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Kyeni - rehabilitation of a rural water supply
1. BACKGROUND

In the last twenty years great emphasis has been placed by the public and Government in Kenya on development of Rural and Urban Water Supply Projects. A large number of schemes have been completed by Departmental Design and construction by direct labour or by use of Consultants for Design and Contractors for construction. During the same period action has been taken to train Technical and Administrative manpower for design, construction and maintenance of schemes. It is now possible to look back and carry out critical analysis of design, construction and maintenance procedures used and the operational aspects of various schemes. The Author had the opportunity to deal with Kyeni Water Supply Project in this context.

2. KYENI

Kyeni is a rural area located on the eastern slopes of Mount Kenya approximately 30 km from Embu, the Provincial Headquarter for Eastern Province. The water supply system was installed in 1972 to serve an area of 130 km². The area is 26 km in length with average width of 5 km situated between the valleys of Itembogo and Thuchi Rivers. The altitude of the area varies from 1100 metres to 1800 metres above MSL.

Kyeni is situated in the high and medium potential agricultural zone suitable for Tea, Coffee and Dairy Farming.

3. WATER SUPPLY SCHEME

The original scheme was designed to provide water to the population in Kyeni from communal water points situated at approx. 2 km intervals i.e. based on average of 1 km walking distances.

The design criteria used for calculation of demand was as follows:

"Water demand was calculated on basis of 450 litres/farm for number of farms existing at time of design (i.e. 1970 - 72). No allowance was made for water demand for Institutions, Trading Centres etc."

As the ground water potential of area is low and the rivers originating from Mount Kenya have perennial flow the supply is based on run of river abstraction. The water has been abstracted from the rivers

outside the settled areas near the forest boundaries. The water is not treated prior to distribution.

The scheme is divided into two parts as follows:

- 1) High level zone with intake from Siangomo River at 1844m A.O.D. - 370 M³/Day.
- 2) Low level zone with intake from Thuchi River at 1822m A.O.D. - 1130 M³/Day.

4. REHABILITATION STUDY

After some years of operation many shortcomings were noticed and there has been pressure from users for the improvement and rehabilitation of the scheme. The Government of Kenya with assistance from SIDA commissioned a detailed study to determine the shortcomings and improvements required.

5. EXISTING CONDITIONS
5.1. Details of scheme

The existing water supply scheme comprises of 49.5 km of uPVC water mains varying in size from 12mm to 150mm dia. and 12 No. storage tanks.

The tanks have been sited to work as break pressure tanks and also for balancing peak flows thus ensuring economy in pipe sizes. The scheme is provided with 160 communal water points out of which 2 are operational.

In practice it has been found that communal water point system has not worked.

At present there are 1800 individual connections and demand is increasing.

5.2. Population

The population of the area in 1979 was 21,427 and in 1983 it was 35,475. It is estimated that on the basis of growth rates of 3.7% (the growth rate assessed from 1969 and 1979 census figures amount to 3.65%) the year 2001 population will be 66,871. The current national annual population growth rate is around 4%.

5.3. Operational problems

The scheme as designed and built is not adequate to supply the demand in the area. There are large fluctuations in water pressure in the system and water does not reach some of the areas at times of peak

demand. The operators have to ration water by turning on supply on a zonal basis. Farmers in the area have installed individual 5 to 10 M³ corrugated iron steel tanks to ensure availability of water. There are frequent blockages in the distribution system. Pipes get blocked with silt, grass, roots etc. Water intakes on the rivers allow passage of silt and floating matter into pipes.

6. INVESTIGATIONS

6.1. Check on survey and preparation of plans

It was noted that the original longitudinal profile drawings for all the mains were drawn to scales of 1:24000 horizontal and 1:2400 vertical. These scales are very small and the design profile does not show all the high and low points occurring along the route of the mains thus resulting in omission of air valves and washouts at relevant points.

Site investigation also shows discrepancies between construction on site and the design drawings.

The pipelines in many places do not follow the ground profile. In certain places mains have been laid so that high points have been introduced while the ground itself may be falling or is flat.

The engineering survey for the pipelines was done to determine exact position of pipelines and the actual profiles so that a comparison could be made between the actual flows, design flows and maximum allowable flow in the pipelines, which could only be determined if the exact pipeline profile was known.

The new plans have been drawn to following scales:

Layout: Scale 1:25000

Longitudinal Sections: Horizontal 1:2000
Vertical 1:200

Trial holes were dug where necessary to determine exact positions and levels of the mains.

This work was started in January 1981 and completed by April 1981.

6.2. Design criteria

The design criteria used in the design of existing scheme was checked and compared with latest criteria established by the Ministry, after experience in operation of various schemes and also compared with actual demands in the scheme area.

The existing water supply scheme had been designed for a capacity of 1500 M³/Day. From the water demand calculations (section 6) it can be seen that the present water

demand, based on the MOWD design criteria, is 2000 M³/Day and the ultimate demand is 4326 M³/Day in year 2001.

It was established that the current average consumption is 1300 litres per day per connection. This high consumption was partly attributed to loss of water through open taps; leaking taps; irrigation; storage of water in earth ponds; and generally unscrupulous use of water due to the fact that connections were unmetered.

The upper Kyeni intake on River Siangomo had been designed to supply 370 M³/Day. This source has very low dry weather flow and therefore during some months of the year it cannot supply enough water to meet the present demand for upper Kyeni. Hydrological analysis of suitable sources was carried out to ensure that 98% probability safe yields are adequate to meet the estimated demand.

6.3. Operation

Operational aspects for the existing scheme were monitored under actual operating conditions. Each water supply zone has been studied over a period of 1 week under varying operating conditions to determine the following aspects:

- 1) Water pressures in the system.
- 2) Maximum daily flows in various parts.
- 3) Operating problems and their effects on the flow.
- 4) Design and construction defects.
- 5) Assessment of water demand.

Flow monitoring: In order to determine the operating characteristics of the existing scheme a flow monitoring study was carried out.

The locations of water meters and pressure gauges were pre-determined on a layout plan of the distribution system. Meters were sited in strategic positions so that water demand for each branch line could be determined and flow rates into and out of storage tanks established. It was also possible to determine hourly demand pattern for the consumers and thus establish peak flow requirements. Water meters were installed at the start of distribution mains and at storage tank outlets.

Pressure gauges were sited at start, middle and end of distribution mains or at existing air valve positions.

Flow monitoring was carried out under following conditions:

- 1st day - normal flow - no rationing
- 2nd day - normal flow - no rationing
- 3rd day - rationing

- 4th day - rationing
- 5th day - flow in main lines
- 6th day - flow in main lines
- 7th day - flow in one part only.

Pressure gauges and water meters were read every hour between 6.00 a.m. and 10.00 p.m. Field recording work was carried out by school leavers and 'O' level students at local schools under supervision of Consultants staff.

Typical flow monitoring record is shown in Fig. 1.

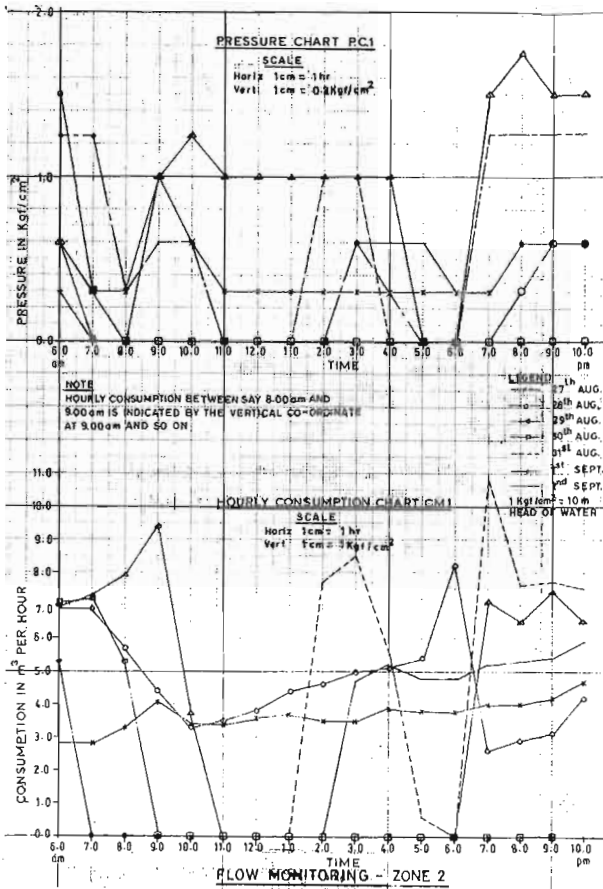


FIG. 1

6.4. Maintenance

The maintenance arrangements made by the Provincial Water Officer and the constraints of staff, plant, vehicles, spares etc. were studied.

6.5. Economic potential and future growth

The information relating to economic potential of the area and future growth was compiled and its effect on water supply system analysed.

7. WATER DEMAND

7.1. Land carrying capacity

In assessing the ultimate water demand for the area it is necessary to establish the

total "land carrying capacity".

The number of people that can reasonably live in an area depends on agricultural potential of the area and the income level. The nature of development and type of farming at any particular time depends on market prices of produce, industrial and economic development in the country, political and socio-economic policies, training and incentives given to farmers and availability of farming inputs. It is therefore not possible to assume or adopt a specific model for future development of an area. The calculations in Table 1 indicate an average situation which is likely to arise and has already materialised in some parts.

Ministry of Agriculture has carried out studies to determine the minimum size of farm to provide subsistence level income for a typical family.

The water demand has been assessed assuming that 100% population will be served by individual connections and livestock units based on zero grazing.

It has been considered that a family with a gross margin of Shs. 2,500/= can live at subsistence level. The size of the farm required for this purpose is 0.6 Ha. for high potential zone which comprises of two thirds of the area of Kyeni.

For medium potential zone the farm size required for subsistence living is estimated at 2.4 Ha.

For cash earning farmers living above subsistence level additional area has been allowed on the basis of 0.6 Ha. and 2.4 Ha. respectively.

It has been assessed that at the stage when population of the area reaches the land carrying capacity 70% of farm land will be used by farmers for subsistence living and 30% by farmers having cash income in addition to subsistence living.

Details of calculation for land carrying capacity are as follows:

Table 1

Calculations for land carrying capacity - population

Total area of Kyeni	9,990 Ha.
Area of high potential zone	6,660 Ha.
Area of low potential zone	3,330 Ha.
a) High potential zone	
Area of the zone	6,660 Ha.
Less land area that cannot be used for farming - 10%	660 Ha.
	5,994 Ha.

70% of the land at subsistence level

when land carrying capacity is reached
 Thus, number of farms = $0.7 \times 5994 \div 0.6$
 = 6,993

30% of the land cash income level when
 land carrying capacity is reached
 Thus, number of farms = $0.3 \times 5994 \div 1.2$
 = 1,499

Thus, total number of farms in high
 potential zone = $6,993 + 1,499$
 = 8,492 farms

Population supported by 8,492 farms at
 7 persons per farm family
 = $7 \times 8,492 = 59,444$ people

b) Low potential zone

(The calculation as for high potential
 zone is repeated)

Area	3,330 Ha.
Less 10%	333 Ha.
Thus, farming area	<u>2,997 Ha.</u>

Farms at subsistence level
 = $0.7 \times 2997 \div 2.4 = 874$

Farms at cash income earning level
 = $0.3 \times 2997 \div 4.8 = 187$

Total number of farms in low potential
 zone = $874 + 187 = 1,061$

Population = $7 \times 1061 = 7,427$ people

Total population of Kyeni when land
 carrying capacity is reached
 = $59,444 + 7,427 = 66,871$ people

This population for Kyeni will be reached
 in the year 2001.

The ultimate water demand for the area
 is given in Table 2.

Table 2

Water Demand

<u>People</u>		
100% population on individual connections		
66,871 people @ 50 l/h/d		3,344.0 m ³ /d
<u>Schools</u>		
Primary - 17,272 pupils		
@ 12.5 l/h/d		215.9 m ³ /d
Secondary - 7,402 pupils		
@ 35 l/h/d		259.0 m ³ /d
<u>Medical Centres</u>		
2,900 out-patients		
@ 20 l/h/d		58.0 m ³ /d
473 in patients @ 100 l/h/d		47.3 m ³ /d
<u>Trading Centres</u>		
220 premises -		
25% @ 200 l/d	11.0 m ³ /d	
75% @ 50 l/d	8.3 m ³ /d	19.3 m ³ /d

Extra demand for resident staff
 in institutions (Schools,
 Hospitals etc.) $2 \times 241 \times 7 \times 25$
84.3 m³/d
4,027.7 m³/d

8. REHABILITATION PROPOSALS

The flow monitoring study together with the engineering survey has enabled the determination of the capacity of distribution system to transmit water in sufficient quantities and with adequate residual pressures. It has also been possible to determine the pattern of water consumption in the area. After completion of engineering survey it was possible to assess the design capacity of the scheme and identify sections of lines requiring vertical and horizontal realignments.

The rehabilitation proposals covered the following aspects:

- 1) Repairing, renovating and rectifying defects in existing scheme.
- 2) Augmentation of existing scheme to meet increased present and ultimate demands.
- 3) Setting up an operations and maintenance organisation with adequate personnel, equipment, offices and supporting services.

The proposal under 8(1) above covered installation of new air valves, washouts, realignment of defective lines, cleaning of existing mains, installation of screening and silt removal facilities at intakes, re-arrangement of distribution system from each intake to suit safe yield from the source, repairs to storage tanks and ancillary works. This work was estimated to cost KShs. 5.5 million (Stg. £1 = KShs. 18.9 - February 1985).

The complete rehabilitation and augmentation scheme was estimated to cost KShs. 28 million.

References

1. Water Supply Rehabilitation Report - VIAK.
2. Central Province - "Integrated Rural Survey" - Central Bureau of Statistics - Kenya.
3. 1979 Census Reports - Central Bureau of Statistics - Kenya.
4. Studies on Rural Development Volumes I & II - Organisation of Economic Cooperation and Development - Paris 1980.
5. Kyeni Water Supply - Preliminary Design Report - Mangat, I.B. Patel and Partners.