180 m^3/day and the other is 48 m^3/day for a total capacity of 228 m^3/day. Water pumped from the wells is delivered to a 12 m elevated storage tank having a capacity of 32 m^3 from where it is distributed to the service area (see Fig.-5).

The population of Taveta Town increased from 1,070 in 1968 to 2,760 in 1987. The population growth in surrounding areas, such as Taveta South, Maranu, Timbila, and Mahoo, has also been quite high. Currently, existing water facilities provide water to about 10,000 people (2,760 in Taveta Town and about 7,000 in surrounding rural areas).

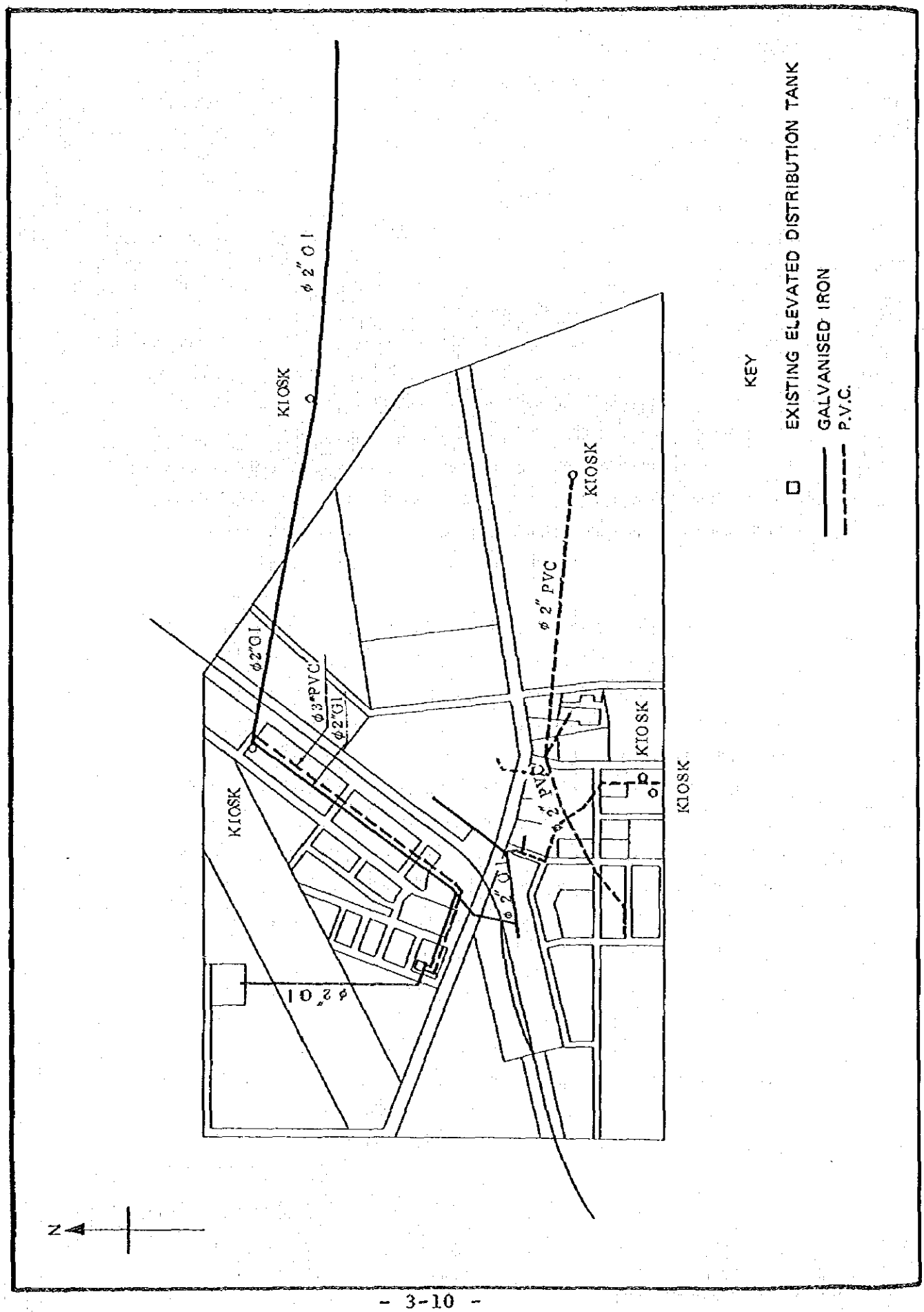
The water supplied to Taveta Town from the elevated storage tank goes to water tanks at the hospital, railroad, and customs office, and to 450 house connections, five kiosks, and other public facilities.

Water is also delivered to five kiosks in the Kimala area from the same elevated tank. However, at the present time, only one kiosk is functioning. The kiosks are about 8 km away from Taveta Town. Distribution pipes to the area are small (25 to 75 mm in diameter), and it is assumed that the friction loss in these pipes causes the kiosks to malfunction. Presently, in the Kimala area there is a water shortage. People in areas not having water supply facilities must obtain water from remote kiosk or springs; this daily chore is performed mainly by women and children.

3-3-7 Drainage and Sewerage

No systematic urban drainage exists in Taveta Town. Also no municipal sewarage is observed, however, septic tanks are installed at the hospital.

Fig.–5 EXISTING WATER SUPPLY FACILITIES



CHAPTER 4 CONTENTS OF THE PROJECT

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4-1 Objective of the Project

The objective of the Project is to supply safe drinking water to Taveta Town and to the southern part of the Taveta Division within the Taita-Taveta District in the Coast Province. For this purpose, water supply facilities are to be constructed under the grant aid cooperation from the Government of Japan.

4-2 Justification of the Request for the Grant Aid Cooperation

Since 1985 the Taita-Taveta District Development Programme has been carried out in the Project area as a rural development project under technical cooperation from the Government of Denmark. Rural water supply from shallow wells is included in the programme. Due to the dry climate in the area, however, field surveys found many locations where suitable ground water for drinking was not available.

In view of the above, the Government of Kenya's request contains a plan for providing good quality drinking water to Taveta Town and to the southern part of the Taveta Division. Therefore, this Project will be to improve the water supply system in Taveta Town and to provide potable water to the rural area in the southern part of the Taveta Division in cooperation with the Taita-Taveta District Development Programme.

In accordance with the development principles of the Government of Kenya, the MOWD has been making great efforts to increase the service rate in the country. However, due to the limitations of the Government's budget, only 11 projects out of 176 planned were completed during the Fourth and Fifth RWS periods of

time. For this reason, it would be exceedingly worthwhile to improve the water supply system in Taveta Town which has been experiencing chronic water shortages, and to provide clean water to the rural area in the southern part of the Taveta Division where suitable ground water is unobtainable from the shallow strata. In this respect, it is recognized that implementation of the project under the Grant Aid Cooperation of the Government of Japan will definitely contribute to success of the national water supply development target.

4-3 Outline of the Project

4-3-1 Project Area

The service areas concerned are Taveta Town and the rural areas in the Kimorigo Location to the south of Taveta Town where potable water is unobtainable from shallow ground strata.

Population change in Taveta Town in the past is shown below:

Year	No. of Population
1969	1,070
1979	1,812
1987	2,976

It can be clearly seen through comparison of aerial photographs taken in the 1950's with those taken in 1986 that the number of houses increased considerably not only in Taveta Town, but also in the area south of Taveta Town and in the Maranu area to the northeast of Taveta Town.

The population growth and the farmland development rate in areas to the south of Taveta Town were remarkable from the end of the 1950's up to 1986 (see Figs.-6 and

7). These changes are evident in areas along the Lumi River that were developed as banana fields, and in the Kithogoto and Kimala areas where traditional farming (maize) was developed.

Since the 1960s, the population growth is significant in the narrow strips of land that run parallel to, but two to three kilometers away from the Lumi River . The reason why many people inhabit the narrow strip of land, is that there are no dwellings in the lowlands along the river because of frequent flooding, the lack of available land due to the intensive cultivation of banana, and the prevalence of malaria. However, there is difficulty in this area to get potable water from ground water because of high salinity. Taking into account the matters mentioned above, the service area concerned was finally selected as shown in Fig.-8.

Fig.-6 LAND USE : 1960

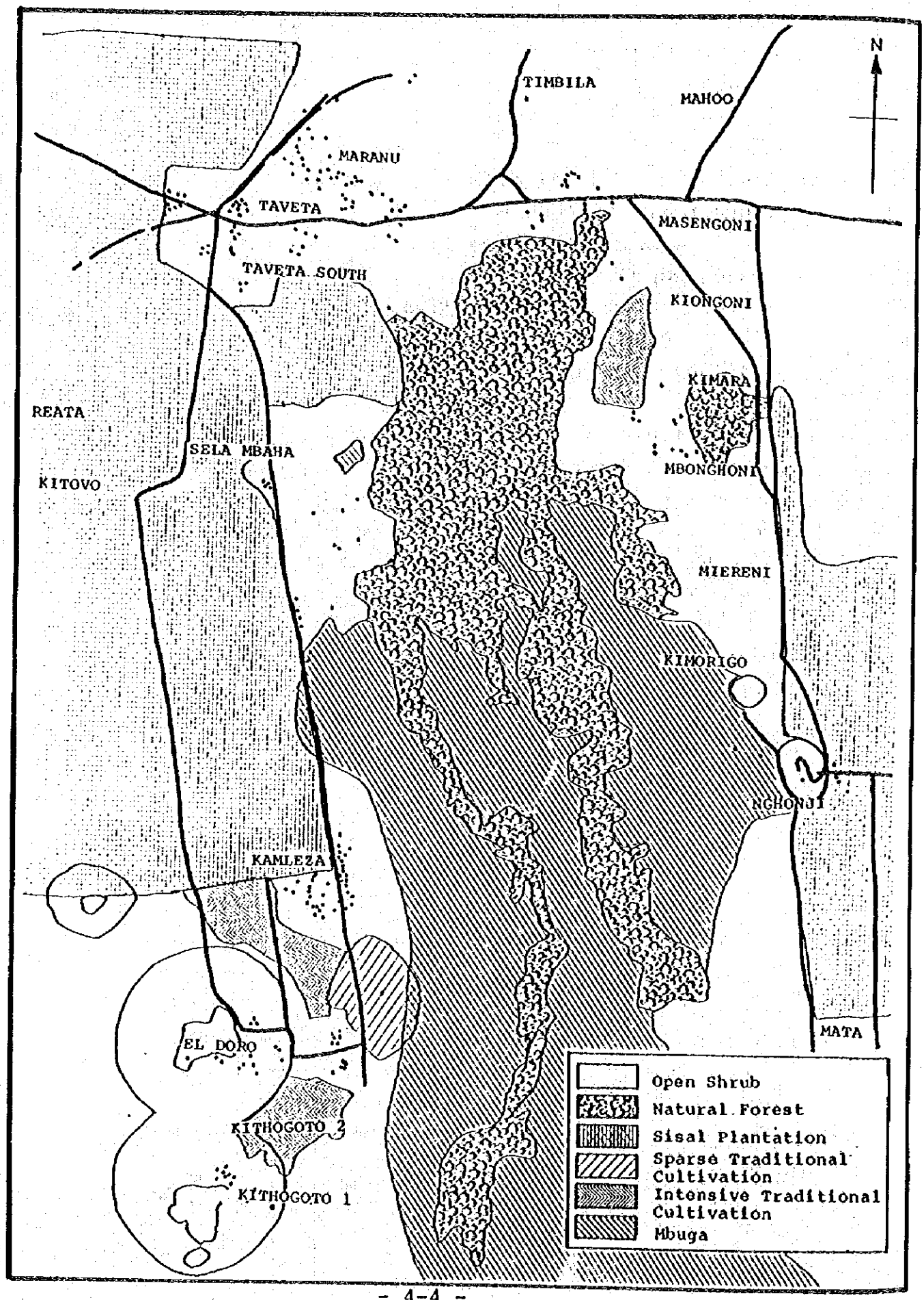


Fig.–7 LAND USE : 1986

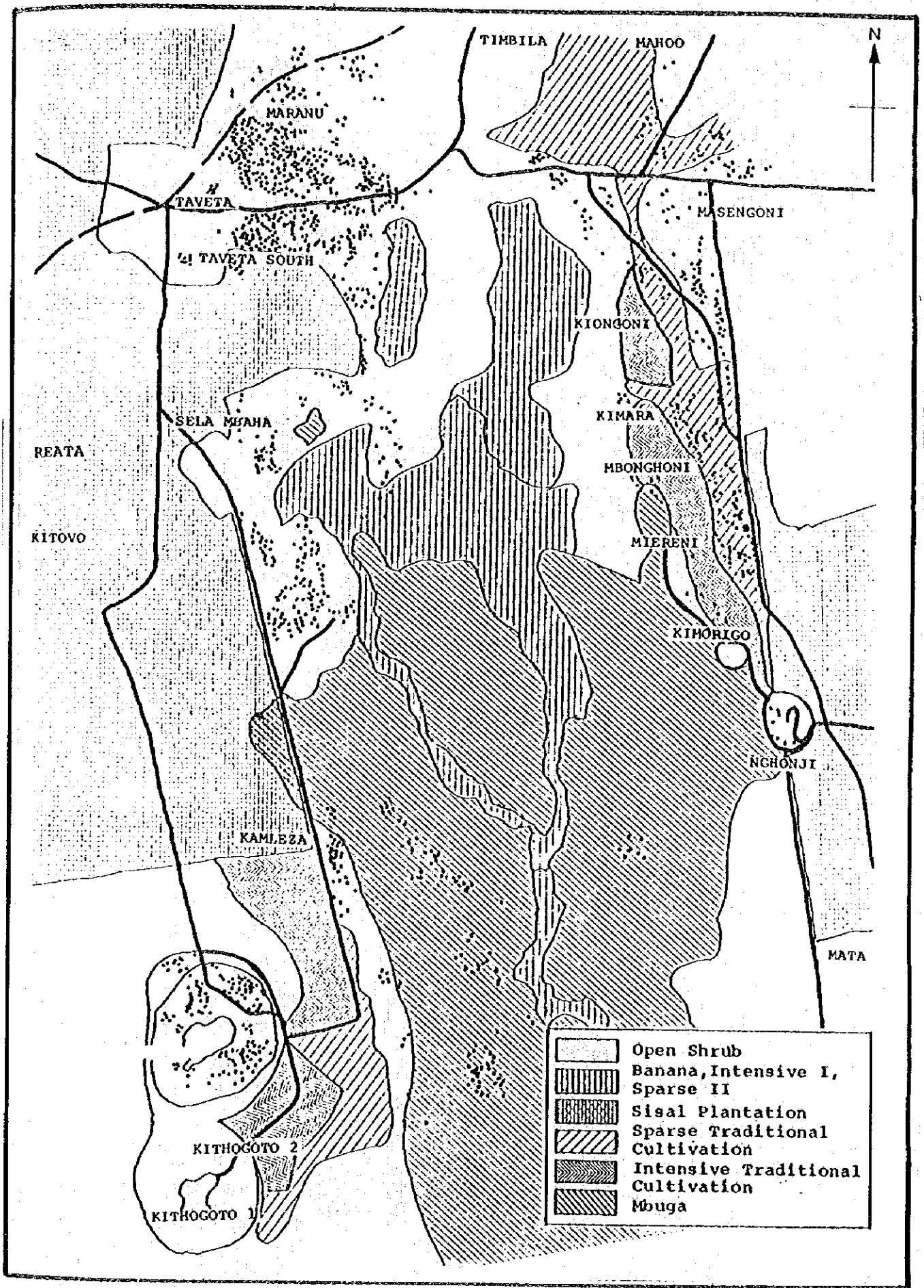
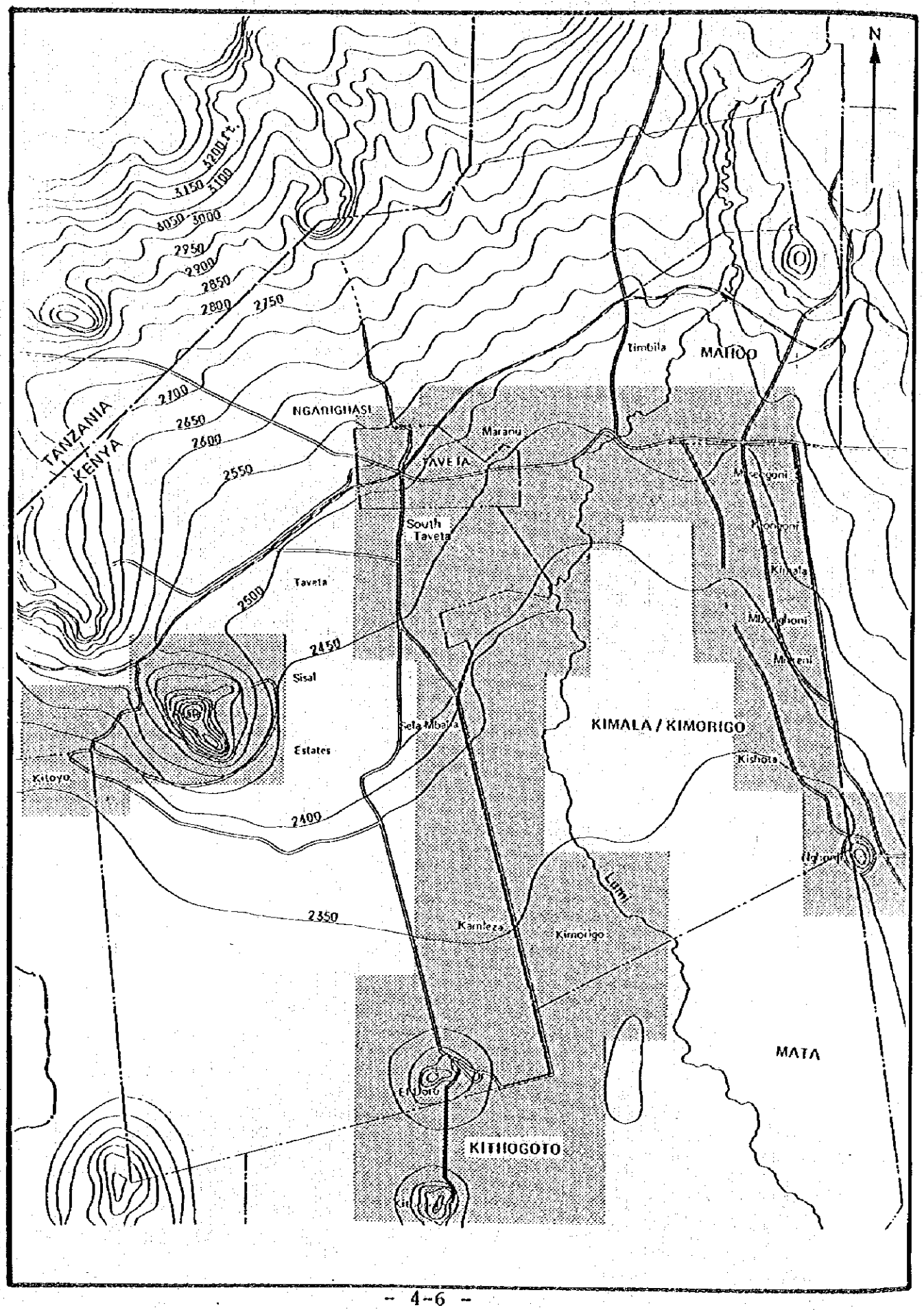


Fig.–8 SERVICE AREA



4-3-2 Project Target Year

The Republic of Kenya set the year 2000 as the target year for completing the country's water supply plan. However, as 2000 is only 13 years away, it is too short to attain the said plan as the Project target year. Present development plans are targeted for the year 2005; therefore, the target year for the Project is determined as 2005.

4-3-3 Water Source

The Project's proposed water source is the Njoro Kubwa Spring that is located 2 km south of Taveta Town. The data in 1955 shows that the spring has a discharge of about 6 m^3/sec (220 ft^3/sec). (H. W. Unerhill, Feb. 1955 and D. Watts, May 1962). However, recent data indicates the discharge as being 5.0 m^3/sec (from the Irrigation Section of MOWD). It is believed that the difference between recorded discharge does not indicate a decrease in the amount of water discharged; it probably due to the leakage occuring through the spring's surrounding embankment (the embankment was built to raise the spring pond water level for construction of irrigation canals). MOWD has a plan to effect repairs to the embankment to stop the leakage.

Water rights to the Njoro Kubwa Spring belongs to the Government of Kenya. The spring is under the control of the Water Apportionment Board of the MOWD. The Taveta Sisol Estate was authorized to use the spring water in 1948 (in the smaller amount of either 1.982 m^3/sec (70 ft^3/sec) or 70% of the spring discharge). In 1955, farmers were also authorized to use the spring water in the smaller amount of 0.850 m^3/sec (30 ft^3/sec) or 30% of the discharge. As the amount of water needed by the Project target year will be less than 0.1 m^3/sec, the spring has a sufficient discharge as the Project water source.

Table-12 Chemical Analysis of Spring Water

Item \ Sample No.	N o . 1	N o . 2	Kenyan Standard
Electric Conductivity	195 μ℧/㎝	195 μ℧/㎝	————
Turbidity	0 JTU	0 JTU	5 JTU
C ℓ ⁻	2.6 ㎎/ℓ	2.7 ㎎/ℓ	250 ㎎/ℓ
T — Fe	< 0.03㎎/ℓ (0.01)	< 0.03㎎/ℓ (0.01)	10 ㎎/ℓ
Tatal Hardness	73.2 ㎎/ℓ	70.2 ㎎/ℓ	500 ㎎/ℓ
F	< 0.3 ㎎/ℓ	< 0.3 ㎎/ℓ	0.3 ㎎/ℓ
Mn	< 0.01㎎/ℓ	< 0.01㎎/ℓ	0.1 ㎎/ℓ
SO_4	3.4 ㎎/ℓ	3.5 ㎎/ℓ	400 ㎎/ℓ
T . S	120 ㎎/ℓ	129 ㎎/ℓ	1,000 ㎎/ℓ

Njoro Kubwa Spring's water quality is quite potable and meets MOWD water quality standards (see Table-12).

4-3-4 Source of Electricity

The source of electricity necessary for the water supply plan is being prepared by the Kenya Power Lighting Corporation (KPLC) by extending the high voltage lines from Voi to Taveta Town. The power line installation work is about to complete. Recently, part of Taveta Town started receiving electric power.

KPLC transmission lines carry 3,300 volts. The voltage is lowered to 220v at a transformer substation in Taveta Town for general use. For the Project, a power source of 415v is required, and therefore requires its own transformer substation.

The Basic Design Study Team and Kenyan Government officials concerned agreed that the power line extension work for the Project is to be undertaken by MOWD.

4-3-5 Land Acquisition for the Project

The followings have to be secured for the Project:

1. Land for water source facilities
2. Land for pipeline routes
3. Land for a distribution reservoir

Land for the water source facilities is within the site of the Taveta Sisal Estate. In 1948, the Government of Kenya and the Estate signed an agreement to put 12.2 acres (about 4.9 ha) of land around Njoro Kubwa Spring under Government control.

The pipelines will be laid along the public roads.

If the distribution reservoir is to be located on public land, the distribution pipe line must cross two rivers

on the lower slope of Mt. Kilimanjaro neighboring on northern Taveta Town. Thus, taking into consideration the safety of the pipeline, the Government of Kenya is negotiating with the Taveta Sisal Estate to obtain the necessary land for the distribution reservoir within their lands.

4-3-6 Responsibility of the Project Implementation

The Government organizations to take responsibility of the project implementation are the Planning and Design Division and the Implementation Division of MOWD.

4-3-7 Facilities to be Provided by The Grant Aid Cooperation

Facilities to be provided by the grant aid cooperation is summarized in Section 5-4-3 "Summary of Facilities" (P. 5-48) in this report.

CHAPTER 5 BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5-1 Basic Design Policy

One of the Kenyan Government's development objectives is to provide safe drinking water to its people throughout the country by the year 2000. To achieve this objective, MOWD has been making a great effort, however, the service rate in rural areas is still low. A large amount of fund is still needed to make this development objective a reality.

The Taita-Taveta District Development Programme is covering the rural water supply project plans for obtaining water from the shallow wells with hand pumps in the Project Area.

The objective of the Project is to supply water through the use of pipelines from Njoro Kubwa Spring to areas where suitable water for domestic supply is unobtainable from shallow wells.

Since this is a part of MOWD's RWS programme, MOWD's design standards are applied for the Basic Design. Project facilities will be designed being mindful of keeping construction, operational and maintenance costs to a minimum, and in simplifying operating and maintenance procedures.

One of the fundamental purposes of the Basic Design is to provide for Project facilities that will maintain their functional use in the rural areas for an extended period of time thereby demonstrating high investment efficiency.

5-2 Basic Design

5-2-1 Service Areas

The project will supply water to Taveta Town and its highly populated surrounding area, and to the rural areas to the south of Taveta Town where suitable source for water supply is unobtainable from shallow ground strata.

Since areas, other than described above, are low marshy areas or areas where irrigation water is unobtainable, the population distribution pattern in the Project Area is not expected to change significantly in future (see Fig.-7).

Including Taveta Town, twenty highly populated areas are selected for the service areas in the Project. (see Fig.-8).

5-2-2 Water Demand Forecast

Water for domestic, public and livestock use are taken into consideration in the Project's water supply demand forecast. Industrial and agricultural water uses were not included.

1) Domestic Water:

Domestic water demand in the area such as Taveta Town and its surrounding area and the less populated rural areas, were estimated in accordance with the MOWD's Design Standards.

The MOWD's Design Standards classifies service areas into different categories of water demand according to the following conditions;

Urban Area:

High-class housing:	Having a 0.2 to 0.8 ha lot, kitchen, and toilet and shower facilities.
Medium-class Housing:	Having a 0.1 ha lot, with the same facilities as high-class housing but with outdoor washing place.
Low-class Housing:	Having only a simple water plug.

Rural Area:

High Potential:	Area having more than 1,000 mm annual rainfall.
Medium Potential:	Area having 500 to 1,000 mm of annual rainfall.
Low Potential:	Area having less than 500 mm annual rainfall.

In accordance with the MOWD's design standards, Timbila, in the Project Area, is classified as a "low populated urban area." However, judging from the present number of houses and land-use pattern, the Timbila area will continue to be a rural area in future.

Taking the above into consideration, the twenty water supply areas in the Project Area can be classified as shown in Table-13.

A national census is conducted every ten years in Kenya. The latest census was made in 1979. According to the last two recent censuses, the population in the Project Area was as follows:

Area	1969 Census	1979 Census	Population Growth Rate(%)
Taveta Town	1,070	1,812	5.4
Taveta South	8,970	15,180	5.4

District office records contain the 1987 population figures for each water supply area; these figures are shown in column (1) Table-14.

Table-13 Classification of Urban and Rural Areas

		URBAN	RURAL	CLASS
1.	TAVETA TOWN	○		MEDIUM CLASS HOUSING
2.	TAVETA TOWN SOUTH		○	MEDIUM POTENTIAL
3.	REATA		○	〃
4.	KITAVO		○	〃
5.	SELA MBAHA		○	〃
6.	KAHLEZA		○	〃
7.	KIHORIGO		○	〃
8.	EL DORO	○		LOW CLASS HOUSING
9.	KITHOGOTO I		○	MEDIUM POTENTIAL
10.	KITHOGOTO II		○	〃
11.	MARANU	○		LOW CLASS HOUSING
12.	TIMBILA		○	MEDIUM POTENTIAL
13.	MAHOO		○	〃
14.	MASENGONI		○	〃
15.	KIONGONI		○	〃
16.	KIMALA		○	〃
17.	MBONGHONI		○	〃
18.	MIERENI		○	〃
19.	NGHONJI		○	〃
20.	MATA		○	〃

Table-14 Existing and Design Population Served

Population / Year / Service Area	Total Population Served			Population Served by House Connection			Population Served by Kiosks		
	1987	1995	2005	1987	1995	2005	1987	1995	2005
1. TAVETA TOWN	2,760	3,778	5,591	1,000	3,022	4,473	1,760	756	1,118
2. TAVETA TOWN SOUTH	2,400	3,017	4,015	0	603	1,606	2,400	2,414	2,409
3. REATA	977	1,228	1,635	0	246	654	977	982	981
4. KITAVO	1,127	1,417	1,885	0	283	754	1,127	1,134	1,131
5. SELA MBAHA	2,554	3,210	4,273	0	642	1,709	2,554	2,568	2,564
6. KAMLEZA	1,352	1,699	2,262	0	340	452	1,352	1,359	1,810
7. KOMORIGO	376	473	629	0	95	252	376	378	377
8. EL DORO	977	1,228	1,635	0	368	817	977	860	818
9. KITHOGOTO I	751	944	1,256	0	189	502	751	755	754
10. KITHOGOTO II	376	473	629	0	142	265	376	331	377
11. MARANU	3,005	3,777	5,027	0	756	2,514	3,005	3,021	2,513
12. TIMBILA	751	944	1,256	0	198	502	751	755	754
13. MAHOO	751	944	1,256	0	189	502	751	755	754
14. MASENGONI	526	661	880	0	132	352	526	529	528
15. KONGONI	263	331	440	0	66	176	263	265	264
16. KIMALA	1,840	2,311	3,078	0	463	1,231	1,840	1,850	1,847
17. MBONGHONI	420	528	703	0	106	281	420	422	422
18. MIERENI	158	199	264	0	40	106	158	159	158
19. NGHONJI	751	944	1,256	0	189	502	751	755	754
20. MATA	751	944	1,256	0	189	502	751	755	754
TOTAL	22,866	29,052	39,226	1,000	8,249	18,195	21,866	20,803	21,031

The 1979 national census was conducted in the rural areas to the south of Taveta Town. These rural areas were classified as Kimorigo, Kitobo, and Kimala Sublocations, and their populations were not classified into service areas of the Project (20 areas in all). For this reason, the future population of each service area must be estimated based on the District Office's 1987 population data.

As shown in Fig.-7, by 1986 agricultural farms were developed on most of the land where irrigation water was obtainable and soil conditions were suitable in the southern rural areas. For this reason, future population growth rates in those rural areas will be less than for the 1968-1979 period (5.4% annual increase rates). In this Study, therefore, a 2.9% annual rate (equivalent to the rural area's annual population increase rate in the MOWD's design standards) was adopted for estimating future populations in those particular areas.

The population growth rate in Taveta Town during the 1979-1987 period was estimated to be 5.4% annually. However, as it is considered that the expansion of farmland in Taveta Town has almost reached its limit, the population growth rate in Taveta Town will lower in future. It was estimated, therefore, to be the annual rate of 4.0% up to the year 2005.

The service rates between the population served by house connection and by kiosk specified in MOWD's Design Standards are as follows:

Area Classification	House Connection	Kiosk
Urban Medium-class Housing	100%	0
Urban Low-class housing	50%	50%
Rural Medium-class Housing	40%	60%

It has been determined that water supply at kiosks will be needed in Taveta Town even in the future. Thus, a house connection rate of 80% and a kiosk water supply rate of 20% of total population were adopted in the basic design.

Based on the above considerations, water supply populations utilizing house connections and kiosks in each service area were forecasted as shown in Table-14.

2) Water for Livestock:

As the Republic of Kenya is an agricultural country, livestock farming in semi-dry climate zones, such as the Taveta Division, has great economical importance. In farming areas that are irrigated, cattle often walk into excavated irrigation channels to drink water thereby inflicting damage to the channels and to the surrounding crops. It is necessary to provide watering places for cattle that is away from irrigated farmland and irrigation channels.

Based on the District Office's data, the number of cattle in each service area within the Project Area is shown in Table-13.

MOWD established the standard wherein the optimum number of cattle in each of the different climatic zones was determined from a land productivity viewpoint; the figures are shown below:

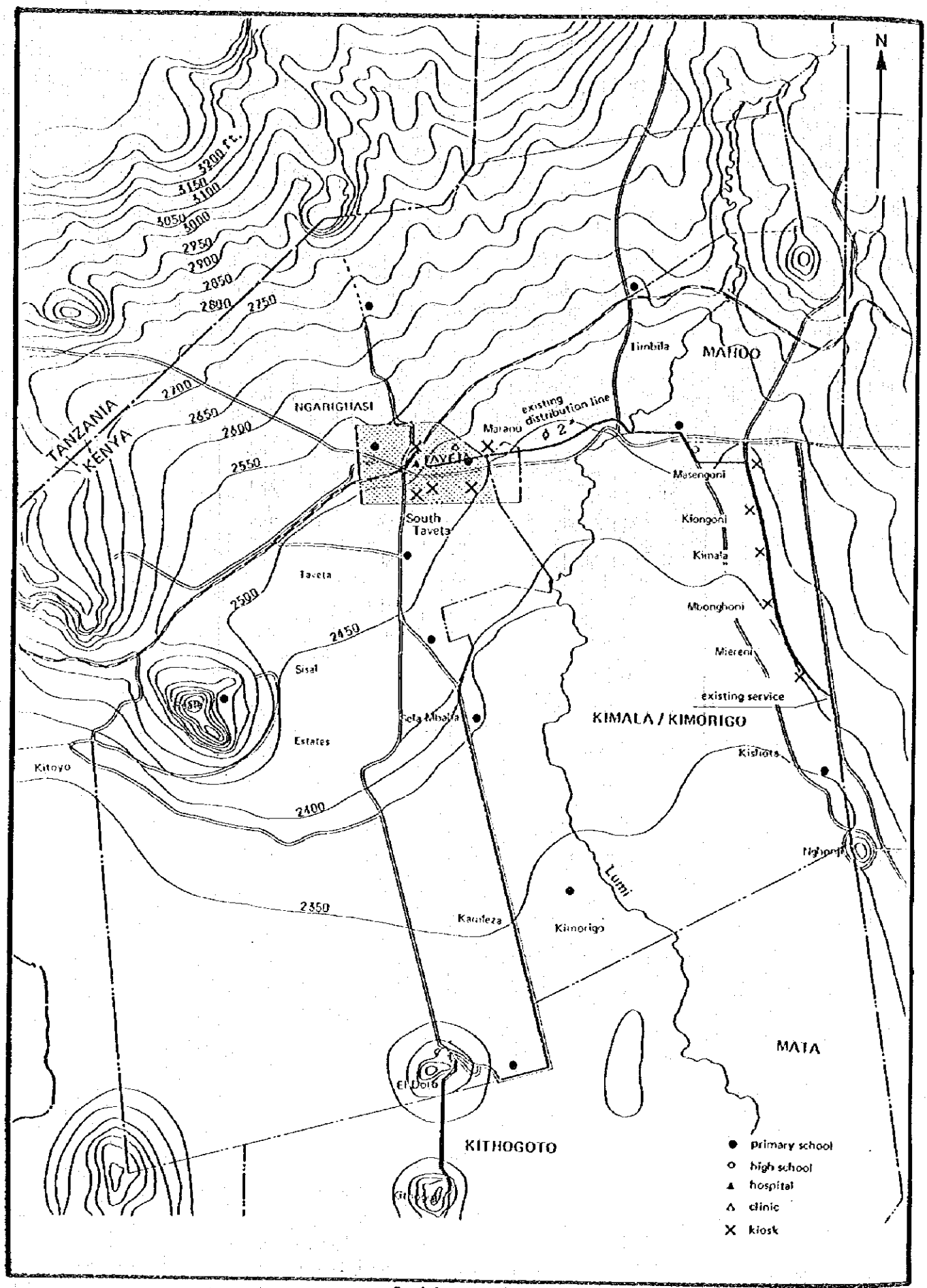
Annual Rainfall (mm/year)	Optimum Number of Cattle (Head/ha)
600 - 800	1.2
800 - 1,000	1.0
1,000 - 1,200	0.8
1,200 - 1,700	0.6
1,700 & above	0.4

From the above figures, it can be considered that the water supply areas in the Project Area have the cattle raising potential of 1.2 cattle/ha. Judging from the size and land-use condition of each service area, future estimated cattle figures are shown in Table-15.

Table-15 Existing and Design Number of Cattle Heads

	SERVICE AREA	1987	2005
1.	TAVETA TOWN	183	0
2.	TAVETA TOWN SOUTH	0	0
3.	REATA	0	0
4.	KITAVO	0	0
5.	SELA HBAHA	137	68
6.	KAHLEZA	110	55
7.	KIHORIGO	1,615	808
8.	EL DORO	500	250
9.	KITHOGOTO I	500	250
10.	KITHOGOTO II	500	250
11.	HARANU	150	0
12.	TEHBELA	1,000	500
13.	HAHOO	900	900
14.	HASENGONI	58	58
15.	KIONGONI	52	52
16.	KIHALA	700	700
17.	HBONGHONI	489	489
18.	HIERENI	511	511
19.	NGHONJI	125	62
20.	HATA	590	295
計		8,120	5,248

Fig.-9 PUBLIC WATER DEMAND



3) Public Water Demand

Public water is for use in public offices, hospitals, schools, restaurants and stores.

Users of public water in the Project Area are as follows (Fig.-9):

(1) Students and Teachers:

Service Area	Students	Teachers
Taveta Town	115	3
Taveta Town south	942	18
Reata	157	8
Sela Mbaha (2 places)	464	12
Kimorigo	314	8
El Doro	400	10
Kithogoto II	621	17
Maranu	811	19
Timbila (4 places)	2,574	63
Miereni	274	8
TOTAL (combined)	6,838	

(2) Hospital:

Taveta Town: 1
Number of Beds: 206
Number of Outpatients: 126

(3) Hospital and Clinic:

Taveta Town South:	1
Kimorigo:	1
TOTAL	2

(4) Hotels:

Taveta Town, low class:	6
Maranu, low class:	6
Kimala, low class:	4
Mbonghani, low class	2
TOTAL	18

(5) Public Offices:

Taveta Town:	22 offices (120 people)

(6) Restaurants:

Taveta Town:	11
Maranu:	2
Kimala:	1
Mbonghani:	1
TOTAL	15

(7) Stores:

Taveta Town:	60
Masengoni	1
Kimala	1
Mbonghani	2
TOTAL	64

4) Forecase of Public Water Use

The future demand for public water was estimated by referring to the MOWD's design standards, and is listed below:

(1) Schools:
30% of the area's population are students and teachers.

(2) Hospitals and Clinics:
There are no plans for building new hospitals in Taveta Town before the year 2005.

In accordance with the MOWD's Design Standards, 0.8 hospital beds are required per 1,000 people. The present Division Hospital has 206 beds. Based on the MOWD's standards, this number of beds correspond to a hospital which accommodate 250,000 people; however, the standard indicates the minimum number of beds

required. Presently, the number of beds at the Division Hospital is insufficient. As the Divisional Hospital is to be the only hospital in town, even in the foreseeable future, the number of beds must be increased in proportion to the population increase. It has been estimated that the Division Hospital will have 353 beds by the year 2005.

The MOWD's design standards stipulates that one health centre and from one to four clinics are to be established for every 35,000 to 40,000 people. The forecasted population in the Project Area by the year 2005 is estimated at 35,000; thus, in the Study, it was assumed that the following health centre and clinics are to be built:

Health Centre:	El Doro
Clinics	Taveta Town South
	Sera Mbaha
	Kimorigo
	Kimala

(3) Hotels:

There are 18 low-class hotels in the Project Area. Each hotel in the Area has 15 rooms in average. Thus, in the Project Area there are 270 hotel rooms per 23,000 of present population. As the future population in the Area is forecasted to be 39,000, 400 hotel rooms (1% of the future population) will be needed. Further, there will be a need for a 50 roomed medium-class hotel in the Area.

(4) Public Offices:

Presently, there are 120 staff members working for 22 Government offices in Taveta Town; these numbers are not expected to increase significantly in the future. Considering the Government's forecasted future budget increase rate (5% to 7% annually) and the increasing importance of the present office, as the town grows the increase rate of staff members was determined to be 4% annually.

(5) Restaurants:

There are 15 restaurants in the Area, most of which are located in Taveta Town and Maranu. Kimala and Mbonghani each have one restaurant. The number of restaurants will increase in direct proportion to the population. It is considered that the increase of water demand will occur in such service areas where restaurants presently exists and, also, where large design populations exist. Thus, in those areas, there will be an increased demand for water supplies.

(6) Stores:

There are 64 stores in the Project Area. Sixty of them are in Taveta Town facing the market area. The number of stores will increase in direct proportion to the population. People living relatively close to Taveta Town, or in areas several kilometers away that are served by better roads will continue to shop in Taveta Town in the future.

In view of the above, there will be an increase in number of stores primarily in Taveta Town and El Doro. There might possibly be new opening of stores in the service areas remote from Taveta Town.

Table-16 shows the forecasted future number of students and teachers, hospital beds and outpatients, clinics, hotels, public offices, restaurants, and stores.

Table-16 Demand Forcast of Public Water Use

		School			Hospital						Clinic			Hotel			Public Office			Restaurant			Store		
		1987	1995	2005	1987		1995		2005		1987	1995	2005	1987	1995	2005	1987	1995	2005	1987	1995	2005	1987	1995	2005
1	TAVETA TOWN	118	1.133	1.677	BED※1 206	OUT※2 126	BED 262	OUT 160	BED 353	OUT 216	0			(L)※3 6	(M) 1 (L) 8	(M)※4 4 (L) 6	120	164	205	11	12	14	60	81	96
2	TAVETA TOWN SOUTH	960	960	720	0	0			0	0	1	1	1(DIS)※5	0			0			0			0		
3	REATA	165	368	491	0	0			0	0	0			0			0			0			0		
4	KITAVO	0	425	566	0	0			0	0	0			0			0			0			0		
5	SELA MBAHA	476	963	1.282	0	0			0	0	0		1(DIS)	0		(L) 2	0			0		2	0	1	3
6	KAMLEZA	0	510	679	0	0			0	0	0			0			0			0			0		
7	KIMORIGO	322	142	189	0	0			0	0	1	1	1(DIS)	0		(L) 2	0			0			0		
8	EL DORO	BOAR※7 410	368	491	0	0			0	0	0		1(HC)※6	0			0			0		2	0		
9	KITHOGOTO I	0	283	377	0	0			0	0	0			0			0			0			0		
10	KITHOGOTO II	638	142	189	0	0			0	0	0			0			0			0			0		
11	MARANU	330	1.133	1.508	0	0			0	0	0			(L) 6	(L) 8	(M) 1 (L) 7	0			2	2	3	0		
12	TIMBILA	2.637	2.637	2.637	0	0			0	0	0			0			0			0		1	0	1	3
13	MAHOO	0	283	377	0	0			0	0	0			0			0			0			0		
14	MASENGONI	0	198	264	0	0			0	0	0			0			0			0			1	1	2
15	KIONGONI	0	99	132	0	0			0	0	0			0			0			0			0		
16	KIMALA	0	694	923	0	0			0	0	0		1(DIS)	(L) 4	(L) 5	(M) 2 (L) 5	0			1	1	2	1	1	2
17	MBONGHONI	0	158	210	0	0			0	0	0			(L) 2	(L) 2	(L) 3	0			1	1	2	2	3	4
18	MIERENI	282	60	79	0	0			0	0	0			0			0			0			0		
19	NGHONJI	0	283	377	0	0			0	0	0			0			0			0			0		
20	MATA	0	283	377	0	0			0	0	0			0			0			0			0		
	TOTAL	6.838	11.122	13.545	206	126	262	160	353	216	2	2	5	(L) 18	(M) 1 (L) 23	(M) 7 (L) 25	120	164	205	15	16	26	64	88	110

※1 No. of Beds ※2 Out Patient ※3 Low Class Hotel ※4 Medium Class Hotel ※5 Clinic ※6 Health Center ※7 Boading School

5-2-3 Water Supply Service Level

MOWD intends, in the future water supply plan, to change from the kiosk water supply method, which is the present rural water supply service level, to the house connected water supply method, in order to raise the country's living standards.

It is believed that the rural water supply service level will be improved in proportion as agricultural productivity increases. For this reason, MOWD has the following water supply planning standard (Table-17):

Table-17 Service Level Forecast

	HOUSE CONNECTION(%)			KIOSK(%)		
	Initial	Future 10 years	Ultimate 20 years	Initial	Future 10 years	Ultimate 20 years
Urban Areas						
High and Medium class housing	100	100	100	0	0	0
Low Class housing	10	30	50	90	70	50
Rural Areas						
High potential	20	40	80	80	60	20
Medium potential	10	20	40	90	80	60
Low potential	5	10	20	95	90	80

5-2-4 Design Consumption of Water

In accordance with the MOWD's design standards, the following water supply units were determined as a result of field surveys:

1) Design Capacity for Individual House Connections:

(1) Taveta Town:

As stipulated in the MOWD's design standards, the proportion of individual connections (IC)

to non-individual connections (NC), ie., kiosks in Taveta Town, can be expressed as follows:

IC : NC = 100% : 0%

However, judging from present and future population distribution, some areas still exist that will continue to need kiosks. Thus, a decision was made to supply water using the proportion of IC :NC = 80% : 20%. The water supply rate using individual house connections is to be 150 l/cap/day.

(2) El Doro and Mananu:

Categorizing these areas as low-class housing areas, the ratio of the water supply methods was established as:

IC : NC = 50%: 50%.

There water supply rate using individual house connections in these areas is to be 75 l/cap/day.

(3) Other Areas:

Categorizing other areas as medium-class housing areas, the ratio of the water supply method was established as:

IC : NC = 40% : 60%

The water supply rate using individual house connections is to be 50 l/cap/day.

2) Kiosks:

The water supply rate at kiosks is to be 20/cap/day in the town and 15 l/cap/day in rural areas.

3) Livestock:

The water supply for livestock is to be measured based on the number of cattle unit. The livestock unit was determined to be one unit for one select breed of cattle, three of cattles native to the

country, fifteen goats, or fifteen sheep. The livestock water supply rate is to be 50 l/unit/day.

4) Schools:

It has been estimated that 30% of the future population will be made up of students and teachers. The water supply rate to day schools is to be 25 l/cap/day and 50 l/cap/day for boarding schools.

5) Hospital:

The water supply rate to hospitals is to be 400/bed/day and 20 l/outpatient/day.

6) Clinics and Health Centres:

The water supply rate to clinics and health centres was set at 5,000 litres/day for each.

7) Hotels:

Based on field surveys and other data, hotels were classified as medium and low-class. The water supply rates to hotels is to be 300 l/room/day for medium-class hotels, and 50 l/room day for low-class hotels.

8) Public Offices:

The water supply rate to public offices was set at 25 l/cap/day. All public offices in the Project Area are in Taveta Town and they are expected to remain there in the future.

9) Restaurants:

The water supply rate to restaurants is to be 500 l/restaurant/day.

10) Stores:

The water supply rate to stores was set at 100 l/store/day.

5-2-5 Design Capacity

The design capacity for the Project was calculated based on design consumption and population in each service area.

Water supply to Taveta Town will be made through house connections and kiosks.

In the rural areas, the service areas are dispersed to each other and the inhabitants of the scattered farmhouses are prevailing.

In accordance with the MOWD's design standards, the farming areas to the south of Taveta Town can be classified as a medium zone; kiosks should be located within 1 km of living areas and one kiosk for every 200 to 500 people. Based on present and future population distribution in those areas, kiosk installation locations were determined as shown in Fig.-10.

Table 12 shows the present year and future years (1995 and 2005) design population in each service area. As it was assumed that the water supply service level in the future will be raised, the kiosks's design population in the rural areas by the year 2005 will almost be equal to the areas' present population (Table-18).

The design capacity of kiosks in each service areas is shown in Table-19. Water demand calculation tables are shown in Appendix 5 considering the peak factor of 2.

Fig.--10 LOCATION OF KIOSKS

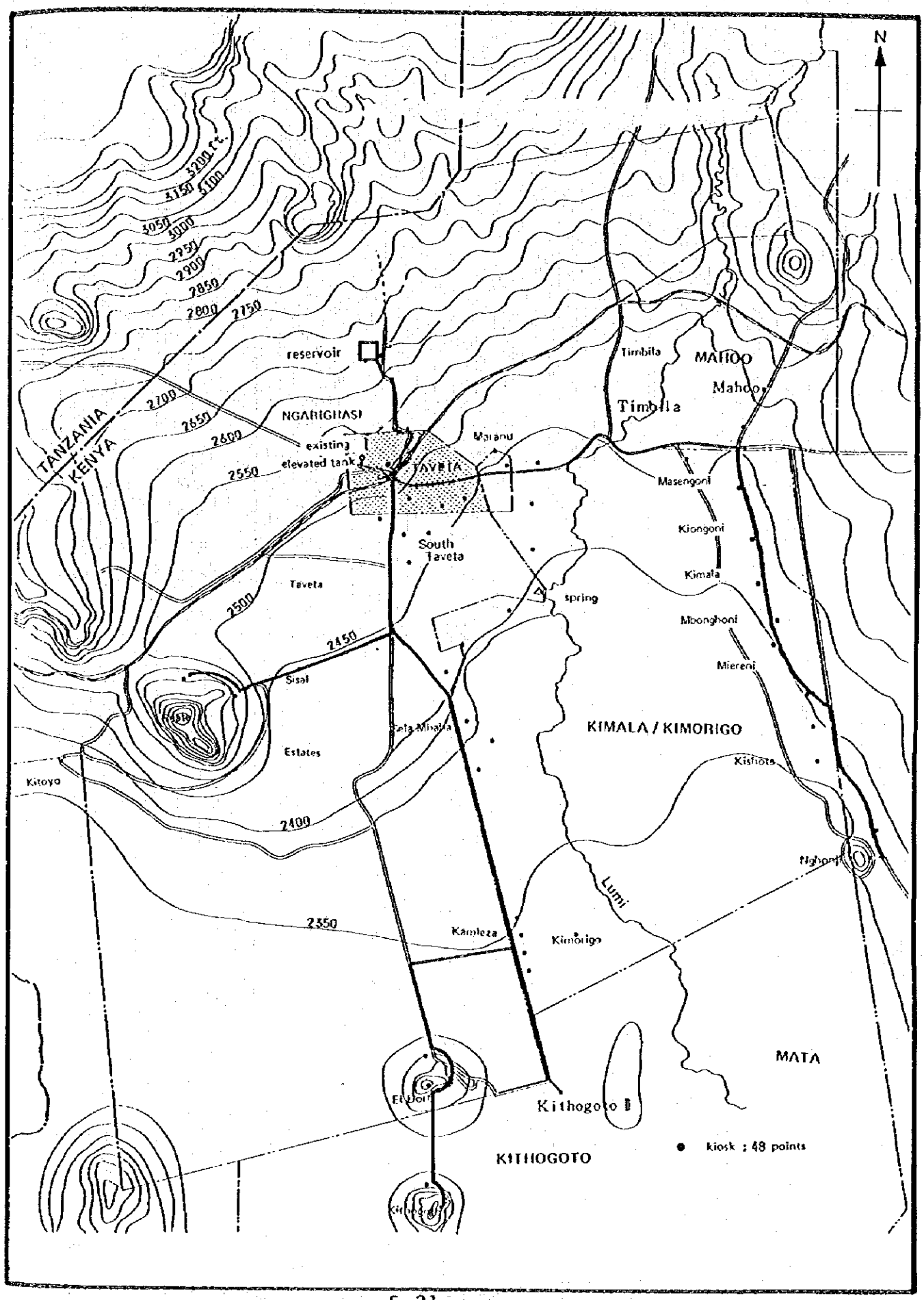


Table - 18 DESIGN CAPACITY

Service Area	1987		1995		2005	
	Population	Design Capacity (m³/day)	Population	Design Capacity (m³/day)	Population	Design Capacity (m³/day)
1. TAVETA TOWN	2,760	301.22	3,778	648.55	5,591	966.99
2. TAVETA TOWN SOUTH	2,400	65.00	3,017	95.36	4,015	139.44
3. REATA	977	18.79	1,228	36.23	1,635	59.70
4. KITOVO	1,127	16.91	1,417	41.79	1,885	68.82
5. SELA MBAHA	2,544	57.06	3,210	99.80	4,273	167.16
6. KAHLEZA	1,352	25.73	1,699	54.29	2,262	69.48
7. KIHORIGO	376	99.44	473	79.57	629	69.89
8. EL DORO	977	65.04	1,228	72.75	1,635	120.69
9. KITHOGOTO. I	751	36.27	944	46.61	1,256	58.34
10. KITHOGOTO. II	376	46.57	473	34.37	629	35.49
11. MARANU	3,005	93.85	3,777	156.20	5,027	298.26
12. TIMBILA	751	127.20	944	124.31	1,256	128.14
13. MAHOO	751	56.27	944	72.86	1,256	90.84
14. MASENGONI	526	10.89	661	22.49	880	35.22
15. KIONGONI	263	6.55	331	12.36	440	18.66
16. KIMALA	1,840	66.20	2,313	107.60	3,078	187.29
17. MBONGHONI	420	32.95	528	42.33	703	53.73
18. MIERENI	158	34.97	199	31.44	264	35.20
19. NGHONJI	751	17.52	944	32.56	1,256	48.94
20. MATA	751	40.77	944	50.01	1,256	60.59
Total	22,866	1,219.27	29,052	1,861.48	39,226	2,712.87

Table - 19 DESIGN CAPACITY OF KIOSK
2005

	Service Area		Design Capacity			Service Area		Design Capacity	
			ℓ /day	ℓ /sec				ℓ /day	ℓ /sec
1	TAVETA TOWN	No. 1	8,440	0.195	9	KITHOGOTO I	No. 1	33,880	0.785
		2	9,940	0.230			2	24,455	0.567
		3	11,480	0.265			Total	58,335	1.352
		4	417,075	9.653	10	KITHOGOTO II		35,480	0.821
		5	520,045	12.033	11	MABANU	No. 1	93,985	2.176
	Total		966,980	22,381			2	41,285	0.956
2	TAVETA TOWN SOUTH	No. 1	54,700	1.267			3	41,285	0.956
		2	31,700	0.734			4	40,535	0.938
		3	31,700	0.734			5	40,535	0.938
		4	21,335	0.494			6	40,635	0.940
	Total		139,435	3.229		Total		298,269	6.940
3	REATA	No. 1	43,885	1.016	12	TIMBILA	No. 1	51,100	1.183
		2	15,805	0.366			2	34,750	0.805
	Total		59,690	1.382			3	47,785	1.106
4	KITOVO		68,815	1.594		Total		128,135	2.966
5	SELA MBAHA	No. 1	33,950	0.786	13	MAHOO	No. 1	46,100	1.067
		2	32,100	0.744			2	34,250	0.793
		3	4,900	0.114			Total	90,335	2.104
		4	8,010	0.186	14	MASENGONI		35,220	0.815
		5	63,100	1.462	15	KIONGONI		18,660	0.432
		6	25,100	0.582	16	KIMALA	No. 1	32,500	0.753
	Total		167,160	3.874			2	90,275	2.090
6	KAHLEZA	No. 1	12,250	0.283			3	33,250	0.770
		2	30,950	0.716			4	31,255	0.724
		3	12,625	0.292			Total	187,280	4.337
		4	13,650	0.315	17	MBONGHONI		53,730	1.244
	Total		69,475	1.606	18	MIERENI		35,195	0.815
7	KIHORIGO		69,880	1.631	19	NGHONJI	No. 1	29,180	0.676
8	EL DORO	No. 1	75,080	1.738			2	19,755	0.458
		2	45,605	1.056			Total	48,935	1.134
	Total		120,685	2.794	20	MATA		60,585	1.402
						Grand Total		2,712,770	95.600

5-3 Facility Design

5-3-1 Consideration of the Project's Water Supply System

Of prime importance to the basic design of the Project's water supply facilities is how to treat head losses in pipelines running from water reservoir to water supply terminals.

As the entire Project Area is flat, after pumped up to reserve water into a distribution reservior, the water reserved is to be distributed throgh pipelines by means of gravity systems.

If a pipeline's hydrodynamic and static pressures become too high, the pipeline should then be divided into several independent systems, each requiring a pumping facility. In such cases, installation costs, and operation and maintenance costs become higher.

Because a very close relation exists between flow velocity and head loss in a pipeline, the water supply piping system was designed to keep the head losses as low as possible by selecting flow velocities within minimum ranges to satisfy the facilities' hydraulic functions and to keep pumping costs low; that is, the water is to be pumped from Njoro Kubwa Spring into a distribution reservior, then distributed from the reservoir to Taveta Town and further to southern rural areas as far as Kithogoto and Nghonji.

5-3-2 Facilities in Taveta Town

For the Project's water supply distribution pipes in Taveta Town, a skelton of pipeline network will be installed under planned streets.

The pipeline network is to be connected to five new kiosks and the existing 32 m^3 capacity elevated storage tank that is located within the MOWD Office site. The storage tank is presently supplying water to house connections and kiosks and will continue to supply existing house connection after receiving the Project water.

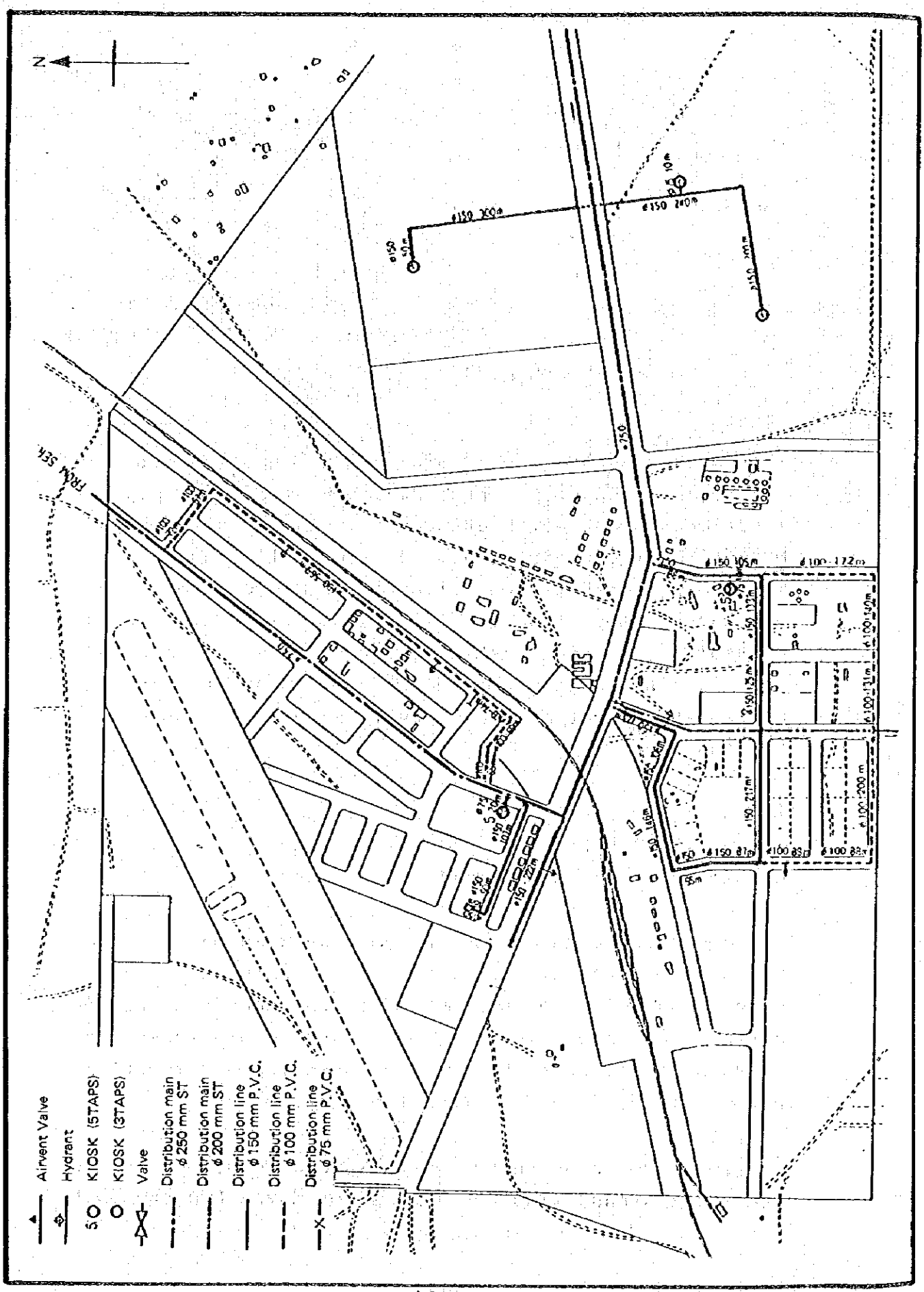
The existing water supply pipes were installed prior to the formulation of the present urben plan. The pipe locations do not match existing or planned streets. Diameters of the eixsting pipes are small. Further, it is considered that these pipes cannot take water pressures higher than the existing storage tank's head pressure. In view of this, existing house connections will continue to be supplied water through the elevated storage tank in the future until the urban planning will be finalized.

The existing pipeline that delivers water to the kiosks in rural areas will be replaced for the new pipelines connected to the new distribution reservoirs.

The new house connections in the town will be connected to the new water distribution pipes. Existing house connections will be reconnected to the new distribution pipes after Taveta Town's urban planning progresses to a certain level; at that time, the existing distribution pipes will be discarded (see Fig.-11).

Hydrants are to be installed in Taveta Town, but not in the rural areas. The required water for a hydrant is to

Fig.-11 FACILITY PLAN FOR TAVETA TOWN



be 10 litres/sec for a two-hour period; this is equivalent to 50% of Taveta Town's total water supply rate. The amount of water to be used having a discharge rate of 10 litres/sec for two hours is 72,000 litres; this is equivalent to 5.3% of the distribution reservoir's 1,360 m^3 capacity. To meet the demand of hydrants the flow velocity in the pipe can be increased, but only to 1.5 m/sec. therefore, the Project's water supply facilities will be sufficient to meet fire fighting requirements.

The MOWD's design standards stipulate that hydrants are to be installed at intervals of from 65 m to 100 m within the centre areas of cities, and at intervals of from 150 to 200 m in residential areas.

Considering present conditions of Taveta Town, 5 hydrants are to be installed. This number will increase in proportion to population increases in future.

5-3-3 Facilities in the Southern Rural Areas

The rural areas will be divided into 19 separate service areas. The Project will supply water in these areas through house connections and kiosks. The areas are categorized as "Medium Potential Areas" in accordance with the MOWD's design standards. The maximum distance from a house to a kiosk should be no further than 1.0 km, and one kiosk should be installed for every 200 to 500 people. Therefore, a decision has been reached as to where the kiosks are to be located, and each kiosk is to serve 500 people; this decision was based on population density and distribution studies.

The ratios of the population provided with house connection water supply and those provided with kiosk were determined to be fourty and sixty percent, except in the Maranu and El Doro areas where the ratios were fifty and fifty percent according to the design standards due to the projected population size.

The Kotovo area's population was included in the Project facilities' design study. The distribution pipe diameter was desgined to supply sufficient amounts of water to the Kitovo and Reata areas although the installation of pipe from Reata to Kitovo is subject to the future extension.

5-3-4 Selection of Construction Materials and Equipment

Materials for use in general construction work, such as sand, cement, reinforcing bars, etc. are available in local markets.

Steel pipes (interior mortar lining, and exterior bitumen coating) and PVC pipes made in Kenya for water supply use are obtainable for Project use. This type of piping is made in conformance with Kenya Industrial Standards (KS), British Industrial Standards (BS), and International Standards. Valves and pipe fittings must be imported.

Pumps, motors, and machinery must be also imported.

The MOWD intends to use steel pipes, for safety purposes, in main sections of the pipelines and in such sections where higher pressures will encounter.

5-4 Basic Design of Facilities

5-4-1 Outline of Facility Design

The Project components are as follows:

1. Intake Facility:
   1) Based on the MOWD's design standards, water source is to be taken from the Njoro Kubwa Spring at a rate of 34.5 l/sec throughout a 24 hour operating system for a total of 2,981 m^3/day.

2) An intake pump will be installed to pump water to a grit chamber for safety purpose although the design of the intake facility does not allow inflow of any foreign particles into pumps. After foreign particles in the water, if any, settle, the water is to be delivered by a main pump to a distribution reservor. (see Fig. 12 for the Project water source).

2. Water Treatment Facility:

1) A grit chamber is to be installed wherein the settling of foreign particles contained, if any, in the water takes place,and where the water can be chlorinated prior to being delivered to the distribution reservoir. The water is to be pumped from a suction well. Installation of the grit chamber is only for assurance of transmission pump safety as the spring water is generally clear and free from foreign particles.

2) A chlorination apparatus is to be installed for injecting hypochlorite into the pump suction well in accordance with the MOWD's standards.

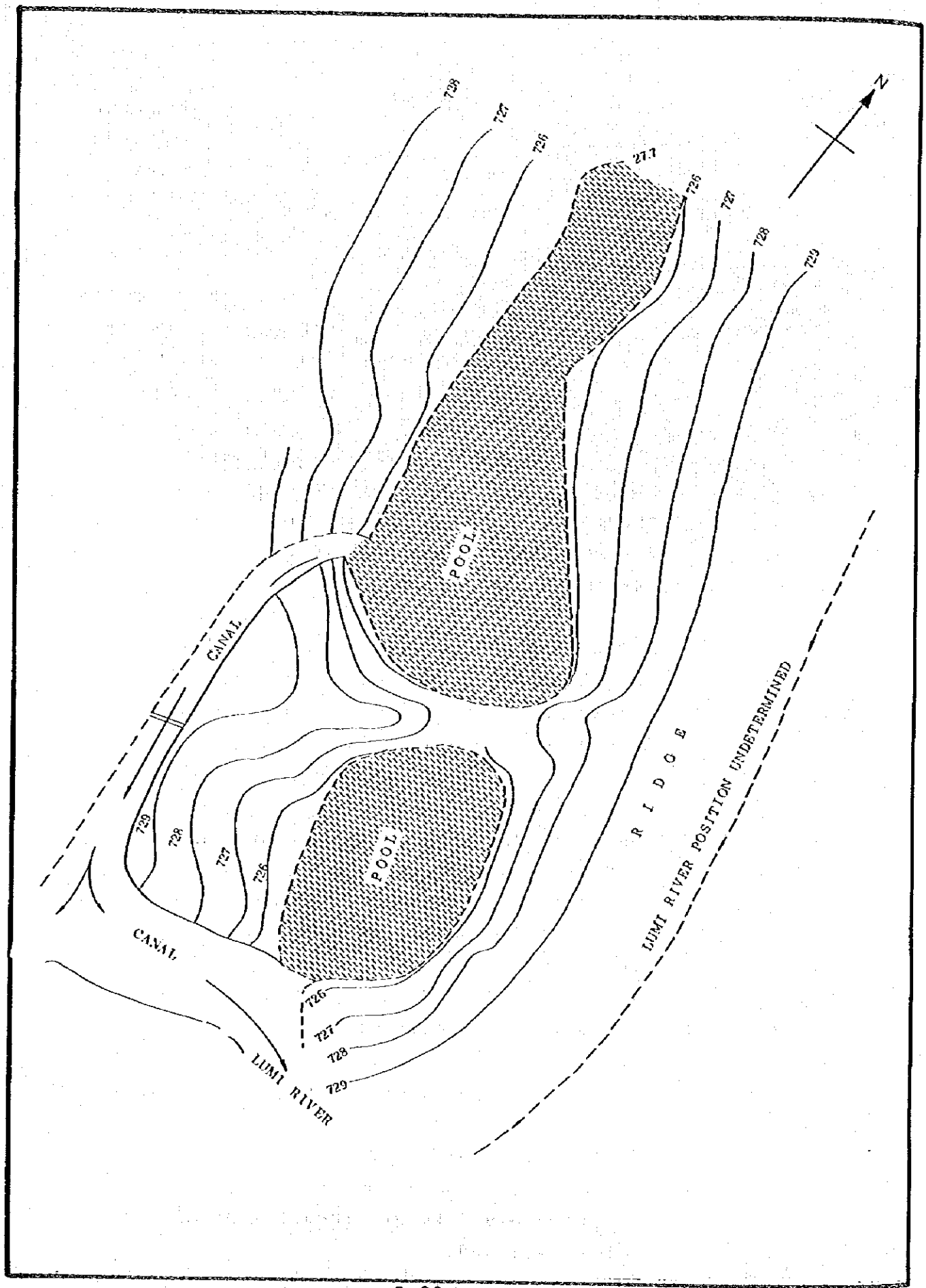
3) A pump room and an operation room are to e installed for pump operation and maintenance purposes. A operators' house for use by operation and maintenance personnel will also be constructed based on MOWD's design standards.

3. Water Transmission Facility:

1) Transmission pumps are to be installed for the purpose of delivering water to the distribution reservoir.

2) Approximately 6 km of transmission pipeline is to be installed.

Fig.–12 WATER SOURCE : NJORO KUBWA SPRING



3) The control of operation of pumps and the reservoir will be made manually.

4. Distribution Facility:

1) A distribution reservoir is to be constructed for storing drinking water.

2) A total of about 46 km of distribution pipeline is to be installed; about 4 km in Taveta Town, and about 42 km in the rural areas.

3) 48 kiosks are to be installed to supply a sufficient amoutn of water to serve the Project Area's population in the year 2005 which is equivalent to the present water supply population.

5-4-2 Facility Design

1. Intake Facility:

The necessary water intake rate is 31.4 l/sec. However, with the inclusion of a 10% allowance for loss, the supply water is to be pumped up to a grit chamber at the rate of 34.5 l/sec, or 2,713 m^3/day. Two pumps are to be installed (one for standby purpose). (see Figs. 24, 25, and 26).

1) Intake Pump Calculations:
The follwoing equations were used in making intake pump calculations:
$D = 146 \sqrt{Q/V} = 146 \sqrt{2.072/2.5} = 133$ mm
D: Pump suction diameter

Q: Pumping rate (2,712.87 X 1,000 (24 X 60 X 60) X 1.1 = 34.5 l/sec

V: Flow velocity, m/sec

H = Ha + hf + ho

= 7 m + 0.6 m + 2.0 m = 9.6 m ≒ 10 m

where, H: total lift,

Ha: Actual lift,

hf: Friction loss = 65 m X 9.0‰ ≒ 0.6 m

ho: Other head loss

$$N = \frac{Q \times H}{102 \times e} = \frac{34.5 \times 10}{102 \times 0.75} = 4.5 \text{ Kw}$$

N : Pump's shaft force.

e: Pump efficiency.

P = N X (1 + α) = 4.5 X 1.15 = 5.2 KW

P: Motor output. α : Allowable value

Therefore, the intake pump features were determined to be as follows. = 125mm

Total lift = 10 m, Power = 5.5 Kw,

Two units (one for standby),

2) Examination for Cavitation

Elevation of the pump center = 732.9 m

Low Water Level of sunction pond = 729.0 m

Hsv = 9.47 - (3.90 + 1.1 + 0.32) = 4.15 m

where, 9.47 = Atomospheric pressure,

Head loss = 1.1

Vapour pressure at 25^{o}C = 0.32

hsv = 1.6 m (specific speed S = 1,390)

Thus, the intake pump is safe against cavitation (where, hsv = Effective suction head required for a pump).

2. Water Treatment Facility

1) The grit chamber, combined with the pump suction well, is to be made with reinforced concrete. (Fig. 27 and 28)

2) Hypochlorite is to be injected into the pump suction well for water chlorination.

3) A pump house is to be built to contain the intake and delivery pumps, gauges, and the chlorination apparatus.

4) An operation house, for operations and maintenance purposes, is to be built. The required staff for Project facilities' operations and maintenance are as follows:

Chief Operator	: 1
Pump Operator	: 1
Assistant Pump Operator	: 1
Chlorination Operator	: 1
Piping Fitter	: 1
Assistant Piping Fitter	: 1
Line Patoroller	: 3
Workers	: 4
Guards	: 2
TOTAL	:15

5) Grit Chamber:

i Criteria:

Water intake quantity: Q = 2.072 m^3/min

Capacity: Enought for 10 to 20 minutes intake operation.

Wall height: 50 cm above the water level

Effective Depth: 3.0 to 4.0 m
Average Velocity: V = 0.85 cm/sec
Particle Settling Velocity:
Particle diameter = 0.1 mm
Specific weight of particle = 2.65
Settleing velocity = 0.8 cm/sec
Shape of the Grit Chamber:
Width/Length = 1/3 to 1/8

ii. Chamber Dimentions:
The dimensions of the grit chamber were calculated by using the following equation:

$$L = K\left(\frac{H}{U} \times V\right)$$

where, L: Chamber's effective length (m)
H: Effective depth, 3.0 m
V: Average velocity in chamber, 0.85 cm/sec
K: Safety factor, 1.5

Thus,

$$L: = 1.5 \times \frac{3.0}{0.8} \times 0.85$$

= 4.8 m, say 5.0 m

Chamber width (w) is to be:
W = 5.0 X (1/3 to 1/8)
= 1.7 to 0.6 m, say 1.5 m
Thus, the chamber dimensions were determined to be as follows:
5.0m (Length) X 1.5m (Width) X 3.0m (Effective Depth)
Tow chambers are to be built for maintenance purpose.
Chamber capaicty check:
V = (5.0 m X 1.5 m X 3.0 m)/2.072 m^3/min
= 10.9 minutes. This is within 10 to 20 minutes.
Thus, the chamber satisfies the required capacity criteria.

iii. Pump Suction Well:

Water flows into the pump suction well from the grit chamber. A pump then delivers the water to the distribution reservoir. The capacity of the pump suction well is to be equivalent to the amount of water for about a 10 minute pump operation. The size of the well was determined based on the grit chamber dimensions, as follows:

Suction well's effective depth: 2.5 m

Well wideth: 3.0 m (1.5 m X 2)

Thus, the necessary well length is:

$L = 10 \text{ min} \times 2.072 \text{ m}^3/\text{min} \div (2.5\text{m} \times 3.0\text{m})$
$= 2.76 \text{ m}$, say 3.0 m

Therefore, the well dimensions were determined to be as follows:

3.0m (Length) X 3.0 m (Width) X 2.5m (Effective depth)

3. Water Transmission Facilities

1) Transmission Pump:

The pump must have an actual lift of 76.3 m with a delivery rate of 34.5 litres/sec, ie., 2.072 m^3/min. thus, based on the MOWD's design standards, the pump should be a centrifugal type (see Fig. 29).

The pump will deliver water from the water source that is at an elevation of 2,400 ft to the distribution reservoir that is located at an elevation of 2,650 ft. There is a height difference between the two of 250 ft, or 76.3 m. (Fig. 13)

The pump design calculations were made through use of the following equations:

$D = 146\sqrt{Q/V} = 146\sqrt{2.072/2.5} = 133$ mm

$Q = 2.072\ m^3/min = 34.5\ \ell/sec$

$H = Ha + hf + ho$

where,

$Ha = 2{,}650\ ft - 2{,}400\ ft = 250\ ft = 76.3\ m$

$hf = 5{,}950\ m \times 2.9\ ‰ \fallingdotseq 17.4\ m$

$ho = 5.0\ m$

Thus, $H = 76.3 + 17.3 + 5.0$

$= 98.6\ m$, say $100\ m$.

$$N = \frac{Q \times H}{102 \times e} = \frac{34.5 \times 100}{102 \times 0.65} = 52.0\ KW$$

$P = N(1+\alpha) = 52.0 \times 1.15 = 59.8 \fallingdotseq 60\ Kw$

Therefore, the transmission pump features were determined to be as follows:

Suction diameter: 150 mm

Total lift: 100 m

Power: 75 Kw

Quantity: 2 Units (one for standby use)

Cavitation Check:

$Hsv = 9.47 - (0 + 0.5 + 0.32) = 8.65\ m$

$hsv = 2.0\ m$ (Specific speed S = 1,200)

Thus, the intake pump is safe against cavitation.

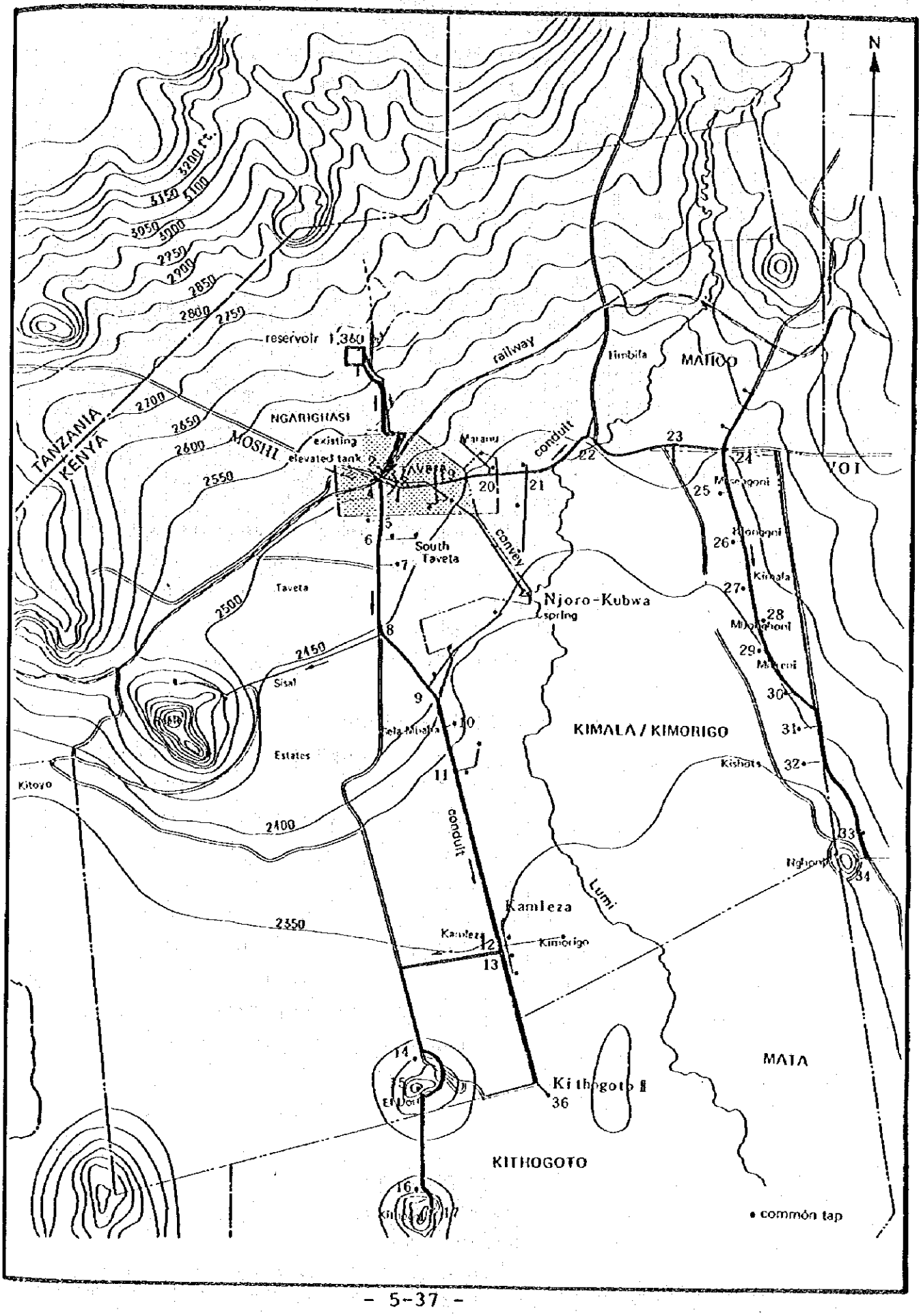
2) Transmission Pipeline:

Hydraulic conditions required for the transmission pipeline are as follows (based on the MOWD's design standards):

Hydralic Conditions for Delivery Pipeline

Location	G.L. (ft)	Length (m)	Diameter (mm)	Quantity (ℓ/sec)	Velocity (m/sec)	Gradient ( )	Friction Loss (ft)	Friction Loss (m)	Satic Level (ft)
Water Source	2,400								
Intake Pump	2,400	65	200	34.5	0.69	9.0	2.0	0.6	
Reservior	2,650	5,950	250	34.5	0.69	2.9	56.6	17.3	2,650

Fig.-13 WATER SUPPLY SYSTEM



Therefore, the features of the transmission pipeline were determined to be as follows:

Pipeline Length: 5,950 m
Pipe diameter: 250 mm
Discharge: 34.5 litres/sec
Flow velocity: 0.69 m/sec
Hydraulic gradient: 2.9 ‰

Because the transmission pump has a total lift of 100 m, there is the possibility that water hammer may result; therefore, steel pipe must be used, and pipeline must be checked for water hammer.

3) Water Hammer:

i A case without a flywheel:
Water hammer pressure curves are shown in Fig. 14. As shown in the figure, negative pressure will occur within a 3 to 6 km section of pipeline, it may cause the deterioration of the pipe.

ii A case with a flywheel:
Fig. 15 shows the hydraulic pressure curves for the case of a pump/motor (GD^2 = 8 kg·m^2) having a flywheel of GD^2 = 40 kg·m^2, GD^2 is the flywheel effect of a rotor. As the figure shows, no negative pressure will occur in the pipeline. The maximum hydraulic pressure will reach 10kg/cm^2.G near the pump discharge point. Thus, it was decided upon to use steel pipes.

4. Distribution Facilities

1) Distribution Reservoir:

Base on the MOWD's design standards, a distribution reservoir is to be installed to store an amount of water equivalent to one half day's supply.

The reservoir is to be built with reinforced concrete (see Figs. 30 and 31).

Reservoir capacity:

$V = 2,712,870$ l/day x 1/2 day

$= 1,356,435$ l $= 1,357$ m^3

By making the effective depth 4.0 m, the reservoir's dimensions were decided upon as follows:

$V = 18.00$ m (Length) x 19.00 m (Width) x 4.0 m (Depth)

$= 1,368$ $m^3 > 1,357$ m^3

Therefore the capacity of the reservoir is $1,360$ m^3.

2) Distribution Pipeline:

Supply water is to be distributed by gravity flow from the reservoir to each service area.

The total length of the distribution pipeline is to be 46.1 km: 4.2 km in Taveta Town, 31.3km of distribution main to the southern rural areas, and 10.6 km of branch lines to house connections and kiosks.

As shown in the hydraulic calculation, six different pipe diameters were selected for use: 250mm, 200mm, 150mm, 100 mm, 75mm, and 50mm.

It was decided upon to use steel pipes (SP) for pipes having diameters of 250mm and 200mm, and PVC for pipes having diameters of 150mm, 100mm, 75mm, and 50mm.

Fig.–14 WATER HAMMER PRESSURE CURVE

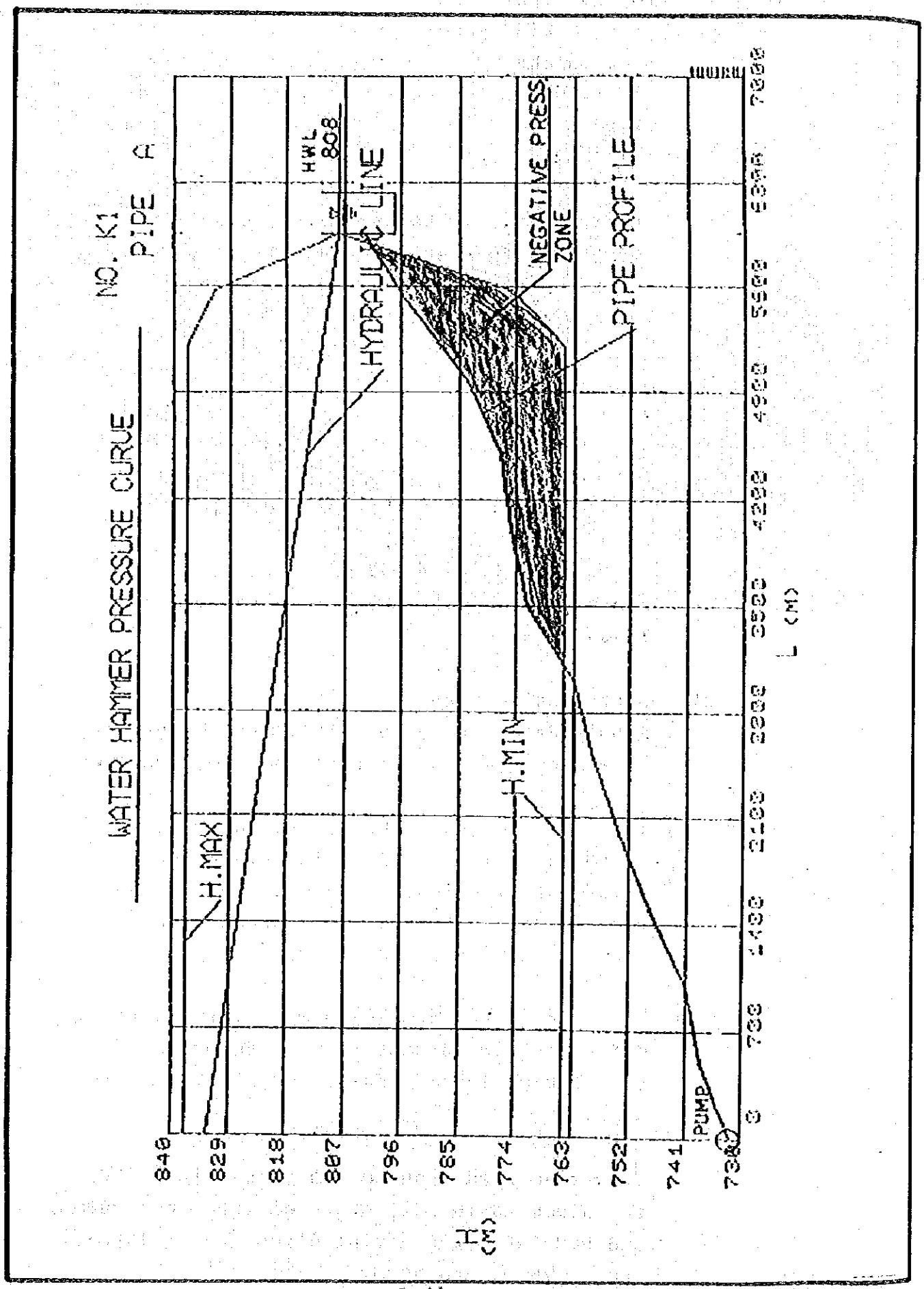
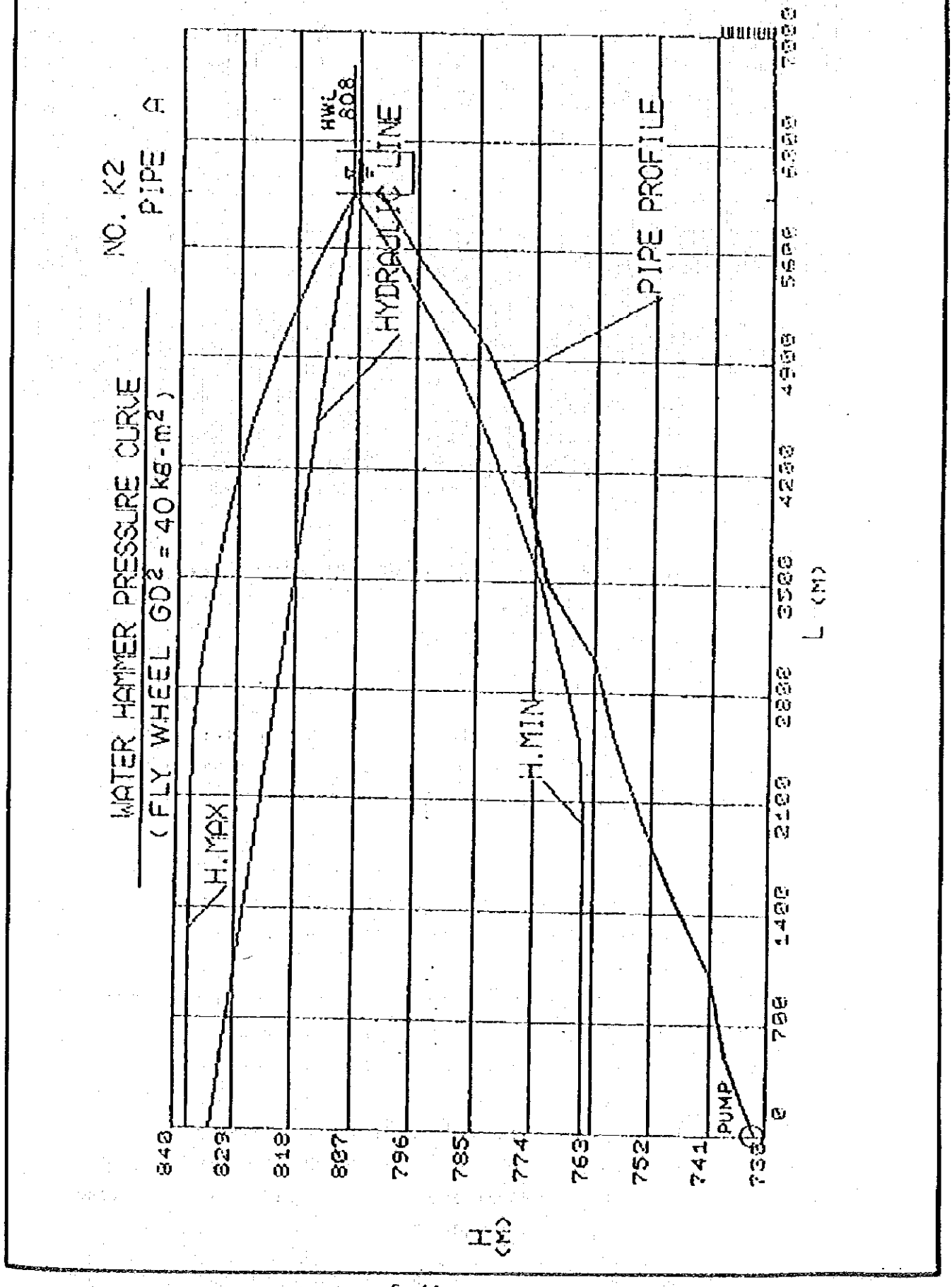


Fig.–15 WATER HAMMER PRESSURE CURVE



The relationship between the basic design's pipe diameters and the Kenya Standards are shown as follows:

Basic Design Pipe Diameter	Kenya Standard Pipe Diameter
150 mm	160 mm
100 mm	110 mm
75 mm	90 mm
50 mm	63 mm

Both steel and PVC pipes are manufactured in Kenya. Thus, it is possible to use them in the Project. Allowable inside pressures for the steel pipe is more than 10 kg/cm^2 and that of PVC pipes ranges between 9 kg/cm^2 and 15 kg/cm^2. The steel pipes for distribution pipeline must be coated in the same manner as described for the transmission pipeline.

100 mm and smaller diameter pipes will be installed in dipression areas. Saline soil exists in some of the area; thus, it is appropriate to use PVC.

Imported pipe fittings are to be used for the distribution pipeline since these are not available locally.

Valves, air relief valves, venturi meters, flow meters, gauges, and pumps are to be imported as they are not manufactured in Kenya.

The hydraulic calculation of the transmission and distribution pipeline was made in accordance with the MOWD's design standards. The pipelines' friction head losses, velocity heads, and static heads were calculated by obtaining the required discharge rates, pipe diameters, flow velocities, and velocity heads from Figs. 16 and 17.

The caculated results are shown in Tables 20 and 21, and in Fig. 13. The standard pipeline cross sections and the standard designs for the associated facilities are shown in Figs. 33, 34, and 35.

3) Kiosks:

As the Project Area is categorized as a "Medium Potential Area", the maximum distance of a beneficiary is to walk from his house to a kiosk which should not exceed 1.0 km, and that one kiosk should be installed for every 200 to 500 people in accordance with the MOWD's design standards.

Judging from the above standards, the obtained data, and the population distribution noted during field surveys, it was decided upon to install one kiosk for every 500 people in the concerned areas.

The kiosks, except for those in Taveta Town, were designed to have 2 taps. Because of the large number of people to be provided with water, the Taveta Town kiosks were designed to have 4 taps (see Fig. 41 and 42).

Fig.–16 HYDRAULIC DIAGRAM

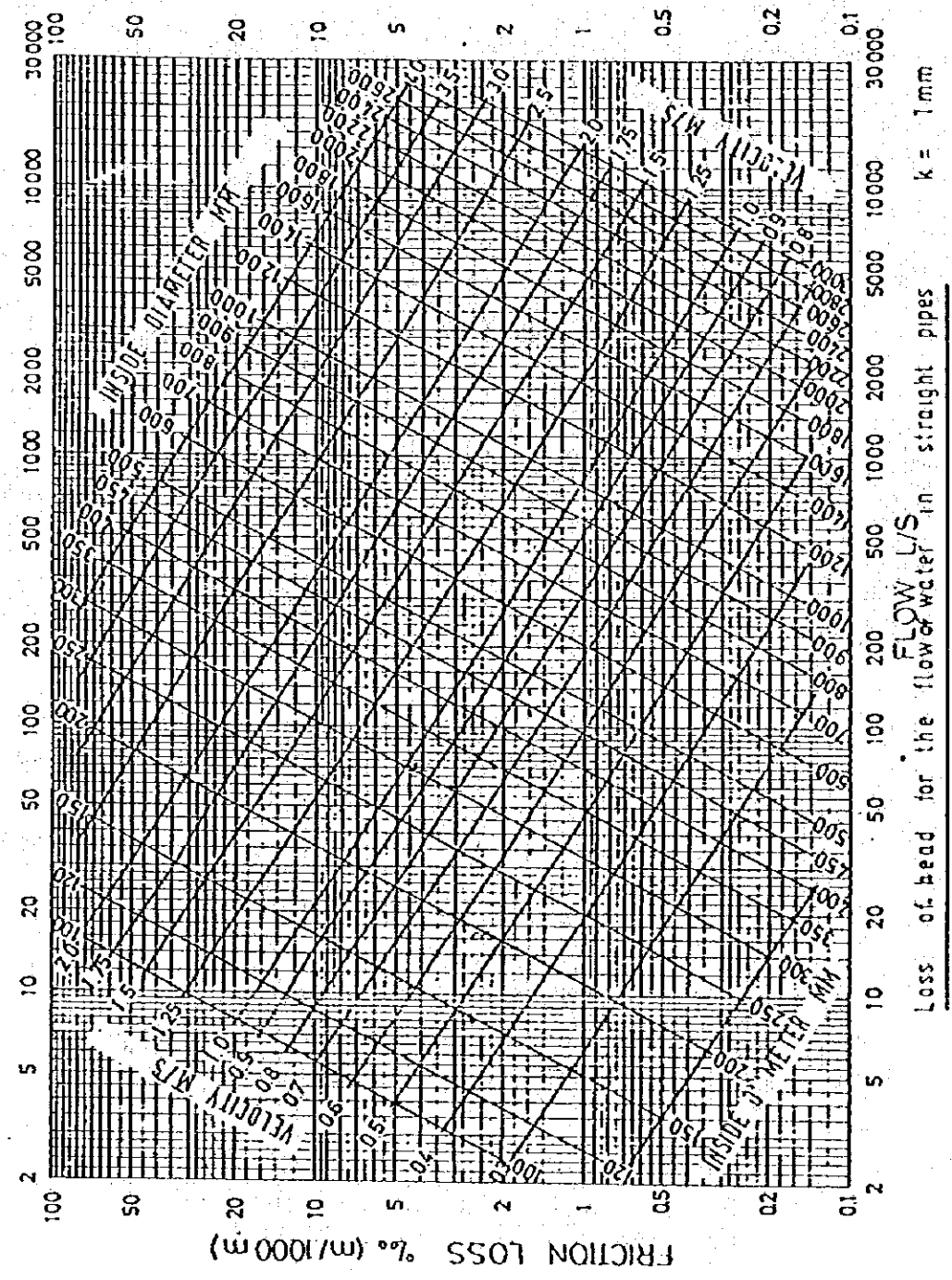


Fig.–17 HYDRAULIC DIAGRAM

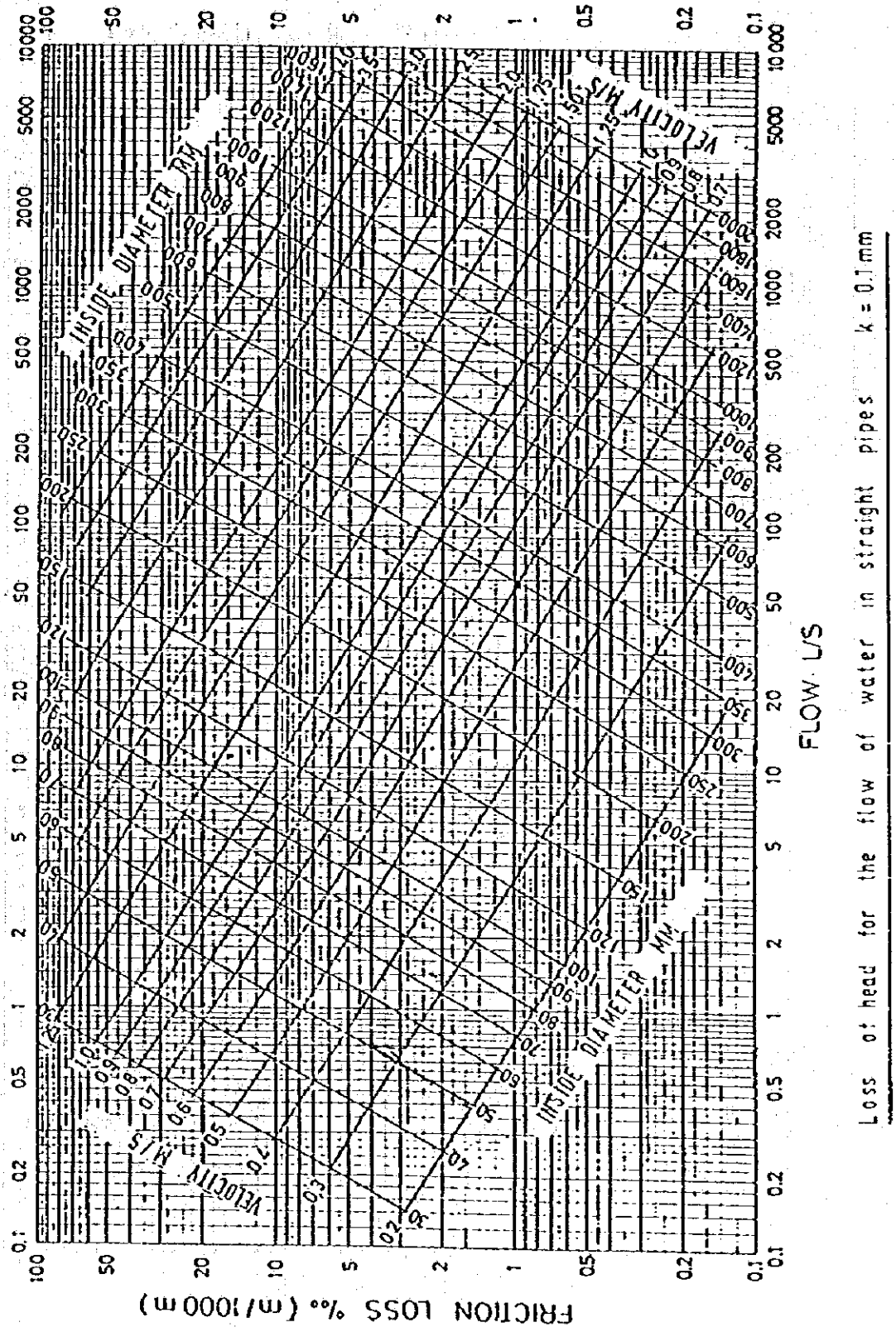


Table - 20 HYDRAULIC CONDITIONS OF DISTRIBUTION PIPES - 1

Location	KIOSK No.	G.L. (ft)	Length (m)	Diameter (mm)	Quantity (ℓ/sec)	Velocity (m/sec)	Gradient (‰)	Friction Loss (ft)	Friction Loss (m)	Hydraulic Head (ft)	Water Head (ft)	Water Head (m)	Static Head (m)
Reservoir	0	2,650	0										
Tinbila	1	2,620	10	250	60.238	1.25	9.0	0.3	0.1	2,649.7	29.7	9.1	9.2
Taveta	2	2,520	2,400	250	59.132	1.20	8.0	63.0	19.2	2,586.7	66.7	20.3	39.7
〃	3	2,520	20	250	49.479	0.99	5.5	0.3	0.1	2,586.4	66.4	20.3	39.7
〃	4	2,508	20	250	49.479	0.99	5.5	0.3	0.1	2,586.1	78.1	23.8	43.3
Taveta South	5	2,470	800	200	16.998	0.55	2.6	6.9	2.1	2,579.2	109.2	33.3	54.9
〃	6	2,475	50	200	16.539	0.53	2.3	0.3	0.1	2,578.9	103.9	31.7	53.4
〃	7	2,470	250	200	15.088	0.48	1.9	1.6	0.5	2,577.3	107.3	32.7	54.9
Reata	8	2,447	1,600	200	15.045	0.48	1.8	9.5	2.9	2,567.8	120.8	36.8	61.9
Sela Mbaha	9	2,410	1,800	150	12.069	0.82	8.0	47.2	14.4	2,520.6	110.6	33.7	73.2
〃	10	2,400	600	150	10.450	0.63	4.6	9.2	2.8	2,511.4	111.4	34.0	76.3
〃	11	2,390	900	150	10.264	0.59	4.8	14.1	4.3	2,497.3	107.3	32.7	79.3
Kamleza	12	2,350	2,000	150	8.225	0.47	2.6	17.1	5.2	2,480.2	130.2	39.7	91.5
〃	13	2,350	300	100	4.752	0.60	7.2	7.2	2.2	2,473.0	123.0	37.5	91.5
El Doro	14	2,400	3,000	100	3.925	0.50	5.0	49.2	15.0	2,423.8	23.8	7.3	76.3
〃	15	2,400	1,100	100	2.285	0.31	2.0	7.2	2.2	2,416.6	16.6	5.1	76.3
Kithogoto	16	2,390	1,350	75	1.352	0.31	2.0	8.9	2.7	2,407.7	17.7	5.4	76.3
〃	17	2,370	800	50	0.567	0.29	2.9	7.5	2.3	2,400.2	30.2	9.2	85.4
Total			17,000					249.8	76.2				

Table - 21 HYDRAULIC CONDITIONS OF DISTRIBUTION PIPES - 2

Location	KIOSK No.	G.L. (ft)	Length (m)	Dia-meter (mm)	Quan-tity (ℓ /sec)	Velo-city (m/sec)	Gra-dient (‰)	Friction Loss (ft)	Friction Loss (m)	Hydraulic Head (ft)	Water Head (ft)	Water Head (m)	Static Head (m)
Taveta	4	2,508	0							2,586.1	78.1	23.8	43.3
〃	18	2,485	1,100	250	32.481	0.65	2.4	8.5	2.6	2,577.6	92.6	28.2	50.3
〃	19	2,470	900	250	20.443	0.42	1.1	3.3	1.0	2,574.3	104.3	31.8	54.9
Maranu	20	2,450	800	200	19.753	0.62	3.2	8.5	2.6	2,565.8	115.8	35.3	61.0
〃	21	2,439	550	200	16.036	0.52	2.2	3.9	1.2	2,561.9	122.9	37.5	64.4
Tiubilia	22	2,455	850	200	14.293	0.48	1.8	4.9	1.5	2,557.0	102.0	31.1	59.5
〃	23	2,465	900	200	13.110	0.42	1.4	4.3	1.3	2,552.7	87.7	26.7	56.4
Kahoo	24	2,455	900	200	12.305	0.40	1.4	4.3	1.3	2,548.4	93.4	28.5	59.5
Masengoni	25	2,450	600	150	10.201	0.60	4.2	8.2	2.5	2,540.2	90.2	27.5	61.0
Kiangoni	26	2,450	650	150	9.386	0.54	3.4	7.2	2.2	2,533.0	83.0	25.3	61.0
〃	27	2,450	800	150	8.942	0.51	3.1	8.2	2.5	2,524.8	74.8	22.8	61.0
Kimala	28	2,440	500	150	8.189	0.47	2.6	4.3	1.3	2,520.5	80.5	24.6	64.1
〃	29	2,425	400	150	6.099	0.35	1.5	2.0	0.6	2,518.5	93.5	28.5	68.6
〃	30	2,420	450	150	5.329	0.30	1.1	1.6	0.5	2,516.9	96.9	29.6	70.2
Mbogani	31	2,420	600	100	4.605	0.60	7.0	13.8	4.2	2,503.1	83.1	25.3	70.2
Mierent	32	2,410	700	100	3.350	0.43	3.7	8.5	2.6	2,494.6	84.6	25.8	73.2
Nghonji	33	2,350	2,200	100	2.535	0.33	2.2	15.7	4.8	2,478.9	128.9	39.3	91.5
〃	34	2,440	700	75	2.077	0.47	4.0	9.2	2.8	2,469.7	29.7	9.1	61.0
〃	35	2,410	700	75	1.401	0.32	2.2	4.9	1.5	2,464.8	54.8	16.7	73.2
Total			14,300					121.3	37.0				

5-4-3 Summary of the Project Facilities

Facility	Description	Specification
1. Water Source & Intake Facilities:		
1) Intake Pond:	Intake pumping pit (Spring intake)	Masonry Work
2) Intake Pump:	Horizontal axis, side suction, single stage, centrifugal pump. 34.5 litres/sec capacity.	Suction: 125 mm Discharge: 100 mm 2 Units (one for standby) Total lift: 10 m Power: 5.5 kw/each
3) Grit Chamber:		Reinforced concrete (1 unit)
4) Treatment Facility	Chlorination Facility	(Hypochlorite) (1 unit)
2. Water Transmission Facility		
1) Transmission Pump:	Horizontal axis, side suction, multi-stage, centrifugal pump. 34.5 litres/sec capacity.	Suction: 150 mm Discharge: 150 mm 2 Units (one for standby) Total lift: 100 m Power: 75 kw/each
2) Building:	Intake Pump Room	Reinforced concrete/ Masonry Block
	Transmission Pump Room	Reinforced concrete/ Masonry Block
	Staff House	Two units: One semidetached and one single unit (Masonry Block)
	Warehouse	One concrete block building
3) Transmission Main:	Pipe diameter: 250 mm Steel Pipe: Inside mortar lining, outside asphalt-jute two layers Valves (stop valves and air-relief valves)	Length: 5,950 m (as required)

(continued on next page)

Facility	Description	Specification
4) Electric Facilities:	Power receiving unit:	1 set
	Power control unit:	1 set
	Lighting fixtures	1 set
3. Distribution Facilities:		
1) Distribution Reservoir:	Capacity: 1,360 m^3 (12 hours per day)	Reinforced concrete 19m x 9m x 4m 2 each
	Valves and fittings:	1 set
	Attendants shelter:	1 unit
2) Distribution Pipeline (in Taveta Town)	Pipe dia: 160mm PVC	Length: 2,440 m
	Pipe dia: 110mm PVC	Length: 1,740 m
	Pipe dia: 90mm PVC	Length: 40 m
	Hydrant	75 mm diameter, 5 places
3) Distribution Main (areas other than Taveta Town)	Pipe dia: 250mm steel pipe	Length: 4,450 m
	Pipe dia: 200mm steel pipe	Length: 6,700 m
	Pipe dia: 160mm PVC	Length: 8,700 m
	Pipe dia: 110mm PVC	Length:10,650 m
	Pipe dia: 90mm PVC	Length: 6,650 m
	Pipe dia: 63mm PVC	Length: 5,550 m
4. Water Supplying Facilities:		
1) Taveta Town:	Kiosk	2 places with 4 taps 3 places with 2 taps
2) Rural Areas:	Kiosk	43 places with 2 taps

Notes - : PVC pipe diameters are to conform to Kenyan standards.