JAPAN INTERNATIONAL COOPERATION AGENCY
THE REPUBLIC OF KENYA
NATIONAL WATER CONSERVATION & PIPELINE CORPORATION

BASIC DESIGN STUDY REPORT

ON

THE PROJECT FOR THE EXPANSION

OF

THE KAPSABET WATER SUPPLY SYSTEM

IN

THE REPUBLIC OF KENYA

NOVEMBER 1993

NIPPON JOGESUIDO SEKKEI CO., LTD.

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PREFACE

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct a basic design study on the Project for Expansion of the Kapsabet Water Supply System and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Kenya a study team headed by Mr. Yasuhiro Morimoto, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs, the Government of Japan, and constituted by members of Nippon Jogesuido Sekkei Co., Ltd. from June 15 to July 12, 1993.

The team held discussions with the officials concerned of the Government of the Republic of Kenya, and conducted a field study at the study area. After the team returned to Japan, further studies were made and as this result the present report was finalized.

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.

November 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

November 1993

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Expansion of the Kapsabet Water Supply System in the Republic of Kenya.

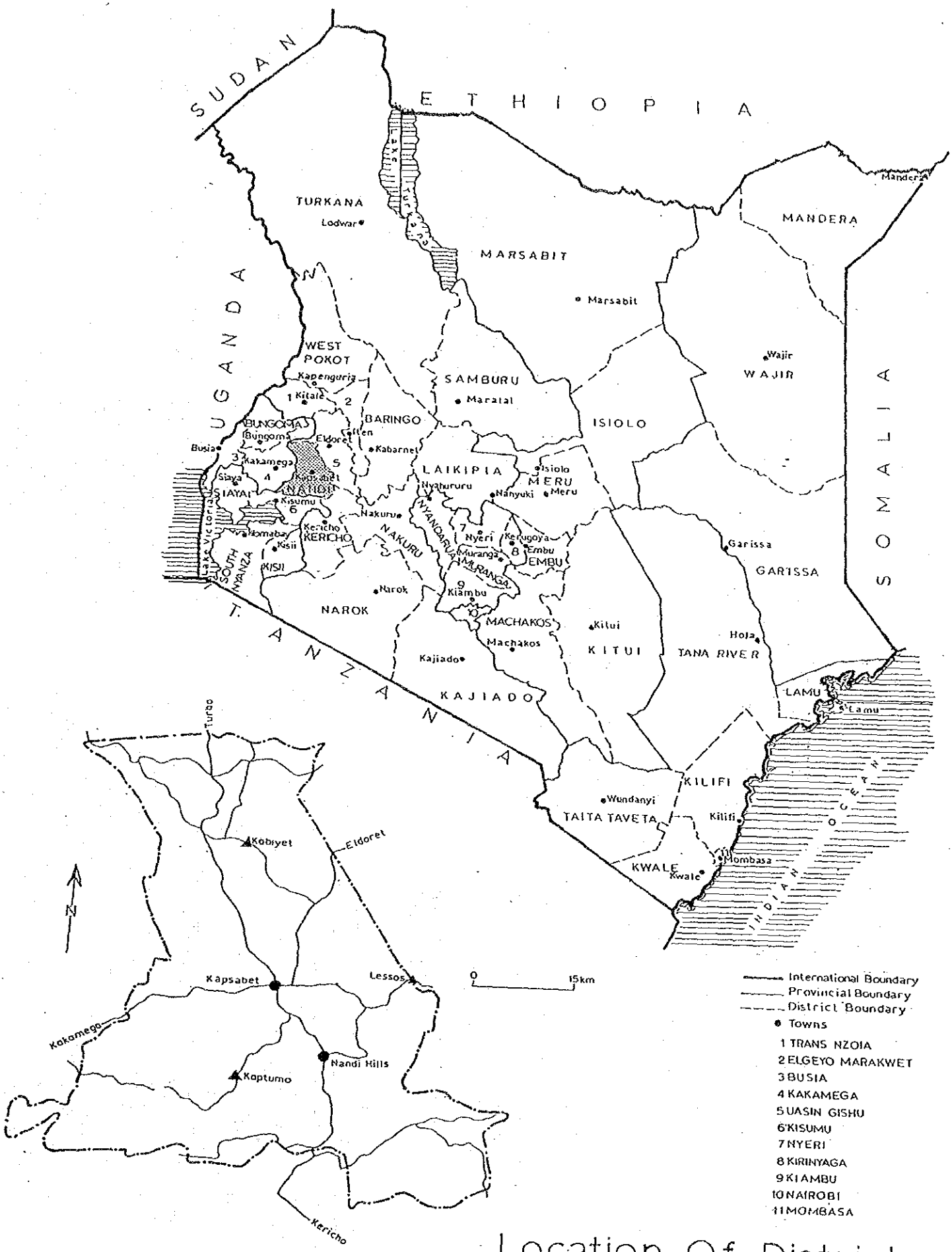
This study was conducted by Nippon Jogesuido Sekkei Co., Ltd., under a contract with JICA, during the period of June 3, 1993 to November 15, 1993. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Kenya and have formulated the most appropriate basic design for the project under Japan's grant aid scheme.

We wish to take this opportunity to express our sincere gratitude to the officials concerned in JICA, the Ministry of Foreign Affairs, and the Ministry of Health and Welfare. We would also like to express our gratitude to the officials concerned in the National Water Conservation & Pipeline Corporation, the JICA Kenya office and the Embassy of Japan in Kenya for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to the further promotion of the project.

Very truly yours,

Ikuo Miwa
Project Manager
Basic design study team on the
Project for Expansion of the
the Kapsabet Water Supply System
Nippon Jogesuido Sekkei Co., Ltd.



Location Of District

SUMMARY

SUMMARY

Kapsabet Town is the administrative capital of the Nandi District in the Rift Valley Province as well as a center of farming and tea culture. Kapsabet Town's estimated population was 10,900 in 1992.

The existing water treatment facilities were constructed in 1948 and then expanded in 1960 and 1980 to a total capacity of 820 m^3/day. However, the capacity has gone down to 620 m^3/day at present, as the first train is no longer functional. The Kapsabet Scheme Office has been managing to meet the growing water demand by increasing the amount of water supply to 1,040 m^3/day and by limiting the time that water is supplied to the four different service zones. Despite these efforts, the water is not distributed evenly between the different zones. Due to the functional constraints in the water distribution pipe network, the residents in the eastern zone can get water all day, while those in the western zone cannot get sufficient water even during their allotted time of water supply. Thus, the people have increasingly complained about the present water distribution system.

In such circumstances, the Government of the Republic of Kenya prepared a rehabilitation and expansion plan for the Kapsabet water supply system and requested grant-aid assistance from the Government of Japan for the implementation of the Project.

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct preliminary and basic design studies on the Project for the Expansion of the Kapsabet Water Supply System. JICA sent to Kenya a preliminary study team from August 31 to September 20, 1992 and a basic design study team from June 15 to July 12, 1993, respectively to hold discussions on the Project with those officials concerned in the Government of the Republic of Kenya, and to conduct a field survey.

The National Water Conservation & Pipeline Corporation (NWCPC) is the executing agency of the Government of the Republic of Kenya for the Project.

The following are the basic policies for the detailed design, based on the results of the study:

1) The source will be changed from the Kabutie River, from which the existing water supply system currently takes water, to the Kimondi River due to the insufficient flow of the Kabutie River regarding the expected future water demand.
2) The existing water treatment plant will not be rehabilitated and will be abandoned in future because of its small treatment capacity and old age.
3) The existing rising main will not be used in the new water supply system due to the change in the location of the water treatment plant. Instead, a new rising main will be installed.
4) The existing service reservoirs will not be used in the new water supply system, since they are small in capacity and are situated at an elevation not able to cover the whole service area. Instead, new reservoirs will be constructed in two separate places.

The proposed new water supply system has a water supply capacity of approximately 4,011 m^3/day for the design target year of 2002 and is composed of intake, treatment, transmission and distribution facilities. The raw water taken from the intake weir, which is to be constructed in the Kimondi River, will be pumped along the river to the water treatment plant 0.6 km away from the intake facilities. The water treated at the water treatment plant will be transmitted by pumps to the ground reservoirs at the Scheme Office and the Bible College School via the booster pump station located midway between the Kimondi River and Kapsabet Town. The design service area is divided into a highland area and a lowland area. As for the lowland area, the water will be directly gravitated from the ground reservoirs, while the highland area water will be pumped from the ground reservoirs to the elevated tanks and then be distributed by gravity. Of the old system, only the existing distribution pipes will be integrated with the new water supply system by being connected to the new distribution mains.

The outline of the major facilities and equipment is shown in Table 1 and the contents of equipment supply in Table 2.

The cost to be borne by the Government of the Republic of Kenya is estimated at KShs. 7,010,000 for investment, excluding the expenses for land acquisition, compensation for private land lease and restoration, the cost for removal of objects remaining at the proposed construction sites, the cost for repair and extension of existing distribution pipes and the expenses for meter installation. Additionally, KShs. 5,700,000 per annum for management of Kapsabet Town's water supply system after the completion of the Project including that for operation and maintenance will be borne by the Kenyan government.

The Project period is 6 months for detailed design including the prequalification and bidding and 16 months for construction. Technical guidance on plant operation will be provided for three months after completion of the facilities.

The implementation of the Project is expected to bring the following benefit and effects:

1) The production volume at the water treatment plant will increase from 1,040 m^3/day to 4,011 m^3/day, four times the present production volume and the number of beneficiaries is estimated to be approximately 30,200 in 2002. The biggest problem in Kapsabet Town's water supply, is the current distribution bottleneck. This problem will be solved by the implementation of the Project.
2) Through the implementation of the Project, Kapsabet Town's water supply facilities will be renewed including new chemical dosing equipment to facilitate proper chemical dosing. Using the renewed system it will be possible to supply clean and safe water, which will meet the Kenyan Drinking Water Standard, to Kapsabet Town. If the system is properly operated and maintained, it will assure the health of the people who before depended on unsanitary alternative water sources.
3) The realization of a stable water supply will bring an increase in water consumption and thereby contribute to an increase in revenue. Also, the complaints regarding the inadequate water supply will be swept away, which will make the collection of water charge easier--resulting in a further increase in revenue.

The Project meets the goal of the national development plan and comprehensively contributes to the improvement of the living standard and public health of the area. Therefore, it is considered that the Project is reasonably justified enough to be implemented under the grant aid assistance program of the Government of Japan, especially when the present poor condition of water supply is taken into consideration.

However, the NWCPC, the executing agency of the Project, currently has the following problems:

1) A poor financial condition due to its low profitability.
2) Inadequately trained operators are engaged in plant operation.
3) All the income from each scheme office is pooled at the NWCPC headquarters and is not controlled by the individual scheme offices.

In relation to these problems, the NWCPC is now preparing plans for financial improvement, organization and systems improvement, and improved staff training. With the implementation of the Project, the Kapsabet Scheme Office will have to bear an increase in operation and maintenance costs for the new water supply system and also have to undertake repair work for leakage control and extension of the existing distribution pipes. For this purpose, a system that would allow each scheme office to have some degree of control over its income will hopefully be established. It is, therefore, the prerequisites for the implementation of the Project that the executing system of the NWCPC be improved based on the plans mentioned above so as to ensure the effectiveness of the Project.

To implement the Project and achieve the objectives of the Project, it is necessary for the Kenyan side to take the following measures:

1) Before Construction of the Project

   a. to assure an adequate budget for the undertakings of the Kenyan side
   b. to acquire the land for the construction of the facilities proposed in the Project
   c. to assure a power supply to the proposed site for the new water

treatment plant

d. to organize the Project team for smooth planning progress planning
e. to prepare plans for leakage control and extension of the existing distribution pipes
f. to resume the suspended construction work in the Kapsabet sewerage project as soon as possible and to complete the works by the second phase.
g. to achieve adequate results on improvement plans for the NWCPC.

2) During the Construction of the Project

a. to assign a Project engineer who will participate in the Project from the planning stage so as to understand the contents of the Project and to master the technology, and who will subsequently operate and maintain the system after the completion of the Project.

3) After the Completion of the Project

a. to budget for operation and maintenance of the system
b. to budget for repair and extension of the existing distribution pipes
c. to establish measures for ensuring the collection of water charges, which are the financial source for the operation and maintenance of the system
d. to conduct a training program to elevate the skills of operators
e. to carry out systematic preventive maintenance to keep the system functioning normally
f. to clarify the personnel responsible for the management of each facility
g. to monitor the quality of raw water so as to properly operate the system corresponding to any raw water change
h. to keep an adequate supply of spare parts

The Minutes of Discussions (Appendix 4) were not signed due to no commitment to the budgetary measures for the items to be undertaken by the Kenyan side including the Kapsabet sewerage project.

Table 1 Outline of Major Facilities and Equipment

Intake Facilities			
Intake Weir	L.S.	Intake Pipe	L.S.
Grit Chamber	2 units	Intake Pump Sta.	1 unit
Intake Pump	3 units	Transmission Pipe	L.S.
Maintenance Road	L.S.		
Water Treatment Plant			
Receiving Well	1 unit	Rapid Mixing Chamber	1 unit
Flocculation Basin	2 units	Sedimentation Basin	2 units
Rapid Filter	4 units	Clear Water Reservoir	2 units
Clear Water Pump Sta.	1 unit	Clear Water Pump	3 units
Sludge Drying Bed	5 units	Elevated Tank	1 unit
Administrative Bldg.	1 unit	Electrical Equip.	L.S.
Chemical Bldg.	1 unit	Chemical Dosing Equip.	L.S.
Staff House	7 units	Inplant Piping	L.S.
Inplant Road	L.S.	Outdoor Lighting	L.S.
Transmission Facilities			
Maintenance Road	L.S.	Aqueduct	L.S.
Rising Main No.1	L.S.	Regulation Tank	2 units
Booster Pump Sta.	1 unit	Booster Pump	3 units
Rising Main No.2	L.S.		
Distribution Facilities			
Ground Reservoir No.1	2 units	Elevated Tank No.1	1 unit
Lift Pump Sta. No.1	1 unit	Lift Pump No.1	3 units
Ground Reservoir No.2	2 units	Elevated Tank No.2	1 unit
Lift Pump Sta. No.2	1 unit	Lift Pump No.2	2 units
Distribution Main for Highland	L.S.	Distribution Main for Lowland	L.S.

Table 2 Outline of Equipment Supply

Water Meter			
Laboratory Instrument			
For Residual Chlorine	1 unit	For pH	1 unit
For Turbidity	1 unit	For Alkalinity	L.S.
Jar Tester Apparatus	1 unit	Analytical Balance	1 unit
Workshop Tool			
For General	L.S.	For Piping	L.S.
Spare Parts			
For Pump	L.S.	For Motor	L.S.
For Valve	L.S.	For Chemical Dosing Equip	L.S.
For Electrical Panel	L.S.	Water Level	L.S.
Flow Meter	L.S.		

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LIST OF ABBREVIATIONS

ORGANIZATION

MLG	Ministry of Local Government
MWD	Ministry of Land Reclamation, Regional and Water Development
NWCPC	National Water Conservation & Pipeline Corporation
KBOS	Kenya Bureau of Standards
KPLC	Kenya Power and Lighting Company Ltd.
KPTC	Kenya Post and Telecommunication Company
JICA	Japan International Cooperation Agency
CIDA	Canadian International Development Agency
DANIDA	Danish International Agency
FINNIDA	Finnish International Development Agency
KfW	Kreditanstalt für Wiederaufbau
NIO	De Nederlandse Investeringsbank voor Ortwikkelingslanden N.V.
NORAO	Norwegian
SIDA	Swedish International Development Authority

STANDARD

IEE	Institution of Electrical Engineers
JIS	Japanese Industrial Standard
JEM	Japan Electrical Manufacturer's Association
JEC	Standard of Japanese Electrotechnical Committee

UNIT

KShs.	Kenya Shillings
kV	kilo-volt
kVA	kilo-volt-ampere
lx	lux
MM	man-month
NTU	nephelometric turbidity unit
ppm	parts per million

prs.	persons
yr	year

OTHERS

Alk.	alkalinity
Cl_2	chlorine
CN	cyanide
HH	household(s)
loc.	location (administrative unit in Kenya)
LPG	liquefied petroleum gas
Mn	manganese
SGP	steel galvanized pipe
SS	suspended solid
Turb.	turbidity

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Project

Kapsabet Town, Kenya, is the capital of the Nandi District in the Rift Valley Province. This town of around 10,900 people is concentrated around the national road and subsequently serves as a distribution center for agricultural produce as well as tea farming activity.

The present water treatment plant was built in 1948 and has since been expanded in 1960 and in 1980. The plant's total design capacity is 820 m^3/day, but the current treatment capacity is only 620 m^3 due to the plant's deteriorated condition.

The Kapsabet Scheme Office has been attempting to meet Kapsabet Town's growing water demand by operating the water treatment plant 24 hours a day and the town, which is divided into four service zones, endures water rationing. Due to the limitations of the water distribution pipe network, the residents in the eastern zone are able to get water all day, while those in the western zone rarely recieve sufficient water even during their allocated time. The plant's output of 1,040 m^3/day exceeds the plants's design capacity.

To combat this problem, the government of the Republic of Kenya prepared an expansion and rehabilitation plan for the water treatment plant in Kapsabet Town and requested grant aid assistance from the government of Japan to finance the Project.

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct preliminary and basic design studies on the Project for the Expansion of the Kapsabet Water Supply System. JICA sent to Kenya a preliminary study team from August 31 to September 20, 1992 and a basic design study team from June 15 to July 12, 1993, respectively, to hold discussions on the Project with the officials concerned of the Government of the Republic of Kenya and to conduct a field study.

The National Water Conservation & Pipeline Corporation (NWCPC), is the executing agency of the Government of the Republic of Kenya for this Project.

The following text contains the basic policies for the detailed design based on the results of the study.

1.2 Dispatch of the Study Team

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct a preliminary study to evaluate and assess the contents of the request and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Kenya a study team, which was headed by Mr. Masashi Fujita, a deputy chief of the First Basic Design Study Division, Grant Aid Study & Design Department, JICA from August 31 to September 20, 1992. The team held discussions with those officials concerned in the Government of the Republic of Kenya and conducted a study on the existing water supply system composed of intake, treatment, transmission and distribution facilities, along with the proposed construction sites for the new facilities. Accordingly, data was collected, and prepared for the Preliminary Study Report as a guideline for the basic design study.

JICA subsequently sent to Kenya a basic design study team, which was headed By Mr. Yasuhiro Morimoto, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs from June 15 to July 12, 1993. The team held further detailed discussions with the officials concerned of the Government of the Republic of Kenya based on the results of the preliminary study and conducted a field survey in Kapsabet Town on the facilities involved as well as a preliminary data collection. This proceeded further work in Japan and preparation of the Basic Design Report.

The member list of the basic design study team, survey schedule, the member list of the concerning party of the Government of the Republic of Kenya, and the minutes of discussions (unsigned) are as shown in Appendices 1 to 4 attached hereto.

1.3 Contents of the Study

(1) Confirmation of Fundamentals

The background, objectives and contents of the request, preparation for the Project implementation such as staff, budget and the operation and maintenance plan, and the scope of work to be undertaken by the Kenyan side was investigated for confirmation.

(2) Study on the Existing Water Supply System

The existing water supply system is composed of intake, raw water transmission, treatment, and clear water transmission and distribution facilities with the water source is the Kabutie River. The facilities were studied in relation to the condition of each facility and the function of the system as a whole.

The existing water treatment plant with three trains, has problems. Namely, one no longer functional train, a limited treatment capacity, plant operation difficulties due to the differences in train structure, and an aging and out-of-date treatment process. Even with major rehabilitation work, the existing water treatment plant offers little hope for an adequate treatment capacity.

(3) Study on Operational Conditions of the Existing Water Treatment Plant

The present status of and the institution for the plant operation was studied including the proper chemical dosing rate.

(4) Study on Water Supply Conditions

The interview survey of residents was made in terms of the type of faucets used, leakage from the faucets, time of water supply, water consumption, water use, complaints regarding the Scheme Office and the supplemental water sources.

(5) Study on the Water Source

The water source was selected based on the quantity and quality of the possible water sources, namely the Kabutie, Kimondi and Mokong Rivers.

(6) Study on Proposed Sites for the New Water Supply System

The sites for the intake facilities, a water treatment plant, a booster pump station and reservoirs to be newly constructed in the Project were selected in a field survey taking into account the locational relationship among the facilities, available space, ease of land acquisition and systematic requirements.

(7) Study on the Progress of the Sewage Works

In the proposed service area, sewage work is now ongoing. To clarify the relationship between the sewerage system and the water supply system, an investigation was conducted on the outline of the sewerage development plan, the progress of the sewage works, the condition of the receiving water body and the problems involved.

CHAPTER 2

BACKGROUND OF THE PROJECT

CHAPTER 2 BACKGROUND OF THE PROJECT

2.1 Background of the Project

Khapsabet is the administrative capital of the Nandi District in the Rift Valley Province as well as a center for farming and tea culturing, with an extimated population of 10,900 as of 1992.

The existing water treatment facilities were constructed in 1948 and expanded twice (1960 and 1980) to a total capacity of 820 m^3/day. However, the capacity has gone down to 620 m^3/day, as the first train is no longer functional. Other facilities have deteriorated significantly. The equipment with a relatively short lifespan have not been replaced or repaired due to financial constraints. The present water supply has been in such an unstable condition that only one clear water pump, without any standby available, and a rising main which ruptures frequently are now used. The Kapsabet Scheme Office has been managing to meet the growing water demand by increasing the amount of water supplied to 1,040 m^3/day and by limiting the time that water is supplied to the four different service zones. However, due to the functional constraints and the current water distribution pipe network, the residents in the eastern zone can get water all day, while those in the western zone cannot get sufficient water even during their allotted time of water supply. Thus, the water shortage problem is getting worse and the people have increasingly complained about the present water supply situation. The water treatment plant in Kapsabet cannot accomplish its primary mission, which is to supply good, safe water to its inhabitants.

In such circumstances, the Government of the Republic of Kenya prepared a rehabilitation and expansion plan for the Kapsabet Town water supply system and requested grant aid assistance from the Government of Japan for the implementation of the Project.

In response to the request from the Government of the Republic of Kenya, the Government of Japan decided to conduct a preliminary study on the Project for the expansion of the Kapsabet Town water supply system and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Kenya a preliminary study team from August 31 to September

20, 1992.

JICA subsequently sent to Kenya a basic design study team from June 15 to July 12, 1993. The team held further discussions with the officials concerned of the Government of the Republic of Kenya based on the results of the preliminary study and conducted a field survey.

2.2 Outline of the Request

An outline of the request is summarized as follows, on the basis of the contents of the request submitted by NWCPC through the Government of the Republic of Kenya in January 1990.

(1) Objectives of the Project

The main objective of the Project is to expand the Kapsabet Town water supply system, and thereby to make an active contribution to the improvement of the water supply situation in the Project area.

(2) Project Area (Figure 2.1)

The Project area is Kapsabet Town, with an area of 2.26 km^2 and its surrounding area within the Kapsabet Municipality of the Nandi Dis trict.

(3) Intent of the Request

The intent of the request is to expand the water supply capacity from the present 620 m^3/d to 7,200 m^3/day, to meet the water demand in the design target year of 2012, and will include the following rehabilitation and construction work:

1) Rehabilitation of Existing Water Supply Facilities

a. Rehabilitation of the intake facilities and renewal of the raw water transmission pipes
b. Rehabilitation of the water treatment plant and renewal of the clear water pumps

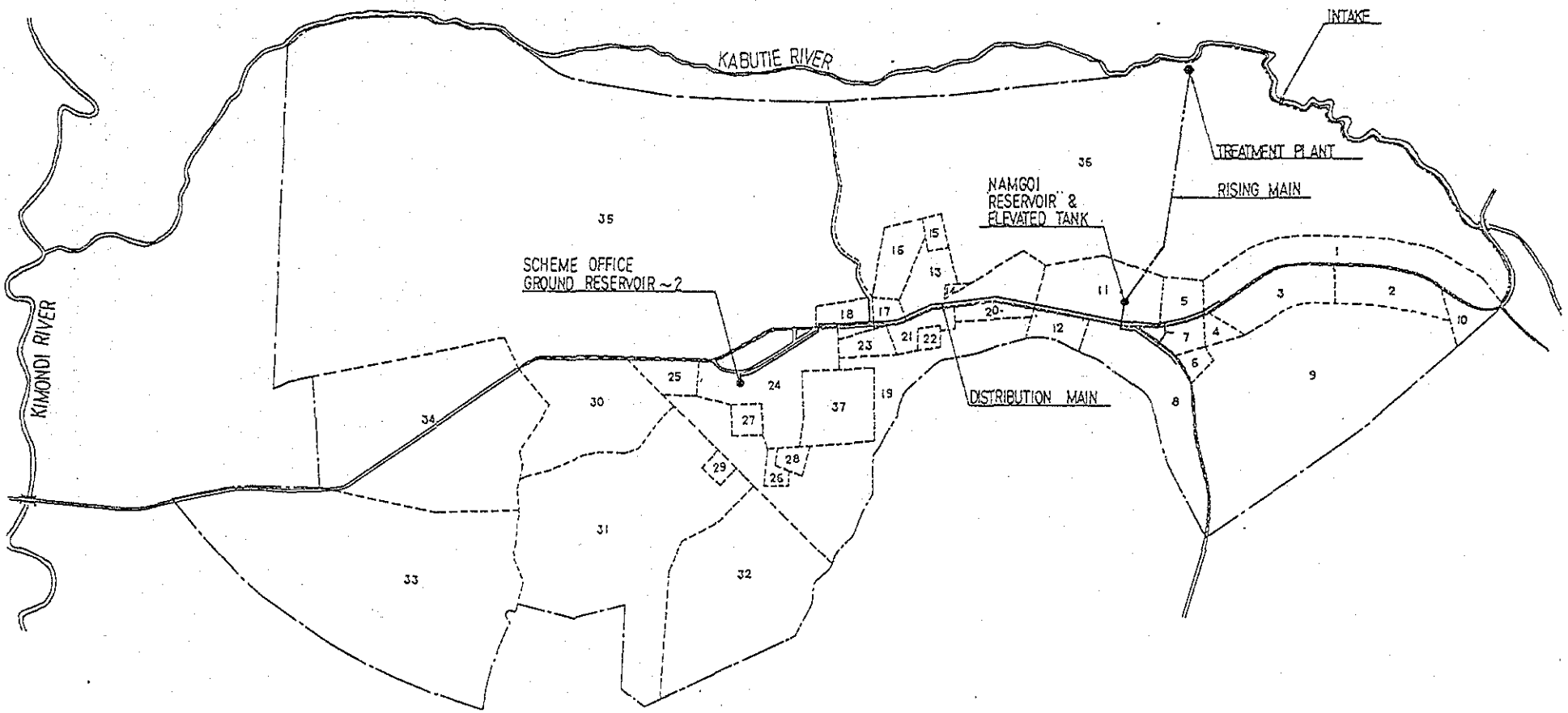


Figure 2.1 Location of Existing Water Supply facilities and Zoning of Service Area

2) Construction of Water Supply Facilities/Equipment

a. Construction of a water treatment plant with a capacity of 6,420 m^3/d

b. Construction of a clear water pump station and installation of rising pipes

c. Construction of ground reservoirs with elevated tanks

d. Installation of distribution pipes

With reference to the above contents requested by the Government of the Republic of Kenya, the following were agreed on and confirmed between the NWCPC and a JICA preliminary study team.

1) The rehabilitation of the existing water treatment plant will be excluded from the Project, because of the minimal utility realized by the rehabilitation of the plant due to its aging, out-of-date treatment method and small capacity. Therefore, the expansion of water treatment capacity shall be enhanced by means of construction of a new treatment plant.

2) Distribution pipes to be installed in the Project will be limited only to distribution mains which will connect the two reservoirs with elevated tanks to be constructed at the Scheme Office and the Bible College School. The rehabilitation and extension of the existing distribution pipes and the extension of the existing distribution pipes shall be undertaken by the Kenyan side.

3) The buildings and pipes for transmission and distribution to be constructed will have a planned 7,000 m^3/day capacity so as to meet the expected water demand in the design target year of 2012. However, the water treatment plant and reservoirs will be designed based on a water supply capacity of 5,000 m^3/day to meet the water demand in the design target year of 2002 for Phase 1, taking into account the initial shortage of an annual revenue.

However, the final components of the Project and the capacity of the facilities may differ from the above items, if it is found necessary to modify the facilities after further study.

2.3 Outline of the Project Area

2.3.1 Location and Socio-Economic Status of the Project Area

(1) Location and Traffic

Kapsabet Town is situated at about longitude 35°06' east and latitude 06°12' north (near the equator). It is at approximately 350 km from Nairobi via Nakuru, Timboroa and Lessos, on Routes 104, 36 and 37. It is 50km from Eldoret northeast via Route 39, and 69 km and 79 m from Kakamega and Kismu west, respectively, via Routes 1 and 39. It has no railway link and no airstrip. The nearest railway runs at Eldoret and Kismu and the nearest airport is in Kismu.

(2) Society

Kapsabet Town, like all other towns in Kenya, was a colonial creation. It was established in 1895 as the administrative headquarters of the Nandi District. Since that, dating from the times that the Sirikwa County Council was headquartered at Eldoret, Kapsabet has so developed as to have an urban council in July 1983, a town council in April 1986 and a municipal council at present.

The area, population and household number in 1989 of each area which composes Kapsabet Municipality is indicated in Table 2.1.

Kapsabet Town has an area of only 2.26 km^2 of the total area of 192 km^2 of Kapsabet Municipality.

According to the census, the population of Kapsabet was 2,298 in 1969, 2,945 in 1979 and 10,000 in 1989, which means the annual average growth rate was 2.5% during the former decade and 13.0% during the latter decade. The population growth was remarkable especially during the latter decade. However, the development of the town has been limited due to its lack of flat ground. Due to the undulating terrain, the people have been living along the national road outside the town or in the limited flat area adjoining

the town. Therefore, comparing the town with its surrounding area, the population scale outside the Kapsabet Town is almost double that of the town itself.

Table 2.1 Area, Population and No. of Households in 1989 in Kapsabet Municipality

		Area		Population		No. of Household	
		(km^2)	(%)		(%)	(HH)	(%)
1. Kapsabet Town	Loc.	14	7.4	10,000	22.2	2,828	32.2
2. Kipsigak	Sub-loc.	11	5.8	2,700	6.0	438	5.0
3. Kabirirsang	Sub-loc.	10	5.3	2,300	5.1	406	4.6
4. Kipture	Sub-loc.	12	6.3	2,700	6.0	449	5.1
5. Chepterit	Sub-loc.	18	9.5	4,750	10.5	746	8.5
6. Kiminda	Sub-loc.	25	13.2	7,100	15.8	1,148	13.1
7. Kamobo	Sub-loc.	45	23.7	6,500	14.4	1,263	14.4
8. Baraton	Sub-loc.	36	18.9	6,500	14.4	1,104	12.6
9. Kaptildil	Sub-loc.	19	10.0	2,500	5.5	403	4.6
Total		190	100.1	45,050	99.9	8,785	100.1

Source : Bureau of Statistics, Kapsabet

(3) Economy

Kapsabet Town is crowded, as it is an administrative center with district offices as well as local offices of the central government. The town has a substantial number of facilities for education. That is to say, aside from the normal day schools, there are boarding schools such as the Kapsabet Boys School, the Kapsabet Girls School, the Bible College School, the AIC Church & College School and the Deaf School. The enrollments in the four primary schools are 2,483, 1,089 in the three secondary schools and 497 in the nine nursery schools. This amounts to 4,500 students, including those in the Bible College School, the AIC College School and the Deaf School as of July 1990.

In addition, Kapsabet Town has been economically developing as a center for both the collection of agricultural goods produced in the surrounding area and the distribution of non-agricultural goods to the inter-district areas. As for industry, there are some small factories which process primary agricultural products such as tea

and milk as indicated in Table 2.2.

Table 2.2 Major Industries in Kapsabet Town

Name of Industry	Year of Establishment	Products	Production Capacity	Number of Employees
Chebut Tea Factory	1972	Processed Tea	3,000,000kg/yr	200
Furaha Bakery	1985	Bread (Loaves)	1,200loaves/yr	22
K.C.C. Milk Cooling Plant	1985	Milk Collection & Cooling	N.A.	32

2.3.2 Natural Conditions

(1) Climate

Rainfall measurement is conducted at the Kapsabet Girls School and at the Chebut Tea Factory, but the recording of temperature and humidity is not done in the town. For this reason, the rainfall is described below based on the past 7-year data (Table 2.3) from June 1986 to May 1993 at the Chebut Tea Factory, while the temperature and humidity based on the past 5-year data (Table 2.4) from January 1988 to December 1992 at the Eldoret Meteorological Station (see Figure 2.2).

Although nearer the equator, Kapsabet Town's climate is tempered by an altitude of about 1,970 meters above sea level. The average annual temperature is 16.9°C, with a 26.6°C maximum and a 8.1°C minimum. The monthly temperature fluctuation ranges 2 to 3°C from those annual values, hence, it is stable throughout the year. However, temperature has a hourly fluctuation of approximately 10°C between the night, early morning and the day. June to August is cold in general and a light mist is apt to occur.

As for rainfall, there is a big disparity between Eldoret and Kapsabet. The annual rainfall in Kapsabet Town is 2,090 mm, which is almost double the 1,070 mm at Eldoret. The number of rainy days is 150 days per annum and occur least in January, but rain occurs throughout the year. There are two rainy seasons: the long rains from March to September and the short rains from October to Decem-

Table 2.3 Rainfall at Cebut Tea Factory

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1986						41.6	107.5	121.6	116.6	49.9	50.5	39.5	
						11	16	12	10	8	9	6	
1987	60.1	36.1	137.4	120.4	159.9	123.6	70.8	121.1	61.0	50.3	164.2	38.7	1,143.6
	10	6	14	12	17	12	12	16	10	17	16	4	146.0
1988	72.2	60.3	203.1	444.5	146.5	219.0	185.2	291.9	189.1	87.9	65.4	40.8	2,005.9
	10	7	10	21	10	14	16	20	17	15	8	3	151.0
1989	59.2	144.0	183.3	364.6	413.0	167.0	171.8	466.4	259.8	170.9	61.0	120.1	2,581.1
	7	6	12	18	16	12	19	22	19	12	11	8	162.0
1990	92.3	378.9	262.9	371.3	163.2	166.0	233.0	319.5	154.9	168.5	58.7	173.1	2,542.3
	4	13	12	19	15	13	16	25	13	10	5	8	153.0
1991	85.9	44.9	214.9	366.0	361.9	237.4	258.8	226.3	164.9	370.4	56.3	65.8	2,475.5
	6	5	10	11	16	13	17	16	12	14	8	8	136.0
1992	9.5	95.5	51.7	291.1	250.4	283.2	271.5	321.6	451.5	329.5	41.6	80.7	2,477.8
	3	9	8	12	16	22	21	21	16	17	5	7	157.0
1993	205.4	90.8	15.9	189.1	403.2								
	13	10	6	14	21								
Mean	83.5	121.5	152.7	306.7	271.2	176.8	185.5	267.2	202.5	175.3	71.1	79.8	2,093.8
Max.	205.4	378.9	262.9	444.5	413	283.2	271.5	466.4	451.5	370.4	164.2	173.1	466.4
Min.	9.5	36.1	15.9	120.4	146.5	41.6	70.8	121.1	61.0	49.9	41.6	38.7	9.5

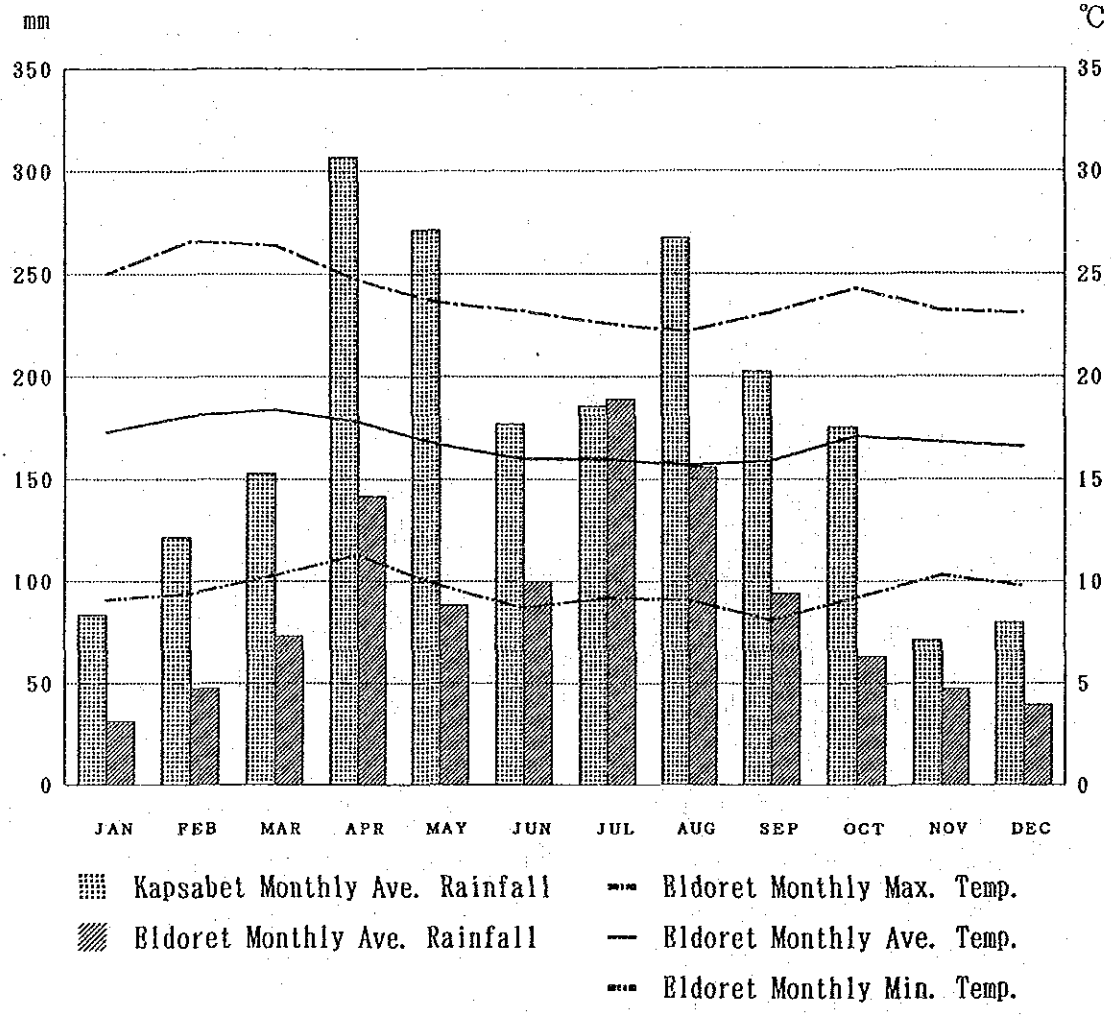


Figure 2.2 Climate of Kapsabet Town

Table 2.4 Temperature, Rainfall and Humidity at Eldoret Meteorological Station

Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
A. TEMPERATURE														
1988	Mean	17.9	19.6	19.2	18.8	16.3	16.6	16.5	16.0	16.1	16.9	16.9	16.2	17.3
	Max.	24.3	26.6	26.0	23.6	22.6	22.6	21.3	21.6	22.2	22.5	22.5	22.5	26.6
	Min.	10.5	12.5	12.4	13.7	9.8	10.5	11.7	10.4	9.9	11.2	11.2	9.9	9.8
1989	Mean	16.8	17.1	17.8	17.0	16.5	15.6	15.4	15.5	16.2	17.0	17.2	17.0	16.6
	Max.	24.3	24.3	25.3	22.2	22.2	22.3	20.4	21.9	22.2	22.8	22.6	23.1	25.3
	Min.	9.2	9.8	10.3	11.7	10.8	8.9	10.3	9.1	10.1	11.1	11.8	10.9	8.9
1990	Mean	16.9	18.1	17.4	17.3	17.2	16.0	15.8	15.8	15.6	17.2	16.8	16.7	16.7
	Max.	23.8	24.5	23.4	23.2	23.6	23.2	22.1	22.2	23.0	24.3	23.2	23.1	24.5
	Min.	9.9	11.7	11.4	11.3	10.7	8.7	9.5	9.3	8.1	10.0	10.3	10.3	8.1
1991	Mean	17.1	17.5	18.7	18.0	17.3	15.5	17.1	15.7	16.0	16.2	16.7	16.3	16.8
	Max.	25.0	25.5	25.6	23.8	23.1	20.9	22.6	21.6	23.1	23.2	22.6	22.8	25.6
	Min.	9.1	9.4	11.8	12.2	11.5	10.0	11.5	9.7	8.8	9.2	10.7	9.8	8.8
1992	Mean	17.7.	18.0	19.0	18.0	16.2	16.2	15.3	15.4	15.6	16.4	16.4	16.9	16.9
	Max.	24.9	25.9	26.4	24.7	22.2	22.3	21.3	21.1	22.3	22.3	22.2	22.6	26.4
	Min.	10.4	10.1	11.5	11.3	10.2	10.1	9.2	9.7	8.8	14.5	10.5	11.1	8.8
Mean		17.3	18.1	18.4	17.8	16.7	16.0	16.0	15.7	15.9	17.1	16.8	16.6	16.9
Max.		25.0	26.6	26.4	24.7	23.6	23.2	22.6	22.2	23.1	24.3	23.2	23.1	26.6
Min.		9.1	9.4	10.3	11.3	9.8	8.7	9.2	9.1	8.1	9.2	10.3	9.8	8.1
B. RAINFALL														
1988		55.7	8.7	35.5	192.1	40.5	146.4	170.2	107.9	134.2	58.8	24.8	16.3	991.1
		6	2	11	18	10	12	16	16	18	5	5	5	124.0
1989		15.0	46.0	121.3	159.1	151.8	101.2	206.9	125.7	110.0	58.9	41.2	116.2	1,253.3
		4	4	13	13	11	8	19	10	12	8	8	8	118.0
1990		45.3	156.3	65.6	128.1	113.3	21.2	164.7	107.8	88.1	21.4	62.0	35.5	1,009.5
		4	10	8	14	9	4	18	11	7	4	7	4	100.0
1991		38.0	11.6	129.3	50.7	48.7	130.8	222.7	192.5	41.8	48.9	68.6	15.7	999.3
		5	4	11	6	9	17	18	24	4	12	3	6	119.0
1992		2.6	14.1	13.3	177.6	87.1	100.0	179.8	244.7	95.8	127.8	39.4	12.4	1,094.6
		1	4	5	10	12	15	21	18	11	14	6	4	121.0
Mean		31.3	47.3	73.0	141.5	88.3	99.9	188.9	155.7	94.0	63.2	47.2	39.2	1,069.6
Max.		55.7	156.3	129.3	192.1	151.8	146.4	222.7	244.7	134.2	127.8	68.6	116.2	244.7
Min.		2.6	8.7	13.3	50.7	40.5	21.2	164.7	107.8	41.8	21.4	24.8	12.4	2.6
Max.(daily)		26.0	49.2	41.0	53.9	48.3	43.5	39.4	81.2	30.3	25.7	61.3	22.0	81.2
C. HUMIDITY														
1988		50	43	46	62	62	64	74	71	69	61	57	53	59
1989		49	43	47	64	65	63	71	67	61	60	60	60	59
1990		52	56	61	67	61	65	67	54	50	49	55	52	57
1991		44	39	47	58	60	71	73	74	60	56	57	55	58
1992		45	47	43	56	59	70	70	73	63	63	54	63	59
Mean		48	46	49	61	61	67	71	68	61	58	57	57	59
Max.		52	56	61	67	65	71	74	74	69	63	60	63	74
Min.		44	39	43	56	59	63	67	54	50	49	54	52	39

ber. Long rains fall mainly during the night and can be exceedingly heavy; they are often accompanied by thunderstorms. The short rains fall during the day and are comparatively light and drizzly. The annual extreme rainfall was 3,965 mm at the maximum and 293 mm at the minimum, while the monthly extreme maximum rainfall was 508 mm in November and the 24-hour extreme maximum was 100 mm in April.

The monthly average humidity is low or 46 to 49% in January to March and high or 57 to 71% in April to December, especially rather high or 67 to 71% in June to August. However, the monthly humidity is 74% at maximum and 39% at minimum.

(2) Topography

Kapsabet Town located at an elevation of 1,970 m above sea level and is long and narrow, stretching 3.2 km from east to west and 1.9 km from north to south, where Route 39 runs through from east to west almost on the ridge and divides the town into north and south areas. Several ridges branch from the above-mentioned main ridge to the north and south to form a complicatedly rolling land. The north has some deep and wide valleys towards the Kabutie River which flows westwards on a parallel course, and the south has a large, rolling valley towards the Chebarbar River which goes southwards. There are swamps along both the Kabutie River and the Chebarbar River.

The Kabutie River flows westwards and joins the Kimondi River, while the Chebarbar River goes southwards to join the Mokong River. The Kimondi River from the north joins the Mokong River from the east in the large South Nandi Forest, then flows westwards after changing its name to the Yala River and finally pours into the Victoria Lake.

(3) Geography

Geologically, the whole area of Kapsabet Town is covered by a thick sequence of reddish brown soils overlying Precambrian metamorphic rocks of the Kabirondian system which forms the basal geological layer and is exposed along some parts of the Chebarbar Valley.

2.3.3 Living Conditions

(1) Sanitation

The sanitation facilities used in Kapsabet Town are mainly composed of septic tanks and pit latrines. As mentioned later, the sewer network completed covers the most area of the Town, however, the houses have been not yet connected to the sewer network due to the incomplete construction works of the sewage treatment plant.

In a septic tank, the nightsoil receives sedimentation and anaerobic treatment and its effluent percolates through the soil. The sludge that accumulates in a concrete tank must be regularly removed. The pit latrine is generally manually dug. The liquid portion separated from the nightsoil soaks into the soil and the solid portion is accumulated in a pit. When the pit is almost filled with the solids, it is then covered with soil and a new pit is dug.

According to a survey in 1990, approximately 15% of houses use septic tanks and the remaining 85% use pit latrines. The former is concentrated in high class residences and some shops, and the latter is used by low class residences. In general, residences with indoor water connections have septic tanks to dispose of all wastewater, and those with a yard connection or without any water connection depend on unimproved pit latrines. Pit latrines are prevalent in the semi-urban areas: opposite the main bus park, Kamobo, showground environs, Kwa Wanja's place etc. and are of unacceptable or poor quality. The septic tanks function well in the zones where there is adequate space for effluent to percolate through the ground. Where backyards have limited areas due to high population densities, problems occur, for example, in the business-cum-residential flats near the Kapsabet Supermarket.

Individuals hire sanitation workers from the Eldoret Municipal Council at a minimum cost of Kshs. 1,500.00 for emptying a septic tank, which is a heavy burden to the residents. Contents from the town's septic tanks are emptied into a pit.

(2) Garbage Disposal

The removal and disposal of domestic waste is the responsibility of the Town Council. All collectors of the solid waste are Town Council employees, Presently, all solid waste collected is transported directly to the disposal site by the Council's tractor. In the Town the solid waste collection is confined to residential/commercial waste.

There are three problems within the Kapsabet solid waste collection and disposal system: (1) unreliability of collection in the periphial urban areas caused by a scarcity of collection trucks, (2) use of a variety of open dust-bins, and (3) roadside dumping and unsatisfactory conditions at the dump site.

2.4 Description of the Kapsabet Water Supply System

2.4.1 Managerial Conditions

(1) Water Sale Performance (see Table 2.5)

According to the past four year record from the fiscal year 1989 to 1992, the Kapsabet Scheme Office has produced the clear water at a rate of 960 to 1,090 m^3/day and sold 870 to 920 m^3/day on average annually. By checking this data carefully, the drastic changes can be found.

Table 2.5 Performance of Water Sales

Classification	1989/90	1990/91	1991/92	1992/93
Metered Volume				
Annual Consumption (m^3)	222,926	222,524	192,601	238,115
Percentage (%)	71.3	57.2	53.2	81.3
No. of Connections (nos.)	691	671	666	766
Assessed Volume				
Annual Consumption (m^3)	82,071	99,533	57,871	25,655
Percentage (%)	26.1	36.5	12.8	7.1
No. of Connections (nos.)	*1	*1	*1	*1
Not-metered Volume				
Annual Consumption (m^3)	16,693	14,946	63,930	56,929
Percentage (%)	2.6	6.3	34.0	11.6
No. of Connections (nos.)	9	64	65	165
Status of Meters (nos.)				
On Water Supply	2	2	1	1
On Connections	671	671	666	666
Serviceable in Store	10	9	9	0
Unserviceable	91	46	46	46
Sent for Repair	165	210	211	211
Total	939	938	933	924

*1 The number of house connections is included in that of the metered volume.
See in more detail in Tables A.1 and A.2 of Appendix.

The percentage of the water volume applied by the meter rate recorded the lowest of 53.2% (worst) in 1991 and then recovered to 81.3%, or up 28.1% within only one and a half years. This improvement is assumed to have been achieved by the repair of water meters, however, there is no evidence to show such improvement in meter repairing on the water supply operation chart during the same period as shown

in Annex 2 (It shows the rapid increase in water meters in 1992, however, such change gives only a four-month effect on the water volume, as the change occurred in March 1992). Interpreting this fact analytically, the number of water meters sent for repair was the same as that which were repaired and replaced. As shown in Annex 3, out of 12 bulk water consumers using the more than 1" meter, six have been applied by the assessed water volume and one has operated for some months applied by the assessed water volume. Therefore, it cannot be considered that the repair of the water meters was successfully accelerated.

The assessed water consumption means that the water consumption is estimated based on the past performance of the particular user due to the trouble of his water meter and recorded on the ledger. The water tariff is also applied to this assessed water consumption. Therefore, the increase in the assessed water volume in 1989 and 1990 implies that troubles occurred in many water meters.

The flat-rate-applied water volume set a record of 34.0% in 1991 and rapidly went down in the following year. The number of house connections to which the flat rate is applied shows little change between 1991 and 1992. The increase of 100 house connections in 1993 suggests that the per connection consumption went suddenly up and then down, since the monthly weighted consumption per connection was 21.4 m^3 in 1990, 82.0 m^3 in 1991 and 44.8 m^3 in 1993. As the flat-rate-applied user has no water meter as a rule, it is doubtful that the Scheme Office could have effectively measured this change.

Since the increase in the water consumption by the flat-rate-applied users did not bring an increase in the revenue of the Scheme Office, the water consumption by the flat-rate-applied users might be counted backwards to get a good unaccounted-for water ratio.

(2) Unaccounted-for Water Ratio (see Table A.1 of Appendix)

The master meter to measure the water volume transmitted from the water treatment plant was out of order since December 1991, therefore, the water volume from that time were estimated. The unaccounted-for water r

functioning was approximately 13% on average annually and 27.6% at the peak. The annual average dropped by 7.5% in 1992 when the master meter was still in use and by 6.4% in 1993 when it was out of order in the middle of the year.

The year of 1991 corresponds to the year when the flat-rate-applied water volume suddenly increased as mentioned earlier.

These unaccounted-for water ratios were calculated assuming the water volume used by connections with troubled water meters and without any water meters, but it is deemed rather lower than the actual one, taking into account the present situation of water supply such as the limited time of water supply and the low water pressure. The actual unaccounted-for water ratio is estimated at around 20%. After the completion of the Project, the conditions for water supply will be improved and water pressure in the distribution pipe will be increased. Therefore, as the unaccounted-for water ratio will rise by more than 30% if there is no improvement to the present rising main and distribution pipe network, it is necessary for the Kenyan side to prepare and implement the leakage prevention program for the existing distribution pipes before the extension of the service area.

(3) Water Rate Collection (see Table 2.6)

There are many unpaid users. The fact that the rate of the collected amount to the billed amount is over 100% suggests that there are much payment by the unpaid users in the particular month. As a rule, when the user does not pay the water charge for more than three months, the Scheme Office takes action to stop the water supplied to that user. There is no seasonal change in collection. The collected amounts are, as a whole, below the billed amount (70 to 90% of the billed amount).

(4) Expenditure and Revenue (see Table 2.7)

The revenue from water charge collections has not covered the expenditures required in the Kapsabet Scheme Office. This problem

Table 2.6 Monthly Water Sales, Production and Revenue

Year		Item	Unit	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
	A.	Produced	cu.m	30,480.00	30,743.00	29,008.00	29,546.00	32,908.00	31,154.00	31,449.00	33,923.00	33,072.00	33,589.00	33,271.00	34,425.00	383,568.00
	B.	Sold	cu.m	28,492.00	26,839.00	24,574.00	23,729.00	26,500.00	27,794.00	29,760.00	29,896.00	26,258.00	25,611.00	27,361.00	29,940.00	326,754.00
	C.	Billed	ksh	59,560.00	56,054.00	51,404.00	49,634.00	59,376.00	57,956.00	61,676.00	52,640.00	51,290.00	53,593.00			553,583.00
1989/90	D.	Collected	ksh	17,945.50	29,240.80	31,336.00	19,376.50	55,214.35	27,174.10	30,019.00	20,000.50	40,188.00	54,383.00	40,187.00	31,678.25	396,745.00
		D/C	%	30.13	52.17	60.96	38.88	92.99	46.89	48.51	37.99	78.35	101.47			71.67
	A.	Produced	cu.m	33,681.00	35,128.00	33,014.00	32,530.00	33,615.00	33,731.00	31,878.00	31,616.00	29,735.00	34,255.00	32,616.00	37,219.00	399,021.00
	B.	Sold	cu.m	26,075.00	24,937.00	29,165.00	29,216.00	26,560.00	28,395.00	29,243.00	27,058.00	25,628.00	31,233.00	26,824.00	32,057.00	336,391.00
	C.	Billed	ksh	52,150.00	49,874.00	58,330.00	59,216.00	53,560.00	56,790.00				57,863.50	56,039.00	56,740.00	500,562.50
1990/91	D.	Collected	ksh	54,574.50	47,948.00	93,353.40	90,562.50	38,670.50	35,976.00	46,862.00	40,958.50	53,346.00	40,869.50			543,122.90
		D/C	%	104.65	96.14	160.04	152.94	72.20	63.35				70.63			108.50
	A.	Produced	cu.m	32,713.00	26,180.00	30,247.00	31,428.00	29,988.00	29,532.00	30,209.00	30,002.00	25,716.00	24,913.00	27,065.00	32,754.00	350,749.00
	B.	Sold	cu.m	27,898.00	23,914.00	27,583.00	28,846.00	27,634.00	26,521.00	27,688.00	27,912.00	24,754.00	23,560.00	22,685.00	30,407.00	319,402.00
	C.	Billed	ksh	38,686.50	37,748.00	32,440.50	108,905.50	147,022.50	92,314.00	92,320.00	88,548.00	88,040.00	74,013.00	82,684.50	92,160.50	974,883.00
1991/92	D.	Collected	ksh	33,497.00	28,867.50	45,988.00	34,783.10	44,916.50	50,232.00	67,833.00	98,465.50	116,708.00	41,734.00	60,016.00	76,017.00	699,059.60
		D/C	%	86.59	76.47	141.76	31.94	30.55	54.41	73.48	111.20	132.56	56.39	72.59	82.48	71.71
	A.	Produced	cu.m	28,926.00	28,475.00	26,162.00	28,381.00	26,936.00	27,418.00	31,405.00	33,130.00	24,700.00	33,600.00	31,500.00	32,250.00	352,883.00
	B.	Sold	cu.m	27,697.00	25,463.00	23,685.00	24,550.00	24,749.00	25,318.00	27,842.00	28,775.00	32,000.00	31,000.00	30,000.00	29,250.00	330,529.00
	C.	Billed	ksh	83,331.00	76,323.00	80,322.50	220,065.50	57,239.00	63,990.00	66,988.50	66,596.50	85,319.50	67,430.50	75,618.00	82,027.00	1,025,251.00
1992/93	D.	Collected	ksh	101,444.50	88,411.00	81,344.50	162,327.00	40,325.50	45,146.50	70,905.00	84,949.00	72,478.50	85,655.00	58,232.00	41,876.50	933,095.00
		D/C	%	121.74	115.84	101.27	73.76	70.45	70.55	105.85	127.56	84.95	127.03	77.01	51.05	91.01

Table 2.7 Monthly Revenue, Expenditure and Average Cost of Production, Western Region

Water Supply	Water Produced *1 (m³) A	Water Unaccounted-for (m³) B	Revenue Target (KShs) C	Revenue Billed (KShs) D	Revenue Collected (KShs) E	Revenue Outstanding (KShs) *2 F	Expenditure *2 O&M *4 (KShs) G	Expenditure Electricity (KShs) H	Expenditure Salaries (KShs) I	Expenditure Total *5 (KShs) J	Cost of Water Prodction (KShs/m³) J/A	Revenue *6 Billed (KShs/m³) Dx0.9/A	Total Average Cost (KShs/m³) J/(A-B)
BUNNGOMA	72,000	6,000	250,000.00	250,389.30	342,936.85	382,037.30	154,425.00	105,527.85	114,925.00	393,621.7	5.5	3.1*3	6.0
LITEIN	248,400	82,031	330,000.00	325,477.20	207,865.50	290,729.20	90,885.00	296,864.35	72,825.00	483,603.1	1.9*7	1.2	2.9
SHITOLI	14,070	5,591	200,000.00	41,048.00	16,243.00	266,761.05	108,221.75	42,193.05	48,195.00	208,540.3	14.8	2.6	24.6
KAKAMEGA	131,682	43,734	410,000.00	584,216.40	775,800.50	2,285,995.45	215,100.00	199,110.50	96,055.00	535,778.8	4.1	4.0	6.1
CHEBANG'ANG	36,000		50,000.00	10,790.00	7,226.00	83,262.35	4,000.00	.00	19,370.00	24,538.5	0.7	0.3	0.7
NYAKACH	42,960	18,902	160,000.00	31,771.00	18,310.00	190,870.05	25,841.80	54,920.00	74,285.00	162,799.1	3.8	0.7	6.8
KISII	103,734	38,156	250,000.00	331,928.60	405,925.00	939,499.50	169,610.00	229,198.45	168,315.00	595,479.6	5.7	2.9	9.1
SIAYA	23,240	1,519	150,000.00	96,135.00	218,699.00	532,536.90	40,495.00	42,605.10	63,565.00	153,998.4	6.6	3.7	7.1
M/KOMBEWA	54,202	41,736	160,000.00	36,230.00	42,144.00	193,446.45	106,250.70	.00	53,955.00	168,216.0	3.1	0.6	13.5
KAPSABET	32,400	6,966	160,000.00	75,618.00	58,832.00	217,180.00	30,640.00	45,000.00	51,640.00	133,644.0	4.1	2.1	5.3
R/OFFICE							148,374.30	.00	218,855.00	385,590.8			
TOTAL	758,688	244,635	2,120,000.00	1,783,603.50	2,093,981.85	5,382,318.25	1,093,843.55	1,015,419.30	981,985.00	3,245,810.2	4.3	2.1	6.3

*1 Water production estimated since there are no master meters.
*2 Cumulative.
*3 Depreciation of assets not taken into account.
*4 Including telephone bills.
*5 Including 5% overhead costs from headquarters.
*6 Assumong 10% bad debt.
*7 Estimate of water production in LITEIN likely to be much higher than actual.

is not limited to only the Kapsabet Scheme Office but also applied to other scheme offices under the Western Regional Office and also to other scheme offices under the NWCPC. Strictly speaking, the profit from the Mombasa and Coastal Water Supply System is appropriated to make up for the losses by other scheme offices. The rate of the expenditures to the revenue at the Kapsabet Scheme Office was 1.96 in May 1993 which is a little better than the average of all the scheme offices under the Western Regional Offices.

2.4.2 Condition of the Facilities

The location of the existing water supply facilities and major distribution pipes are shown in Figure 2.1.

(1) Intake Facilities

The intake weir was constructed in the Kabutie River to take water for the existing water supply system, and is affixed to the rocks exposed in the Kabutie River, but there are considerable water leaks emanating from its bottom. The base of the intake weir is deemed to be partly consisting of boulders which may cause the leakage. According to this finding, the safety in the strength and stability of the intake weir itself are doubtful and this requires a detailed survey before using the intake weir continuously in future.

Although the connecting part of the intake pipe with the intake weir cannot be observed as it is buried under the soil, it has a possibility to be clogged with soil. Therefore, it is necessary to change the structure of this connecting part.

The water taken at this intake weir flows to the water treatment plant by gravity.

(2) Water Treatment Plant

The first train of the existing water treatment plant was constructed in 1948 and subsequently expanded in 1960 and in 1980 to have a treatment capacity of 820 m^3/day, however, the first train is no

longer used due to its age. The present treatment capacity is 620 m^3/day with the two functional trains. But the plant operates to produce water at the rate of 960 to 1,100 m^3/day and is obviously in an overloaded condition.

The plant is not well operated and maintained as described below.

- The basins receive no cleaning.
- The dosing rate and volume of chemicals, especially alum and soda ash does not correspond to the quality of raw water and the constant volume is always dosed. The dosing rate during the field survey was 40 ppm in alum, 10 ppm in soda ash and 1 ppm in chlorine which were proper during the dry season when the quality of raw water was relatively stable. However, according to the water supply operation chart, there were little change in the dosing rate of chemicals against the change in the quality of raw water during the wet season. The chemical dosing control is not well done.
- It is impossible to determine the proper dosing rate due to the lack of the flow meter for raw water.
- The chemical volume dumped into the chemical solving tank is not correctly measured but done by eye measure.
- The quality of raw water and treated water is not analyzed due to the lack of analyzing instruments in the laboratory (the Scheme Manager possesses only a color comparator test kit for residual chlorine monitoring. As stated previously, the plant cannot function fully due to its age and it has been operated in an overloaded condition--namely 160% of its treatment capacity. The quality of clear water is 10 to 20 color unit in color and 10 to 20 NTU in turbidity which does not meet the Drinking Water Standard of the WHO, which is 15 color unit in color and 5 NTU in turbidity. During the implementation of the Project, it will be necessary to train the engineer using on- the-job-training so he will understand the basic principles of water treatment technology .
- The operators operate and clean each facility without understanding the objective, operational method or the operational procedure.

- Some equipment is left unrepaired in spite of their necessity; for example, (1) the drain valve of the basin cannot be opened, (2) the standby pump is left inoperable, and (3) the master meter is also left not functioning.
- As handrails and steps necessary for maintaining the basins are not provided, it is impossible to effectively operate the basins.

The condition of each facility is as follows:

As for the rapid mixing chamber, hydraulic mixing by the triangle notch is used for the second train and mixing by horizontally baffled flow is used for the third train. In both trains, only alum is fed into the rapid mixing chamber and soda ash is fed before the clear water reservoir for pH adjustment. For this reason, the pH is around 7 in raw water, 5.7 to 6.0 at the outlet of the rapid mixing chamber after coagulant dosing, and 5.3 to 5.9 at the outlet of the sedimentation basin, which is out of the proper range for alum dosing. Soda ash be fed into the rapid mixing tank with alum to adjust the pH and to form the settlable floc.

As the sedimentation tank is operated with a hydraulic load of double the treatment capacity in addition to the unsettlable floc, the velocity in the basin is double of that during the normal operation and the floc is carried over without settling.

There is no surface washing equipment in the second and third trains and back washing is not well done due to low backwashing velocity. There is little filter sand in the third filter so that underdraining is observed. It means that there is no filtration effect in the third filter. Furthermore, the sludge made of floc is piled on the bottom. As for the second filter, there is no way to observe the condition of the filter sand due to a non-functioning drain valve.

The clear water reservoir is always kept filled with treated water at the volume exceeding the clear water pump capacity.

(3) Transmission Facility

A variety of switches for power receiving and for operation control are installed concentratedly or in a scattered manner in the clear water pump station. Due to poor maintenance, the voltage meter and the ampere meter for power reception are out of order; the switches are heavily worn and the clear pump No.2 is inoperable.

The present water supply is maintained with the continuous operation of the clear water pump No.1, therefore, if it ceases to function, the water supply operations will be forced to halt. In addition to this, the water volume transmitted from the water treatment plant cannot be measured due to the broken master meter. There are some descriptions in the water supply operation chart which note the consequences of the clear water pump No.1 being out of order.

As the clear water pump has a head of more than 10 kg/cm^2, it is recorded that frequent bursts in the rising main cause leaks to occur(see Table 2.8).

(4) Distribution Facilities

The clear water transmitted by the clear water pump enters into the ground reservoir and the elevated tank at Namgoi. The water from the elevated tank is distributed to the center of the town and its surrounding area by gravity and is supplied to two ground reservoirs at the Kapsabet Scheme Office for the distribution to its peripheral low land service area. However, one of them has been not in use due to heavy leakage problems since its completion. The remaining one, although available, has been idle due to a lack of inflow for distribution. For this reason, some residents in the neighborhood who cannot receive a sufficient water supply refuse to pay the water charge and the situation has gotten serious.

To supply the water to the elevated tank at the Bible College School near Namgoi, a single phase, 240 V small booster pump is installed at the outflow pipe from the ground reservoir at Namgoi, however, its operation switches have deteriorated due to continuous use.

TABLE 2.8 RECORD ON BURSTS

Year	Month	Contents of Burst (Estimated Loss)
1989	Jul.	burst on 6" PVC rising main (50 m^3)
	Aug.	bursts on 6" PVC rising main (200 m3) and line (50 m3)
	Sep.	bursts on 6" PVC rising main, 4" line and the other (290 m3)
	Oct.	bursts on 4" main (250 m3) and 1" line (20 m3)
	Nov.	leakage on 6" PVC rising main
	Dec.	frequent bursts on 6" PVC rising main mainly (1,100 m3)
1990	Jan.	repair on 6" PVC rising main (300 m3) and burst on 3" line (50 m3)
	Feb.	burst on 6" PVC rising main (300 m3)
	Mar.	burst on 6" PVC rising main (260 m3) and 2" PVC line (280 m3)
	Apr.	burst on 4" line (80 m3)
	May	burst (180 m3)
	Jun.	burst on 3" line (60 m3)
1990	Jul.	burst on 6" PVC rising main (200 m3)
	Aug.	bursts on 6" PVC rising main (250 m3), and on 4" and 1" lines (250 m3)
	Sep.	two bursts on 6" PVC rising main (450 m3)
	Oct.	burst (550 m3)
	Nov.	damage by grader (250 m3) and burst on 3" line (80 m3)
	Dec.	two bursts on 6" PVC rising main (500 m3) and burst on line (300 m3)
1991	Jan.	
	Feb.	burst on 6" PVC rising main (300 m3)
	Mar.	two bursts on 6" PVC rising main (600 m3)
	Apr.	
	May	two bursts (1,200 m3)
	Jun.	burst (600 m3)
1991	Jul.	three bursts (900 m3)
	Aug.	two bursts on 6" PVC rising main (140 m3)
	Sep.	burst on 6" PVC rising main (900 m3)
	Oct.	burst on 6" PVC rising main (300 m3)
	Nov.	burst on 6" PVC rising main (300 m3)
	Dec.	burst on 6" PVC rising main (300 m3)
1992	Jan.	burst on 6" PVC rising main (600 m3)
	Feb.	
	Mar.	
	Apr.	
	May	burst on 6" PVC rising main (300 m3)
	Jun.	two bursts (600 m3)
1992	Jul.	
	Aug.	burst on 6" PVC rising main (500 m3)
	Sep.	burst on 6" PVC rising main (600 m3)
	Oct.	frequent bursts on 6" PVC rising main
	Nov.	burst on 6" PVC rising main (600 m3)
	Dec.	frequent bursts on 6" PVC rising main (900 m3)
1993	Jan.	
	Feb.	frequent bursts on 6" PVC rising main (1,000 m3)
	Mar.	bursts on 6" PVC rising main (700 m3)
	Apr.	frequent bursts on 6" PVC rising main (500 m3)
	May	
	Jun.	

The eastern area of the town receives 24-hour water supply from the elevated tank at Namgoi, while the other area receives a time-limited

water supply. Two workers are engaged in the valve operation for this purpose.

2.4.3 Condition of Water Supply

(1) General

There is a big gap between the water demand in the service area and water supply from the existing facilities due to the rapid increase in urban population and the aging water supply facilities. The measures are noted blow currently taken in light of this situation. However, complaints about insufficient water supply even at the allotted time of water supply, for example, have increasingly become serious.

- limitation of service area
- 24-hour operation of a water treatment plant
- overloaded operation exceeding the treatment capacity
- time limitation of water supply

As of June 1993, the status of water supply is as follows:

1) Number of House Connection 931

with meter	720
with meter out of order	46
without meter	165

2) Amount of Water Supply

The actual amount of water supply by type is as follows:

The water tariff of the NWCPC is applied to the users in the Kapsabet Town water supply system. The users without meters are applied by the flat rate, but their exact water consumption cannot be confirmed. The installation of water meters to all users is indispensable for the normal management of the waterworks, especially after the completion of the Project.

Table 2.9 Amount of Water Supply by Type

Type	No. of HH	Water Supply (m^3/mo)	Consump. per HH (m^3/mo)
w/ meter	720	23,780	33.0
w/ meter out of order	46	2,080	45.2
w/o meter	165	3,390	20.5
Total	931	29,250	31.4

The water consumption of the user with a meter which is out of order is calculated based on the user's past performance and the meter rate is applied to the assessed consumption.

3) Service Coverage

According to the 1989 census, there were 2,828 households in Kapsabet Town and this number will be an estimated 3,200 in 1993.

The Kapsabet Scheme Office has no survey on the past service coverage and the number of house connections is the only data available. Assuming that one house connection is used by two households, the service coverage is predicted at approximately 45%.

Even at present, when the water shortage is serious, the Scheme Office supplies water to 80 to 90% of new applicants for water supply. Out of these applicants, the number of the residents who live in the service area and want to change the type of water supply from the common faucets to the house connection is the largest, and followed by immigrants from the outside of the service area, and then residents living outside the service area but requesting water supply.

As the water demand is ever increasing, caused by such new application for water supply and by the increase in water

consumption caused by improvement of life style. The water pressure in the distribution pipes has dropped near the ends of distribution pipe networks and causes shortages. Resulting from this situation, more than 200 users have canceled their use of the water supply, which shows the serious situation of water supply.

Figure 2.3 shows the area where the water supply is insufficient, which is prepared based on the opinion of the Scheme Office staff and the results of the questionnaire survey and water pressure survey conducted during the basic design study.

(2) Questionnaire Survey

In order to understand the present condition of water supply in the Project area, a questionnaire survey was conducted by visiting local houses, hotels, etc. during the field survey. To get the general result, the households served and unserved by water supply in each service zone, which was set for administration of the water supply service by the Scheme Office, were studied to get well-balanced information and the sum of collected data was 83, out of which 58 were from inside the service area and 25 were from outside the service area. The result of the survey is shown below.

1) Number of Collected Data (see Figure 2.3)

The number of collected data is as follows:

Table 2.10 Number of Interviewees

Zone	I	II	III	IV	Total
Inside	18	12	18	10	58
Outside	6	4	10	5	25
Total	24	16	28	15	83

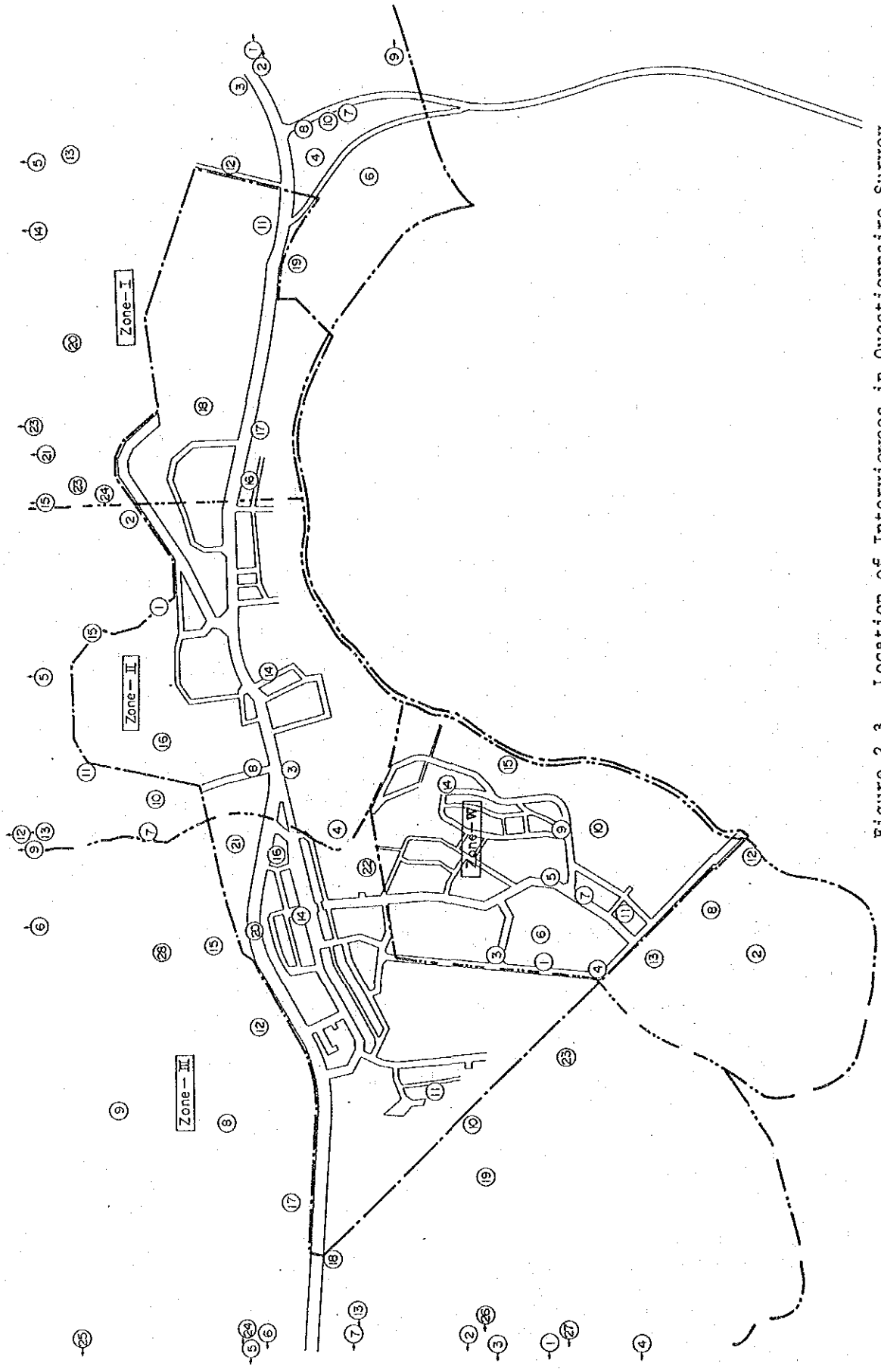


Figure 2.3 Location of Interviewees in Questionnaire Survey

2) Classification of Water Service

Water service is classified as follows:

Table 2.11 Classification of Water Service

Zone	I	II	III	IV	Total
1. House connection w/ meter	15	10	15	9	49
2. House connection w/o meter	0	1	2	0	3
3. Common house connection w/ meter	3	1	1	0	5
4. Common house connection w/o meter	0	0	0	1	1
Total	18	12	18	10	58

3) Situation of Leakage from Water Supply Equipment

The situation of water leakage from water supply equipment such as faucets and meters is as follows:

Table 2.12 Situation of Leakage from Supply Equipment

Zone	I	II	III	IV	Total
1. No leakage	6	1	2	1	10
2. A little of leakage	10	9	10	8	37
3. With leakage	2	2	6	1	11
Total	18	12	18	10	58

The water leakage from water supply equipment amounts to 83 % of the interviewees which is expected to increase after the implementation of the project because the water pressure in the distribution pipes will be improved and increased.

4) Time of Water Service

The time of water service a day in which consumers can obtain water are as follows:

Table 2.13 Time of Water Service from Waterworks

Zone	I	II	III	IV	Total
1. Less than 6 hrs.	1	2	8	0	11
2. 6-10 hrs.	2	5	6	0	13
3. 10-12 hrs.	4	0	2	0	6
4. All the day	11	3	0	0	14
5. No water even during supply hour	0	2	2	10	14
Total	18	12	18	10	58

It is observed that Zones I and II are in a good water supply condition with suitable pressure due to the area being nearby to the ground reservoir and elevated tank. Zone IV on the other hand, is in the worst situation with almost no water pressure, even though it is located in the lower elevation of the service area, because the area is situated at the end of the distribution pipe network and as a result faces a shortage of water.

5) Water Consumption

The monthly water consumption per family inside and outside the existing service area are classified as shown in Table 2.14. The residents who get insufficient water from the waterworks use river water, spring water or rain water that is collected from the roofs of residential houses. This volume of water is also added to the water consumption.

The survey results indicates that the number of families who use water less than 30 m^3 per month is the upper limit for the basic charge is 39 families, or 67 %. This figure is expected to increase with the improvement of the water supply situation after the completion of the Project.

Table 2.14 Water Consumption

Zone / In-/Outside	I In.	I Out.	II In.	II Out.	III In.	III Out.	IV In.	IV Out.	Total In.	Total Out.
1. Less than 10m^3/mo	6	3	7	1	5	2	4	1	22	6
2. 10-20 m^3/mo	1	2	3	2	4	0	1	1	9	4
3. 20-30 m^3/mo	2	0	0	0	3	2	3	1	8	3
4. 30-40 m^3/mo	6	1	1	0	4	2	2	1	13	4
5. 40-50 m^3/mo	2	0	1	0	2	3	0	0	5	3
6. More than 50 m^3/mo	1	0	0	0	0	1	0	0	1	1
7. No answer	0	2	0	1	0	0	0	1	0	4
Total	16	8	12	4	18	10	10	5	58	25

6) Water Usage

The water usage is classified as follows:

Table 2.15 Water Usage

Zone / In-/outside	I In.	I Out.	II In.	II Out.	III In.	III Out.	IV In.	IV Out.	Total In.	Total Out.
1. living only	6	1	8	0	12	3	4	1	30	5 (42%)
2. living + livestock	11	5	4	4	6	6	6	4	27	19 (56%)
3. living + livestock + others	1	0	0	0	0	1	0	0	1	1 (2%)
Total	18	6	12	4	18	10	10	5	58	25(100%)

The number of families who use water for the purpose of living only is 35 or 42% of the total families interviewed in the study, which is further classified into 52% for inside and 22% for outside of the existing service area. As for the families outside the existing service area in the Project area, 80% of these families use water for livestock and other purposes.

7) Rate of Water Usage for Livestock

The rate of water usage for livestock compared to the total consumption at each family who answered in Items 2 or 3 in the above 7) is calculated as follows:

Table 2.16 Rate of Water Usage for Livestock

Zone	I	II	III	IV	Total
1. Less than 20%	4	3	6	1	14
2. 20-40%	10	3	2	5	20
3. 40-60%	2	2	3	2	9
4. More than 60%	1	0	2	2	5
Total	17	8	13	10	48

It is estimated that the rate of water usage for livestock is about 17% (58% x 30%) of the total consumption in the Project area. This figure will decrease when the Project is completed, since the usage volume for living will be increased by the improvement of the water supply situation and life style. In this situation, the water usage for livestock is calculated at 366 m^3/day or 13.7 % of the total consumption reported in 1990 in the Feasibility Study Report prepared by the NWCPC.

8) Complaints/Requests to the NWCPC

In the survey, complaints/requests of the consumers to the NWCPC regarding to water supply is as shown below.

Table 2.17 Complaints/Requests of Consumers to NWCPC

Zone	I	II	III	IV	Total
1. No	5	0	0	0	5
2. Yes	11	12	18	10	51
Breakdown of the above					
- Shortage of water	6	9	17	10	42
- Low pressure of water supply	9	6	15	10	40
- No water during supply hour	1	3	15	10	29
- Problem on water quality	4	2	1	0	7
- Hour-restricted water supply	1	3	0	0	4
- Leakage trouble	1	1	0	1	3

The result shows that 90% of the surveyed consumers in the area had made some complaints/requests to the NWCPC. Such complaints/ requests deal mainly with the shortage of water, though there are a few complaints regarding water quality, which suggests that the improvement of the existing water

supply system is an urgent matter for the people living in the Project area.

9) Supplemental Water Source

The water sources which were used for daily consumption by the people living outside the existing service area, and were used to supplement the water supply by the people living inside the existing service area, were determined to be the following:

Table 2.18 Other Water Sources for Consumption

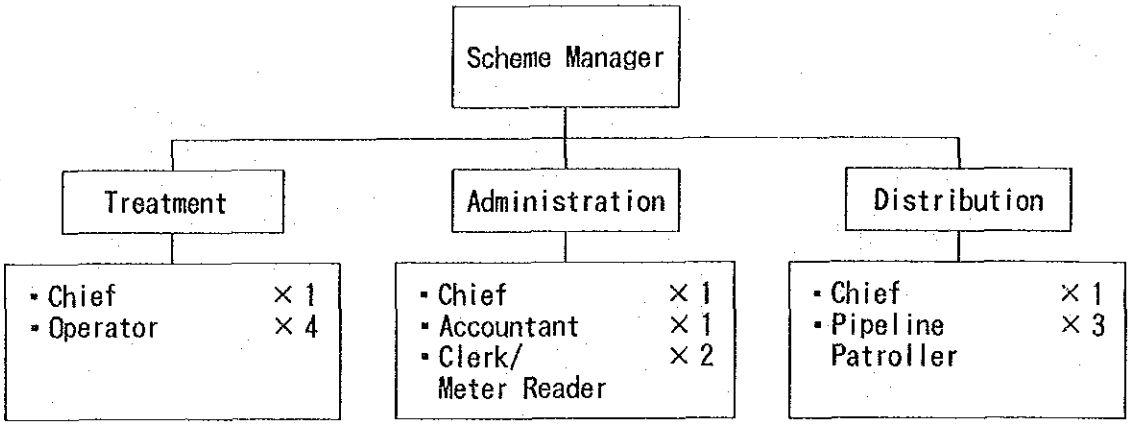
Zone	I		II		III		IV		Total	
In-/Outside	In.	Out.	In.	Out.	In.	Out.	In.	Out.	In.	Out.
1. River water	1	3	0	2	1	0	0	0	3	5
2. Spring Water	0	2	1	2	4	3	2	3	7	10
3. River and/or spring+Rain water	0	1	0	0	12	7	8	2	15	10
Total	1	6	1	4	17	10	10	5	25	25

Ten families use the river or spring water inside the existing service area and 15 outside of the existing service area. Also, the number of families which use rain water from the roof in addition to the above are 15 and 10, respectively. Consequently, 25 families or 43%, almost half of the total interviewees inside the existing service area, use other water sources to supplement their water supply because of the shortages caused by the troubled waterworks.

2.4.4 Management Organization

Based on the organizational structure of the NWCPC, (Figure 2.4) each scheme office is responsible for water supply service and for collection of water charges. The Kapsabet Scheme Office tasks are the operation and maintenance of the water treatment plant and reservoirs, the maintenance of the distribution pipe network and water meters, and taking applications for water supply and the water charge collection duties.

Figure 2.4 Present Organization Chart of Kapsabet Scheme Office



2.5 Outline of the Kapsabet sewerage Project

2.5.1 Background of the Sewerage Project

The Kapsabet Sewerage Project has the following historical background:

Sep. 1981	The chief engineer water of the MWD instructed African Consulting Engineer to carry out the preliminary design for the Project.
July 1985	African Consulting Engineer submitted "Preliminary Engineering Report for Kapsabet Sewerage Project" to the MLG.
Dec. 1989	African Consulting Engineer submitted "Final Engineering Report for Kapsabet Sewerage Project" to the MLG.
Apr. 1990	Intex Construction Ltd. commenced the construction work with a construction period of two years. The MLG extended the completion date of the construction work by Intex Construction Ltd. by November 30, 1992.
Apr. 1992	The MLG suspended the construction work by accepting the claim from Intex Construction Ltd. that the 50 to 60% escalation of the material cost could not be covered by the contingency which was set at 10% to the total direct construction cost.

2.5.2 Outline of the Sewerage Project

The subject area of the Kapsabet Sewerage Project covers Kapsabet Town and its periphial urban area including the Kapsabet Girls School in the east, the western area adjoining the Chebut Tea Factory in the west, the northern area adjoining the national road in the north, and Showground in the west (see Figure 2.5).

The scheme is divided into two phases as indicated in Table 2.19.

Table 2.19 Outline of the Kapsabet Sewerage Project

	Target Year	Design Population	Design Flow (m^3/day)
Phase 1	1995	5,226	1,290
Phase 2	2005	7,480	1,820

As Kapsabet Town is long and narrow, being originally developed along the national road running on the ridge from east to west, it is natural that the town is topographically divided into northern and southern areas in the planning of a sewerage system. The sewage treatment plant is located in the southern area where the major facilities in the town are concentrated. The sewage generated in the southern area is gravitated to the sewage treatment plant, while that in the northern area is collected to the sewage pump station and then pumped to the main plant in the southern area, running along the national road. Phase 1 covers most of the southern area and Phase 2 covers the northern area and Showground in the southern area. Sewers in Phase 1 are planned under/along the roads, but those in Phase 2 are on private land along the topographical contour line due to the absence of a road.

The location of the sewage treatment plant for Phase 1 was expected to be along the Chebardar River, which formed the boundary of the town, in the preliminary engineering design, but this was changed a location in the Ururu Forest along the Chebarbar River 2 km southward of the initial location, as the Phase 2 plant site is planned to be placed adjoining to that of Phase 1. Alternatively, it was suggested that a site be looked

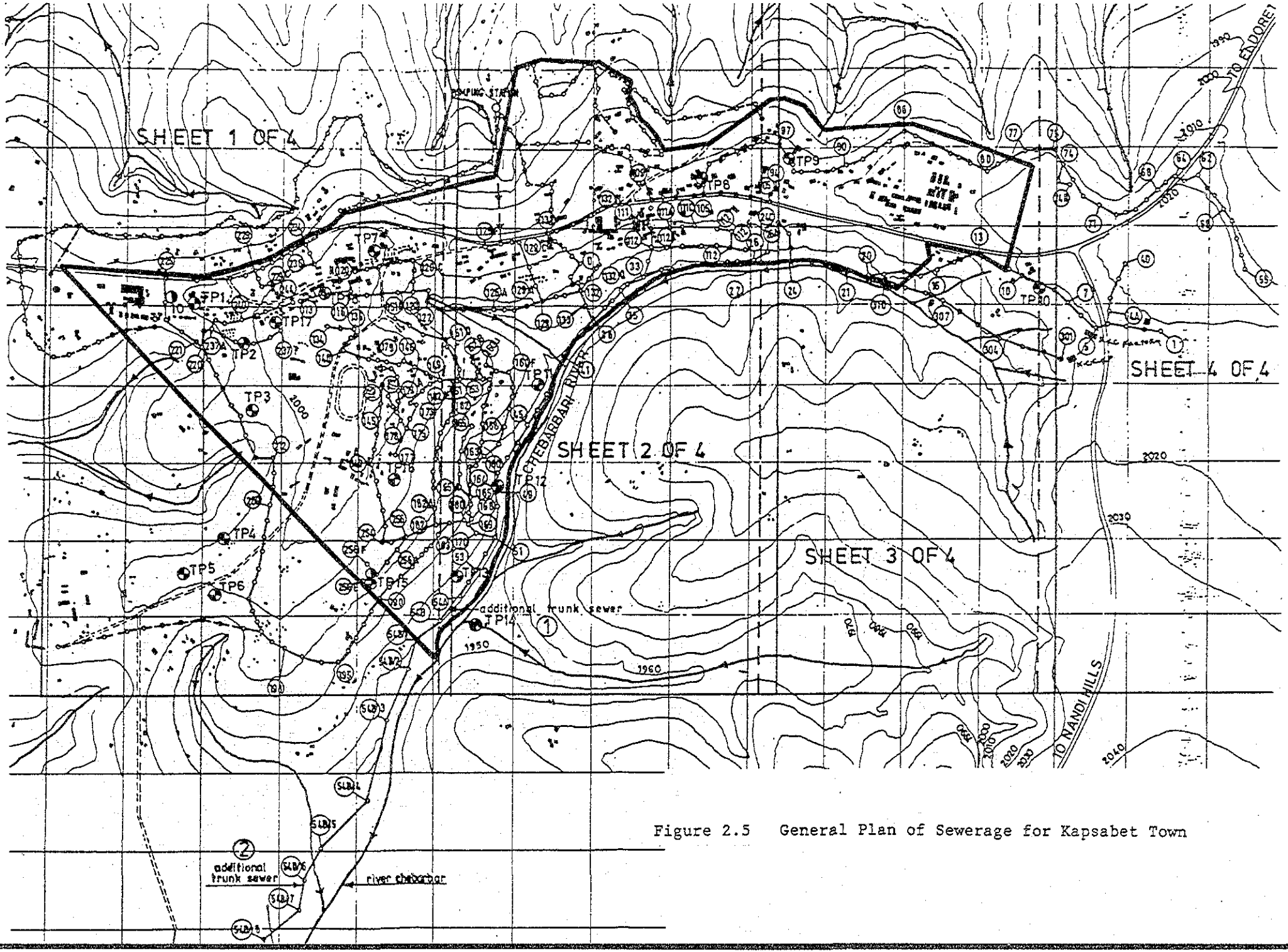


Figure 2.5 General Plan of Sewerage for Kapsabet Town

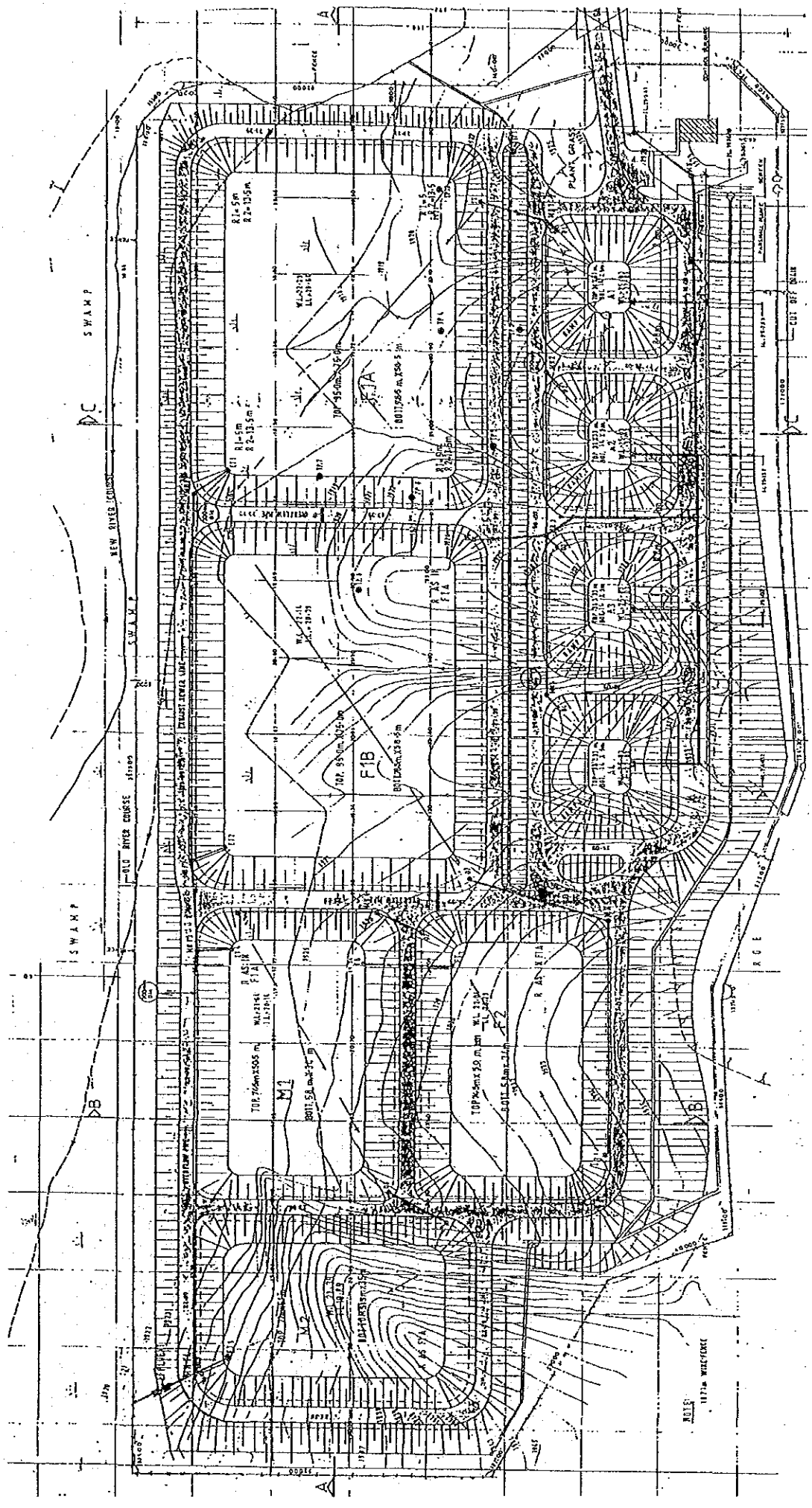


Figure 2.6 Layout of Sewage Treatment Plant

for in the northern area. When the sewage treatment plant for Phase 2 is be located adjacent to the one in Phase 1, it will be necessary to cut the slope and reclaim the swamp in front of the site, as it will be in Phase 1. The design population and flow is projected as indicated in Table 2.20.

Table 2.20 Design Population and Flow

Year	1976	1985	1995	2005
Design Population (nos.)		3,652	5,226	7,480
Design Flow (m^3/day)				
Residential	272.000	375.571	518.289	715.238
Commercial	178.000	255.222	365.268	522.763
Industrial	-	146.500	209.667	300.070
Institutional	99.600	137.448	196.712	281.530
Total	549.930	914.741	1,289.936	1,819.601

However, the design flow of the sewage treatment plant for Phase 1 is calculated at 723 m^3/day with the following equation in the capacity calculation sheet of the Preliminary Engineering Report, while the nominal treatment capacity is 1,000 m^3/day. Both are not equal to a design flow of 1,290 m^3/day as shown in Table 2.20. There are some obvious discrepancies in the Preliminary Engineering Report.

Design Flow = Design Pop. x Per Capital Daily Design Flow + Industrial Wastewater
723.36 m^3/day = 3,226 m^3/day x 100 lpcd / 1,000 + 209.63 m^3/day

2.5.3 Problems in Planning

As noted above, it is apparent that there are some differences in design population and design flow between the two plans regarding water supply and sewerage. In determining its cause, it can be determined that the problem can be attributed to the design population projection. The base year of the project design population was 1990 in the water supply project and 1979 in the sewerage project. As described previously, the planning of a sewerage system started in 1981 and the frame work was done in 1982 and 1983, although the Final Engineering Report was submitted rather later, and the 1979 census data available at that moment was used for the design population projection. The census data shows that the actual

population of Kapsabet was 2,298 in 1969, 2,945 in 1979 and 10,000 in 1980 with an average annual growth rate of 2.5% for the former decade and 13.0% for the latter decade. However, an annual growth rate of 3.65% was used for the design population projection starting from the year of 1979 and this resulted in the figure of 4,369 people in 1989, which was about one half the actual population. In comparison with the average annual growth rate of 3.4% for the whole country and 4.9% of the urban areas, the growth rate for Kapsabet was considerably higher. The problem is that the construction work was commenced in 1990 without any review of the plan prepared seven years ago and the project failed to reflect the development of the town during the intervening time period. The Preliminary Engineering Report says that an average annual growth rate of 3.65%, as decided at the meeting with the MWD in December, 1983.

The residential area was divided into three classes: (1) high, (2) middle, and (3) low, to calculate the design flow by class, assuming that the per capita daily design flows were 300, 150 and 75 lpcd and the conversion rate of water to wastewater was 75, 80 and 75%, respectively. The Kenyan Water Supply Design Manual defines the per capital daily design flows at 250, 150 and 75 lpcd by class, which are almost equal to those mentioned above.

Therefore, as the assumption of the per capita daily design flows are reasonable, it is understood that the problem was in the design population projection.

2.5.4 Present Status of the Construction Works

The progress rate of the construction work was 75.8% as a whole, including the earth works at the time of its suspension as indicated in Table 2.21.

In fact, the sewer installation work has been completed, except for the span close to the sewage treatment plant. The sewer system has the following features: (1) the top of manholes are above the ground level, (2) some sewers are running on private land, and (3) the manholes are generally bigger than similar sewerage projects in Japan. The sewers were initially planned to be installed under the roads, but some of them were probably changed to be installed on private land at the stage of construc-

tion.

The sewage treatment plant has adopted a stabilization pond system composed of four anaerobic ponds, three facultative ponds and two maturation ponds for Phase 1. The site for the anaerobic pond has been left half

Table 2.21 Progress Rate of Construction Works at the Time of its Suspension

Facility	Planned	Completed	Progress Rate (%)
Sewer	18.085 km	17.221 km	94.4
Manhole	422 pcs.	411 pcs.	97.4
Treatment Plant			55.4

excavated. Although the facultative ponds and the maturation ponds have been almost completed, the erosion of their embankments has been already occurred in some places due to no lining of the embankment surface. In addition, the site of the sewage treatment plant was constructed by cutting the slope and reclaiming the swamp in front of the site, however, the cut slope is not protected against the erosion. This has caused soil to accumulate in the facultative pond. The soil in this area is erosion-resistant when covered with plants, but weak and apt to be eroded once its surface is exposed.

2.5.5 Condition of the Receiving Water Body

The receiving water body (the Chebarbar River) has a swamp with a stretch of pupils. Its main stream cannot be identified on the 1/50,000 topographical map. It joins the Mokong River. The Chebarbar River is forced to reduce its sectional area in the neighborhood of the sewage treatment plant due to the reclamation as described previously and shows signs that the river is polluted by the inflow of wastewater. However, approximately 1.5 km downstream from the sewage treatment plant, the algae which does not normally grow in polluted water is observed and the transparency is apparently better than the water near the sewage treatment plant. The possible reasons why the river water is purified would be (1) the dilution

by the water incoming from a number of small valleys, although their number cannot be identified, (2) the absorption of pollutants by the algae growing in the swamp, and/or (3) the sedimentation of the pollutants in the slow flow till reaching to this point. Although the real cause cannot be identified, the observation implies a high self-purification capacity of the Chebarbar River.

Two water samples were taken twice from the Chebarar River immediately upstream of the sewage treatment plant where the inflow pipe crosses the river and 1.5 km downstream from the sewage treatment plant and analyzed at the Bureau of Standards in Nairobi. The results are shown in Table 2.22.

Table 2.22 Water Quality of the Chebarbar River

Sampling Date	26/06/93		06/07/93	
Place	Upstream	Downstream	Upstream	Downstream
pH	6.56	6.67	6.39	6.98
Total Dissolved Solids	56.0	56.5	164.5	52.0
Suspended solids	6.5	3.0	13.0	22.5
COD	98.15	138.7	34.52	129.46
Total Hardness	50.0	48.0	56.0	56.0
Nitrate	7.757	3.84	-	-
Fluoride	0.414	0.121	0.2	0.16
Chloride	17.347	10.065	16.56	13.09
Sulfate	15.71	3.298	1.94	3.57
Na	565.0	525.0	6.65	5.3
Phenolic Substances	4.41	1.046	-	-
Cyanide	0.192	0.164	-	-
As	N.D	N.D	-	-
Cd	N.D	N.D	-	-
Pb	N.D	N.D	-	-
Se	N.D	0.0002	-	-
Cr	N.D	N.D	-	-
Ba	N.D	N.D	-	-
Al	7.0	9.0	41.75	6.8
Cu	N.D	N.D	N.D	N.D
Fe	4.15	0.72	1.78	0.74
Mn	0.14	0.01	-	-
Zn	N.D	N.D	-	-
Mg	0.1	0.1	0.92	0.58
Ag	N.D	N.D	-	-

CHAPTER 3

OUTLINE OF THE PROJECT

CHAPTER 3 OUTLINE OF THE PROJECT

3.1 Objective

The existing water treatment facilities were constructed in 1948 and subsequently expanded in 1960 and 1980, but at present most of the facilities are so aged or have such trouble functioning that they cannot function at their designed capacity. In addition, notwithstanding that the plant has been operating in a condition exceeding its capacity to alleviate the shortage of water, it has not been able to cope with the problem, and has required the preparation and implementation of urgent measures in both quantity and quality.

In such a situation, the objective of the Project is to rehabilitate or improve the existing water treatment facilities as well as to construct a new treatment plant with enough capacity to solve the water shortage problem, including the construction of a new rising main and new reservoirs and distribution pipes for the effective supply of water to the existing distribution pipe network in the service area

3.2 Study and Examination of the Project

3.2.1 Necessity and Appropriateness of the Project

(1) Conformity with the National Plan

The Government of the Republic of Kenya has recognized the necessity to improve the water supply situation in rural cities to foster rural development, and commenced the First Rural Water Supply Development Plan in 1970. It has now started to implement the Fifth Rural Water Supply development Plan. In line with this policy, the rural water supply facilities have been progressively provided with the aid of various foreign assistance agencies. The Government of the Republic of Malawi, aiming at the swift provision, sound management, and proper operation and maintenance of rural waterworks, established the National Water Conservation & Pipeline Corporation (NWCPC) to make the waterworks successful on a business basis. However, the NWCPC is now in such a situation that it cannot pay the

interest on the loan which the Ministry of Land Reclamation, Regional and Water Development (MWD) entrusted to the NWCPC as a debt, and cannot depreciate the facilities due to insufficient revenue from water charge collection.

In the NWCPC, all the revenue of each scheme office from water charge collection is transmitted to the headquarters, which pays the personnel and power expenses as required. The chemical requirement is requested by each scheme office through an assessment by each regional office and is purchased by the headquarters for distribution to each scheme office. Construction work, such as for required expansion in each scheme office are budgeted in accordance with the priority within the NWCPC. Therefore, even though there is an increase in revenue at the scheme office, the scheme office cannot use it freely for its own purpose to repair or replace the equipment at its own discretion.

The NWCPC has prepared a financial improvement plan to improve this situation and revised the water tariff in 1991 to increase revenues, but it still remains in a financially difficult situation. In light of this, the NWCPC has been conducting the following series of studies under the assistance of the World Bank:

a. A corporate development plan
b. Improvement of revenue collection, financial management and management information system
c. Formulation of a training programme and development of an in-house training facility

Specifically, the corporate development plan has the following objectives:

a. to undertake a water sector study (delineation study) in order to more clearly define and distinguish the Corporation's role in the water sector from other agencies responsible for water supplies and sanitation services,
b. to prepare a 5-Year corporate development plan, based on the expected role of the corporation over the medium term, including an investment and financing plan and policies,

c. to develop a planning capability within the corporation, and
d. to undertake a water tariff study.

When the result of the study are realized and implemented, the clarification of its role, an improvement in its function, an improvement of its financial status and an improved usage of human resources will be achieved in the NWCPC. This will lead to, at the level of the scheme office, the improvement of aged facilities, the improvement of water productivity, the full operation and maintenance of facilities, and finally the sound management of the scheme office.

By the implementation of the Project, the facilities will be renewed and the amount of water supplied will be up by four times the present capacity, which will result in the improvement of water productivity and the water supply conditions of the users. It is expected that the number of complains against the water supply service will decrease and that the collection rate of water charges will be improved.

The Project's goals are in line with the basic policy of the Government of the Republic of Kenya.

(2) Benefit

The following measures are currently taken to cope with the shortage of water supply in the worst condition:

a. limitation of the service area
b. 24-hour operation of the water treatment plant
c. overloaded operation with an emphases on quantity rather than quality
d. limitation of the water supply time

However, despite these measures, the complaints against the waterworks, such as insufficient or no water even at the alloted time of water supply, have become more serious.

The number of households in the design service area is estimated at 3,200 as of 1993. The service coverage by water supply is predicted to be 1,450 households or 45% of the possible users, although the exact number of households which benefit the water supply service is unknown, since one house connection is sometimes used by multiple households.

Through the implementation of the Project, the service coverage is expected to expand to approximately 94% of user households in the design target year of 2002. In addition, as the quality will be improved by the operation of the complete water treatment plant as well as the improvement in quantity, the supply of sufficient and safe water will be attained. This will contribute to the improvement in the health and living standards of the residents.

3.2.2 Implementation and Management Plan

The executing agency of the Project is the NWCPC, which is responsible for the development of water supply for rural cities and for the management of waterworks and was separated from the MWD in 1988 to manage the waterworks based on a self-sustaining system that would operate without any subsidy from the central government by covering the costs of managing, operating and maintaining the waterworks in rural cities with revenues from water charge collections.

The NWCPC divides the country into five regions for management and places an Office of the Regional Manager in each region to direct the management, operation and maintenance and service of the scheme offices under its jurisdiction.

When the Project is finished, the Corporate Service Department and the Development Service Department of the Nairobi Headquarters will be in charge of planning and construction of the Project, and the Western Regional Office, directing the Kapsabet Scheme Office, will be responsible for field operations. Therefore, under the direction and supervision of the Development Services Department, it is necessary to assign the Western Regional Manager to the leader of the Project team as well as some other personnel to the engineers in charge of construction of the water treat-

ment plant and distribution pipes, respectively.

After the completion of the project, the Kapsabet Scheme Office will undertake the operation and maintenance of the system and members of the above Project team will be hopefully assigned to the engineers in charge of operation and maintenance of the facilities that they will be assigned to.

The existing water treatment plant is operated with three shifts of five operators whose work is mainly simple, other than the tasks of solving and dosing the chemicals and operating the clear water pump. The plant is operated in an overloaded condition, and in an effort to alleviate the shortage of water, there is little consideration given to quality and the plant is heavily worn.

When the Project completed, the plant will be complete and will have a treatment capacity of four times that of the existing one. The volume of operation and maintenance works including withdrawal, drying and disposal of settled sludge, regular once-a-day backwashing of filters and so on, will increase quantitatively and qualitatively. Hence, it is indispensable to increase the number of personnel such as engineers, clerks, and personnel for the distribution services, as shown in Figure 3.1.

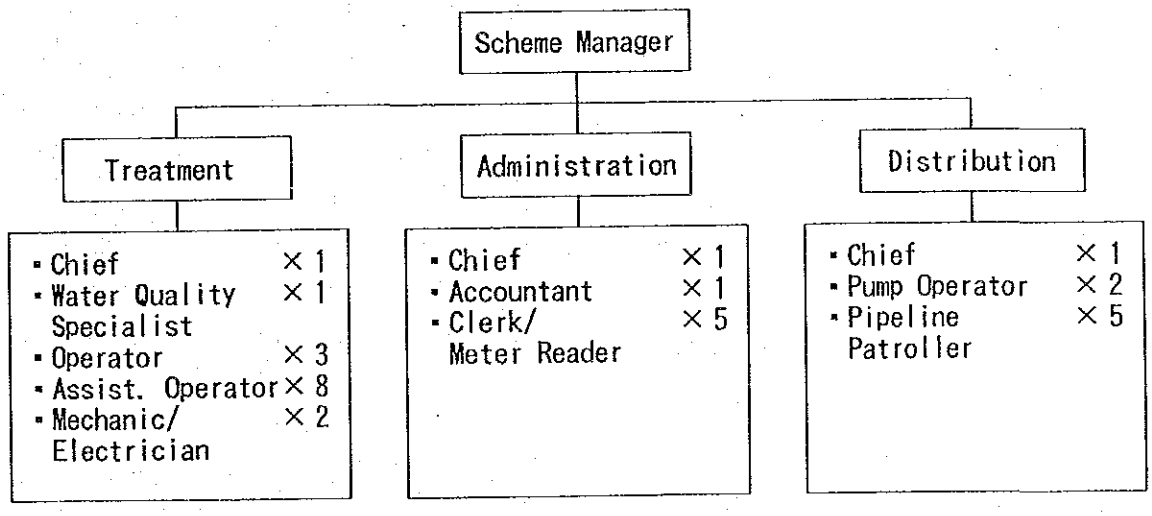


Figure 3.1 Proposed Organization Chart of Kapsabet Scheme Office

In the operation of the plant, the proper control of chemical dosing corresponding to the change in turbidity of the raw water will be required in addition to the simple tasks such as the traditional valve and pump operation. The assignment of a group for chemical dosing and quality surveillance will be necessary under a supervisor who will have a training in basic principles for water treatment.

One water quality engineer is now allocated to the Western Regional Office managing the Kapsabet Scheme Office but is mainly engaged in information control of the water quality and the examination of applications on the amount of chemicals requested by each scheme office for submission to headquarters. Therefore, there is in fact no engineer to direct the operation and maintenance work of the full water treatment plant.

Consequently, it will be necessary to have such an engineer in the Kapsabet Scheme Office itself. As mentioned earlier, the NWCPC has been formulating a training programme and it will be a prerequisite for the implementation of the Project that one engineer who will have a training in such a programme be assigned to the Kapsabet Scheme Office.

The average water production and sale costs of the Kapsabet Scheme Office for the last five months from January to May 1983 was KShs. 3.8 and 2.8 per m^3, respectively, excluding the expenditures in the headquarters and the regional office, hence, the water sale cost is 1.4 times the water production cost. Considering that the personnel expenses amount to 41% of the water production costs, which will be decreased after the completion of the Project, it is expected that the productivity of the system will be improved. However, it is necessary to make arrangements for personnel and to take budgetary measures regarding the increase in chemical and power consumption so as to operate the system as planned from the first year after the completion of the Project. The maintenance cost to be required is described in 4.4.2 in detail.

Table 3.1 indicates the plan for an increase in revenue from 1990 to 1997 based on the present financial status and financial improvement plan with the following results:

a. With the water tariff revised in 1991, the net operation income in

1992/93 will increase by 4.5 times that of 1991/92 and 1.5 times that of 1990/91. A net operation income of Kshs. 135 million in 1992/93 is equivalent to 61% of the total operating expenses.

b. The depreciation expense for facilities entrusted from MWD is Kshs. 342 million equivalent to 2.5 times the net operating income, which means the continuation of the deficit if the present water tariff is maintained.

c. According to the financial improvement plan, it is possible to pay for 40% in 1992/93 and 90% in 1993/94, respectively of the depreciation expenses and the financial condition will be changed into the surplus in 1994/95 including the payment for the interest of the loan.

d. The above financial improvement plan was prepared on the assumption that the average water rate would be 50% up from the previous year every year for five years starting from 1992/93, and this financial improvement plan seems to be very difficult to implement.

The NWCPC has just started a study to develop a radical financial improvement plan with the assistance of the World Bank and the draft plan is scheduled to be submitted in September 1994.

With the implementation of the Project it will be necessary to increase the number of personnel at the Kapsabet Scheme Office. It is expected that the operation and maintenance costs will increase and new investment for the repair and extension of the existing distribution pipes will be required. Although the revenues from water charge collection will increase through the increase in the amount of water supply, the Kapsabet Scheme Office will not be able to use such income at its discretion under the current management system of the NWCPC as described earlier, and there is no assurance that the budget for such operation and maintenance and investment will be kept for the Kapsabet Scheme Office at this moment. It should be accordingly conditional for the implementation of the Project to confirm how the financial condition and management system of the NWCPC will be improved and how the management of the Kapsabet Scheme Office will be correspondingly affected.

Table 3.1 Financial Improvement Plan of NWCPC

(Unit : x10³ KShs)

		1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Mombasa and Coastal Region:										
Available Water Supply	(m^3/day)		196,000	209,960	217,309	224,915	224,915	232,787	240,934	249,347
Available Sales Volume	(m^3/day)		66,500	66,500	66,500	80,500	94,500	108,500	108,500	108,500
Annual Sales Volume	(10^3 m^3)		24,273	24,273	24,273	29,383	34,493	39,603	39,603	39,603
Average Water Tariff	(ksh/m^3)		7.96	10.48	6.28	9.42	14.13	19.78	28.68	38.72
No. of Connections			66,000	68,310	70,701	73,175	75,737	78,387	81,131	83,970
Other Regions:										
Annual Sales Volume	(10^3 m^3)		33,110	48,533	48,533	58,140	58,140	58,140	58,140	59,140
Average Water Tariff	(Ksh/m^3)		0.38	0.52	0.88	1.32	1.98	2.77	4.01	5.42
Fiscal Year Inflation Rate	(%)	10.65	11.60	12.05	10.50	8.50	7.50	7.50	7.50	7.50
Average Overall Water Tariff	(Ksh/m^3)		3.50	3.84	2.68	4.04	6.50	9.66	14.01	18.91
Income										
Water Sales - Mombasa/Coast			193,120	254,376	152,431	276,783	487,379	783,417	1,135,954	1,533,538
Water Sales - Other Regions		540	12,482	25,084	42,643	76,626	114,939	160,914	233,325	314,989
Miscellaneous Receipts		540	406	1,998	2,038	2,079	2,120	2,163	2,206	2,250
Total Income			206,008	281,458	197,112	355,488	604,438	946,493	1,371,486	1,850,778
Operating Expenses										
Salaries and Wages		213	31,161	76,488	50,000	60,000	72,000	86,400	103,680	124,416
Administration		702	12,118	19,462	21,408	23,549	25,904	28,494	31,344	34,478
Transport Operating Expenses		94	7,958	6,000	7,200	8,640	10,368	11,403	12,545	13,800
Electricity		0	23,656	42,000	50,400	60,480	72,576	87,091	104,509	125,411
Fuel		0	1,522	4,000	4,400	4,840	5,324	5,856	6,442	7,086
Chemicals		0	15,118	28,000	33,601	48,472	61,563	77,650	93,540	112,248
Maintenance		879	14,567	6,524	7,829	9,395	11,273	13,528	16,234	19,481
Provision for Bad Debts		0	6,963	8,949	(7,444)	5,371	6,468	5,806	2,285	9,940
Total Operating Expenses		1,888	113,063	191,423	167,395	220,746	265,476	316,532	370,580	446,860
Net Operating Income before Deprec. & Int.		(1,348)	92,946	90,035	29,717	134,741	338,962	629,962	1,000,906	1,403,917
Depreciation		467	1,590	2,065	325,456	342,456	365,343	388,021	391,246	413,056
Net Operating Income before Interest		(1,815)	91,346	87,970	(295,717)	(207,714)	(26,381)	241,941	609,660	990,862
Interest		0	0	0	1,163	23,210	62,752	194,928	531,420	865,770
Net Operating Income		(1,815)	91,346	87,970	(296,880)	(230,924)	(89,133)	47,013	78,240	125,092
Operating Subsidy from Government		0	0	12,657						
Net Income		(1,815)	91,346	100,627	(296,880)	(230,924)	(89,133)	47,013	78,240	125,092

Source : World Bank, "Staff Appraisal Report" (December 1991)

3.2.3 Similar Projects and Projects Financed by Foreign Donors

Since 1970, the World Bank, starting from the water supply projects for big cities such as Nairobi, Mombasa, Kismu, etc., has carried out assistance programs for rural cities such as Kitale, Eldoret, Nyeri, Thika, Nile, etc. and has subsequently assisted the Nairobi Water Supply Expansion Project. In addition, foreign donors such as the Scandinavian countries (SIDA, NORAO, DANIDA and FINIDA), Netherlands (NIO), Canada (CIDA), and Germany (KFW) have provided assistance for water supply projects in other areas.

The budget of the MWD for 1992/93 lists water supply development projects assisted by Italy, Finland, Sweden, Austria, Germany, Netherlands, Denmark, Belgium, France and other international agencies.

The rural Water supply projects assisted by the Government of Japan are as follows:

Table 3.2 Grant Aid and Loan Projects

(Unit : Million Yen)

Year	Project Name	Amount	Type
1977	Itanga Water Supply Project	400	Grant Aid
1982	Itanga Water Supply Expansion Project	35	Equipment Supply
1986	Greater Nakuru Water Supply Project	5,000	Loan
1987	Greater Nakuru Water Supply Project	4	Loan
1988	Water Supply Project in Taveta-Lumi	936	Grant Aid

Table 3.3 Technical Assistance

Year	Project Name	Type
1979	Mombasa Water Supply Expansion Project (F/S)	Development Study
1988	Malewa Dam Construction Project (F/S)	Development Study

The Greater Nakuru Water Supply Project implemented in 1986 as a loan project was completed in January 1990 and has started to supply water. The capacity of it water supply is 18,000 m^3/day to Nakuru and 4,700 m^3/day to Gilgil. The water source is the Turasha Intake Dam located about 10 km upstream of the confluence of the Malewa River and Turasha River. The raw water taken from the dam is gravitated to the water treat-

ment plant. The treatment process is composed of chemical coagulation-sedimentation and rapid filtration. By the completion of the project, the service area for water supply was extended from 16.76 km^2 to 68.5 km^2/

In Kapsabet Town, sewage work is now ongoing for the present urban area. The Project scale in the final plan or in the target year of 2005, is 7,480 in design population and 1,820 m^3/day in design flow. A sewage treatment plant has been constructed along the Chebarbar River 2km away from the southern boundary of the town. However, the construction work has been suspended since April 1992 due to the price escalation of construction materials. The progress rate of the whole construction works (consisting of phase I and II) was about 55% at the time of suspension (see in more detail on the scale and contents in the "Outline of the Kapsabet Sewerage Project" on page 36.

As the design service area for water supply of the Projects also involves sewerage, it is necessary to study the Project's effect on the environment of the surrounding water bodies during and after the Project will be carried out and before the completion of the sewage works. To conduct a detailed environmental assessment, a variety of data on the surrounding area involved such as topography, meteorology, watershed, river flow, river quality, industrial products, number of livestock farmed, water supply condition, treatment and disposal status of domestic wastewater, sewerage development plan, etc. are required.

3.2.4 Project Components

(1) Contents of Discussion s during Preliminary Study

The contents of the request by the Government of the Republic of Kenya are to carry out the following rehabilitation and expansion so as to change the present nominal water supply capacity of 820 m^3/day to 7,200 m^3/day which meets the estimated water demand in the design target year of 2012.

1) Rehabilitation of Existing Water Supply Facilities

a. reconstruction of intake facilities and replacement of raw

water transmission pipes

b. reconstruction of the water treatment plant and replacement of the clear water pump

2) Construction of Water Supply Facilities/Equipment

a. construction of the water treatment plant with a capacity of 6,420 m^3/day
b. construction of a clear pump station and installation of rising pipes
c. construction of ground reservoirs with elevated tanks
d. installation of distribution pipes

With reference to the above contents of the request, the results of the discussions during the preliminary study are as follows:

a. As for the rehabilitation of the existing water treatment plant, It is considered that no significant effect will be expected from its rehabilitation, as the plant is about 50 years old and it has many structural deficiencies, and the treatment method adopted is out-of-date. The Kenyan side also agreed to exclude the rehabilitation of the existing treatment plant from the request.
b. Although there were three alternatives in the location of the water source in the request, namely (1) the Kabutie River (the present water source), (2) the Kimondi River, and (3) the Mokong River, the Kimondi River is the most appropriate water source, taking into account the river flow, river water quality, location and so on.
c. As for the construction of the transmission and distribution facilities, the contents of the request seem to be basically reasonable, but the distribution pipes, which are one of the components of the above it should be limited to lines from the water treatment plant to the ground reservoirs and between the elevated tanks. The Kenyan side agreed to undertake the installation of other distribution pipes.
d. The scale of the water supply facilities shall be 7,000 m^3/day in the design target year of 2012 for water distribution and

5,000 m^3/day in the design target year of 2002 for the water treatment plant in consideration of the initial shortage of revenue, maintenance of the facilities and so on. The facilities will be so designed as to facilitate their expansion in the final plan. However the scale will be decided through a detailed study taking the account of the sewerage development plan, environmental conservation and balance with the service area by water supply.

(2) Results of the Study

Based on the contents of the request and discussions during the preliminary study, the basic design study team examined the appropriateness of the components of the Project mainly in consideration of the following items:

a. review of the service area by water supply and water demand
b. availability after the rehabilitation of existing water treatment facilities
c. location of water source and the water treatment plant
d. scale and location of ground reservoirs and elevated tanks
e. necessity and location of distribution mains for a stable water supply for the existing distribution pipe network
f. power supply capacity and scope of work

The components of the Project to achieve the objective of the Project are summarized in Table 3.4 based on the results of the study.

Table 3.4 Components of Facilities and Result of the Study

Facility Name	Purpose	Contents of the Request	Result of the Study
Existing Water Treatment Plant	Use of existing facilities	Rehabilitation/improvement of aged existing facilities	Less effect by rehabilitation due to heavy aging, out-of-date facilities and small capacity
Intake facilities	Water source	From one of three alternatives, namely the Kabutie River (present water source), the Kimondi River and Mokong River	The Kimondi River is appropriate in consideration of river flow, river water quality and location of new water treatment plant
New water treatment plant	Water treatment	Construction of a new plant with a capacity enough to meet the water demand in the target year of 2012 including that of a existing plant	Construction of a new plant with a capacity to meet the water demand to in the target year of 2002 for reducing the initial maintenance cost and with a layout in consideration of future expansion in 2012.
Transmission facilities	Clear water transmission to ground reservoirs in the design service area	Installation of rising mains between a new plant and ground reservoirs	Same as the left
Ground reservoir and elevated tank	Water storage and assuance of water level	Construction of two pairs of a ground reservoir and a elevated tank	Same as the left
Distribution pipes	Stable water supply to a existing distribution pipe network	Expansion of distribution pipes	Installation of distribution mains connecting two elevated tanks and covering the town center

3.2.5 Contents of Facilities/Equipment Requested

(1) Selection of River for Water Intake

In a Feasibility Study Report prepared by the NWCPC, three rivers are listed as alternative sources for water intake, namely the Kabutie River or the present water source, the Kimondi River and the Mokong River. The general characteristics of the rivers are as follows:

Table 3.5 Characteristics of Alternative Rivers for Water Intake

	Kabutie River	Kimondi River	Mokong River
Background	proposed in the request	given the first priority by JICA Preliminary Study Team	proposed in the Study on the National Water Master Plan
Flow	possibility of shortage during the non-rainy period	possibility of shortage throughout a year	possibility of shortage during the non-rainy period
Water Quality (Measured during the preliminary study)	good (7 NTU)	good (9 NTU)	high in turbidity (250 NTU)
Construction Site for Treatment plant			
- Access Road	not good	good	slightly good
- Distance from Project Area	approx. 1 km	approx. 7 km	approx. 9 km
- Area for Construction of the Plant	impossible near the river	possible	possible

Among the above alternatives, the Mokong River is excluded from further discussions to select the water source, because the construction and operation costs will be higher than others due to its long distance from the Project area and high turbidity.

The following is the result of further discussions on the Kabutie River and the Kimondi River.

There are two reports describing the river flow in relation to the Project, as shown below.

a. "Preliminary Design Report on Kipsigak, Kaplamai, Meswo Water Supply Project", MWD, 1985
b. "Feasibility Study for Rehabilitation and Extension of Kapsabet Water Supply Project", NWCPC, 1990

Shown below is the data quoted from the above reports.

Table 3.6 Flow of the Kabutie and Kimondi Rivers

	Preliminary Design Report		Feasibility Study Report	
	Kabutie	Kimondi	Kabutie	Kimondi
Catchment Area	105 km^2	835 km^2	105 km^2	835 km^2
Attachment Elevation	2,300 - 1,900m	2,600 - 1,880m	2,300 - 1,900m	2,600 - 1,880m
Gauging Station	--	No. 8935168	--	IEGI
95% Probability Low-flow	0.035 m^3/s = 3,020 m^3/d	0.49 m^3/s = 42,300 m^3/d	0.1365 m^3/s = 11,800 m^3/d	-- --

As shown in Table 3.6, the 95% probability of low-flow in the Kabutie River is apparently different between both reports. In the Feasibility Study Report, the flow is shown only by means of the figure quoted from the WHO Report No. 6, while in the Preliminary Design Report, the flow is analyzed on the basis of frequency distributions of low-flow values since the year of 1965. Accepting the flow shown in the Preliminary Design Report as a low-flow, the 95% probability of low-flow in the Kabutie River, which is assumed at 3,020 m^3/day, is insufficient for the design water intake flow. Accordingly, the Kabutie River is not proper as the stable water source for water supply.

In the field survey during the basic design study, it was observed that the flow of the Kabutie River at the confluence with the Kimondi River was approximately 10% of the flow at the existing intake weir. This means that, although there is a distance of about 8 km and an elevation difference of about 20 m between the water intake point and the confluence of two rivers, the river water is absorbed

into the surrounding forest area as either subsoil water or as surface water. As the catchment area of the Kabutie River is small, the importance of such absorbtion and its impact on the environment should not be disregarded, when the raw water will be taken from the Kabutie River for the Project. Therefore, it is justified to select the Kimondi River as the water source for the Project.

(2) Water Treatment Facilities

As described in "2.4.2 Condition of Facilities", it is expected that the effect of any rehabilitation of the existing water treatment plant will be minimal due to its advanced age and small capacity. In addition, the existence of two small water treatment plants would lead to an increase in number of operators and to a decrease in water productivity. Accordingly, the rehabilitation of the existing water treatment plant shall be excluded from the scope of the Project and the full amount of water shall be produced at the new water treatment plant.

In the request, the water treatment method is planned using chemical sedimentation and sand filtration processes which is the same as the existing treatment system. Though the raw water for treatment will be changed from the Kabutie River to the Kimondi River, it is considered that the requested treatment processes is appropriate as there is little difference in water quality between two rivers; the composition of water and the seasonal variation of turbidity are similar.

In a slow sand filter, the suspended solid is retained only at the surface of the sand layer, hence water with high turbidity or abnormally high plankton levels causes the rise in head loss at the filter surface in a short time and the shortening of the duration time of filtration.

The further study was done on the following subjects:

a. daily variation of river water quality on turbidity
b. water quality analysis on all parameters defined in the Drink-

ing Water Standard

c. operational condition of the existing water treatment plant and effect by treatment
d. beaker test on treatability (chemical requirement and test result)

1) Daily Variation of River Water Quality on Turbidity

Table 3.7 shows the turbidity and water depth in the rivers which was measured by the Kenyan side using a turbidity meter and a velocity meter provided by JICA. The measurement has been suspended due to the fact that the meter is out of order.

From the result of the measurement the following is observed:

a. The turbidity of both rivers rises by 80 to 90 NTU in the rainy season but are usually 10 to 20 NTU.
b. The turbidity in the rainy season is almost the same between both rivers.
c. The average turbidity in the non-rainy season is 16 NTU in the Kabutie River and 11 NTU in the Kimondi River.
d. The water depth of the Kimondi River is always deeper than that of the Kabutie River.
e. The water depth variation of the Kabutie River is always larger than that of the Kimondi River.

Taking the above results into consideration, the Kimondi River is more stable than the Kabutie River in respect of both water quality and quantity as the water source.

2) Result of Water Quality Analysis

The result of water quality analysis on all parameters defined in the Drinking Water Standard is shown in Table 2.8 (see in more detail Appendix 6). The following is a summary of major parameters:

Table 3.7 Turbidity and Water Depth in the Kabutie and Kimondi Rivers (1992)

Date	Kabutie River		Kimondi River	
	Turbidity (NTU)	Water Depth (m)	Turbidity (NTU)	Water Depth (m)
Sep. 12	85	1.10	87	1.76
13	82	1.07	87	1.92
14	86	0.99	88	1.82
15	86	0.77	87	1.75
16	86	0.62	87	1.65
17	85	0.57	86	1.52
18	87	0.52	85	1.44
19	86	0.52	90	1.42
Oct. 1	15	0.66	15	1.39
2	30	-	10	1.36
3	32	-	32	1.50
4	15	-	20	1.50
5	17	0.74	16	1.50
6	17	0.66	15	1.49
7	15	0.54	11	1.46
8	10	0.61	8	1.42
9	17	0.52	10	1.36
10	15	0.49	10	1.31
11	16	0.51	14	1.40
12	38	0.62	7	1.40
13	13	-	11	1.40
14	23	0.74	20	1.36
15	13	0.56	17	1.38
16	8	0.62	10	1.33
17	-	-	-	-
Nov. 4	15	0.29	7	1.26
7	13	-	7	1.25
8	20	0.30	13	1.26
9	17	0.27	8	1.24
10	16	0.28	7	1.22
11	15	0.29	10	1.26
12	15	0.29	8	1.24
13	17	0.27	7	1.22
14	14	0.28	7	1.20
16	15	0.27	8	1.19
17	15	0.27	7	1.18
18	14	0.25	8	1.16
19	16	0.24	8	1.15
21	19	0.17	7	1.10
22	17	0.17	9	1.13
23	17	0.15	8	1.12

Table 3.8 Summary of Water Quality Analysis

Sampling Point	Kabutie River			Kimondi River		WHO
Sampling Date	13/06/93	26/06/93	06/07/93	13/06/93	26/06/93	Standard
Laboratory	KBOS	KBOS	in Japan	KBOS	KBOS	
pH	6.50	6.80	6.9	6.60	6.75	6.5 - 8.5
SS		6.3			29.5	
Total Hardness	24.0	28.0	16	28.0	54.0	
Total Alkalinity	69.0		25	69.0		
CN		0.155			0.153	1.0
Hg						0.001
Cu		N.D.			N.D.	1.0
Fe	0.88	1.72	4.68	1.26	2.30	0.3
Color			100			15
COD		30.7			113.31	
Turbidity			21			5
E.C.	62.0		57	51.0		

Unit : mg/l except pH, color, turbidity and E.C.

According to the result of the analysis, the value of iron (Fe) other than those of turbidity and color is over the WHO Standard. The iron contents are 1.72 ppm in the Kabutie River and 2.30 ppm in the Kimondi River, respectively. Generally, the iron in surface water exists as the colloidal iron binding with the organic matter and causes the appearance of color, which can be removed in general by chemical sedimentation and filtration after being coagulated under the low range of pH to form the so-called color block. However, in case of insufficient floc formation due to a lot of the organic matter, a further detailed analysis and coagulation test is necessary, since it may require prechlorination.

3) Operational Condition and Performance of the Existing Treatment Plant

As mentioned before, the operational condition of the existing treatment plant is not proper and insufficient from the viewpoint of treated water quality because of its deteriorated condition, out-of-date treatment process and overloaded operation.

According to the water supply operation chart, the plant is

not operated in a manner that allows a change in the dosing rate of chemicals which proportionately corresponds to the change in turbidity of raw water but is operated in almost same manner every day.

The current status of plant operation is shown in Table 3.9.

Table 3.9 Current Operational Status

Date	Raw Water			Chemical Dosing			Treated Water				Production	Remarks
	pH	Turb. (NTU)	Color (ppm)	Alum (ppm)	Soda (ppm)	Cl_2	pH	Turb. (NTU)	R.Cl_2 (ppm)	Color	Capacity (m^3/d)	
July 1	6.7	17	-	44	10	1.0	7.0	16	0.6	-	1,000	Record
3	6.8	16	-	45	10	1.0	6.9	7	0.4	-	1,050	Record
	6.9	17	25				7.3	5	1.5	8		JICA
5	6.8	16	-	45	10	1.0	6.9	15	0.5	-	1,000	Record
				Before soda dosing ->			6.2	14	-	13	Alkali. 7ppm	JICA
				After soda dosing ->			7.3	16	-	15	38ppm	JICA

4) Beaker Test for Coagulation

A beaker test was conducted in order to confirm the effect of coagulation and floc formation. From the result of the test, it was observed that floc formation was slightly different between the alum dosing rates of 30 ppm and 40 ppm, but the settling velocities of the floc were slow and almost the same, which mostly depended on the characteristics of the raw water -- namely low turbidity and high color as shown in Table 3.10.

Table 3.10 Result of Beaker Test

Sampling	Water Temp.	Raw Water Quality				Chemical Dosing		Floc Formation	Treated Water Quality	
	(°C)	pH	Turb. (NTU)	Color (NTU)	Alk. (ppm)	Alum (ppm)	Soda (ppm)		pH	Alk. (ppm)
Kimondi River (June 28)	25	6.8	17	30	36	20	10	fine, slow	-	-
						30	10	fine, slow	6.1	-
						40	10	slightly small, slow	5.7	21
						40	20	slightly small, slow	7.1	34

5) Annual Chemical Consumption

The annual chemical consumption at the existing water treatment plant in the past 4 years or 1989/90 to 1992/93, is shown in Table 3.11. The chemical dosing rate is estimated on the basis of 3 additional percent added to the annual water production as the physical loss at the plant.

Table 3.11 Annual Chemical Consumption

Year	Alum		Soda Ash		Bleaching	
	Consump. (kg)	Dosing Rate (ppm)	Consump. (kg)	Dosing Rate (ppm)	Consump. (kg)	Dosing Rate (ppm)
1989/90	19,553	49	5,692	14	988	2.5
1990/91	19,289	47	6,266	15	979	2.4
1991/92	16,143	45	4,568	13	897	2.5
1992/93	15,348	42	3,617	10	907	2.5
Average	-	46	-	13	-	2.5

According to the observation of the actual operation at the plant and to the result of the beaker test, it is considered that the annual chemical consumption is reasonable.

The operational condition at the Turasha Water Treatment Plant of the Greater Nakuru Water Supply Project with a capacity of 18,000m^3/d, which was constructed in 1992 with a Japanese loan, is shown in Table 3.12.

Table 3.12 Operation Condition at Turasha Water Treatment Plant

Raw Water	In Case of Low Turbidity	In Case of High Turbidity
Date	Jan. 1, 1993	June 16, 1993
Production	10,917 m^3/d	3,223 m^3/d
Raw Water		
pH	7.2	7.0
Turbidity	28 NTU	100 NTU
Chemical Dosing		
Alum	40 ppm	80 ppm
Soda Ash	20 ppm	30 ppm
Bleaching	2 ppm	2 ppm
Treated Water		
pH	6.8	6.8
Turbidity	3 NTU	10 NTU

Source : Operation Record

(3) Ground Reservoir and Elevated Tank

The purposes of the reservoir are to adjust the hourly fluctuation of the amount of water supply and to alleviate the effect on users with stored water during times of emergency.

The ground reservoir shall be constructed at the Scheme Office with enough space, and another ground reservoir shall be installed at the Bible College School which is located at the highest point in the design service area, since at the Scheme office it is necessary to substantially increase the elevation of the elevated tank so as to cover the whole of the design service area. However, as the space available for reservoirs are limited at the Bible College School, such an arrangement will be made as to make the scale of the ground reservoir large at the Scheme Office and small at the Bible College School. The service area covered by each reservoirs has a different elevation, hence it will be divided into the highland and lowland areas to which water is distributed from the elevated tank and the ground reservoir, respectively, by gravity. Clear water pumped from the water treatment plant will enter into the ground reservoirs and then some of water will be further lifted to the elevated tanks.

As for the capacity of the ground reservoir, the Kenyan Water Supply Design Manual requires 12 hours for balancing the hourly fluctuation in water demand and 18 hours for emergency, respectively. However, even though the reservoir will be constructed for balancing it will also function for an emergency. Therefore, the storage time shall be 12 hours to the daily water supply amount, taking into account the performance in Taveta-Lumi which was constructed under grant aid assistance from the Government of Japan in 1988.

(4) Distribution Pipes

The installation of the distribution pipes shall be limited to the distribution mains connecting between the elevated tanks at the Scheme Office and the Bible College School for the highland service area and looping around the commercial center in the Town. As for the lowland service area, it is considered appropriate that the distribution mains will be installed from the each ground reservoir at the Scheme Office and the Bible College School to the entrance of each lowland service area. The valves for dividing the service area and for isolation during an emergency will be provided on the above distribution mains which will be connected to the existing distribution pipes at several points

3.2.6 Necessity foy Technical Cooperation

When the Project is completed, sufficient explanations and instructions on the plant operation and equipment handling will be provided by a contractor. However, it hardly can be expected that elaborate guidance on proper plant operation (i.e. the determination of the chemical dosage rate corresponding to the change in raw water turbidity, judgment of the flocculation result, timing of settled sludge discharge from sedimentation basins and its disposal, backwashing frequency of filters, etc.) be provided. Also, there is no engineer in the Office of the Western Regional Manager who is able to provide such a guidance. Although no technical cooperation program is requested from the Kenyan side, it is considered that a technical cooperation program, such as technical guidance on plant operation by the consultant, would be necessary for the successful operation and maintenance of the water treatment plant. The technical assistance program

shall be comprised of lectures and on-the-job training on the following subjects:

a. basic water treatment method and processes
b. water quality analysis necessary for plant operation
c. determination of proper chemical dosing rate
d. evaluation of conditions of floc formation and sedimentation
e. backwashing frequency of filters and washing method
f. frequency of sludge withdrawal from sedimentation basins during the normal operation
g. frequency of sludge removal from and cleaning of sedimentation basins
h. proper thickening and drying of discharged sludge at sludge drying beds
i. practice in operation and maintenance of other facilities
j. recording of data on plant operation and maintenance

The period of the technical cooperation program is recommended to be around three months after the completion of the test run in the construction works

When the Project will be executed, the Kenyan side shall undertake not only extension work but also the repair work of the existing distribution pipes for leakage protection

3.2.7 Basic Policy for Project Implementation

Based on the above study, the objective and effect of the Project and the capability of the executing agency are summarized below:

(1) Objective

The Project is planned to solve the water shortage problem in Kapsabet Town and its surrounding area by constructing intake, treatment, transmission and distribution facilities. However, the rehabilitation of the existing water treatment plant which is heavily worn and has a small capacity will be excluded from the Project due to its inability to be renovated successfully.

(2) Effect of the Project

Through the implementation of the Project, the water supply capacity will be increased by 4,011m^3/day or four times the present performance of approximately 1,000m^3/day and the service coverage by water supply will be improved to 94%, from the present estimated 45%.

The Government of the Republic of Kenya established the NWCPC to improve water supply conditions which are indispensable to help foster rural development. The renewal of the existing water supply system by the execution of the Project will hopefully lead to a technical gain on the Kenyan side.

(3) Capability of the Executing Agency

The executing agency of the Project is the NWCPC which was established in 1988 and has been studying the revision of the water tariff to improve the fragile financial condition of the system and developing a management improvement plan for restructuring the organization and institution of the NWCPC in cooperation with the World Bank. Such an improvement plan is scheduled to be submitted in September 1994. With the implementation of the Project, not only is an increase in revenue incidental to the increase in the amount of water supply expected but also an increase in the operation and maintenance costs resulting from an increase in personnel, such as engineers and clerks to cover the expanded facilities and service area is expected. It will be important to follow up on the results of this improvement plan, which is to be prepared by the World Bank.

Prior to the implementation of the Project, it is indispensable that the financial condition and the management system of the NWCPC be improved, and also that the on-going sewerage project be completed, along with an environmental impact assessment concerning the sewerage project be performed to allow for the sound management of the Kapsabet Scheme Office. When such improvement will be made in the NWCPC, it is considered reasonable to implement the Project under grant aid assistance of the Government of Japan, since the nature of the Project itself meets the intention and requirements of grant aid assistance from the Government of Japan, consid-

ering the necessity and effect of the Project.

3.3 Project Description

3.3.1 Executing Agency and Operational Structure

(1) Executing Agency

The NWCPC is responsible for the implementation of the Project, which is headquartered in Nairobi and has five Offices of the Regional Manager. The Office of the Western Regional Manager, one of the five regional offices, administers ten Offices of the Scheme Manager including the Office of the Kapsabet Scheme Manager and is responsible for the direction, instruction and support.

(2) Operational Structure

After the completion of the Project, the Office of the Kapsabet Scheme Manager will be in charge of the management of the water supply system under the direction of the Office of the Western Regional Manager.

(3) Personnel Arrangements

The capacity of the new water treatment plant will be four times the present plant's capacity, with up-to-date facilities instead of the existing out-of-date ones. For this reason, a working group in charge of chemical dosing and water quality control will be newly organized under the direction of an engineer who will be trained in the basic principles of water treatment in the special training program and assigned to the leaderhip of the operation and maintenance of the new water treatment plant.

The leading engineer will be also in charge of disposal of the sludge to be handled at the sludge drying beds. Although the sludge generated in the sedimentation basins has been traditionally disposed into the river without any treatment, it is now required that treatment be done for water pollution control. The task of removal

and disposal of the sludge may be entrusted to an outside source.

With the expansion of the waterworks, an increase of the personnel in both the administration and distribution sections will be also required. Figure 3.1 shows such a personnel arrangement.

3.3.2 Plan of Activity

The Project is planned to improve the very poor water supply situation of Kapsabet Town. The existing facilities and equipment will be abandoned or left as is, except for the distribution pipes. A new water supply system to be composed of new facilities and equipment will be connected to the existing distribution pipes for integration.

The facilities to be constructed in the Project are as follows:

(1) Intake Facilities

a. intake weir and intake pipes
b. intake pump station
c. raw water transmission pipes
d. maintenance road (intake facilities - water treatment plant)

(2) Water Treatment Plant

a. receiving well, rapid mixing chamber and flocculation basin
b. sedimentation basin
c. rapid sand filter
d. clear water reservoir
e. chemical building and chemical equipment
f. sludge drying bed
g. inplant piping
h. administrative building
i. inplant maintenance road
j. inplant outdoor lighting
k. staff house

(3) Transmission Facilities

a. maintenance road (water treatment plant - national road)
b. aqueduct across the Kimondi River
c. rising main including the restoration works of roads
d. booster pump station

(4) Distribution Facilities

a. ground reservoir
b. elevated tank
c. lift pump station
d. distribution main including the restoration works of roads

3.3.3 Location and Condition of the Project Site

Figure 4.2 shows the location of the intake facilities, water treatment plant, booster pump station, ground reservoirs and elevated tanks, rising main and the distribution main to be constructed in the Project.

(1) Condition of the Project Site

1) Water Treatment Plant

The new water treatment plant is located along the right bank approximately 400 m upstream of the crossing of the Kimondi River and the national road approximately 7 km west of the center of the town. The area around the site for the water treatment plant is owned by the central government and the area is leased to a sawmill and tea farmer at present. An access road will be constructed by cutting the forest along the Kimondi River. The other side of the Kimondi River is protected forest.

2) Rising Main and Booster Pump Station

The rising main will be installed along the national road and a booster pump station will be constructed midway between the

water treatment plant and the Scheme Office. The site proposed for a booster pump station is now privately owned but not used for any purpose. It has an area of about 1.5 ha, enough to keep the construction material.

3) Ground Reservoir and Elevated Tank

Two pair of ground reservoir and elevated tank will be constructed at the Scheme Office and the Bible College School of which both have enough space for the facilities within the premises and poses no trouble for construction. The private Bible College School has expressed to the Scheme Manager its intention to cooperate with the construction work with some restriction on the location of the facilities to be constructed.

4) Distribution Mains

The locations to install the distribution mains are along the national roads and streets near the center of the town. The enforcement of one way traffic will be necessary during the construction work for safety, and probably no traffic stoppage will be required.

(2) Condition of Infrastructure Development

1) Power Supply

Electricity is distributed by the Kenya Power and Lighting Co., ltd. (KPLC) to the service area. According to the Methods of Charge (KPLC) Bylaws, as the receiving voltage is supplied with three phase-three wire system, 415/240V, 50Hz, electricity are three phase, 415V for power and single phase, 240V for lighting.

Power failures occur three to four times per month for one to three hours at a time, caused mainly by thunderstorms.

Since there is no power supply near the proposed site for the water treatment plant, a temporary power supply equipment or power genera-