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No. 52

JAPAN INTERNATIONAL COOPERATION AGENCY
THE MINISTRY OF LAND RECLAMATION, REGIONAL AND WATER DEVELOPMENT
THE REPUBLIC OF KENYA

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

FINAL REPORT

SUMMARY REPORT

OCTOBER 1997

NIPPON KOEI CO., LTD.
NIHON SUIDO CONSULTANTS CO., LTD.

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PREFACE

In response to the request from the Government of the Republic of Kenya, the Government of Japan decided to conduct the study on the Water Supply for Seven Towns in Eastern Province in the Republic of Kenya and entrusted the study to the Japan International cooperation Agency (JICA).

JICA sent to Kenya a study team headed by Mr. Keisuke Okazaki of Nippon Koei Co., Ltd., working in association with Nihon Suido Consultants Co., Ltd. The team was dispatched three times between July 1996 and July 1997.

The team held discussions with the officials concerned of the Government of Kenya, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Kenya for their close cooperation extended to the team.

October, 1997

Kimio Fujita
President
Japan International Cooperation Agency

October, 1997

Mr. Kimio Fujita
President
Japan International Cooperation Agency (JICA)
Tokyo, Japan

Dear Sir,

Letter of Transmittal

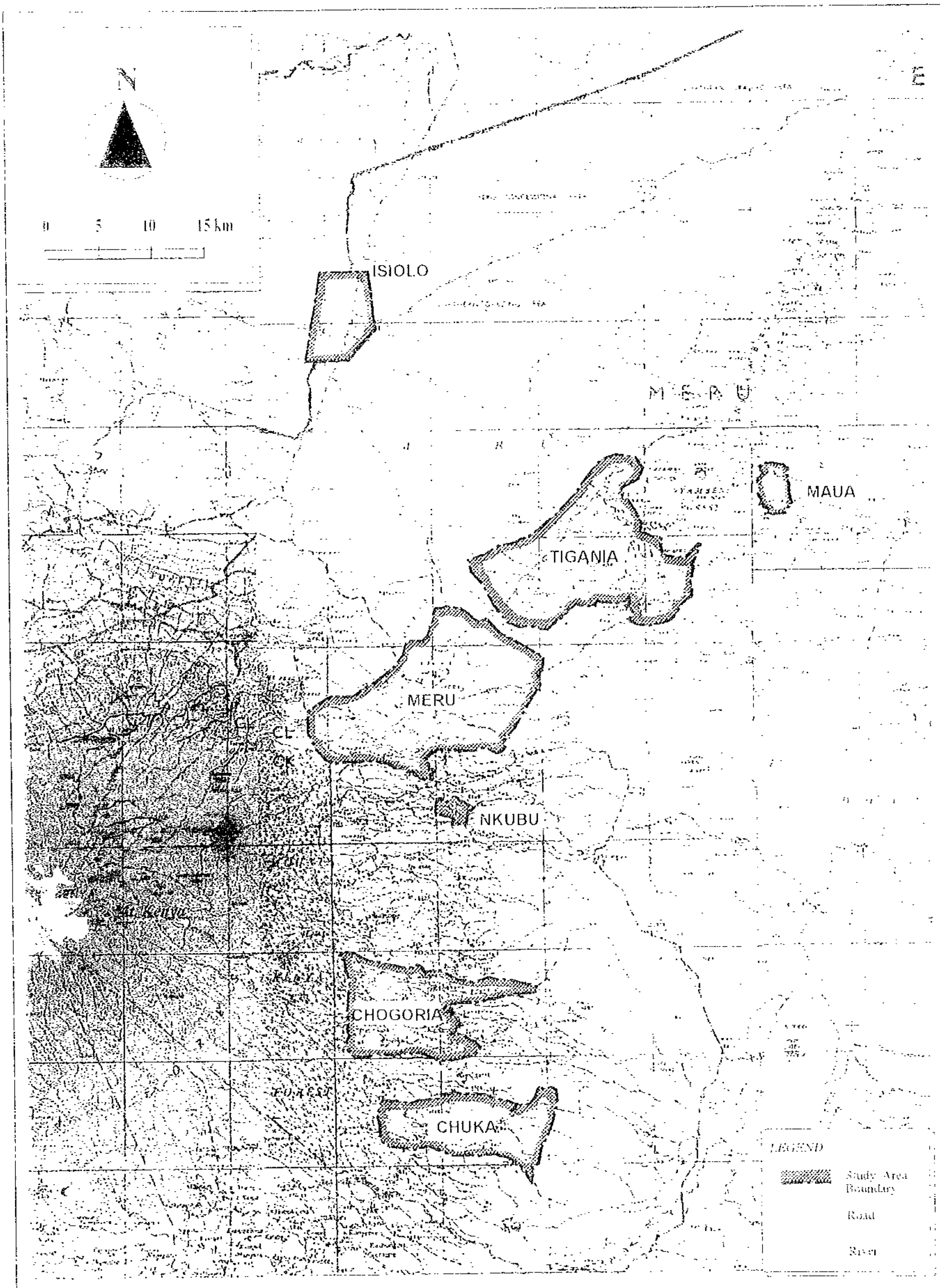
It is with great pleasure that we submit to you the Final report of "The Study on the Water Supply for Seven Towns in Eastern Province in the Republic of Kenya" completed by our Study Team with cooperative efforts of MLRRWD and other Kenyan parties concerned. The Report has been prepared for the Government of Kenya for consideration in implementing the future water supply projects in the Eastern Province.

The main outputs from the Study are broadly grouped into two components. One is the Master Plan Study for Water Supply in the Eastern Province, which shows the specific direction of future water supply projects based on National Water Master Plan. The Master Plan indicates that Meru, with the highest number of potential beneficiaries, is the most prioritized and urgent project needing implementation among the seven towns studied. The other output of the Study is the Feasibility Study for Meru Water Supply Project, which deals with the assessment of viability of the project implementation with urgency in compliance with the results of preliminary design of facilities, cost estimates and economic and financial evaluations.

All members of the Study Team would like to take this opportunity to express their heartfelt gratitude for the kind assistance and cooperation extended by personnel from JICA, Advisory Committee, Ministry of Foreign Affairs, Ministry of Welfare as well as officials from MLRRWD Counterpart Team and Steering Committee comprises of relevant government agencies, without which this study could not be completed efficiently and successfully. The Study Team hopes that the results of this Study will contribute to the future water supply projects in particular and to socioeconomic development of Kenya.

Sincerely,

Mr. Keisuke Okazaki
Study Team Leader



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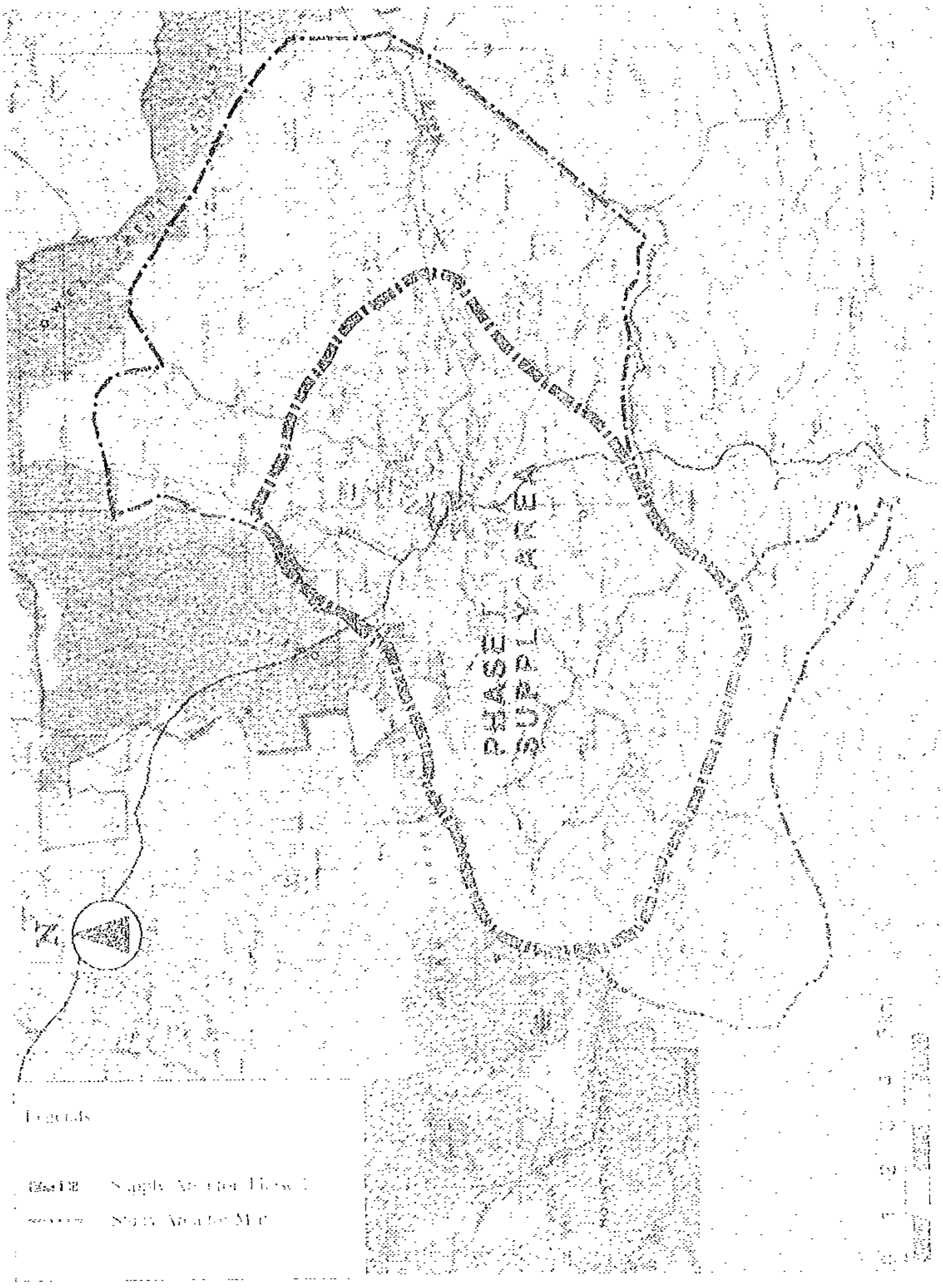
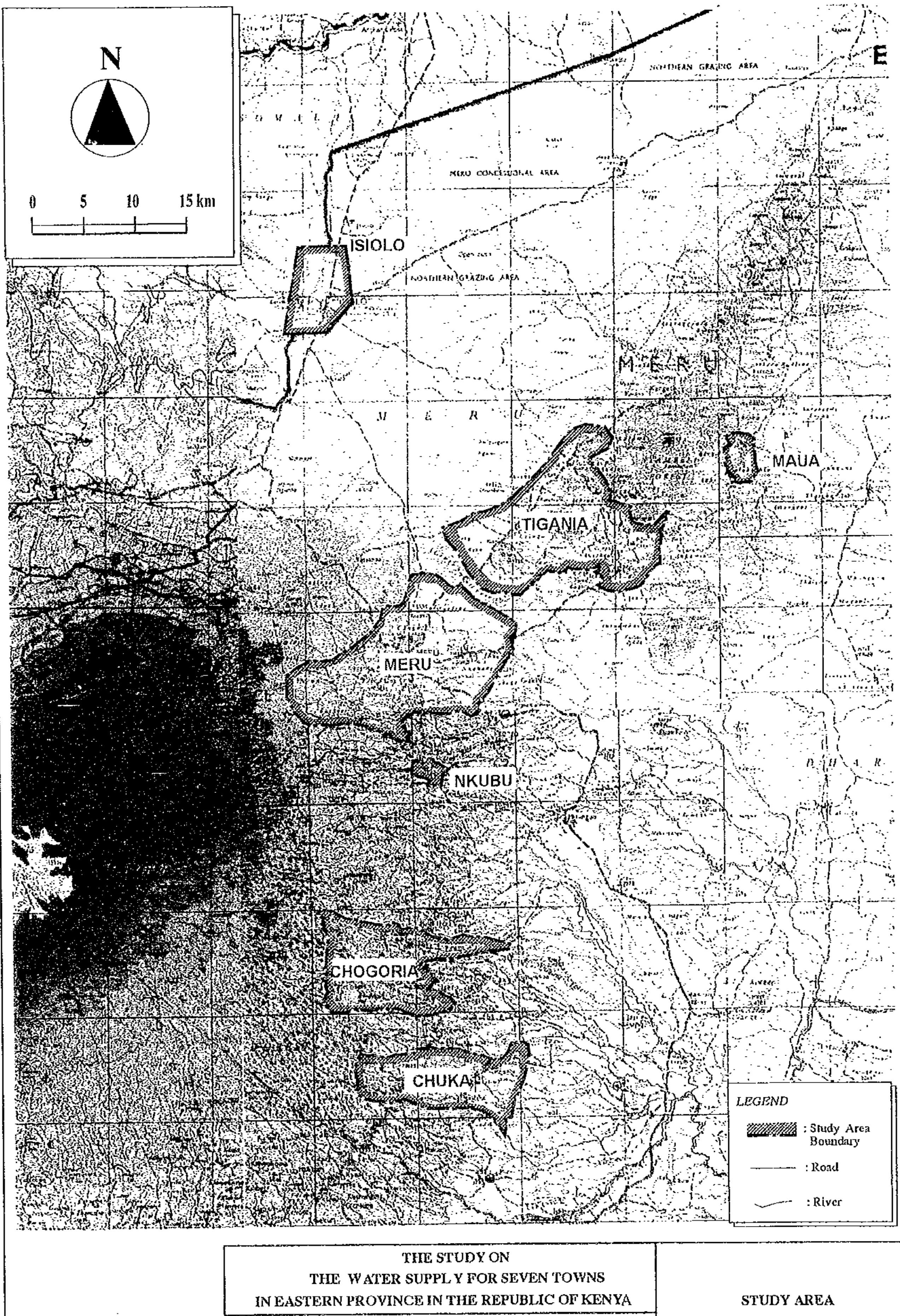


THE STUDY ON
THE WATER SUPPLY FOR SEVEN TOWNS
IN EASTERN PROVINCE IN THE REPUBLIC OF KENYA

JAPAN INTERNATIONAL COORERATION AGENCY

Meru Project Study Area



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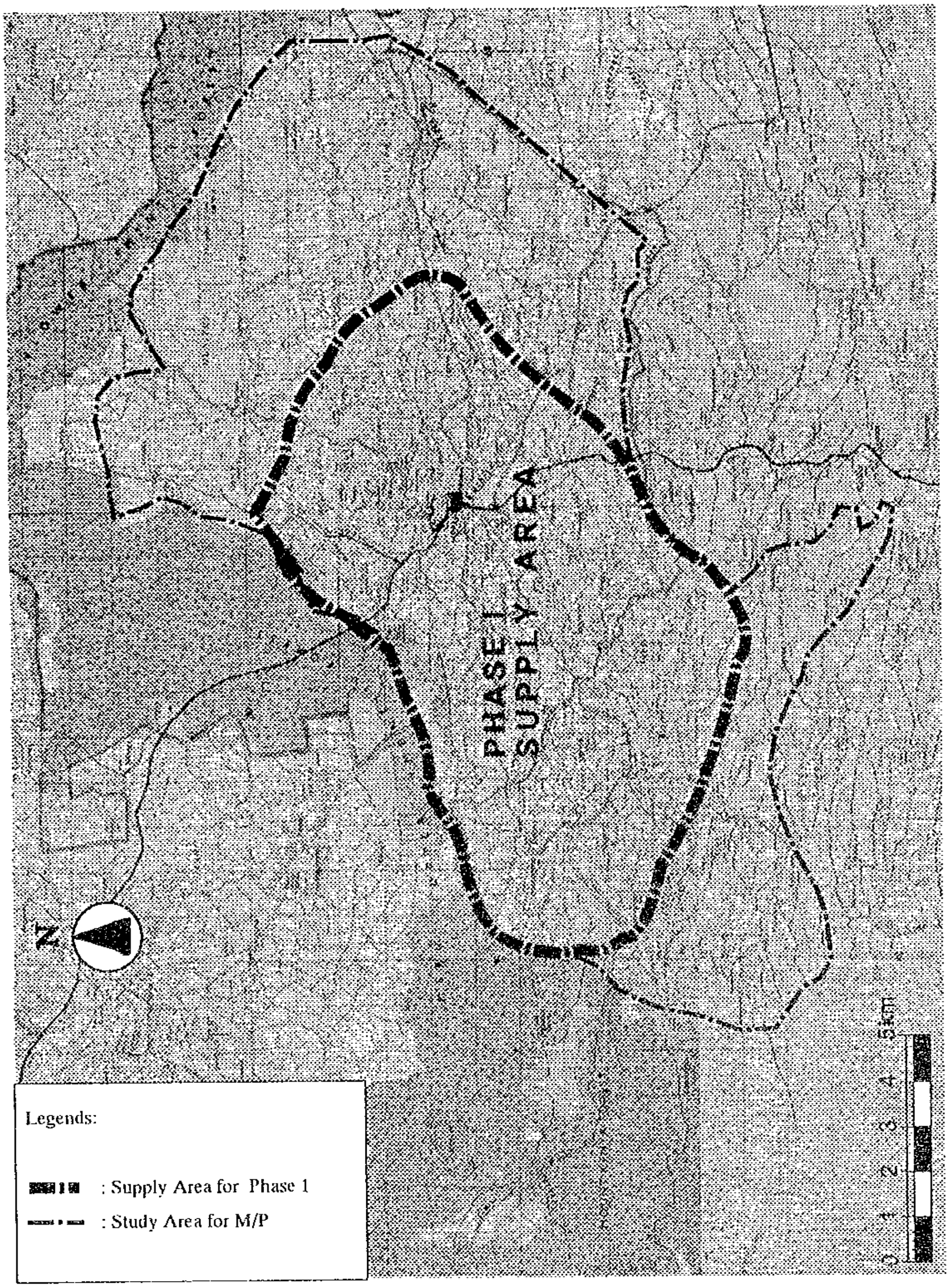

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THE STUDY ON THE WATER SUPPLY FOR SEVEN TOWNS IN EASTERN PROVINCE IN THE REPUBLIC OF KENYA

EXECUTIVE SUMMARY

Preface

Recognizing that urgently required improvements to water supplies in Eastern Province were constrained due to availability of funds, the Government of Kenya requested the Japan International Cooperation Agency (JICA) to implement a study to improve the water supplies to seven identified areas. The objectives of the Study being:

- to formulate a Master Plan for water supply in the Study Area to the year 2010
- to conduct a Feasibility Study on priority project(s) to be selected from the Master Plan, and
- to transfer technology on planning methods and skills to counterpart personnel in the course of the Study.

Consequently, a contract was signed on July 15, 1996 with the joint venture of Nippon Koei Co., Ltd. and Nihon Suido Co., Ltd. for implementation of the study.

MASTER PLAN

1. Location and Character of Study Areas

Six of the seven projects lie within the high agricultural potential zone that exists between the mountainous forested areas of Mount Kenya and Nyambeni, and the lower arid areas, where rainfall and hence agricultural potential is limited. The seventh scheme, Isiolo, lies on the edge of this rid area.

Meru and Nkubu water projects, in Meru District, and Chogoria and Chuka water projects, in Tharaka Nithi District, are all located on the lower eastern slopes of Mt. Kenya at elevations between 1,900 m and 1,300 m. In these areas surface water resources are relatively abundant and agricultural land is of high potential.

Maua and Tigania water projects in Nyambeni District are located below the Nyambeni Hills of the north east of Mount Kenya at elevations between 1,800 and 1,300 m. The more limited surface water resources originate in the forested Nyambeni Hills. Agricultural land varies from high potential in the higher areas around the hills, to low potential in the lower plains to the north and south.

Isiolo water project lies to the north of Mount Kenya at 1,100 m in a semi arid zone, where there is competition for the limited surface water resources, and where agricultural potential is generally low.

With the exception of the urban areas of Meru and Isiolo the supply areas are strongly rural in character and the economy is almost entirely dependent upon agriculture. Economic activity in the relatively small rural centers is concentrated on commercial trading, shops, bars, etc.

2. Existing Water Supply Situation

All the Study Areas have existing water supply schemes which, for various reasons, are not currently providing a satisfactory level of service due to inadequate production and distribution capacities, infrastructure that is past its service life, inadequate water reassures etc.

3. Basis of Master Plan

3.1 Study Area and Baseline Population

The supply areas given below were based on the consideration of a number of factors including; water resource potential; topography; administrative boundaries; existing infrastructure; etc. The baseline population figures were determined from a detailed analysis of the 1989 National population census, adjusted as appropriate to suit sub-location boundaries.

Table 3.1 Baseline Areas and Populations

Scheme	Meru	Nhubu	Isiolo	Chuka	Chogoria	Maua	Tigania
Gross supply area (km^2)	185	3.5	45	88	58	11	93
1989 population	125,191	6,882	18,658 *27,987(1)*	31,265	25,148	3,223	51,826

(1) Includes allowance for seasonal migration.
Source: District Water Offices & 1989 Population Census

3.2 Population and Water Demand Projections

The population and water demand projections were conducted for the whole of each Study Area. Analysis of past population census data and other studies indicated that growth rates were related to the degree of urbanization, and this relationship was included in the population projections. The per capita water demand figures and service levels recommended in the MLRRWD design Manual were found to be reasonable assuming fully metered supplies and acceptable levels of unaccounted water. The resulting projections are given below:

Table 3.2 Population and Water Demand Projections

Scheme	Meru	Nhubu	Isiolo *(1)*	Chuka *(2)*	Chogoria	Maua	Tigania *(3)*
2010 population	251,668	15,611	65,471	64,433	44,376	13,344	83,121
2010 Water demand (m^3/day)	22,725	1,915	10,671	4,403	2,886	1,493	3,778

Notes: *(1) Includes allowance for seasonal migration*
(2) Figures are given for the Chuka Municipal supply area only
(3) Figures are given for the New Phase of Tigania Water supply only

3.3 Water Resources

- **Meru** An intake on the Kathita River was located some 8 km inside Mt. Kenya forest with good quality water close to an exiting intake where water can be supplied by gravity to the treatment plant site. The estimated daily low flow of 49,700 m^3/day is adequate to meet the ultimate needs of 22,000 m^3/day for this scheme and all other exiting projects.
- **Nkubu** An intake on the Kiguandequa River can provide adequate flows by gravity but, due to its location within farmed areas it will require full treatment.
- **Isiolo** Further abstraction from the Isiolo River is not possible, and alliterative surface water sources investigated did not have sufficient potential. Extending the investigations to a regional study is recommended. There is potential for further groundwater development, but again, a regional water balance study is required to determine long term potential.
- **Chuka** An intake on the Ruguti River deep in the forest will provide adequate flows by gravity. The only problem being access.
- **Chogoria** An intake on the Mara Manyi stream is very similar to the Ruguti intake for Chuka.
- **Maua** With alternative springs being already utilized by community projects, the Mboone Wtream is the only source that con supply water by gravity. The supply area is therefore constrained by the low flows of this stream.
- **Tigania** The Thangatha Stream has adequate flows, the final intake location needs to be optimized in the final design.

3.4 Water Quality and Treatment Requirements

Based on a water-sampling program covering both wet and dry seasons the following levels of treatment are indicated to provide water quality required by the MLRRWD.

Table 3.3 Water Treatment Requirements

Scheme	Meru	Nhubu	Isiolo	Chuka	Chogoria	Maua	Tigania
Plan sedimentation	Yes			Yes	Yes		Yes
Rough filtration						Yes	
Rapid sand filters (1)		Yes					
Chlorination	Yes	Yes	Yes (2)	Yes	Yes	Yes	Yes

Notes: *(1) Includes chemical coagulation, sedimentation and rapid sand filters*
(2) Assumes groundwater service

4. Establishment of Master Plan

4.1 Strategy and Phasing

The objective of the project is to assist with the provision of an adequate reliable and sustainable potable water supply to the identified areas. To achieve sustainability higher levels of cost recovery is required, for which universal metering is essential.

To assist operation and maintenance, the maximum use of gravity supplies has been made and, good quality sources, requiring low levels of treatment, preferred.

Phasing has been recommended in each scheme to provide water to the areas suffering from the most acute water shortages.

4.2 Proposed Facilities

- **Intakes and raw water pipelines** have been designed to avoid ingress of floating and submerged material, and to ensure adequate self cleansing velocities and cleaning arrangements.
- **Treatment** proposals are based on the lowest technology level required to suit the raw water quality, as discussed in Section 3 above.
- **Storage requirements** for rural areas have been based on 12 hours average demand in order to balance peak daily flows. For urban areas additional 12 hours storage has been included to allow for closures for maintenance and emergency storage.
- **Trunk mains** have therefore been sized to the average daily demand for downstream supply zones, plus the peak daily flow for the zone through which it is passing.

5. Cost Estimates

Cost estimates have been based on unit rates applicable in October 1996, using an exchange rate of 1US$ = 56 Kshs. The average incremental costs (AIC) given below include the full financial cost discounted at 9 % per annum and the annual recurrent operation and maintenance, power, chemicals, staffing and transport costs.

Table 5.1 Investment Costs US$ x 1,000

Scheme	Meru	Nhubu	Isiolo	Chuka	Chogoria	Maua	Tigania
Total – Phase 1	7,930	1,343	5,289	3,010	2,445	1,172	2,993
Total - Phase 2	5,775	486	*4,772*	822	615	180	770
Total	13,705	1,829	*10,061*	3,832	3,060	1,352	3,763
Cost/capita US$/cap	54	117	154	59	69	101	45
AIC @ 9% US$/$m^3$	0.58	0.66	0.96	0.58	0.71	0.61	0.65

6. Selection of Schemes for Feasibility Study

Prioritization between the schemes was based on consideration of the relative financial, economic and social benefits as indicated below:

Table 6.1 Overall Project Evaluation

Scheme	Meru	Nhubu	Isiolo	Chuka	Chogoria	Maua	Tigania
A. Financial and Economic Evaluation							
FIRR	-	-	-	-	-	-	-
EIRR	●	-	-	●	-	-	○
B. Cost performance							
Cost per capita	●	○	-	●	●	○	●
O&M cost recovery	●	○	●	●	○	○	○
C. Socio Economic Considerations							
Public health	●	○	●	●	●	○	●
Burden of collection	●	○	●	●	●	●	●
D. Water Supply Services							
Coverage	●	○	○	○	●	○	●
Reliability	●	○	●	○	●	●	●
Overall evaluation	■	□	□	■	■	□	■

Key:
- ● = Viable, good performance or, urgently required
- ○ = Justified, relatively low performance but, highly recommended
- \- = Not viable, low performance or, improvement not urgently required
- ■ = Prioritized projects with urgent needs
- □ = Recommended for less urgent implementation

All schemes can be seen to have a high priority for implementation especially Meru, Chuka, Chogoria and Tigania and it is difficult to select one scheme instead of another. Nevertheless it can be seen that on almost every aspect, Meru has the highest priority of all schemes. The long established local government infrastructure in Meru is also seen as an advantage for ensuring sustainability of the project. The Meru Water Supply Project therefore, having both the greatest need and highest potential for sustainability was assessed as having the highest priority for implementation of all the projects.

FEASIBILITY STUDY

1. Study Area

Out of the total study area of 185 km^2, the Master Plan identified 85 km2 including Meru's urban, peri-urban and surrounding rural areas, as in greatest need for improved water supplies. This area was therefore adopted as the prioritized area for implementation in Phase 1 of this project with the target horizon of 2005.

2. Basic Development Policy and Strategy

The design capacity of pipelines have assumed the Master Plan horizon of 2010, whereas for treatment plant and reservoirs, which are more cost effective to duplicate, have been designed at 50 % of the 2010 demand, which is sufficient to meet the 2005 requirements. Although there are many small community water supply schemes supplying untreated water in the area, the capacity of the designed facilities have assumed that the whole area will ultimately receive potable water form the scheme.

3. Population and Water Demand

The population of the prioritized area including, Ntakira, Lower Igoki, Mpuri, Nthimbiri, Katheri and most of Upper Igoki and Mulanthankare sub-locations, by the year 2005 is estimated as 129,191, with a water demand of 10,482 m^3/d.. This assumes that by 2005, a proportion of the population will still obtain water from other sources such as community water supplies.

The water demand calculations make two important assumptions; Firstly that full metering will be implemented and, secondly that a program for reducing the current levels of unaccounted water will be introduced. Without these measures the system will be inadequate to meet the resulting high level of water requirements.

4. Preliminary Design

4.1 Design Framework

The preliminary design has aimed at proving a simple, robust system that will be easy to operate and maintain. It is based on an intake deep in the Mount Kenya Forest with good raw water quality that will require minimum treatment. The whole scheme is based on gravity supply so that no pumping is required. The treatment proposed is also simple to operate and maintain and requires no chemicals or power, except for lighting.

To safeguard the water source, its catchment area needs to be conserved. This should not be a problem since it lies within the Mount Kenya Forest reserve. However some adjacent catchments are being deforested, and the treatment plan layout has therefore been designed so that full treatment can be included if this proves to be necessary in the future due to deterioration of raw water quality.

4.2 Intake and Raw Water Pipeline

The intake will comprise a Crump weir designed to reduce intake of sediment and floating material and thereby to reduce maintenance requirements. The intake and first part of the raw water main will be constructed inside a deep ravine, with difficult access and working conditions. The raw water pipeline will be of steel of 500 mm dia designed to maintain self cleansing velocities.

4.3 Treatment Works

The treatment plant will be sized with a capacity of 10,000 m^3/d and will comprise, inlet chamber, plan sedimentation, chlorination, clear water tank, and office and store.

The inlet chamber will provide flow control, flow measurement and fine screening.

The sedimentation tank will be a horizontal flow tank with a loading rate of 0.75 m/hr, sufficient to settle suspended solids due to erosion without chemicals. A simple hydrostatic sludge removal system will be provided. Sludge volumes are not expected to be sufficient to require more sophisticated methods.

Chlorination will be by drip feeders requiring no moving parts. Two mixing tanks will be provided each with a capacity for 12 hours operation at design demand assuming a dosage rate of 2 mg/l and a 2 % solution.

Clear water storage of 200 m^3 is provided to balance peak flows of the supply area immediately downstream of the works. With the location of the plant inside the forest reserve, there are no immediate downstream consumers, and full chlorine contact time is available within the trunk main. Nevertheless a 10 minute minimum retention is provided in the clear water tank by the addition of a weir.

An administration building has also been included with office, store, workshop and laboratory.

Four staff housing units will be constructed adjacent to the treatment plant.

4.4 Transmission and Distribution Facilities

The design of pipelines has been based on the projected 2010 demands with maximum and minimum pressures of 60 m and 10 m respectively. Steel pipes have been adopted for pipelines of 350 mm and above, and at river and road crossings. UPVC pipes will be used elsewhere. A total length of 61,200 m of transmission and distribution pipelines ranging from 90 to 400 mm dia will provide a pipe network which will bring water to within easy reach of all consumers in the Phase 1 area. This does not include the smaller service mains, estimated at about 46 km which will need to be constructed by the MLRRWD to make individual household connections.

Storage based on 12 hrs of average demand, plus for urban areas, an additional 12 hrs emergency storage has been included, totaling 7,040 m^3.

4.5 Rehabilitation and Provision of Leak Detection Equipment

Improved performance of the system is even more important that the provision of new works, and the costs of the following have been included in the project:

- The replacement of many valves and all the bulk water meters.
- The costs of repair and replacement of existing household meters has also been included in the costs of the project.
- In addition two full sets of leak control equipment have been included, plus transport.

5. Cost Estimate

A review of construction prices and exchange rates indicated that they had remained stable since the Master Plan. The same unit rates were therefore applied, using an exchange rate of US$ = 56 Shs.

The total construction cost was estimated to be US$ 9,761,000. The cost of leak control and repair equipment and transport came to US$ 338,000. The cost of service mains to be constructed by the MLRRWD was estimated at US$ 580,000, which would be funded from project revenue.

Annual recurrent costs were estimated a US$ 250,000, rising to US$ 335,000 by 2005.

The average incremental cost of water over 20 years was estimated at US$ 0.75/m^3, discounted at 9 %.

6. Organization and Management

The organization and management of the project needs to be strengthened to improve performance on reduction of unaccounted water, reporting, accounting procedures and training. The provision of new bulk and household meters and the leak detection exercises will improve the performance but additional assistance will be required. The Kenya Water Institute, based in Nairobi could play a more important and significant role in this respect.

7. Environmental Impact Assessment

Mitigation measures to avoid negative environmental impacts include:

- traffic control during construction of pipelines especially in urban areas
- careful attention to methods of work within Mount Kenya Forest
- the provision of appropriate sanitation facilities for the disposal of the additional wastewater that will be generated by the scheme. In urban areas, the Municipality should give consideration to provisions for enforcing such requirement and for improving existing sewage disposal facilities.

8. Financial and Economic Evaluation

8.1 Financial Evaluation

An analysis of the income profile for Meru, taken from the household survey suggests that there is a reasonably high ability to pay for water at the current water tariff rates. Data obtained from the DWO on consumption rates for the different categories of consumers suggest that Low income households spend, on average, 4.7 % of their income on water, and middle and high income households 2.2 % and 1.4 % respectively.

The financial evaluation showed that although the scheme could easily cover operational costs the revenue, using current tariff rates, was not sufficient to recover all investment costs.

8.2 Economic Evaluation

The economic evaluation applied appropriate conversion factors and added the economic benefits of the time saved in collection of water as a result of the project. The resultant internal rate of return came to 6.3 % suggesting that the scheme becomes viable by including the economic benefits in the analysis.

8.3 Social Concerns

The provision of an adequate water supply is considered to be one of the most important basic human needs. Shortages of water or, poor water quality have direct influence on public health and on the quality of daily life.

The severity of water shortages and water quality were therefore key factors used in the household survey in prioritizing areas for new supplies, which concluded that the Phase 1 area was in acute need of improved water supplies.

8.4 Overall Evaluation

The project is socially and economically viable, but can not recover the full financial costs of implementation. There would therefore appear to be some justification in considering a grant to cover a proportion of the implementation costs to ensure that it will also be financially viable.

Financial management of the project needs strengthening.

A framework needs to be established for reviewing the water tariff annually, in line with inflation.

9. Conclusions and Recommendations

9.1 Conclusions

Approximately 129,000 people will be provided with access to potable water by the year 2005 in a supply area of 85 km^2.

The proposed project provides an easily maintainable gravity supply to the whole area using good quality raw water needing only minimum treatment.

The total cost of constructing Phase 1 including the costs of leak control equipment comes to US$ 10,100,00.

The resulting cost per capita of US$ 81 is high due to the rural nature of much of the supply area and difficult terrain. However, part of the investment is to feed the larger Master Plan area of 185 km^2. If the Phase 2 costs and beneficiaries are included, the cost per capita reduces to US$ 60.

The success of the project is highly dependent upon the universal installation of consumer meters and on the reduction of unaccounted water levels.

Other aspects that require improving include financial and technical accounting and reporting and an annual review of the tariff structure.

The project was found to be socially and economically viable. However, although the operation and maintenance cost could be easily covered, it was found not to be possible to recover the full costs, including investment costs, using the current tariff.

9.2 Recommendations

It is recommended that the project be considered for grant aid on the following understanding;

- Full metering will be implemented.
- A loss reduction program will be initiated.
- Assistance is provided in the fields of water loss reduction, institutional improvement and construction management.

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Master Plan

Feasibility Study

ABBREVIATIONS

AC	Asbestos Cement (Pipe)
AFW	Accounted For Water
AIDS	Acquired Immune Deficiency Syndrome
ASK	Agricultural Society of Kenya
CH1	Survey Points in Chogoria
CK2	Survey Points in Chuka
dia	diameters
DWE	District Water Engineer
DWO	District Water Office
EIA	Environmental Impact Assessment
GI	Galvanized Iron
GOK	Government of Kenya
GPS	Global Positioning System
Ha	Hectares
IEE	Initial Environmental Examination
IS	Survey Points in Isiolo
ITCZ	Intertropical Convergence Zone
JICA	Japan International Cooperation Agency
KEWI	Kenya Water Institute
KM	Kilometer
KNUT	Kenya National Union of Teachers
Kshs	Kenya Shillings
lcd	Litres per Capita per Day
L/sec	Litres per second
M3/day	Cubic Meters per Day
M6	Survey Points in Meru
MLRRWD	Ministry of Land Reclamation, Regional and Water Development
N1	Survey Points in Nkubu
NWCPC	National Water Conservation and Pipeline Corporation
NWMP	National Water Master Plan

ODA	Overseas Development Assistance
PE	Polyethylene Pipe
PH	Plan and Height Point
PIO	Project Implementation Office
PVC	Polyvinyl Chloride
RDF	Rural Development Fund
RGS	River Gauging Station
S, T, ST, TT	Trigonometric Station Points
SIDA	Swedish International Development Agency
SOI	School of Infantry
SOK	Survey of Kenya
Sq. KM	Square Kilometers
TW	Tigania Water Points
UFW	Un-accounted For Water
UNICEF	United Nations Children's Fund
US$	United States Dollar
USAID	United States Agency for International Development
UTM	Universal Transverse Mercator
WAB	Water Apportionment Board
WC	Water Closet
WID	Women In Development
WQPCL	Water Quality and Pollution Control Laboratory
WRAP	Water Resources Assessment Project
WTP	Water Treatment Plant
WDD	Water Development Department

MASTER PLAN - SUMMARY

CHAPTER I INTRODUCTION

1.1 Authorization

Based on the Scope of Work agreed upon between the Ministry of Land Reclamation, Regional and Water Development (hereinafter referred to as "MLRRWD") of Kenya and the Japan International Cooperation Agency (hereinafter referred to as "JICA") on March 6, 1996 in Nairobi, JICA made a contract with the joint venture of Nippon Koei Co., Ltd. and Nihon Suido Consultants Co., Ltd. on July 15, 1996 to conduct the Study on the Water Supply for Seven Towns in Eastern Province in the Republic of Kenya (hereinafter referred to as the "Study").

JICA, the official agency of the Government of Japan responsible for implementation of technical cooperation programs undertook the Study in accordance with the relevant laws and regulations in force in Japan and in close cooperation with the authorities of the Government of the Republic of Kenya. The MLRRWD acted as a counterpart agency to the Japanese Study Team and as a coordinating body in relation to other relevant organizations for smooth implementation of the Study.

1.2 Background of the Study

In the Republic of Kenya, water scarcity is a serious problem in many regional and rural areas. The Government of Kenya is committed to improve water supplies, however, financial constraints have meant their objectives have not been fully achieved.

The water supply system in Meru Municipality utilizes surface water originating from the foot of the Mt. Kenya. However, water supply coverage in the Municipality is only about 20%. There is a need for expansion and improvement of the water supply facilities due to development and subsequent increase of population in the urban area and deterioration of existing water supply facilities and equipment. Whereas, Isiolo Municipality, which is located in a semi-arid region suffers from shortages due to water source constraints of the Isiolo river, during dry periods.

The National Water Master Plan implemented by JICA in 1992 proposed an index for domestic and industrial water supply schemes including provision of safe water supply to the whole population in the country by the year 2010. The detailed water supply development plan includes "provision of safe and stable water supply in urban areas with more than 5,000 population and whole rural areas in the country by the year 2000, and provision of wastewater disposal facilities in both areas by the year 2010."

In the light of the need for water and Governmental policy, improvement of water supplies in the eastern region of Kenya is urgently required to meet the existing demand. Current development of water supply facilities in the region is far behind the national target. Infrastructure facilities for water supply is a prerequisite factor for people's life and economic development in small to medium towns.

In parallel with the possible increase of water supply facilities in the future, improvement of wastewater disposal facilities in the region is also required to prevent or mitigate water generated pollution and to conserve the habitat from unsanitary and hygienic problems.

Taking the above circumstance into consideration, the Government of the Republic of Kenya requested the Government of Japan to conduct the Study on the Water Supply for Seven Towns in Eastern Province in the Republic of Kenya.

1.3 Objective of the Study

The objective of the Study is to formulate a Master Plan for the target year of 2010 regarding water supply systems for the areas comprising six towns and one region in the eastern province of Kenya, to conduct a Feasibility Study for the selected projects in the Master Plan, and to transfer technology to Kenyan counterparts in the course of the Study.

1.4 Study Area

The study includes seven separate schemes which are located in Eastern Province of Kenya, as shown on the location plan, covering the following areas:

Table 1.4-1 Study Areas

Study Area	Land Area (km2)	Population (1989)
Meru	185	125,000
Nkubu	3.5	7,000
Isiolo	45	19,000
Chuka	88	31,000
Chogoria	58	25,000
Maua	11	3,200
Tigania	93	52,000

Source: National Census, 1989

1.5 Organization of the Study

1.5.1 Japanese Organization

The Japanese organization consists of the Study Team under JICA headquarters and the Advisory Committee set up at the JICA headquarters.

The members of the Study Team were as follows:

Mr. Keisuke Okazaki	Team Leader
Mr. Hiroyasu Yoda	Water Supply Planner
Mr. Masayuki Ogino	Water Resources Planner
Mr. Michael Douglas Allport	Design Engineer, Cost Estimator
Mr. Takehiko Oga	Organization, Institution Expert
Mr. Kenichi Ishii	Environment, Wastewater Expert
Ms. Julia Akello Kunguru	Social, Hygiene Education Expert
Mr. Kazuhiko Dobeta	Project Economist
Mr. Kiyofumi Tamari	Topographic Survey Engineer
Mr. Seikou Uchisawa	Hydrogeologist
Mr. Tadashi Hatakeyama	Geophysics Expert
Mr. Jun Wada	Assistant

The members of Advisory Committee are as follows:

Mrs. Keiko Yamamoto	Chairman of Advisory Committee
Mr. Kenji Nakanosono	Member of Advisory Committee

1.5.2 Kenyan Organization

The Kenyan organization consisted of the MLRRWD Counterpart Team and Steering Committee composed of the representatives of the organizations concerned with the Study in coordination with the MLRRWD.

The principal members of the MLRRWD Counterpart Team and Steering Committee were as follows.

MLRRWD:

Mr. E. K. Mwongera	Permanent Secretary, MLRRWD
Mr. P.N. Machiri	Director of Water Development
Mr. D.N. Stower	Senior Deputy Director, Water Resources Development
Mr. T.W. Kibaki	Deputy Director, Planning and Design
Mr. D.K. Barasa	Deputy Director, Operation and Maintenance
Mr. F.K. Mwango	Deputy Director, Groundwater
Mr. P.L. Ombogo	Deputy Director, Construction
Mr. J.R. Nyaoro	Register, Water Rights
Mr. K. Kung'u	Assistant Director, Project Planning
Mr. D.N. Nyaga	Provincial Water Engineer, North Eastern (Previously the District Water Engineer, Tharaka Nithi)
Mr. F.K. Kyengo	District Water Engineer, Isiolo
Mr. R.M. Gakubia	District Water Engineer, Meru
Mr. D.N.S. Nderi	District Water Engineer, Nyambene
Mr. R. Gathigo	Water Development, Planning Section
Mr. E. M. Chege	Superintendent Hydrologist, MLRRWD
Mr. B.I. Kasavuli	Design Engineer, Design Section
Mr. J.M. Omwenga	Assistant Director, Water Quality Surveillance
Mr. K. Kitagawa	JICA Coordinator, MLRRWD
Mr. V.Y. Jani	Assistant Director, Research Technology
Mr. O. Mbaya	Economist, Economic Planning Division
Mr. F.M. Muiruri	Assistant Director, Groundwater Supervision
Mr. C.N. Irungu	Assistant Director, Groundwater Conservasion
Mr. W. Wakaranja	Assistant Director, Groundwater Engineering Geology

Steering Committee:

Mr. J.M. Mwangi	Ministry of Local Government
Mr. J.K. Kanithi	Treasury, Ministry of Finance
Mr. W.N.K. Murage	Ministry of Lands and Settlement
Mr. N. Arap Chumo	Ministry of Environment and Natural Resources
Mr. N.N. Waweru	Ministry of Health

1.6 Report Organization

This report forms part of the Final Report for the Study and is divided into two main sections: Master Plan and Feasibility Study. The Final Report comprises:

(1) Summary Report
(2) Main Report
(3) Supporting Reports
(4) Drawings

CHAPTER II GENERAL CONDITIONS OF THE STUDY AREA

2.1 Natural Conditions

2.1.1 Topography

The locations of the study areas are indicated on the location plan. The character of the areas is strongly influenced by their position in relation to Mount Kenya, the major feature in the region, and their altitude.

Meru, Nkubu, Chuka and Chogoria are all located on the eastern slopes of Mount Kenya at elevations between 1,600 and 1,400 m. Surface water resources are relatively abundant in these areas, with numerous rivers flowing eastwards through deep valleys fed from the high rainfall over Mount Kenya Forest.

Maua and Tigania lie to the east and south respectively of the Nyambene Hills to the east of Mount Kenya. Water resources, although reasonable locally in the Nyambene Hills are generally more constrained with very few perennial streams.

Isiolo lies to the north of Mount Kenya at an elevation of 1,100 m on a volcanic, semi arid plain, which slopes gently towards the Ewaso Ngiro River in the north.

2.1.2 Meteorology

Due to the influence of the Intertropical Convergence Zone (ITCZ) rainfall occurs in two seasons; from March to May, and from October to December. The average annual rainfall is strongly influenced by location and altitude. Meru at an altitude of 1,600 m has an annual rainfall of 1,300 mm, whereas Isiolo at an elevation of 1,100 m has an annual rainfall of 600 mm.

2.1.3 Geology

The underlying Precambrian Basement System is covered by volcanic rocks and soils originating from the major eruption centres of Mt. Kenya and the Nyambene Hills with associated parasitic ash cones.

Precambrian Basement rock composed of gneisses, schists and quartzites outcrop locally east of Maua, in Tharaka Nithi District to the south, and on the isolated outcrops on hilltops west of Isiolo.

The Mount Kenya Series of volcanic rocks were formed by eruptions in the Miocene to the middle Pliocene. The rocks comprise phonolite, kenyte lavas, tuffs and agglomerates. Rocks outcropping on the eastern slopes and in the low-lying volcanic plains are mainly composed of basalt. The rocks in the mountainous areas include phonolite and tephrite.

2.2 Water Resources

2.2.1 Surface Water Resources

The slopes of Mount Kenya and the Nyambene Hills provide the major source for both surface water and groundwater. The eastern slopes of Mount Kenya are abundant with rivers and streams. There are however only a few perennial streams flowing from the Nyambene Hills, and the situation is even more critical at Isiolo, where the main source, the Isiolo River, becomes seasonal immediately downstream of the existing water supply intake.

A network of river gauging stations provides historical data for the area. This data has previously been assessed by a number of projects, including the 1992 National Water Master Plan (NWMP) and the 1991 Water Resources Assessment and Planning Project (WRAP).

The estimated low flows for the catchment areas were calculated by correlating each catchment area with the characteristics of the closest or most representative gauging station. Smaller stream and spring catchments are more difficult to correlate due to the small size of catchment area. Flow measurements were therefore taken during the dry season of 1996 to calibrate the correlation.

Locations for intake sites for each project were selected together with MLRRWD staff, the basic characteristics of which are given below:

Table 2.2-1 Low Flow Estimates for Intake Locations

Scheme	River	Raw water requirements m3/d	Estimated 95% daily low flow m3/d	Minimum measured low flow m3/d	Safe yield adopted m3/d
Meru	Kathita	22,000	49,000	78,200	35,300
Nkubu	Kiguandequa	2,200	21,900	18,600	14,100
Isiolo	Isiolo	8,800	2,000		2,000
Chuka	Rugati	4,400	25,800		12,800
Chogoria	Mara Manyi	3,300		13,200	13,200
Maua	Mboone	1,650		1,900	1,900
Tigania	Thangatha	4,400		4,500	4,500

The identified sources would therefore appear to be adequate for Meru, Nkubu, Chuka and Chogoria.

Alternative spring sources for Maua were found to be used by community water supply schemes, and to avoid pumping from the Ura River in the south, it was considered advisable to reduce the overall supply area to the area that could be served by gravity from the Mboone. This reduces the supply area to the area immediately around Maua Town itself.

The surface water resources in Isiolo were found to be particularly scarce. Sites in the immediate vicinity for impounding dams were found to have insufficient capacity and alternative spring sources were found to be already heavily utilised by local farms and communities primarily for irrigation. It was therefore necessary to undertake a groundwater investigation in the area.

2.2.2 Groundwater Resources

(1) Hydrogeology

The forested areas of Mount Kenya and the Nyambene Hills, with high levels of rainfall are considered to be a major groundwater recharging zone for the area. Rainfall infiltrates into the ground in this zone and outcrops at the base of the mountains as springs.

Groundwater potential in the basement system is limited due to the impervious nature of the rocks, and potential in the volcanic plains is limited due to low rainfall and high levels of dissolved solids.

Groundwater potential and yields from boreholes in the region are generally low. Although sufficient for small community projects, the potential for groundwater development for large water supply schemes is limited.

(2) Groundwater Investigations at Isiolo

Due to the poor surface water resources at Isiolo, a groundwater investigation of the area was conducted to assess the potential for groundwater development. A review was made of a large number of borehole records from the area, and of the WRAP report. This review indicated reasonable potential for groundwater development, but that groundwater quality, especially in the vicinity of Isiolo and northwards had high levels of total dissolved solids.

A reconnaissance electrical resistivity survey was undertaken, targeting the area to the south of Isiolo towards Mount Kenya. The results of this survey confirmed the potential for groundwater development and identified sites for exploratory boreholes.

Three exploratory boreholes were subsequently drilled all of which were found, by Kenyan norms, to have high yields. A conservative safe yield of about 15 m3/hr per borehole was adopted.

After completion of test pumping Borehole TW2, it became artesian with flows estimated at 18 m3/hr being discharged from the well head.

The results of the groundwater investigations suggest that there is good potential for further development. Two subjects however require additional investigation before further development is initiated; A water balance study of the groundwater basin based on rainfall, surface water runoff, evaporation and recharge to the groundwater; Further sampling for water quality analysis after long term pumping from the acquifer.

2.3 Socio-economic Conditions

2.3.1 Administration

All the supply areas are 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 and Nkubu are located in Meru District with the District Headquarters in Meru. Isiolo is the District Headquarters for Isiolo District, Chuka and Chogoria lie in Tharaka Nithi District, with the newly formed headquarters located at Chuka and, Maua and Tigania are located in Nyambene District, with the District Headquarters located just north of Maua.

2.3.2 Population

Baseline population levels and current growth rates were obtained from an analysis of past population census results, as indicated below.

Table 2.3-1 1989 Scheme Populations, and 1969-1989 Inter-census Growth Rates for Identified Supply Areas.

Project	Kenya	Eastern Province	Meru	Nkubu	Isiolo	Chuka (1)	Chogoria	Maua (2)	Tigania
1989 population	21,443,636	3,768,677	125,191	6,881	18,658	62,784	25,148	3,223	51,826
1969-1989 annual growth rate	3.4%	3.65%	3.6%	3.5%	4.2%	2.7%	3.4%	3.4%	2.4%
1997 population	28,000,000	5,020,000	165,980	9,471	25,679	81,034	32,134	5,537	63,891

Notes (1) *Chuka population includes for additional area outside supply area, for which water will be delivered from the proposed treatment plant.*

(2) *Maua supply area is limited to the urban areas within Amwathi sub-lcation. A higher growth rate than that for the full sub-location has therefore been applied.*

(3) *The Tigania area does not include the area covered by the existing scheme.*

2.3.3 Land Use and Economic Activities

The supply areas lie within the agriculturally high potential zone that exists between the mountainous forested areas of Mount Kenya and Nyambene, and the lower arid areas, where rainfall, and hence agricultural potential is limited. With the exception of Meru and Isiolo towns and some urban centres, the region is rural in character, and the economy is highly dependent on agriculture.

Land use potential increases with elevation, and high income generating crops, such as tea and coffee are grown in the higher areas, whereas livestock and subsistence cropping become more predominant at lower elevations, as at Isiolo.

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.

2.3.4 Existing Infrastructure

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. However all other roads are unsurfaced, and access to remoter parts of the supply areas during rainy periods is problematical.

Electricity and telephone coverage extends to all large towns and most rural centres, however the main consumers are commercial, institutional and industrial. Only about 5% of domestic households have connections.

Sewer reticulation systems exist only in Meru and Isiolo Townships where they serve 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.

CHAPTER III EXISTING WATER SUPPLIES

3.1 Overview

Ministry water supply schemes generally adopt simple conventional treatment and chlorination providing water through individual connections or Water Kiosks. Charges are made either as a flat rate or, increasingly, metered to increase the level of cost recovery. However, expansion of the existing systems to serve more of the rapidly growing population has been seriously constrained by lack of funding.

The expansions of Government water supplies to meet growing demands have been constrained mainly due to limited financial resources. In an attempt to satisfy the growing water demand a number of communities and self-help water supply schemes have been implemented in the rural areas, often assisted by external organizations such as NGOs. They tend to be small systems supplying untreated water by gravity. Apart from initial contributions from the beneficiaries, there are normally no charges raised on water consumption in this type of system.

3.2 Ministry Schemes

Basic data for the Ministry Water Supply Schemes for the seven projects was obtained from data provided by the various District Water Offices, and also from the MLRRWD's Monthly Operation, Maintenance and Financial Monitoring Report (1994-1996). There are many inconsistencies contained within this data, and the conclusions drawn must therefore be treated with caution.

Most of the schemes are considered unsatisfactory for one reason or another. All of them have insufficient capacity to meet the demand of their supply areas.

Isiolo, Maua and Tigania suffer due to the inadequate capacity of the existing water resources.

The capacity of the treatment plants at Meru, Nkubu, Chogoria, Isiolo, and Maua are insufficient to meet the demand, and those at Nkubu and Maua have passed their serviceable life.

The distribution systems are all inadequate and need strengthening, particularly Chogoria and Chuka.

It is interesting to note that metered connections represents almost 90% of all billings, whereas very few meters were found to be in working order. This suggests, as confirmed by the DWOs, that most of the billings are based on estimated consumption.

Personnel costs represented, on average, 50% of all operational costs, and expenditure on chemicals was the next largest item at 30%. 13% was spent on transport, utilities and fuel, and only 7% on Maintenance, repairs and spares.

3.3 Community Schemes

The lack of proper records makes it difficult to identify all schemes within the project areas. Sixty six schemes were identified in the Meru supply area alone, out of which 20 were surveyed in more detail to gain a better understanding of their status.

From this survey, a typical scheme would have the following characteristics:

Table 3.3-1 Profile of Typical Community Water Supply Scheme

Supply area		6 km2
Number of households served		200
Water demand		150 m3/d
Source	River/stream	60%
	Spring	40%
Treatment		None
Designed by:		MLRRWD
Average costs		Kshs 350,000
Funding		23% Community
		77% External/NGO
Operated and managed by		Community
Charges for water consumption		None
Management committee size		10 (ranges from 7-13)
Bank account		Yes
Management composition:	Men	84%
	Women	16%
Initial construction year:		
	1960s	10%
	1970s	25%
	1980s	35%
	1990s	30%
Water use:		
	Domestic	55%
	Institutional	5%
	Irrigation	40%
Water quality supplied		
	Faecal coliform pollution	50% of samples

In nearly all cases the original design of the schemes have been assisted by the MLRRWD but this assistance has not been carried into the operational phase of the schemes.

The costs of the schemes have been very low (US $ 30 per household). But this figure needs to be adjusted for inflation. It is also low due to the very simple nature of the schemes, and due to the provision of free labour. Donors include Plan International, CARE, Catholic Diocese of Meru and the Methodist church.

3.4 Monitoring Community Water Points

With the objective of improving overall operational performance, a number of communal water points were constructed and rehabilitated at locations identified by the local communities, and their subsequent operation monitored.

The main findings and recommendations were:

(1) To minimize operational problems, communities, or individuals, must initially identify their own priorities and lodge a request with the MLRRWD, they should be involved in the design and location, contribute towards the costs, establish a water user committee if appropriate and, undertake the responsibility for operation and maintenance. Only after all these steps are in place should construction commence.

(2) Higher levels of sustainability can be expected by giving women at least 50% representation on management committees.

(3) The management committee should be provided with simple training for health education, book keeping etc. Responsibilities between the members should be clearly established, agreed kiosk opening times strictly adhered to, and provision made for meetings and elections.

3.5 Initial Environmental Examination

Screening and scoping for the EIA has been designed to conform with the draft Kenyan Guidelines.

Most of the project components are either buried, or are small in scale, and their impact will not be serious. One potential major impact is the alternative proposal for a dam at Isiolo, however this was proved not to be technically viable.

The most significant impacts will be:

(1) Land acquisition and impact of constructional activities

(2) Increase in wastewater quantities leading to pollution

(3) Depletion of surface water resources

3.6 Construction and Monitoring of Wastewater Disposal Facilities

Only Meru and Isiolo have water borne sewerage systems. These were surveyed, and both found to be serving approximately 30% of the developed town areas and that they were both overloaded, particularly Meru which did not have a proper treatment plant system.

A pilot pond was constructed at Meru in order to monitor performance and define design criteria for extensions to the works.

CHAPTER IV POPULATION AND WATER DEMAND PROJECTIONS

4.1 Population Projections

4.1.1 Human Population

Baseline population and historic growth rates for the different schemes were based on the results of the National Population censuses of 1969, 1979 and 1989. Future population projections were estimated after consideration of these baseline figures together with a review of a number of past studies and reports.

The resultant projections are summarized below:

Table 4.1-1 Population Projections

Year Project	1989	1997	2000	2010
Meru	125,191	165,980	183,527	251,668
Nkubu	6,882	9,471	10,648	15,611
Isiolo	18,658	25,679	29,029	43,648
Isiolo *(1)*	27,987	38,518	43,544	65,471
Chuka *(2)*	31,265	41,502	46,238	64,433
Total	62,784	81,034	88,861	116,577
Chogoria	25,148	32,134	34,920	44,376
Maua	3,223	5,537	6,763	13,344
Tigania *(3)*	51,826	63,891	68,891	83,121

Notes (1) *Including allowance for seasonal migration (Source: MLRRWD)*

(2) *Chuka intake and treatment plant to be sized for a larger area than required to serve the Municipal area alone.*

(3) *Figures for new Tigania scheme only.*

4.1.2 Livestock

Existing livestock ownership levels have been estimated using the results of the WRAP livestock census conducted in Meru District during 1988. 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.

However, since many households will prefer to take their livestock to water free at local streams. A figure of 15% of the livestock water demand being supplied from the metered supply has been suggested as being a reasonable allowance.

4.2 Water Demand Projections

4.2.1 Per capita Consumption and Service Levels

The per capita consumption rates recommended in the 1986 MOWD Design Manual were found by the consumer survey 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 target to introduce full metering to its supplies and, assuming full metering is affected, it supports the use of design manual consumption rates, as given below, for design.

Table 4.2-1 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/communal water points	Rural		l/c/d	10
	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

Table 4.2-2 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%

4.2.2 Water Demand Projections

Water demand projections based on the above design criteria and population projections are summarized below:

Table 4.2-3 Total Water Demand Projections for 2000 and 2010

Project Year	Meru m3/d	Nkubu m3/d	Isiolo (1) m3/d	Chuka (2) m3/d	Chogoria m3/d	Maua m3/d	Tigania (3) m3/d
2000	13,188	1,142	6,692	2,192	1,578	719	2,125
2010	22,725	1,915	10,671	4403	2,886	1,493	3,778

Note (1) Includes for seasonal migration

(2) Chuka supply area only

(3) New Tigania supply area only

Table 4.2-4 Breakdown of 2010 Water Demand

Project	Meru m3/d	Nkubu m3/d	Isiolo m3/d	Chuka m3/d	Chogoria m3/d	Maua m3/d	Tigania m3/d
Domestic	17,311	1,577	5,626	3,659	2,371	1,181	3,193
Livestock	306	25	258	100	61	16	127
Industry	3,627	91	234	206	106	83	64
Institution	779	87	4,292	160	239	54	184
Health	217	73	120	55	71	46	51
Commerce	485	63	140	223	36	114	159

CHAPTER V ESTABLISHMENT OF MASTER PLAN

5.1 Basic Strategy

5.1.1 Supply Areas

In accordance with Government policy, the ultimate demand capacities of each scheme have been based on the assumption that improved water supplies will be made available to all areas within the identified supply areas, unless there are logistical reasons for not doing so.

5.1.2 Prioritized Areas and Phasing

Prioritization of areas for implementation in Phase 1 was based on the household survey results. Social factors and supply efficiencies were evaluated over each supply area and the results agreed with the DWOs with phasing as follows:

(1) Phase 1:

Intake and raw water pipelines to be built for 100% of ultimate capacity; Treatment works and storage reservoirs for 50%, and trunk mains to feed prioritized areas at 100% of ultimate capacity. Individual connections and water kiosks being built in response to applications to the MLRRWD.

(2) Phase 2:

Remaining treatment works and storage reservoirs plus the remaining transmission mains.

5.1.3 Improved Sustainability

In order to improve the sustainability of the schemes the follow strategy was adopted:

(1) the use of gravity supplies and to avoid pumping

(2) the use of good quality raw water to minimize treatment needs and costs

(3) the introduction of universal metering

5.2 Scheme Strategies

5.2.1 Meru

The 185 km2 supply area ranges from an altitude of 2,060 m at the forest edge to the west to 1,200 m to the east. The projected demand comes to 22,725 m3/day compared to the existing treatment capacity of 3,172 m3/day, which is located in Meru Town at an elevation of 1,690 m and where the raw water quality is poor. It is not possible to supply the whole area from the existing works by gravity, and the northern parts of the existing supply area, which are supplied by pumping, suffers the most acute water shortages. It is therefore proposed to construct a new treatment to the west of the area taking water of good quality from within Mount Kenya forest at an elevation that can supply the whole area by gravity.

The high level of unaccounted water in Meru makes it essential that improvement in the institutional arrangements for the operation, maintenance and management of the system are effected in parallel.

5.2.2 Nkubu

The existing treatment plant providing a pumped supply of 400 m3/day to Nkubu was built in 1952. It is now beyond its service life and its capacity is inadequate to serve the projected water demand for the town of almost 2,000 m3/day.

It is proposed that a new intake be built on the Kiguandegwa River, 4 km upstream of the existing intake, at a sufficiently high elevation to enable gravity supply to the town. Full treatment will however be required.

5.2.3 Isiolo

The current gravity system, built in 1980, takes water from Isiolo River, with a design capacity of 2,800 m3/day. It is still generally in good condition, but is insufficient to supply existing demands, and requires an additional 8,000 m3/day capacity to meet the projected 2010 demand. However the source is inadequate to meet even the existing demands.

Investigations of potential dam sites close to Isiolo proved unsuccessful. Further investigations of potential sources and dam sites, hydrological studies, site investigations etc. are recommended to establish the viability of alternative surface water sources in the area.

Full feasibility of the groundwater potential and its water chemistry needs to be confirmed, but the initial investigations carried out by this study suggests that there is potential for groundwater development to the south of Isiolo towards Mount Kenya.

5.2.4 Chuka

Chuka's existing water supply is from the Karingani water supply scheme, built in 1976, with a capacity of 3,260 m3/day. The system was designed as a rural water supply system to supply Karingani, Mthanbe and Magumoni Locations, with a supply area totalling some 150 km2. The system however is inadequate to supply this area.

The proposed supply area is basically the new Chuka Municipal area, which covers approximately 50% of the original Karingani scheme, and has a 2010 projected demand of 4,403 m3/day.

The remainder of the Karingani supply area has an estimated 2010 water demand of 2,852 m3/day, which is close to the capacity of the existing intake and treatment works.

It is therefore proposed that the existing Karingani system should continue to supply the areas outside the municipal area, and that the new system should be specifically designed to supply the Chuka Municipal area.

5.2.5 Chogoria

Chogoria's existing water supply is based on the Mwimbe Water Supply scheme, built in 1975, with a capacity of only 500 m3/day. The capacity is insufficient for the supply area, and Chogoria, with a 2010 estimated demand of 3,000 m3/d, lies in the south of the Mwimbe scheme, connected by a single 150 mm dia pipeline and receives very little water. Complicating matters further, Chogoria is located in the newly formed Tharaka-Nithi District, whereas the remainder of the Mwimbe scheme, including the intake and treatment plant lie in Meru District. A number of factors therefore combine to make it logical for Chogoria to have its own independent scheme.

Chogoria's proposed new raw water source is very similar to Chuka and Meru: An intake in Mount Kenya Forest will combine the advantages of good raw water quality and will provide sufficient elevation to supply most of the area by gravity. In this case however, the higher parts of Murugi sub-location are too high to be supplied by gravity, and moving the intake higher into the forest will reduce its yield. This relatively small area will therefore either have to be served by pumping or, by a separate intake and gravity supply.

5.2.6 Maua

The existing system, built in 1956, takes water from the Mboone River 1 km north west of the town is now beyond its service life.

Water resources in the area are scarce. Mboone River is the main source in the area with the ability to supply Maua by gravity. The supply area is therefore limited by the available yield of this river estimated to be 1,650 m3/d. The supply area was therefore reduced accordingly to Maua Town itself. It being proposed that the area to the south could be supplied by a separate system from the Ura River.

5.2.7 Tigania

Tigania is a large rural water supply scheme, phase 1 of which was designed and constructed in the 1970s. The supply however is constrained by its inadequate spring water sources and there would appear to be little potential in developing them further. Phase 2 of the project to the south was never constructed and is in even more urgent need for water.

The strategy established for this study is to concentrate on the Phase 2 area to the south. The identified source, the Thangatha River is the main river flowing from the Nyambene Hills and resources are comparatively plentiful. It is therefore proposed that water from this source is transferred via transmission mains which will also serve the Phase 2 project to augment the supplies to the Phase 1 area.

5.3 Scheme Requirements

The population, water demand projections and scheme requirements are summarised below in ***Table 5.3-1***. The required raw water capacity allows for 10% losses in the treatment plant.

Table 5.3-1 Required Production Capacities for Individual Schemes

Scheme	2010 Population	2010 Demand (m3/day)	Supply Area km"	Existing Production Capacity (m3/day)	Required Production Capacity (m3/day)	Required Raw Water Capacity (m3/day
Meru	251,668	22,725	185	3,172	20,000	22,000
Nkubu	15,611	1,915	3.5	(400)	2,000	2,200
Isiolo [1]	65,471	10,671	45	2,800	8,000	8,000[2]
Chuka (Whole Area)	116,577	7,255	150	3,260	4,000	4,400
Chuka (Supply Area)	64,433	4,403	88	0	4,000	4,400
Chogoria	44,376	2,886	58	0	3,000	3,300
Maua	13,344	1,493	5	(200)	1,500	1,650
Tigania (Whole Area)	168,929	6,871	300	3,500	3,500	3,850
Tigania (Supply Area)	83,121	3,778	92	0	4,000	4,400

Notes: *[1] Includes allowance for seasonal migration (Source: Habitat)*

[2] additional 10% treatment losses is not required in the event of groundwater sources.

( ) Denotes production capacity beyond service life, to be abandoned

Shaded lines include areas outside the study areas.

5.4 Proposed Works

5.4.1 Intake and Raw Water Pipelines

The intakes and raw water pipelines have been designed to avoid ingress of floating and submerged material, and to ensure a minimum self cleansing velocity of 0.75 m/s and cleaning arrangements.

5.4.2 Treatment

Proposals for treatment processes for each scheme are shown below. They are based on the raw water quality monitoring programme undertaken during both dry and wet seasons. They also take account of the potential for future pollution and simple existing technologies.

Table 5.4-1 Treatment Processes and Number of Units per Scheme

	Meru	Nkubu	Isiolo	Chuka	Chogoria	Maua	Tigania
2010 demand (m3/d)	22,725	1,915	10.671	7,256	2,886	1,493	3,778
Existing capacity (m3/d)	3,172	0	2,800	3,260	0	0	0
Required capacity (m3/d)	20,000	2,000	8,000	4,000	3,000	1,500	4,000
Phase I units							
Chlorine dosers	2	2	2	2	2	2	2
Flocculation tanks		1					
Sedimentation basins	4	1		2	2	1	2
Roughing filters						3	
Rapid sand filters		3					
Sludge concentrators		2					
Sludge drying beds		3					
Phase II units							
Chlorine dosers	2	2	2	2	2	2	2
Flocculation tanks		2					
Sedimentation basins	8	2		4	4	2	4
Roughing filters						4	
Rapid sand filters		4					
Sludge concentrators		3					
Sludge drying beds		5					

5.4.3 Transmission System and Storage

(1) Storage Requirements

Storage needed to balance peak flows has been sized using 12 hours at average water demand. In the case of urban areas, an additional 12 hrs emergency storage is provided as indicated below:

Table 5.4-2 Storage Capacity Requirements

Scheme	2010 Demand (m3/day)	Urban demand as % of total	Required Storage (m3)	Existing Storage Capacity (m3)	New Storage Required (m)
Meru	22,725	61%	18,260	1,008	17,250
Nkubu	1,915	68%	1,605	50	1,550
Isiolo	10,671	53%	8,144	2,150	6,000
Chuka (Supply Area)	4,403	30%	2,860	0	2,900
Chogoria	2,886	12%	1,610	0	1,650
Maua	1,493	64%	1,223	45	1,300
Tigania (Supply Area)	3,778	0%	1,840	0	1,900

(2) Transmission Mains

The total lengths of main transmission mains are indicated below.

Table 5.4-3 Main Transmission Pipe Requirements

	Main Transmission Pipe lengths (m)					
Scheme	**400 dia**	**315 dia**	**280 dia**	**225 dia**	**160 dia**	**Total**
Meru	3,800	15,300	5,800	19,000	38,000	81,900
Nkubu				1,300	2,300	3,600
Isiolo			6,700	9,400	2,900	19,000
Chuka (Supply Area)			2,900	3,800	3,600	10,300
Chogoria				6,000	18,000	24,000
Maua				1,500	4,200	5,700
Tigania (Supply Area)			11,800	8,900	7,100	27,800

5.5 Cost Estimates

Cost estimates have been based on unit rates applicable in October 1996, using an exchange rate of 1 US$ = 56 Kshs

Investment and operational costs are summarised below. The average incremental costs include the full financial and operation and maintenance costs, discounted at 9% per annum.

Table 5.5-1 Total Project Costs (thousand US$)

Scheme	Meru	Nkubu	Isiolo	Chuka	Chogoria	Maua	Tigania
Total - Phase 1	7,930	1,343	5,289	3,010	2,445	1,172	2,993
Total Phase 2	5,775	486	4,772	822	615	180	770
Total	13,705	1,829	10,061	3,832	3,060	1,352	3,763
Cost/capita US$/cap	54	117	154	59	69	101	45
AIC @9% US$/m3	0.58	0.66	0.96	0.58	0.71	0.61	0.65

In terms of cost per capita, Tigania was the cheapest scheme. This was due to the low per capita demands applied to this entirely rural scheme, but in terms of cost per m3 of water supplied, it was the fourth cheapest. Meru was the next cheapest in terms of per capita costs and was also the cheapest, together with Chuka, in terms of costs per m3 of water.

5.6 Institutional and Organizational Development Plan

Recommendations for Operation and Management of the Schemes include the following National initiatives:

(1) Provision of full metering systems. This implies improvement in meter reading, accounting, revenue recovery levels, repair and replacement of meters and provision of bulk water meters

(2) Leakage detection campaign. Improved performance of the schemes can be achieved by reducing the present high unaccounted water levels.

(3) Improved water quality monitoring and control.

(4) Review tariff systems on a regular index linked basis.

(5) Improvements in water right allocation procedures, and their monitoring and control.

(6) Improved levels of budgeting for operations, and improved levels of accounting.

(7) Improved training, particularly through greater use of the Nairobi based Kenya Water Institute (KEWI).

(8) Technical assistance to strengthen O&M at District Level.

The following recommendations address more local issues at Scheme level:

(1) Improvement on data recording. This includes operational data as well as construction records.

(2) Improved chemical dosing arrangements

(3) Improved customer registration

(4) Improved accounting and auditing arrangements

(5) Recruitment and training of meter readers

(6) Recruitment and training of staff for leakage control

(7) Public relations campaign aimed at:

  1) improved community relations
  2) the need for metering
  3) the negative impact of illegal connections and the need for penalties
  4) health and hygiene education and the need for good quality water
  5) obtaining feedback of information on consumer complaints etc.

(8) Improved facilities to assist O&M including stores, equipment and workshops

5.7 Financial and Economic Evaluation

5.7.1 Financial Evaluation

Average household income levels obtained from the household survey are given in ***Table 5.7-1*** below, together with average per capita consumption levels provided by

DWOs. The resultant levels of household expenditure for water are given in the right hand column.

Table 5.7-1 Household Income Levels and Affordability

Household income level	Average income KShs/month	Proportion of population	per capita consumption (lcd)(1)	Proportion of income spent on water
Low	2,985	38%	66	5.0%
Medium	9,616	54%	82	1.9%
High	18,773	8%	98	1.2%

Source: Household survey; (1) DWO records.

A criterion often applied to water supplies in developing countries is that people should not pay more than about 5% of their income on water. It can therefore be seen that there is a reasonable affordability in the supply areas at the current tariff.

A financial cash flow analysis was undertaken to assess the financial viability of the projects based on their Financial Rate of Return (FIRR), Net Present Values (NPV) and their Revenue Expenditure Ration (RER). The results are indicated in ***Table 5.7-2*** below:

Table 5.7-2 Financial Evaluation by Water Supply Scheme

Scheme	Meru	Nkubu	Isiolo	Chuka	Chogoria	Maua	Tigania
FIRR	1.7%	-2.6%	n.a.	0.3 %	-2.8%	-2.3%	n.a.
FIRR Viability	-	-	-	-	-	-	-
NVP (10%)	-6,336	-1,119	-9,821	-2,002	-1,993	-850	-2,799
NVP viability	-	-	-	-	-	-	-
RER	1.13	0.87	0.22	1.02	0.84	0.89	0.66
RER Viability	●	○	-	●	○	○	○

Key: ● = Financially viable
○ = Financially justifiable, but with conditions
\- = Not financially viable.

This table shows that none of the schemes, at current tariff levels, can recover the full costs of investment and O&M. Meru and Chuka can recover O&M costs, and Nkubu, Chuka, Maua and Tigania could in the long term, but require subsidies to cover losses in the initial years. The situation would however greatly improve if the current tariff were increased, and doubling the tariff would result in full cost recovery at Meru, Chuka and Maua.

5.7.2 Economic Evaluation

The benefits of water supplies include health improvements, encouragement of local economics and reduction in time spent in fetching water. However, the time saved in fetching water is the only benefit that can be relatively reliably quantified.

The time taken by women in collecting water, taken from the household survey results averaged at 3.5 hours per day. Applying an opportunity cost of labour of 35.1 Kshs/hr, the annual household benefit can be shown as almost Shs 44,000.

Table 5.7-3 Illustrates the Economic Evaluation, using the same evaluation techniques used for the financial evaluation but adding the benefit of time saving and applying a 0.9 conversion factor for the local cost component

Table 5.7-3 Economic Evaluation by Water Supply Scheme

Scheme	Meru	Nkubu	Isiolo	Chuka	Chogoria	Maua	Tigania
EIRR	11.6%	n.a.	n.a	14.9%	n.a	n.a	7.2%
EIRR Viability	●	-	-	●	-	-	○
NVP (10%)	855	-1,890	-8,129	885	-1,705	-1,181	-398
NVP viability	●	-	-	●	-	-	-
CBR	1.06	0.12	0.2	1.21	0.51	0.33	0.91
CBR Viability	●	-	-	●	-	-	-

Key: ● = Economically viable

○ = Economically justifiable

- = Not economically viable.

This suggests that only Meru and Chuka are economically viable.

5.7.3 Social Concerns

Concern over the impact of water shortages and public health were surveyed in the household survey as given below:

Table 5.7-4 Social Evaluation by Water Supply Scheme

Scheme	Meru	Nkubu	Isiolo	Chuka	Chogoria	Maua	Tigania
Public Health	●	○	●	●	●	○	●
Water shortages	●	●	●	○	○	●	●

Key: ● = High priority

○ = Improvement recommended.

5.8. Selection of Schemes for Feasibility Study

Prioritization between the schemes was conducted by combining all the above considerations to provide an overall assessment of the relative costs and benefits of the schemes as illustrated in ***Table 5.8-1*** below.

Table 5.8-1 Overall Project Evaluation

Scheme	Meru	Nkubu	Isiolo	Chuka	Chogoria	Maua	Tigania
A. Financial and Economic Evaluation							
FIRR	-	-	-	-	-	-	-
EIRR	●	-	-	●	-	-	○
B. Cost performance							
Cost per capita	●	○	-	●	●	○	●
O&M cost recovery	●	○	●	●	○	○	○
C. Socio Economic Considerations							
Public health	●	○	●	●	●	○	●
Burden of collection	●	○	●	●	●	●	●
D. Water Supply Services							
Coverage	●	○	○	○	●	○	●
Reliability	●	○	●	○	●	●	●
Overall evaluation	■	❑	❑	■	■	❑	■

Key:
● = Viable, good performance or, urgently required
○ = Justified, relatively low performance but, highly recommended
- = Not viable, low performance or, improvement not urgently required
■ = Prioritized projects with urgent needs
❑ = Recommended for less urgent implementation.

All schemes can be seen to have a high priority for implementation and it is difficult to select one scheme instead of another. Nevertheless it can be seen that on almost every aspect, Meru has the highest priority of all schemes.

Strong backing by the local administration is also seen as being an important element in achieving successful implementation, and sustainability of the project. This will be needed to support measures that may not be popular with all consumers such as the disconnection of illegal, and non-paying consumers, installation of meters and in establishing environmental guidelines, or by-laws, to ensure acceptable disposal of wastewater. In this respect also, it would appear that Meru has an advantage in terms of both experienced administration and physical infrastructure.The Meru Water Supply Project therefore, having both the greatest need and highest potential for sustainability was assessed as having the highest priority for implementation of all the projects.

FEASIBILITY STUDY FOR MERU WATER SUPPLY-SUMMARY

CHAPTER I INTRODUCTION

1.1 Background

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. The need was more acutely felt in Meru, Chuka, Chogoria and Tigania, but Meru, with the highest number of potential beneficiaries, the largest urban population, the lowest per capita costs and highest potential for sustainability was ranked as the most urgent project needing implementation.

1.2 Study Area

Out of the total area of 185 km2, the area prioritized by the Master Plan as being in most urgent need of improvement amounted to approximately 85 km2, or about 50% of the study area. Factors considered in the prioritization process included unserved ratio, water scarcity during the dry season, health conditions, public opinion and logistics.

The prioritized area includes Meru's urban, peri-urban and surrounding rural areas.

1.3 Basic Policy and Strategy

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

(1) To provide for the projected 2005 water demands of the areas in most urgent need for improvement.

(2) The design capacity will allow for connections to community water supply schemes, but actual connections will depend upon agreement with the appropriate committees.

(3) Treatment works and reservoirs will be sized at 50% of ultimate capacity, but transmission mains at full capacity for the projected 2010 demand.

(4) The construction of water kiosks and individual connections will require participation and contributions from beneficiaries.

(5) The water demand projections have assumed that ultimately, the whole area will require potable water supplied from the Ministry scheme.

CHAPTER II EXISTING CONDITIONS

2.1 Water Resources

Due to difficulties in supplying water by gravity from the original intake, an alternative site was chosen further upstream close to an intake which is under construction by CEFA, an Italian NGO, for the Kirua Water Supply Scheme, north of Meru.

The safe yield was estimated for this site by correlation with river gauging stations in the area to 35,300 m3/day after allowing for other demands and 15% river maintenance flow. This is sufficient for all currently foreseen water demands of this and other schemes. But future planning should be coordinated through the MLRRWD to ensure the safe yield is not exceeded.

Water quality test results for samples taken at this location indicate good water quality.

2.2 Socio-economic Conditions

2.2.1 Administration

The supply area is located in Eastern Province, which has its Provincial Headquarters in Embu. Meru being one of the eight Districts in the Province, 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

Based on National census results, the 1989 population for the supply area was 125,000 and growing at a rate of 3.6% per annum, which is close to the Provincial average of 3.65% and the National average of 3.4%. The current (1997) population was estimated as 165,980.

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 Mount 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.

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

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

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. However all other roads are unsurfaced, and access to remoter parts of the supply area during rainy periods is problematical.

Electricity and telephone grids connect all large towns and most rural centres. However, the main consumers are commercial, institutional and industrial and only about 5 % of the population have connections.

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.

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

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

(3) Housing type distribution:

Permanent	Semi-permanent	Temporary
22%	61%	16%

(4) Water Resources

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

(5) Distance from primary water source

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

2.3 Existing Water Supply Facilities

The existing Milimani waterworks has a production capacity of 3,770 m3/day. The distribution network is divided into two zones. The northern high level zone, comprising 7,785 m of pipework was originally fed by pumping, but from 1988, has been supplied directly by gravity from the Gatabora spring, but which is insufficient to meet the demand. The lower zone, comprising a network of 18,310 m of pipes, is fed directly from the treatment works.

The total storage volume comprises 1,100 m3.

In 1996 there were 990 recorded disconnections for non-payment, leaving a total of 2,519 connections. A survey of 330 connections revealed that 81% were registered, 68% were metered, but only 14% had working meters. Households with working meters consumed between 80 and 100 lcd, but households without working meters used 500 lcd.

Accurate estimates of unaccounted water are difficult to make due to the lack of meters and, in some cases, inconsistent data. The DWOs estimate is about 20%, the MLRRWD's Monthly Operation, Maintenance and Financial Monitoring Report (1994-1996), suggests a level of about 44%, and a leak detection survey in a central part of the supply system indicated an even higher figure of 70%.

Revenue collected represents only 42% of billings. (MLRRWD Monitoring Report 1994-1996).

Operational and maintenance activities are constrained by the lack of equipment, materials and transport.

CHAPTER III WATER DEMAND PROJECTIONS

The overall population and water demand projections are essentially the same as the Master Plan.

The existing (1997) population for the whole area of 166,000 is estimated to grow to 215,300 by 2005 and 250,000 by 2010. ***Table 3.1-1*** provides population and water demand projections for the whole area and for the prioritized areas only.

Table 3.1-1 Population and Water Demand Projections

	1989	2005
Prioritized population	72,775	129,191
Total population	125,191	215318
Prioritized water demand (m3/day)		10,482
Total area water demand (m3/day)		17,470

The prioritized areas include, Ntakira, Lower Igoki, Mpuri, Nthimbiri, Katheri and most of Upper Igoki and Mulanthankare sub locations. The total population in 2005 of 129,191 represents 60% of the total supply area population.

The resultant water demand for 2005 comes to 10,482 m3/d.

A breakdown of the water demand for Phase 1 only by category of consumer is given in ***Table 3.1-2*** below:

Table 3.1-2 Breakdown of Prioritized Area's 2005 Water Demand by Consumer Category

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

CHAPTER IV PRELIMINARY DESIGN OF FACILITIES

4.1 Water Supply Facilities

4.1.1 Design Framework

(1) Objectives and 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 and distribution mains and storage facilities required to meet the demands of the prioritised areas. Phase 1 also includes some service mains, but it is assumed the these will be extended on an annual basis by the Ministry, as the demand and priorities require.

In accordance with Master Plan proposals, the phase 1 treatment plant capacity has been taken as 10,000 m3/day.

(2) 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 1750 m and can only supply the lower half of the supply 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.

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 are the most acute water shortages. This will be extended in Phase 2 to cover most of the supply area by trunk mains.

2) Water Losses

In addition to any improvement in water supply infrastructure, the high level of unaccounted for water in Meru makes it essential that improvement 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. A Crump Weir is proposed just upstream of an existing broken weir for the Kiwari and Kiamogo intake.

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

(2) Raw Water Pipeline

The raw water pipeline route and profile are shown in the Main Report. 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 dia 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. 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.

Plain sedimentation followed by chlorination has been proposed as being appropriate. The need to include a filter system to remove partially decomposed leaves will be reviewed in the Detailed Design.

Due to possible future water quality deterioration, it was 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 in the Main Report

(2) Inlet Chamber

An inlet chamber, as shown in the Main Report, is provided before the sedimentation tank, designed to provide flow control, flow measurement and fine screens.

(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 be 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 preliminary design of the horizontal sedimentation tank units is shown in the Main Report.

(4) Disinfection

Disinfection will be by calcium hypochlorite solution as it is easier to use than tropical 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 in the Main Report.

(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. Additional contact time requirements for chlorination can be reduced due to time spent in the transmission main downstream of the treatment plant. However, an additional 10 minimum retention has been provided for chlorination.

(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, as shown in the Main Report.

4.1.4 Transmission and Distribution Facilities

The design criteria for the distribution system is summarised below:

(1)	Basic design flow	: Average 2010 demand
(2)	Peak hourly flow	: 2.0 times basic design flow
(3)	Retention time for storage	: 12 hrs at 2005 demand
(4)	Emergency storage (urban areas only)	: 12 hrs at 2005 demand
(5)	Maximum water pressure	: 60 m

(6) Minimum water pressure : 10 m

(7) Hydraulic equation used : Colebrook White formula

Unplasticised polyvinyl Chloride pipes are proposed for the majority of transmission and distribution mains of diameters less than 350 mm. Steel pipes are proposed for larger pipelines and for road and river crossings. Details, for Phase 1 only, are given below:

Table 4.1.1 Proposed Pipeline Lengths for Phase 1

Diameter (mm)	Length (m)
Transmission and distribution mains	
400 Steel	3,800
350 Steel	6,800
315 uPVC	8,500
280 uPVC	5,800
225 uPVC	11,800
160 uPVC	12,900
110 uPVC	8,200
90 uPVC	3,400
Total	61,200
Service mains	
110 uPVC	15,900
90 uPVC	12,060
63 uPVC	18,000
Total	45,960

Storage requirements for Phase 1 are as follows

Table 4.1.2 Proposed Storage Reservoir Capacities for Phase 1

Reservoir	Capacity (m3)
ST-WTP	200
ST-1	4,500
ST-7	200
ST-11	400
ST-12	250
ST-EX1	1,500
Total	7,050

4.1.5 Rehabilitation

Rehabilitation works will concentrate on the replacement of meters and valves, as described in the Master Plan.

4.2 Provision of O&M Equipment

4.2.1 Metering and Registration

The costs of repair and replacement of existing meters has been included in the costs of the project. The cost of meters for new connections has been assumed to be borne by the consumers. A total of 1,875 1/2" and 208 3/4" meters will be required plus 6 sets of pressure tapping machines and a meter test bench for calibration of meters.

In parallel with the meter replacement/repair programme, it will be necessary to undertake a public relations exercise to eliminate all non-registered customers and to prepare registration of all new customers.

4.2.2. Recording and Monitoring

Bulk meters are required for the four existing main distribution pipelines. In addition, district meters to gauge inflow to the distribution zones will be installed at each inlet.

4.2.3. Equipment for Leakage Control

To attain a reasonable level of accounted-for water, leakage control is considered most effective. To this end, two full sets of leak control equipment will be required together with transport.

CHAPTER V COST ESTIMATE AND CONSTRUCTION PLAN

5.1 Unit Construction Prices

A review of construction prices since the Master Plan was conducted and it was concluded that the prices and the exchange rate of 1 US$ = 56 Kshs had remained static and were both still valid in March 1997 and therefore application to the Feasibility Study.

5.2 Construction Cost Estimates

A basic list of requirements and costs for Phase 1 is given below:

Table 5.2.1 Basic List of requirements and Cost Estimate for Phase I

Item	Details	Capacity/ quantity	Cost Estimate US$
MAIN CONTRACT			
Rehabilitation	Valves and meters	item	179,000
Intake weir	Reinforced concrete weir	22,000 m3/d	224,000
Raw water pipeline	5,825 m of 500 dia steel pipe	22,000 m3/d	1,326,000
Treatment plant	Inlet works	10,000 m3/d	
	Plain horizontal sedimentation	10,000 m3/d	
	Chlorination	20,000 m3/d	
	Clear water reservoir	300 m3	
	Office/store/laboratory	.	1,055,000
Operations	Administration building		75,000
Transmission mains	400 mm dia steel pipeline	3,800 m	696,000
	350 mm dia steel pipeline	6,800 m	1,032,000
	315 mm dia uPVC pipeline	8,500 m	659,000
	280 mm dia uPVC pipeline	5,800 m	353,000
	225 mm dia uPVC pipeline	11,800 m	553,000
	160 mm dia uPVC pipeline	12,900 m	374,000
	110 mm dia uPVC pipeline	8,200 m	151,000
	90 mm dia uPVC pipeline	3,400 m	53,000
Reservoirs	Reinforced concrete reservoirs		651,000
Ancillaries/ contingencies			1,107,000
Preliminaries			1,273,000
TOTAL			9,761,000
ADDITIONAL COSTS			
Leak control and repair equipment etc.			338,000
COUNTERPART CONTRIBUTIONS			
Annual extensions for service mains			580,000

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

5.3 Recurrent Costs

Annual operating and maintenance costs are estimated at US $ 250,000 initially, rising to US $ 335,000 by 2005. This includes for staffing, chemicals, transport, power and repairs and maintenance work.

5.4 Construction Plan

5.4.1 Basic Considerations

(1) 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.

(2) Economics of Phasing

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 and distribution mains to serve the prioritised areas.

(3) Materials

The major components of the project; Steel and uPVC pipes and cement, are all manufactured locally in Kenya to International and Kenyan Standards.

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

(4) Seasons and the Effect of Wet Weather Conditions

Construction, especially of the intake and raw water pipeline will be seriously affected by the wet weather expected from March to May, and during November and December. Other construction will also be affected, but to a lesser extent

(5) Special Considerations

The construction work is not particularly demanding except for the intake and raw water pipeline where contractors will need to allow for the difficult access and confined working conditions in the deep ravine.

5.4.2 Construction Schedule

Construction is planned to be completed and operational before the end of 1999 with the construction activities peaking during the dry periods of 1999. The manufacture and delivery of pipeline materials present little problem within this time frame, the more critical components will be the imported valves and penstocks, and the manufacture of specials to suit amendments to pipeline arrangements, that could not have been foreseen during the design stages. Nevertheless, the most critical component will remain the construction of the raw water intake and pipeline.

CHAPTER VI ORGANIZATION AND MANAGEMENT

For successful completion of the project, it will be necessary to strengthen the existing organisation and management of the project in the following areas:

(1) administrative procedures

(2) enforce universal metering

(3) enhance quality control of Ministry operations and assistance to Communities

(4) strengthen leak control, meter repair and quality control activities

(5) improve reporting and accounting

(6) improve public relations

(7) training and recruitment staff

The Kenya Water Institute, based in Nairobi is seen as an important means of providing regular training for all staff, together with the provision of operational procedures and manuals specific to Meru's circumstances.

It would also be beneficial for a specialist in leak detection to train the leak control team, and conduct the first leakage control surveys.

CHAPTER VII ENVIRONMENTAL IMPACT ASSESSMENT

7.1 Objective and Scope

In accordance with Kenyan EIA guidelines, the primary objective of the EIA was to manage the safety of the environment during the project's implementation, commissioning, operation and decommissioning.

The Initial Environmental Examination conducted during the Master Plan identified a number of aspects relating to the construction and operational stages of the project that were of potential concern, and these were the subject of this EIA.

7.2 Environmental Impact Assessment

7.2.1 Land Acquisition

Wayleaves, 6 m wide, are required along pipeline routes to allow access for construction. After commissioning the land is returned to the land owner although a right of access to the pipeline is retained for maintenance and repair. Most of the wayleaves will be within road reserves and therefore will have little impact on farmers. Where farming land is required, it will be important to provide farmers with adequate warning and compensation.

The permanent land requirements for structures need to be confirmed as early as possible to commence the process of land acquisition and compensation. The largest land requirement is for treatment plant, but this is on Government land within the forest boundary no resettlement will be required.

7.2.2 Local Transport

To avoid local disruption to traffic it will be necessary to employ strict supervision over the construction of pipelines in roads, to employ traffic control and safety measures, especially in urban areas and, in critical areas, avoid construction during peak traffic times..

7.2.3 Natural Resources of Mt. Kenya

In order to conserve the natural resources of Mount Kenya, it is suggested that construction methods requiring deforestation should be forbidden, the raw water pipeline route carefully routed to ensure minimum impact and, the catchment is carefully monitored to ensure that the deforestation that is occurring in neighbouring catchments does not spread further.

7.2.4 Wastewater Disposal

The increase in quantities of wastewater requiring disposal as a result of the project has the potential for a significant impact. The impact will be lowest in rural areas where the use of appropriate sanitation facilities should be encouraged. In Urban areas, the Municipality needs to consider provisions for enforcing such requirements for adequate on site disposal and at the same time to the improving the existing sewerage system.

CHAPTER VIII FINANCIAL AND ECONOMIC EVALUATION

8.1 Financial Evaluation

An analysis of the income profile for Meru, taken from the household survey suggests that there is a reasonably high ability to pay for water at the current water tariff rates. Data obtained from the DWO on consumption rates for the different categories of consumers suggest that low income households spend, on average, 4.7% of their income on water, and middle and high income households 2.2% and 1.4% respectively.

The financial evaluation showed that although the scheme could easily cover operational costs the revenue, using current tariff rates, was not sufficient to recover all investment costs.

8.2 Economic Evaluation

Economic benefits were assessed by applying appropriate conversion factors to the financial costs and adding economic benefits. Economic benefits include time saved in collection of water, improved health, reduction in the use of fuelwood for boiling water, and the removal of a significant constraint to the expansion of industry in the area. Most of these benefits are however difficult to quantify and the analysis was therefore limited to the more quantifiable benefit of time saved in collection of water, assuming the time saved would be used in other household economic activities.

The average time spent in collection of water by households was found in the household survey to be approximately 4 hours. The hourly opportunity cost was derived from the average household income.

The resulting economic internal rate of return came to 6.3% suggesting that the scheme becomes viable by including the economic benefits in the analysis.

8.3 Social Concerns

The provision of an adequate water supply is considered to be one of the most important basic human needs. Shortages of water or poor water quality have a direct influence on public health and on the quality of daily life.

The severity of water shortages and water quality were therefore key factors used in the household survey in prioritizing areas for new supplies, which concluded that the Phase 1 area was in acute need of improved water supplies.

8.4 Overall Evaluation

The project is socially and economically viable, but can not recover the full financial costs of implementation. There would therefore appear to be some justification in considering a grant to cover a proportion of the implementation costs to ensure that it will also be financially viable.

Financial management of the project needs strengthening.

A framework needs to be established for reviewing the water tariff annually, in line with inflation.

CHAPTER IX CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

Approximately 129,000 people will be provided with access to potable water by the year 2005 in a supply area of 85 km2.

The proposed project provides an easily maintainable gravity supply to the whole area using good quality raw water needing only minimum treatment.

The total cost of constructing Phase 1 including the costs of leak control equipment comes to US $ 10,100,000.

The resulting cost per capita of US $ 81 is high due to the rural nature of much of the supply area and difficult terrain. However, part of the investment is to feed the larger Master Plan area of 185 km2. If the Phase 2 costs and beneficiaries are included, the cost per capita reduces to US $ 60.

The success of the project is highly dependent upon the universal installation of consumer meters and on the reduction of unaccounted water levels.

Other aspects that require improving include financial and technical accounting and reporting and an annual review of the tariff structure.

The project was found to be socially and economically viable. However, although the operation and maintenance costs could be easily covered, it was found not to be possible to recover the full costs, including investment costs, using the current tariff.

9.2 Recommendations

It is recommended that the project be considered for grant aid on the following understanding,

(1) Full metering will be implemented.

(2) A loss reduction programme will be initiated.

(3) Assistance is provided in the fields of water loss reduction, institutional improvement and construction management.

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