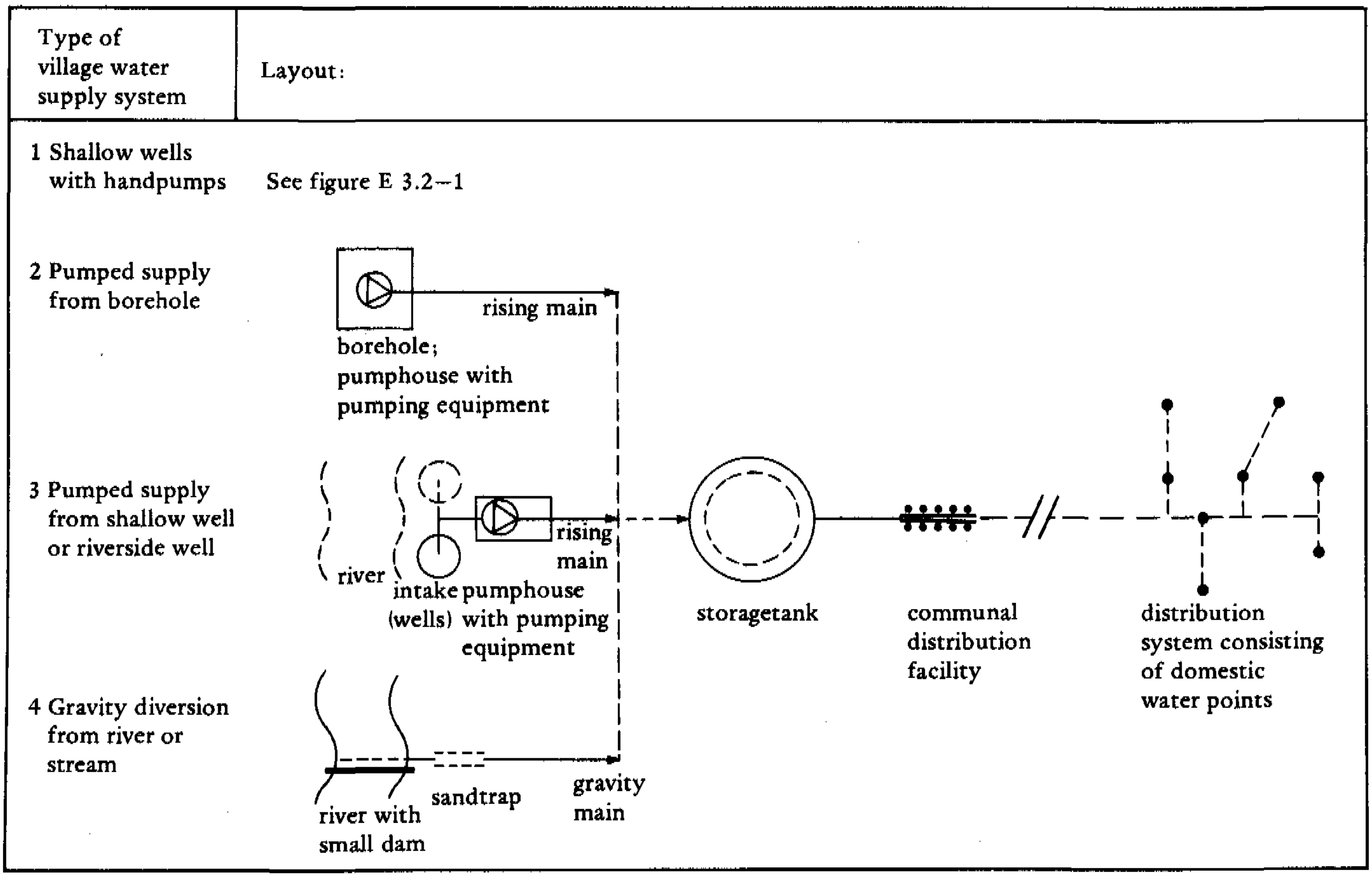


Figure E 3.3-2 Layout of typical village water supply systems.

Essentially these typical designs only differ from each other for the type of water source (shallow well, riverside well, borehole or surface water intake), and transmission system (pumped or gravity diversion).
The typical designs are made for villages with design populations of 1000, 2000, 4000, 7000 and 10,000 people corresponding to present populations of 500, 1000, 2000, 3500 and 5000 people respectively. The design water demands for such villages cover the range of projected future water demands of individual villages in the survey area, as indicated in par. B 3.4.2. The design criteria applied were set ou in Table E 3.2-1. The general assumptions for the typical topographical conditions of the village, the construction techniques and materials applied, and the services provided are summarized below (see also Figure E 3.3-2):

- design population: 1000 - 2000 - 4000 - 7000 - 10,000 people
- total length transmission main: 0.5 - 2.0 - 5.0 - 7.5 - 10 km

- level difference between water level in water source structure and water level in storage tank: 50 m
- pipe material: GS, class M, for transmission, and PE/PVC, class B, for extensive distribution systems
- structures: in accordance with standard Maji Drawings
- distribution system: 1. phase I
  communal water distribution facility at 100 m from storage tank with one tap for each 125 people. In other words, only rudimentary distribution facilities are provided. This system is considered to be a temporary provision, and is designed for a design period of 10 years. See Figure E 3.3-3.

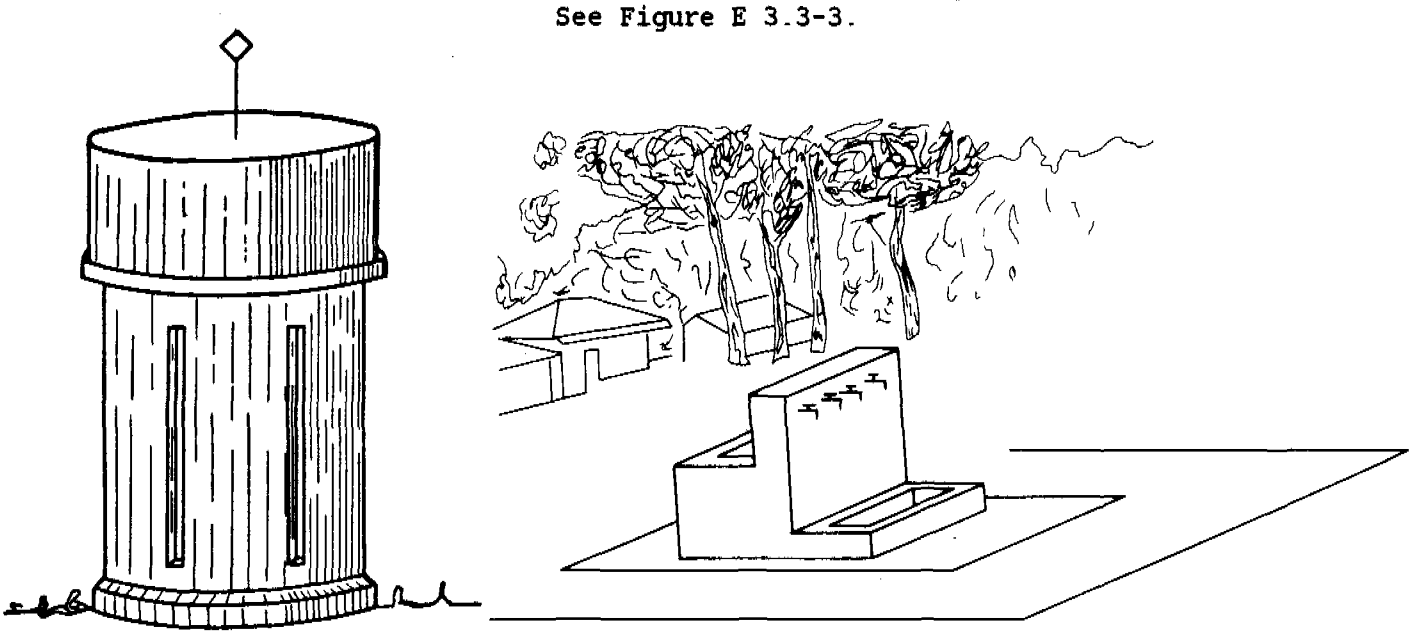


Figure E 3.3-3 Storage tank and temporary communal water distribution facility

2. phase II
   extensive distribution with communal domestic water points, at preferably 400 m walking distance at the maximum.
   Total length of distribution lines is based on allocation of 1 m/cap (for design population).

The typical designs and cost estimates which have been used to establish cost functions for individual village water supply systems are described in Annex EA I.

The cost functions are summarized in Table E 3.3-14, and in Figure E 3.3-4 a graphical presentation of the cost functions for each of the typical schemes is given in terms of the capital investment costs per capita versus the design population.
The cost functions are considered to be valid for a design population of up to some 10,000 people and, in case of piped supplies, a transmission main length of some 10 km at the maximum.
It can be concluded that shallow wells with handpumps will require the lowest investment costs per capita for such individual village water supplies. For piped supplies, on the basis of equal length of the transmission main, the lowest investment costs will be incurred for gravity piped water supplies.
The investment costs for pumped supplies from a borehole, shallow well or riverside well only differ slightly, depending on the design population. For smaller villages, pumped supplies from shallow wells or riverside wells will be cheaper, for larger villages borehole supply will require lower investment costs.

The economic choice between alternative systems for a certain village water supply should not be determined by the investment costs but by the annual costs, as these costs really reflect the total amount of yearly out of pocket payments which can be expected once a system is in operation.
In the comparison between gravity water supplies and pumped water supplies, it is of particular interest to evaluate the difference in transmission main length which can be allowed for otherwise equal annual costs. For example, a village is to be provided with a piped water supply system and a suitable river intake can be found at a distance of say 2 km from the village, at a level equal to or slightly below the level of the village. Such layout would require a pumped water supply system, at some specific annual costs. Alternatively the possibility of constructing a gravity water supply, from the same or different source, could be considered. This would most likely require a longer transmission main, but if this length remains within reason, the annual costs of the gravity system may be of the same order as for the pumped supply. The essential parameters in the comparison of the two alternative solutions are the respective lengths of the transmission mains and the design populations catered for.
From the cost functions for annual costs, (see Table E 3.3-14), the following general relations can be derived for alternative systems having the same annual costs (AC):

- comparison of shallow wells (SW) with piped diversions (PD):

  (i) : $AC_{SW} = AC_{PD} \rightarrow L_{PD} = f$ (population)

- comparison of piped diversions between themselves:

  (ii) : $AC_{PD1} = AC_{PD2} \rightarrow L_{PD1} - L_{PD2} = f$ (population, L_{PD2})

  where AC_X = Annual costs of particular system X

  L_Y = Transmission main length of particular system Y

Table E 3.3-14 Cost functions for various typical village water supplies

	SHALLOW WELLS + HANDPUMP	PUMPED WATER SUPPLY SYSTEMS: from borehole	PUMPED WATER SUPPLY SYSTEMS: from shallow well or riverside well	GRAVITY DIVERSIONS
Investment costs (IC)	$IC_{SW} = 57.8\,x + 22200$	$IC_B = 25.44x + 278300 + 1.2x^{0.54}\,L_B + [60x]$	$IC_{RS} = 36.62x + 185600 + 1.2x^{0.54}\,L_{RS} + [60x]$	$IC_G = 24.73x + 76100 + 2.32x^{0.44}\,L_G + [60x]$
Annual Costs (AC)	$AC_{SW} = 14.53x + 6150$	$AC_B = 7.1\,x + 55500 + 0.18x^{0.54}\,L_B + [7.38x]$	$AC_{RS} = 9.2x + 37300 + 0.18x^{0.54}\,L_{RS} + [7.38x]$	$AC_G = 4.2x + 18600 + 0.34x^{0.44}\,L_G + [7.38x]$
O & M Costs (OM)	$OM_{SW} = 3.78x + 2220$	$OM_B = 3.44x + 12290 + 0.023x^{0.56}\,L_B + [x]$	$OM_{RS} = 3.58x + 11010 + 0.023x^{0.56}\,L_{RS} + [x]$	$OM_G = 0.38x + 7740 + 0.047x^{0.43}\,L_G + [x]$
Conditions	One SW/250 people Welltype: handdrilled SW (Ø 15 cm) with kangaroo pump	$0 < x \leq 10{,}000$ (people) $0 < L_x \leq 10{,}000$ (m) $\Delta H_s = 50$ (m) Pipematerial: Transmission: GS, class M* Distribution: PE/PVC, class B		
Assumptions for Cost-functions (based on Annuities)	Depreciation periods: shallow well : 10 years pump : 5 years Interest rate: 12 % O & M Costs: Tshs 1000-1500/SW/year The cost functions show higher investment costs than mentioned in Table E 3.3-13, because here costs of transport and workshop equipment have been included.	Depreciation periods: Riverintake, borehole, shallow well : 10 years Pumphouse, storage tank : 35 years Pumping equipment : 10 years Pipelines transmission/distribution : 25 years Temporary distribution facilities : 10 years Interest rate : 12% Fuel consumption : 0.31 l/kWh (at Tshs 0.88/kWh, including transport)	O & M Costs: Borehole, shallow well, riverside well : 1% of IC Intake for gravity diversion : 2% of IC Storage tank : 1% of IC Pumphouse, pipelines : 2% of IC Pumping equipment : 5% of IC	
Legend	x = design population L_x = length of transmission main (L_B for borehole, L_{RS} for shallow well or riverside well, L_G for gravity diversion) ΔH_s = level difference between water levels in water source structure and storage tank [ ] = cost component for extensive distribution (several domestic water points)			

* Selected for general costing purposes only, normally PE or PVC will be more attractive

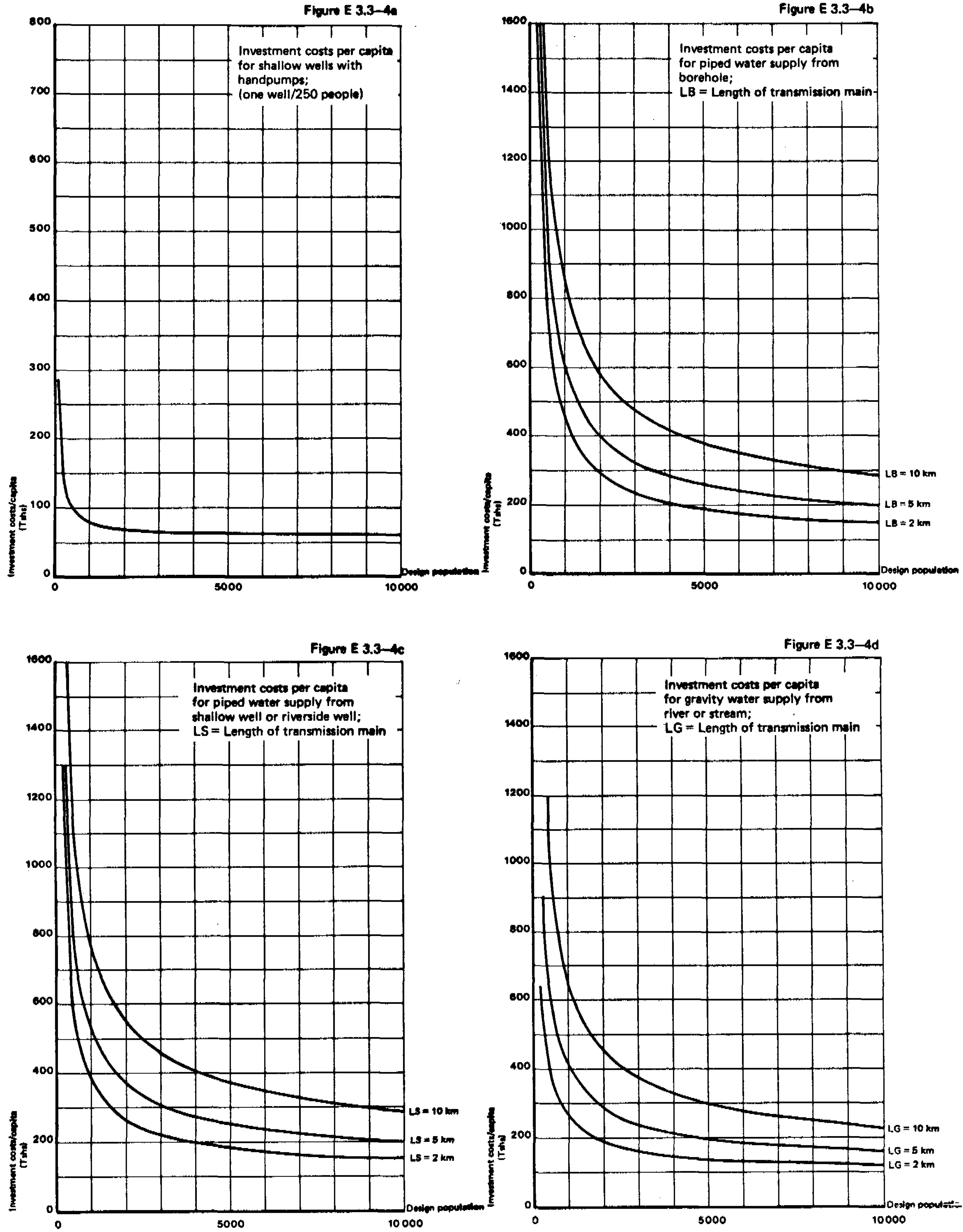


Figure E 3.3-4 Capital investment costs per capita of various village water supply schemes.

The relations are presented graphically in Figure E 3.3-5. The graphical presentation of (i) shows for each design population (between 1000 - 10,000 people) at which length of transmission main of a particular piped water supply, the annual costs of that system are equal to those of village water supply by means of shallow wells with handpumps (see Figure E 3.3-5a). The graphical presentations of (ii) show, for equal annual costs of each two piped water supply systems, the difference in the length of the transmission mains which can be allowed for as a function of the design population and the transmission main length of one of the piped systems involved (see Figure E 3.3-5b-d).

The following conclusions can be drawn from these graphs for individual village water supplies with a design population not exceeding 10,000 people:

1. The annual costs for shallow wells with handpumps are lower than those for pumped supplies with only rudimentary distribution facilities and any length of the transmission main, supposing both are for a design population of less than 7000 people. For a design population between 7000 - 10,000 people the annual costs of pumped supply systems with a length of the transmission main between 0.1 - 1 km are comparable to those of shallow wells with handpumps.
   The annual costs for shallow wells with handpumps are considerably below those for pumped supplies with extensive distribution systems.

2. The annual costs of gravity diversions with rudimentary distribution facilities are lower than those for shallow wells, supposing the transmission main length does not exceed 0 - 4.6 km, depending on the design population.
   Shallow wells will have lower annual costs than gravity diversions with extensive distribution facilities if the length of the transmission main exceeds 1 km.

3. Where annual costs are equal, a gravity supply system may have a transmission main some 3 - 7 km longer than the transmission main of a pumped supply from a borehole, shallow well or riverside well, for a design population varying between 1,000 - 10,000 people and a transmission main length between 500 - 10,000 metres.

4. Where annual costs are equal, a pumped supply from a shallow well or riverside well may have a transmission main some 0 - 2 km longer than that of a borehole supply, for a design population varying between 1,000 - 8,500 people and a transmission main length (of that borehole supply) between 500 - 10,000 m. At higher design populations, the borehole supply will have lower annual costs for otherwise similar conditions.

Length of transmission main of various piped water supply systems where annual costs are equal to those for a domestic water supply system consisting of shallow wells with hand-pumps, as a function of the design population

Figure E 3.3–5a

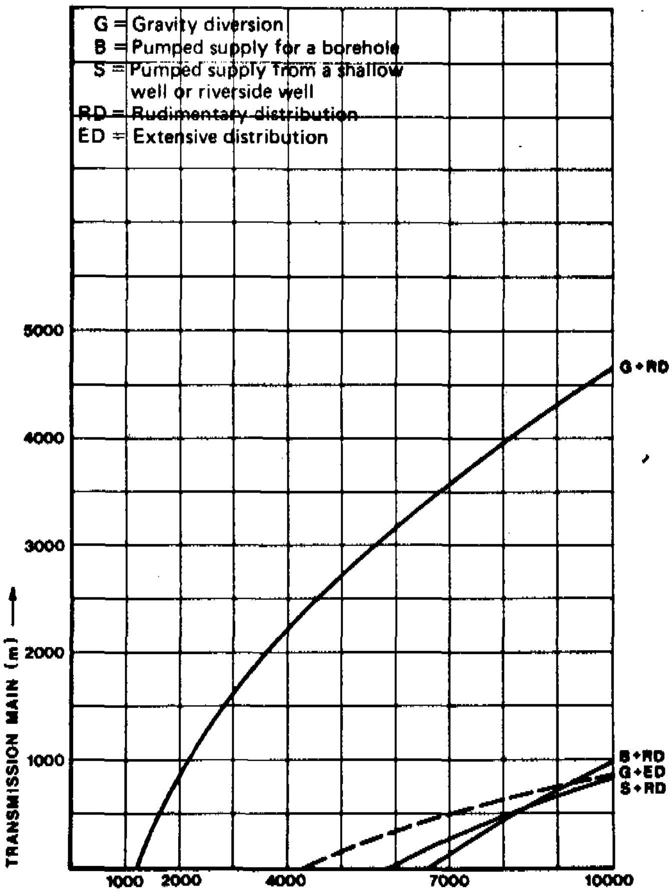


Figure E 3.3–5b

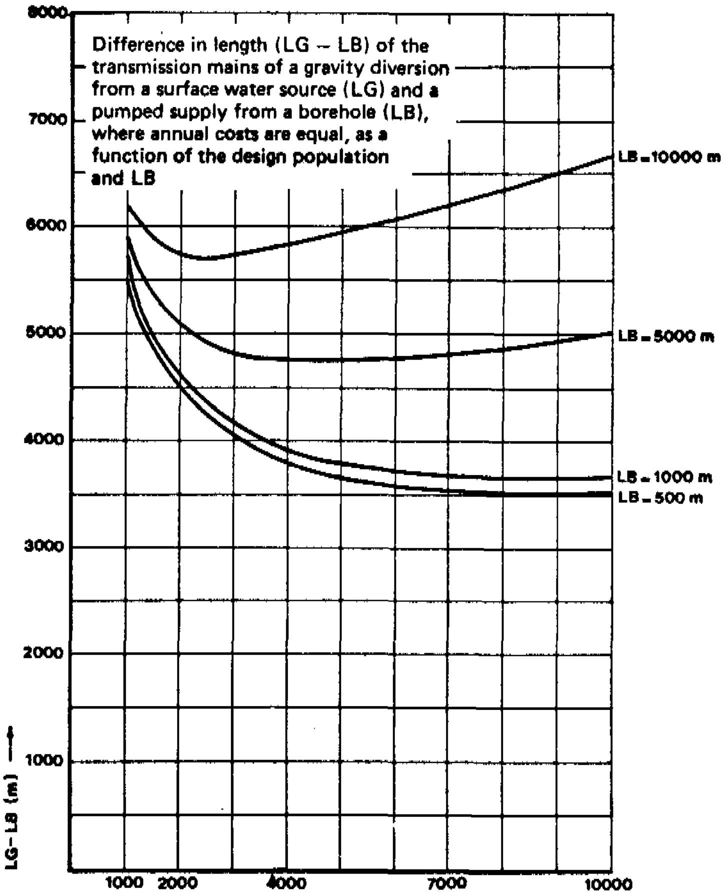


Figure E 3.3–5c

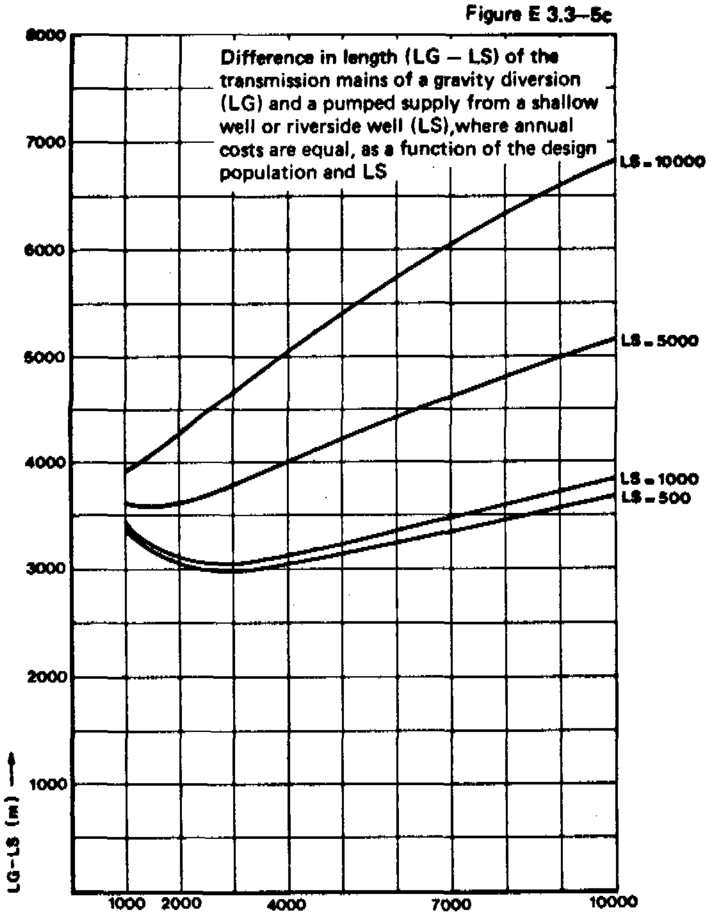


Figure E 3.3–5d

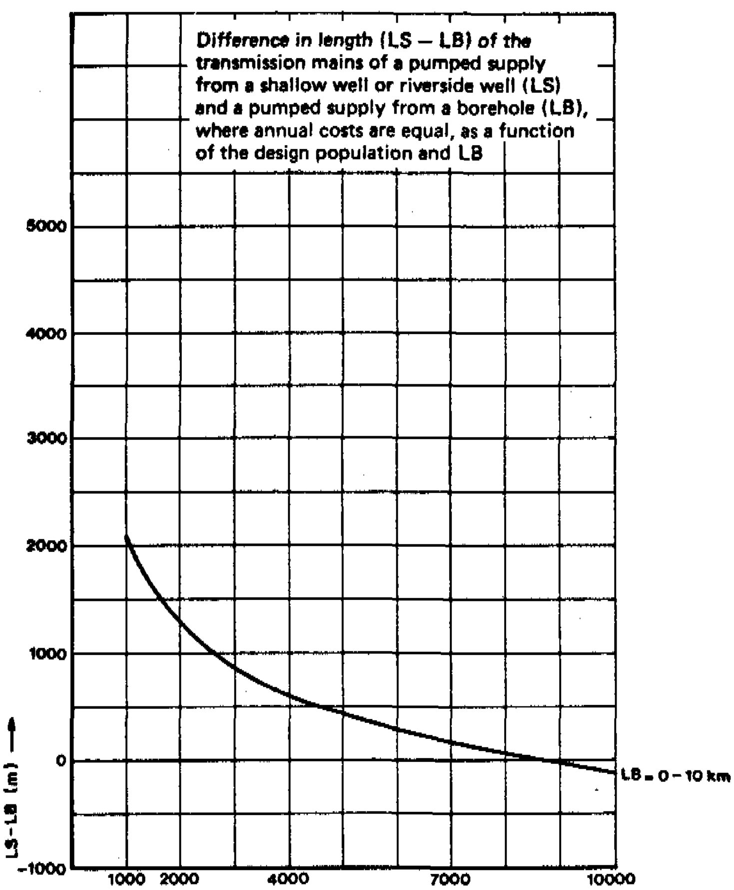


Figure E 3.3-5 Comparison of various village water supply systems at equal annual costs.

3.4. Future village water supply development programmes

3.4.1. Introduction

The water potential in the survey area is reported on in Part C, Hydrology, and Part D, Hydrogeology. Detailed field surveys and regular measurement programmes were carried out to trace suitable and dependable water sources for village water development.
Special attention has been given to the selected problem villages (see Part B), in accordance with the Terms of Reference of the MDWSP survey. The Consultant has undertaken to work out some additional recommendations for the future water supply development of all other villages in the survey area, as long as this does not require surveys and activities largely beyond the scope of the Terms of Reference.
Identification of suitable water sources for individual villages requires due attention to small rivers, streams, springs and very small hydrogeological subareas. Such water sources may have no significance in a larger hydrological or hydrogeological context and yet be essential to alleviate the present constraints to obtaining water for domestic consumption in villages.
The survey area's water potential for village water supply, as identified by the Consultant's Hydrologists and Hydrogeologists, is visualized in various maps. The shallow ground water potential is summarized in Map D4, that of medium depth and deep ground water in Map D3 and the surface water potential is summarized in Map C4.

In the following paragraphs the suitability of these potential water sources for the future village water supply development is discussed. The Consultant describes his recommendations for the phased implementation and exploitation of water supply systems within the context of Tanzania's general objectives and policies in the rural water supply sector. Estimates are given of the cost involvements and manpower requirements for both a short-term crash programme and a medium and long-term water supply development programme. The short-term programme has been primarily aimed at alleviating the current constraints experienced by problem villages.
In addition some recommendations are given for the rehabilitation of existing improved supplies which suffer from regular breakdowns. The medium and long-term programmes have been geared to the gradual improvement of village water supply systems to make them comply with the long-term targets.

3.4.2. Suitable and dependable water sources for village water supply

The MDWSP survey area is rather well endowed with both ground water and surface water resources. In general there are no serious technical constraints to the utilization of these resources for village water supply. In various parts of the survey area several suitable and dependable water sources exist for the development of future village water supply systems. In some villages up to four alternatives may be distinguished for future water supply systems: shallow wells with handpumps, pumped supply from a shallow well or riverside well, pumped supply from a borehole, and supply by gravity diversion.

On the other hand, a number of villages are located in areas where water sources suitable and dependable for village water supply development are virtually absent.
The most important water sources for the various subareas are briefly discussed below.

3.4.2.1 Shallow ground water

The development of shallow ground water resources (up to a depth of 12 m) appears to offer an attractive method to cater for the domestic water requirements of villages in the survey area. A comprehensive field survey, including numerous test drillings and pumptests, was carried out by the Hydrogeological section for the inventory of these shallow groundwater resources (See Part D).
Usually, shallow groundwater occurs in confined aquifers located within the village grounds, or unconfined aquifers in, or along, the riverbeds of (non)perennial rivers with suitable alluvial deposits.
The quality of the shallow ground water in confined aquifers is normally quite satisfactory. In some subareas, however, shallow ground waters with a rather elevated level of mineralisation do occur (see Map D4). It may be assumed that the confined aquifers are bacteriologically safe, provided a suitable water withdrawal structure is utilized. This judgement has been confirmed by bacteriological tests, carried out for a number of shallow wells equipped with Kangaroo pumps (MWCP-Project).
The unconfined aquifers in the survey area have acceptable physical and chemical characteristics, except for some distinct river basins, e.g. the Kibedya river, part of the Berega river, and the Ngerengere river between Kihonda and Ngerengere Township. Unconfined aquifers may be contaminated with pathogenic organisms of faecal origin if no measures are taken to protect a sufficiently large area around a withdrawal point against such contamination. The field survey revealed that hand-dug holes in river beds often suffer from such bacteriological contamination.
From Map D4, it appears that the following areas have conditions suitable for shallow ground water development:

- villages along the Kinyolisi River and along part of the Berega River
- villages along the Turiani - Kilosa - Mikumi road
- villages in the foothills of the E., S.E., and N.W. Ulugurus
- villages along the Ngerengere river, downstream of Ngerengere Township

Various other suitable sites are to be found, dispersed over the whole survey area, at locations where sufficient deposits of alluvial material have created aquifer conditions suitable for ground water withdrawal.

For the majority of the subareas, shallow ground water development programmes for individual village water supplies may make use of handpumps or any type of mechanically driven pumping system. On the other hand, some particular areas, such as the Ngerengere area, have poor aquifer conditions, only suitable for the small withdrawal rate of a hand pump.

3.4.2.2. Medium depth and deep ground water

The Consultant has carried out a comprehensive survey for the inventory of the medium depth and deep ground water resources (see Part D). This survey included an extensive geo-electrical survey and exploratory drilling programme in part of the Wami River basin. Successful boreholes were completed in such a way as to make them suitable water sources for pumped water supplies.
The outcome of this survey is presented in Map D3. It appears that suitable locations for medium depth and deep ground water exploitation may be found in the following areas:

- the major part of the Mkata/Wami basin (medium-depth and deep ground water)
- the plain between the foothills of the Migomberame and Uluguru Mountains, or the area south of Mikumi and Mikumi lodge (medium-depth and deep ground water)
- the foothills of the S.E. Uluguru (medium depth ground water).

The quality of the ground water in these areas is good to excellent, although the elevated carbondioxide content makes the water slightly aggressive towards concrete structures and commonly used pipe materials. In fact, some degree of aeration will be required to remove this aggressivity and to enrich the oxygen-free deep ground water with oxygen (see par. E 3.2.3.).
Alternatively pipe materials and coatings may be applied which are not susceptible to corrosion.
Pumped piped water supply systems are normally most appropriate for the exploitation of medium-depth and deep ground water resources. Occasionally such boreholes may be provided with handpumps if the low yield does not allow higher withdrawal rates.

3.4.2.3. Surface Water

The survey area is rather well endowed with perennial rivers and streams, which offer suitable possibilities for village water supply systems. The field survey and regular measurement programme of the hydrological section included numerous small rivers, streams and springs, which could be useful for village water supply (See Part C).
Comparative analysis of these and existing data produced estimates for the 5% and 10% low flows of such potential surface water sources. The outcomes of this survey are summarized in Map C4.
It may be concluded that suitable sources for surface water supplies mostly occur in the following areas:

- the foothills of all mountains: Nguru, Kaguru, Migomberame and Uluguru Mountains. Numerous perennial streams and rivers emerge from these mountains
- Mountainous areas where small tributaries of major rivers flow throughout the year, especially in the Nguru and Uluguru Mountains
- Parts of the Wami and Ruvu plains were villages are located at reasonable distance from the rivers of the same name

The surface waters have a good quality in the upper parts of the river basins, especially if this part of the catchment area is covered with forest and there is only limited habitation. No substantial treatment will be required, only a suitable sand trap structure and disinfection facilities if a larger group of population depends on the same source.
In the lower parts of the river basins considerable amounts of sediment and bacterial pollution may be carried by the rivers. Such water demands a specific design of the water intake structure, if not some more elaborate treatment facilities.
Utilization of surface water may be realized by means of pumped water supplies or gravity diversions. The hydrological section has paid special attention to the technical feasibility of such gravity diversions. Within the areas with suitable surface water resources for village water supply, the following potential sources for future gravity diversions may be distinguished:

- tributaries of the River Milindo in the Ukaguru forest, for gravity diversion to a large group of villages in Gairo district and the N.W. part of Mamboya district. These villages are located in an area where no suitable groundwater or surface water sources exist (see Maps D3, D4 and C4). The area is one of the main problem areas in the survey area (see Map B1).
  Ten villages in this area are already provided with a gravity water supply, but the system is inadequate as the low flows of its sources are far below the present water demand of the supply area.
- the Rivers Msowero and Tundu, emerging from the Migomberame mountains. Suitable intakes for gravity diversion to five villages in the foothills of these mountains may be found at very short distance from those villages. At present, the population uses traditional ways of obtaining water for domestic purposes. The hydrogeological survey indicates that no possibilities for shallow ground water development exist (see Map D4)
- the River Ngerengere, upstream from Konga - Vikenge.
  Three intakes for gravity diversions already exist in this stretch of the river. The low flows above Konga - Vikenge would allow the construction of new gravity diversions to villages such as Konga - Vikenge and Sangasanga, where possibilities for ground water exploitation are very limited.
  Water from the River Ngerengere, collected in the Mindu dam (under construction), could supply the problem villages in the lower Ngerengere area from the new water treatment facilities for the Morogoro town area.
- the River Msonge, for gravity diversion to Msonge village.
  Exploitation of ground water sources is not considered feasible in this village
- numerous small streams in the mountainous areas where small scale run-of-river systems may be constructed to supply villages or clusters of households. At present these villages obtain water for domestic purposes by traditional methods

- the River Miyombo, for gravity diversion to villages between Nyameni and Zombo - Lumbo. The same area has also suitable possibilities for shallow ground water development programmes
- the Rivers Divue and Mkindo emerging from the Nguru mountains. Gravity diversion may be constructed to villages along the road between Mvomero and Turiani. For the majority of those villages suitable shallow ground water resources also exist for the construction of shallow wells with handpumps
- the River Mvuha, for gravity diversions to six villages in the foothills of the E. Ulugurus: the Tandari - Mtamba - Tambuu triangle
- the River Kisungusi, emerging from the Kaguru mountains. Gravity diversion could serve villages between Kilosa and Mugudeni. For the same villages suitable shallow and medium depth ground water resources exist within the boundaries of the villages.

3.4.2.4 Inventory of water resources development options for village water supply

The findings of the hydrological and hydrogeological sections have been used to indicate which suitable water sources are available for future water supply development for each and every village. This inventory is given in Annex EA 2, Table EA 2-1. It includes data for each village on the technical feasibility of the following alternatives:

1.	Shallow ground water development	: - Shallow wells with handpumps - pumped supply from shallow wells
2.	Medium depth and deep ground water development	: - Pumped supply from borehole
3.	Surface water development	: - Pumped supply from riverside well or other river intake structures - gravity diversion from river intake structure.

This inventory has been used to design future water development programmes for individual villages, or for clusters of villages which could be supplied from one common water source. The procedures followed to select for each village a future water supply system from the several technical alternatives is described in the next paragraph.
The recommended programmes themselves are discussed in Chapter E 4.

3.4.3. Selection of systems from the various water sources development options

The inventory of possible water sources development options, summarized in Table EA 2-1, shows that there are several alternatives for the future water supply of the majority of the villages.

Making a selection from those alternatives of village water supply facilities which fit into both the short-term and medium/long-term water resources development programmes requires a decision game which involves aspects such as:

- the requirements resulting from the Government's targets and policies
- the economic feasibility of each of the various options
- the economic feasibility of a sequence of certain options, when a phased development of the facilities is striven after.

Such a decision game is needed to prevent technical and financial conflicts of interest occurring between the short-term and long-term implementation programmes.

The Consultant's approach to the implementation of piped water supply systems in relation to the Government's targets has been described in par. E 2.3. One of the essential aspects of this approach is the phased development of such piped supplies into two distinct stages. The first stage (short-term) puts emphasis on source development and includes only rudimentary distribution facilities. The second stage (medium/long-term) is mainly concerned with extension of these distribution facilities to various locations inside the village area, providing communal water points at a reasonable distance for all villagers.
Alternatively one can also suggest phased programmes in which the first phase focuses on one supply system, e.g. shallow wells with handpumps and in which the second phase deals with the construction of a pumped water supply system, either pumped or gravity diversion.
The various possible systems for short-term and medium/long-term water development programmes are summarized in Table E 3.4-1. The table indicates which combinations of systems for short-term and medium/long-term implementation are applicable for village water supply and worthy of further investigations.
The matrix of Table E 3.4-1 assumes that, if the first phase includes a piped water supply system, a proper selection is made of a water source for that piped system. The piped system should only be approved if its source is suitable for long-term utilization. Therefore the combinations 2 - 5 and 3 - 5 are not considered, as they imply a poor performance of the original water source. In other words the alternative system No. 2 should have been rejected right from the beginning after a proper field survey.
The combinations 3 - 3, 3 - 7, 5 - 5, 5 - 7 and 7 - 7 are put between brackets because these combinations imply that during the short-term programme systems would be constructed which would be above standard as far as the 1981 targets are concerned. The correct combinations in this respect are 2 - 3, 2 - 7, 4 - 5, 4 - 7 and 6 - 7.
The combinations 2 - 7 and 4 - 7 are rather theoretical but still feasible possibilities. They refer to situations where a village, having no possibilities for shallow wells within the village area and therefore provided with system No. 2 (riverside well) or system No. 4, is located in an area where other villages are given system No. 1 as short-term solution and system No. 7 as long-term solution, since long-term solutions based on system No. 3 and 5 turned out to be impossible in these villages.

Table E 3.4-1. Suitability of various combinations of alternative water supply systems for short-term and medium/long-term programmes in village water supply.

System no.	Alternative systems (short-term)	Targets 1981	Targets 1991	Alternative systems (medium/long-term) 1	2	3	4	5	6	7
1.	Shallow wells with handpumps	A*	A	+	-	+	-	+	-	+
2.	Pumped supply from shallow well or riverside well+rudimentary distribution	A	NA*	-	-	+	-	-	-	(+)
3.	Pumped supply from shallow well or riverside well + extensive distribution	A	A	-	-	(+)	-	-	-	(+)
4.	Borehole supply + rudimentary distribution	A	NA	-	-	-	-	+	-	(+)
5.	Borehole supply + extensive distribution	A	A	-	-	-	-	(+)	-	(+)
6.	Gravity diversion, rudimentary distribution	A	NA	-	-	-	-	-	-	+
7.	Gravity diversion + extensive distribution	A	A	-	-	-	-	-	-	(+)

*) A = Applicable, NA = Not applicable

However the implementation of system No. 7 in the area could also provide suitable long-term alternative for the particular village mentioned above. In the survey area this situation may occur in the area between Mugudeni and Kilosa, or in part of the lower Ngerengere area.

It appears that seven attractive combinations of short-term and medium/long-term development programmes exist. In case the short-term programme consists of shallow wells with handpumps, then the medium/long-term solution may consist of a mere extension of that programme, or alternatively an implementation of piped supplies, such as pumped supply from a shallow well, riverside well or borehole, and gravity diversion. In those areas where shallow wells are not feasible, the short-term solution will consist of a piped supply, either pumped or gravity diversion, with a rudimentary distribution system, and the medium/long-term programme will be geared to the extension of that distribution system.

From the above, it becomes clear that one of the most crucial questions in the decision game is: Whether to reject or choose shallow wells with hand-pumps in those villages where such wells are indeed possible? The matter depends basically on economic criteria (economies of scale) as the shallow well in itself constitutes an acceptable solution for the 1991 targets (see also subpar. E 3.1.1.)
The answer to the question is indicated in Figure E 3.3-5. A comparison of the annual costs of shallow wells and piped supplies with only rudimentary distribution systems shows that gravity diversions may to some extent be more attractive than shallow wells for individual water supplies. Pumped supplies only become more attractive than shallow wells if the transmission mains required are very short.
The long-term targets, however, demand a maximum walking distance of 400 m to a domestic water point. In other words, piped supplies will then have to be equipped with an extensive distribution system resulting in a considerable increase of their annual costs. These total annual costs should be compared to the annual costs of shallow wells. Under such conditions only gravity diversions with very short transmission mains (up to 1 km) and a design population over and above 7000 people have annual costs which are comparable to those of shallow wells.
Pumped supplies with extensive distribution systems will have annual costs considerably higher than those of shallow wells.

In villages where no shallow wells are possible, a choice has to be made between various types of piped water supply systems. It has been stipulated in subpar. E 3.3.3. that, where annual costs are equal, the transmission main of gravity supplies may be some 3 - 7 km longer than that of a pumped supply from a borehole, a shallow well or riverside well, depending on the design population and the required length of the transmission main for those pumped supplies.

In addition, a pumped supply from a shallow well or riverside well may, at equal annual costs, have a transmission main some 2 km longer than the transmission main of a borehole supply, depending on the design population. At higher design populations, the borehole supply will have lower annual costs, under otherwise similar conditions.

In conclusion, the following procedure is recommended:

1. Villages with suitable sites for shallow wells.

1a. Shallow wells are to be constructed in villages with a design population not exceeding 7000 people.

1b. Further investigations are required for villages with a design population over and above 7000 people.

    Again shallow wells will be the appropriate solution, if:
    - no possibilities for gravity diversions exist
    - the transmission main length is over and above 0.5 - 1 km for a gravity system, in each particular case the maximum permissible length of the transmission main depending on the design population

- the population of a large village is so dispersed that the maximum walking distance criterion of the 1991 target (400 m) could only be realized by a relatively expensive distribution system from a piped supply facility.

2. Villages without suitable sites for shallow wells.

2a. A gravity supply is to be selected if the location of the source requires a transmission main length which does not exceed the transmission main length of an alternative pumped water supply by more than 3 - 7 km, depending on the design population.

2b. If a suitable water source for gravity water supply, in accordance with the conditions mentioned in 2a, is not available, a selection is to be made between a pumped supply from a borehole and a riverside well (or shallow well at some distance from the village).
Pumped supply from a riverside well or shallow well deserves preference for a design population not exceeding 8500 people, for equal lengths of the transmission mains.

3. Group supplies.

The guidelines given above are applicable to individual villages. The decision procedure for group supplies requires further investigation of the geographical and topographical layout of the cluster of villages under consideration. The main criterion will again be formed by the relation between total length of transmission main and total design population.
In each particular case expert judgement will be required to take the proper decisions.

Finally, the Consultant wishes to draw attention to the fact that the cost functions applied in the decision procedure described above are subject to certain conditions (e.g. topography) as mentioned in Table E 3.3-14. It is obvious that if conditions deviate significantly from those adopted for the cost functions, a new appraisal of the alternative solutions is required.

4. IMPLEMENTATION PROGRAMMES

This chapter discusses the Consultant's recommendations for a short-term implementation programme and medium/long-term development programmes for village water supply in the survey area.
It describes the recommended water supply improvements for all problem villages, and gives a general picture of the financial resources, manpower and training required to execute the recommended programmes for these villages. The Consultant has undertaken to design similar programmes for the future water supply of all other villages in the survey area. Estimates are given of the number of each of the various village water supply systems involved in such an extensive programme, and again a general picture of the required financial resources and manpower is given.

4.1. Short-term implementation programme

4.1.1. Water supply improvements for problem villages

The villages where problems are experienced in the present domestic water supply condition are described in Part B, Table B 4.3-1.
On the basis of the data from the hydrological and hydrogeological sections (see Parts C and D) on the water resources potential for village water supply, and the procedure for the selection from alternative systems described in subpar. E 3.4.3, short-term improvements have been recommended for each of these villages.
The recommendations are summarized in Table E 4.1-1. The outcomes for each village separately are listed in Table E 4.1-2.

Table E 4.1-1 Summary of recommended village water supply improvement programme for problem villages.

Type of system	No. of systems	No. of villages	No. of population (1978)
Shallow wells with handpumps	403 [1])	50	84,986
Gravity diversion	2	16	28,255
Pumped supply from shallow well or riverside well	7	7	9,066
Pumped supply from borehole	9	9	17,538
Totals		82	139,845

[1]) excluding 24 SWHP in those villages where borehole supplies will be installed in due course

Table E 4.1-2 Recommended village water supply improvement programme for problem villages

Village/Division		Population 1978	Village score	Potential water supply systems						Recommended short-term implementation programme	Remarks
				SWHP	SWP	RP	BH	G	Surface water source		
Bwakira Juu	Bwa	2020	12	+		(+)			Bwakira R.	SWHP: 10(Nos)	
Chakwale	Gai	4416	12				+		Milindo T.	G.	Gairo gravity scheme
Chanyumba	Nge	2272	12	+	+					SWHP: 11;	
Chanzuru	Mas	2297	12	+	+		+			SWHP: 5[1]); BH + 2 km + SRD	[1]) for part of village
Dakawa	Bwa	1871	12	+[2])		+	+		Mgeta R.	BH[2]) + 2 km + SRD	[2]) medium depth
Difinga	Tur	461	12	+[3])						SWHP: 2	[3]) RSW's along Lusonge R. (2 km)
Diguzi	Nge	868	12	+	+	+			Ngerengere R.	SWHP: 4	
Dihinda	Tur	1267	14	+	+					SWHP: 6	
Dumila	Mam	2606	12			+	+	(+)[4]	Mkundi R.	BH + 2 km + SRD	[4]) Kisungusi R.
Fulwe	Nge	2212	13	(+)				+[5]	Ngerengere R.	(SWHP: 11)[5])	[5]) Alt.: G. from Upper Nger. R.
Gairo	Gai	5008	12					+	Milindo T.	G.	Gairo gravity scheme
Gomero	Bwa	2842	14	+		+			Mgeta R.	SWHP: 14	
Ibindo	Mam	1558	12	+		+			Berega R.	SWHP: 8	
Ibuti	Gai	1245	12					+	Milindo T.	G.	Gairo gravity scheme
Idibo	Gai	2715	12	+		+			Magera R.	SWHP: 14	
Ihenje	Gai	1483	14					+	Milindo T.	G.	Gairo gravity scheme
Ilakala	Ula	1502	14	+	+			+	Miyonbo R.	SWHP: 8	
Iyogwe	Gai	2856	12	+		+			Kinyolisi R.	SWHP: 14	
Kambala	Tur	1009	12	+	+			+	Mkindu R.	SWHP: 5	
Kibedya	Gai	3271	12					+	Milindo T.	G.	Gairo gravity scheme
Kidogobasi	Mik	3424	12	+	+		+			SWHP: 5[1]); BH + 2 km + SRD	
Kidudwe	Tur	2183	12	+	+					SWHP: 11	
Kiegea	Mam	1217	12					+		G.	Gairo gravity scheme
Kihonda	Nge	1707	13			+		+[5])	Ngerengere R.	RP + 1 km + SRD[5])	
Kilama	Gai	800	13			+				RSWP + 5 km + SRD	Alt.: resettlement
Kinonko	Nge	651	12	(+)				+[5])	Ngerengere R.	(SWHP: 3)[5])	
Kiroka	Mat	3327	13	+		+	+	+	Kiroka R.	SWHP: 17	
Kisemu	Nge	966	12	(+)			+			(SWHP: 5)[6])	[6]) Alt.: borehole
Kitaita	Gai	624	13					+	Milindo T.	G.	Gairo gravity scheme; Alt.: resettlement
Kitete	Mam	1171	12	+		+	+		Kitete R.	SWHP: 3[1]);BH + 2 km + SR	
Kiwege	Nge	937	14	(+)				+[5])	Ngerengere R.	(SWHP: 5)[5])	
Kiziwa	Mat	2210	13	+		+	+	+	Kiroka R.	SWHP: 11	
Kondoa	Mas	1021	12	+	+		+			SWHP: 3[1]);BH + 2 km + SRD	
Kunke	Tur	1326	12	+	+					SWHP: 7	
Leshata	Gai	2285	13	+	+	+			Magera R.	SWHP: 11	
Lubungo	Nge	967	14	(+)				+[5])	Ngerengere R.	(SWHP: 5)[5])	
Luhindo	Tur	812	10			+	(+)[7]		Wami R.	BH[7]) + 4 km + SRD	[7]) supply from Dakawa borehole
Lukobe	Nge	1380	13	+	+	+			Ngerengere R.	SWHP: 7	Alt.: B.T.S. project
Mabula	Mam	1069	12	+		+			Kinyolisi R.	SWHP: 5	
Machatu	Mam	829	14					+	Milindo T.	G.	Gairo gravity scheme
Madege	Gai	2050	16	+		+				SWHP: 10	
Madizini	Tur	2443	13	+		+			Diwale R.	SWHP: 12	
Madudu	Mam	1296	12	+	+		+			SWHP: 6	
Magubike	Mam	2919	14	+		+			Mamboya R.	SWHP: 15	

Table E 4.1-2 (continued)

Village/Division		Population 1978	Village score	Potential water supply systems						Recommended short-term implementation programme	Remarks
				SWHP	SWP	RP	BH	G	Surface water source		
Maharaka	Mla	1840	13	+		+			Maraka R.	SWHP: 9	
Makuyu	Gai	2089	12	+		+			Kinyolisi R.	SWHP: 10	
Mandela	Mam	1643	12	+			+			SWHP: 2[1]);BH + 2 km + SRD	
Manza	Mla	580	12	+		+			Manza R.	SWHP: 3	
Maseyu	Mge	1216	13	(+)				+[5])	Ngerengere R.	(SWHP: 6)[5])	
Matuli	Nge	2061	12	+		+			Ngerengere R.	SWHP: 10	
Mbigili	Mam	2555	12			+	(+)		Mkundi R.	RSWP + 2 km + SRD	in future: extension to Mabana
Mbili	Mam	821	12					+	Milindo T.	G.	Gairo gravity scheme
Meshugi	Gai	1240	13					+	Milindo T.	G.	Gairo gravity scheme
Mfulu	Mam	1016	12	+	+		+			SWHP: 5	
Mirama	Tur	1248	12	+	+		+			SWHP: 6	
Mkalama	Gai	1436	13					+	Milindo T.	G.	Gairo gravity scheme
Mkambarani	Nge	564	12	(+)				+[5])	Ngerengere R.	(SWHP: 3)[5])	
Mkonowamara	Nge	623	13			+		+[5])	Ngerengere R.	RP + 1 km + SRD[5])	
Mkulazi	Nge	602	10	(+)		+			Mkulazi R.	(SWHP: 3)[8])	[8]) Alt.: RSWP+4 km+SRD
Mkundi	Mam	814	12	+		+			Mkundi R.	SWHP: 4	
Mkundi	Nge	685	12	+	(+)					SWHP: 3	
Mlilingwa	Nge	474	11	(+)				+[5])	Ngerengere R.	(SWHP: 2)[5])	
Msonge	Bwa	1085	10			+	(+)	+	Msonge R.	G. + 4 km + SRD	
Mtamba	Mat	3160	12	+				+	Mtamba S.[9])	SWHP: 10	[9]) or Mvuha R.
Mtumbatu	Mam	1588	13					+	Milindo T.	G.	Gairo gravity scheme
Mugudeni	Tur	1187	13	+	+			(+)[4])		SWHP: 6	
Muhenda	Ula	1978	15	+	+			+	Miyombo R.	SWHP: 10	
Mwandi	Mam	2558	12	+		+			Berega R.	SWHP: 13	
Ngerengere	Nge	3753	12	+	+	+			Ngerengere R.	SWHP: 8	
" Dar.	Nge	1384	12	(+)				+[5])	Ngerengere R.	(SWHP: 7)[5])	
Ngiloli	Gai	1000	11					+	Milindo T.	G.	Gairo gravity scheme
Nguyami	Gai	1792	14					+	Milindo T.	G.	Gairo gravity scheme
Nyarutanga	Bwa	1685	13	+		+			Mgeta R.	SWHP: 8	
Rudewa Batini	Mas	2693	12	+	+	+	+	+[4])	Wami R.	SWHP: 6[1]);BH +2 km + SRD	
Rusanga	Tur	2897	12	+	+			+	Mjonga R.	SWHP: 14	
Sagasaga	Nge	887	12	(+)			(+)[11])			(SWHP: 4)	[11]) 10 km from village; Alt.: resettlement
Sangasanga	Mla	776	12	(+)				+[10])	Ngerengere R.	(SWHP: 2)[1]);G.	[10]) with Konga-Vikenge
Seregete A	Nge	380	13			+			Ngerengere R.	RSWP + 5 km + SRD	Alt.: resettlement
Seregete B	Nge	683	12			+			Ngerengere R.	RSWP + 5 km + SRD	Alt.: resettlement
Tabu Hotel	Gai	1200	13					+	Milindo T.	G.	Gairo gravity scheme
Tindiga	Mas	3941	13	+	+	+	+		Mkondoa R.	SWHP: 20	
Tungi	Nge	2318	14			+		+[5])	Ngerengere R.	RP + 1 km + SRD[5])	

LEGEND:
BH = Borehole
G = Gravity
RD = Rudimentary distribution system
RP = pumped supply from river
RSWP = pumped supply from riverside well
S = storage tank
SWHP = shallow well with handpump
SWP = pumped supply from shallow well
BH + 2 km + SRD = borehole supply with transmission main of 2 km, storage tank and rudimentary distribution facilities
\+ = suitable conditions for that particular supply system
(+) = doubtful conditions for that particular supply system

It can be seen from Table E 4.1-1 that the large majority of the problem villages can be provided with shallow wells with handpumps. The second most important group is gravity diversion for the problem villages where shallow wells or other means of ground water exploitation are not possible. The proposed Gairo gravity scheme is by far the largest scheme of the proposed short-term implementation programme. It includes 15 seriously hit problem villages and 10 other villages in the Gairo area.
Pumped supplies from surface water sources are provided to a limited number of villages for which neither shallow or deep wells nor gravity diversion are feasible solutions.
Pumped supplies from a borehole will be offered to those problem villages where successful boreholes were constructed by Maji, or by MDWSP during the hydrogeological survey for the deep groundwater resources. (see Part D).
At present, some of these villages are also being provided with some shallow wells within the framework of the MWCP-project, as the completion of the boreholes may take another 2 years.

4.1.2. Rehabilitation of existing piped supplies

A description and appraisal of the existing piped water supply systems is given in Part B, subpar. B 3.1.3.
Table B 3.1-4 indicates that the majority of the existing piped water supplies from rivers suffer from serious drawbacks such as poor water intake structure, limited capacity and regular operation and maintenance problems.

The Consultant is of the opinion that the performance of these piped supplies can be improved a great deal by some rehabilitation works, covering the water intake structure and an overhaul of the pumping equipment. Once the water intake structure produces enough water of good quality (e.g. free of sand and suspended matter), the number of breakdowns of the pumping equipment and other parts of the transmission and distribution system may significantly drop below their present level. Some systems will also require increase of capacity. Such activities however are considered to be part of a medium-term programme as they will in most of the cases also include extensions to the distribution systems.
The Consultant's recommendations for rehabilitation works which should be included in the short-term implementation programme cover the following existing piped supply systems: Turiani/Kilimanjaro, Lukenge, Mvumi, Msowero, Kivungu, Kilangali, Berega, Mlali/Kipera and Kiswira. The rehabilitation programme should consist of the construction of new intake structures, such as riverside wells, or a direct water intake combined with a sandtrap or sedimentation unit (see subpar. E 3.2.3), and the overhaul of pumping units (see Table EA 2-1).
The programme should be supported by an appropriate training course (including on-the-job training) for pump attendants to make them more familiar with operation and maintenance, trouble shooting and repair of pumping equipment.

Rehabilitation of existing supplies is also proposed for some villages which are provided with run-of-the river gravity diversions from River Mgolole. It is recommended to provide the villages concerned, Kitungwa and Legezamwendo, with a storage tank and communal water distribution facility so as to secure a more reliable water supply to these villages. Another village, depending on River Mgolole, Kisinga, is only provided with a distribution line from the Pangawe storage tank and it is proposed to construct a storage tank with communal water distribution facility in this village to improve the reliability of its supply.

4.1.3. Additional components of short-term implementation programme

The proposed Gairo gravity scheme includes 10 more villages which are located in the same supply area. These villages were not selected in the category priority I of problem villages, but still regularly experience problems in their domestic water supply conditions (see Map B1). No suitable hydrogeological conditions for shallow wells exist in those villages. See Table EA 2-1.

Some of the Maji and MDWSP boreholes are located in the category priority II villages and were therefore not considered in subpar. E 4.1.1. The Consultant recommends that the waterworks required for the exploitation of those five boreholes be included in the short-term implementation programme.

The Maji department has recently completed designs for gravity diversions to some villages in the Upper Ngerengere area (Sangasanga, and Konga-Vikenge), and the Mgolole area (Misongeni). These designs are briefly described in Table E 3.1-4. It is recommended to incorporate these projects in the short-term implementation programme, as they considerably improve the water supply condition in the villages concerned at relatively low costs. No suitable conditions for shallow wells exist in these villages. See Table EA 2-1.

Table E 3.1-4 lists Maji designs of piped water supplies for some other problem villages in the survey area. The Consultant's recommendations as given in Table E 4.1-2 show that for the majority of those villages the far cheaper shallow wells are proposed as alternative water supply system, in accordance with the approach described in subpar. E 3.4.3. In problem villages where shallow wells are not possible, piped supplies similar to the Maji designs have been suggested. Exceptions have been made for Kibati and Lukobe, since budgets for the construction of piped water supplies in these villages have already been secured from donor organizations.

Another gravity diversion scheme is proposed for 5 villages in the foothills of the Migomberame mountains. These villages, Msowero, Iwemba, Tundu, Kifinga and Ruaha at present use the traditional ways to obtain water for domestic purposes. No suitable hydrogeological conditions exist for the construction of shallow wells, whereas the proposed gravity diversion from River Tundu can be constructed at relatively low costs due to the short length of the transmission main.

The hydrogeological survey indicates that in some 98 other villages in the survey area conditions are suitable for exploitation of shallow ground water by means of shallow wells with handpumps (see Map D4). It is recommended to include all those villages in the short-term implementation programme, as Morogoro Region is now provided with all the facilities required for an extensive shallow well construction programme. Execution of this additional shallow well programme will require an extension of the current MWCP project (see subpar. E 4.1.7)

Finally, the lower Ngerengere area between Kihonda and Ngerengere is considered to be an area where the suitability of shallow wells is doubtful. The hydrogeological section has carried out extensive field surveys in the area (see Part D), and has opted for the construction of a few shallow wells in each of the problem villages in that area within the scope of the MWCP project. The performance of these wells during the dry season will be closely observed. The full number of shallow wells required in each problem village will be constructed once it is established that this is a viable undertaking. A possible poor performance of the shallow wells, on the other hand, will require the set up of an alternative water supply system for that area. The Consultant then recommends the construction of a gravity water supply scheme to 13 villages in the affected area from the future waterworks at the Mindu Dam site (see Table E 4.1-2). Once this gravity scheme is decided on, it should become part of the programmes which require implementation shortly, as the villages concerned are problem villages.

4.1.4. Summary of the proposed short-term implementation programme

The previous paragraphs have described the various components of the proposed short-term implementation programme. The programme contains village water supply schemes for 82 problem villages, rehabilitation of existing piped supply schemes for 14 villages, shallow wells for 98 villages and various village water supply schemes for another 24 villages. This latter group includes gravity water supply to 10 villages in the Gairo area as part of the proposed Gairo gravity scheme, gravity diversion to 3 villages in the Upper Ngerengere and Mgolole area, gravity diversion to 5 villages in the foothills of the Migomberame mountains, pumped water supply from a borehole for 4 villages in the Wami basin area, and pumped supplies from a riverside well for 2 villages. A summary of all villages concerned is given in Table E 4.1-3.

4.1.5. Cost estimates

The investment costs required for the execution of the various components of the proposed short-term implementation programme have been estimated by using the cost functions given in Table E 3.3-14 for individual village water supplies. Separate cost estimates have been made for the proposed group water supply schemes.
The estimated Investment costs and Operation and Maintenance costs for the proposed short-term implementation programme are summarized in Table E 4.1-4.

Table E 4.1-3 Summary of the proposed short-term implementation programme

Programme components	Villages		Remarks
	Nos	Names	
1. *Improvement programme for problem villages*	*82*	*See Table E 4.1-2*	*Type of system* — *No. of systems* — *No. of villages* Shallow wells with handpumps — 403 * — 50 Gravity diversion — 2 — 16 Pumped supply from shallow well or riverside well — 7 — 7 Pumped supply from borehole — 9 — 9
2. Rehabilitation programme - pumped supplies	11	Turiani/Kilimanjaro, Lukenge, Mvumi Msowero (Mas), Kivungu, Kilangali Berega, Mlali/Kipera, and Kiswira	Rehabilitation of intake structure and overhaul of pumping equipment
- gravity diversions	3	Kitungwa, Legezamwendo, Kisinga	Construction of storage tanks and some rudimentary distribution facilities (see Table EA 2-1)
3. Additional programmes - gravity diversions	10	Ikwamba, Kisitwe, Kitange I, Kitange II, Kwipipa, Luhwaji, Majawanga, Msingise, Rubeho, Ukwamani	Part of Gairo gravity scheme, see Table EA 2-1
	2	Konga/Vikenge, Sangasanga	Upper Ngerengere scheme, see Tables E 3.1-4 and EA 2-1
	1	Misongeni	see Tables E 3.1-4 and EA 2-1
	5	Msowero, Iwemba, Tundu, Kifinga, Ruaha	Tundu gravity supply scheme, see Table EA 2-1
- pumped supply from a borehole	4	Dakawa-Wami, Dibamba, Makuyu (Tur), Mbwade (Mas)	MDWSP boreholes constructed during hydrogeological survey, see Table EA 2-1
- pumped supply from a riverside well	2	Lukobe, Kibati	See Tables E 3.1-4 and EA 2-1
- shallow wells	98	See Table EA 2-1	Construction of 726 shallow wells
4. Lower Ngerengere gravity scheme	13**	Kihonda, Tungi, Mkambarani, Mkonowamara, Fulwe, Lubungo, Maseyu, Ngerengere Darajani, Mikese, Muhungamkola, Kinonko, Kiwege, Mlilingwa	This gravity scheme is proposed as an alternative to a shallow well construction programme, if practical experience shows that shallow wells do not offer a dependable solution.

* Excluding 24 SWHP in those villages where borehole supplies will be installed in due course (see also Table E 4.1-2)

** These villages are included in the improvement programme for problem villages (see remark).

The cost estimates cover the investment costs for the construction of the various waterworks facilities, and do not include cost components such as survey and design, establishment of transport and workshop facilities, and technical overheads.

Table E 4.1-4 Estimated investment costs and operation and maintenance costs of the proposed short-term implementation programme (1978 - Price Level)

Facilities	Investment Costs (IC)	Annual O & M Costs	
	Tshs	Tshs	% of IC
Shallow wells (problem villages)	7.6×10^6	0.53×10^6	7 %
Shallow wells (other villages)	12.8×10^6	0.90×10^6	7 %
Gravity diversions	32.8×10^6	0.68×10^6	2 %
Pumped supplies (SW or RSW)	3.3×10^6	0.18×10^6	5.5%
Pumped supplies (borehole)	6.6×10^6 1)	0.45×10^6	5.5%
Rehabilitation of existing pumped supplies	0.9×10^6	pm	
Totals	64.0×10^6	2.70×10^6 2)	-

1) exclusive Tshs 1.3×10^6 for the construction of 12 boreholes (already completed)

2) exclusive O & M costs of those existing supplies which are incorporated in the rehabilitation programme.

Note: cost estimates are based on schemes with only rudimentary distribution facilities.

It can be concluded that the investment costs of the proposed short-term implementation programme are about 64 million shillings at the price level of 1978.

The total investment budget which will be required if the recommended programme is executed during a six year period (1979 - 1984), may be estimated using the following formula:

$$C_t = \sum_{n=1}^{6} C_o/6 \times (1 + r)^n$$

where: C_t = total investment budget required (Tshs)

C_o = investment budget required, based on the 1978 price level (Tshs)

r = rate of overall yearly price increase (%/100)

It can be calculated that the total investment budget required will amount to Tshs 90.6 million at a yearly price increase of 10%, and to Tshs 107.4 million at a yearly price increase of 15%.
The annual O & M costs will be in the order of 3 - 5 million shillings, once the schemes are implemented. This will require a four to six-fold increase of the Maji Office's budget for O & M costs, including the extra funds which would be required to carry out proper O & M of the existing improved supplies (See subpar. E 3.1.4.).

The investment costs for the Ngerengere gravity scheme, recommended as an alternative solution for villages in the lower Ngerengere area if shallow wells turn out not to be suitable, are estimated at 17 million shillings (for rudimentary distribution facilities), at the 1978 price level.

4.1.6. Manpower requirements

Estimates of the manpower requirements for the labour force required for the execution of the short-term implementation programme may be based on the average value of daily production for different construction activities. The values relevant to the proposed programme are summarized in Table E 4.1-5.

Table E 4.1-5 Average value of daily production for different construction activities, executed by unskilled and semi-skilled craftsmen (1978 price level)

Activity	Average value (Tshs)	Source
Civil works (reservoirs, pumphouses, etc)	100 shs/employee/day	RWE's office
Construction of pipelines and general mechanical works	200 shs/employee/day	RWE's office
Construction of simple village water supply schemes	170 shs/employee/day	MDWSP estimate
Construction of shallow wells with handpumps (including production of handpumps)	150 shs/employee/day	SSWP and MWCP projects

The average manpower requirements in terms of technical staff for surveys and investigations, designs, and supervision of the construction works are estimated at 10% of the labour force.

A summary of the total estimated manpower requirements for the proposed short-term implementation programme is given in Table E 4.1-6. These estimates are based on the assumptions given above. In addition, it is assumed that each year contains 250 effective working days.

Table E 4.1-6 Estimates of manpower requirements for the execution of the proposed short-term implementation programme

	Investment costs (Tshs)	Implementation period	Manpower requirements (persons)	
			Labour force	Technical staff
Shallow wells	20.4×10^6	6 years	91	9
Gravity diversion schemes	32.8×10^6	3.5 years	220	22
Pumped supplies (SW; RSW)	3.3×10^6	2 years	39	4
Borehole supplies and rehabilitation of existing pumped supplies	7.5×10^6	2 years	88	9
TOTAL	64×10^6	-	438	44

It appears that some 480 people are required to execute the recommended programmes. From Table E 3.1-3 it can be concluded that the construction sections of the Maji Department is, with its present labour potential, not able to fulfil these manpower requirements. Although part of the labour force can be established by temporary employment of unskilled labourers recruited among the population of the villages concerned, a substantial amount of (semi)skilled labour will still have to be attracted from other sources to ensure acceptable standards of work.
The Consultant, therefore, recommends the setting up of a new temporary organization, in close co-operation with the Maji Department, which employes semi-skilled and skilled labour recruited among the regional or national labour potential.
A similar approach is recommended for the highly qualified manpower required for the technical management and supervision of the construction works. It is proposed that the Maji Department approaches bilateral or multilateral aid organizations for the temporary enrolment of design and construction engineers to implement the programmes and to train sufficient local manpower for the proper follow-up of the programmes once they are implemented. Some aspects of such training programme will be discussed in subpar E 4.1.8.

4.1.7. Recommended procedures for the realization of the proposed short-term implementation programme

The implementation of the proposed short-term programme requires careful planning of the execution of the different activities involved in the various components of the programme.

These activities include:

- detailed hydrogeological surveys for the siting of suitable shallow well locations, taking into account other factors such as village layout and population distribution within the village
- detailed hydrogeological surveys for the siting of suitable locations for the construction of intake wells along river beds as part of the proposed rehabilitation and pumped water supplies programme
- detailed topographical surveys for the design of transmission mains, reservoirs and distribution works of various proposed piped water supply schemes
- procurement of sufficient stocks of equipment and materials to secure an uninterrupted execution of the works
- enrolment of appropriate manpower at various levels, and acquisition of sufficient financial resources for the implementation of the proposed programmes
- provision of facilities for manpower development, training, transfer of technology and on-the-job training.

The Consultant is of the opinion that part of the survey activities, in particular for small separate schemes such as shallow wells and piped water supplies for individual villages, can best be carried out on a basis of day to day engineering. Such an approach requires the setting up of a sufficiently skilled and independent survey crew, but it will result in considerable savings in terms of time and costs. This survey group should be considered as a support group for the construction crews, and its work schedule should enable an uninterrupted implementation of the construction works.

The various parts of large schemes such as the proposed Gairo and Tundu gravity schemes are largely interdependent, and smooth running and operation of these schemes can only be secured if the systems are based on a detailed hydraulic design of all their components. Such schemes, therefore, require the full completion of survey and design activities before the procurement of equipment and materials, and the construction itself can start.
The survey team should produce all relevant design and construction drawings and specifications required for the execution of these gravity diversion schemes.

The recommended procedures for the execution of each of the programme components are discussed in brief below.

4.1.7.1. Shallow wells: The Morogoro Wells Construction Project

The Shinyanga Shallow Wells Project provides a good example of the procedures according to which shallow wells may be constructed under Tanzanian circumstances.
A similar programme, the Morogoro Wells Construction Project, was started in the survey area in September 1978 as part of the Dutch bilateral aid programme. This project should be considered as a first follow up programme of the Morogoro Domestic Water Supply Plan, and during the period that both

projects were running simultaneously a fruitful co-operation existed between them (see also Part D). The MWCP has secured its own premises containing facilities such as offices, workshops, rolling stock, stores, a vehicle maintenance and repair unit, and has at present an enrolment of about 80 employees.
The Terms of Reference of the MWCP call for the construction of 550 shallow wells in Morogoro Region in a period of two years. An essential aspect of the project is the training of siting and construction crews that can execute shallow wells programmes for Maji Departments in various regions in Tanzania.
The proposed short-term implementation programme recommends the construction of 427 shallow wells in 56 problem villages, and 726 shallow wells for other villages in the survey area, giving a total of 1156 shallow wells for the survey area for the next 5 years. In accordance with the Terms of Reference of the MWCP, part of the first 550 shallow wells will have to be constructed in the southern part of Morogoro Region (the Kilombero and Mahenge Districts). A first estimate of the total number of shallow wells required for this southern part may be based on the percentage of the region's rural population living in this part of the region. This is estimated at 25%, and therefore it may be taken that about 385 shallow wells are to be constructed in the Kilombero and Mahenge Districts. For a more accurate estimate a detailed hydrogeological survey will be required. In other words, some 1540 shallow wells are required in the Morogoro Region, assuming a design period of 5 years.
It is recommended to extend the MWCP by at least two years to assure the completion of the major part of these 1540 shallow wells during the next 5 years, and to enable construction crews to obtain sufficient experience so that the shallow well programme can be successfully continued afterwards. See also Figure E 4.1-4.

The MWCP should first focus its attention on the identified problem villages, although it may occasionally be more favourable in a specific area to complete the work in all villages where suitable conditions for shallow wells exist. Is is Government policy that those problem villages should be provided with dependable water sources, e.g. shallow wells, by the year 1981.

4.1.7.2 Large gravity schemes: The Morogoro Gravity Plan

The proposed gravity schemes for the Gairo area and the villages in the foothills of the Migomberame Mountains (the Tundu gravity scheme) require various survey, design, costing and planning activities before their construction can be started. It is recommended to establish a special survey team for these two gravity projects, with the task of preparing detailed design and construction drawings complete with technical specifications, bills of quantities, and cost estimates. The Terms of Reference of such a "Morogoro Gravity Plan" should include the following activities:

- project preparation
  Existing topographical maps and aerial photographs are to be processed to produce topographical maps (preferably scale 1 : 20,000) that will enable the establishment of a limited number of alternative alignments for the gravity mains to the supply areas.

- field surveys
  The field surveys should start with a general survey to select the most appropriate alignment for the gravity main.
  Subsequently a detailed topographical survey has to be carried out along the selected alignment and a geotechnical survey should be executed to investigate the soil conditions and to establish the possible occurrence of land slides.

- design
  The schemes should be planned for a design period of 20 years, and the designs should include alternative distribution facilities as proposed for the phased implementation of piped water supplies (see par. E 2.3). Recommendations and designs should be given for the phased incorporation of simple treatment works such as sedimentation, filtration and/or disinfection to make sure that the distributed water meets the quality standards as set by the Tanzanian Authorities. The alignment of mains and distribution lines should be drawn up on maps with a scale of 1 : 20,000. Longitudinal profiles of the pipelines are to be presented at a scale of 1 : 5000, and detailed drawings of construction elements such as intakes, reservoirs, crossings, connections and domestic water points are to be given at a scale of 1 : 100. It is recommended to make the maximum possible use of the current standard designs of the Maji Department for construction elements such as reservoirs and domestic water points. The designs of the various waterworks components should be adopted to locally available materials and skills.

- tender documents
  The essential data for the execution of the works are design and construction drawings, technical specifications and bills of quantities. However if the services of a contractor should be required to enable the completion of the projects within a reasonable period of time, than tender documents will also be required to define clearly the duties of the contractor. It is therefore recommended to include in the Terms of Reference the preparation of tender documents for one tender holding different groups of works (lots). In the course of the project it should be defined which project components can be executed by the Maji Department, and which project components require the establishment of tender documents.

- cost estimates
  Cost estimates for the construction of the designed schemes can be drawn up on the basis of unit costs of construction components on the one hand and bills of quantities on the other hand. These cost estimates are essential for the procurement of sufficient financial resources required for the implementation of the proposed schemes.

It is estimated that the survey described above will require a period of about one year provided the services of 3 - 4 experienced surveyors and design engineers are available.
The time planning of the survey should be such that the field survey can be completed during the dry season, i.e. between May and November. The recommended barchart of activities for the Morogoro Gravity Plan is given in Figure E 4.1-1, and the barchart of personnel is presented in Figure E 4.1-2.

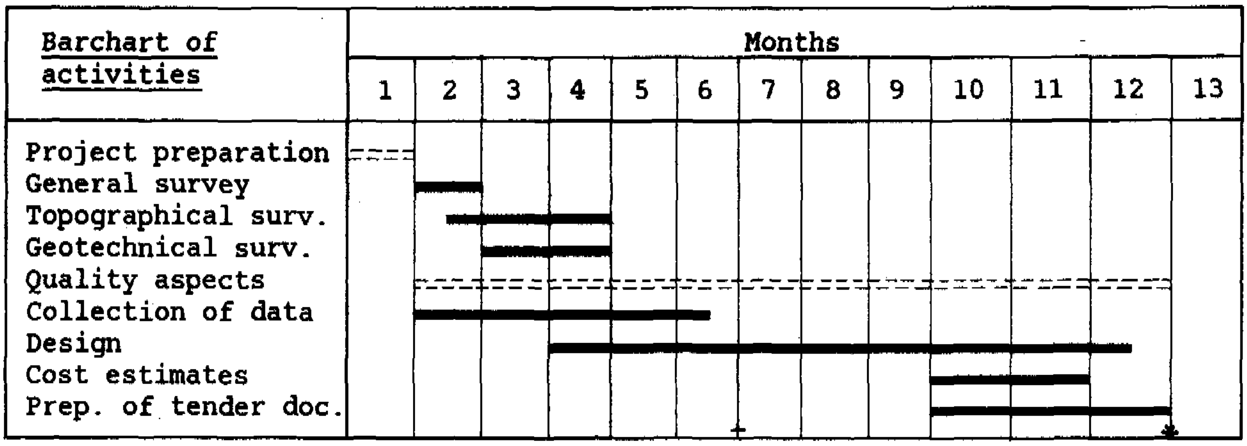
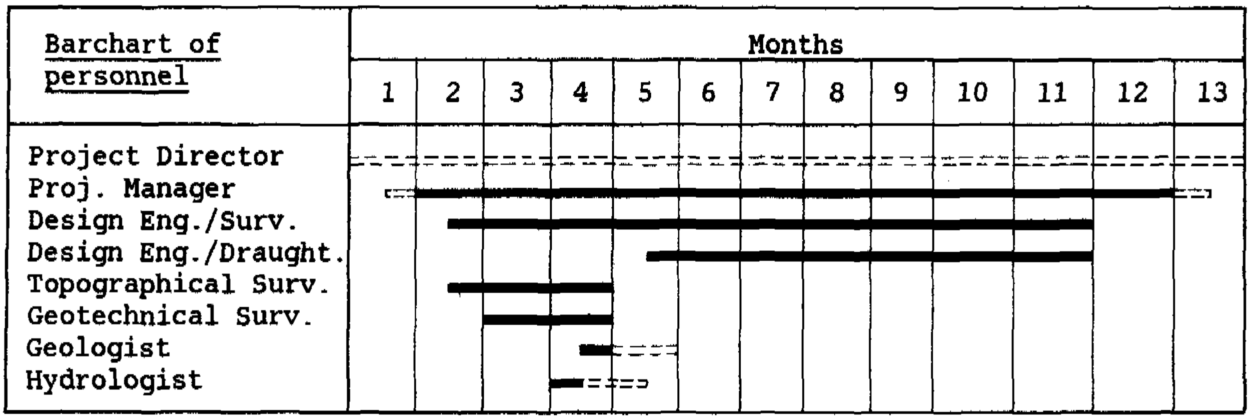


Figure E 4.1-1 Proposed barchart of activities for Morogoro Gravity Plan



+ Report of the surveys
* Final report: design, drawings, tender documents

Figure E 4.1-2 Proposed barchart of personnel for Morogoro Gravity Plan

The proposed Gairo gravity scheme is to supply water to a number of seriously hit problem villages. It is therefore recommended to proceed with the implementation of the scheme as soon as the survey has been completed, and sufficient financial resources have been secured. The manpower enrolment should be such that the construction works will not take more than 3 years, so that the delay in realizing the 1981 targets for the villages concerned is limited to a minimum. The proposed construction period is indicated in Figure E 4.1-4.

An aspect which deserves some special consideration is the provision of livestock watering facilities. The hydrological data collected during the MDWSP survey indicate that the water sources selected for the Gairo gravity scheme have sufficient base flows (in particular, 5% low flows) to cater for the domestic water demand of the supply area for the next 20 years. However, extensive stock herding activities are practised in the same area, and the significant additional livestock water demand cannot be catered for by the sources available for the scheme.

Government policy calls for livestock watering facilities based on rain-water reservoirs constructed by means of small dams. The MDWSP study has carried out a general study on the feasibility of such small reservoirs in the Gairo area (see Part C), but more detailed studies and various meetings with the District's and Regional authorities will be required to arrive at the most appropriate solution for this issue.

The proposed Tundu gravity scheme covers 5 villages where at present slight to moderate problems are experienced in the domestic water supply conditions. Its inclusion in the Morogoro Gravity Plan is recommended because of the availability of the MGP survey team, whose manpower and equipment can be utilized to carry out the survey for the Tundu scheme at minimum costs. Moreover, the conditions in this supply area are not suitable for shallow wells. Hence, the proposed, and financially attractive, gravity scheme is considered to be an appropriate solution in the framework of the fulfilment of the 1991 targets. It may be concluded from the above that implementation of the scheme may be delayed by a few years, and it is therefore recommended to start construction works at the completion of the proposed Gairo gravity scheme. See Figure E 4.1-4.

The recommended programme for the water supply improvements of problem villages includes one more gravity scheme. This scheme, for Msonge village, is a relatively small scheme for one single village, and it is considered most appropriate to include this scheme in the proposed "Morogoro Piped Water Supplies" project (see below).

4.1.7.3. Borehole schemes and rehabilitation programme: The Morogoro Piped Water Supplies Project

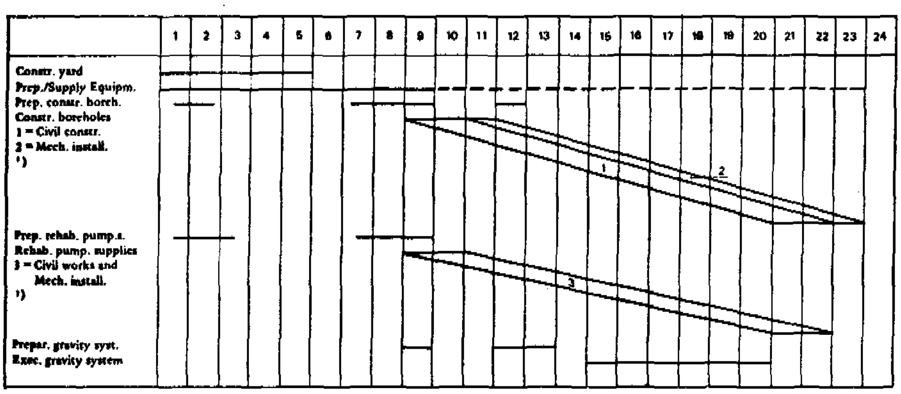
The recommended short term implementation programme includes construction works for a number of piped water supplies. For part of these schemes designs have already been completed by RWE's office, financial resources have been obtained from the Ministry or other institutions, and construction is underway or will start shortly. These works will be implemented by the Construction Section of the RWE's Office. See Table EA 2-1.
Another group of proposed schemes still requires survey and design works, and procurement of financial resources for their construction.
These schemes include:

- the completion of pumped supplies for 13 villages from 12 boreholes which were constructed by the Maji Department and the MDWSP survey team
- the rehabilitation of intake structures of nine pumped surface water supplies for 11 villages, and an overhaul of their pumping equipment
- the construction of some waterworks components (reservoirs and communal water distribution facilities) for existing gravity diversions from the River Mgolole, and the construction of a gravity diversion scheme for Msonge village.

The implementation of these schemes requires significant enrolment of manpower for survey, design, and construction works (see Table E 4.1-6). It is considered that the relevant divisions of the RWE's office are insufficiently staffed to carry out the proposed programme in addition to their current activities (see Table E 3.1-3 and Table EA 2-1). It is therefore recommended to set up, in close co-operation with the Maji Department, a new temporary project organization, the "Morogoro Piped Water Supplies" project, similar to the Morogoro Wells Construction Project. This organization should be made responsible for the execution of the works and training of sufficient and appropriate manpower to operate and maintain the schemes once they are implemented. Similar to the MWCP project, survey and design of the various relatively small and independent schemes should be carried out on a basis of day to day engineering, and close co-operation should be secured between the project preparation and construction teams. This approach will involve considerable savings in terms of time and costs, as no elaborate design drawings, bills of quantities and technical specifications will have to be prepared and printed beforehand. It is estimated that the implementation of a separate survey period to prepare all relevant technical documents before the start of the construction works would result in cost increases of 20 - 30%, and a delay of the implementation by at least 1 year.

The Morogoro Piped Water Supplies Project (MPWSP) will require a period of about two years to implement the proposed schemes, provided only rudimentary distribution facilities, i.e. a communal water distribution facility at the storage tank, are catered for (see par. E 2.3). Timely procurement of equipment and materials should be ensured to prevent any disruptions during the construction programme. The MPWSP should have a central yard with facilities similar to the MWCP, and it is recommended to consider close co-operation between the two projects.

A barchart of activities as suggested by the Consultant is listed in Figure E 4.1-3, and the recommended period of implementation is given in Figure E 4.1-4.



) Detailed planning per location to be established after first survey

Figure E 4.1-3 Proposed barchart of activities for the Morogoro Piped Water Supplies Project.

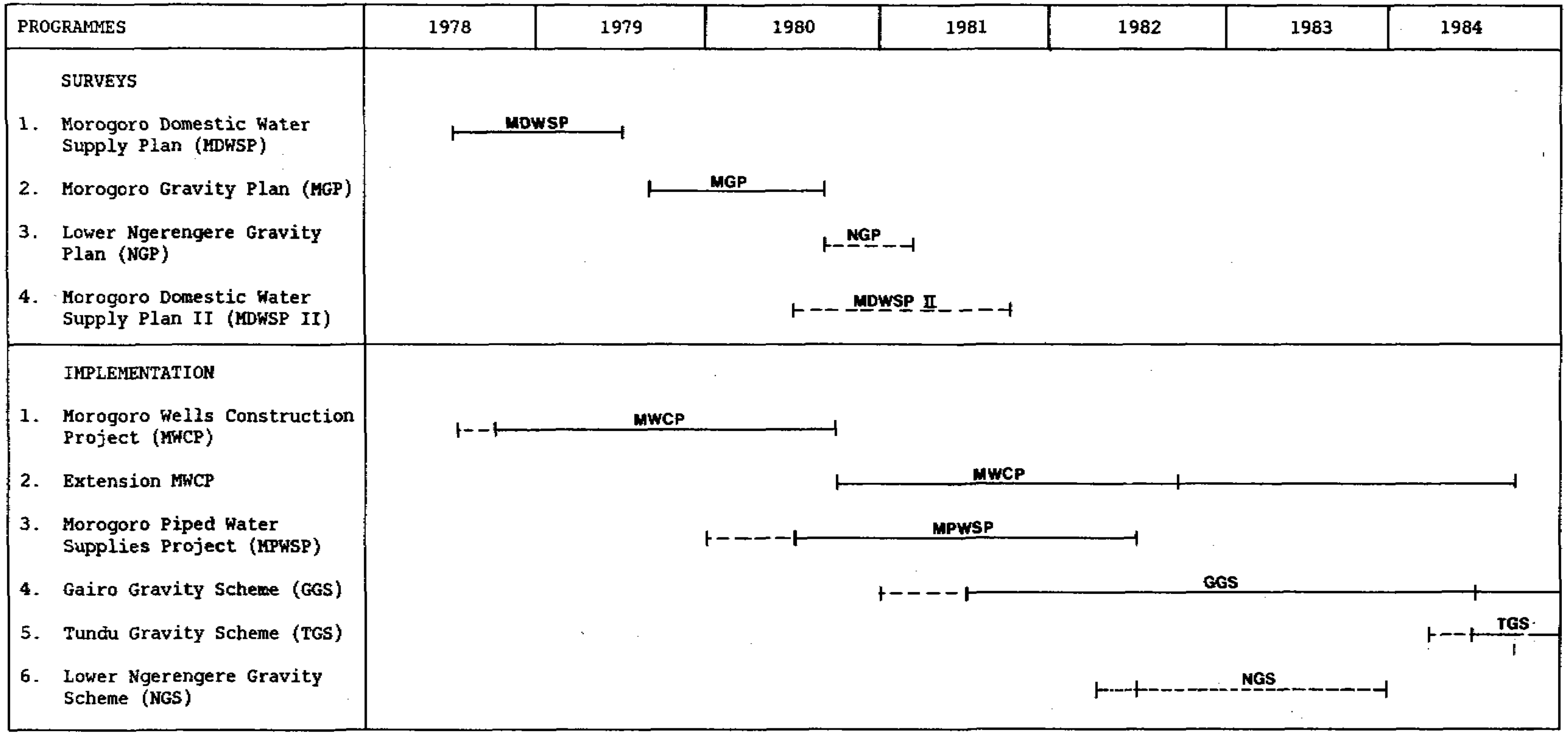


Figure E 4.1-4 Proposed general bar-chart for rural water supply development programmes in Morogoro Region.

4.1.7.4. Other piped schemes

The proposed short-term implementation programme contains seven more piped water supply schemes for seven separate problem villages. Three of these villages, Kihonda, Tungi and Mkonowamara are located in the part of the Ngerengere division where a large gravity diversion scheme may be required if shallow wells turn out to be unsuccessful (see Table E 4.1-2). It is recommended to await the outcome of the pilot shallow well programme in this area before taking further action on the implementation of separate schemes for these 3 villages.
Three other villages, Seregete A, Seregete B, and Kilama are located in areas with very unfavourable conditions for domestic water supply. These rather small villages therefore require transmission of water over long distances, incurring high capital and recurrent costs. It is recommended that all parties concerned first consider the alternative of resettlement before further steps are taken to implement systems at high costs.
A similar procedure should be followed for Kitaita village, which is included in the proposed MGP survey. Its inclusion in the construction programme may meet financial objections, however.

Finally, for Mbigili village a pumped water supply from River Mkundi has been suggested (see Table E 4.1-2), but as intermediate solution some shallow wells could be constructed on the river banks of River Mkundi. The MWCP will prospect the feasibility of medium-depth wells within the village itself, and it is therefore suggested to opt for the given intermediate solution until the data of such detailed surveys are known.

The Lower Ngerengere gravity scheme has been suggested as an alternative water supply to 13 villages in Ngerengere division if shallow wells do not prove to provide a dependable water supply system. Most likely such data will be known by the end of 1979, and it is suggested that a decision is taken on the basis of these data as to whether or not carry out a detailed survey for the gravity scheme during the 1980 season. See Figure E 4.1-4.

The proposed programmes have so far been restricted to the survey area of the MDWSP survey. It is recommended to carry out an additional MDWSP survey for the southern part of the region, in support of future water supply development programmes in that area. The Terms of Reference of such a study should be more or less similar to the MDWSP survey for the northern part of the region, but the inclusion of an exploration deep borehole drilling programme is not recommended. In order to enable the shallow well construction programme to make the best use of such a survey, it is suggested that it should be carried out during the 1980/1981 period. See Figure E 4.1-4.

4.1.8. Long-term village water supply development programmes

The Terms of Reference of the MDWSP study demanded the set up of a short-term implementation programme for village water supply improvements, with special attention to problem villages. This programme has been reported on in the previous paragraph.

In addition, the Consultant has undertaken to draw up recommendations for the future water supply development of all villages in the survey area provided this could be realized more or less within the framework of the MDWSP survey.
The various ways in which the villages in the survey area may be supplied with a reliable water source are summarized in Table EA 2-1. For some villages no data are given, as this would have required elaborate surveys beyond the scope of the present study. Various recommendations for future water development programmes can be formulated on the basis of the given data, depending on the targets aimed at. The Government's targets stipulate that by 1991 each villager should have access to a dependable source of clean water at 400 m distance from the homestead. Since properly located shallow wells with handpumps fulfil these requirements, it is recommendable to provide villages with shallow wells whenever suitable hydrogeological conditions occur. All other villages that lack provisions complying with the 1991 target will have to be provided with a piped water supply, complete with extensive distribution facilities.

The original long-term target of the Tanzanian Government, as formulated in the early seventies, demanded piped water supplies for all villages by 1991. It is obvious that the modification of these targets in favour of shallow wells will have a significant impact on the total investment budget required for the implementation of the targets. For an insight in the cost aspects of future water supply programmes in the survey area, the Consultant has undertaken to make cost estimates for the following two alternative future development programmes:

- village water supply by means of shallow wells, whenever feasible on hydrogeological grounds, and piped water supplies for all other villages
- village water supply by means of piped supplies to all villages in the survey area.

These cost estimates are based on the proposed water supply improvements (see Table EA 2-1), the 1978 price level, and a design population equal to the estimated 1998 population. In other words they are applicable for a programme whose execution would start today.
The cost estimates for both alternative development programmes are given in Table E 4.2-1. They include the costs of the short-term implementation programme, and are applicable for schemes with extensive distribution facilities.

Table E 4.2-1 Cost estimates for two alternative future water supply development programmes for the survey area (1978 price level; 1998 design population)

Alternative future programmes	Estimated investment costs (Tshs)	Average investment costs per capita (Tshs)	
		present population	design population
1. Shallow wells/piped supplies	192×10^6	345	172
2. Only piped supplies	270×10^6	485	242

Alternative 1 will be about 30% cheaper than alternative 2 and allow a saving of some 78 million shillings at the 1978 price level.
In alternative 1 about 41% of the population will be served by shallow wells, the remaining 59% by piped supplies.
The average per capita investment cost for of the 1998 design population is some 70 shs cheaper for alternative 1 than for alternative 2.

The shallow well component of alternative 1 should be realized in various stages. During the period 1978/1983 construction of about 1150 shallow wells is recommended in the survey area (see subpar. E 4.1.7); some additional 200 shallow wells will be required in each succeeding 5-year period to ensure that the number of shallow wells keeps pace with the increase of population.

The piped supplies component of both alternatives contains various pumped and gravity diversions for individual villages or clusters of villages. Once the short-term implementation programme has been completed, construction of piped supplies can be started for those villages (not included in the short-term programme) where no suitable conditions for shallow wells exist. Preference should be given to schemes with the lowest investment costs per capita, and special attention should be paid to gravity diversions for which some quite attractive schemes can be constructed.
A summary of the proposed gravity schemes for clusters of villages, together with their estimated total construction costs and per capita construction costs is given in Table E 4.2-2. The estimates are based on schemes with extensive distribution facilities.

Table E 4.2-2 Summary of proposed gravity schemes for clusters of villages, with their estimated construction costs (price level 1978)

Gravity schemes	Villages	Design population (1998)	Estimated costs (Tshs)	Costs/Cap. of design population (Tshs)
Gairo scheme	25 villages, see Table EA 2-1	88,000	33×10^6	375
Tundu scheme	Msowero, Iwemba, Tundu, Kifinga, Ruaha	28,200	4.7×10^6	167
Lower Ngerengere scheme	13 villages, see Table EA 2-1	31,200	18.6×10^6	596
Miyombo scheme	Nyameni, Ulaya Kibaoni, Ulaya Mbuyuni, Kikunga, Zombo Lumbo, Madudumizi, Nyali	18,300	6.4×10^6	350
Upper Ngerengere scheme	Konga/Vikenge, Sangasanga	4,450	0.6×10^6	135
Mkindu scheme	Hembeti, Dihombo, Mkindo, Kigugu, Mbogo, Kwamtonga	20,400	4.7×10^6	230
Mvuha scheme	Tandari, Vihengele, Tambuu, Mtombozi, Kibwege, Mtamba	22,200	4.3×10^6	194

The Gairo, Tundu and Upper Ngerengere schemes are part of the proposed short-term implementation programme. The lower Ngerengere scheme, by far the most expensive scheme, may require implementation as part of the short-term programme if shallow wells are unsuccessful. Of the remaining schemes, the Mvuha and Mkindu schemes are quite favourable as the per capita construction costs are significantly below the average per capita construction costs given in Table E 4.2-1. The Miyombo scheme seems less attractive, but its O & M costs and most likely also its annual costs will be less than those for individual pumped schemes from River Miyombo.

From Table EA 2-1 it can be concluded that several other satisfactory gravity diversions for individual villages may be constructed. Only relatively short transmission mains may be required to divert the water from a river or stream to a village, especially in hilly and mountainous areas. The location of various villages in clusters along perennial rivers also allows the construction of several communal pumped water supply systems for 2 or 3 villages. Such communal systems can most likely be provided with better operation and maintenance facilities at even lower costs than for separate systems.

A group of villages which deserves some special attention is the group 25, as classified in Table EA 2-1. This group includes villages in mountainous areas which are rather well endowed with surface water sources. The population in such areas live relatively scattered over the whole village area, while various perennial streams may cross this village area. Future piped water supplies will only be utilized by the population if they do not involve a considerably increased walking distance to the water source, since aspects such as a better quality of the water and a higher reliability of the improved water supply only provide limited incentives to accept such longer walking distance. In general, therefore, piped supplies in mountainous areas will only be technically and financially feasible if they constitute relatively low cost solutions. Appropriate low cost technologies under such circumstances are the application of bamboo pipes for (run-of-the-river) gravity diversions of water from a stream to individual houses or small cluster of houses. Small storage reservoirs may be constructed of ferrocement or wood. If the topographical conditions demand pumped diversions, simple concrete or wooden hydraulic rams may be applied with plastic or reinforced bamboo pipes as rising mains.
Such schemes could be carried out on a self-help basis with some technical and financial input from the Tanzanian bamboo project, and organizations such as SIDO and CDTF, which could in turn be supported by international appropriate technology organizations such as ITDG, VITA and TOOL.

To conclude, various future water supply development programmes may be designed depending on the targets aimed at.
In accordance with the Tanzanian Government's targets, shallow wells with handpumps comply with the objectives which are laid down for the year 1991. For the period after that no long-term targets have been formulated as yet. It is recommended to proceed with the following programmes, once the short-term programme has been fully implemented:

1. Construction of additional shallow wells with handpumps in those villages where this has proved to be a viable undertaking, thus making sure that the amount of shallow wells in each village keeps pace with the increased population.

2. Construction of piped water supplies with extensive distribution systems in those villages where no suitable conditions for shallow wells exist.
   First of all such villages in priority category II should be provided and after that villages in priority catergory III (see Part B, Chapter 4).

3. Construction of extensive distribution systems for those villages which were provided with piped water supplies during the short-term implementation programme.

4. Construction of small scale low-cost water supply systems for villages or clusters of households in mountainous areas using appropriate technologies such as (run-of-the-river) bamboo piped systems, simple ferrocement or wooden storage tanks, and concrete or wooden hydraulic rams.

Table E 4.2-3 Recommended short-, medium- and long-term water supply development programme for the survey area in regard of the realization of the Government's 1991 targets to the largest possible extent.

<table>
<tr><th>Period 1978-1984</th><th>Period 1985-1990</th><th>Period 1990-1995</th><th>Period 1995-2000</th></tr>
<tr>
<td rowspan="3">Implementation of proposed short-term programme:
1. Shallow Wells
Construction of about 1150 shallow wells for some 154 villages
2. Gravity diversion schemes:
- Gairo gravity scheme (25 villages)
- Tundu gravity scheme (5 villages)
- Msonge gravity scheme (1 village)
3. Construction of pumped supplies from boreholes (13 villages)
4. Rehabilitation of existing pumped supplies (11 villages), and extensions to some existing gravity schemes (3 villages)
5. Construction of some additional Maji Projects not included above (5 villages)
6. Construction of Lower Ngerengere Gravity schemes if shallow wells fail to be successful in that area (13 villages, which are also included in shallow well programme)
NOTE: all villages are to be provided with rudimentary distribution facilities only.</td>
<td>1. Shallow Wells
Construction of 200 shallow wells to ensure that the number of shallow wells keeps pace with the increase of population</td>
<td>1. Shallow Wells
Construction of 200 shallow wells to ensure that the number of shallow wells keeps pace with the increase of population</td>
<td>1. Shallow Wells
Construction of 200 shallow wells to ensure that the number of shallow wells keep pace with the increase of population</td>
</tr>
<tr>
<td colspan="2">2. Piped water supplies to Priority Category II and III villages where no shallow wells can be constructed, and which are not classified in the Group 25 villages
- Gravity supply schemes (29 villages): Chabima, Chagongwe, Chanjale, Ibingu, Mvuha gravity scheme (Tandari, Vihengele, Tambuu, Kibwege, Mtombozi, Mtamba), Kigugu, Kisimagulu, Kizagira, Koloni, Konde, Kumbulu, Kwelikwiji, Lumbiji, Luwemba, Mafuta, Mfuluni, Mhonda, Mkololo, Mlaguzi, Msimba, Mulunga, Ndole, Ulelilíng'ombe, Uponela
- Pumped supply schemes (23 villages): Bungu, Changa, Digoma, Kifindike, Kisaki Kituoni, Logo, Lubasazi, Luhembe, Lukange, Makwambe, Mamboya, Masalawe, Mazimba, Mbigili, Mabane, Mfumbwe, Msolokelo, Mwasa, Ntala, Peko-Misegese, Pemba, Ubili, Uponda Chini</td>
<td>2. Piped water supplies
Construction of extensive distribution facilities for Priority Category II and III villages which were provided with piped water supplies and rudimentary distribution facilities during the period 1985-1995</td>
</tr>
<tr>
<td></td>
<td colspan="2">3. Construction of extensive distribution facilities for villages which were provided with piped water supplies and rudimentary distribution facilities during the short-term implementation programme
4. Group 25 villages (76 villages)
Construction of low cost schemes using appropriate technologies at the village level for villages which are located in mountainous areas with abundant perennial streams and rivers</td>
</tr>
</table>

The proposed programmes are schematically presented in Table E 4.2-3. The estimated investment costs of these programmes were given in Table E 4.2-1, assuming the 1978 price level, and the 1998 population as design population. Estimates of the actual investment budget required for execution of the proposed medium/long-term programmes at a later stage, i.e. after completion of the short-term implementation programme, can be made by deducting the estimated investment costs of the short-term programme from the total estimated investment costs of the proposed future development programmes (alternative 1), and correcting the outcome for the yearly increases in prices and for the yearly increase in design population. The aggregate cost increase caused by these two factors is estimated at 10 - 15% a year for shallow wells and 15 - 20% a year for piped water supplies. In formula:

$$C_t = \sum_{n=1}^{n=P} (1+r)^m \, C_{o}/P \times (1+r)^n$$

where: C_t = total investment budget required (Tshs)

C_o = investment budget required, based on the 1978 price level (Tshs)

P = total construction period (years)

m = time interval between 1978 and the year that implementation starts (years)

r = rate of aggregate yearly cost increase (%/100)

It can be calculated that the total investment budget required for the implementation of the proposed medium/long-term development programmes will amount to Tshs 528 million at an aggregate yearly cost increase of 10%, and Tshs 1080 million at an aggregate yearly cost increase of 15%. This assumes that execution of the programmes will start in 1985 and last a period of 15 years.

The manpower requirements for the execution of the proposed programmes can be calculated from the estimated costs at the 1978 price level, and the average value of daily production (1978 price level) for the construction of simple village water supply schemes (see Table E 4.1-5).
It appears that execution of the programmes during a period of 15 years would require a labour force of 200 craftsmen and 20 technicians, or about three times the present enrolments in the RWE's project preparation and construction divisions.

4.2. Training Programme

The manpower required for the construction, and operation and maintenance of the waterworks covered by the proposed short-term programme, includes:

- well qualified engineers for design activities, and management and supervision of construction works
- qualified technicians for design activities, site supervision, and supervision of operation and maintenance of completed works

- unskilled, semi-skilled and skilled craftsmen for the execution of the construction works and the operation and maintenance of completed works (e.g, carpenters, masons, plumbers, pump-attendants, and well sinkers).

It has been noted in the subpar. B 3.1.1.3 and E 4.1.6 that at present the Maji Department of Morogoro Region lacks part of the manpower listed above. Yet the effectiveness of the water supply facilities implemented during the proposed short-term implementation programme will largely depend on the successful completion and follow up of such programmes.
The Consultant therefore recommends strongly that sufficient attention should be given to training activities during the execution of the short-term implementation programme. It is suggested that the following training components be included in the proposed construction programmes for shallow wells and piped water supplies.

1. Shallow wells programme
    - training in siting, construction, and pump installation
    - establishment of a local basis for the procurement of equipment, tools and materials relevant to the construction of shallow wells (e.g. pump factory, general workshop facilities, vehicle maintenance and repair unit, stores, and the like)
    - training of pump attendants preferably at village level, in the regular maintenance, and repair, of handpumps
    - assistance to the organization and execution of regional shallow well programmes.

2. Piped water supplies
    - training of skilled craftsmen for the construction, operation and maintenance of piped water supply facilities, such as plumbers, fitters, mechanics, pump attendants
    - training of water technicians in various aspects of survey, design, construction, and management of piped water supply schemes for village water supply
    - assistance to the re-organization of supporting facilities, such as a supply division for the distribution of tools, materials and spare parts, and a transport division for the distribution of essential goods such as fuel and oil.

The training components suggested for the shallow wells programme have already been included in the MWCP, and groups of different regions in Tanzania will receive training in the various aspects of shallow well construction.

The Consultant is of the opinion that for all the training aspects, emphasis should be placed on on-the-job training, as this will give the best guarantee that trainees can proceed independently with their duties once the training programme is completed. It is essential, however, that some theoretical courses are included in the training programme.

Moreover, the set-up of appropriate instruction manuals for the operation and maintenance of different piped water supplies may significantly improve the quality of work of pump attendants.

5. WATER SUPPLY DEVELOPMENT SUMMARY AND CONCLUSIONS

5.1. Introduction

The Terms of Reference of the MDWSP study call for the definition of village water supply development programmes for those villages in the survey area which experience serious problems with their domestic water supply. Such programmes should be based on detailed studies of existing water supplies, domestic water demand, and hydrological and hydrogeological conditions prevailing in the survey area.
The Consultant's recommendations should include a short term implementation programme for the problem villages which are identified aimed at providing these villages with water supply systems which comply with the Tanzanian Government's objectives as laid down in the 1981 and 1991 targets for rural water supply.
This chapter summarizes the water supply development studies. It contains a description of the current objectives and Government policy and the present design and construction practice for the rural water supply sector. Alternative construction methods for water works structures are described and cost estimates are given for various water works components and typical village water supply schemes.
The collection and processing of all relevant data has resulted in a detailed short term implementation programme and a phased, future, village water supply development programme aimed at the optimum realization of the national objectives.

5.2. Review of the current development in the rural water supply sector in Morogoro Region

The present study is part of the Government's efforts to speed up the development of the rural water supply sector in support of its villagization programme which was virtually completed in 1977. Tanzania has formulated its own national targets for domestic water supply to rural dwellers. These targets are comparable to, but more advanced than, the rural water supply targets which were formulated during the Habitat conference in Vancouver (1977).
The Tanzanian objectives for rural water supply development refer to the two target years 1981 and 1991, and aim at the provision of:

- a source of clean, potable and dependable water within a reasonable distance of every village by 1981 as a free basic service.
- a reliable water supply with clean potable water to the rural areas by 1991, so that all people will have ease of access (i.e. a distance of 400 m) to a public domestic water point. Preferably this supply should consist of a piped system with communal water points, but also shallow wells with hand pumps comply with the requirements.

Rural water supply development programmes are devided into national and regional components. Programmes are established for an annual or a five year planning period.

The Government has formulated the following general guidelines for the development of the rural water supply sector during the Third Five Year Development Plan Period (1976 - 1981):

- village water supply systems should consist of small, simple, cheap schemes.
- various methods of water collection should be used, e.g. rainwater harvesting and charcos. Suitable water lifting devices are hand pumps and wind-mills.
- the development of water sources in the village should be such that by 1981 all villages are provided with at least one dependable water source.
- the village water supply programme is not primarily aimed at providing piped water. First of all, water should be made available at places where there is a shortage of water. Methods to be used are construction of shallow wells, and diversions from rivers and dams using a gravity transmissiom system.
- water for live-stock and irrigation should be collected from rainwater reservoirs which are constructed using small dams. The villagers should be assisted with technical expertise to carry out such programmes.

Budget allocations can be divided between development budgets and recurrent budgets for both the national and regional level. Development budgets are used to finance the implementation of new water supply programmes. The recurrent budgets cover the regular staff (managerial, technical, administrative) and labour force for the day to day running of the Maji Departments, and include the costs of operation and maintenance of implemented programmes.

In Morogoro Region about 15% of the Government development budget for the third five year plan period will be allocated to water supply. Rural water supply will obtain 9%, and urban water supply 6%. The votes for annual development and recurrent expenditure for the budget year 1978/79 show that the total estimated budget for water supply amounts to Tshs 10,354,400 or 8% of the total development and recurrent budgets noted for Morogoro Region. The allocation to rural water supply is 6% (Tshs 7,332,900), and that to urban water supply 2% (Tshs 3,021,500).

For the budget year 1978/79, the RWE's governmental budget for water supply development projects in Morogoro Region amounts to Tshs 4,190,000. The distribution is as follows: Tshs 1,350,000 for Morogoro District, Tshs 650,000 for Kilosa District, Tshs 1,100,000 for Kilombero District, Tshs 890,000 for Ulanga District, and Tshs 200,000 for surveys and investigations.

The 1978/79 annual development programme of the RWE's office for Morogoro and Kilosa districts included the contruction of piped water supplies for six villages and shallow wells (for ten villages one shallow well each). So far, six shallow wells have been completed and two of the piped water supply projects are under construction. The other programmes have been cancelled or deferred due to lack of manpower and financial resources.

For similar reasons, about 50% of the designs which were prepared by the Project Preparation Division (Morogoro Region) during the last two years have not been proposed yet for implementation.

In 1972 the responsibilities of the Ministries were regionally decentralized and the direct control of the majority of the rural and urban water supply programmes was handed over to the regional authorities. From 1975 the Ministry of Water, Energy and Minerals has been the principal Government agency responsible for the domestic water supply sector. Annual development programmes are divided into national and regional components. Maji Headquarters plays a principal role in the planning of the national programme, but is not necessarily formally involved in the planning of regional programmes, which generate from the village level through the District and Regional Administrations and the Prime Minister's Office.
The highest officer for the Maji Department of the Ministry of Water, Energy and Minerals is the Principal Secretary who is directly responsible to the Minister for Water, Energy and Minerals. The Maji Department is divided into four divisions, and four units. The divisions are responsible for activities closely related with water development, i.e. programme and man-power planning, construction, operation and maintenance etc. They are split up in a number of different sections. The units deal with administrative and financial matters.

At the regional level a similar organization structure is implemented. Some of the divisions, sections, or units mentioned above are combined in new groups, or are represented by the Regional Water Engineer (RWE). In 1978, the total number of employees in the Maji Department for Morogoro Region amounted to 435 persons. The functional managers are the RWE at the regional level, and four DWE'S at the district level. The planning and project preparation division consists of 64 persons, the construction division of 67 persons, the regional maintenance unit of 126 persons, the finance and administration units together of 44 persons, and the urban water supply unit of 128 persons.

All construction works involved in domestic water supply systems are carried out under the responsibility of the Regional Water Engineer (RWE). This functional manager has to report to the Principal Secretary on all matters and deals directly with regional and district officials on matters in their respective areas. The RWE's are not responsible for the construction works carried out by rotary drilling rigs and heavy dam construction units, which come under the direct supervision of Maji Headquarters as part of the national development programme.
The Regional Water Engineers are technically responsible for the operation and maintenance of schemes completed by them. Recurrent funds for operation and maintenance are issued by the Ministry of Finance and Planning (Treasury) to the Regional and District Administrations (RDD's and DDD's) who act as the accounting officers. Funds are not allocated to the RWE but are advised of a vote number by the accounting officer who is responsible for the actual payment of expenses incurred by the RWE.

One of the main constraints in the development of the rural water supply sector is the present level of Maji output. This output falls far short of that required to meet the official target of providing every village with an adequate water supply by 1981. The total implementation capacity of the present programme can just keep pace with the population increase, and in fact no significant improvements are being reached.

Another serious problem area is the operation and maintenance sector. A considerable number of supplies in the survey area are not operating at all or are subject to temporary interruptions because of the inadequate provision of manpower, or lack of operation and maintenance funds. Lack of spares and/or fuel are very often the cause of such interruptions.

Finally, it is obvious that the available development and recurrent budgets are far too small to cope with the financial resource requirements imposed by the 1981 and 1991 targets. Moreover, in Tanzania, domestic water supply is considered to be a basic commodity, which should be available free of charge for those who make use of communal facilities. Therefore, in general, no funds are generated at the village level to support operation and maintenance activities, although efforts are being made to stimulate villages to supply their own waterworks operators.
It is estimated that the funds required to operate and maintain existing improved schemes in the survey area in a satisfactory manner amount to about Tshs 2,500,000 annually, which is about 30% more than the 1978/1979 allocation of some Tshs 1,900,000 for the Morogoro Region as a whole. Assuming that 65% of this budget is allocated to schemes in the survey area, the estimated budget requirements demand a 100% increase of the budget allocation to schemes in the survey area.

5.3. Design criteria and construction methods for village water supply systems

The design criteria normally applied by the Maji Department are contained in a Ministerial Note of 1975. Current construction methods are defined in standard construction drawings of various waterworks components as shallow wells, pumphouses, storage tanks, domestic water points and cattle troughs.

The Consultant has only suggested some slight alterations to the design criteria, as the majority of them are considered to be very suitable for the current conditions in village water supply.

The comments on some of the construction methods have been more elaborate. It has been observed that the techniques applied by the construction division for the construction of shallow wells, deep boreholes and surface water intakes are below the appropriate standard, and obstruct a proper exploitation of water sources structures and water transport facilities.

The Consultant has comprehensively discussed these water works components and has suggested alternative construction techniques which are appropriate for the conditions prevailing in the survey areas. In addition, some simple water treatment systems were discussed.

5.4. Cost estimates for village water supply systems

Cost estimates for capital investment costs of various waterworks components, such as water source structures, pumphouses and pumping equipment, transmission mains, storage tanks, distribution lines and domestic water points, have been discussed in detail.
All estimates given include the following cost components:

- material costs
- labour costs
- transport costs
- administrative overheads (1%)

Technical overhead costs for design and construction are not included in the estimates. The Maji Department has traditionally calculated with an overhead component of 20%. Recently many rural water supply projects were implemented with the assistance of bilateral or multilateral aid organizations and cost analyses of such projects indicate that the overhead costs incurred by expatriate assistance may add 50 - 200% to the direct construction costs. The WHO/World Bank study mentions an average overhead component of 60%. The Consultant suggests the application of this figure for general estimates of overall overhead costs.

The cost estimates are based on recent estimates by the technical staff of the Regional Maji Office in Morogoro Town, and estimates from local contractors and equipment supplies. In some cases, the cost estimates are the result of the Consultant's own judgement or recent experience, obtained from the construction of some waterworks as part of the MDWSP-programme (i.e. borehole programme). All cost estimates represent the 1978 price level.

The cost estimates have been used to derive cost functions for some typical village water supply schemes of various capacities and lay-outs of transmission and distribution systems.
Essentially, these typical designs only differ from each other for the type of water source (shallow well, riverside well, borehole or surface water intake), and transmission system (pumped or gravity diversion).
The typical designs are made for villages with a design population of 1000 - 10,000 people, and a length of the transmission main between 0.5 - 10 km. The cost functions are subject to the assumptions made for the topographical conditions of source and village area, the construction techniques and materials applied, and the services provided for.
A graphical presentation of the capital investment costs per capita versus the design population for each of the four typical village water supply systems considered is shown in Figure E 5.4-1.

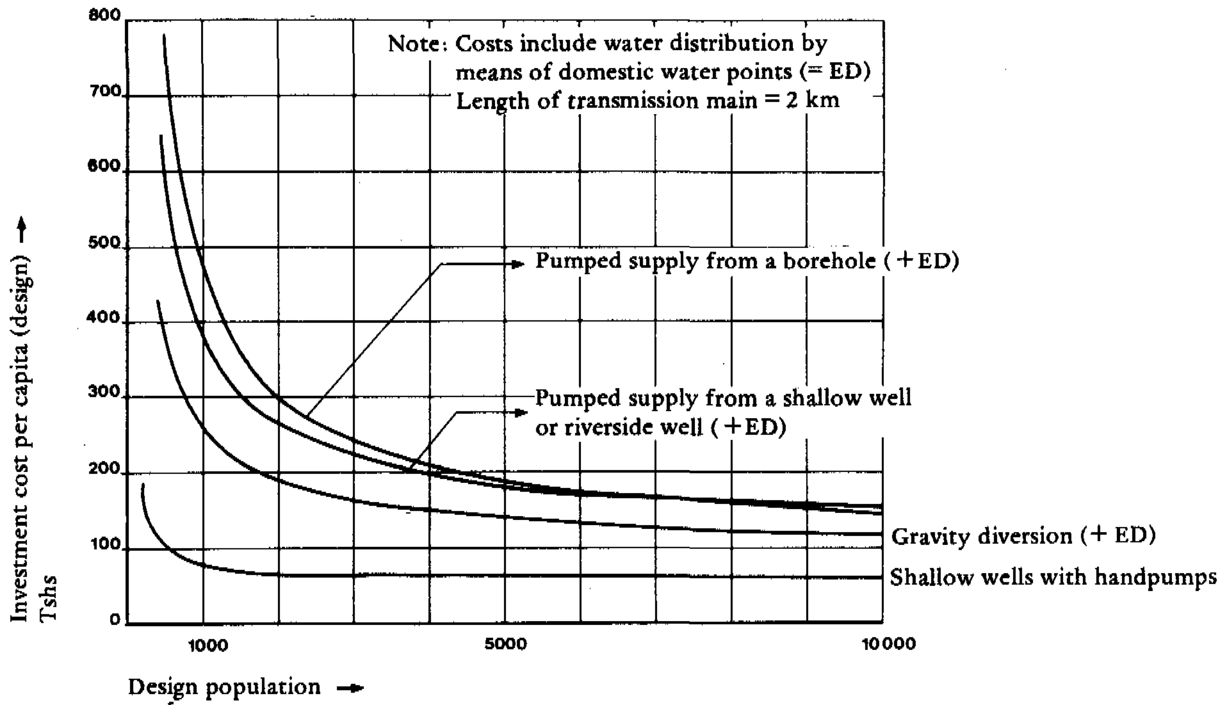


Figure E 5.4-1 Investment costs of village water supply systems.

The economic choice between alternative systems for a projected village water supply schema should not be determined by the investment costs but by the annual costs, as these costs really reflect the total amount of yearly out-of-pocket payments which can be expected once a system is in operation. In the comparison between gravity water supplies and pumped water supplies, it is of particular interest to evaluate the difference in transmission main length which can be allowed, for otherwise equal annual costs.

The following conclusions can be drawn from the comparison of annual costs of those typical village water supplies which were used for the costing operations:

1. The annual costs for shallow wells with handpumps are lower than those for pumped supplies with only rudimentary distribution facilities and any length of the transmission main, supposing both are for a design population less than 7000 people. For a design population between 7000 - 10,000 people the annual costs of pumped supply systems with a length of transmission main between 0.1 - 1 km are comparable to those of shallow wells with handpumps.
   The annual costs for shallow wells with handpumps are considerably lower than those for pumped supplies with extensive distribution systems.

2. The annual costs of gravity diversions with rudimentary distribution facilities are lower than those for shallow wells, if the transmission main length does not exceed 0 - 4.6 km, and depending on the design population. Shallow wells will have lower annual costs than gravity diversions with extensive distribution facilities if the length of the transmission main exceeds 1 km.

3. Where annual costs are equal, a gravity supply system may have a transmission main some 3 - 7 km longer than the transmission main of a pumped supply from a borehole, shallow well or riverside well, for a design population varying between 1000 - 10,000 people and a transmission main length between 500 - 10,000 metres.

4. Where annual costs are equal, a pumped supply from a shallow well or riverside well may have a transmission main some 0 - 2 km longer than that of a borehole supply, for a design population varying between 1000 - 8500 people and a transmission main length (of that borehole supply) between 500 - 10,000 m. At higher design populations, the borehole supply will have lower annual costs for otherwise similar conditions.

5.5. Future village water supply development programmes

One of the essential issues in the design of future village water supply development programmes is the selection of a strategy regarding the staging of various planning phases.
Improved water supplies are normally constructed in one single phase for a design period of 20 years. In other words, schemes which are implemented have an over-capacity of about 100% and consume considerable amounts of capital and manpower which could have been allocated to other problem areas. The attainment of the Government's objectives puts a heavy burden on resources of money, manpower and administrative capacity which can be made available, and there should be no stone left unturned in the efforts to arrive at an optimum allocation of these resources.
The Consultant has opted for a division of future programmes into three more or less distinct phases of which phase one and part of phase two are applicable for the Consultant's assignment to design short term improvement programmes for problem villages.

Phase one: crash programme and source development

Emphasis is put on source development, i.e. the development of shallow wells, boreholes, pumped and gravity water supplies to such a degree that water is conveyed to a point at a reasonable distance from the village. This phase includes for the piped systems a pumphouse, transmission main and storage tank for a design period of 20 years.
Distribution works, for a design period of 10 years are limited to an absolute minimum, e.g. a communal water distribution facility with a number of taps, located close to the storage tank.

Phase two: extension or scheme development

Emphasis is put on scheme development, i.e. up-grading of the basic facilities provided in phase one to a level which makes the waterworks comply with the long term targets.
This phase will primarily involve the construction of more shallow wells with handpump, or, for piped water supplies, the development of distribution systems, so as to provide domestic water points within an average walking distance of 400 m (in accordance with the 1991 targets).
Alternative sources, such as boreholes, and piped water supply systems from nearby suitable river intakes, can be developed for larger villages and for a common water supply system to a group of villages (e.g. gravity schemes).

Phase three: water treatment

Once all villages are provided with a water supply system which has sufficiently high standards in quantity, accessibility and reliability, available resources can be allocated to essential water quality improvements.
Suitable water treatment techniques for rural water supplies include storage, plain sedimentation and chemical disinfection. More advanced treatment techniques are flocculation/coagulation and sand filtration. Especially slow sand filtration is a very suitable technique, as it combines physical, chemical and bacteriological improvements of the raw water or pre-treated water.
Although it involves rather complicated purification mechanisms, slow sand filtration allows for relatively simple operation and maintenance operations at low recurrent costs, provided a suitable design has been made and no extensive pre-treatment is necessary.

Water supply development programmes should furthermore be based on the water resources potential, the water demand, and the present water supply conditions in each supply area.
Identification of suitable water sources for individual villages requires due attention to be given to small rivers, streams, springs and very small hydrogeological sub-areas. Such water sources may have no significance in a larger hydrological or hydrogeological context, and yet be essential to alleviate the present constraints to obtaining water for domestic consumption in villages.
The survey area's water potential for village water supply, as identified by the Consultant's Hydrologists and Hydrogeologists, is visualized in various maps. The shallow groundwater potential is summarized in Map D4, that of medium depth and deep grounwater in Map D3 and the surface water potential is summarized in Map C4.

The development of shallow groundwater resources (down to a depth of 12 m) appears to offer an attractive method of catering for the domestic water requirements of villages in the survey area.
A comprehensive field survey, including numerous test drilling and pumping-tests, was carried out by the Hydrogeological section for the inventory of these shallow groundwater resources.

The following areas have conditions suitable for shallow groundwater development:

- villages along the Kinyolisi River and along part of the Berega River;
- villages along the Turiani - Kilosa - Mikumi Road;
- villages in the foothills of the E., S.E., and N.W. Ulugurus;
- villages along the Ngerengere River, downstream of Ngerengere Township;

Various other suitable sites are scattered over the whole survey area, at locations where sufficient deposits of alluvial material have created aquifer conditions suitable for groundwater withdrawal.

The Consultant has also carried out a comprehensive survey for the inventory of the medium depth and deep groundwater resources. This survey included an extensive geo-electrical survey and exploratory drilling programme in part of the Wami River basin. Successful boreholes were completed in such a way as to make them suitable water sources for pumped water supplies. It appears that suitable locations for medium depth and deep groundwater exploitation may be found in the following areas:

- the major part of the Mkata/Wami basin (medium-depth and deep groundwater);
- the plain between the foothills of the Migomberame and Uluguru Mountains, or the area south of Mikumi and Mikumi Lodge (medium-depth and deep groundwater);
- the foothills of the S.E. Uluguru (medium depth groundwater).

The survey area is fairly well endowed with perennial rivers and streams, which offer suitable possibilities for village water supply systems. The field survey and regular measurement programme of the hydrological section included numerous small rivers, streams and springs, which could be useful for village water supply.
It may be concluded that suitable sources for surface water supplies mostly occur in the following areas:

- the foothills of all mountains: Nguru, Kaguru, Migomberame and Uluguru Mountains. Numerous perennial streams and rivers emerge from these mountains.
- Mountainous areas where small tributaries of major rivers flow throughout the year, especially in the Nguru and Uluguru Mountains.
- Parts of the Wami and Ruvu plains were villages are located at reasonable distance from the rivers of the same name.

In conclusion, the MDWSP survey area is well endowed with both groundwater and surface water resources. In general there are no serious technical constraints to the utilization of these resources for village water supply. In various parts of the survey area several suitable and dependable water sources exist for the development of future village water supply systems. In some villages up to four alternatives may be distinguished for future water supply systems: shallow wells with hand pumps, pumped supply from a shallow well or riverside well, pumped supply from a borehole, and supply by gravity diversion.

On the other hand, a number of villages are located in areas where water sources suitable and dependable for village water supply development are virtually absent. In areas with such limited resources a choice has to be made between alternative recommendations such as installation of a very expensive system, provision of a system which is not in accordance with the current policies in domestic water supply development or resettlement of the village in a more suitable location.

The Consultant has made an inventory of possible village water supply development options for all villages in the survey area. Making a selection from those options for village water supply facilities which fit into both the short-term and medium/long-term water resources development programmes requires a decision game which involves aspects such as:

- the requirements resulting from the Government's targets and policies;
- the economic feasibility of each of the various options;
- the economic feasibility of a sequence of certain options, when a phased development of the facilities is striven after.

Such a decision game is needed to prevent technical or financial conflicts of interest occurring between the short-term and long-term implementation programmes.

Taking all these aspects into account, the following strategy for the design of future village water supply development programmes is recommended:

1. Villages with suitable sites for shallow wells.

1a. Shallow wells are to be constructed in villages with a design population not exceeding 7000 people.

1b. Further investigations are required for villages with a design population above 7000 people.
Again shallow wells will be the appropriate solution, if:
    - no possibilities for gravity diversions exist;
    - the transmission main length is above 0.5 - 1 km for a gravity system. In each particular case the maximum permissible length of the transmission main should depend on the design population.
    - the population of a large village is so dispersed that the maximum walking distance criterion of the 1991 target (400 m) could only be achieved by a relatively expensive distribution system from a piped supply.

2. Villages without suitable sites for shallow wells.

2a. Depending on the design population, a gravity supply is to be selected if the location of the source requires a transmission main length which does not exceed the transmission main length of an alternative pumped water supply by more than 3 - 7 km.

2b. If a suitable water source for gravity water supply, in accordance with the conditions mentioned in 2a is not available, a selection is to be made between a pumped supply from a borehole and a riverside well (or shallow well at some distance from the village).
Pumped supply from a riverside well or shallow well is preferable for a design population not exceeding 8500 people, for equal lengths of the transmission mains.

3. Group supplies.
   The guidelines given above are applicable to individual villages. The decision procedure for group supplies requires further investigation of the geographical and topographical layout of the cluster of villages under consideration. The main criterion will again be formed by the relation between total length of transmission main and total design population.
   In each particular case expert judgement will be required to take the correct decisions.

The Consultant wishes to draw attention to the fact that the cost functions applied in the decision procedure described above are subject to certain conditions such as topography. It is obvious that if conditions deviate significantly from those adopted for the cost functions, a new appraisal of the alternative solutions will be required.

5.6. Proposed implementation programmes

The proposed implementation programmes are divided in two: a short-term and a long-term implementation programme.

5.6.1. Short-term implementation programme

It is recommended that the following projects be included in the short-term implementation programme (see also Table E 5.6-1):

1. Water supply improvements for identified problem villages

   The villages where problems are experienced with the present village water supply were identified through the assessment of existing water supply conditions in all villages in the survey area (see Part B).
   The group of villages which deserves first priority in the implementation of improved village water supply schemes consists of 82 villages which are summarized in Table B 5.6-2. For each of these villages short-term, improvement programmes have been recommended, based on the strategy as described in the previous paragraph together with data on the water resources potential. (See Table E 4.1-2).
   It appears that the large majority of the problem villages can be provided with shallow wells with hand pumps. The second most important group is gravity diversion for the problem villages where shallow wells or other means of groundwater exploitation are not possible.
   The proposed Gairo gravity scheme is by far the largest scheme of the proposed short-term implementation programme. It includes 15 seriously hit problem villages and 10 other villages in the Gairo area.
   Pumped supplies from surface water sources are provided for a limited number of villages for which neither shallow nor deep wells nor gravity diversion are feasible solutions.
   Pumped supplies from a borehole will be offered to those problem villages where successful boreholes were constructed by Maji, or by MDWSP during the hydrogeological survey for the deep groundwater resources.

At present, some of these villages are also being provided with shallow wells within the framework of the MWCP project, since the completion of the boreholes may take another 2 years.
The proposed improvement programme for problem villages is incorporated in Table E 5.6-1.

2. Rehabilitation of various existing piped supplies

It has been observed that the majority of the existing piped surface water supplies suffer from serious drawbacks such as a poor water intake structure, a limited capacity or regular operation and maintenance problems. The performance of these piped supplies can be improved a great deal by some rehabilitation works, covering the water intake structure and an overhaul of the pumping eqipment.
The following existing piped supplies are recommended for the rehabilitation works: Turiani/Kilimanjaro, Lukenge, Mvumi, Msowero, Kivungu, Kilangali, Berega, Mlali/Kipera and Kiswira.
The programme should be supported by an appropriate training course (including on the job training) for pump attendants to make them more familiar with operation and maintenance, trouble shooting and repair of pumping equipment.

Rehabilitation of existing supplies is also proposed for some villages which are provided with run-of-the river gravity diversions from the River Mgolole. It is recommended that the villages concerned, Kitungwa, Legezamwendo, and Kisinga be provided with a storage tank and communal water distribution facility so as to secure a more reliable water supply to these villages.

3. Additional projects

A substantial number of the problem villages are located in the Gairo division. In this area a large scale gravity diversion scheme from sources in the Mamwira Forest Reserve has been proposed. It is recommended that 10 more villages, located in the same area and having moderate problems in the supply of domestic water, be included in the Gairo gravity scheme.

Other schemes which are recommended for incorporation in the short-term implementation programme, include:

- The completion of waterworks for 4 MDWSP boreholes which are located in villages not belonging to the group of most seriously hit villages (see under 1), but which regularly experience problems in their domestic water supply. These villages are Dakawa - Wami, Dibamba, Makuyu (Tur.), and Mbwade (Mas.).
- Gravity diversion schemes to Sangasanga and Konga/Vikenge in the Upper Ngerengere area, and Misongeni in the Mgolole area. The Maji Department has recently completed designs for these gravity diversions, and financial resources have been secured as well (UNICEF).

- Gravity diversion to five villages in the foothills of the Migomberame mountains. These villages, Msowero, Iwemba, Tundu, Kifinga and Ruaha at present use the traditional ways of obtaining water for domestic purposes. No suitable hydrogeological conditions exist for the construction of shallow wells, whereas the proposed gravity diversion from Tundu River can be constructed at relatively low costs due to the short length of the transmission main.
- Pumped water supply schemes to Kibati village and to Lukobe village. The Maji Department has recently completed designs for these projects, and financial support has been promised by international donor organizations.
- A shallow well construction programme for those other villages in the survey area, where shallow wells with hand pumps are considered to be a viable undertaking (see Map D4). Some 98 villages are to be included in this programme, requiring about 726 shallow wells.

Finally, the lower Ngerengere area between Kihonda and Ngerengere is considered to be an area where the suitability of shallow wells is doubtful. The construction of a gravity water supply scheme to 13 villages in this area from the future waterworks of the Mindu Dam site is recommended if further investigations indicate a low feasibility for shallow well construction. Once this gravity scheme is decided on, it should become part of the programmes which require implementation immediately, as the villages concerned are problem villages.

The estimated investment for the construction of the various waterworks facilities included in the proposed short-term implementation programme amount to about 64 million Tshs at the price level of 1978. These estimates cover the net construction costs and do not include cost components such as survey and design, establishment of transport and workshop facilities and technical overheads.
The carrying out of the proposed programmes (excluding the possible lower Ngerengere gravity scheme) during the period 1979 - 1984 will require a total investment budget for the construction works amounting to about 107 million Tshs. This estimate assumes a constant annual expenditure rate during the six year construction period (based on the 1978 price level), and an annual price increase of 15%. The future annual O & M costs will be of the order of 3 - 5 million Tshs thus requiring a significant increase of the RWE's budget for O & M activities.
It is obvious that bilateral and multi-lateral aid organizations must be contacted and requested to offer assistance in the procurement of sufficient financial resources to carry out the proposed programmes.

The manpower requirements for the execution of the proposed programme during a period of some 6 years are estimated to be about 480 persons, including labour force and technical staff. The Maji Department will not be able to fulfil these high manpower requirements. Thus it is recommended that local contractors and appropriate local and expatriate sources of manpower be invited to assist in the carrying out of the works.

The implementation of the proposed short-term programme requires careful planning of the execution of the different activities involved in the various components of the programme.
These activities include:

- detailed hydrogeological surveys for the siting of suitable shallow well locations, taking into account other factors such as village layout and population distribution within the village;
- detailed hydrogeological surveys for the siting of suitable locations for the construction of intake wells along river beds as part of the proposed rehabilitation and pumped water supplies programme;
- detailed topographical surveys for the design of transmission mains, reservoirs and distribution works of various proposed piped water supply schemes;
- procurement of sufficient stocks of equipment and materials to secure an uninterrupted completion of the works;
- enrolment of appropriate manpower at various levels, and acquisition of sufficient financial resources for the implementation of the proposed programmes;
- provision of facilities for manpower development, training, transfer of technology and on-the-job training.

The Consultant is of the opinion that part of the survey activities, in particular for small separate schemes such as shallow wells and piped water supplies for individual villages, can best be carried out on a basis of day to day engineering. Such an approach requires the setting up of a sufficiently skilled and independent survey crew, but it will result in considerable savings in terms of time and costs. This survey group should be considered as a support group for the construction crews, and its work schedule should enable an uninterrupted implementation of the construction works.

The various parts of large schemes such as the proposed Gairo and Tundu gravity schemes are largely interdependent, and smooth running and operation of these schemes can only be secured if the systems are based on a detailed hydraulic design of all their components. Such schemes, therefore, require the full completion of survey and design activities before the procurement of equipment and materials, and the construction itself can start. The survey team should produce all relevant design and construction drawings and specifications required for the completion of these gravity diversion schemes.

The recommended procedures for the execution of each of the programme components are discussed in brief below.

Shallow wells: The Morogoro Wells Construction Project

The proposed short-term implementation programme recommends the construction of 427 shallow wells in 56 problem villages, and 726 shallow wells for 98 other villages in the survey area, giving a total of 1153 shallow wells. A shallow well construction programme, the Morogoro Wells Construction Project (MWCP) was started in the survey area in September, 1978, as part of the Dutch bilateral aid programme.

The Terms of Reference of the MWCP call for the construction of 550 shallow wells in Morogoro Region in a period of two years. An essential aspect of the project is the training of siting and construction crews that can execute shallow wells programmes for Maji Departments in various regions in Tanzania.
It is recommended that the MWCP project, in its present structure, be extended by at least two years to assure the completion of the major part of the estimated 1540 shallow wells which will be required for the survey area (1153 wells) and other parts of the Morogoro Region (about 385 wells). Moreover, the construction crews should be enabled to obtain sufficient training and experience so that the shallow well programme can be successfully continued afterwards. See Figure E 5.6-1.

Large gravity schemes: The Morogoro Gravity Plan

The proposed gravity schemes for the Gairo area and the villages in the foothills of the Migomberame Mountains (the Tundu gravity scheme) require various survey, design, costing and planning activities before their construction can be started. It is recommended that a special survey team for these two gravity projects be established, with the task of preparing detailed design and construction drawings complete with technical specifications, bills of quantities, cost estimates, and tender documents for those works which require the services of contractors.
Cost estimates for the construction of the designed schemes can be drawn up on the basis of unit costs of construction components on the one hand and bills of quantities on the other hand. These cost estimates are essential for the procurement of sufficient financial resources for the implementation of the proposed schemes.
It is estimated that this "Morogoro Gravity Plan" survey will require a period of about one year provided the services of 3 - 4 experienced surveyors and design engineers are available.
The porposed Gairo gravity scheme is to supply water to a number of seriously hit problem villages. It is therefore recommended that the implementation of the scheme should be proceeded with as soon as the survey has been completed and sufficient financial resources have been secured. The manpower enrolment should be such that the construction works will not take more than 3 years, so that the delay in attaining the 1981 targets for the villages concerned is limited to a minimum.
The porposed Tundu gravity scheme covers 5 villages where at present slight to moderate problems are experienced in the domestic water supply conditions. Its inclusion in the Morogoro Gravity Plan is recommended because of the availability of the MGP survey team, whose manpower and equipment can be utilized to carry out the survey for the Tundu scheme at minimum costs. The implementation of the scheme may be delayed by a few years, and it is recommended that construction works should be started at the completion of the proposed Gairo gravity scheme.

Borehole schemes and rehabilitation programme: The Morogoro Piped Water Supplies Project

The recommended short term implementation programme includes construction works for a number of piped water supplies. For part of these schemes designs have already been completed by RWE's office, financial resources were obtained from the Ministry or other institutions, and construction is underway or will start shortly. These works will be carried out by the Construction Section of the RWE's Office.
Another group of proposed schemes still requires survey and design work and procurement of financial resources for their construction. These schemes include:

- the completion of pumped supplies for 13 villages from 12 boreholes which were constructed by the Maji Department and the MDWSP survey team;
- the rehabilitation of intake structures of nine pumped, surface water supplies for 11 villages and an overhaul of their pumping equipment;
- the construction of some waterworks components (reservoirs and communal water distribution facilities) for existing gravity diversions from the River Mgolole, and the construction of a gravity diversion scheme for Msonge village.

The implementation of these schemes will require significant enrolment of manpower for survey, design, and construction works. It is considered that the relevant divisions of the RWE's office are insufficiently staffed to carry out the proposed programme in addition to their current activities. Therefore, the setting up, in close co-operation with the Maji Department, of a new temporary project organization, the "Morogoro Piped Water Supplies" project, similar to the Morogoro Wells Construction Project is recommended. This organization should be made responsible for carrying out the works and training sufficient and appropriate manpower to operate and maintain the schemes once they are completed. Similar to the MWCP project, survey and design of the various relatively small and independent schemes should be carried out on a basis of day to day engineering, and close co-operation should be secured between the project preparation and construction teams. The Morogoro Piped Water Supplies Project (MPWSP) will require a period of about two years to implement the proposed schemes, provided only rudimentary distribution facilities, i.e. a communal water distribution facility at the storage tank, are catered for. Timely procurement of equipment and materials should be ensured to prevent any disruptions during the construction programme. The MPWSP should have a central yard with facilities similar to the MWCP, and consideration of close co-operation between the two projects is recommended.

Other piped schemes

The proposed short-term implementation programme contains seven more piped water supply schemes for seven separate problem villages. Three of these villages, Kihonda, Tungi and Mkonowamara, are located in the part of the Ngerengere division where a large gravity diversion scheme may be required if shallow wells turn out to be unsuccessful.

It is recommended that the outcome of the pilot shallow well programme in this area should be awaited before taking further action on the implementation of separate schemes for these 3 villages.
Three other villages, Seregete A, Seregete B, and Kilama are located in areas with very unfavourable conditions for domestic water supply. These fairly small villages, therefore, require transmission of water over long distances, incurring high capital and recurrent costs. It is recommended that all parties concerned first consider the alternative of resettlement before further steps are taken to implement systems at high costs.
A similar procedure should be followed for Kitaita village, which is included in the proposed MGP survey. Its inclusion in the construction programme may, however, meet financial objections.
Finally, for Mbigili village, a pumped water supply from the River Mkundi has been suggested, but, as an intermediate solution, some shallow wells could be constructed on the banks of the River Mkundi. The MWCP will survey the feasibility of medium-depth wells within the village itself, and it is therefore suggested to opt for the given intermediate solution until the data from such detailed surveys are known.

The Lower Ngerengere gravity scheme has been suggested as an alternative water supply to 13 villages in Ngerengere division if shallow wells do not prove able to provide a dependable water supply system. It is most likely that this information will be known by the end of 1979, and it is suggested that a decision is as to whether or not carry out a detailed survey for the gravity scheme during the 1980 season should be taken on the basis of these data.

5.6.2. Recent developments in the bilateral co-operation between the Governments of the Netherlands and Tanzania

In April, 1979, during the bilateral meetings between representatives of the Governments of Tanzania and the Netherlands, it was agreed that the Netherlands would provide financial and technical assistance for the execution of the recommended Morogoro Gravity Plan and the Morogoro Piped Water Supplies Project.
It was agreed that the financial resources required will be made available by the Government of the Netherlands as part of its bilateral aid programme for the year 1979, while DHV Consulting Engineers will be made responsible for the implementation of the projects.

In November 1979, an agreement was reached and a contract was signed between the Ministry of Water, Energy and Minerals and DHV Consulting Engineers for carrying out of the Morogoro Gravity plan survey and for the implementation of the MDWSP.

The proposed short-term implementation programme is summarized in Table E 5.6-1, which also indicates the present status of the various parts of this programme. A layout for a general bar-chart of activities for rural water supply development programmes, including the different components of the short-term implementation programme, is given in Figure E 5.6-1.

5.6.3. Long-term village water supply development programmes

The Government's targets stipulate that by 1991 each villager should have access to a dependable source of clean water at a maximum of 400 m from the homestead. Since properly located shallow wells with hand-pumps fulfil these requirements, the provision of villages with shallow wells, whenever suitable hydrogeological conditions occur, is recommended. All other villages which lack provisions complying with the 1991 target, will have to be provided with a piped water supply, together with extensive distribution facilities.

It is recommended that the following programmes be proceeded with, once the short-term programme has been fully implemented:

1. Construction of additional shallow wells with hand pumps in those villages where this has proved to be a viable undertaking, thus making sure that the number of shallow wells in each village keeps pace with the increased population.

2. Where no suitable conditions for shallow wells exist, construction of piped water supplies with extensive distribution systems in those villages with only traditional water supply provision.
   First-of-all, villages with moderate problems in the supply of domestic water should be considered, and after that villages with only slight problems.

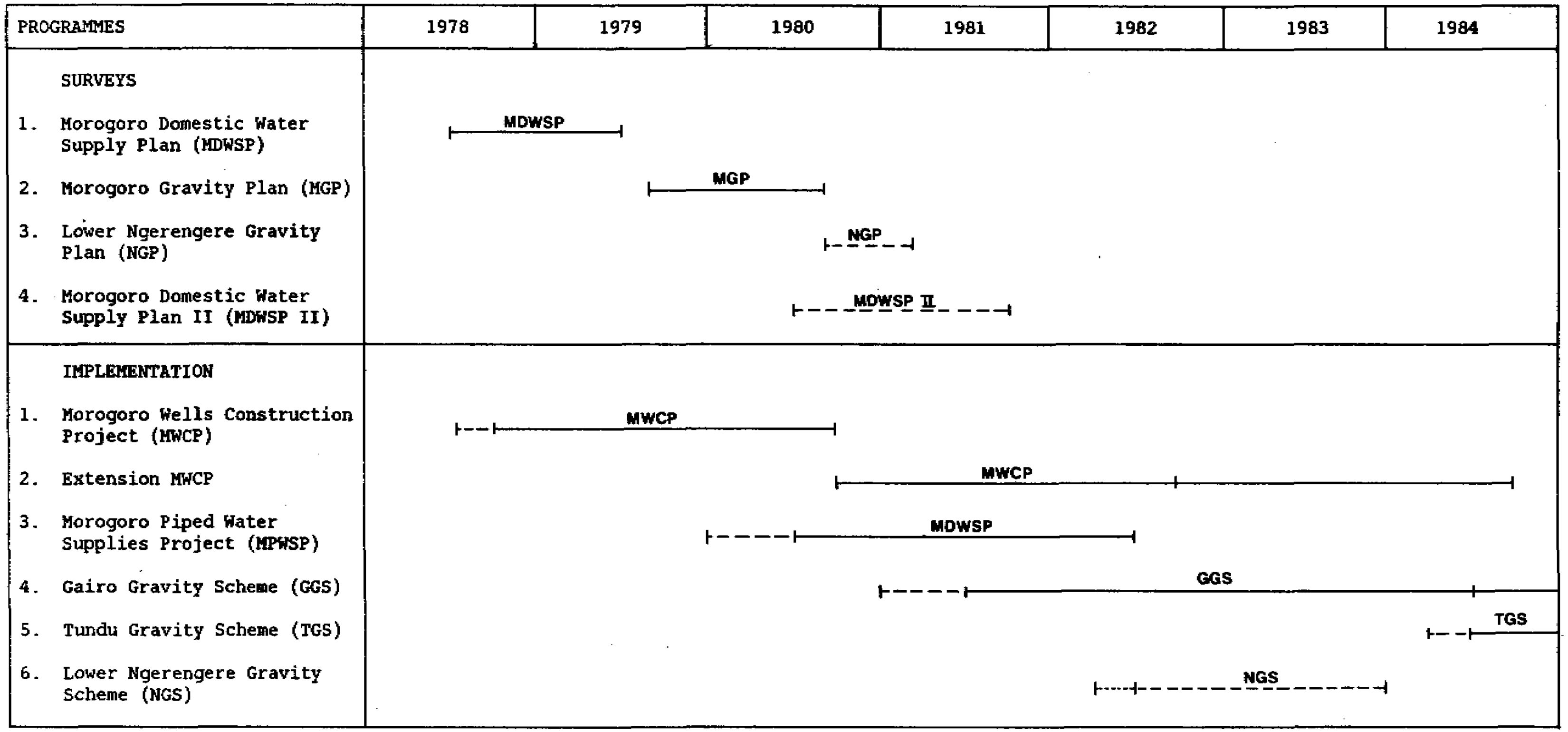


Figure E 5.6-1 Proposed general bar-chart for rural water supply development programmes in Morogoro Region.

Table E 5.6-1 Summary of proposed short-term implementation programme

Programme components	Villages		Remarks			Status of different programme components
	Nos.	Names	Type of system	No. of systems	No. of villages	
1. Improvement programme for problem villages	82	See Table E 4.1-2				
			Shallow wells with handpumps	403 *	50	MWCP (1978-1980)
			Gravity diversion	2	16	MGP-survey (1979-1980) for Gairo area, and MPWSP for Msonge village
			Pumped supply from shallow well or riverside well	7	7	Postponement of implementation recommended
			Pumped supply from borehole	9	9	MPWSP (1980-1982)***
2. Rehabilitation programme						
- pumped supplies	11	Turiani/Kilimanjaro, Lukenge, Mvumi Msowero (Mas), Kivungu, Kilangali Berega, Mlali/Kipera, and Kiswira	Rehabilitation of intake structure and overhaul of pumping equipment			MPWSP (1980-1982)
- gravity diversions	3	Kitungwa, Legezamwendo, Kisinga	Construction of storage tanks and some rudimentary distribution facilities (see Table EA 2-1)			MPWSP (1980-1982)
3. Additional programmes						
- gravity diversions	10	Ikwamba, Kisitwe, Kitange I, Kitange II, Kwipipa, Luhwaji, Majawanga, Msingise, Rubeho, Ukwamani	Part of Gairo gravity scheme, see Table EA 2-1			MGP-survey (1979-1980)
	2	Konga/Vikenge, Sangasanga	Maji Project, see Tables E 3.1-4 and EA 2-1			Construction underway
	1	Misongeni	Maji Project, see Tables E 3.1-4 and EA 2-1			Construction underway
	5	Msowero, Iwemba, Tundu, Kifinga, Ruaha	Tundu gravity supply scheme, see Table EA 2-1			MGP-survey (1979-1980)
- pumped supply from a borehole	4	Dakawa-Wami, Dibamba, Makuyu (Tur), Mbwade (Mas)	MDWSP boreholes constructed during hydrogeological survey, see Table EA 2-1			MPWSP (1980-1982)
- pumped supply from a riverside well	2	Lukobe, Kibati	Maji Projects, See Tables E 3.1-4 and EA 2-1			Construction not yet started
- shallow wells	98	See Table EA 2-1	Construction of 726 shallow wells			MWCP + extension (to be considered)
4. Lower Ngerengere gravity scheme	13**	Kihonda, Tungi, Mkambarani, Mkonowamara, Fulwe, Lubungo, Maseyu, Ngerengere Darajani, Mikese, Muhungamkola, Kinonko, Kiwege, Mlilingwa	This gravity scheme is proposed as an alternative to a shallow well construction programme, if practical experience shows that shallow wells do not offer a dependable solution.			Not yet under discussion See Remarks

* Excluding 24 shallow wells in those problem villages where borehole supplies will be installed in due course

** These villages are included in the improvement programme for problem villages (see remark).

*** Pending agreement on contract

3. Construction of extensive distribution systems for those villages which were provided with piped water supplies during the short-term implementation programme.

4. Construction of small scale low-cost water supply systems for villages or clusters of households in mountainous areas using appropriate technologies such as (run-of-the-river) bamboo piped systems, simple ferrocement or wooden storage tanks, and concrete or wooden hydraulic rams.

It is estimated that the investment costs for these medium/long-term programmes amount to Tshs 128 million, assuming the 1978 price level and the 1998 population as design population. These programmes, however, are only to be carried out after completion of the short-term implementation programme, and it may be expected that considerable cost increases will occur due to price increases and population growth.

The total investment budget required is estimated to be Tshs 528 million at an overall yearly cost increase of 10%, and Tshs 1080 million at an overall yearly cost increase of 15%. This estimate assumes that carrying out of the programmes will start in 1985 and last a period of 15 years.

The manpower requirements for the completion of the proposed programmes during a period of 15 years are estimated at 200 craftsmen and 20 technicians, or about three times the present enrolments in the RWE's project preparation and construction divisions.

ANNEX EA 1

COST FUNCTIONS FOR VILLAGE WATER SUPPLY SYSTEMS

CONTENTS:

TABLES:

FIGURES:

ANNEX EA 1 COST ESTIMATES FOR VILLAGE WATER SUPPLY SYSTEMS

1. Introduction

This annex will summarize the methods and data which have been used for the definition of cost functions for the four typical village water supply schemes given in Figure E 3.3-2. Essentially these schemes only differ from each other due to the type of water source (shallow well, riverside well, borehole, or surface water intake), and transmission system (pumped or gravity diversion).
The cost functions (see Table E 3.3.-14) have been used for the selection and cost evaluation of the most appropriate water supply scheme for individual villages.

2. Approach

Firstly, cost estimates were carried out for each typical village water supply scheme, considering different design populations and different lengths of the transmission mains. The general assumptions for these estimates were given in subparagraph E 3.3.4., while the technical designs and cost estimates for these typical schemes are summarized in Tables EA 1-2 a/e.
The total investment costs of each typical scheme were plotted versus the length of the transmission main with the design population as parameter.
Secondly, mathematical relationship between the plotted variables were derived using linear curve-fitting. In other words, a relationship of the form $y = ax + b$ was found for each typical scheme and each design population.
Thirdly, these linear relations between costs and length of transmission main were further evaluated as follows:

- the gradient (a), a parametric characteristic for the costs of the transmission main, has a specific value for each design population. The mathematical relation between these two parameters can best be described by power curve-fitting; or in the formula:

  $y_1 = c\,x^d$, where y_1 = cost of transmission main per unit of length (Tshs/m)
  x = design population
  c,d = constants

- the constant (d) has a specific value for each design population and its value represents all costs except the transmission main. The mathematical relation between these (all-but-transmission main) costs and the design population can best be described by linear curve-fitting, or in the formula:

  $y_2 = fx + g$, where y_2 = everything but transmission main costs (Tshs)
  x = design population
  f,g = constants

The total investment costs for a particular typical design can now be calculated using the relationship:

$$y = y_1 L + y_2 = cx^d L + fx + g$$

where y = total investment costs (Tshs)
L = length of transmission main (m)
x = design population
c,d,f,g = constants

Such relationships were derived for each of the typical schemes with piped water supply. The relationships are based on cost estimates for schemes with only rudimentary distribution facilities.
Cost functions for systems with extensive distribution facilities will require inclusion of a cost component for such distribution. These costs were estimated at Tshs 60/capita, and this will result in the following overall formula (see Tabel E 3.3. - 14):

$$y' = y + [60x]$$

where y' = total investment costs for systems with extensive distribution (Tshs)
y = total investment costs for systems with only rudimentary distribution (Tshs)
$[60x]$ = cost component for extensive distribution facilities, with x = design population.

Cost functions for annual costs and O & M costs were derived from the cost estimates for the typical designs in a way similar to those for the investment costs.

The cost functions described above are subject to certain conditions (e.g. design criteria, material selection, topography), as mentioned in subparagraph E 3.3.4.
Moreover, the cost functions do not include a budget allocation for water treatment, so that they are only relevant to those water sources which are suitable for direct domestic use.
It is obvious that new cost functions will have to be formulated if conditions deviate significantly from those adopted.

3. Further details on typical designs

The designs of the typical village water supply schemes which were used for the cost functions, are based on the design criteria given in Table E 3.2 -1.
These typical designs further include considerations, such as:
- working pressures recommended by the Maji Department;
- most economical pipe diameter.

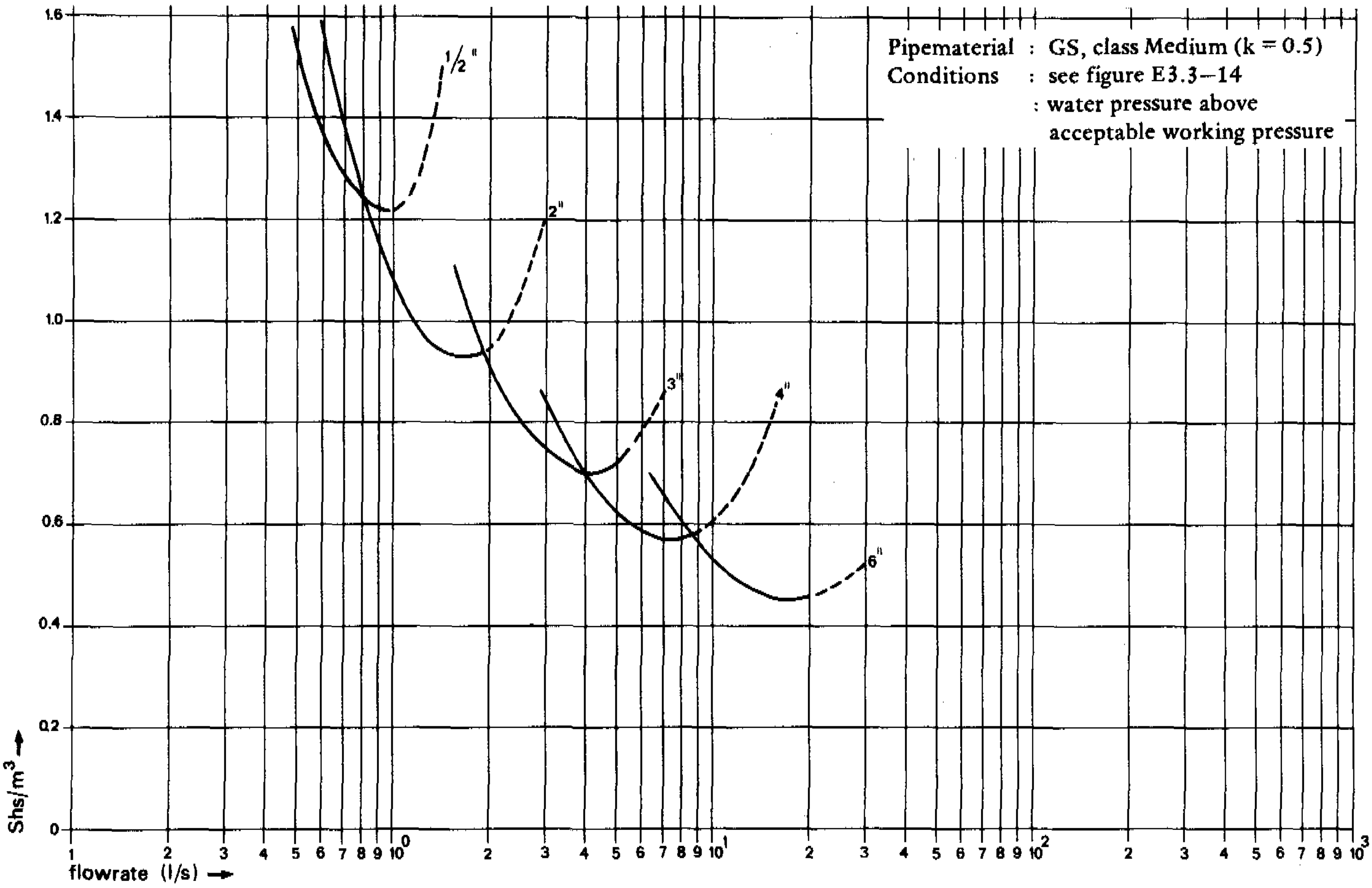
The working pressures for various pipe materials are summarized in Table EA 1-1.

Table EA 1-1 Working pressures (in meters head) recommended by the Maji Department.

diameter	PE - pipes		PVC - pipes			GS - pipes	
	B	C	B	C	D	Medium	Heavy
½"						242	
¾"						242	
1"	60	100				208	
1½"	60	100				173	
2"	60	100				138	
2½"	60	100					
3"			60	100	120	138	173
4"			60	100	120	104	138
6"			60	100	120	87	104
8"			60	100			

The calculations of the most economical pipe diameter were carried out for the specific conditions and assumptions adopted for the typical village water supply schemes considered, e.g. level difference of 50 m between water levels in water source and storage tanks, and transmission length of 2 or 5 km. The graphs, given in Figure EA 1-1 a/b, indicate the total exploitation costs of transmission mains of 2 km or 5 km length respectively (in Tshs/m^3 water transported) as a function of the flow rate for various pipe diameters.
It can be concluded from these graphs that the most economical pipe diameter for GS pipes (class medium) can be found for velocities of 0.85 - 0.95 m/s. The selection of the GS pipes was made for general costing purposes only. Normally, it will be more attractive to apply PE and PVC pipes for transmission and distribution lines.

The cost estimates for the typical village water supply schemes were based on unit costs for water works components as given in Table E 3.3 - 13. Some more elementary unit rates, for earth work and building materials, are summarized in Table EA 1-3.



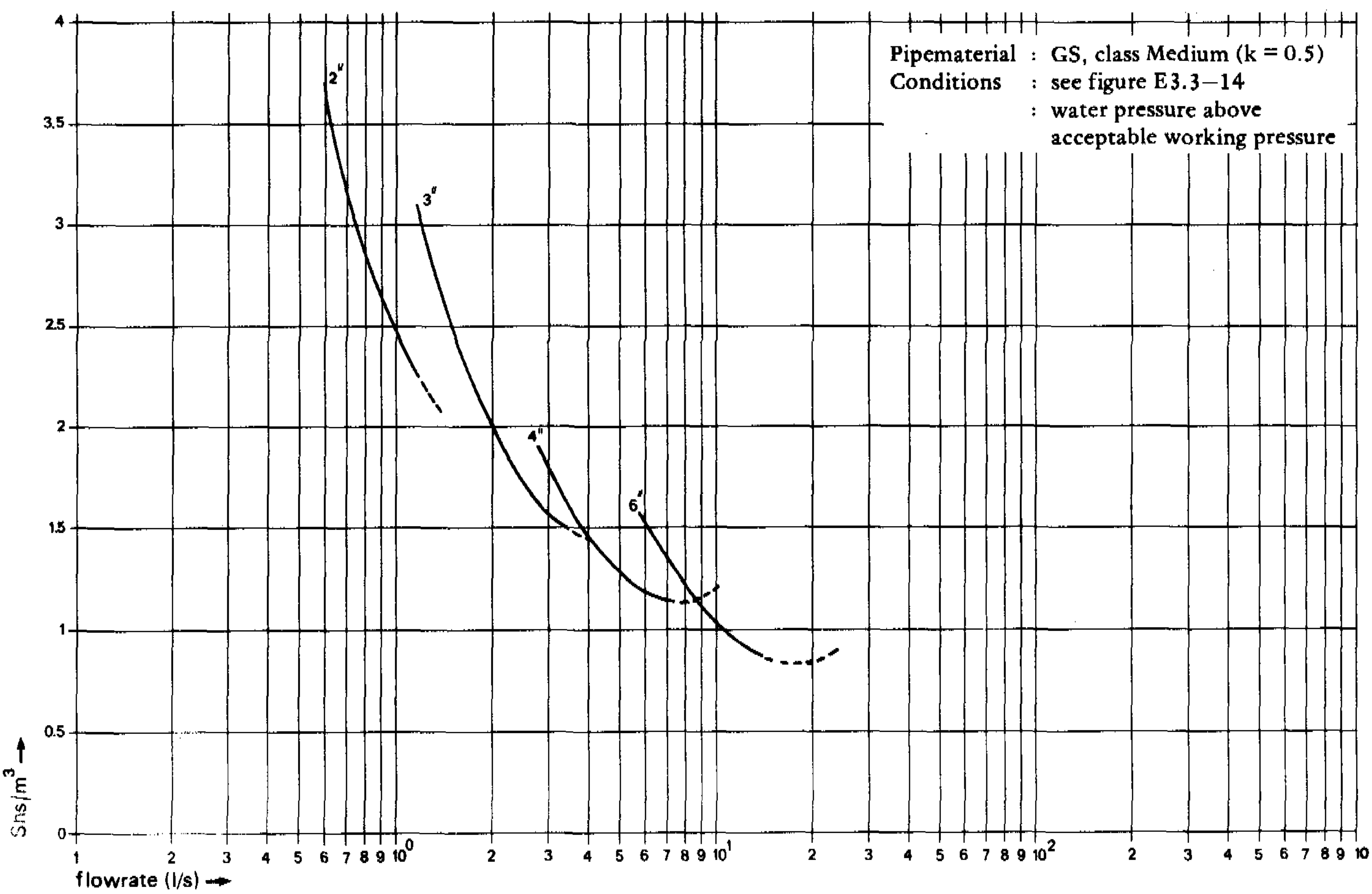


Figure EA 1-1 a/b Exploitation costs for water transmission (for GS pipes, class medium, 1978 price level).

Table EA 1-2a Investment costs of typical village water supply schemes; Transmission main of 0.5 km length.

Supply system	Specifications					Investment costs (Tshs)				
	Design Population					Design Population				
	1000	2000	4000	7000	10,000	1000	2000	4000	7000	10,000
<u>Borehole supply</u>										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						107,000	107,000	107,000	107,000	107,000
Pumphouse + Equipment						90,000	90,000	90,000	110,000	110,000
Transmission main (Ø)	2"	2"	3"	4"	6"	21,700	21,700	36,550	50,600	83,400
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						337,010	343,010	407,670	511,280	617,080
<u>Surface water supply (pumped)</u>										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						30,000	30,000	60,000	90,000	120,000
Pumphouse + equipment						90,000	90,000	90,000	115,000	115,000
Transmission main (Ø)	2"	2"	3"	4"	6"	21,700	21,700	36,550	50,600	83,400
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						260,010	266,010	360,670	499,280	635,080
<u>Gravity supply</u>										
Flow rate (l/s)	0.46	0.93	1.85	3.24	4.63					
Intake structure						30,000	30,000	60,000	75,000	90,000
Pumphouse equipment	-	-	-	-	-	-	-	-	-	-
Transmission main (Ø)	1"	1½"	2"	0.25 km 2" 0.25 km 3"	3"	13,550	16,450	21,700	29,125	36,550
Storage tank (m^3) **	22.5	45	90	135	225	65,000	85,000	110,000	140,000	175,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						121,860	150,760	225,820	302,805	378,230

* Designed for 10 years (50% population increase)
** Ground reservoirs

Table EA 1-2b Investment costs of typical village water supply schemes; Transmission main of 2 km length.

Supply system	Specifications					Investment costs (Tshs)				
	Design Population					Design Population				
	1000	2000	4000	7000	10,000	1000	2000	4000	7000	10,000
<u>Borehole supply</u>										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						107,000	107,000	107,000	107,000	107,000
Pumphouse + Equipment						90,000	90,000	90,000	110,000	110,000
Transmission main (Ø)	2"	2"	3"	4"	6"	86,800	86,800	146,200	202,400	333,600
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						402,110	408,110	517,320	663,080	867,280
<u>Surface water supply (pumped)</u>										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						30,000	30,000	60,000	90,000	120,000
Pumphouse + equipment						90,000	90,000	90,000	115,000	115,000
Transmission main (Ø)	2"	2"	3"	4"	6"	86,800	86,800	146,200	202,400	333,600
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						325,110	331,110	470,320	651,080	885,280
<u>Gravity supply</u>										
Flow rate (l/s)	0.46	0.93	1.85	3.24	4.63					
Intake structure						30,000	30,000	60,000	75,000	90,000
Pumphouse equipment	-	-	-	-	-	-	-	-	-	-
Transmission main (Ø)	1.5 km 1½"	1.5 km 2"	0.5 km 2"	1.5 km 3"	1 km 3"					
			1.0 km 3"		0.5 km 4"					
	0.5 km 3"	0.5 km 3"	0.5 km 4"	0.5 km 6"	0.5 km 6"	85,900	101,650	145,400	193,050	207,100
Storage tank (m^3) **	22.5	45	90	135	225	65,000	85,000	110,000	140,000	175,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						194,210	235,960	349,520	466,730	548,780

* Designed for 10 years (50% population increase)
** Ground reservoirs

Table EA 1-2c Investment costs of typical village water supply schemes; Transmission main of 5 km length.

Supply system	Specifications					Investment costs (Tshs)				
	Design Population					Design Population				
	1000	2000	4000	7000	10,000	1000	2000	4000	7000	10,000
Borehole supply										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						107,000	107,000	107,000	107,000	107,000
Pumphouse + Equipment						90,000	90,000	90,000	110,000	110,000
Transmission main (Ø)	2"	3"	4"	4"	6"	217,000	365,500	506,000	506,000	834,000
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						532,310	686,810	877,120	966,680	1,367,680
Surface water supply (pumped)										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						30,000	30,000	60,000	90,000	120,000
Pumphouse + equipment						90,000	90,000	90,000	115,000	115,000
Transmission main (Ø)	2"	3"	4"	4"	6"	217,000	365,500	506,000	506,000	834,000
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						455,310	609,810	830,120	954,680	1,385,680
Gravity supply										
Flow rate (l/s)	0.46	0.93	1.85	3.24	4.63					
Intake structure						30,000	30,000	60,000	75,000	90,000
Pumphouse equipment	-	-	-	-	-	-	-	-	-	-
Transmission main (Ø)	2"	4.5 km 2" 0.5 km 3"	3"	3 km 3" 2 km 4"	4"	217,000	231,850	365,500	421,700	506,000
Storage tank (m^3)	22.5	45	90	135	225**	105,000	140,000	185,000	240,000	350,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						365,310	421,160	644,620	795,380	1,022,680

* Designed for 10 years (50% population increase)

** 135 m^3 on raiser, and 90 m^3 on ground level

Table EA 1-2d Investment costs of typical village water supply schemes; Transmission main of 7.5 km length.

Supply system	Specifications					Investment costs (Tshs)				
	Design Population					Design Population				
	1000	2000	4000	7000	10,000	1000	2000	4000	7000	10,000
<u>Borehole supply</u>										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						107,000	107,000	107,000	107,000	107,000
Pumphouse + Equipment						90,000	90,000	90,000	110,000	110,000
Transmission main (Ø)	2"	3"	4"	3.5 km 4" 4 km 6"	6"	325,500	548,250	759,000	1,021,400	1,251,000
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						640,810	869,560	1,130,120	1,482,080	1,784,680
<u>Surface water supply (pumped)</u>										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						30,000	30,000	60,000	90,000	120,000
Pumphouse + equipment						90,000	90,000	90,000	115,000	115,000
Transmission main (Ø)	2"	3"	4"	3.5 km 4" 4 km 6"	6"	325,500	548,250	759,000	1,021,400	1,251,000
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						563,810	792,560	1,083,120	1,470,080	1,802,680
<u>Gravity supply</u>										
Flow rate (l/s)	0.46	0.93	1.85	3.24	4.63					
Intake structure						30,000	30,000	60,000	75,000	90,000
Pumphouse equipment	-	-	-	-	-	-	-	-	-	-
Transmission main (Ø)	2"	4 km 2" 3.5 km 3"	3"	2 km 3" 5.5 km 4"	6.5 km 4" 1.0 km 6"	325,500	429,450	548,250	702,800	824,600
Storage tank (m^3)	22.5	45	90	135	225**	105,000	140,000	185,000	240,000	350,000
Distribution line* (Ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						473,810	618,760	827,370	1,076,480	1,341,280

* Designed for 10 years (50% population increase)

** 135 m^3 on raiser, and 90 m^3 on ground level

Table EA 1-2e Investment costs of typical village water supply schemes; Transmission main of 10 km length.

Supply system	Specifications: Design Population					Investment costs (Tshs): Design Population				
	1000	2000	4000	7000	10,000	1000	2000	4000	7000	10,000
<u>Borehole supply</u>										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						107,000	107,000	107,000	107,000	107,000
Pumphouse + Equipment						90,000	90,000	90,000	110,000	110,000
Transmission main (ø)	8 km 2"			3 km 4"						
	2 km 3"	3"	4"	7 km 6"	6"	493,400	731,000	1,012,000	1,471,200	1,668,000
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						808,710	1,052,310	1,383,120	1,931,880	2,201,680
<u>Surface water supply (pumped)</u>										
Flow rate (l/s)	0.93	1.85	3.7	6.5	9.3					
Intake structure						30,000	30,000	60,000	90,000	120,000
Pumphouse + equipment						90,000	90,000	90,000	115,000	115,000
Transmission main (ø)	8 km 2"			3 km 4"						
	2 km 3"	3"	4"	7 km 6"	6"	493,400	731,000	1,012,000	1,471,200	1,668,000
Storage tank (m^3)	22.5	22.5	45	90	135	105,000	105,000	140,000	185,000	240,000
Distribution line* (ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						731,710	975,310	1,336,120	1,919,880	2,219,680
<u>Gravity supply</u>										
Flow rate (l/s)	0.46	0.93	1.85	3.24	4.63					
Intake structure						30,000	30,000	60,000	75,000	90,000
Pumphouse equipment	-	-	-	-	-	-	-	-	-	-
Transmission main (ø)		3.5 km 2"	9 km 3"		7 km 4"					
	2"	6.5 km 3"	1 km 4"	4"	3 km 6"	434,000	627,050	759,100	1,012,000	1,208,800
Storage tank (m^3)	22.5	45	90	135	225**	105,000	140,000	185,000	240,000	350,000
Distribution line* (ø)	3"	3"	4"	6"	6"	7,310	7,310	10,120	16,680	16,680
D.W.P.* (Taps)	6	12	24	42	60	6,000	12,000	24,000	42,000	60,000
Total costs						582,310	816,360	1,038,220	1,385,680	1,725,480

* Designed for 10 years (50% population increase)

** 135 m^3 on raiser, and 90 m^3 on ground level

Table EA 1-3 Unit rates for civil works (1978 price level)

	Item		Unit	rate(Tshs)
	EARTHWORKS			
1.	Cleaning sites for structures		m^2	1/-
2.	Excavation (mixed)		m^3	30/-
3.	Excavation of trenches		m^3	15/-
4.	Backfill and disposal of excess material (from trenches)		m^3	5/-
5.	Service roads (cleaning/levelling)		m	10/-
	BUILDING MATERIALS			
6.	Sand, sieved according to size (manual operation), excl. transport		m^3	60/-
7.	River sand for concrete, excl. transport (quarrying)		m^3	30/-
8.	Quarry aggregates, excl. transport		m^3	50/-
9.	Crushed aggregate		m^3	50/-
10.	Cement (ex Dar-es-Salaam)		ton	720/-
11.	Plain concrete, incl. mixing and placing (excl. transport)		m^3	500/-
12.	Reinforced concrete, incl. mixing and placing (excl. transport)		m^3	575/-
13.	Concrete blockwork		m^3	450/-
14.	Formwork with scaffolding		m^2	25/-
	MISCELLANEOUS			
15.	Transport	landrover	km	2/70
		lorry	ton/km	2/-
16.	Fuel	diesel	litre	2/70
		petrol	litre	5/10

Annex EA2 Table EA 2-1 Proposed future water supply development programmes for all villages in the survey area

Village		Population 1978	Potential water supply systems						Recomended water supply improvement programme in accordance with targets		Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
			SWHP	SWP	RP	BH	G	Surface water source	Period 1978-1983 /	Period 1983-1993		
Amini	Mat	1116			+		+		-	Group 25	Group 25	
Baga	Mat	1276			+		+		-	Group 25	Group 25	
Bagiro	Mat	1471			+		+		-	Group 25	Group 25	
Balami	Bwa	771			+		+		-	Group 25	Group 25	
Berega	Mam	2890	+		+			Berega R.	STIP: REH(IW + PE)	EXT: ED	EXT: ED	
Bigwa	Nge	1063	+		(+)			Bigwa R.	SWHP: 5	SWHP: +2	(RSWP + 2km + SED)	
Bonye	Bwa	2205	+		+			Dutumi R.	SWHP: 11	SWHP: +4	Group 4	
Bumu	Mge	1383			+		+		-	Group 25	Group 25	
Bunduki	Mge	1501			+		+	Mgeta R.	-	Group 25	Group 25	
Bungu	Bwa	1183			+				-	RP + 2km + SRD	RP + 2km + SED	
Bwakira Chini	Bwa	1379	+		+			Bwakira R.	-	EXT: ED	EXT: ED	
Bwakira Juu	Bwa	2020	+		(+)			Bwakira R.	STIP: SWHP(10)	SWHP: +4	(RSWP + 2km + SED)	
Bwila	Bwa	2331	+		+			Ruvu R.	SWHP: 12	SWHP: +4	RSWP + 2km + SED	
Chabi-Mgogozi	Mik	1623	+		+		+		SWHP: 8	SWHP: +3	G + 5km + SED	
Chabima	Mas	458			+		+		-		G + 4km + SED	
Chagongwe	Non	1451			+		+		-		G + 1km + SED	
Chakwale	Gai	4416					+		STIP: Group 1	Group 1	Group 1	
Changa	Mat	1274			+				-		Group 12	
Changarawe	Mas	1590	+	+	+			Miyombo R.	SWHP: 8	SWHP: +3	SWHP + 2km + SED	
Changarawe	Mla	1305					+		-	EXT: ED	EXT: SED	
Chanjale	Non	1856			+		+		-		G + 5km + SED	
Chanyumbu	Nge	2272	+		(+)				STIP: SWHP(11)	SWHP: +5	(RSWP + 5km + SED)	
Chanzuru	Mas	2297	+	+		+			STIP: BH + 2km+SRD* SWHP (5)	EXT: ED	EXT: ED	* Maji Project, see Table E 3.1-4
Chogowale	Gai	1430	+		+			SWHP: 7	SWHP: +3	RP + 2km + SED		
Chonwe	Mik	1611			+		+		-		Group 25	
Dakawa	Bwa	1871	+*		+	+		Mgeta R.	STIP: BH* + 2km+SRD	EXT: ED	EXT: ED	* medium depth
Dakawa Wami	Tur	1774	+	+	+	+		Wami R.	STIP: BH + 2km +SRD	EXT: ED	EXT: ED	
Dibamba	Tur	801	+	+		+	+	Mkindo R.	STIP: BH + 2km +SRD	EXT: ED	EXT: ED	
Diburuma	Tur	879	+	+					SWHP: 4	SWHP: +2	SWP + 2km + SED	
Difinga	Tur	461	+*		+			Lusonge R.	STIP: SWHP(2)*	SWHP: +1*	RSWP + 2km + SED	* RSW's along Lusonge R. (2 km)
Digalama	Tur	549			(+)		(+)		-	(Group 25)	(Group 25)	
Digoma	Tur	2190			+						RSWP + 2km + SED	
Diguzi	Nge	868	+		+			Ngerengere R.	STIP: SWHP(4)	SWHP: +2	RSWP + 3.5km + SED	
Dihinda	Tur	1267	+	+					STIP: SWHP(6)	SWHP: +3	SWP + 2km + SED	
Dihombo	Tur	984	+	+			+		SWHP: 5	SWHP: +2	Group 21	
Dimiro	Mat	1020			+		+		-	Group 25	Group 25	

Annex EA2 Table EA 2-1 (continued)

Village		Population 1978	Potential water supply systems: SWHP	SWP	RP	BH	G	Surface water source	Recomended water supply improvement programme in accordance with targets: Period 1978-1983	Period 1983-1993	Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
Dodoma	Mas	650	+	+					SWHP: 3	SWHP: +2	SWP + 2km + SED	
Doma	Mla	2801	+	+	+				SWHP: 14	SWHP: +6	SWP + 2km + SED	
Dumila	Mam	2606			+	+	+	Mkundi R.	STIP: BH + 2km +SRD	EXT: ED	EXT: ED	River Kisungusi
Fulwe	Nge	2212	(+)				(+)		STIP: SWHP(11)*	SWHP: +4*	Group 3	* see Table E 4.1-2
Gairo	Gai	5008					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Gomero	Bwa	2842	+		+			Mgeta R.	STIP: SWHP(14)	SWHP: +6	Group 22	
Gozo	Mat	1797	+					Mvizigo R.	SWHP: 9	SWHP: +4	RSWP + 2km + SED	
Hembeti	Tur	1827	+	+			+	Mkindu R.	SWHP: 9	SWHP: +4	Group 21	
Hewe	Mat	789			+		+		-	Group 25	Group 25	
Homboza	Mla	1827							-	Group 25	Group 25	
Hoza	Tur	1542	+	+	+				SWHP: 8	SWHP: +3	SWP + 2km + SED	
Ibindo	Mam	1558	+		+				STIP: SWHP(8)	SWHP: +3	RSWP + 2km + SED	
Ibingu	Ula	601					+		-		G +2 km + SED	
Ibuti	Gai	1245					+	Milindo T	STIP: Group 1	Group 1	Group 1	
Idibo	Gai	2715	+		+			Magera R.	STIP: SWHP(14)	SWHP: +5	RSWP + 2km + SED	
Ihenje	Gai	1483					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Ikwamba	Non	2594			+		+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Ilakala	Ula	1502	+	+			+	Miyombo R.	STIP: SWHP(8)	SWHP: +3	SWP + 3km + SED	
Ilonga	Mas	1881	+	+	+		+*	Ilonga R.	SWHP: 9	SWHP: +4	RSWP + 2km + SED	* River Kisungusi
Italagwe	Gai	3014	+		+			Kinyolisi R.	SWHP: 15	SWHP: +6	RSWP + 3km + SED	
Iwemba	Mik	1425			+		+	Tundu R.	STIP: Group 2	Group 2	Group 2	
Iyogwe	Gai	2856	+		+			Kinyolisi T.	STIP: SWHP(14)	SWHP: +6	RSWP + 2km + SED	
Kalundwa	Mat	1754			+		+		-	Group 25	Group 25	
Kambala	Tur	1009	+	+			+	Mkindu R.	STIP: SWHP(5)	SWHP: +2	SWP + 2km + SED	
Kanga	Tur	1166	+	+					SWHP: 6	SWHP: +2	SWP + 3km + SED	
Kasanga	Bwa	1428			+		+		-	Group 25	Group 25	
Kauzeni	Mla	781			+		+	Ngerengere R.	-	-	-	
Kibaoni	Mge	979			+		+	Mgeta R.	-	Group 25	Group 25	
Kibangile	Mat	1162	+		+			Ruvu R.	SWHP: 6	SWHP: +2	RSWP + 2km + SED	
Kibati (Salawe)	Tur	2783	+	+					Maji Project*	-	-	* See Table E 3.1-4
Kibedya	Gai	3271					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Kibigiri	Mge	1978			+		+		-	Group 25	Group 25	
Kibogwa	Mat	1718			+		+		-	Group 25	Group 25	
Kibuko	Mat	1482	+	+					SWHP: 8	SWHP: +2	SWP + 2km + SED	
Kibuko	Mge	942			+		+		-	Group 25	Group 25	
Kibungo (Kib.)	Mat	1053			+		+		-	Group 25	Group 25	
Kibungo (Kir.)	Mat	1135	+	+					SWHP: 6	SWHP: +2	SWP + 2km + SED	
Kibwaya	Mat	1406	+	(+)					SWHP: 7	SWHP: +3	(SWP + 2km + SED)	
Kibwege	Mat	1006			+		+		-	Group 24	Group 24	
Kichangani	Tur	3593			+			Diwale R.	STIP: REH(IW + PE)	EXT: SED	EXT: SED	

 Table EA 2-1 (continued)

Village		Population 1978	Potential water supply systems						Recomended water supply improvement programme in accordance with targets		Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
			SWHP	SWP	RP	BH	G	Surface water source	Period 1978-1983 /	Period 1983-1993		
Kidete-station	Ula	1382	+		+			Lumuma R.	SWHP: 7	SWHP: +3	RSWP + 2km + SED	
Kidogobasi	Mik	3424	+	+		+			STIP: BH + 2km +SRD*	EXT: ED	EXT: ED	* also: SWHP (5)
Kidudwe	Tur	2183	+	+					STIP: SWHP(11)	SWHP: +4	SWP + 2km + SED	
Kidudwe/ Ujamaa	Tur	649	+	+					SWHP: 3	SWHP: +2	SWP + 2km + SED	
Kidugallo	Nge	2133			+	+		Ngerengere R.	-	REH: BH + SED	REH: BH + SED	
Kiduhi	Mas	452	+		+			Miyombo R.	- *	-	-	* See Table E 3.1-4
Kidunda	Nge	1402	+		+			Ruvu R.	SWHP: 7	SWHP: +3	RSWP+2km+SED	
Kiegea	Mam	1217					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Kifindike	Mat	1287			+		+	Ruvu R.	-	RSWP + 2km + SRD	RSWP + 2km + SED	
Kifinga	Mik	1958			+		+	Tundu R.	STIP: Group 2	Group 2	Group 2	
Kifuru	Mat	806			+		+		-	Group 25	Group 25	
Kiganila	Bwa	829	+		+			Ruvu R.	SWHP: 4	SWHP: +2	Group 6	
Kigugu	Tur	1530					+	Mkindu R.*	-	Group 21	Group 21	* or Divue R.
Kihonda	Nge	1707			+		+	Ngerengere R.	STIP: RP + 1km +SRD	EXT: ED	Group 3	
Kikeo	Mge	1435			+		+		-	Group 25	Group 25	
Kikundi	Mat	1489	+		+				SWHP: 4*	SWHP: +2*	EXT: SED	* only for sub-villages
Kikunga	Ula	771	+		+			Miyombo R.	SWHP: 4	SWHP: +1	Group 7	
Kilama	Gai	800			+			Kinyolisi R.	STIP: RSWP +5km+SRD*	EXT: ED	EXT: ED	* see Table E 4.1-2
Kilangali	Mas	2357	+		+			Miyombo R.	STIP: REH(IW + PE)*	EXT: SED	EXT: SED	* also: SWHP (4)
Kilimanjaro	Tur	2235			+			Diwale R.	STIP: REH(IW + PE)	EXT: SED	EXT: SED	
Kilosa									-	-	-	
Kimamba									-	-	-	
Kinda	Tur	1397			+		+		-	Group 25	Group 25	
Kinonko	Nge	651	(+)				(+)	Ngerengere R.	STIP: SWHP(3)*	SWHP: +2*	Group 3	* see Table E 4.1-2
Kinyolisi	Gai	800	+		+			Kinyolisi R.	SWHP: 4	SWHP: +2	RSWP + 2km + SED	
Kipera	Mla	2289	+		+			Mlali R.	STIP: REH(IW + PE)*	EXT: SED	EXT: TM + SED	* for sub-villages: SWHP (5)
Kiroka	Mat	3327	+		+		+	Kiroka R.	STIP: SWHP(17)	SWHP: +6	Group 9	
Kirunga	Mat	1215			+		+		-	Group 25	Group 25	
Kisaki-Kituoni	Bwa	2015			+	+		Mgeta R.	-	BH* + 2km + SRD	BH* + 2km + SED	* medium depth
Kisala	Tur	1340	+		+			Diwale R.	SWHP: 7	SWHP: +2	TSED*	* extension from Turiani
Kisanga	Mik	2464	+		+		+		SWHP: 12	SWHP: +5	G + 2.5km + SED	
Kisanga-stand	Nge	1099	+		+			Ruvu R.	SWHP: 5	SWHP: +3	RSWP + 2km + SED	
Kisemu	Nge	966	(+)			(+)			STIP: SWHP(5)	SWHP: +2	BH + 2km + SED	
Kisimagulu	Tur	1180			+		+		-	G + 2km + SRD	G + 2km + SED	
Kisinga	Nge	938					+	Mgolole R.	STIP: REH (SRD)	EXT: ED	EXT: ED	
Kisitwi	Gai	2130					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Kisongwe	Mas	1508			+		+		-	Group 25	Group 25	
Kiswira	Mat	1230			+		+	Mvizigo R.	STIP: REH(IW + PE)	-	-	
Kitaita	Gai	624					(+)	Milindo T.	STIP: Group 1	Group 1	Group 1	

Annex EA2 Table EA 2-1 (continued)

Village		Population 1978	Potential water supply systems						Recomended water supply improvement programme in accordance with targets		Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
			SWHP	SWP	RP	BH	G	Surface water source	Period 1978-1983	Period 1983-1993		
Kitange I	Mam	1151					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Kitange II	Mam	2113					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Kitete	Mam	1171	+		+	+		Kitete R.	STIP: BH + 2km +SRD*	EXT: ED	EXT: ED	* also: SWHP (3)
Kitete-Msindazi	Mik	1542	+		+			Gr.Ruaha R.	SWHP: 8	SWHP: +3	RSWP + 2km + SED	
Kitonga	Bwa	1011			+		+		-	Group 25	Group 25	
Kitungwa	Nge	2211					+	Mgolole R.	STIP: REH(SRD)	EXT: ED	EXT: ED	
Kitungwa	Mat	1192			+		+		-	Group 25	Group 25	
Kivungu	Mas	2265	+		+			Miyombo R.	STIP: REH(IW + PW)	EXT:TSED	EXT: TSED	
Kiwege	Nge	937	(+)				(+)	Ngerengere R.	STIP: SWHP(5)*	SWHP: +2	Group 3	* see Table E 4.1-2
Kizagira	Bwa	628			+		+		-	G + 2km + SRD	G + 2km + SED	
Kiziwa	Mat	2210	+				+	Kiroka R.	STIP: SWHP(11)	SWHP: +4	Group 9	
Kododo	Mge	2134	(+)	(+)					-		(SWP + 2km + SED)	
Kolero	Bwa	1540	(+)	(+)					-		(SWP + 2km + SED)	
Koloni	Bwa	1485			+		+		-	G + 2km + SRD	G + 2km + SED	
Konde	Mat	1231			+		+		-	G + 2km + SRD	G + 2km + SED	
Kondoa	Mas	1021	+			+			STIP: BH + 2km +SRD*	EXT: ED	EXT: ED	* also: SWHP (3)
Konga/Vikenge	Mla	1449	+		+		+	Ngerengere R.	Maji Project*	-	-	* see Table E 3.1-4
Kongwa	Bwa	1157	+		+			Mvuha R.	SWHP: 6	SWHP: +2	Group 11	
Kumba	Bwa	961			+		+		-	Group 25	Group 25	
Kumbulu	Non	1255			+		+		-	G + 2.5km + SRD	G + 2.5km + SED	
Kunke	Tur	1326	+	+					STIP: SWHP(7)	SWHP: +2	SWP + 2km + SED	
Kwaba	Nge	718	+		+			Ngerengere R.	SWHP: 4	SWHP: +1	RSWP + 2km + SED	
Kwambe	Mam	-							-	-	-	
Kwamtonga	Tur	1109	+	+	+		+	Divue R.	SWHP: 6	SWHP: +2	G + 2km + SED	
Kwelikwiji	Tur	1464			+		+	Diwale R.	-	G + 2km + SRD	G + 2km + SED	
Kwipipa	Gai	1273					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Langali	Mge	2201			+		+	Mgeta R.	-	Group 25	Group 25	
Lanzi	Mat	1010			+		+		-	Group 25	Group 25	
Legezamwendo	Nge	1373					+	Mgolole R.	STIP: REH(SRD)	EXT: ED	Group 8	
Leshata	Gai	2285	+		+			Kinyolisi R.	STIP: SWHP(11)	SWHP: +5	RSWP + 2km + SED	
Logo	Mat	871			+			Ruvu R.	-	Group 12	Group 12	
Longwe	Bwa	635			+		+		-	Group 25	Group 25	
Luale	Mge	2303			+		+		-	Group 25	Group 25	
Lubasazi	Bwa	861	(+)	(+)					-		(SWP + 2km + SED)	
Lubumu	Nge	372	+		+				SWHP: 2	SWHP: +1	Group 13	
Lubungo	Mla	1095	+	(+)					SWHP: 5	SWHP: +3	(SWP + 2km + SED)	
Lubungo	Nge	967	(+)				(+)		STIP: SWHP(5)*	SWHP: +2*	Group 3	* see Table E 4.1-2
Lufukiri	Non	1004			+		+		-	Group 25	Group 25	
Lugeni	Mat	707			+		+		-	Group 25	Group 25	
Luhembe	Mik	303	(+)	(+)					-		(SWP + 2km + SED)	

Table EA 2-1 (continued)

Village		Population 1978	Potential water supply systems						Recomended water supply improvement programme in accordance with targets		Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
			SWHP	SWP	RP	BH	G	Surface water source	Period 1978-1983 /	Period 1983-1993		
Luhindo	Tur	812			+	+*		Wami R.	STIP: TSRD*	EXT: ED	Group 14	* connection to Dakawa borehole
Luholole	Mat	1645	+						SWHP: 8	SWHP: +4	Group 15	
Luhwaji	Gai	879					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Lukange	Bwa	1841	(+)	(+)					-		(SWP + 2km + SED)	
Lukenge	Mat	1103			+		+		-	Group 25	Group 25	
Lukenge	Tur	864			+			Diwale R.	STIP: REH(IW + PE)	EXT: ED	EXT: ED	
Lukobe	Nge	1380	+	+	+			Ngerengere R.	STIP: SWHP(7)*	SWHP: +3*	SWP + 2km + SED*	* or BTS-project, see Table E 3.1-4
Lukulunge	Bwa	636	+		+				SWHP: 3	Group 11	Group 11	
Lukunguni	Mge	1694			+		+		-	Group 25	Group 25	
Lukuyu	Mge	791							-			
Lulongwe	Nge	883	+		+				SWHP: 4	SWHP: +2	RSWP + 2km + SED	
Lumango	Mik	835	+		+				SWHP: 4	SWHP: +2	RSWP + 2km + SED	
Lumba Chini	Bwa	2154			+		+		-	Group 25	Group 25	
Lumba Juu	Bwa	860			+		+		-	Group 25	Group 25	
Lumbiji	Non	1861			+		+		-	G + 4km + SRD	G + 4km + SED	
Lumuma-Idole	Ula	1729	+		+			Lumuma R.	SWHP: 9	SWHP: +3	G + 2km + SED	
Lundi	Mat	2006	+	+					SWHP: 10	SWHP: +4	SWP + 2km + SED	
Lusange	Mat	1237			+		+		-	Group 25	Group 25	
Lusungi	Mge	1214			+		+		-	Group 25	Group 25	
Lut.Twat-watwa	Mas	1032	+		+			Wami R.	SWHP: 5	SWHP: +2	RSWP + 2km + SED	
Luwemba	Ula	1181			+		+		-	G + 3km + SRD	G + 3km + SED	
Mabana	Mam	1050			+			Mkundi R	STIP: Group 16	EXT: ED	EXT: ED	
Mabula	Mam	1069	+		+			Berega R.	STIP: SWHP(5)	SWHP: +2	RSWP + 2km + SED	
Machatu	Mam	829					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Madege	Gai	2050	+	+					STIP: SWHP(10)	SWHP: +4	RSWP + 2km + SED	
Madizini	Tur	2443	+						STIP: SWHP(12)	SWHP: +5	Group 12	
Madizini	Mik	862	+		+		+		SWHP: 4	SWHP: +2	G + 2km + SED	
Madoto	Mas	1731	+			(+)			SWHP: 7*	SWHP: +3	BH + 6km + SED	* two Maji SWHP are available
Madudu	Mam	1296	+	+		+			STIP: SWHP(6)	SWHP: +3	Group 20	
Madudumizi	Ula	1414	+		+		+		SWHP: 7	SWHP: +3	Group 7	
Mafuta	Tur	809			+		+	Diwale R.	-	G + 2km + SRD	G + 2km + SED	
Magali	Mla	647	+		+				SWHP: 3	SWHP: +2	RSWP + 2km + SED	
Magela	Nge	460	+		+				SWHP: 2	SWHP: +1	Group 13	
Magera	Mam	1567	+		+				SWHP: 8	SWHP: +3	RSWP + 2km + SED	
Magogoni	Bwa	786	+		+				SWHP: 4	SWHP: +2	Group 6	
Magole	Mam	3752				+			Maji Project*	-	-	* BH + SED under construction
Magomeni	Mam	5400	+		+			Mkondoa R.	SWHP: 27	SWHP: +9	RSWP + 2km + SED	

Annex EA2 Table EA 2-1 (continued)

Village		Population 1978	Potential water supply systems: SWHP	SWP	RP	BH	G	Surface water source	Recomended water supply improvement programme in accordance with targets: Period 1978-1983	/ Period 1983-1993	Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
Magubike	Mam	2919	+		+			Mamboya R.	STIP: SWHP(15)	SWHP: +5	RSWP + 2km + SED	
Maguha	Mam	1827	+	+	+*				-	EXT: ED	EXT: ED	* spring
Magunga	Tur	546			+		+		-	Group 25	Group 25	
Maguruwe	Mge	1541			+		+		-	Group 25	Group 25	
Maharaka	Mla	1840	+		+			Maraka R.	STIP: SWHP(9)	SWHP: +4	RSWP + 2km + SED	
Majawanga	Gai	955					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Makuyu	Tur	2342	(+)			+			STIP: BH + 2km +SRD	EXT: ED	EXT: ED	
Makuyu	Gai	2089	+		+			Kinyolisi R.	STIP: SWHP(10)	SWHP: +5	RSWP + 2km + SED	
Makwambe	Mam	1153			+			Msowero R.	-	RSWP + 2km + SRD	RSWP + 2km + SED	
Malangali	Mas	3126	+		+			Mkondoa R.	SWHP: 16	SWHP: +6	RSWP + 2km + SED	
Malani	Bwa	815			(+)		(+)		-	Group 25	Group 25	
Malolo	Mik	2612	+		+		+		SWHP: 13	SWHP: +5	G + 2km + SED	
Malui	Mas	2977	+		+			Mkondoa R.	SWHP: 15	SWHP: +6	Group 18	
Mambani	Mat	1512			+		+		-	Group 25	Group 25	
Mamboya	Mam	956	(+)	(+)					-	(SWP + 5km + SRD)	(SWP + 5km + SED)	
Mamoyo	Mas	4509	+						SWHP: 23	SWHP: +9	Group 19	
Mandela	Mam	1643	(+)			+			STIP: BH + 2km +SRD*	EXT: ED	EXT: ED	* also: SWHP (2)
Mangae	Mla	952	+	(+)					SWHP: 5	SWHP: +2	(SWP + 2km + SED)	
Manyinga	Tur	2156	+						SWHP: 11	SWHP: +4	Group 17	
Manza	Mla	580	+		(+)			Manza R.	STIP: SWHP(3)	SWHP: +1	(RSWP + 2km + SED)	
Masalawe	Mge	989	(+)	(+)					-		(SWP + 2km + SED)	
Masenge	Gai	1592			+		+		-	Group 25	Group 25	
Maseyu	Nge	1216	(+)				(+)	Ngerengere R.	STIP: SWHP(6)*	SWHP: +3*	Group 3	* see Table E 4.1-2
Maskati	Tur	2631			+		+		-	Group 25	Group 25	
Matale	Tur	1185	+		+			Chogowale R.	SWHP: 6	SWHP: +2	RSWP + 2km + SED	
Matuli	Nge	2061	+		+			Ngerengere R.	STIP: SWHP(10)	SWHP: +4	Group 13	
Mazimba	Tur	908		+					-	RSWP + 2km + SRD	RSWP + 2km + SED	
Mbamba	Ula	1505	+		+				SWHP: +8	SWHP: +3	RSWP + 2km + SED	
Mbigili	Mam	2555			+			Mkundi R.	STIP: Group 16	Group 16	Group 16	
Mbili	Mam	821					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Mbogo	Tur	2423	+				+		SWHP: 12	SWHP: +5	Group 21	
Mbwade	Bwa	2289	+	+	+			Dutumi R.	SWHP: 11	SWHP: +5	Group 4	
Mbwade	Mas	1004	+			+			STIP: BH + 2km +SRD	EXT: ED	EXT: ED	
Melela	Mla	3489	+	+					-*	-*	-*	* see Table E 3.1-4
Meshugi	Gai	1240					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Mfulu	Mam	1016	+						STIP: SWHP(5)	SWHP: +2	Group 20	
Mfuluni	Mas	1093			+		+	Kisungusi R.	-	G + 3km + SRD	G + 3km + SED	
Mfumbwe	Mat	1661			(+)				-		(RSWP + 2km + SED)	
Mgata	Bwa	1580			+		+		-	Group 25	Group 25	
Mhale	Mge	1207			+		+		-	Group	Group 25	
Mhonda	Tur	2011			+		+	Diwale R.	-	G + 3km + SRD	G + 3km + SED	
Mifulu	Mat	1924			+		+		-	Group 25	Group 25	
Mikese	Nge	2081	+			+			STIP: REH(PE + SED)*	-	-	* Maji project, see Table E 3.1-4

 Table EA 2-1 (continued)

Village		Population 1978	Potential water supply systems						Recomended water supply improvement programme in accordance with targets		Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
			SWHP	SWP	RP	BH	G	Surface water source	Period 1978-1983 /	Period 1983-1993		
Mikumi		(4274)							-	-	-	
Milawilila	Mat	809			+		+		-	Group 25	Group 25	
Milengwe-lengwe	Bwa	889			+	+		Mngazi R.	MWHP: 4	MWHP: +2	Group 5	
Mindu	Nge	2162			+				-*	-*	-*	* village to be replaced (Mindu Dam)
Mirama	Tur	1248	+			+			STIP: SWHP(6)	SWHP: +3	BH + 2.5km + SED	
Misongeni	Nge	1428					+	Mgolole R.	Maji Project*	-	-	* see Table E 3.1-4
Mkalama	Gai	1436					+	Milindo R.	STIP: Group 1	Group 1	Group 1	
Mkambarani	Nge	564	(+)				(+)	Ngerengere R.	STIP: SWHP(3)*	SWHP: +1*	Group 3	* see Table E 4.1-2
Mkata Ranch	Mla	400	+		+			Mkata R.	-*	-*	-*	* see Table B 3.1-3
Mkata-Ujamaa	Mla	388	+		+			Mkata R.	-*	-*	-*	* see Table B 3.1-3
Mkindo	Tur	2336	+		+		+	Mkindu R.	SWHP: 12	SWHP: +4	Group 21	
Mkobwe	Non	1183			+		+		-	Group 25	Group 25	
Mkololo	Bwa	438			+		+		-	G + 2km + SRD	G + 2km + RD	
Mkonowa-mara	Nge	623			+		+	Ngerengere R.	STIP: RP + 1km +SRD	EXT: ED	Group 3	
Mkulazi	Nge	602	(+)		+			Mkulazi R.	STIP: SWHP(3)*	SWHP: +1*	RSWP + 4km + SED	* see Table E 4.1-2
Mkundi	Mam	814	+		+			Mkundi R.	STIP: SWHP(4)	SWHP: + 2	RSWP + 2km + SED	
Mkundi	Nge	685	+	+					STIP: SWHP(3)	SWHP: +2	SWP + 2km + SED	
Mkunghulu	Ula	1155			+		+		SWHP: 6	SWHP: +2	G + 2km + SED	
Mkuyuni	Mat	1983	+		+		+	Ruvu R.	SWHP: 10	SWHP: +4	G + 6km + SED	
Mlaguzi	Tur	667			+		+		-	G + 2.5km + SRD	G + 2.5km + SED	
Mlali	Mla	2196	+		+			Mlali R.	STIP: REH(IW + PE)	EXT: SED	EXT: SED	
Mlilingwa	Nge	474	(+)				(+)	Ngerengere R.	STIP: SWHP(2)*	SWHP: +1*	Group 3	* see Table E 4.1-2
Mlono	Mat	1505			+		+		-	Group 25	Group 25	
Mngazi	Bwa	1344	+		+			Mngazi R.	SWHP: 7	SWHP: +2	Group 5	
Mnyanza	Mla	1931			+		+		-	Group 25	Group 25	
Morogoro									-	-	-	
Msimba	Mik	1301					(+)		-	-	(G + 3km + SED)	
Msingise	Gai	1582					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Msolokelo	Tur	513			(+)				-		(RSWP + 2km + SED)	
Msolwa	Mik	1204	+		+		+		SWHP: 6	SWHP: +2	G + 4km + SED	
Msonge	Bwa	1085			+		+	Msonge R.	STIP: G + 4km + SRD	EXT: ED	EXT: ED	
Msongozi	Mla	1423	+		+				SWHP: 7	SWHP: +3	RSWP + 3km + SED	
Msowero	Mik	1220			+		+	Tundu R.*	STIP: Group 2	Group 2	Group 2	* or Msowero R.
Msowero	Ula	1450	+	+	+		+	Lumuma R.	SWHP: 7	SWHP: +3	G + 2km + SED	
Msowero	Mam	4845			+	+		Tami R.	STIP: REH(IW + PE)	EXT: SED	EXT: SED	
Msufini	Tur	733	+	+					SWHP: 4	SWHP: +1	SWP + 2km + SED	
Mtamba	Mat	3160	+				+	Mvuha R.	STIP: SWHP(10)	SWHP: +4*	Group 24	* or Group 24
Mtega	Non	1688			+		+		-	Group 25	Group 25	
Mtombozi	Mat	1007	+				+	Mvuha R.	SWHP: 5	SWHP: +2*	Group 24	* or Group 24
Mtumbatu	Mam	1588					+	Milindo T.	STIP: Group 1	Group 1	Group 1	

Table EA 2-1 (continued)

Village		Population 1978	Potential water supply systems: SWHP	SWP	RP	BH	G	Surface water source	Recomended water supply improvement programme in accordance with targets: Period 1978-1983	Period 1983-1993	Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
Mugudeni	Tur	1187	+	+					STIP: SWHP(6)	SWHP: +2	SWP + 2.5km + SED	
Muhenda	Ula	1978	+	+			+	Miyombo R.	STIP: SWHP(10)	SWHP: +4	Group 7	
Muhungam-kola	Nge	474	(+)				+	Ngerengere R.	SWHP: 2*	SWHP: +1*	Group 3	* or Group 3
Mulunga	Mik	755					+		-	G + 2km + SRD	G + 2km + SED	
Munisagara	Mas	1042	+		+			Mkondoa R.	SWHP: 5	SWHP: +2	RSWP + 2km + SED	
Mvomero	Tur	3458	+		+		(+)	Mvomero R.	SWHP: 5*	SWHP: +2	RSWP + 4km + ED	* see Table B 3.1-3
Mvuha	Bwa	2539	+		+			Mvuha R.	SWHP: 13	SWHP: +5	RSWP + 2km + SED	
Mvumi	Mam	3406			+			Kisangate R.	STIP: REH(IW + PE)	EXT: SED	EXT: SED	
Mwalazi	Mge	1420			+		+		-	Group 25	Group 25	
Mwandi	Mam	2558	+		+			Berega R.	STIP: SWHP(13)	SWHP: +5	RSWP + 2km + SED	
Mwarazi	Mat	1016	+		+			Ruvu R.	SWHP: 5	SWHP: +2	RSWP + 2km + SED	
Mwasa	Ula	1117			+				-	RSWP + 2km + SRD	RSWP + 2km + SED	
Mzaganza station	Ula	835	+		+			Mkondoa R.	SWHP: 4	SWHP: +2	RSWP + 2km + SED	
Mziha	Tur	1916	+		+			Lukigura R.	SWHP: 10	SWHP: +3	RSWP + 2km + SED	
Ndogomi	Gai	1434	+	+					SWHP: 7	SWHP: +3	SWP + 2km + SED	
Ndole	Tur	726			+		+		-	G + 3km + SRD	G + 3km + SED	
Ngerengere	Nge	3753	+		+			Ngerengere R.	STIP: SWHP(8)*	EXT: SED	EXT: SED	* see Table B 3.1-3
Nger./Dar.	Nge	1384	(+)		+		+	Ngerengere R.	STIP: SWHP(7)*	SWHP: +3*	Group 3	* see Table E 4.1-2
Ngiloli	Gai	1000*					+	Milindo T.	STIP: Group 1	Group 1	Group 1	* MDWSP estimate
Ngong'oro	Mat	1605	+	+					SWHP: 8	SWHP: +3	SWP + 2km + SED	
Ngugulu	Mge	1028			+		+		-	Group 25	Group 25	
Nguyami	Gai	1792					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Ng'weme	Mat	624			+		+		-	Group 25	Group 25	
Njungwa	Mam	1628			+		+		-	Group 25	Group 25	
Nongwe	Non	1338			+		+		-	Group 25	Group 25	
Ntala	Bwa	1066			(+)				-	(RSWP + 2km + SRD)	(RSWP + 2km + SED)	
Nyachiro	Mat	2363			+		+		-	Group 25	Group 25	
Nyali	Ula	1142	+		+		+	Miyombo R.	SWHP: 6	SWHP: +2	Group 7	
Nyameni	Ula	1490	+		+		+	Miyombo R.	SWHP: 7	SWHP: +3	Group 7	
Nyamigadu A	Bwa	942			+		+		-	Group 25	Group 25	
Nyamigadu B	Bwa	823			+		+		-	Group 25	Group 25	
Nyandira	Mge	2065			+		+		-	Group 25	Group 25	
Nyangala	Mam	558	+	(+)					SWHP: 3	SWHP: +1	(SWP + 2km + SED)	
Nyarutanga	Bwa	1685	+		+			Mgeta R.	STIP: SWHP(8)	SWHP: +4	Group 22	
Nyingwa	Mat	1696			+		+		-	Group 25	Group 25	
Pandambili	Tur	925	+	+					SWHP: 5	SWHP: +2	SWP + 2km + SED	
Pangawe	Nge	886					+	Mgolole R.	-	EXT: ED	EXT: ED	
Peapea	Mas	842	+	+		+	+	Kisungusi R.	SWHP: 4	SWHP: +2	SWP + 2km + SED	
Peko-misegese	Mla	2667			+		(+)		-	RSWP + 2km + SRD	RSWP + 2km + SED	
Pemba	Tur	2275			(+)				-	RSWP + 2km + SRD	RSWP + 2km + SED	

 Table EA 2-1 (continued)

Village		Population 1978	Potential water supply systems: SWHP	SWP	RP	BH	G	Surface water source	Recomended water supply improvement programme in accordance with targets: Period 1978-1983	Period 1983-1993	Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
Pinde	Mge	897			+		+		-	Group 25	Group 25	
Ruaha	Mik	7369			+*		+	Tundu R.	STIP: Group 2	Group 2	Group 2	* River Great Ruaha
Rubeho	Gai	2872					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Rudewa	Mat	2576			+		+		-	Group 25	Group 25	
Rudewa-Batini	Mas	2693	+	+	+	+	+	Wami R.	STIP: BH + 2km +SRD*	EXT: ED	EXT: ED	* and SWHP: 6
Rudewa-Gongoni	Mas	1764	+	+	+		+*	Wami R.	SWHP: 9	SWHP: +3	Group 23	* River Kisungusi
Rudewa-Mbuguni	Mas	1682	+	+	+		+*	Wami R.	SWHP: 8	SWHP: +4	Group 23	* River Kisungusi
Ruhembe	Mik	2399	+	+	+			Ruhembe R.	SWHP: 12	SWHP: +5	RSWP + 2km + SED	
Rusanga	Tur	2897	+	+			+	Mjonga R.	STIP: SWHP(14)	SWHP: +6	Group 17	
Sagasaga	Nge	887	(+)			(+)			STIP: SWHP(4)*	SWHP: +2*	(BH + 10km + SED)*	* see Table E 4.1-2
Sangasanga	Mla	776	(+)				+	Ngerengere R.	STIP: SWHP(2)*	-	-	* also Maji Project, see Table E 3.1-4
Semwali	Tur	858			+		+		-	Group 25	Group 25	
Seregete A	Nge	380			+			Ngerengere R.	STIP: RSWP + 5km+SRD	EXT: ED	EXT: ED	
Seregete B	Nge	683			+			Ngerengere R.	STIP: RSWP + 5km+SRD	EXT: ED	EXT: ED	
Sesenga	Bwa	1046	+		+			Mgeta R.	SWHP: 5	SWHP: +2	Group 22	
Singisa	Bwa	1410			+		+		-	Group 25	Group 25	
Senyaulime	Nge	832	(+)		+			Ngerengere R.	(SWHP: 4)	(SWHP: +2)	TSED*	* extension from Ngerengere
Tabu-Hotel	Gai	1200*					+	Milindo T.	STIP: Group 1	Group 1	Group 1	* MDWSP estimate
Tambuu	Mat	3325					+	Mvuha R.	-	Group 24	Group 24	
Tandai	Mat	2827			+		+		-	Group 25	Group 25	
Tandari	Mge	1097			+		+		-	Group 25	Group 25	
Tandari	Mat	1626					+	Mvuha R.	-	Group 24	Group 24	
Tangeni	Mla	1776			+		+		-	Group 25	Group 25	
Tawa	Mat	3036			+		+		-	Group 25	Group 25	
Tchenzema	Mge	1645			+		+		-	Group 25	Group 25	
Tegetero	Mat	1250			+		+		-	Group 25	Group 25	
Temekero	Bwa	728			+		+		-	Group 25	Group 25	
Tindiga	Mas	3941	+	+	+			Mkondoa R.	STIP: SWHP(20)	SWHP: +8	Group 18	
Tulo	Bwa	825	+	+	+			Mvuha R.	SWHP: 4	SWHP: +2	Group 11	
Tundu	Mik	2112			+		+	Tundu R.	STIP: Group 2	Group 2	Group 2	
Tungi	Nge	2318			+			Ngerengere R.	STIP: RP + 1km +SRD	EXT: ED	Group 3	
Tununguo	Nge	1510	+	+	+			Ruvu R.	SWHP: 8	SWHP: +3	RSWP + 2km + SED	
Ubili	Tur	725			+		+	Diwale R.	-	RSWP + 2km + SRD	RSWP + 2km + SED	
Udung'hu	Mik	2456			+		+		-	Group 25	Group 25	
Ukwama	Bwa	1265			+		+		-	Group 25	Group 25	
Ukwamani	Gai	1609					+	Milindo T.	STIP: Group 1	Group 1	Group 1	
Ulaya-Kibaoni	Ula	2010	+	+	+		+	Miyombo R.	SWHP: 10	SWHP: +4	Group 7	
Ulaya-Mbuguni	Ula	659	+	+	+		+	Miyombo R.	SWHP: 3	SWHP: +2	Group 7	

Annex EA2 Table EA 2-1 (concluded)

Village		Population 1978	Potential water supply systems: SWHP	SWP	RP	BH	G	Surface water source	Recomended water supply improvement programme in accordance with targets: Period 1978-1983	Period 1983-1993	Recommended water supply improvement programme based on piped water supply with communal water points	Remarks
Uleling'-ombe	Mik	1281			+		+		-	G + 2km + SRD	G + 2km + SED	
Unone	Mas	999	+		+			Wami R.	SWHP: 5	SWHP: +2	RSWP + 4km + SED	
Uponda-Chini	Mat	1547			+			Ruvu R.	-	Group 12	Group 12	
Uponela	Mam	1526					(+)		-	(G + 2km + SRD)	(G + 2km + SED)	
Usungura	Nge	538	+*		+			Ruvu R.	SWHP: 3*	SWHP: +1*	RSWP + 2km + SED	* along River Ruvu
Vidunda	Mik	1595			+		+		-	Group 25	Group 25	
Vigolegole	Bwa	2181	+		+			Mngazi R.	SWHP: 11	SWHP: +4	Group 5	
Vihengele	Mat	943			+			Mvuha R.	-	Group 24	Group 24	
Vinile	Mge	795			+		+		-	Group 25	Group 25	
Visaraka	Nge	1112	+					Ngerengere R.	SWHP: 6	SWHP: +2	RSWP + 2km + SED	
Zombo-Lumbo	Ula	1683	+		+		+	Miyombo R.	SWHP: 8	SWHP: +4	Group 7	

LEGEND:
BH = borehole ; PE = pumping equipment ; S = storage tank
ED = extensive distribution system ; RD = rudimentary distribution ; STIP = short term implementation programme
EXT = extension works ; REH = rehabilitation ; SWHP = shallow well with hand pump
IW = intake works ; RP = pumped supply from river ; SWP = pumped supply from shallow well
G = gravity ; RSWP = pumped supply from riverside well ; T = transmission main
BH + 2km + SRD = borehole supply with transmission main 2 km long, storage tank and rudimentary distribution facilities
Group X = group supply system for several villages (see below)
\+ = suitable conditions for that particular supply system
(+) = doubtful conditions for that particular supply system

SHORT DESCRIPTION OF PROPOSED GROUP SUPPLY SYSTEMS

1. Gairo gravity scheme : 22 villages ; T ~ 120 km
2. Tundu gravity scheme : 5 villages ; T ~ 12 km
3. Lower Ngerengere gravity scheme : 13 villages ; T ~ 105 km
4. Pumped water supply (Dutumi R.) : 2 villages ; T = 4 km
5. Pumped water supply (Mngazi R.) : 3 villages ; T = 7 km
6. Pumped water supply (Ruvu R.) : 2 villages ; T = 3 km
7. Miyombo gravity scheme : 7 villages ; T ~ 26 km
8. Mgolole gravity scheme : 5 villages (existing)
9. Pumped water supply (Kiroka R.) : 2 villages ; T = 3.5 km
10. Upper Ngerengere gravity scheme : 2 villages ; T = 2 km
11. Pumped water supply (Mvuha R.) : 3 villages ; T = 5 km
12. Pumped water supply (Ruvu R.) : 3 villages ; T = 3.5 km
13. Pumped water supply (Ngerengere R.): 3 villages ; T = 6 km
14. Pumped water supply (borehole, Dakawa) : 2 villages ; T = 3 km
15. Pumped water supply (shallow well) : 2 villages ; T = 4 km
16. Pumped water supply (Mkundi R.) : 2 villages ; T = 5 km
17. Pumped water supply (shallow well) : 3 villages ; T = 6 km
18. Pumped water supply (Mkondoa R.) : 2 villages ; T = 5 km
19. Pumped water supply (borehole, Kondoa) : 2 villages ; T = 2 km
20. Pumped water supply (borehole, Madudu) : 2 villages ; T = 4 km
21. Mkindu gravity scheme : 6 villages ; T ~ 22 km
22. Pumped water supply (Mgeta R.) : 3 villages ; T = 8 km
23. Pumped water supply (Wami R.) : 3 villages ; T = 4 km
24. Mvuha gravity scheme : 6 villages ; T ~ 16 km
25. Group of all villages which are located in mountainous areas, having possibilities for pumped supplies or gravity supplies from small perennial streams (see par. E 4.2).