THE STUDY
ON
THE WATER SUPPLY
FOR
SEVEN TOWNS IN EASTERN PROVINCE
IN
THE REPUBLIC OF KENYA

FEASIBILITY STUDY REPORT

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CHAPTER I INTRODUCTION

1.1 Background

Prioritisation of water supply projects in developing countries is generally difficult to assess due to the problems involved in quantifying benefits. Nevertheless, a combination of qualitative and quantitative comparative assessments of the seven water supply projects was conducted in the Master Plan stage of this study. This showed that all the projects were in urgent need of improved water supplies, but that the need was more acutely felt in Meru, Chuka, Chogoria and Tigania.

Meru, with the highest number of potential beneficiaries, the largest urban population and the lowest per capita costs was ranked as the most urgent project needing implementation.

However, in addition to the "Basic Human Needs", on which the above assessment was made, it is also necessary to assess the potential for sustainability of the resulting schemes in terms of their capabilities for management, operation, maintenance and financial performance.

Strong backing by the local administration is also seen as being an important element in achieving successful implementation, and hence, the longer term goals of the project. This will be needed to support measures that may not be popular with all consumers, but which are essential to the project, such as; the loss reduction programme, the installation of meters and in establishing environmental guidelines or by-laws for the disposal of wastewater.

In these respects, Meru, which has long been established as the location for the District Headquarters and, has the support of a strong Municipal Council, would also appear to offer better resources in terms of experienced personnel as well as physical and administrative infrastructure.

The Meru Water Supply Project therefore, having both the greatest need and the highest potential for sustainability, was assessed as having the highest priority for implementation, and is the subject of this Feasibility Study.

1.2 Study Area

The Study horizon for the Master Plan was set at 2010. However the objective of this Feasibility Study is to provide for the projected 2005 water demands of the areas in most urgent need for improvement.

Although it contains Meru Municipality, the character of the area is predominantly rural. With annual rainfall well in excess of 1,000 mm and, with good quality soils, all the area is classified as having high agricultural potential. The economy of the region is therefore strongly agriculturally based, as are the main industries of coffee, tea, timber, dairy processing etc.

The supply area boarders Mount Kenya Forest in the west, with altitudes of around 2,060. Rainfall and agricultural potential is generally highest in these higher western areas, and reduces in an easterly direction with lower elevations.

1.3 Basic Policy and Strategy for Feasibility Study

Basic policy and strategies used in compiling the feasibility study are as follows:

The Feasibility Study is based on the recommendations of the Master Plan. This concluded that the improvement, rehabilitation and expansion of the existing Meru Water Supply Project was the most urgent and prioritised project of the seven schemes studied.

(1) The objective of this Feasibility Study is, as stated above, to provide for the projected 2005 water demands of the areas in most urgent need for improvement. Out of the total area of 185 km2 included in the Master Plan Study area, the area prioritised as in most urgent need of improvement amounted to approximately 85 km2, or about 50% of the study area as indicated in ***Figure 1.3-1***. Factors considered in the prioritization process included unserved ratio, water scarcity during the dry season, health conditions, public opinion and logistics. These areas, which include the urban, peri urban and surrounding rural areas. are therefore the target area for this Feasibility Study and for implementation in Phase 1.

(2) Many community water supply schemes, of various sizes, supplying untreated water, exist within the supply area. Following consultation with the MLRRWD, the demand for potable treated water of the population served by these schemes, has been included in the water demand projections. However, connection of these schemes to the Ministry system requires careful discussion and participation with each scheme management. There are therefore no immediate plans for connecting these schemes to the proposed Ministry supply under the feasibility

study.

(3) Works which are not economical to phase, such as the intake, raw water pipeline and trunk mains have been designed for the estimated demand capacity of 2010. Elements such as the treatment plant and reservoirs, which are economical to phase, have been designed at approximately 50% of ultimate capacity, assuming that these will be duplicated in 2005 to keep pace with the growing demand.

(4) The construction of water kiosks and individual connections require contributions and active participation from the respective beneficiaries. It has therefore been assumed that these works will be executed by the Ministry, after completion of the main infrastructure, programmed to satisfy the actual growth of demand for connections. Minor distribution lines have also been included in this category.

(5) The whole area is classified as having high agricultural potential. This implies relatively high household income levels and a high demand for water over the entire area. The water demand projections have therefore assumed that ultimately, the whole area will require potable water supplied from the Ministry scheme.

CHAPTER II EXISTING CONDITIONS FOR WATER SUPPLY IN MERU

2.1 Water Resources

2.1.1 Low Flow Rate

The Study Area is located on the north western boundary of the Tana river basin, one of the most important river basin systems in Kenya. . The number of river gauging stations in the sub-basin is given in ***Table 2-1.1*** below. Which includes those currently operating and already closed.

Table 2.1-1 Number of River Gauging Stations

Sub-basin No.	Major Streams	Number of RGS
4FA / 4FB	Kathita, Thingithu, Thanantu, Thangatha, Ura, Rojiwero	37

Source : NWMP

The results of flow analyses based on these gauging stations carried out by WRAP and NWMP are appropriate to this Study. The analyses provide 1) average flow, 2) daily low flow with 95 % probability 3) minimum monthly flow, and 4) minimum daily flow as given in ***Table 2.1-2***.

Table 2.1-2 Summary of Runoff Data at Existing River Gauging Stations

No. of RGS	River	Period Recorded	Catchment Area	Mean Monthly Flow	95% Daily Flow	Minimum Monthly Flow	Minimum Daily Flow
		year	km2	m3/sec	m3/sec	m3/sec	m3/sec
4F03	Kathita	1952-1961	246	2.45	1.25	1.09	1.04
4F04	Thingithu	1953-1988	91	2.32	0.96	0.89	0.79
4F05	Mariara	1956-1974	42	1.44	0.56	0.38	0.36
		1980-1988					
4F10	Kathita	1960-1987	878	13.43	2.63	1.78	1.28
4F17	Thingithu	1965-1987	303	4.16	0.57	0.55	0.14
4F08	Thangatha	1958-1988	210	5.07	0.33	0.32	0.06
4F09	Ura	1958-1988	198	5.36	0.48	0.45	0.07

2.1.2 Water Sources Investigations

(1) General

The original Kathita river intake site was proposed by MLRRWD. However, the topographic survey of the raw water pipeline revealed problems with difficult terrain for water transmission by gravity. Therefore, an alternative site at a higher elevation was identified. A review of the catchment characteristics suggested that this site will also provide adequate water of good quality. However, confirmation of suitable water quality was needed as discussed below.

The alternative site is located approximately 5 km upstream of the site originally proposed. Approximate elevation of this site is 2,450 m. The river flows through the bottom of a U-shaped deep rocky gorge in Mt. Kenya Forest. The bottom width of the gorge is about 25 m wide. The river bed material is mainly composed of gravel and boulders.

At this site, the Italian NGO group, CEFA, has been constructing an intake for the the Kathita-Kirua Water Project. A small intake for two community water supplies is also found about 100 m upstream of the CEFA's intake, but the weir and raw water pipelines are severely damaged.

(2) Flow Rate at Intake Site

1) Reliability

The safe yield at the intake site was estimated from an assessment of the 95 % daily low flow at existing gauging stations in the vicinity, and by correlation of catchment characteristics, supported by spot flow measurements at the intake site.

2) River Maintenance Flow

Minimum maintenance flow in perennial rivers is not specifically mentioned in the Design Manual for Water Supply in Kenya. However, it is necessary to maintain a certain amount of water for conservation of the natural river environment as recommended by NWMP. The same concept of river maintenance flow is therefore proposed for the estimation of safe yield for this Study.

NWMP recommended that the river maintenance flow should be assumed to be equivalent to the minimum daily flow. The NWMP estimated the ratio of the minimum daily flow to the average flow as 6.2 % based on the average of 15 representative rivers covering the whole country. However, this ratio was estimated as 14.8 % based on the runoff records for the sub-basins within this Study Area. This higher ratio results from the hydrologic characteristics of the abundant water resources on the eastern slopes of Mt. Kenya. The value of 14.8 % was applied as a regional factor for estimating river maintenance flow in the Study Area.

3) Safe Yield for River Intakes

The safe yield of surface water sources were obtained from the balance between the 95 % daily low flow and the minimum river maintenance flow. The estimated safe yields are shown in ***Table 2.1-3***

Table 2.1-3 Safe Yield in Meru Project

Water Sources	Flow rate given by DWO	Estimated 95% daily low flow	Flow rate measured	Flow rate applied as safe yield	Remarks
(1) Kathita River	97,600	80,520		57,100	existing intake site
(2) Gatabora Spring	1,500			1,500	
(3) Kathita River		60,900	(105,300)	43,200	originally proposed intake site
(4) Kathita River		49,700	(78,200)	35,300	Selected site

(3) Water Quality at Intake Site

Water quality standards for drinking water in Kenya follow closely to those established by the World Health Organization (WHO). The Design Manual for Water Supplies in Kenya stipulates bacteriorological and chemical water quality requirements. Water quality analysis is performed by the Water Quality and Pollution Control Laboratory. Chemical quality testing is performed on approximately 27 constituents, in addition to bacteriological examination.

A water quality survey for the proposed water resources was conducted during September 1996 and March 1997. Twenty seven (27) chemical quality parameters and two bacteriological quality parameters were assessed. The water quality results are attached in ***Table 2.1-4***, which indicate suitability for the purpose of water supply.

Table 2.1-4 Water Quality at Kathita Intake Site

Parameters	Unit	MLRRWD Standard for Drinking Water	Dry Season	Wet Season
PH		6.5-8.5	7.9	8.3
Apparent Color	oH		15	<5
True Color	oH	5	<5	<5
Conductivity	us/cm		145	98
Turbidity	F.T.U	15	1.6	0.8
Calcium Hardness as CaCo3	mg/l	500	26	2
Total Hardness as CaCo3	mg/l		76	18
Total Alkalinity as CaCo3	mg/l		53	92
Carbonate Alkalinity	mg/l		0	0
Iron	mg/l	0.3	0.02	0.02
Fluorides	mg/l	1.5	0.38	0.32
Sulfates	mg/l	400	33	38
Phosphates	mg/l		0.02	0.01
Silica	mg/l		66	55
Dissolved Oxygen	p.p.m		5.9	5.8
Nitrates	mg/l	10	0.01	0
Manganese	mg/l	0.1	0	0
Chlorides	mg/l	250	16	14
Chromium	mg/l		0	0
Copper	mg/l		0	0.01
Total Coliform	/100 ml	0	350	210
Total Faecal Coliform	/100 ml	0	9	35
Dissolved Solids	mg/l	1000	65	140
Suspended Solids	mg/l		5	18
Total Solids	mg/l		70	158
Biochemical Oxygen Demand	mg/l		10	4
Chemical Oxygen Demand	mg/l		12	8

2.2 Socio - economic Conditions

2.2.1 Administration

The supply area is located in Eastern Province which, in terms of both area and population, is the second largest of Kenya's eight Provinces.

Eastern Province has its Provincial Headquarters in Embu and is divided into eight Districts. Meru being one of the Districts, with its Headquarters based in Meru Town.

District Development Plans are prepared at District level and it is significant to note that the current plans place a high priority on the improvement of water supplies.

2.2.2 Population

Baseline population levels and current growth rates were obtained from an analysis of past population census results, as shown in more detail in ***Chapter 3*** and summarised below:

Table 2.2-1 1989 Scheme Population, and 1969-1989 Inter-census Growth Rates

	Kenya	Eastern Province	Meru Supply Area (185 km2)
1989 Population	21,443,636	3,768,677	125,191
1969-1989 annual growth rate	3.4%	3.65%	3.6%
Implied 1997 population	28,000,000	5,020,000	165,980

These figures indicate that population growth rates during the twenty years between 1969 and 1989 were among the highest in the world. Government Policy is aimed at reducing these high growth rates in the future, however there is little evidence to suggest that the population growth rate in the District has changed significantly since the 1989 census, and the District Development Plans have used similar figures of about 3.4% to estimate current and short term future population.

2.2.3 Land Use and Economic Activities

The supply area lies within the agriculturally high potential zone that exists between the mountainous forested areas of Mt. Kenya to the west, which have high levels of precipitation, and the lower, more arid plains to the east, where rainfall, and hence agricultural potential becomes more limited. Nevertheless the average annual rainfall throughout the supply area remains above 1,000mm, and all land is classified as having high agricultural potential.

With the exception of Meru Town and some urban centres, the region is rural in character, and the economy is heavily dependent on agriculture.

Land potential generally increases with elevation, and high income generating crops, such as tea and coffee are grown in the higher areas, whereas livestock and subsistence cropping increases at lower elevations towards the east. Other cash crops include maize, horticultural products, cotton and sunflower. Subsistence crops include Irish potatoes, beans, sorghum, millet, cow peas, green grams, cassava and sweet potatoes.

Family farming activities, income and socio-economic status are therefore predominantly determined by the area and location of land the household controls. The socio economic survey, conducted during the Master Plan stage of this Study, indicated that about 50 % of households lived on plots of less than 2 acres, with an average family size of 8.

Existing livestock ownership levels have been estimated as approximately 1.5 livestock units per household. This is roughly equivalent to 3 indigenous cattle and 8 sheep or goats. The socio economic survey indicated a similar figure.

The main industries in the area such as coffee and tea processing, maize milling, dairy factories, textiles and timber yards are all based on agricultural production. Tea and coffee factories tend to be located in rural areas close to the production areas, but there is a growing industrial presence in Meru Town itself.

2.2.4 Existing Physical and Social Infrastructure

(1) Roads

All weather surfaced roads are limited to the main Embu - Meru - Isiolo road, the secondary Meru - Maua road, and other limited lengths of access roads, principally within Meru Town itself. These roads provide good access for through traffic. However all other roads are unsurfaced, and access to remoter parts of the supply area during rainy periods can be problematical. The road network density is high in the more populated high potential area to the west, but becomes less dense towards the east. Maintenance of the existing road network system is constrained by the available resources.

(2) Electricity

National Government Policy towards rural electrification has resulted in an extensive electricity grid, connecting all large towns and most rural centres. In the supply area however, the main consumers are commercial, institutional and industrial. As shown by the socio-economic survey, only about 5 % of the population have electricity connections.

(3) Telephones

The telephone infrastructure coverage is similar to electricity, with most rural centres being connected, but only about 5% of the surveyed population had telephone connections.

(4) Water

As described in the following section, water supply services are less than adequate. Only 9% of the surveyed population were served by Ministry supplies, whereas 51% were supplied from untreated community water supply schemes, and the remainder obtain water from traditional sources such as surface water sources (23%) and hand dug wells (13%).

(5) Sanitation

Pit latrines were used by the majority of people (94%), many of which however were poorly constructed and maintained.

Septic tanks were used by the remaining 6% of the population surveyed. None of the surveyed households were connected to the Municipal Sewerage system, which serves approximately 30% of the urban population.

The low sewer reticulation coverage in urban areas, and the poor condition of sanitary facilities, especially in urban areas, gives cause for concern over the spread of water related diseases.

(6) Health

There are currently approximately 3 hospital beds available per 1,000 population in the supply area, and 14 outpatients are treated daily, per 1,000 population.

Malaria is the most frequent disease reported as affecting people in the supply areas. This is surprising, since these high elevations had previously been considered free of malaria. Typhoid, dysentry and cholera, (all of which are also water related diseases), together with respiratory diseases, are amongst the most common diseases reported by Ministry of Health statistics.

(7) Education

The number of pupils attending educational establishments within the supply area represents about 26% of the population. To accommodate them, there are 20 primary, 10 secondary and 4 technical schools within the supply areas.

(8) Social

A summary of some of the main findings of the socio economic survey, taken from a random sample of 100 households, is listed below.

1) Average family size: 8.1 person per family

2) Approximate average household income: Ksh. 9,000 per month.

3) Housing type distribution:

Permanent	Semi-permanent	Temporary
22%	61%	16%

4) Households with electricity 5%

5) Households with telephone 5%

6) Water Resources

River	Hand dug well	Ministry	Community water supply	Others
23%	13%	9%	51%	4%

7) Distance from primary water source

0 km	<0.5 km	0.5 to 2 km	2 to 4 km
20%	59%	18%	3%

8) Water availability from primary source in dry season: 54%

9) Alternative dry season water sources for the remaining 46%:

River	Well/spring	Neighbour	Kiosk/vendor
31%	6%	7%	2%

Interpretation of these results should however bear in mind the method adopted for random selection of households. This was done on an area basis, which will tend to give a rural bias.

(9) Women's Role in relation to Water Supplies

Household responsibilities for water supply, waste disposal, economic resources and health have traditionally been those of women.

Improved water supplies, especially when combined with improved sanitation and health education, can make a valuable contribution towards reducing the time spent by women in collecting water, improvement of health and hence, general household economic benefits.

Women are therefore potentially the main contributors and beneficiaries of water and sanitation projects, and are also therefore well motivated to ensure that an implemented project is managed effectively.

However, women suffer from a number of disadvantages:

1) They do not traditionally make decisions on disposable household income. Household expenditure on water is therefore often given a lower priority than it would otherwise have.

2) The education of daughters is seen as a lower priority to that of sons, leading in some cases, to a lack of knowledge of the way diseases are transmitted and the value of improved household hygiene.

3) women are not allowed to inherit land. Without this as collateral it is difficult to acquire credit.

These imbalances will not be corrected without a great deal of effort and commitment culminating in changes of deep seated traditional beliefs and attitudes. These issues can not be solved by this project alone. Nevertheless, by the encouragement of women to become involved at all levels of planning and in the operation and management of the Meru Water Supply Project it may be possible to contribute towards this goal.

2.3 Existing Water Supply and Facilities

Milimani waterworks has a production capacity of 3,770m3/day in total (according to our field survey), serving approximately 20,000 population (or 17% of the total population) in the center of Meru township. In the study area, a number of the small-scaled Community Water Supplies or self-help projects serve untreated water to approximately 50,000 population, or 37%. The description of Meru Water Supply in the following paragraphs is mainly taken from excerpts or reproduction from the Master Plan Report and/or the Supporting Report.

2.3.1 Water Supply Facilities

(1) Overview

The present water supply for Meru Town is operated and maintained by the Ministry of Land Reclamation, Regional and Water Development. The system was first built in 1952 with an intake on Gatabora Stream. The Treatment Works is located in the Milimani area and originally comprised of a sedimentation unit and a composite treatment unit with a total capacity of 450 m3/day. Two filtration units (capacity 1,992 m3/day in total) were added in 1978. An intake on Kathita River was constructed in 1988 to supply raw water to The Treatment Works by gravity. Two composite treatment units (capacity 960 m3/day each) were built in 1995. Presently only the filtration units and the new composite treatment units are in use.

In addition, two 150m3 capacity ground level masonry tanks were built in Kaithe in 1978 to supply water to the high level zone of Meru Township. These tanks were fed initially by pumping water from the Milimani Treatment Works. However, pumping was discontinued sometime in 1988 when the tanks were supplied from the Gatabora spring water by gravity.

The Distribution Network is divided into the High Level and Low Level Zones. The High Level Tanks supply the northern high level area which comprises three (3) distribution zones. The low level zone is supplied from the Treatment Works to the central and southern area of the township, which comprises 8 zones. As the central Kaaga Zone is supplied by both High Level and Low Level Zones, the current distribution system is separated into 10 supply zones.

(2) Treatment Facilities

The Milimani Treatment Works supplies treated water to the low level distribution zones. Production capacity of the Milimani Waterworks totals 3,770/m3/day. This excludes the sedimentation unit which is currently not in operation. ***Figures 2.3-1*** and ***2.3-2*** show a general plan and hydraulic profile of the Treatment Works. ***Table 2.3-1*** below summarizes the component facilities giving size and capacity.

Table 2.3-1 Treatment Facilities

Facility	Capacity and No. of Basins	Type and Structure
1 Sedimentation Unit	225 m3/day x 2 basins	Circular horizontal flow type made of concrete, not in current use
2 Filtration Units	926 m3/day x 2 basins	Gravity, simple media filter made of concrete
3 Backwash tank1	13 m3 x 1 No.	Elevated tank made of steel, not in current use
4 Backwash tank 2	77 m3 x 1 No.	Elevated tank made of steel
5 Composite Treatment Unit I	40 m3/hr (960 m3/day)	Circular unit made of concrete
- Inlet and mixing chamber	2.0 m x 2.0 m - 1 No.	
- Alum mixing chamber	0.7 m x 0.6 m x 0.9 m - 1 No.	FRN type gravity doser
- Sedimentation	-	Horizontal flow
- Filter	-	Rapid sand filter
6 Composite Treatment Unit II	40 m3/hr (960 m3/day)	Rectangular unit made of concrete
- Inlet and mixing chamber	1.6 m x 0.6 m - 1 No.	
- Alum mixing chamber	0.65 m x 0.45 m x 1.0 m - 1 No.	FRN type gravity doser
- Sedimentation	-	Horizontal flow
- Filter	-	Rapid sand filter

Source: JICA Study Team

(3) Storage and Distribution Facilities

Storage tanks in Meru Water Supply, as listed below have a total storage capacity of 1,100m3, or nearly 8 hours of production capacity. It is smaller than the figure designated in the Design Manual in Kenya of 12hours for balancing, plus 12hrs emergency storage for urban areas.

Table 2.3-2 Storage Facilities

Facility	Capacity	Type and Structure
1. Storage Tank 1	265m3	Underground masonry, circular shaped
2. Storage Tank 2	91m3	Underground masonry, circular shaped
3. Storage Tank 3	455m3	Underground masonry, circular shaped
4. High Level Tanks	150m3 - 2 Nos	Maonry, circular shaped

Source: JICA Study Team

Distribution is through three distribution mains. Two distribution mains from the Milimani Treatment Works convey treated water from west to east by gravity. The northern 200mm diameter main, decreasing to 100mm at the fringe of the town center, supplied the Nubian, Kooje and Town zones, including the most densely populated area of the town center after diverting into two sub-mains. These smaller mains extend to the eastern end of the Gakoromone zone. The southern main of 150mm diameter covers Milimani Low Level Zone and Gakoromone Zone, a southern tip of the town center and the housing area. Existing distribution pipe network is shown in ***Figure 2.3-3***.

In addition to the above, a high level zone serves, the northern part of the Meru town, directly from high level tanks through a 150mm diameter distribution main. The total pipe length of the distribution pipe network is estimated at 26,195m as given in ***Table 2.3-3***.

Pipe materials used are mainly uPVC. Asbestos cement (AC) with galvanized steel (GI) pipes being used for the smaller mains.

Table 2.3-3 Total Pipe Length of Distribution Network

Zone	Pipe Diameter (mm)	Pipe Materials	Length (m)
High Level Zone	150	uPVC	1,185
	100	uPVC	1,040
	75	uPVC	2,790
	50	uPVC	2,770
Low Level Zone	200	uPVC	560
	150	uPVC	1,010
	100	uPVC	2,105
	100	AC	1,440
	75	uPVC	1,495
	75	AC	610
	50	uPVC	8,755
	50	GI	2,435
Total			26,195

Source: JICA Study Team

(4) House Connections

Half inch service pipelines have been predominantly installed since the commencement of Meru's water supply system. However, the pipe materials used have been shifting more recently from GI to PVC. The total length of service mains is approximately 60 km, but this is not sufficient to supply water to all residents on a continuous basis.

Service connections have been gradually increasing in the last decade from 1,909 connections in 1986 to 2,519 connections in 1996. This number is not including 990 disconnected due mainly due to nonpayment. People, particularly large consumers, are likely to shift from the Ministry Water Supply to more reliable Communal Water Projects, which have been developed in the periurban area of the municipality. Nevertheless, they still believe that Ministry's water supply is potentially the best because it is treated.

Table 2.3-4 Nos. of Connections (Meru) Registered Connections

Year	Nos. of Individual Connections	No. of Connections (flat rate)	Total	Disconnected	Responsible organization
1990	2,001	0	2,001		Municipality
1991	2,090	0	2,090		ditto
1992	2,123	122	2,245		District office
1993	2,182	139	2,321		ditto
1994	2,205	146	2,351		ditto
1995	2,235	272	2,507		ditto
1996	2,247	272	2,519	990	ditto

Source: DWO

To obtain an understanding of actual meter conditions, a field survey was carried out covering 330 house connections in Meru town center, which gave valuable information for formulating a future plan. ***Figure 2.3.4*** below shows that non-registered connections account for 20% of the customers, and metered connections account for almost 70%, but that most of these meters are malfunctioning.

<table>
<tr><td colspan="3">Registered (81%)</td><td colspan="2">Non-registered (19%)</td></tr>
<tr><td colspan="2">Metered (68%)</td><td rowspan="2">Non-metered (13%)</td><td rowspan="2">Metered (13%)</td><td rowspan="2"></td></tr>
<tr><td>Working (14%)</td><td>Not working (54%)</td></tr>
</table>

Source: JICA Study Team

Fig 2.3-4 Non-registered and Non-metered Connections

2.3.2 Water Production and Consumption

(1) Water Production

As none of the bulk meters installed on the outlets from the treatment works are functioning, accurate data on water production is not available. The DWO estimates, according to their experience give relatively smaller figures than the JICA Study Team's survey estimates. As can be seen, the treatment plant is being overloaded by more than double the production capacity.

(2) Water consumption

DWO records for the working meters suggest that the unit water consumption averages between 80 - 100 lpcd, similar to the MLRRWD design guideline. To the contrary, the field survey indicated that the many consumers who are unmetered, non-registered and even who have defective meters are consuming significantly more water than those who have working meters. Their unit water consumption jumps to 500 lpcd, nearly 5 times larger.

(3) Accounted-for Water

The survey of the 330 connections in the Pilot Area of Meru town center suggests that only 30% of the water production is accounted-for. The annual report prepared by DWO presumes 80% accounted-for water ratio but the MLRRWD Monthly Operating Maintenance and Financial Monitoring Report (1994-1996) indicated 56% accounted-for water.

2.3.3 Operational Equipment

The DWO in Meru suffers from a serious shortage of operational equipment. Vehicles available to the DWO include 4 sets of the folk jembe for civil work. No servicable 4 wheel drive vehicles for monitoring and patrol of the distribution pipe network are available. Pipes and fittings are chronically in short supply. Furthermore, chemicals for coagulation and disinfection are not sufficient. The Major reason for this situation is due to the weak financial standing of the DWO.

2.3.4 Organization and Institution

(1) District Water Office and Staffing

The District Water Engineer presides over 9 sections and 8 divisional water offices, under which 212 staff and personnel are employed. He manages and controls all ministry water supplies in Meru district. Milimani waterworks is being operated by the Operation and Maintenance Section with 42 staff and technicians under his control and direction.

The Sections of administration, planning and design, electrical and mechanical support the Engineer by conducting liaison, preparing the Development Plan and repairing damaged equipment and appurtenances. There are 23 staff responsible for water rights and water resources issues. Other sections include Pollution Control (2 staff), Surface Water (7 staff), Water Rights (8 staff) and Groundwater (6 staff). In addition, the Water Quality Section periodically conducts water quality testing of raw water and treated water.

(2) Water Tariff

The 1995 Water Act, Kenya Gazzette Supplement No.5, defines the standard water tariff as presented in ***Table 2.3-5***. Water charges are based on water consumption through water meter readings. For consumers who are unmetered, or have meters which are not working, water charges are based on the flat rate, of 90Kshs/month, regardless of the water consumption.

Table 2.3-5 Water Tariff in the Study Area

	Classification	Rates
I.	Where no meter is installed, a monthly charge of	90Ksh
II.	Where a meter is installed; Where the ammount of water sold through the meter in any one month:	
	1. does not exceed 10m3.	90Ksh
	2. is more than 10m3 but does not exceed 30m3,	12Ksh
	3. is more than 10 m3 but does not exceed 30 m3, charge per m3 in excess of 10 m3.	15Ksh
	4. exceed 60m3 but does not exceed 100m3, the charge per m3 in excess of 30m3.	20Ksh
	5. exceeds 100m3, charge per m3 in excess of 100m3.	30Ksh
III.	Where water is sold through a meter at a kiosk, the charge per m3.	7Ksh
IV.	Where water is sold by retail at a kiosk per unit of 20 litres or part therof, charge perunit.	0.5Ksh
V.	For the bulk sales to an undertaker for resale, charge per m3.	6Ksh

Source: The Water Act, Kenya Gazette Supplement No. 5, 27th January, 1995

(3) Customer Registration

The number of customers of the Meru Water Supply scheme is gradually increasing, as seen in ***Table 2.3-4.*** Because of delay in payment of water charges, 990 customers had been disconnected as of September 1996. Registration is carried out by the DWO of households with piped water from the Ministry water supply. Registration fees including connection fees, materials cost, etc. are charged to every customer.

(4) Metering, Accounting and Bill Collection

Meter readers, (2 personnel) read every house meter on a monthly basis. However, working meters, as stated above, are few in number. Therefore, their task is not currently a heavy burden. Water consumption is computed at the DWO for issuing water bills to every customer.

Under the rules and regulations adopted by the Government of Kenya, bill collection is not the responsibility of the DWO. Payment of water charges is to the District Treasury Office.

(5) Financing

Financing for all activities at the DWO is based on the water revenue collected through the District Treasury Office. The MLRRWD allocates budget with a minimum of 85% of the revenue to each DWO. The actual allocation ratio is determined in view of the financial conditions.

According to the 1996 financial monitoring report of the DWO, almost 60% of the water bills are lost or delinquent due to delayed payment. This situation resulted in shortage of funds for routine operation and maintenance.

(6) Training

KEWI is an organization under MLRRWD, responsible for training and technological development. Every year, it invites several numbers of staff and engineers from each DWO for training and seminar.

2.3.5 Problems DWO Encounters

The Major problems identified in a series of the field surveys are listed below.

(1) Chemicals are not necessarily being dosed on a continuous basis because of serious fund shortages for operation and maintenance.

(2) Some mechanical equipment and piping materials installed at the waterworks are defective and many leakage losses were identified.

(3) The Distribution pipe network does not have sufficient capacity. One reason for this may be attributable to the overloaded operation of the existing treatment plant.

(4) Non-registered connections exist broadly throughout the supply area, and may exceed 20% of all the customers. Further, such non-registered water users are generally consuming excessive water for domestic purpose including gardening, irrigation and watering animals.

(5) Most of the installed service meters are malfunctioning due to the long term absence of proper maintenance.

(6) A drastic shift of large consumers from the Ministry Water Supply to Community Water Supplies has been seen in the past decade because of the high water tariff, and frequent water rationing, of Ministry supplies.

(7) The DWO substantially lacks operational equipment such as vehicles, tools and chemicals required for proper operation and maintenance of the water supply system.

CHAPTER III WATER DEMAND PROJECTIONS

3.1 Human and Livestock Projections

3.1.1 Population

National population censuses have been held in Kenya every ten years since 1969. Each census has covered the whole country in detail and the results have been the primary basis for national projections and planning. These National census figures were therefore assessed for every sub-location within the project boundary. Information from the 1969, 1979 and 1989 censuses were used in the analysis as summarised in ***Table 3.1-1*** below:

Table 3.1-1 Population Census figures for Meru Supply Area

Sub Location	1969 Population	1979 Population	1989 Population
U.Igoki	9982	Values	26913
Ntakira	6290	included	9414
L.Igoki	3113	under	4759
Nthimbiri	4612	Municipality	5324
Mpuri		"	4492
Ngonyi-Gitugu	3174	"	5227
Total Ntima Loc'n	27171	"	56129
Mulathankare	4565	"	5054
Thuura	4567	"	8879
Chungu	12219	"	13499
Munithu	4812	"	8021
Nkabune	1540	"	3645
Total Nyaki Loc'n	27703	"	39098
Municipality	54874	72049	95227
Katheri	8039	11508	14172
Githongo	4597	5827	7094
Kithrune	5470	7320	8698
Total Abothuguchi	18106	24655	29964
TOTALS	72980	96704	125191

Source: Central Bureau of statistics: 1969,1979 and 1989 censuses

Due to the widespread changes in sub-location boundaries, and the fact that the 1979 census did not provide a breakdown by sublocation for Ntima and Nyaki Locations, it is impossible to estimate growth rates between 1969-1979 and 1979-1989 for every sub location.

It was also found that the overall growth rates between the 1969 and 1979 census, and the 1979 and 1989 census indicated considerable changes and inconsistencies in their short term trends, but that the longer term growth rates indicated by comparing from the

1969 census and the 1989 census provided a more uniform trend that was in fairly close agreement with District and National trends and predictions. This is consistent with the assumption that reliability and accuracy of data increases with the length and quantity of data, and suggests that the growth rates obtained from assessment of the 1969 and 1989 population figures would be more reliable than using the shorter term results from between the 1979 and 1989 censuses.

The National and District Growth rates between 1969 and 1989 are indicated below in ***Table 3.1-2.***

Table 3.1-2 National and District Population Growth Rates

	1969 to 1989 Annual Growth Rate
National Growth Rate	3.43 %
Meru District Growth Rate	3.12 %
Project area Growth Rate	3.57%

Source: Central Bureau of statistics, 1969 and 1989 censuses
(Note: rates adjusted where appropriate to suit changes in administrative boundaries).

These figures indicate that population growth rates in Kenya, and the project area, during the twenty years between 1969 and 1989, have been among the highest in the world.

Since the 1989 census, there has been no similar widescale and detailed population survey, although a number of local population estimates have been made. These however have invariably used the 1989 census figures as the baseline for their projections.

The above 1989 census figures as given in the tables above, have therefore been used for the baseline for population projections.

Future projections were estimated after consideration of these baseline figures and their implied growth rates together with a review of a number of past studies, reports and additional factors, including:

(1) District Development Plan (1994-1996)

(2) National Master Water Plan (1992)

(3) Water Resources Assessment Project for Meru District (1991)

(4) Analysis of past census results and trends

(5) Views of District Planning Officers

(6) Population pressures

(7) Land potential and land costs

(8) Inward and outward migration

(9) Government population policies

An analysis of growth rates conducted in the region during the Master Plan stage of this Study revealed, as expected, that urban areas were growing at a faster rate than rural areas, i.e. at 5.0% and 2.8% per annum respectively. The spatial variability of population growth can therefore be modelled by applying these rates in proportion to the rural and urban population in each sublocation.

Based partly on historic evidence, and also on Government policy, it was assumed that the above high growth rates will slow down over the design horizon. But, due to resultant population pressure on rural land, the reduction in growth would be felt mostly in the rural areas, and that the urban areas would continue to grow at similar rates to present.

The District Development Plan also predicts a modest reduction in the growth rate from the figure obtained for the project area between the 1969 census and 1989 census.

The National Water Master Plan, which was produced before the 1989 census figures were available, predicted long term growth rates for Urban and Rural areas within this project area of 5.2% and 1.9% respectively.

The earlier 1991 Water Resources Assessment and Planning Project (WRAP) predicted lower urban growth at 4.2% but higher rural growth at approximately 3.5%. However the report recognised that the rural population growth rates also vary with the agricultural potential of the area, with higher growth rates in higher potential areas. The advantage of this method is that the resultant growth rates of the different sub locations will adjust automatically to suit their varying characteristics, resulting in a potentially more realistic forecast for the spatial distribution of population.

The final projections have been based on consideration of the above factors. The format is similar to that developed by the WRAP project, using the following classifications for urban and rural households as given in ***Table 3.1-3*** below:

Table 3.1-3 Urban Housing and Rural Land Classification

	Classification	Definition
Urban	High class housing	0.2 to 0.8 ha plot hot and cold water internal WC
	Medium class housing	0.1 ha plot internal water supply internal WC
	Low class housing	High density housing external water supply
Rural	High potential land	annual rainfall over 1,000 mm
	Medium potential land	annual rainfall between 500 and 1,000 mm
	Low potential land	annual rainfall below 500 mm

Source: MOWD Design Manual, 1986

As a result of the above analysis of census data and the review of other sources, the growth rates for the different household categories over the plan horizon are given below. Where the growth rates for household categories varied with time, it was assumed that the variation would be gradual over the period, varying linearly with time. Accordingly, the growth rate for High potential rural population during the year 2005 would be 2.25%, and that for Medium potential 1.5%.

Table 3.1-4 Annual Growth Rates for Household Categories

Year	Rural			Urban		
	High Potential	Medium Potential	Low Potential	High Class	Medium Class	Low Class
1997	3.0%	2.5%	2.0%	5.0%	5.0%	5.0%
2000	2.5%	2.0%	1.0%	5.0%	5.0%	5.0%
2010	2.0%	1.0%	1.0%	5.0%	5.0%	5.0%

Source: JICA Study Team

The spatial distribution of the different household categories was taken from the WRAP report as below:

Table 3.1-5 Household Classification Distribution by Sub Location

	URBAN Housing Classification			RURAL Land Potential		
Sub Location	High	Medium	Low	High	Medium	Low
U.Igoki	10%	30%	60%	0	0	0
Ntakira	2%	7%	6%	77%	0	0
L.Igoki	2%	6%	12%	80%	0	0
Nthimbiri	0	0	0	100%	0	0
Mpuri	0	0	0	100%	0	0
Ngonyi-Gitugu	0	0	0	100%	0	0
Mulathankare	10%	30%	60%	0	0	0
Thuura	0	0	0	100%	0	0
Chungu	0	0	0	100%	0	0
Munithu	0	0	0	100%	0	0
Nkabune	0	0	0	100%	0	0
Katheri	0	0	0	100%	0	0
Githongo	0	0	0	100%	0	0
Kithrune	0	0	0	100%	0	0
Average	2.8%	8.4%	16.8%	72.0%	0	0

Source: WRAP 1991

The resultant projections were prepared by applying the respective growth rates for each household category in each sub location as shown in ***Table 3.1-4*** and summarised on ***Table 3.1-6*** below:

Table 3.1-6 Population Projections by Sub Location

Sub Location	1989	2000	2005	2010
U.Igoki	26913	46030	58748	74979
Ntakira	9414	13640	15887	18415
L.Igoki	4759	6847	7939	9155
Nthimbiri	5324	7298	8197	9095
Mpuri	4492	6158	6916	7673
Ngonyi-Gitugu	5227	7165	8048	8929
Mulathankare	5054	8644	11032	14080
Thuura	8879	12172	13671	15168
Chungu	13499	18505	20784	23060
Munithu	8021	10995	12350	13702
Nkabune	3645	4997	5612	6227
Katheri	14172	19427	21820	24209
Githongo	7094	9725	10922	12118
Kithrune	8698	11924	13392	14858
Total	125191	183527	215318	251668

Source: JICA Study Team

Annual details of the population forecasts for each land and housing category are given in ***Table 3.2-4.***

3.1.2 Schools, Institutions and Industrial Growth

Baseline figures for numbers of pupils, institutional staff and commercial and industrial establishments, were adapted from a number of sources, but principally the 1991 WRAP Report which provided details down to the sub-location level.

The existing pupil population, as a percentage of overall population, is approximately 26%. (District Development Plan 1994-96). The distribution between number of day pupils and boarders was taken as 90% and 10% respectively (WRAP 1991). Details are given on ***Table 3.2-4.*** per sub-location.

The numbers and distribution by sub location of commercial premises, other institutions and industries were also taken from the WRAP Report. Details of which are given in ***Table 3.2-4.***

3.1.3 Livestock

Existing livestock ownership levels have been estimated using the results of the WRAP livestock census conducted in Meru District during 1988. This indicated approximately 200 livestock units per 1000 population, which was in close agreement with the findings of the socio economic survey conducted in the project area during the Master Plan stage of this study, when a figure of 250 was obtained. The WRAP figures however, being based on a more detailed survey, targeted specifically on livestock, and having already been accepted was adopted.

Livestock population projections have been based on WRAP's scenario 1, which assumed that increasing pressure on land will constrain future growth of livestock to around 2 % per annum.

3.2 Water Demand Projections

3.2.1 Per Capita Consumption and Service Levels

The per capita consumption rates recommended in the 1986 MOWD Design Manual were found by the consumer survey, undertaken during the Master Plan stage of this project, to be reasonable for metered connections. It was also found however that consumption of up to 5 times higher is to be expected if meters are not connected. This is an important finding since it supports the MLRRWD's current policy of greater cost recovery for its supplies and, assuming full metering is affected, it supports the use of design manual consumption rates, as given in ***Table 3.2-1***, for design.

These figures include an allowance of 20% for losses from leakage and waste. However, as discussed elsewhere, the actual total level of unaccounted water was found to be considerably higher than this figure. The use of these figures for design therefore assumes that considerable effort will be directed towards reducing the current high level of unaccounted water.

It was also suggested that, at current tariff levels, an improved reliable water supply system could result in higher consumption levels than the MOWD design guidelines.

However, in order to achieve Government policy to improve current cost recovery levels, it will be necessary to increase the current tariff, in real terms, in the future.

The precise effect of higher water prices is difficult to predict and depends upon many factors. Nevertheless, due to normal price elasticity, these higher costs will undoubtedly have the effect of reducing consumption levels. Consumption levels above the MOWD guidelines were therefore not considered justifiable.

This subject was discussed with the MLRRWD when it was agreed that, for present purposes, the MOWD guidelines for unit consumption rates and for connection levels should be assumed for the design horizon of the Master Plan of 2010. These are given in ***Table 3.2-1***, and ***Table3.2-2*** respectively.

Table 3.2-1 Design Water Consumption Rates

Category			unit	Demand
Individual connections	Rural	High potential land	l/c/d	60
		Medium potential land	l/c/d	50
		Low potential land	l/c/d	40
	Urban	High class housing	l/c/d	250
		Medium class housing	l/c/d	150
		Low class housing	l/c/d	75
Water Kiosks/	Rural		l/c/d	10
communal water points	Urban		l/c/d	20
Schools		Boarding	l/c/d	50
		Day school with WC	l/c/d	25
		Day school without WC	l/c/d	5
Hospitals		Regional	l/bed/d	400
		District	l/bed/d	200
		Other	l/bed/d	100
		Out patients	l/patient/d	20
Dispensary/Health centre			m3/day	5
Hotels		High class	l/bed/d	600
		Medium class	l/bed/d	300
		Low class	l/bed/d	50
Offices			l/c/d	25
Bars			l/day	500
Shops			l/day	100
Unspecified industry			m3/ha/d	20

Source: MOWD Design Manual, 1986

Table 3.2-2 Service Levels as Percent of Individual Connections

Category		Initial	Intermediate	Design Horizon
Rural	High	20%	40%	80%
	Medium	10%	20%	40%
	Low	5%	10%	20%
Urban	High	100%	100%	100%
	Medium	100%	100%	100%
	Low	10%	30%	50%

Source: MOWD Design Manual, 1986

3.2.2 Schools, Institutions, Commercial and Industrial Growth

The per capita consumption rates for schools, commercial and industrial demand are given in ***Table 3.2-1*** above. The criteria used for the future water demand projections are given, in ***Table K.2-5*** of the apendix, together with a brief assessment of the sensitivity of the overall water demand projections to alternative assumptions.

3.2.3 Livestock

Assuming fully metered water supplies, the use of metered water for watering livestock will be limited, with many households preferring to take their livestock to local streams where water is free, particularly as the supply area is relatively abundant with perennial rivers. A figure of 15% of the livestock water demand being supplied from the metered supply has been suggested as being a reasonable allowance. The overall water demand is not sensitive to realistic alternative assumptions of this level.

3.2.4 Projected Water Demand

Water demand projections based on the design criteria and population projections are summarised below for each category of consumer.

Table 3.2-3 Breakdown of Water Demand by Consumer Category

Consumer Category	2000 m3/d	2005 m3/d	2010 m3/d
Domestic	9,212	12,830	17,311
Livestock	251	277	306
Industry	2,645	3,097	3,627
Institution	568	667	779
Health	158	185	217
Commerce	354	414	485
Total	13,188	17,470	22,725

Source: JICA Study Team

A more detailed breakdown of how these figures have been calculated is given in ***Table 3.2-4***. Similar projections were also prepared for each sub location. A summary of the results for the design year of 2005 is given in ***Table 3.2-5***.

3.2.5 Projected Demand for Prioritized Area

Table 3.2-6 shows projections for 2005 for the prioritised area which includes Ntakira, Lower Igoki, Nthimbiri, Mpari, Katheri and most of upper Igoki.

Table 3.2-7 Water Demand for Prioritised Area

Consumer Category	2005 (m3/d)
Domestic	6,356
Livestock	124
Industry	3,192
Institution	312
Health	156
Commerce	342
Total	10,482

CHAPTER IV PRELIMINARY DESIGN OF FACILITIES AND EQUIPMENT

4.1 Water Supply Facilities

4.1.1 Design Framework

(1) Objectives

The objective of this project is to improve, rehabilitate and extend the Meru water supply scheme.

In accordance with the basic strategy established during the Master Planning Phase of this project, the preliminary design of Meru's Phase 1 water supply facilities will, in addition to providing the required capacity, be aimed at improving the ease of operation and maintenance by:

1) the use of good quality raw water requiring minimum treatment,
2) gravity supply and,
3) the avoidance of electrical and mechanical equipment as far as possible.

(2) Scope

This feasibility study, for Phase 1 of the project, is required to meet the projected demands of the year 2005, as identified in the Master Plan, which used the year 2010 as its planning horizon. Trunk mains, which are not economical to duplicate, are therefore designed for the projected 2010 demand, whereas the treatment plant and storage reservoirs, which are economical to duplicate, are designed for the required 2005 capacity.

Phase 1 includes the main infrastructure including intake, raw water main, treatment plant, trunk mains and storage facilities required to meet the demands of the prioritised areas. Phase 1 also includes a certain amount of smaller distribution pipework, but it is assumed that this will be extended on an annual basis by the Ministry, as the demand and priorities require.

The water demand projections for the whole area are given in Chapter 3. However, this assumes that the entire area is covered by the distribution system from the first year of operation of the project.

The construction of distribution systems will, in practice, be phased according to established priorities. The initial supply will therefore be less than the initial demand calculated in Chapter 3 and will be similar to that indicated on ***Figure 4.1-1.***

The existing usable treatment production capacity is approximately 3,000 m3/d. It can therefore be seen that, an additional 10,000 m3/d will be adequate to meet the Phase 1 demand by the year 2005 and, that an additional 10,000 m3/d, will be required to meet the 2010 projected demand.

(3) Other Strategic Considerations

1) Topographical

Meru's supply area of 185 km2 ranges in elevation from 2,060 m at the forest edge, in the west of the area to 1,200 m in the east. The existing treatment plant is located close to Meru Town, and therefore close to the centre of demand but is at an elevation of approximately 1,690 m and can therefore only supply the lower parts of the supply area by gravity. The northern section of the existing supply area which was supplied by pumping, now suffers the most acute water shortages and is in most urgent need for augmentation. It is required therefore to provide additional capacity at a sufficiently high elevation to supply this area by gravity. The proposed location, on a cleared site within the forest reserve has a number of advantages including gravity flow and ease of land acquisition.

2) Priorities

Approximately 50% of the demand is located in the area around Meru Town, where the consequences of an inadequate water supply on public health is seen to be greatest. The improvement and expansion of supplies to these urban areas is therefore of highest priority. Phase 1 will therefore concentrate on these areas and those rural areas where there is the most acute water shortages. This will be extended in Phase 2 to cover most of the supply area by trunk mains.

3) Water Losses

In addition to any improvement in water supply infrastructure, the high level of unaccounted for water in Meru makes it essential that improvements in the institutional arrangements for the operation, maintenance and management of the system are effected in parallel.

4.1.2 Intake and Raw Water Main

As a contingency against possible future raw water quality deterioration, the intake and raw water main have been designed with a capacity of 22,000 m3/d, which is 10% above the projected future demand, to allow for possible future treatment plant losses due to backwashing etc.

(1) Intake

The proposed intake on the Kathita River is located approximately 8 km inside Mount Kenya Forest, close to the Kirua intake, which is under construction ,and to the Kimori and Kiamogo Community Water Supply intakes, which share a common weir. This weir, and their uPVC raw water mains are however in need of total reconstruction.

There are a number of mutual advantages by locating these intakes in close proximity including access and co-ordination of operational activities. Nevertheless, careful liaison between the scheme management committees will be required.

A survey of the proposed intake site, just upstream of the broken Kimai and Kiamogo weir was conducted, and the proposed Weir intake is indicated on ***Figure 4.1-2***.

The design includes a number of features to reduce maintenance requirements and to limit the intake of sediment, floating material and submerged objects, including.

1) Weir profile to encourage sediment to pass over the structure rather than build up on the upstream face and thereby cover the inlet.
2) Submerged intake opening to avoid intake of floating debris
3) Intake opening raised well above river bed level to reduce intake of sediment
4) Low inlet velocity
5) Upstream weir scour arrangement
6) Constant flow scour from intake chamber
7) Angled, self cleansing coarse screen, with 50 mm spacing between bars.

(2) Raw Water Pipeline

The raw water pipeline route and profile are shown on ***Figures 4.1-3 and 4.1-4.*** Construction of this pipeline will be difficult, particularly the initial sections where it passes along the narrow gorge of the Kathita River and, where it will need to be protected against erosion. Careful optimisation of this route will need to be considered during the final design. For the purposes of this feasibility study however, a 500 mm diameter steel pipe has been assumed throughout.

4.1.3 Treatment Works

(1) Basis of Design

Water samples were taken from the Kathita River for analysis during both the wet and dry seasons. Average values for the samples are given below, together with the MLRRWD guideline values where appropriate.

Table 4.1-1 Raw Water Quality and Drinking Water Guidelines

Parameter	Units	MLRRWD Guidelines for Drinking quality	Dry Season	Wet Season
pH		6.5 - 8.5	7.9	8.3
Apparent colour	°H		15	<5
True colour	°H	5	<5	<5
Conductivity	mS/cm		145	98
Turbidity	FTU	15	1.6	.8
Calcium Hardness as $CaCo_3$	mg/l	500	26	2
Total Hardness as $CaCo_3$	mg/l		76	18
Total Alkalinity as $CaCo_3$	mg/l		53	92
Carbonate alkalinity as $CaCo_3$	mg/l		0	0
Iron	mg/l	0.3	.02	.02
Fluroride	mg/l	1.5	.38	.32
Sulphate	mg/l	400	33	38
Phosphate	mg/l		.02	.01
Silica	mg/l		66	55
Dissolved oxygen	mg/l		5.9	5.8
Nitrates	mg/l	10	.01	0
Manganese	mg/l	0.1	0	0
Chlorides	mg/l	250	16	14
Chromium	mg/l		0	0
Copper	mg/l		0	.01
Total coliform	/100ml	0	350	210
Faecal coliform	/100ml	0	9	35
Dissolved solids	mg/l	1000	65	140
Suspended solids	mg/l		5	18
Total solids	mg/l		70	158
Biochemical oxygen demand	mg/l		10	4
Chemical oxygen demand	mg/l		12	8

Source: MLRRWD Design Manual (1986) and JICA Study Team

These results indicate that the raw water was of good physical and chemical quality. The only parameters that failed to meet the MLRRWD drinking water guideline values were bacteriological, confirming the need for chlorination.

On the basis of these results, it could be argued that no treatment, other than chlorination, is required. However, it should be stressed that the number of samples taken were limited, and that from experience, higher values of Turbidity and suspended solids do regularly occur in these rivers. Some form of treatment is therefore required both to safeguard the potable water quality and to protect the system from sedimentation.

The simplest form of treatment is plain sedimentation followed by chlorination, and this has therefore been proposed as being appropriate to Phase 1.

Surface water quality in Kenya however, has been deteriorating with time due to clearing and development of land for its rapidly increasing population. Although the Kathita River catchment does not appear to be under immediate threat, this is occurring in adjacent catchment areas. Therefore, as there is sufficient land available at the treatment plant site, it has been considered prudent to plan the layout for Phase 1 on the assumption that full treatment may be required at some time in the future.

The treatment plant layout plan is given on ***Figure 4.1-5***.

(2) Inlet chamber

An inlet chamber, as shown on ***Figure 4.1-6*** is provided before the sedimentation tank, designed to provide the following functions:

1) Flow diversion and flow control
2) Fine screens with 10 mm space between bars
3) Weir to provide flow measurement and, possible future mixing of chemicals

(3) Sedimentation Tanks

Due to their ease of operation, simple horizontal sedimentation tanks have been adopted, using a design loading rate of 0.75 m/hr. Turbidity and suspended solids will primarily be due to erosion, the resultant silt should be readily settleable at this loading rate without the need for flocculation. Other criteria include a minimum length/breadth ratio of 3:1 and a maximum weir loading rate of 150 m3/m/d.

The main disadvantage of horizontal tanks is the method of sludge removal. Most of the sludge will be removed from the inlet end of the tank on a regular basis under hydrostatic pressure. However, accumulation of sludge over the rest of the tank will occur and needs to be removed periodically by flushing, aided by manual sweeping or, by mechanical scrappers. The interval between manual tank cleaning is entirely dependent upon raw water quality. Making conservative assumptions, this should not be necessary at more than yearly intervals, when it can take place at the same time as annual maintenance. The use of mechanical scrapers can not therefore be justified. With the installation of four parallel tanks, during maintenance of one tank, the full flow will pass through the remaining three tanks, increasing the loading rate to 1.0 m/hr, which should still prove acceptable, particularly as annual maintenance should only occur when demand is low and raw water quality is high.

The preliminary design of the horizontal sedimentation tank units is shown on ***Figure 4.1-7.***

(4) Disinfection

Disinfection will be by calcium hypochlorite solution as it is easier to use than Topical chloride of lime. Storage space for up to three months requirements have been allowed for together with two mixing tanks, each with a capacity for 12 hours, assuming a maximum dosage rate of 2 mg/l and a solution strength of 2%. Dosing will be by gravity dosers, which are available in Kenya.

A preliminary design of the Chlorination Building is shown of ***Figure 4.1-8.***

(5) Clear Water Storage

Clear water storage at the treatment plant site is required for two reasons; firstly to balance flows to the immediate downstream area, and secondly to provide chlorination contact time.

The volume required to balance flows is estimated as 200 m3 (see ***Section 4.1.4***).

The contact period required for chlorination to be effective is normally conservatively taken as 30 minutes. However, other than the treatment plant itself, there are no immediate consumers within 2 km of the treatment plant and, therefore, the time spent within the delivery main can contribute towards the contact time. Nevertheless, a minimum contact period of 10 minutes is considered prudent, to arrive at a total storage volume, including balancing, of 300 m3. The minimum retention time is ensured by the provision of a weir before the outlet of the tank, as indicated on ***Figure 4.1-9***. The minimum volume remaining in the tank being equivalent to 10 minutes retention at maximum flow.

(6) Administration Building and Staff Housing

The site of the treatment plant is fairly remote and an administration building and 4 staff housing units have therefore been included.

The administration building, as shown on ***Figure 4.1-10*** will include:

1) Basic offices
2) Laboratory with basic equipment for turbidity and chlorine residual measurements.
3) Washroom
4) Store
5) Workshop including basic tools and equipment.

Although not required for the water treatment processes, electricity is required for site lighting to ensure that operation and maintenance can be carried out during night time. The costs of providing an electricity supply to the site has therefore been included.

4.1.4 Transmission and Distribution Facilities

(1) General

As described in previous chapters, from the seven towns included under the Master Plan Stage of this Study, Meru was identified as the town having the greatest priority for improved water supplies. Transmission and distribution facilities for Phase 1 have been based on **Chapter V** of the Master Plan and the proposed supply area for Phase 1 as shown in ***Figure 4.1-11***.

The 2005 projected water demand for the Study Area is estimated at 10,482 m^3/day, as described in **Chapter III "Water Demand Projection"**.

In accordance with these results, the proposed facilities to be constructed for Phase 1 are shown in ***Figure 4.1-11***. As seen in the figure, the proposed facilities concentrate on supplying water to the urgent areas of Meru's south-eastern division and the high level distribution zone of the existing system, just north of the town center.

The proposed system consists of two independent supply systems which receive raw water from different sources. One system is based on supplying water from the existing treatment plant, and the other, much larger system supplies water from the proposed new treatment plant. Considering the importance of water supply to the largely urban area covered by the existing plant, the existing pipe connecting existing storage tank (ST-EX2) to the existing treatment plant should be maintained as an emergency pipe for transmitting water from the proposed new system to the existing system.

Figure 4.1-12 shows the allocation of water demands by distribution zones based on the proposed pipeline routes and the estimated water demand for each sub-location in 2005. ***Figure 4.1-13*** shows the results of hydraulic calculations for each proposed pipeline, including flow rate, length, diameter, hydraulic gradient, and flow velocity. Hydraulic calculation results are also shown in **Tables 4.1-2 to 4** in detail. ***Figure 4.1-14*** summarizes the proposed plan for transmission and distribution facilities schematically.

(2) Summary of Proposed System for Phase 1

1) Design Criteria

Basic design flow	: Average demand
Peak hourly factor	: 2.0 times average flow
Retention time of storage tank	: 12 hours average demand
Emergency store of storage tank	: 12 hours average demand for urban areas
Maximum water pressure	: 60 m
Minimum water pressure	: 10 m
Hydraulic equation used	: Colebrook-White formula

2) Supply Area

The supply area of the proposed phase 1 system extends over the entire Meru central area, including sub-locations Upper Igoki, Ntakira, Nthimbiri, Mpuri and Mulathankare, and part of Lower Igoki, Ngonyi and Chungu, totaling approximately 85 km^2, out of the whole study area of 185.3 km^2, as shown in ***Figure 4.1-15***. This indicates an increase of 73 km^2 from the existing supply area of approximately 12 km^2.

Part of Upper Igoki and Mulathankare will be covered by gravity from the existing system. The remaining Phase 1 areas will be covered also by gravity, by the proposed new system. Some areas, particularly the higher areas, will shift from the existing system to the proposed system.

Water produced in the existing treatment plant, which has an estimated reliable production capacity of 3,172 m^3/day, will be used to supply part of Upper Igoki, in which the urban center of Meru Town is located, and Mulathankare.

3) Pipe Materials

Unplasticised polyvinyl chloride (uPVC) pipes which comply with Kenyan Standard, KS 06-149, 1981, are proposed for the majority of transmission and distribution mains with diameters less than 350 mm. Steel pipes are proposed for pipes of diameters 350 mm and more, the treated water transmission main to storage tank ST-1 and some sections such as road and river crossings.

4) Transmission and Distribution Main

The transmission and distribution system proposed for Phase 1 consists of two major supply areas, i.e. north and south. The north area covers the center of Meru Town, including the high elevation zone of the existing system. The southern area covers the rural areas prioritized as in most need of improved water supplies.

The total length of transmission and distribution mains to be constructed in Phase 1 is 61.2 km, as summarized in ***Table 4.1-5***. As mentioned above, steel pipes are proposed for diameters 400 mm and 350 mm and for the transmission main from the proposed plant to storage tank ST-1. Other pipelines are uPVC pipes.

Table 4.1-5 Proposed Pipeline Lengths for Phase 1 in Meru

Diameter	Length (km)	
(mm)	Phase 1	Total
400 SP	3.8	3.8
350 SP	6.8	6.8
315 PVC	8.5	8.5
280 PVC	5.8	5.8
225 PVC	11.8	19.0
160 PVC	12.9	37.8
110 PVC	8.2	34.7
90 PVC	3.4	23.5
Total	61.2	139.9

The hydraulic gradient along the transmission main route (see ***Figure 4.1-16***) from the proposed treatment plant to storage tank (ST-1) is based on the topographic survey conducted by the Study and is shown in ***Figure 4.1-17.*** Additional reasons for proposing steel pipes for this route include the importance of this main to the system, geological conditions and the difficulty of repairing it.

In addition to transmission and distribution mains, fittings such as bends, flow meters, section valves and air-release valves, and appurtenances such as road and river crossings, thrust blocks, washouts (blow-off) and valve chambers, will be needed for the entire system.

5) Storage Tanks

Storage Tanks, or balancing reservoirs, provide water which can be withdrawn during peak periods of demand and then replenished during the night when the system demand is low.

Storage tanks to be constructed during Phase 1 are listed in ***Table 4.1-4***. A total storage capacity of 7,050 m^3 from 6 tanks has been planned for Phase 1. Storage tank ST-EX1 is located at the existing treatment plant, as shown in ***Figure 4.1-18.*** It is required to increase the existing storage capacity of 911 m^3.

Table 4.1-6 Proposed Storage Capacity for Phase 1 in Meru

Tank No.	Capacity (m^3)	
	Phase 1	Total
ST-WTP	200	800
ST-1	4,500	9,000
ST-7	200	400
ST-11	400	800
ST-12	250	500
ST-EX1	1,500	2,250
Others	-	4,150
Total	7,050	17,900

6) Break Pressure Tank (BPT)

The design of BPTs has assumed a retention time of minimum 2 minutes at design flow. A typical drawing is shown in ***Figure 4.1-19***. Basically, BPTs will be located to keep static pressures as low as possible within a maximum pressure of 60 m.

7) Service Main and Water Kiosks

Service mains and water kiosks are important facilities for developing a total water supply system. The operation and maintenance of water kiosks (as shown in ***Figure 4.1-19***) have however proved problematical in the past. To improve on this performance it is suggested that recipient communities be involved in their planning and location, they should contribute towards their cost and undertake training before it is agreed to construct each facility. For this reason they should not be constructed until these provisions have been successfully completed.

4.1.5 Rehabilitation

As stated in the Master Plan, a full-scale rehabilitation is considered premature and unpractical. However, some old facilities and pipelines need repair and replacement. Leakage is found from the storage reservoirs constructed in the treatment works. Some bulk meters and gate valves installed in 1970s and 1980s are not functioning. The scope of the rehabilitation proposed in the Master Plan is reproduced below;

Table 4.1-7 Rehabilitation in Meru

Facilities		Diameter (mm)	Quantity	Scope
Treatment Works				
Filtration Units	Inlet valves	150	4	Replacement
	Outlet valves	150	4	ditto
Storage Tank 1	Outlet valve	150	1	ditto
Storage Tank 2	Outlet valve	150	1	ditto
		75	1	ditto
Storage Tank 3	Concrete wall			Leak repair
Delivery Mains	Bulk meter	200	1	Replacement
		150	1	New installation
		75	1	ditto
		50	1	ditto
Distribution Pipe Network				
Milimani Zone	Sluice valve	150	5	Replacement
		75	1	ditto
		50	1	ditto
Town Zone	Sluice valve	100	2	ditto
		75	1	ditto
		50	1	ditto
Gakoromone Zone	Sluice valves	50	2	ditto
Other materials	Adapters	50	10	Installed at both ends
		75	8	ditto
		100	4	ditto
		150	32	ditto
		200	2	ditto

Source: JICA Study Team

Some of the above works may require a few hours of water supply suspension during rehabilitation. In view of the present water supply conditions in the supply area, this may not be a crucial factor to the customers. However, some provisions, such as tankers should be made to supply water even during rehabilitation. Due to normal deviation in pipe size and wall thickness between standards, provision for adapters at both ends of valves and meters is needed to ensure smooth progress.

4.2 Provision of O&M Equipment and System

To achieve efficient operation of the expanded water supply facilities, the equipment listed below will be provided under the current project.

4.2.1 Metering and Registration

In Kenya, the entire cost of installing service connections is borne by customers. Accordingly, the cost of materials and equipment required for establishing the metering system is only that for replacement and repair of the defective customer meters so far installed.

Table 4.2-1 Equipment Required for Metering

Year	Customers	Non-working meters
1996	2,519	2,083
	Diameter	Meters
	1/2"	1,875
	3/4"	208
		Pipe borers
	13 -100mm	3
	100 - 250mm	3
		Meter Calibrator
		1

Source: JICA Study Team

To eliminate and register the non-registered connections, the project should endeavour to obtain public understanding through frequent dialogue with the public. Support by Meru Municipality will play a key role in these activities.

4.2.2 Recording and Monitoring

None of the bulk meters installed at Milimani Waterworks are working. To establish a metering system, and initiate leakage control activities, all inflow and outflow to and from the Milimani Waterworks shall be provided with flow meters. In addition, district meters to gauge inflow to the distribution zones will be installed at each inlet as follows.

Table 4.2-2 Equipment for Recording and Monitoring

Diameter (mm)	Bulk Meters	Remarks
75	1	Milimani
100	1	Milimani
150	1	Milimani
200	1	Milimani
	District Meters	
100	10	Each zone
	Adapters	
75	2	both ends of meters
100	22	ditto
150	2	ditto
200	2	ditto

Source: JICA Study Team

4.2.3 Equipment for Leakage Control

To initiate activities for leakage control at the earliest date possible, early establishment of the metering system is recommended. Leakage control is considered most effective in attaining a reasonable level of accounted-for water ratio. For this purpose, acoustic bars, leak detectors, portable flow meters, pressure gauges, pipe detectors (iron, PVC), and survey vehicles (pick-ups) will be required by the project.

Table 4.2-3 Equipment for Leakage Control

Equipment	Type	No.	Remarks
Acoustic Bars	L=1.0m	3	
Pipe Detectors	iron type	3	
Leak Detectors	Sounding	3	
Flow Meters	Portable, ultrasonic	2	
Pressure Gauges		6	
Survey Vehicles		2	one standby

Source: JICA Study Team

CHAPTER V COST ESTIMATE AND CONSTRUCTION PLAN

5.1 Unit Construction Prices

A review of current construction prices in Kenya was conducted, based on a combination of recent tender rates for the construction of similar works, and suppliers quotations for materials.

The unit rates derived from this review are given in ***Table 5.1-1***. These rates have been used to make an estimate of the construction costs for the works identified to be included under Phase 1 of the proposed project. To facilitate cost estimates, these rates were also used to calculate "all in" costs for concrete, pipeline construction using different materials and estimates for the costs of standard reservoir sizes.

Preliminary and general items have not been included in the unit rates, as these will generally differ between locations. These have therefore been estimated separately.

The base date for the costs estimate is March 97, with an exchange rate of 1 US$ = 56 Kshs.

5.2 Construction Cost Estimates

Quantities have been taken off for each of the proposed structures, and bills of quantities priced using the above unit construction prices to prepare cost estimates of the proposals to meet the 2005 water demand requirements. All major items of expenditure have been quantified. Minor details, such as individual pipe fittings, window cills, skirtings, etc., have not been itemised separately, however, an appropriate allowance has been made for the cost of these for each structure. The bills of quantities are included in Appendix L. For comparative purposes, cost estimates of conventional full treatment and slow sand filters are also given in addition to the costs of the proposed plain sedimentation only.

The resultant estimates are summarised on ***Table 5.2-1,*** which also provides a breakdown of disbursements per year for each of the major components and, running costs. Investment costs are further summarised on ***Table 5.2-2*** below, which also indicates the estimated costs for the subsequent Phase 2 of the project. These tables indicate that the cost averages at about US $ 60 per capita, with 70% of the costs incurred during the initial phase, 30% during the second. Taking Phase 1 in isolation, the cost per capita of US $81 is higher as this includes elements required for future investment in the Phase 2 area.

Table 5.2-2 Summarised Cost Estimates

Item	Phase 1 Initial investments (1998-1999)	Phase 1 extensions (2000-2005)	Phase 2 Initial investments (2006)	Phase 2 extensions (2006-2010)
Rehabilitation and equipment	179	-	-	-
Intake	224	-	-	-
Raw water pipeline	1,327	-	-	-
Treatment plant	949	-	703	-
Staff housing	106	-	35	-
Branch offices	75	-	0	-
Reservoirs	651	-	854	-
Pipelines	3,870	696	1,059	1,144
Ancillaries & contingencies	1,107	-	398	-
Preliminaries & general	1,273	-	457	-
Operational equipment	338	359	-	718
Total	10,099	1,055	3,506	1,862

The main costs are related to the transmission and distribution systems, followed by treatment, the costs of raw water pipelines and storage.

Due to the conceptual nature of the designs, and to reduce the operation and maintenance costs to a minimum, there are no electrical requirements, other than treatment plant lighting, and specialised mechanical components, such as gravity dosing equipment, represent only approximately 1% of the total.

The foreign and local components of the costs were also estimated from an analysis of the materials, labour and plant resources required to construct each element of the project. Details of this analysis are provided in the seven columns on the right of ***Table 5.1-1***. The resultant distribution, after integration over the whole project, as indicated in ***Table 5.2-3***, was approximately 45% for both foreign and local currency requirements.

5.3 Recurrent Costs

(1) Operation and Maintenance

Historically levels of operation and maintenance costs have generally been low, but this would appear to have resulted in a deterioration of the water supply infrastructure and reduced its expected lifetime. To safeguard investments in infrastructure so they continue to provide a reliable service for the whole of their expected lifetimes, it is therefore advisable to budget for higher levels of maintenance costs. The 1986 Design Manual suggests guidelines for annual maintenance budgets which are in reasonable agreement with figures used in other developing countries. These are based on a percentage of the investment costs, which can be simplified as shown in ***Table 5.3-1*** below.

Table 5.3-1 Annual Maintenance Costs

Asset	Annual maintenance cost as % of investment costs
Civil works	1%
Pipelines	1%
Electrical & Mechanical works	5%

The actual maintenance costs will tend to be initially lower but increase as the assets become older. However, the above rates represent a reasonable average to be expected over the asset lifetime, and have been applied to the investment costs to arrive at the annual maintenance cost of assets.

(2) Economic Life

All assets have an economic lifetime, after which it is no longer considered economic to maintain them. The 1986 Design Manual provides the following guidance:

Table 5.3-2 Economic Life of Assets

Asset	Economic Lifetime (Years)
Civil works	30
Pipelines	30
Electrical & Mechanical works (assuming electrical power)	10

These economic lifetimes are again similar to those used in other developing countries, although they are much lower than those currently used in most developed countries. This is probably due to the harsher conditions in developing countries, and the higher levels of training and commercialisation in developed countries.

(3) Power Costs

Power costs are not significant for the proposed scheme, as it is designed for purely gravity flow. Power however will be required for treatment plant site lighting. The annual costs have been calculated using the Kenya Power and Lighting Tariff Method B1, (Oct 1996) for supplies metered at a pressure of 240 volts single phase, or 415 volts three phase as follows:

Table 5.3-3 Electricity Tariff (KP&L Tariff B1 Oct 1996)

No.	Type
1	a fixed charge of Shs 500 per month
2	unit consumption charge of Shs 4.40 per unit
3	Shs 250 per month per KVA of demand.

(4) Staffing Costs

Staffing requirements have been estimated for the treatment plant and distribution system, as given below. Staffing includes for local management, meter reading, billing and collection, but does not include Ministry overheads at District and National headquarters offices. The annual projections are shown, using similar salary scales as currently applicable for Government staff in ***Table 5.3-4***.

Table 5.3-4 Staffing (Phase 1)

Category	Existing treatment plant	Proposed treatment plant	Distribution
Engineer 1			1
Engineer 2			2
Inspector	2		3
Senior operator	2	1	4
Operator	2	2	5
Meter readers, line patrolmen, clerks, watchmen	3	3	20

(5) Chemical Costs

Chemical costs have been estimated using current unit costs for supply of chemicals, as quoted by suppliers, and using dosage rates appropriate to the raw water quality. The cost per m3 of treated water range from Shs 0.7 per m3 for chlorination alone, to Shs 1.0 per m3 if Aluminium sulphate (Alum) is added at a dosage rate of 10 mg/l. The future projection of annual chemical costs is given in

Appendix L. The costs for dosing Alum and Soda Ash however, are given for illustrative reasons only.

Table 5.3-5 Chemical Costs

Chemical	Cost per US $/kg	Dosage rate mg/l	Cost of water US $/m3
Aluminium Sulphate	0.45	10	0.0045
Chlorine	6.25	2	0.0125
Soda Ash	0.25	4	0.0010

(6) Transport

The cost of some basic transport has also been included in the annual projections. Replacement of vehicles has been assumed to be every 5 years, and an operation and maintenance budget amounting to 20% of vehicle costs per annum has been allowed.

5.4 Construction Plan

5.4.1 Basic Considerations

(1) Planning Period

The Master Plan stage of this study proposed an overall plan for the provision of water to the supply area, using a design horizon of 2010. The first phase of this overall plan, to provide facilities to meet the expected water demands of the year 2005 is the subject of this Feasibility Study.

The implementation schedule therefore covers the period up to the year 2005 and indicates that, to ensure sufficient water supplies beyond the year 2005, Phase 2 needs to be operational by the year 2006, and that preparatory work should commence in mid 2004.

(2) Rehabilitation and Institutional Strengthening

There are a number of issues that need to be addressed under this heading including the installation of new meters, the repair or replacement of existing meters, leakage reduction survey, disconnection of illegal connections, etc. The majority of this work is labour intensive and is probably best conducted by Ministry staff themselves supported by the provision of equipment, technical advice and training.

(3) Economics of Phasing

Financial optimisation of investments can be achieved if the timing of investments is closely linked to increase in demand, and hence revenue.

For treatment plants and reservoirs, the economy of scale is not very significant, and the cost of constructing half of the final capacity in the first phase is only just over half the cost of providing the total plant capacity at once. It is therefore usually economical to phase the construction of these structures, and this has been proposed for this project.

With pipelines however, because their capacity is proportional to the square of the diameter, and their costs bear a closer relationship to being linearly proportional to the diameter, and due to the fact that excavation, handling and laying costs are largely duplicated, the cost of providing 50% pipeline capacity is closer to 75% of the cost of providing the total capacity at once. It is therefore seldom economical to duplicate pipelines.

A more cost effective way of phasing the construction of pipelines, as proposed for the Meru project, is to phase their construction spatially, by initially providing the main pipelines to serve the highest priority areas, and gradually extending transmission and distribution pipelines to cover the rest of the area over the design horizon.

In accordance with this strategy, the initial construction contract for Phase 1 will provide the raw water intake and pipeline, the first phase requirements for treatment plant and storage and the major transmission mains to serve the prioritised areas. Extension of the distribution system to cover the whole of the Phase 1 area will gradually take place over the next few years, and will be substantially complete by the year 2005. Phase 2 will provide the expansion to the treatment works and storage, built under phase 1 and the whole requirements for phase 2 storage and extend the trunk mains into the Phase 2 area, for the distribution system to be gradually extended over the next few years.

(4) Materials

Steel and uPVC pipes are both manufactured locally in Kenya to International and Kenyan Standards, although the raw materials in both cases, are imported, resulting in significant foreign exchange requirements.

Kenya also has one of the largest concrete manufacturing plants in Africa, the production being used for both local and international consumption. In this case, although the raw materials are local, the plant and equipment costs are mainly foreign and represent a significant proportion of the overall costs.

The main requirements for importation for the contract will therefore be pipeline valves, and intake and treatment plant penstocks.

(5) Division of Contracts

The construction of the raw water intake, raw water pipeline, treatment works and the main transmission lines and reservoirs all require fairly high levels of planning, skilled workmanship and supervision. In order to make the work atractive to the larger contractors who are more likely to have these skills, it is therefore desirable to tender these works as one large contract.

The electrical and mechanical components have been designed to be an absolute minimum, with any mechanical requirements such as sluice valves and penstocks being generally available "off the shelf". No separate contract is required for these items.

Although good workmanship and supervision is equally required for smaller distribution pipes, this type of work is generally less demanding and is more within the capabilities of smaller local contractors. This work can therefore be let to smaller contractors on an annual basis or, constructed on the basis of direct labour by the MLRRWD.

This division fits well with the Master Plan proposals that the larger civil engineering components should be built at the initial stage of the project, and that the smaller distribution pipework be constructed gradually over the project horizon.

(6) Seasons, and the Effect of Wet Weather Conditions

The project area has two distinct rainy seasons; from March to May, and during November and December. Nearly all the roads in the supply area are unpaved, and although some may be termed "all weather roads" this rarely applies to heavy construction traffic. The rainfall intensities, and road gradients generally increase with altitude, making the higher roads more susceptible to wet conditions. During these periods therefore, it is inadvisable to plan any work on the intake and the raw water pipeline, as they are likely to be inaccessible to construction traffic. The same applies to a lesser extent to the pipeline routes. The treatment plant and reservoir sites will also be affected but, especially at the lower altitudes, construction should be able to continue for most of the time during these periods.

(7) Special Considerations

The type of construction work generally employs low level technology, and should not therefore represent any particular problems apart from logistics, to a reasonably experienced contractor.

The one exception is the construction of the raw water pipeline, especially the initial length where it passes through a deep ravine. The difficulties of access and of working in this confined space needs to be brought to the attention of the bidders in the tender documents, so they can make appropriate allowances in their tenders for the additional costs which this will entail.

5.4.2 Construction Schedule

A construction schedule for the works is shown in ***Figure 5.4-1***. The starting date will depend upon completion of financing arrangements. The schedule allows for an 18 months construction period for the main contract. The manufacture and delivery of pipeline materials presents few problems within this time frame, the more critical components will be the imported valves and penstocks, and the manufacture of special appurtenance to suit amendments to pipeline routes, that inevitably occur during construction. Nevertheless, the most critical component will remain the construction of the raw water intake and pipeline.

CHAPTER VI ORGANIZATION AND MANAGEMENT

6.1 Organization for Project Implementation

The Water Development Department (WDD) of the Ministry of Land Reclamation, Regional and Water Department (MLRRWD) will act as the executing agency for the project implementation. Under direction of the WDD, the District Water Offices (DWO) will supervise through the use of professional supervising engineers all construction works, keeping close coordination and liaison with the agencies concerned throughout the period of project implementation. For this purpose, a project management organization (PMO) will be established at the DWO in Meru. This PMO will be headed by a project manager, consisting of administration, logistic, design and inspection sections. Engineers and staff will be mobilized from the DWO and the WDD. The proposed organization chart of the PMO and its relationship to related agencies is drafted in ***Figure 6.1-1***.

For assisting the PMO in preparing engineering design and conducting construction supervision, engineering consultant/s will be employed during the detailed design and construction stages. Contractors selected through international/local tender, will perform the construction works under the supervision of the PMO with the assistance of the consultants.

6.2 Organization for Operation and Maintenance

6.2.1 Roles of MLRRWD

In addition to the routine works normally executed by the MLRRWD, the following are considered important for smooth implementation of the project;

(1) to carry out all administrative procedures to be required for implementing projects,

(2) to support the project's efforts to establish the metering system by enacting regulations for meter installation,

(3) to urge the project to practice appropriate chemical dosing at the treatment works on a continuous basis,

(4) to enhance the MLRRWD efforts for water quality control and management of communities water supplies already developed, and

(5) to mobilize staff and personnel by strengthening their skills particularly in the

field of leakage control, meter repair, calibration and water quality control.

6.2.2 Proposed Organization

The District Water Office will have direct and overall responsibility for the operation and maintenance of the constructed facilities under the direction and control of the MLRRWD. Main roles of District Water Office are as follows;

(1) to supply safe and reliable potable water,

(2) to plan, design, operate, and maintain efficiently water supply facilities,

(3) to take preventive measures for maintenance of the water supply facilities, by conducting periodical patrol at the water sources, the transmission, distribution pipelines,

(4) to establish an efficient metering system,

(5) to improve the financial status of the project by adopting an generally accepted accounting principles, and improve monitoring and reporting

(6) to conduct an intensive campaign to obtain public understanding on water supply,

In order to attain these objectives, it is proposed that the Meru Project Office is strengthened in the following 4 major areas.

(1) to organize new subsections of;
- Production for operating the Intake & Treatment Works
(4 personnel x 2 teams in addition)
- Pipeline Networks and Leakage Control (20 personnel in addition)

(2) to organize Meter subsection under Operation and Maintenance Section, responsible for procurement, repair, installation and calibration of customer meters (15 personnel)

(3) to rearrange the Administration Section by diverting duties to newly established Customer Subsection, responsible for "Meter Reading (8 personnel in total)", "Billing" (when required)" and "Public Campaign (3 personnel in total)",

(4) to strengthen Planning and Design Section by introducing computers for recording, update and processing, and

The basic concept for the organizational set-up and staffing is given in an organization chart, ***Figure 6.2-1***.

6.2.3 Staffing and Mobilization

A number of staff and personnel as described above are urgently required for system operation and management. Since the current staffing of the DWO is seemingly not sufficient, the hiring of new staff will inevitably be required. During the construction stage, inspectors will be organized at the PMO for inspection and supervision of construction works. These inspectors may be ideal candidates for system operators. Trained accountants and leakage control engineers, however, will need to be recruited. In case of shortfalls in such qualified personnel in Kenya, assignment of expatriates under the technical cooperation program of JICA, Japan will be of benefit to the Project. They will transfer technology through on-the-job training to the in-house staff.

6.2.4 Management and Operation

The expansion of the water supply system in Meru leads to increase in operation and maintenance works. One careless operation of the treatment plant, for instance, may have serious repercussions to the whole water supply system.

To minimize the potential for such misoperations, the creation of internal communication channels within the Project is considered important. Daily activities shall be communicated to the Project Manager and the DWE from the treatment works through portable radios purchased under this project supported by simple reporting forms. Although operators learn to become efficient through experience, operation manuals will be prepared during the detailed design stage for easy reference. In addition, it is recommended that the KEWI carry out regular training programs through periodical training at Nairobi.

The supply area will be expanded from the present 12 km2 to 85 km2 after construction of the Phase 1 project facilities. The location of existing DWO office might be inconvenient for some customers inhabiting the western hilly area. For the customers' convenience and effective operation of the distribution facilities, a new branch office will be constructed in Katheri.

However, the Project Manager will be located at the DWO which will act as a central supervisory office, by providing direction and order to the treatment works and the branch office. Each treatment works will be operated by the operators living at the staffing houses which will be constructed adjacent to the treatment works. They will report their activities and problems on a daily basis. Records required for overall operation of the water supply system include intake rate, water production, hourly fluctuation of the water level at the storage reservoirs, storage and consumption of chemicals, power consumption, repair and maintenance undertaken and the tools and equipment.

At the branch office and DWO, distribution teams will carry out routine patrols of the pipe network. Meters and service pipelines will be installed and/or repaired on request by the customers. Meter readers perform their duties visiting all customers once a month. This information will be reported to the DWO. For efficiency of these works, an appropriate stock of customer meters, pipeline materials and tools will be kept at a store house.

Relationship between these offices and treatment works are illustrated in ***Figure 6.2-2***.

6.2.5 Financial Management

Section 3.3 of the Master Plan describes the financial management of Meru water supply. Bill collection is being carried out by Meru Municipality. Under the present law and regulation of the Government of Kenya, an entire change in billing system cannot be expected for the time being. The DWO office and the branch office will carry out the meter reading and billing. As metering is the basis for running a sound water supply business, the non-registered customers should be eliminated as early as possible. To achieve this, obtaining full understanding of customers with regard to the meter installation is significant and necessary.

Instead of the simple accounting procedures currently adopted by the DWO, generally accepted accounting principles shall be applied for effective financial management and control. In order to establish this system, mobilization of the trained and experienced accountants is indispensable.

CHAPTER VII ENVIRONMENTAL IMPACT ASSESSMENT

7.1 Objective and Scope of EIA

Kenyan EIA guidelines stipulate that the objective of an EIA is to manage the safety of the environment during the project's implementation, commissioning, operation, and decommissioning. This approach was therefore adopted for the EIA of this project.

Environmental impacts of the project were studied during the Master Plan (M/P) stage of the study through an Initial Environmental Examination (IEE) study. The results of this study, given in the Interim Report indicated that there are several items requiring a more detailed EIA study during this Feasibility Study (F/S) stage. Project components of the F/S and M/P are similar, but the supply area by the F/S study is approximately half of the master plan area.

Environmental impact will occur in the different phases of the project which can mainly be classified as construction and operation. The IEE results suggested impacts on both the construction stage and operation stage, the following EIA therefore considers both stages.

(1) Construction Stage

Construction activities will mainly affect the human environment through resettlement, deterioration of roads, interruption of local transport, etc.

Working and material stock areas are necessary for construction. This can lead to interruption of local transportation, and degradation of the regional economy may occur close to the town area. Land acquisition is potentially an issue, particularly if it causes resettlement of residents. In this case the project needs to provide for adequate compensation or alternative land for those affected. Other impacts are relatively insignificant, and no serious environmental problems are anticipated. It is therefore the estimation of the impact of land requirements that will be the main focus of the EIA for the construction stage.

Items affecting the natural environment are limited. However, Mt. Kenya Forest is a significant environmental conservation area in which the intake and raw water pipeline are located. It will therefore be necessary to estimate the impacts on plants, animals, and soils in this area.

(2) Operation Stage

Wastewater disposal is one of the major problems arising from the water supply project. It includes water pollution and the degradation of sanitary conditions for residents. Meru Town's sewerage system covers only 30% of the town and appropriate solutions will be required for the remainder of the project area.

7.2 Environment Impact Assessment

7.2.1 Land Acquisition

(1) Land Acquisition for the Existing Project

Land acquisition for the existing project was carried out for pipeline routes and the treatment plant and reservoir sites. In the case of pipeline routes, land acquisition is in the form of wayleaves, where land is occupied during the construction period only, but with the Ministry retaining a right of access to the pipeline after construction. Even if the route passes through private land, landowners can therefore manage their land again after completion of the work. On the other hand, land required for permanent structures such as treatment plants, storage tanks, and so on, needs to be procured from the owners.

(2) Land Acquisition Method

Land acquisition methods depend on whether it is government or private land. For government land such as in gazetted forests, roads, etc., a letter of request for the land is required. It is issued under the name of Permanent Secretary of MLRRWD and is addressed to the Commissioner of Lands to allocate, or degazette the land.

In the case of private land there are three methods as follows:

1) District Water Office makes agreement with the land owners, or community to donate the land for the project.

2) MLRRWD negotiates with the individual land owner for the land.

3) Land evaluation is carried out by the physical planner belonging to District Commissioner's office.

(3) Land Acquisition for this project

The Meru project is similar to other water supply projects and wayleaves will therefore be required for pipeline routes and full land acquisition for permanent structures.

1) Pipeline Routes

Wayleaves will be required along all pipeline routes which will be mainly within existing road reserves. The land will be restored to the previous land owners after construction. Most local roads pass through agricultural areas where plots are often cultivated up to the road edge. A six meter wayleave width is required as shown in ***Figure 7.2-1*** for pipeline construction, it is therefore temporarily necessary to acquire a strip of land along the road edge. However, judging from past experience, few problems will arise.

2) Permanent Structures Spaces

Land acquisition for structures differs from pipeline routes, as it needs to be obtained permanently. The project needs to procure land for local administration offices, the treatment plant and storage tanks. Land ownership of the identified areas is uncertain at present, and confirmation of ownership is required before project implementation.

7.2.2 Local Transport

Typical road widths in the project area range from 2.0 m to 6.0 m as shown in ***Figure 7.2-1***. Areas where local transportation may be particularly affected are shown in ***Figure 7.2-2***. Small tracks with around 2.0m road width, allow only one vehicle to pass at a time. However, the traffic volume on these small tracks is very light and, as they will not be used for the main transmission pipelines, there will be little impact except, locally by the timber industry. The overall impact is therefore negligible. Roads connecting local communities are generally around 6.0m wide, with enough room for vehicles to pass each other. These roads however have a larger traffic volume, some of which are utilized as local bus routes, giving an important service to the communities. Confirmation of traffic volumes and road widths of these rural roads is required. Some pipeline routes plan to cross the trunk road to Isiolo and other important roads in the urban area. Although vehicles can not travel at high speed inside the town area, the volume of traffic is high especially in daytime. Hence, it is necessary to carefully control construction work to prevent disruption of the transportation system especially within the urban areas.

7.2.3 Natural Resources in Mt. Kenya Area

An environmental conservation survey for Mt. Kenya forest was carried out in the early 1980s. The forest conservation study however concentrated on the western side of the mountain and impacts on the eastern side, where this project is located, were not mentioned. Timber is a major industry within the area and deforestation has spread remarkably close to the intake site. Construction methods requiring deforestation should be strictly forbidden, and the raw water pipeline routed carefully to ensure minimum impact.

7.2.4 Wastewater Disposal

Wastewater volumes will increase in parallel with improved water supplies. If this wastewater is not effectively treated and disposed of, the sanitary environment for the residents will deteriorate with consequential impact on human health. There are several plans for protection against wastewater pollution, and current District plans concerning wastewater are listed below.

(1) Environmental Action Plan

An Environmental Action Plan was prepared in 1992 at district level. It described the present situation and prepared a strategy concerning a 5 year period. However, the Plan merely indicated a planning direction and did not consider the detail planning such as project scale, project cost, and funding sources.

The report concluded that certain diseases could be controlled through a primary health program and suggested that malaria control programs should be executed by the government.

(2) District Development Plan

District Development Plans are prepared every 5 years. They describe development strategy by sector and prepare a prioritized list of projects for implementation.

Most projects relating to environmental health improvement were concerned with the construction or renovation of hospitals or related facilities. There were, for example, no projects carried out for the improvement of sanitary conditions during 1989-1993. The District-wide water and sanitation program was the only project (ranked 5th) which was included in the 1994-1996 Plan period. Although Local Government is also concerned with improvement in sanitation, no such projects were included under this heading. On site sanitation improvement is not therefore given a high priority and almost all projects concentrated on health center construction. It therefore appears that significant sanitation improvement will not be accomplished in the immediate future.

(3) Physical Sewage Planning

Physical planning for extending the existing Meru sewerage project took place in 1983 but this was not implemented and the existing facilities have continued to be used without augmentation. Proposed new sewered areas to be connected to the existing facilities were as follows;

1) Makutano
2) Kenyare Housing Estate
3) Mujini Area
4) Majengo Area
5) Shauri Yako Area

This sewerage improvement project was not mentioned in the 1994-1996 District Development Plan. Hence, project implementation is unlikely to be in the immediate future. The next District Development Plan is however under preparation.

(4) Estimation of Wastewater Volume

Existing wastewater flows were estimated by monitoring flows into the existing wastewater treatment plant. The results of which are shown below.

Table 7.2-1 Wastewater Flows

Unit: m3/day

Date	9/5	9/12	12/5	12/19	1/2	1/16	1/29	2/15	2/26	2/27	2/28	Average
Volume	271	280	295	1,111	1,088	1,172	1,708	1,148	685	753	368	807

The present water supply volume is approximately 3,200 m3/day, therefore the wastewater flows are around 25 % of the quantity of water supplied. Wastewater volumes for 2005 was roughly estimated in the following table by applying this percentage to the projected future flows. The result indicates that the projected wastewater volume is approximately twice the existing volume, which is already overloading the existing facilities. New facilities are required at a new location, outside the urban area, at an elevation that will enable all the town to be connected by gravity. Rural areas will also be affected by an increase in wastewater volumes. However, in these areas it is not economical, or feasible to construct water born sewerage systems. Improvement of on-site sanitation systems, linked to the promotion of hygiene education is required for improving the sanitary conditions in rural areas.

Table 7.2-2 Estimated Wastewater Volume of Meru Project (2005)

m3/day

Area	Water Supply in F/S	Wastewater Volume
U. Igoki	5,615	1,404
Mulanthankare	656	164
Nkabune	157	39
Ngonyi	211	53
L. Igoki	290	73
Thura	378	95
Munithu	361	90
Chungu	538	135
Ntakira	568	142
Nthimbiri	221	55
Githongo	318	80
Kithrune	378	95
Mpuri	184	46
Katheri	606	152
Total	10,481	2,623

7.3 Environmental Impact Mitigation Method

7.3.1 Land Acquisition

Land acquisition along pipeline routes is temporary, and major impacts can be avoided by good liaison between the DWO and land owners during project planning. On the other hand, permanent land acquisition is required for structures. Confirmation of land requirement and agreement with owners is a prerequisite for project implementation, and should take place well in advance of construction for the project to proceed smoothly.

7.3.2 Local Transportation

Pipeline crossings of trunk, and busy urban roads, present the greatest potential serious impact on local transportation and even regional economy. These roads are busy especially in the morning and evening, requiring careful traffic control measures to be applied. It is recommended that these measures give adequate consideration to working space for construction, and to avoid working in critical locations during peak traffic times.

7.3.3 Flora and Fauna in Mt. Kenya Area

Many types of animals are living in the forest area but the project should have minimal impact on them. Manual labour construction is considered more suitable to conserve the environment rather than using heavy equipment inside the forest. Construction methods listed below should be avoided within the forest habitat.

(1) Excessive widening or grading the existing road inside the forest for the use of heavy equipment

(2) Excessive use of heavy equipment

(3) Construction of base camp or work space inside the forest

(4) Use of blasting for construction

7.3.4 Wastewater Disposal

Wastewater disposal facilities were constructed in 1974 but no charges were raised on connected households until 1996. A sewage billing and collection system was initiated in January 1997 with the sewage charge set at 60 % of the water tariff price. However, the income from this billing and collection system is not sufficient to budget for rehabilitation and expansion of facilities. This situation could be improved, however, through comprehensive metering of water supplies and other methods of reducing the level of unaccounted water The establishment of a metering system and a leakage reduction program is therefore seen as the quickest way to support sewerage system improvement. There are no sewerage systems in the rural areas. The District Development Plan does not plan to construct any. Hence, promotion of appropriate on-site sanitation linked to hygiene education is recommended.

7.4 Conclusion

Environmental impacts and assessment of the project are summarized below.

(1) Land acquisition for permanent structures such as the treatment plant and reservoirs is necessary for project implementation. Procedures for this, together with liaison with land owners should commence well in advance of construction.

(2) Construction methods appropriate for the conservation of the natural environment in Mt. Kenya forest is given high priority. Also, natural resources should be monitored under the control of appropriate authorities.

(3) Implementation of a realizable sanitation improvement program is recommended for the town. Promoting appropriate low cost on-site sanitation systems such as VIP latrines together with a sanitary hygiene education program is recommended.