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REPUBLIC OF KENYA

MINISTRY OF LOCAL GOVERNMENT
ON BEHALF OF
NYERI MUNICIPAL COUNCIL

KfW Kreditanstalt für Wiederaufbau
(KfW ASSISTED)

NYERI WATER SUPPLY FEASIBILITY STUDY

SITUATION ASSESSMENT REPORT

Volume I :
Main Report

JBG Gauff Ingenieure

FRANKFURT AM MAIN, GERMANY
AND
NAIROBI, KENYA

JULY 1995

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SUMMARY

1. Scope of Study

This feasibility study is in three distinct stages, and this report covers the initial assessment stage of the existing situation (Inception Report). Aspects reported include - the existing water and sanitation facilities in Nyeri Municipality; present water production, demand and consumption; costs of production; billing and revenue collection; and the Municipal Council's finance and organisation.

2. Project Area

The Municipality is 208 km^2 in area but most of this is essentially rural and outside the service area of the Council water and sanitation supplies. Two separate service areas of Nyeri town and Kiganjo exist, the latter downslope and to the east of Nyeri town. Nyeri town is important as an administrative centre with limited industrial activity. Kiganjo is the railway station for Nyeri, and has institutional and some industrial significance.

The Terms of Reference (TOR) required assessment of the present situation in the existing supply areas for both the Nyeri town and Kiganjo water supplies. A less detailed analysis has also been undertaken of the areas outside the Municipal Council water supplies, but inside the Municipality. Although further stages of this study are said by the TOR to be confined to the Nyeri town water supply area, it is considered that the future of the Kiganjo system must to be addressed, as this has a significant impact on the financial/administrative aspects of the Municipal water supply operations.

3. Raw Water Sources

The Chania river with its headwaters on the Aberdare (Nyandarua) mountains is the present source of water for Nyeri town and has a 98% daily reliable flow of 27,560 m^3/day, against present abstraction of about 6,000 m^3/day. The present source for Kiganjo is the Nairobi river which originates on the slopes of Mount Kenya but is unreliable due to a level of upstream abstraction which almost dries up the river in the dry seasons. The Amboni river also flowing from the Aberdares, would be a more reliable source for Kiganjo, having a 98% daily reliable flow of about 10,370 m^3/day. Alternatively a clear water trunk main from Nyeri town, could supply Kiganjo.

4. Demography

Boundary changes between the 1979 and 1989 cencii, and the refusal by the Central Bureau of Statistics to release the associated mapping, which for 1989 is reported to have been very detailed, make precise analysis of population growth difficult. The Nyeri Municipal area of 1989 (167 km^2) had 91,539 people, of whom 51,415 are estimated by the Consultant to have been in "urban" areas. Growth rates are estimated at 3.7% for urban areas, 2.2% for rural areas and 3.0% for the Municipality as a whole, but these figures are based on available information and some approximations.

5. Water Supply Systems

The Nyeri Town water supply system is based on gravity abstraction from the Ihwa intake, on the Chania river, 6 km from the treatment works and on a less important pumped intake on the Chania river, near the town. The treatment works are at Kamakwa and have a nominal capacity of 5,580 m^3/day but have recently produced around 6,500 m^3/day after a leak on the raw water main which was limiting raw water supply was discovered and repaired. The distribution of treated water is essentially by gravity.

Kiganjo has a separate water supply system based on pumping from the Nairobi river, and pumping into distribution. Production has fallen from an average of 1,020 m^3/day in 1991 to 765 m^3/day in 1994. This is due to problems in pump maintenance and increased abstraction from the Nairobi river by upstream users.

Existing drawings from the previous (1982) study were not released, since that Consultant required the authority of the Water Ministry, and the authority was not given. Other drawings held by the Water Ministry from when they were the water undertaker were also not released. Field reconfirmation of details of the reticulation is needed before augmentation measures can be designed.

The rural areas of small scale farming to the south and west of Nyeri town are served by two rural water supplies. One is the Aguthi Water Supply (NWCPC) which is not generally adequate except in the extremities of the distribution, such as near the Nyeri town urban area, where water rarely reaches. The other is the Tetu-Thegenge Water Supply (Water Ministry) which is wholly inadequate. Some other areas have small water supplies in various stages of implementation. Few heavily populated areas remain outside these supplies. A number of large (mainly institutional) consumers have individual supplies.

6. Water Consumption and Demand

The Council records are that there are 4577 registered consumers (both Nyeri and Kiganjo) of which 550 were "inactive" (they have a connection but have closed their account, largely due to lack of water in their area), the balance being 4027 "active" consumers who have a running account. The Consultant enumerated 3884 consumers in the meter reading books.

Consumption of water is estimated to be domestic users 42%, institutions 36%, commercial use 19% and industry 3%.

There are 96 No. large consumers (>100 m^3/month) who consume nearly half the water supplied and generate 60% of the revenue. Most of the large consumers are public institutions. Large consumers account for most of the consumption in Kiganjo. On the other hand, small consumers have a higher rate of suppressed demand, thus the large consumers would have a lower proportion of consumption if the supplies were adequate.

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Average daily demand including 37% water losses for the existing consumers in Nyeri town during peak use seasons is presently estimated to be 14,000 m^3/day, more than twice the treatment works capacity. With adequate supply, the consumers who at present have closed their accounts would come back into the consumer base, and a significant number of new consumers in areas of the reticulation presently experiencing little or no supply could be expected; this would increase the required production capacity for existing potential demand.

The reticulation system is of insufficient size (largest pipes 200 mm dia) and with adequate water production would only assure a few consumers around the treatment works of at least their average daily demand. Large areas obtain occasional or no water supply. The next stage of the study will include determination of the necessary distribution augmentation.

7. Billing and Revenue Collection

Based on sampling, over 80% of consumers have functioning meters that are accessible and regularly read, 2% do not have meters at all, and the balance are out-of-order meters, buried meters, and properties where access to the meter is often difficult. The large consumers' meters are all read regularly; only bills of very small consumers are allowed to be estimated. Meter reading is very closely supervised, and all estimated bills are based on estimates done personally by the Council Engineer.

Bills are issued for about 63% of water produced in Nyeri Town, and 83% in Kiganjo. Revenue collection is very commendable, and is over 99% of billing in the last 3 financial years. Water bill debts (total value of unpaid water bills) have held steady at the equivalent of about 4 months billing. Great significance is placed on revenue collection and billing, with direct attention to these aspects by senior council officials. Most of the water unaccounted for is attributable to physical causes.

8. Tariffs and Costs

In 1992/93 the revenue from water and sanitation services just about covered O & M costs, but went in to serious deficit after the high inflation of 1993. Annual revenue between the 1991/92 and 1993/94 financial years ranged from Shs 11.3 mio to Shs 14.2 mio. In September 1994 the tariffs were doubled, and it is projected that in the 1995/96 financial year, O & M costs will be covered, but only part of existing loan obligations. The present tariff is from Shs 14/m^3 in the 6 - 20 m^3/mth range, to Shs. 22/m^3 for over 50 m^3/mth. This is roughly equivalent to the NWCPC tariff (such as in is applied in Aguthi) but is only half the NWCPC tariff in the above 100 m^3/month range. This has significant financial implications. A tariff revision is recommended by the Consultant to be implemented in mid 1996 to allow some time gap from the recent very large increase. The recommended magnitude of increase will be reported on in the next study stage.

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9. Organisation and Staff

The water and sanitation services fall under the Town Engineer's department, but a separate department within the Municipal Council is being set up. There is a serious shortfall within senior positions for these services, with vacancies in both assistant engineer posts, no sewage works manager, and all 13 foremen posts vacant. The Engineer is assisted in the Water Section by a superintendent and two technicians, and in the Sewerage Section by an assistant works manager and 3 technicians. The dedication of the present Engineer is a significant factor in the continued running of the services. The capabilities of the staff are to be assessed in later parts of this study.

10. Financing

The Council does not have monies set aside in a replacement and renewals fund, due to financial constraints. Water and Sanitation loan debts stand at Shs. 250 million, 95% being for sewerage. No significant repayments have been made on the sewerage loan and arrears are accumulating.

Council revenue is maintained in four separate accounts in different banks, one being for water and sewerage. The monies are kept distinct, but some "borrowing" between accounts is practised when one is in surplus and another in deficit. In 1994 the Water account was a net borrower, but after the tariff increase has "repaid" most of the amounts obtained from other accounts.

There is no distinction made between revenue/expenditure for water and that for sewerage.

11. Sanitation

The Nyeri town sewerage system covers almost all densely built up areas. The Kiganjo sewers cover the main Kiganjo centre and most large institutions; the other densely populated parts of the Kiganjo area would need a new sewage pumping station if they were to be included in the coverage. The rest of the Municipality is served by on-plot systems. Based on physical inspections, in the large part septic tanks were of acceptable standards, but many pit latrine slabs were not. There were a few VIPs found, but the concept did not seem to be understood and they were not properly constructed.

The recently completed Nyeri town sewage works are based on double stage biofiltration and maturation ponds. Principal problems are extensive recirculation pumping due to the inadequate in-flows to the works (needed to turn the bio-filter arms) and failure of mechanical seals on submersible sewage pumps. For the first problem, a reduction in length of bio-filter distributor arms or other alternatives would be practicable. The requirements for pumps with lesser maintenance difficulties also need to be investigated.

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The Nyeri town sewage works are designed for 6,000 m^3/day in-flow; measurements taken by the Consultant over 3 months put the present in-flows at about 2,100 m^3/day.

The Kiganjo sewers terminate at a sewage pump station with submersible pumps which are similar to those at the Nyeri works, and with similar problems. The sewage is then pumped 2 km to sewage ponds (anaerobic, facultative and maturation). The sludge drying beds for these works are in a swampy area so do not work; thus sludge draining from the anaerobic ponds is not carried out.

12. Urgent Measures

Measures urgently required are seen to include (i) computerization of billing, (ii) a block mapping and consumer survey, (iii) a leak detection exercise, and (iv) an immediate works rehabilitation/augmentation programme.

The computerization of billing is in hand under an addendum to the Consultancy agreement with arrangements being finalised.

The blockmapping and consumer survey is particularly necessary due to the lack of access to existing drawings and information related to past cencii. Such an exercise is recommended to include an assessment of unconnected consumers, and those with closed accounts, in "dry" parts of the existing reticulation, and to make available detailed data on existing consumers, to be incorporated into the new computer database. Digitised mapping of consumer locations would allow further development towards a geographical management system. Due to the absence of as-built reticulation drawings, a field exercise of pipework confirmation would be a further area of necessary work. Draft terms of reference for the above work are being prepared and will be forwarded under separate cover.

Water leakage losses in the Nyeri town reticulation system are the major part of the overall 37% losses, since the administrative attention to billing limits the potential for billing lapses, and authorised unbilled water use is insignificant. The soil conditions in the area hinder visual identification of leakage. Any attempts to reduce leakages must involve use of leak detectors. Proposals for examination of appropriate techniques and equipment will be prepared and forwarded under separate cover.

The Consultant has found that cost effective measures can increase the existing works throughput capacity from 5,580 to 9,000 m^3/day, and a ring main could carry this increased water to the lower parts of the central business district, Kangemi and Ruringu, which are presently the densely built up areas worst hit by shortages. Rehabilitation measures required in all aspects of the works have been identified and are detailed in this report. The Consultant recommends that authority is given for an immediate works rehabilitation/augmentation package to proceed for detailed design and implementation.

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ASSESSMENT OF SITUATION

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1. BACKGROUND

1.1 Scope of Study

The Terms of Reference are contained in Annex 1 hereof.

Essentially, the study is divided into three distinct stages, each of which was required to be completed and reported on separately, and before proceeding to the next study stage. The study stages and their principal components are as follows:

(a) Assessment of Situation (Inception Report):

An assessment of the existing situation with regard to:

i) water supply facilities, water connections, and urgent rehabilitation measures.
ii) water consumption
iii) water demand and supply capacity
iv water production, billing and revenue collection, the necessity for a block mapping and consumer survey
v) cost of water supply; cost covering tariff
vii) Municipal budget and water/sanitation expenditure
viii) a brief description of sanitary facilities including on-lot systems, and necessity for sewer network and sewage works expansion.

(b) Pre-feasibility

i) water consumption, and future demand for the years 2010 and 2015; the need for a project.
ii) define alternatives for a project
iii) layouts, preliminary quantities and cost estimates for project alternatives
iv) recommendations on optimum solutions by technical/economic comparison
v) implications of project proposals on sanitation situation
vi) environmental and socio-economic impacts of proposed project
vii) define project objectives and achievement indicators

(c) Feasibility

i) preliminary design of selected project alternative, including cost estimates
ii) detailed elaboration of operation and maintenance (O & M) costs
iii) economic/financial analysis of the project and its effects on the population.
iv) proposals for tariff structure
v) guidelines on staffing and personnel establishment

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vi) detailed proposals on billing and revenue collection
vii) proposals for water and sanitation services organisational setup.

This report covers the scope of services with regard to the assessment of the existing situation.

1.2 Project Area

Nyeri Municipality is located in the Nyeri District of the Central Province of Kenya, approximately 150 km north of the City of Nairobi.

The Municipality is located at approximately 0°25'S 37°E in an area which is essentially a valley between the Nyandarua (Aberdare) Range of Mountains, and Mount Kenya.

The whole of Nyeri Municipality covers an area of 208 Km^2, but this is an area of diverse land use, most of it not of an urban nature. The central urban area (Mukaro) is associated with the nearby Ruringu trading centre to the south east, and the Kamakwa centre to the west, both of which have grown to merge with the Mukaro area as one urban population concentration. A separate significant urban area is Kiganjo to the north east of Nyeri town. Another population centre is Mathari, but this is primarily an institutional area, comprising the Mathari Catholic Mission, and it's associated institution (hospital, orphanage, secretarial college, boarding primary school, seminary, etc.), Nyeri High School, and Kamwenja Teachers College.

The rest of the Municipal area is largely rural in nature. The southern and eastern parts, and Kihuyo sub-location to the northwest, are dominated by small scale agricultural holdings, interspersed with small trading centres. Areas to the north of Nyeri town are predominantly large scale agriculture, the land use shifting from coffee near the town to ranching further north. Some of these large holdings are however being sub-divided into small holdings on a progressive basis. Some forest land exists in the Municipal area, around Nyeri Hill, to the north between the Nyahururu road and Nyaribo, and around Kiganjo.

By way of communications, Kiganjo is better situated than Nyeri Town. It through Kiganjo that the railway passes. The trunk road from Nairobi to northern Kenya also passes through Kiganjo rather than Nyeri Town. A loop road from Marua and on to Kiganjo does however link Nyeri town to this transport corridor. The other principle links to Nyeri are the tarmac roads to Nyahururu, and on to Nakuru and Gilgil, and the road to Othaya, and on to Muranga and hence to Nairobi.

Nyeri has an airstrip at Nyaribo, but it is not proximate to a surfaced road, and thus is put to limited use.

The principal role of Nyeri Town is in administration due to its status as the provincial and district capital. There are also institutions of national importance, particularly the two teachers colleges (Kamwenja and Kagumo), the country's main police training college, which also houses the adjacent high altitude athletics training centre of international repute, the Mathari centre mentioned above, and the national high schools of Kagumo and Nyeri High School.

Industry is limited, but there are a number of important facilities. In the Kingongo area, there are two soft drink bottlers (Coca-cola and Highlands) as a well as light industry park. At Kiganjo is a milk processing plant which serves all of the neighbouring districts, and a large wheat mill.

Although surrounding areas are important for their tourism value, especially the Mt. Kenya and Aberdare national parks, the only significant tourist hotel in the Municipality is the Outspan. The Greeen Hills Hotel is largely used by those attending seminars and residential workshops and other hotels mostly service the local accomodation market.

The general topography is marked by the Nyeri Hill, and a series of river valleys. Development is largely on the ridges between these valleys, as are the principal roads. The Chania River valley is the predominate feature of Nyeri Town. The main road starts from Kamakwa and runs on the ridge, following the south bank of the river, through the town centre, past the Provincial hospital and Kangemi housing area, upto the area where the sewage works are. The only principal parts of the town on the north bank of the Chania river are Kingongo (directly opposite the town) and Mathari.

Kiganjo town stands on a ridge between the Nairobi and Amboni (Honi) rivers.

Although the Aberdares rise to 3,999 m and Mt. Kenya to 5,199 m, Nyeri town is in the valley between, with altitudes between 1,700 and 2,000 m. Nyeri Hill does however rise to 2,216 m.

Due to the altitude, and the influence of the nearby mountains, the climate is moderate. Daily temperatures range from $11^{o}C$ to $25^{o}C$, and rainfall averages about 1000 mm per annum. The rainfall is in two seasons, the "long rains" in March to May, and the "short rains" in October to December.

1.3 Historical Development

At the turn of the century, the area around which the built-up area of Nyeri town stands was in the large part an uninhabited forested area, although there were agricultural holdings to the west (Tetu), to the northwest (Kihuyo and Ihururu) and to the south from Gatitu. The area towards Kiganjo and northwards was in use by Masai pastoralists.

The town began from military activity. A trading caravan had been ambushed, as a result of which one military expedition was sent from Naivasha, through the Nyandarua Mountains, commanded by Colonel Meinertzhagen, and another led by M/s Barlow, Hinde and Hemsted came up from Fort Hall (now Muranga)<1>. Meinertzhagen reached the base of Nyeri Hill on 4th December 1902 and found Hinde camped there. On 6th December they moved to

<1> *Nyeri Townsmen Kenya; C.A. Dutto, East African Literature Bureau, 1975.*

the present location of the district and provincial administrative offices, where they built a fort. This location was considered better placed for defence and obtaining provisions.

The fort was surrounded by a deep defensive ditch (mukaro in Kikuyu) leading to the present name of the central area of Nyeri Town.

The principal military function lasted upto 1905, but in the interim, Asian traders had been attracted to set up business within the area of relative safety near the fort, and missionaries also moved in at the request of the military officials.

The pioneer businessmen were Osman Allu, whose shop remained in family hands until recently, occupying a central place in the commercial district, and Mohamed Ali, a manager with the firm of Allidina Visram.

The Catholic missionaries of the Consolata Society for Foreign Missions of Turin, Italy, started a mission centre at Tetu, 5 km from the fort, in March, 1903, and another at Mathari later that year. Church of Scotland Missionaries had established a small centre earlier, in 1902, but eventually opened a full scale mission at Tumutumu (1909) rather than at Nyeri.

On 15th May, 1911, Nyeri was gazetted as a township, comprising an area of one mile (1.6 km) radius from the flag post of what is now the District Commissioner's office. The following year the town became the administrative capital of Nyeri District, and also headquarters of the Kenya Province of the East African Protectorate. The "Kenya Province" constituted only a small part of what is today the Republic of Kenya. It was in 1913 that the "old town" borders were established, remaining Nyeri town's borders for the next sixty years.

In 1927, the railway reached Kiganjo, which had been chosen as the Nyeri railroad station, both due to it's topographical advantages and also its closer proximity to the settler farmlands which had developed to the north, after the 1912 relocation of the original Masai inhabitants to areas around Narok.

After some boundary changes in the Kenya Colony, Nyeri town became the capital of the Kikuyu Province in 1924. Some more changes occurred, so that in 1933, Nyeri was the capital of the then Central Province, which included Nanyuki and Meru to the north, Nairobi to the south, and the Machakos/Kitui areas to the east. This remained the case until the boundary revisions of 1961 to 1965, where Nyeri remained the administrative capital of much smaller Central Region and then Central Province.

For all of it's formative years, Nyeri town was administered by the District Commissioner. In June 1954 the Nyeri Urban District Council was created. This was a structure whose function was to assist the District Commissioner, and exercised its functions in Nyeri, Kiganjo and Mweiga. In 1963 however, the Urban Council assumed a representative nature with the election of councillors.

Nyeri Town obtained the status of a Municipality in May 1971, when the first mayor was elected. The elevation in status was accompanied by a ten fold increase in the town area, from the area defined by 1913 survey and distribution of plots.

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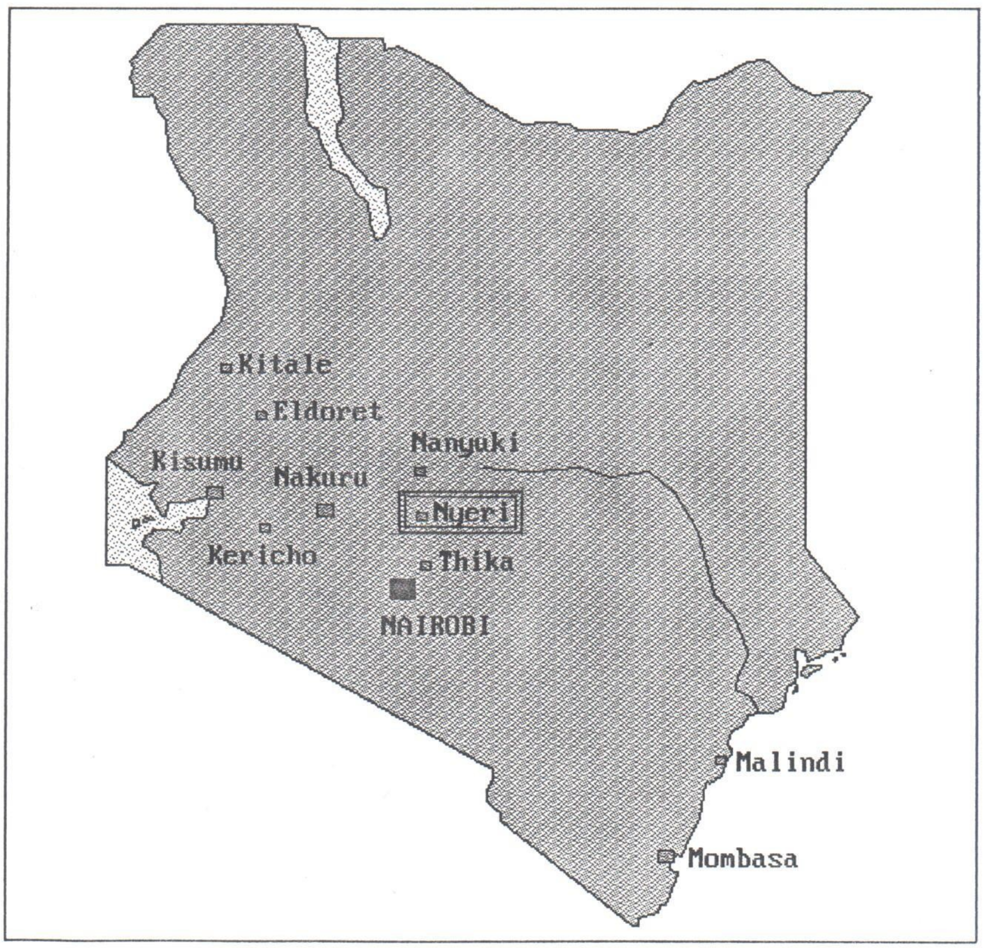
As seen from the foregoing, the beginnings of Nyeri were from a military function, but this was very quickly replaced by an administrative role. Commercial development started with trading stores located in the shadow of the fort, but this was gradually transformed into the only centre of commerce for the northern farmlands (until Nanyuki took some of this business away) as well as a market centre for nearby small scale farming.

Figure 1.1
PROJECT AREA LOCATION



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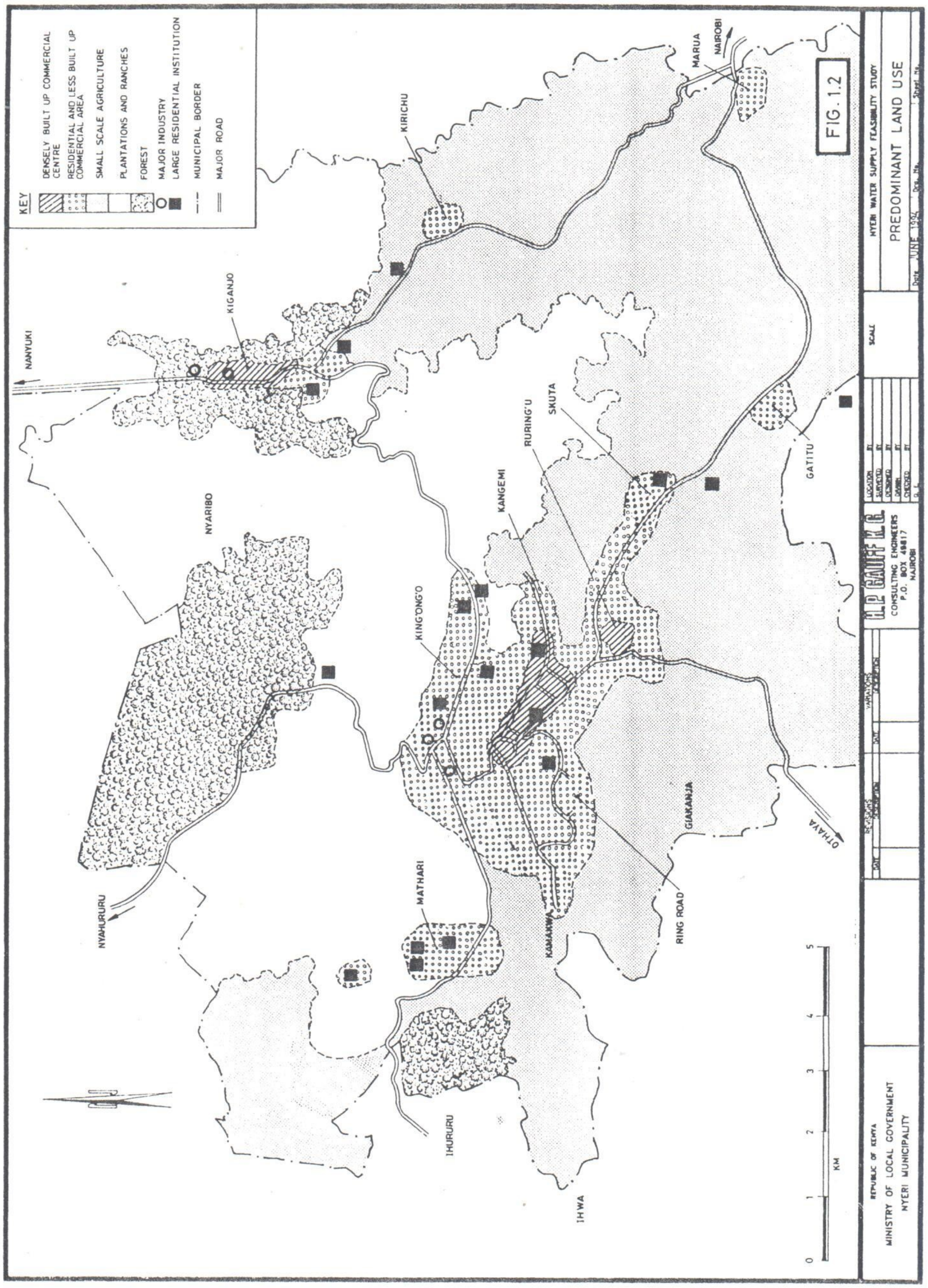
KEY
DENSELY BUILT UP COMMERCIAL CENTRE
RESIDENTIAL AND LESS BUILT UP COMMERCIAL AREA
SMALL SCALE AGRICULTURE
PLANTATIONS AND RANCHES
FOREST
MAJOR INDUSTRY
LARGE RESIDENTIAL INSTITUTION
MUNICIPAL BORDER
MAJOR ROAD
NAIROBI
MARUA
KIRICHU
KIGANJO
NANYUKI
NYARIBO
KING'ONG'O
KANGEMI
RURING'U
SKUTA
GATITU
NYAHURURU
MATHARI
KAMAKWA
GIAKANJA
RING ROAD
OTHAYA
IHURURU
IHWA
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0
1
2
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5
FIG. 1.2
NYERI WATER SUPPLY FEASIBILITY STUDY
PREDOMINANT LAND USE
JUNE 1992
SCALE
H.P. GAUFF K.G.
CONSULTING ENGINEERS
P.O. BOX 49817
NAIROBI
REPUBLIC OF KENYA
MINISTRY OF LOCAL GOVERNMENT
NYERI MUNICIPALITY

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2. DOCUMENTATION & REVIEW

2.1 Introduction

With certain exceptions as indicated below, all relevant documentation that could be traced was obtained both in Nairobi and Nyeri. The documentation obtained included reports from previous water designs and reports and some drawings from previous sewerage designs, government reports on the macro-economic situation, hydrological and meteorological data, demographic data, proposals for changes in water & sewerage management within Local Government, Central Government Acts in the fields of Water, Local Government and Public Health and technical and financial data on Nyeri Municipality and its water and waste disposal activities.

In four instances, incomplete information was obtained namely pre-1980 river gauging station data that was not already with the Consultant; the census Maps for 1979 and 1989 and the detailed unpublished household data for 1989; detailed design drawings from the previous water supply design that was not constructed; and as-built water supply drawings in the custody of the Water Development Department of the Ministry of Land Reclamation, Regional and Water Development.

In the case of the hydrological data, a recent decision by the holding Ministry to charge not insignificant sums of money for release of such data meant that only strictly relevant and qualitatively sufficient data for the purpose of this study was obtained.

In the case of the 1979 and 1989 census maps, the Central Bureau of Statistics (CBS) indicated that release of the information contained on the maps was not considered to be in the best public interest. In the absence of the relevant maps and the not inconsiderable sum of money that would have been charged by CBS to abstract detailed household information from the 1989 census database, this was not considered justified.

The Consultants who undertook the 1980-82 water supply design required authority from the then water undertaker (MoLR,R & WD) to release copies of the drawings. To date, this has not been forthcoming, and so copies have not been obtained.

A number of as-built drawings of the Nyeri Water Supply were apparently not handed over by the previous water undertaker, (MoLR,R & WD), to Nyeri Municipal Council at the time of the transfer. Efforts to obtain these drawings have to date proven unsuccessful.

As a result, there are a number of areas where this initial assessment is incomplete and where additional fieldwork has proven necessary to get as complete a picture of the existing situation as is practicable in the time available.

Should the outstanding water supply drawings not be obtained before commencement of the next Study stage then this could have both time and cost implications on this Consultancy.

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2.2 Documentation

A complete list of the documentation obtained is given in Annex 2. This includes the following key documents studied and reviewed in detail for this assessment report.

The Kenyan Economy

1. Economic Survey 1994. Nairobi (1995).
   Central Bureau of Statistics, Office of the Vice-President and Ministry of Planning and National Development, Republic of Kenya,

2. Development Plan 1994 - 96
   Central Bureau of Statistics, Office of the Vice-President and Ministry of Planning and National Development, Republic of Kenya.

3. National Master Water Plan Stage I
   Tippets-Abbett- Mcarthy-Stratton, September 1980

4. The Study on the National Water Master Plan
   Japanese International Corporation Agency, July 1992

5. Nyeri Sewerage Scheme, Final Design Report & Sewage Network Drawings
   Mangat, I.B. Patel, September 1978

6. Nyeri Water Supply, Preliminary & Final Design Reports
   Alexander Gibb & Partners, December 1980 & 1982

7. Kenya Population Census, 1979, Volume I
   Central Bureau of Statistics
   Ministry of Economic Planning & Development, June 1981

8. Kenya Population Census, 1989, Volumes I & II
   Central Bureau of Statistics
   Office of the Vice President & Ministry of Planning & National Development
   April, 1994

9. Nyeri District Development Plan 1994 - 1996
   Office of the Vice President & Ministry of Planning & National Development

2.3. Review of Documentation

All documentation obtained was studied and salient or relevant information abstracted. The resulting reviews are dealt with in the following Chapters and Annexes:-

Hydrology in chapter 4 and Annex 4
Survey & Mapping in chapter 5
Demography & Population in chapter 6 and Annex 5
Existing Water Supplies in chapter 7 and Annex 6

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Water Consumption in chapter 8
Water Demand in Chapter 9 and annex 5
Water Production in chapter 10
Present Costs and Tariffs in chapter 10
Municipal Organisation in chapter 12
Municipal Budgets in chapter 13

The various aspects of review of documentation has been incorporated into the text of the reporting on that subject.

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3. KENYA AND THE WATER SECTOR

3.1 The Kenyan Economy

3.1.1 Demography

The 1989 population census revealed that the Republic of Kenya had some 21.4 million inhabitants. Compared to the results of the previous census (1979) the intercensal population growth rate was approximately 3.4 % per annum. Assuming that the rate of growth of the population since 1989 has been approximately the same as the one observed in the intercensal period, the Kenyan population for 1995 can be estimated to amount to some 26.3 million.

The average population density in Kenya increased from some 26.3 inhabitants per square kilometre in 1979 to about 36.8 and 45.2 inhabitants per square kilometre in 1989 and 1995, respectively. Other highlights of the 1989 population census include:

- The average number of inhabitants per household in Kenya was approximately 4.9 persons.
- About 57 % of the population in Kenya are 18 years of age or younger.
- The sex ratio for Kenya amounts to 100 male per 102 female inhabitants.

The distribution of population, number of households and population density by province is presented in Table 3.1.

3.1.2 Overall Economic Development

The aggregate economic development of Kenya for the period 1989 to 1993 is presented in Table 3.2, which indicates the annual values of gross domestic product (GDP) by sector of economic activity and GDP per capita at factor cost and constant 1982 prices.

Thus, in 1993 the GDP of Kenya amounted to some K£ 4,300 million (provisional), equal to an estimated GDP per capita of approximately K£ 177 per inhabitant, both in constant terms. Note that 1 Kenya Pound [K£] = 20 Kenya Shillings. Overall, sectors of the monetary economy contributed some 94 % of the 1993 GDP of Kenya. Thus, the non-monetary economy accounts for the remaining 6 % of the 1993 GDP.

As indicated in Table 3.2., it can be seen that agriculture is the most important economic sector in Kenya, contributing some 25 % to GDP in 1993. Other important sectors are manufacturing (13 %) and trade, hotels and restaurants (11 %). Government services account for some 16 % of GDP.

Between 1989 and 1993 the average rate of growth of GDP increased by some 1.7 % per year overall and by -1.6 % per year per capita, both in real terms. Provisional results from National Account aggregates indicate that the rate of growth of GDP at constant 1982 prices declined for the five consecutive years shown in Table 3.2. Between 1992 and 1993 the annual rate of growth of GDP registered was 0.1 %.

This is considerably lower than in previous years. According to the 1994 Economic Survey, this is attributed to the following factors:

- Prolonged drought and consequently, reduced agricultural output.
- Low aggregate domestic demand which resulted in sluggish growth in output of manufacturing.
- Foreign exchange shortage during the first half of 1993.
- High inflation, principally a consequence of severe drought, excessive growth in money supply; massive depreciation of the Kenya Shilling and liberalisation policies pursued by the Government.

Among the major economic sectors, agriculture's growth of real GDP declined from 3.4 % between 1989 and 1990 to negative 4.1 % between 1992 and 1993. Overall, the real GDP growth of agriculture declined by 1.4 % on average between 1989 and 1993. The sector recorded significant declines in the output of major food crops while the output of coffee fell. Real value added for the trade sector stagnated at the 1992 level with a growth rate of only 0.1 % between 1992 and 1993.

Real growth of GDP of the manufacturing sector increased by 1.8 % from 1992 to 1993, averaging a real growth of some 2.9 % over the entire period indicated in Table 3.2. This was mainly due to higher export demand for non-traditional manufactures especially textiles and manufactured food products and partly as a result of an increased inflow of foreign exchange in the second half of 1993.

In 1993 tourism (trade, restaurants and hotels) accounted for some 11 % of the GDP. The number of visitors arriving and departing from Kenya improved markedly in 1993 after successive declines recorded in 1991 and 1992. In the 1994 Economic Survey of Kenya this is attributed to successful tourism promotion. Visitor arrivals increased by 5.7 % in 1993, while hotel bed-night occupancy increased by 12 % in the same year. Other tourist attractions such as national parks, game reserves, museums and historical sites all recorded increased numbers of visitors in 1993 compared to the previous year. Foreign exchange earnings increased by 71 % from K£ 713 million in 1992 to K£ 1,222 million in 1993. Europe and America continue to be the most important tourist generating regions in 1993.

The highest real growth of GDP from 1992 to 1993 was recorded by the financial sector with 7.5 %. The sector benefited mainly from the liberalisation of foreign exchange controls and the introduction of weekly auctions on high yield treasury bills.

In an effort to rectify some of the macro-economic imbalances responsible for poor economic performance in the recent past the Government of Kenya introduced significant economic reforms in 1993, including:

- liberalisation of foreign exchange controls;
- abolition of import licensing;

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- introduction of export retention account scheme for exporters;
- removal of price controls, particularly on maize, wheat and sugar;
- tighter controls in the entire financial management system.

3.1.3 Employment & Income

The total number of persons employed rose from 0.8 million in 1972 to some 2.1 million persons in 1992. Sectorial distribution of wage employment for earlier years shows that between 1972 and 1986, employment in the public sector grew faster than that of the private sector.

According to the 1994 economic survey, it is estimated that total employment in Kenya had reached just under 3 million persons by 1993. In 1993 employment increased by some 8.9 %, mostly attributable to the fast growing informal sector which increased by 18.5 % to some 1.5 million persons in 1993. The informal sector accounts for some 48.9 % of total persons engaged outside small agriculture in 1993. The notable expansion of employment in the sector underscores its potential in absorbing the estimated 410,000 unemployed labour force. Employment in the modern sector increased only marginally by 1.0 % to just over 1.5 million persons in 1993.

The gazetted minimum wage for agricultural workers in urban areas within the private sector was raised by 31.4 % with effect of 1 May 1993 to a monthly wage of KShs. 941 from the previous level of KShs. 716. The lowest paid employees within the sector, i.e. unskilled labour under 18 years of age, had the minimum wage raised from KShs. 412 to KShs. 539; while the highest paid, e.g. farm foreman, had their minimum wages increased from KShs. 1,040 to KShs. 1,363.

The general minimum wage of other categories, that is for workers in urban areas within the private sector was raised by 30.5 %. Monthly basic wages in Nairobi and Mombasa were on average raised from KShs. 1,706 to KShs. 2,227. For workers in all other municipalities, the minimum wage was raised from KShs. 1,576 to KShs. 2,066.

The rate of inflation, as measured by the revised Nairobi consumer price index, has been rising steadily since 1991. The rate increased from 19.6 % in 1991 to 27.3 % in 1992 and further to 46 % in 1993. The inflatory pressures were more pronounced in the upper income group, whose index rose by 53.3 % in 1993, compared with 16.3 % recorded for the preceding year. Indices for both lower and middle income groups rose by 45.8 % and 45.9 % in 1993, respectfully; compared with corresponding increases of 29.5 % and 21.1 % in 1992.

The high inflationary pressures are ascribed to a number of factors, among them, the devaluation of the Kenya Shilling and unfavourable weather conditions. Following a series of devaluations totalling 72 % in 1993 there were significant price increases of most imported goods and locally manufactured goods requiring imported raw materials. Other reasons for the significant rises in the consumer price index were increases in petrol and petroleum product prices, and also a widening of the value added tax base to encompass a

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Table 3.1:

PROVINCE	POPULATION 1979	1989	1995*	NUMBER OF HOUSEHOLDS (1989)	LAND AREA (Km2)	DENSITY (Inhabitants /Km2, 1989)	AARG 1979 - 1989
	(Number of inhabitants)						
NAIROBI	827,775	1,324,570	1,756,194	382,683	693	1,911	4.8
CENTRAL	2,345,833	3,116,703	3,696,021	664,241	13,236	235	2.9
COAST	1,342,794	1,829,191	2,201,957	360,882	84,113	22	3.1
EASTERN	2,719,851	3,768,677	4,583,267	677,740	154,354	24	3.3
NORTH EASTERN	373,787	371,391	369,961	70,076	126,186	3	-0.1
NYANZA	2,643,956	3,507,162	4,155,055	700,916	12,507	280	2.9
RIFT VALLEY	3,240,402	4,981,613	6,448,113	1,020,772	182,413	27	4.4
WESTERN	1,832,663	2,544,329	3,097,902	475,261	8,285	307	3.3
TOTAL	15,327,061	21,443,636	26,308,470	4,352,571	581,787	37	3.4
* = estimate	AARG = Annual average rate of growth.						
Source: [002, pp. 1-1 and 1-2], [003, p. 13] and own calculations.							

Table 3.2.

ITEM	1989	1990	1991*	1992*	1993**
NON-MONETARY ECONOMY					
FORESTRY	30.46	31.37	32.19	33.04	33.90
FISHING	1.54	1.49	1.39	1.27	1.15
BUILDING & CONSTRUCTION	71.50	72.93	74.39	75.45	75.84
WATER COLLECTION	23.44	24.14	24.87	25.33	25.51
OWNERSHIP OF DWELLINGS	96.41	99.71	101.70	102.34	103.18
TOTAL NON-MONETARY ECONOMY	223.35	229.64	234.54	237.43	239.58
MONETARY ECONOMY					
1. ENTERPRISES					
AGRICULTURE	1,152.51	1,192.04	1,178.93	1,134.83	1,088.30
FORESTRY	40.62	42.65	46.23	48.16	47.58
FISHING	12.83	13.39	13.10	12.19	11.33
MINING & QUARRYING	10.62	11.25	11.97	11.01	11.23
MANUFACTURING	532.47	560.34	581.63	588.61	599.21
BUILDING & CONSTRUCTION	131.40	134.30	129.30	122.20	114.01
ELECTRICITY & WATER	39.53	43.69	45.97	45.11	45.52
TRADE, RESTAURANTS & HOTELS	455.47	465.95	472.05	478.94	479.56
TRANSPORT & COMMUNICATION	241.06	249.74	259.10	263.60	265.71
FINANCE, INSURANCE, REAL ESTATE & BUSINESS SERVICES	313.11	333.15	353.47	377.94	406.29
OWNERSHIP OF DWELLINGS	220.63	229.35	235.31	238.98	239.46
OTHER SERVICES	127.86	135.93	141.11	144.50	145.68
LESS IMPUTED BANK CHARGES	-129.12	-134.03	-138.59	-142.03	-148.09
SUB-TOTAL	3,148.99	3,277.75	3,329.58	3,324.04	3,305.79
2. PRIVATE HOUSEHOLDS	62.36	70.52	78.28	85.26	93.10
3. GOVERNMENT SERVICES	618.40	645.72	669.10	685.43	699.14
TOTAL MONETARY ECONOMY	3,829.75	3,993.99	4,076.96	4,094.73	4,098.03
TOTAL NON-MONETARY AND MONETARY ECONOMY (GDP)	4,053.10	4,223.63	4,311.50	4,332.16	4,337.61
GDP PER CAPITA	189.01	190.46	188.00	182.66	176.85
* = revised, ** = provisional.					
Source: [001, p. 17], TABLE 3.1 and own calculations.					

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much wider range of goods and services, including the retailing of motor vehicle spare parts and the hotel industry.

3.1.4 Health

As part of the Structural Adjustment Programme, the Government of Kenya has encouraged the private sector to participate in the provision of health services. Thus, the health infrastructure has been expanding in recent years, partly due to the participation of non-governmental organisational and the private sector. Out of an estimated 3,100 health institutions in Kenya, about 60% are under governmental control and are administered by the Ministries of Health and Local Government, the latter at municipality level. As an indication of the expanding provision of health services, the bed - population ratio improved by 7.6% between 1992 and 1993 from 1:156 to 1:145.

3.1.5 Foreign Trade and Balance of Trade

In international trade, agricultural commodities are the main foreign exchange earner of the Kenyan economy. However, the level of earnings from other services determine the level at which investments can be financed, and ultimately the rate at which the overall economy can grow.

The import bill rose from K£ 191.1 million in 1972 to K£ 2,954 million in 1992, an average growth rate of 15.1 % per year, while the value of exports increased from K£ 128.2 million in 1972 to K£ 1,742.3 in 1992, equal to an annual average rate of growth of 13.9 %. Consequently, the balance of trade deficit facing Kenya has risen from negative K£ 62.9 million in 1972 to negative K£ 1,212 million in 1992.

Despite a good export performance in 1993, the balance of trade worsened as the value of imports rose sharply. On the other hand the overall picture in balance of payments recorded an exceptionally high surplus of K£ 1,284 million, mainly as a result of a large short term in-flow of capital, attracted by high interest rates on treasury bills and also by the liberalisation on exchange controls. The increase in the 1993 export earnings resulted mainly from substantial increases in export quantity and value of coffee, tea, horticulture, cement, soda and pyrethrum products among other commodities.

3.1.6 Development Constraints & Targets

During the Sixth National Development Plan (1989 - 1993) the targeted annual average rate of GDP growth set at 5.4 % was not achieved. The average growth rate between 1988 and 1992 was only 3.1 %. More significant, however, is the fact that there was a steady and sharp decline in the annual growth rate over this period; to an all-time low (since independence in 1963) of 0.4 % in 1992. The Seventh National Development Plan attributes this rapid deceleration mainly to the following factors:

- collapse of the international prices of coffee in mid-1989;
- insufficient and uneven rainfall for four consecutive years since 1990;

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- the suspension of quick dispensing donor aid in November 1991;
- uncertainties and disruptions associated with the transition to political pluralism ushered in by the general elections in December 1992.

Thus, the Seventh National Development Plan (1994 - 1996) has been launched at a critical time in Kenyan history and faces numerous challenges which can be summarised as follows:

- to establish a basis for mitigating the unemployment problem from high labour force growth rates;
- rejuvenating the economy to achieve higher growth rates in GDP in order to improve and maintain per capita incomes a least to higher than the population growth rate at 3.4 % per year;
- placing "safety nets" to mitigate deterioration in the welfare of the poor resulting from implementing Structural Adjustment Programmes;
- planning and achieving development goals without the reliance of foreign assistance.

Sessional Paper No. 1 of 1986, on Economic Management for Renewed Growth, set the target growth rate of real GDP at 5.9 % per year between 1988 and 2000. This was considered necessary if per capita incomes were to grow at 1.8 % per year during the period, coupled with an overall employment growth rate of 3.4 % per year during the same period. However, as mentioned above, the country has experienced a rapid deceleration in GDP growth between 1989 and 1993.

Considering that some of the factors which led to the deceleration of GDP growth are still active, the Seventh National Development Plan assumes a gradual recovery of growth to 5.1 % in 1996. However, even this modest growth scenario can not be achieved unless the following assumptions are fulfilled:

- satisfactory rainfall is received between 1994 to 1996;
- current policies of structural reform, particularly liberalisation and privatisation of the economy, are continued;
- restoration of development aid;
- reduction in the average annual rate of inflation to a single digit by 1995, through strict control on growth in money supply.

In general, the agricultural sector (broadly defined to include forestry and fishing) was expected to recover to an annual GDP growth rate of about 2.0 % in 1994 and thereafter to grow at some 5.8 % in 1995 and 1996. This growth is dependant upon better rainfall in the latter two years of the Seventh Development Plan. Overall, the annual average rate of growth of the agricultural sector is forecast to be about 4.4 % between 1994 and 1996.

Industry (mining and quarrying, manufacturing, building and construction and electricity and water) which had plummeted to a historically low growth rate of 0.2 % in 1992 was expected to recover to about 2.0 % in 1994, and further to 5.1 % in 1995 and 7.2 % the following year. To some extent these high growth rates will mark a process of recovery to a more normal rate of growth. If this is achieved, the average rate of growth of the industrial sector from 1989 to 1996 will be approximately 3.3 % per year.

The services sector (comprising all other sectors apart from government services) is expected to grow at an annual average rate of some 4.5 %. The expected rate of growth of the government sector will be moderated to no more than 3.2 % per year during the Seventh Development Plan period.

3.2 The Kenyan Water Sector

3.2.1 General

This assessment contains a brief overview on the national and regional [1] water supply and sanitation sectors.

Whereas information on the national water supply sectors abounds - even though being widely dispersed - information related to the national and regional sanitation sectors and the regional water supply sector is scarce and often vague.

3.2.2 Sector Organisation

Since Kenya's independence in 1963, the provision of adequate supplies of water has been one of the main concerns of her Government. With its creation in 1974, the Ministry of Water Development (since 1992, the Ministry of Land Reclamation, Regional & Water Development), has become the "principle agency responsible for management, development, operation and maintenance of water supplies, sewage disposal and pollution control". [2]

Other agencies involved in the water supply sector comprise:

- the Ministry of Local Government which - through the various municipal councils is, indirectly, responsible for the water supply schemes of most of the major urban (municipal) centres [3].

<1> *i.e. in Nyeri District.*

<2> *Republic of Kenya: Development Plan 1984-1988; p.36 - previous to 1974, these tasks came under the responsibility of the then Water Department of the Ministry of Agriculture.*

<3> *The Coast Province towns of Mombasa, Voi, Kwale, Kilifi and Malindi, as well as Kakamega in Western Province, are the only major urban centres whose water supply comes under National Water Conservation and Pipeline Corporation.*

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- The National Water Conservation and Pipeline Corporation, which is a government body responsible for a number of selected projects across the country, and reporting to the water ministry
- the Ministry of Health which runs a number of small rural water supply schemes
- the Ministry of Housing and Social services which contributes to self-help water supply projects
- the Ministry of Agriculture which is involved in water supply schemes for irrigation
- the Ministry of Lands and Settlements which is responsible for water supply systems in settlement institutions
- missions, churches, population groupings (Harambee), etc.

3.2.3 Sector Objectives

The overall long-term objective related to the national water supply sector, as stated by the Kenya Government in the 1984 -88 Development Plan, is the "supply of water, of good quality, in sufficient quantity and in close proximity to the population".

At the beginning of the International Drinking Water Supply and Sanitation Decade in 1981, the government policy targeted the population that ought to have access to potable water. However, due to the general worsening of the overall economic situation at the beginning of the 1980s, it soon became clear that neither the intermediate targets for 1985 nor the final targets set for 1990 could be reached. It is also now clear that the revised target of year 2000 is also unreachable, even though the above-stated long-term objective is still adhered to, its full realization has been postponed to an as yet unspecified later date.

3.2.4 Strategies and Policies

It is estimated that several thousand water supply schemes are currently in operation throughout Kenya.

Development expenditure of the public sector on water supply, and related services increased from K£ 15.2 million in 1979/80 to about K£ 33.8 million in 1985/86, indicating an average annual increase of some 17.3 per cent. Between 1985/86 and 1993/94 a further increase to about K£ 152 million occurred *<1> <2>* indicating an average annual increase to about 20.7 %. In 1994/95, the allocation increased significantly to K£ 232 million. However, between mid 1986 and mid 1994, the Kenyan Shilling depreciated against the US Dollar by a factor of about 3.5 which largely offset the numeric increases in expenditure.

The overall expenditure on water supplies and related services as a proportion of the total development expenditure of the Government has varied little since 1981/82 when it was approximately 10 % . In 1983/84 it was 11.1 % and in 1984/85, it amounted to some 11.4 %. Water supply schemes directly under the Ministry of Local Government accounted for about one-fifth of water sector development expenditure in 1994/95.

<1> *Development Estimates 1994/95*
<2> *Supplementary Estimates (Development Expenditure) 1994/95*

Since the early 1980's, a large proportion of the capital expenditure on water supplies and related services has been provided for under bilateral and multilateral foreign agreements. During 1994/95 this amounted to approximately 65 % of the total.

Overall planning, design, and supervision of water supply schemes, is primarily the responsibility of the Ministry responsible for Water Development, either directly by the Water Development Department, or more recently indirectly by the National Water Conservation & Pipeline Corporation.

In practice, the Ministry with its limited manpower resources has never been able to cope with the total workload, and a considerable part of the planning, design, and supervision work has therefore been undertaken by local and foreign consulting companies under the control of the Ministry. Planning and design of water supply schemes is done in general accordance with the specifications elaborated by the Ministry and as compiled in a Water Design Manual. Exceptions to this control have been the water and sewerage projects for Nairobi City, and some feasibility studies, such as this one.

Operation and maintenance of water supply schemes, depending on the type of scheme, are the responsibility of the various agencies in Section 3.2.2 above.

3.2.5 Service Coverage

Estimates of the percentages of the population served by water supply schemes vary widely. The 1984/88 Development Plan indicated that an estimated average 25 % were covered by mains sewerage and 75 per cent supplied with piped water, estimates varying from between 10 to 20 per cent for rural areas and 50 to 70 per cent for urban areas, sewerage and water respectively.

The 75% with improved water supplies was subsequently shown to be a considerable overestimate, and the 6th Development Plan covering the period 1991/93 set as its target a 61% coverage of people served by organised water points. This target was not achieved, and the revised 1993 figure is 55.5% (66.5% urban, 44.5% rural)<1>. For 1996, the 7th Development Plan targets a 62% coverage (74.0% urban and 50.0% rural), stating that this will be achieved by removing past constraints including the rationalization of project selection by releasing funds for priority activities, completing on-going projects, and the rehabilitation of existing facilities.

3.2.6 Cost Recovery and Water Supply Tariffs

Until the early 1980's, Central Government heavily subsidised the construction of new and the operation and maintenance of existing water supply schemes in both urban and rural areas. Not only was it considered to be the task of the Government to provide cheap water supplies but it also proved difficult to enforce payments for water provided where it was intended to recover at least part of the cost involved. With more and more water supply

<1> *Development Plant 1994/1996*

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schemes coming into operation and ever increasing quantities of treated water being produced and distributed, the amounts of subsidies increased to the extent that the total amount required could no longer be made available by the Government.

The inevitable consequences were lack of funds for maintenance and operation followed by delivery interruptions and lengthy system breakdowns. This, together with the worsening of the economic situation, forced the Government to re-think its cost recovery policy.

The national programme under the International Water Supply and Sanitation Decade devoted lengthy passages to the cost recovery problem.

The programme stated <1> that "cost-recovery should be an essential feature of the Water Supply and Sanitation programmes", and proposals were made for the service standards to be achieved by the various types of water supply projects. The following principles for the application of a system for the recovery of the cost of the schemes were suggested:

- For rural water supply projects, the Government would underwrite a maximum of 90 per cent of the capital costs; the communities concerned would have to contribute 10 per cent of the capital and all operation and maintenance costs.

- For minor urban centres, source development costs would be shared by the Government and the town councils concerned by 90 and 10 per cent, respectively; the town councils, in addition, would have to bear 90 per cent of the costs of the distribution system as well as all operation and maintenance costs; whereby costs attributed to the town councils would have to be recovered from the beneficiaries via appropriate water charges.

- Municipal Councils in the large urban centres would have to pay for up to 90% of the capital costs, and all the operation and maintenance costs; the recovery of costs to be through water charges from the consumers; although socialized pricing - in the form of cross-subsidies from better-off to low-income consumers - would be possible.

In order to facilitate the financing of capital costs of town and municipal councils, it was proposed that the Government should consider providing them with loans at easily affordable terms. Since the mid 1980's, this has proved impracticable, and even Donor provided soft loans have been onward lent at significantly higher interest rates, at least in theory.

The aspects of sharing the costs of services with those who benefit in general and with particular application in respect to water supplies was taken up in the 1982 report of the Ndegwa Commission, and in 1983, it was taken up in the context of the 1984/88 Development Plan and became an official policy.

<1> *For this and the following see Ministry of Water Development: Ten Year Plan for the Provision of Drinking Water Supply and Sanitation, Nairobi, 1981; pg 30-32*

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In practice, the goals were rarely achieved throughout the 1980's, although since the early 1990's, tariff increases instituted by some municipal authorities, often under donor pressure, and since 1994 by NWC & PC under World Bank pressure now make it practicable to achieve these goals in these areas.

The 7th Development Plan does not make specific reference to cost recovery. It does however state that the Government will encourage community and private sector participation so as to supplement Government resources and that appropriate water rates are to be applied to reflect actual consumption levels.

3.2.7 Problems and Constraints

Problems and constraints observed in the water supply sector relate to three levels:

i) bureaucratic procedures inside the Ministries involved and in the other Government agencies involved

ii) problems related specifically to the Ministry responsible for Water Development, such as shortages of experienced, qualified staff, and an organizational structure which combines resource management and allocation with planning, design & scheme operation, (however, see section 3.4). The advent of the NWC & PC, whilst providing a basis for improving the organisational structure for the water sector, has also had the negative impact of splitting the already limited experienced personnel.

iii) problems and constraints on the regional, local, and user level, including:

- limitations in the implementation capacity rather than in financing, ineffective use of available development funds, and considerable delayed schedules in the rural areas,

- the critical financial position of most of the town and municipal councils due to an inadequate revenue basis, and internal financial management short comings, including the use of water funds for other urban area functions,

- local, often politically caused, delays in allowing tariff increases to keep pace with requirements, such that the tariff levels have been insufficient to allow for more than a partial recovery of capital costs (urban schemes) and operation and maintenance costs (rural schemes),

- failure to deal with high levels of both physical and administrative losses in the supply of water, often as a result of lack of bulk water meters, and non-working consumer meters (urban areas), and lack of both bulk and consumer meters (rural schemes), and,

- problems with the administration of the utility in the fields of meter reading, billing, and revenue collection.

3.2.8 Water Supply at the District Level

Information on the supply of water in Nyeri District has been obtained from the District Water Office, and by reference to the current District Development Plan (1994/96).

There is a relatively better coverage in the higher potential areas of Mukurweini, Tetu, Othaya, Mathira, and Municipality than in the medium potential areas of Kieni East and Kieni West. In part this is as a result of the relatively recent settlement in Kieni and the relative scarcity of water resources.

Within the Municipal Division, the principal water supplies are those of Nyeri urban and Kiganjo, both under the Municipal Council. However parts of the Municipality are supplied by rural and institutional water supplies, the former under the auspices of the Ministry responsible for Water and the National Water Conservation and Pipeline Corporation. The Nyeri Municipal water supplies are dealt with in detail in chapter 7.

Mukurweini Division is covered by Mukurweini rural water supply. Built in the 1970's, it was designed to cover the whole Division, but the supply only adequately benefits about 50% of the division's population as a result of high and unmetered per capita consumption in the upper zones. Without metering, especially in rural areas, unrestrained use of water for agricultural purposes can be expected. With metering and minor extensions, the supply could probably reach 80% of the population at current production rates.

Othaya Division is covered largely by the Othaya and partly by the Mukurweini rural water supplies. Othaya water supply was also constructed in the late 1970's, and currently benefits approximately 60% of the division's population. Also designed to cover the whole division, lack of metering and high per capita consumption in the upper areas limits that reaching the lower ones.

Tetu Division is covered by the Aguthi, Zaina and Tetu/Thegenge rural water supplies, together with two partly operational self help schemes in the western parts of the division. Aguthi water supply covers the whole of Aguthi Location and a small part of Thegenge Location, and operates for the most part with minimal problems, except for water shortages at the distribution system extremities. That water supply is largely metered, and operated by NWCPC. Tetu/Thegenge and Zaina water supply cover the rest of the Division and are unable to meet demand, being both old and in urgent need of rehabilitation and without consumer metering. As a result, communities in Muhoyas Location have started the Muhoyas and Kinaini self help water supply schemes to supplement the Zaina scheme.

In Mathira Division, Karatina Urban Water Supply serves Karatina town reasonably well and with an acceptable level of operation. The rest of the division is covered by the Mathira rural water supply, and some partly completed self help schemes. Demand within the Mathira scheme area is well in excess of supply, whilst the north and north eastern parts of the scheme distribution system have never been constructed.

In Kieni East Division, the County Council operated Naromoru Water Supply serves Naromoru Town. Both current source and capacity fail to meet demand. The rest of the

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Division is covered by at least seven self help water supply schemes in various stages of construction.

In Kieni West Division, the County Council operates Mweiga Town Water Supply. The rest of the Division has a number of self help water supply schemes, several of which are in various stages of construction. Groundwater and water conservation structures will remain the major water sources in this Division. A large number of some 33 reasonably yielding boreholes in this division are currently abandoned since the large scale settlers were replaced by small scale settlements after sub-division.

3.3. The Legal Basis of the Kenyan Water Sector

3.3.1 General

The three major national acts in the context of the present study are the Water Act, the Local Government Act, and the Public Health Act. Other relevant national legislation comprises - amongst others - the Town Planning Act, the Building Code, the Housing Act etc.

Regulations issued under Nyeri Municipal Council authority comprise various by-laws, standing orders, and financial regulations.

The most important aspects of the above mentioned legal base governing the water and sanitation activities of a municipality such as NMC are briefly described in the following paragraphs.

3.3.2 The Water Act

(a) General

The Water Act, 1972, consisting of 12 parts with a total of 183 sections, together with the related subsidiary legislation, regulates the national water sector as concerns the conservation, control, apportionment, and use of water resources.

(b) General Provisions of the Water Act as Related to Local Authorities

Section 4 provides that the control of and right to use any body of water is exercised by the Minister responsible for Water Development in accordance with the Act (currently the Minister for Land Reclamation, Regional and Water Development); and section 10 empowers the Minister to levy rates and charges on those benefiting from any works undertaken on his initiative.

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c) Provisions of the Water Act as Related to the Water Supplies of Local Authorities

By force of section 124 <1>, the relevant sections of the Water Act <2> apply to local authorities that are appointed <3> water undertakers.

Part XV (sections 124 to 152) regulate the appointment, duties, and responsibilities of water undertakings.

Section 142 empowers a water undertaker to prohibit or restrict, under certain circumstances, the use of water.

Section 143(3A) empowers a local authority water undertaking - either by approval from or on request of the Minister responsible for Water Development - to make by-laws providing for tariffs and the management of the supply and for the prevention of waste and pollution of the supply in accordance with the relevant sections (201 to 211) of the Local Government Act.

Section 143(4) confirms the right of the water undertaker to cut off a person's individual water supply under certain circumstances. Section 146(1) compels the water undertaker to enforce the established (water) by-laws, and in case of his default to do so, provides the Minister responsible for Water Development with the power to exercise his default powers as described in section 147.

Rule 71 of the Water (General) Rule (3) makes water supply undertakings subject to the provisions of the Public Health and Malarial Prevention Acts.

The Water (Undertakers) Rules (3) constitute a water works code and regulate, amongst others:

- the appointment of water undertakers (rules 3 to 5)
- works, lands etc. of water undertakers (rules 6 to 14)
- the supply of water for domestic and public purposes (rules 15 to 24)
- the laying of services and communication pipes (rules 25 to 29)
- details in respect to waste prevention, meters and other fittings (rules 35 to 56) which include Provisions related to:
    - illegally operated private water kiosks
    - the fraudulent manipulation of meters
    - illegal water connections.

Rules 30 to 34 deal with charges for water:

<1> *which is done exclusively by the Minister responsible for Water Development.*
<2> *And its subsidiary (relevant) legislation.*
<3> *Established under section 182 of the Water Act*

- Rule 30 provides for water supply (and other charges) not exceeding those embodied in the regulations of the water undertaker and, under certain circumstances, give the Minister responsible for Water Development the power to alter or substitute the charges or method of charge.

- Rule 31 allows discounts or rebates to be made in consideration of the prompt payment of water charges, provided the rebates/discounts are uniformly applied.

- Rule 32 provides that where water supplies are metered, the register of the meter is the prima facie evidence of the quantity of water consumed; furthermore, it regulates details in respect to meter testing.

- Rule 33 confirms the right of the water undertaker to cut off the water supply to the premises of customers under certain circumstances and to restore the water supply only after payment of the moneys due.

Subsequent rules amongst others, deal with:

- illegal private water kiosks (rule 39(1))
- the illegal abstraction of water (rule 39(2))
- the fraudulent altering of the index of a water meter (rule 40(1))
- the illegal alteration of existing water distribution installations (rule 42(1))
- the illegal connection or disconnection of water meters (rule 43(1))

- the vesting of the property of water meters and connected fittings with the water undertaker (rule 44(4))

- the circumstance under which a water undertaker has the right to discontinue the supply of water to any consumer (rule 66).

(d) Provision of the Water Act as Related to the Sanitary Activities of Local Authorities

All regulations of the Water Act affecting the sanitary activities of local authorities contain provisions for the prevention of pollution of water sources and water supplies. Such provisions are to be found in sections 143(3A), 158, and 160(2b), and in rules 72 to 81 of the Water (General) Rules.

3.3.3 The Local Government Act

(a) Outline of Contents

The Local Government Act, 1986, consists of 21 parts with a total of 271 sections, four active schedules, and two sets of rules established under sections 53 and 72, and 151 respectively, of the Act <1>.

The main areas of concern are aptly described by the headings of the various parts thereof:

- parts I to IV deal with preliminaries, local government areas and their constitution, local government elections and membership, respectively
- parts V to VII regulate meetings and proceedings, committees, and joint boards, respectively
- part VIII is concerned with the appointment, qualifications, tenure of office, status and duties, and the accountability of the major officers of local authorities
- parts IX to XIII refer to the powers, duties and provisions of local authorities
- part XIV deals with by-laws of local authorities
- parts XV to XVIII are concerned with financial provisions, loans, account and audit, and reports and inquiries of local authorities
- part XIX regulates the power of the Minister of Local Government on default of local authorities
- parts XX and XXI contain regulations in respect of legal proceedings and miscellaneous items, respectively.

In their turn, the four active schedules to the Local Government Act cover:

- model declarations of office and of councillors
- standing orders of local authorities
- statutes, powers, duties and responsibilities of the town clerk, and chief financial officer of local authorities
- local authorities elections.

An overall assessment of local government in Kenya and a review of the Local Government Act as relates to the provision of water supply and sanitation services of municipalities, is presented in the following section:

(b) Overall Assessment of Local Government in Kenya

Seen historically, local government in Kenya is a pre-independence legacy; the actually existing Kenyan local government legislation can be interpreted as a series of updated

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<1> *The rules are concerned with local government elections are not considered further here*

versions of the regulations and principles dominating the then - slightly modified - British local government system that was in force in Kenya prior to independence <2>.

Local authorities <3> are established as corporate bodies, i.e. they are legal entities subject to the civil procedure code; their powers, duties and responsibilities are devolved to them by an act of parliament. They are responsible for the provision of a large variety of community services which target the improvement of the social and economic welfare of their inhabitants.

In order to discharge their functions, local authorities are empowered to spend funds and to raise funds to cover the expenditure incurred.

Other salient features of the local government system in Kenya are:

- In accordance with the British perception of the nature of local government <3>, local authorities in Kenya generally are thought to be allowed to become active only in those fields where the law explicitly states they might intervene, i.e local authorities are subject to the doctrine of ultra vires <4>. Accordingly, the Local Government Act is seen as leaving no room for the interpretation that unless there is a formal legal prohibition to do so - local authorities might engage in any field of activity they choose.

- Since independence at least, local government in Kenya has been somewhat neglected, a fact which gains even more importance when taking into consideration that the central government system in Kenya remains largely centralized <1>.

- Even though the central government over the years has taken over a certain number of functions that previously were fulfilled by the local authorities, the position of these authorities has deteriorated continuously. On the one side, the areas and hence numbers of people they are responsible for have increased resulting in an ever increasing demand for services to be provided thereby stretching their financial resources. On the other side, the financial basis of the local authorities has been eroded both by including non revenue generating rural areas under their jurisdiction, and by various central government decisions <2>.

<2> For support of this opinion see e.g. Ministry of Local Government/Kenya Institute of Administration: Report on Training Needs in Local Government Section in Kenya, Nairobi, 1984; p:5

<3> The notions "local authority" and "Municipality" in the following are used synonymously as the only legal aspects considered are those relating to municipalities.

<1> The introduction of the District Focus for Rural Development policy in 1984 has not yet resulted in effective decentralization of central government authority.

<2> Such as e.g. the abolition of the Graduated Personal Tax which was one of the most important sources of income to local authorities.

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The general tenor of the Local Government Act <3> is such that the underlying concern is easily detectable: the devolution of authority to local authorities, together with the fact that local authorities are accountable for the handling of public funds, requires that local authorities are subjected to tight controls - in the first instance by central government, especially by the Ministry of Local Government and secondly, and indirectly, by parliament - as far as the execution and especially the raising, administration, and disbursement of funds are concerned.

Even though the Local Government Act provides for a large number of areas where the co-operation between local authorities and the Ministry of Local Government is regulated in meticulous detail <4>, both partners, in practice, have very often not complied with the relevant requirements. Therefore, it can be said that there actually exists a certain laxity in respect to and lack of enforcement of the Act, respectively. Some experts on local government in Kenya have even gone so far as noting "a general breakdown in communication between the local authorities and the Ministry of Local Government officers in terms of attitude and in the implementation of ministerial directives and circulars" <1>.

Taking into consideration the above-mentioned aspects, one gains the definite impression that the provisions of the Local Government Act are in principle sound but require certain amendments and updating, and that the major problems facing the local government system in Kenya are the inadequacy of the revenue basis of the local authorities and a certain lack of enforcement of the existing legal provisions.

(c) Provisions of the Local Government Act as Related to the Functions of Local Authorities.

The Local Government Act contains over 160 powers, duties, and responsibilities that are assigned to local authorities. Out of this multitude of functions, only four - namely primary education, public health, roads and the burial of destitute persons - are mandatory <2>. The other, permissive, functions rank so high in importance that the Act empowers the Minister for Local Government to direct any local authority at any time to perform many of these functions, thus making it mandatory for the local authority.

<3> In fact, this is not only a feature of the Local Government Act but equally is of predominant importance to both the Water and Public Health Acts and other national legislation which contain provisions affecting the operation of local authorities. To do justice to the Kenya system, it has to be noted that such tight control by central government in respect to local authorities is common to most developing - and developed- countries where part of the central government authority is devolved to lower level administrative agencies.

<4> This is especially so in provisions relating to financial control, reporting and matters of approval

<1> MoLG/KIA: Report on Training Needs in Local Government Sector in Kenya, Nairobi, 1984; pg 56

<2> Other mandatory functions are assigned to local authorities under the Water and Public Health Act etc.

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(d) Provisions of the Local Government Act as Relates to the Supply of Water

Sections 178 to 180 of the Act relate to the provision of water supplies by Municipalities.

Section 178 provides that:

- within its own area, or with the consent of any other local authority within the area of that local authority, a municipal council may undertake the supply of water and establish, acquire and maintain works for this purpose

- a municipal council may make by-laws in respect to its water undertaking to the extent to which a water undertaker may make regulations under the Water Act

- a local authority is empowered to refuse the supply of water to a person's premises if this person has not cleared all charges previously raised in connection with the supply of water; this relates both to new and existing connections. Where a connection was cut off, this provision also extends to include the payment of a reconnection fee

- any officer appointed hereto, under certain circumstances, may enter premises or land in order to install or inspect water pipes, meters or other fittings and works connected with the supply of water or to ascertain the quality and quantity of water supplied or consumed.

According to section 179, a local authority may, under certain circumstances and subject to the Water Act, undertake certain works and actions on and related to streams or watercourses.

A local authority has the power to enforce the provision of a proper and sufficient water supply for any dwelling-house, school, shop, factory or workshop, or the local authority considers that the provision of such supply is necessary, practicable and reasonable (section 180).

Another section relevant to the supply of water is Section 148(b) which provides that a local authority may "... impose fees or charges for any service or facility provided or goods or documents supplied by the local authority or any of its officers in purchase of or in connection with the discharge of any duty or power of the local authority or otherwise"; any fees or charges imposed have to be regulated either by by-laws or a resolution of the authority supported by consent of the Minister of Local Government.

This provision of course, applies not only to water supplies but equally to all types of sanitary services etc.

Prior to the 1986 Act there was a Section 272 which contained the provision that nothing in the Local Government Act shall be deemed to over-ride the provisions of the Public Health Act. In the present context, this saving of the Public Health Act meant that its provisions relating to water supply, sanitation etc. had to be complied with in full by local authorities who provided these services. This section has been deleted entirely from the 1986 Act, although unlike other repealed sections, this deletion is not acknowledged in the index.

(e) Provisions of the Local Government Act as Related to Sanitation

Section 160(a) provides that every municipality is empowered "to establish and maintain sanitary services for the removal and destruction of, or otherwise dealing with, all kinds of refuse and effluent and, where any such service is established, to compel the use of such service by persons to whom the service is available".

Sections 168 to 176 deal with sewerage and drainage in municipalities.

Section 168 provides that any municipality may establish and maintain sewerage and drainage works within or outside of its area of jurisdiction.

The following three sections empower a municipality:

- to carry out sewerage and drainage works (section 169)

- to have a right of access to private property to inspect, maintain etc. any such sewerage and/or drainage works that are vested in such authority (section 170)

- to establish and maintain sewage farms and sewage disposal works (section 171).

Section 172 regulates the details of giving notice by a municipality in case it intends to start sewerage works outside its area of jurisdiction; and section 173 contains a provision for the protection of sewers and drains.

Section 174 provides that charges fixed by a municipality for the use of its drains, sewers or sewerage works are deemed to be charges for sanitary services and that they are recoverable from the owner of the land or premises connected with drains, sewers or sewerage or sewerage works vested in the authority in accordance with section 264 of the act.

Sections 175 and 176 contain regulations in respect to charges for the installation and use of sewers and drains. Section 175 regulates, among others, the recovery of costs incurred by the authority in connection with the carrying out of drainage or sewerage works; the whole or part of the capital cost for such works can be recovered from the owners of such land and premises. The costs may either be recovered over a number of years by way of a special rate or they may be apportioned between the owners who then have to pay them either in one lump sum or by installment.

Section 176 provides for such diverse items as the power of local authorities

- "to compel, at the cost of the owner both or either the construction of private drains, and the connection of private drains to public drains, sewers or pipes"

- to regulate, at the cost of the owner, the construction of house drains from the main sewer to the boundary of the property concerned.

- to fix the use of the authority's drains sewers, and sewerage works

- to require the licensing of plumbers and drain- layers.

Section 264 specifies the general provisions of sections 148(b) and 174 in so far as it stipulates that all " charges due for sewerage, sanitary and refuse removal shall be recoverable jointly and severally from the owner and occupier of the premises in respect to which the services were rendered". Section 264, furthermore, regulates in detail the legal positions and rights of the authority, the owners and occupiers of such premises in so far as the recovery of the imposed charges is concerned.

3.3.4 The Public Health Act

(a) General

The Public Health Act consisting of 15 parts with a total of 169 sections, together with its subsidiary legalisation, contains provisions for the securing and maintaining of public (and private) health.

(b) Provisions of the Public Health Act as Related to Local Authorities in General

The Public Health Act imposes on local authorities mandatory duties in connection with a wide variety of health aspects. Those of the duties related to water supply and sanitation are considered in the following.

Section 2 of the Act defines the municipal council of a municipality as the health authority in relation to the area of jurisdiction of that municipality.

Through section 10(2), the Medical Department of the Ministry of Health is assigned the duty of giving advice and directing local authority in regards to matters affecting public health.

Section 13 imposes on every health authority the duty "to take all lawful, necessary and,... reasonably practicable measures for preventing the occurrence or dealing with any outbreak or prevalence of any infectious, communicable or preventable disease, to safeguard and promote the public health and to exercise the powers and to perform the duties in respect to the public health conferred or imposed on it by this Act or by any other law".

The link between certain types of diseases and water supply and sewage having been established beyond reasonable doubt, the statutory interests and duty of every local authority in water supply (and pollution control) and sanitation measures can easily be construed.

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Section 14 describes some of the defaulting powers of the Minister for Health, and section 15 provides that the Minister for Health has to agree to any by-law made by a municipal council affecting public health before it is approved by the Minister for Local Government.

(c) Provisions of the Public Health Act as Related to Water Supplies

Sections 129 and 130 contain regulations in respect to the protection and the prevention of pollution dangerous to public water supplies; these provisions make water pollution control a mandatory function of every local authority and provide protection for both water used for public purposes as well as to traditional sources.

The provisions of part XII - The Prevention and Destruction of Mosquitoes - have a bearing on water supply as well as on sanitation in so far as mosquito control measures are not inconsistent with good water supply, pollution prevention and sanitation practices.

(d) Provisions of the Public Health Act as Related to Sanitation

The Act and its subsidiary legislation contain numerous provisions related to sanitary activities of local authorities.

The general regulations of part IX of the Act

- define the nature of nuisances (section 118)

- prohibit the causing, suffering or existence of nuisances (section 115) - oblige local authorities to maintain clean and sanitary conditions and to prevent nuisances within their area of jurisdiction (section 116)

- outline the powers, duties, and responsibilities of the medical officer of health (section 119) - empower the Minister for Health to impose duties - in connection with the carrying out and enforcement thereof - on local authorities in respect to:

    - the drainage of land, streets or premises
    - the disposal of offensive liquids
    - the removal and disposal of rubbish, refuse, manure, and waste matters
    - the standards of purity of liquids discharged as effluent after treatment from purification works (section 126)

- empower and require <1>, respectively, local authorities to make by-law - that have to be agreed to by the Minister for Health before approval is given by the Minister for Local Government - in respect to works and fittings for regulating certain components of human water supplies in connection with buildings, private sewers and communications between drains and sewers (section 126A).

<1> On initiative of the Minister for Local Government.

The Public Health (Drainage and Latrine) Rules, established under section 126 of the Act and comprising 100 rules and two schedules, form a detailed code of sewerage (and latrine) works.

3.3.5 Water Sector Legislation and Local Authorities - Conclusions

The outlines in the previous paragraphs give a clear although incomplete picture of the complexity of the legislation affecting local authorities in the fields of water supply and sanitation.

The salient features of and major conclusions to be drawn from the presently existing legal framework governing the provision of water supply and sanitation services by local authorities can be summarized as follows:

- There are not less than three central government ministries - Local Government, Water Development, and Health - that intervene in the provision of these services; this multiplicity of authorities involved is accompanied by an even greater multitude of acts and other statutory and permissive instruments regulating the relevant activities of local authorities.

- Overlapping legal provisions contained in the various acts - to a certain extent - result in duplication of functions and efforts of the ministries involved and tend to veil basic responsibilities.

- Other areas and aspects connected to the provision of these services are dealt with in yet other acts or statutory instruments or are not dealt with (satisfactorily) at all.

- Even though the basic provisions of all of these acts seem to be fundamentally sound and adequate, the actual performance of local authorities, as far as the provision of these services is concerned, leaves much to be desired which is, not least, due to the fact that all the ministries involved encounter certain difficulties in discharging their regulatory and control functions as is expressed by a rather poor degree of enforcement of the relevant legal provisions.

3.3.6 Other Relevant National Legislation

As already mentioned, other national laws relevant to the provision of water supply and sanitation services by local authorities comprise the Town Planning Act, the Housing Act, and the Building Code. Their influence is however minor in comparison to the three main Acts described above.

3.3.7 Ministerial Memoranda and Circulars

Apart from regulations and directives, the Ministers responsible for Local Government, Water Development, and Health issue a more or less continuous stream of memoranda and circulars to local authorities which - directly or indirectly - bind the local authorities in the fulfillment of their functions. These memoranda and circulars are to fill in any gaps that might have been left by the more general intended provisions of the acts and other regulations. In general, they are very specific and detailed.

3.4 New National Water Policy

In August 1994, a draft National Water Policy Document was issued by the Ministry of Land Reclamation, Regional & Water Development.

The Policy Paper is not yet in the public domain, but is expected to change the role of the Ministry in the water sector by removing from the Water Development Department the role of water undertaker. In this respect, it is expected to promote decentralisation but will at the same time strengthen the position of that Department as the agency for the measurement, control, regulation, coordination and allocation of Kenya's water resources.

It will recognise that water is an economic good that must be paid for by the users. This then requires that water undertakers must be allowed a more regular review and adjustment in tariffs than has been the case in the past.

To pay for the various water resource oriented activities, the Water Development Department will be allowed to charge for water abstraction and for effluent return to watercourses, as well as for other services it is intended it should provide decentrally in such fields as water leakage and meter repair.

Whether or not this draft will be adopted remains to be seen, however the overall objectives can be considered a step in an appropriate direction.

3.5 Task Force on Local Government Reform

By a special issue of the Kenya Gazette dated 26th May, 1995, the President of Kenya appointed a Commission of Enquiry to enquire into "the future structure, powers, legal framework, functions, financing and staffing of local authorities at all levels country wide". The establishment of the commission was in two notices in that issue.

Gazette Notice No. 2939 appointed the Commission. It is comprised of 8 members, chaired by Mr. William O. Omamo, and two secretaries to the Commission. One of the members is a Kenyan water and sanitation consulting engineer, Mr. H.S. Mangat. This Notice required the commission to "report back within a period of three months" which would be by the end of August 1995.

Gazette Notice No. 2940 then gave the terms of reference which are as follows:

a) to enquire into the future structure, powers, legal framework, functions, financing and staffing of local authorities at all levels country wide;

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b) look into the elevation of Mombasa, Kisumu, Nakuru, and Eldoret to city status;

c) consider the division of Nairobi City Council and the above cities into boroughs;

d) to recommend a system that will significantly increase active local community participation in the designing and implementation of development plans;

e) examine local authority licences and regulations that inhibit development;

f) look into unacceptable practices such as nepotism, misallocation of plots and deliberate disregard of planning regulations;

g) to enquire generally or in particular into any other matter pertaining to the foregoing.

This notice also added a rider to the required reporting period, making it 3 months "or such further period as may be determined".

The aspects of the terms of reference which have attracted the most public attention are (b) and (c), whereas quite clearly the most significant are the aspects under paragraph (a). The "Omamo Commission" has the potential of leading to far reaching improvements in the local government system if these critical issues are given sufficient consideration, and if the resulting recommendations are then implemented.

At present (July, 1995) the Commission is visiting various local authorities and receiving their views on the matters under consideration.

4. RAW WATER SOURCES

4.1 Introduction

Groundwater has not been considered as a suitable Municipal water source, given the level of water demand for a such a water supply and the very limited groundwater potential indicated by the National Master Water Plan for the area.

In the relevant drainage basin, reference 4A, which includes Nyeri and the surrounding areas where volcanic bedrock predominates, mean borehole depth was 122 m with mean rest levels of 53 m. With a mean drawdown of 42 m, initial yield averaged 97 l/mm and specific capacity 4 l/min-m.

This suggests that for current water demand levels within Nyeri town, the order of 100 successful boreholes would be required. This alternative is therefore considered to be unviable.

Attention has therefore focussed on the river systems currently exploited, namely the Chania River and the Nairobi River and on the river system between them, that of the Amboni River. All these rivers are tributaries of the Tana River which flows east and southwards into the Indian Ocean.

For details of the surface water hydrology of these rivers, reference should be made to Annex 4. Water quality is dealt with in this chapter, and Annex 6.

4.2. Surface Water Hydrology

4.2.1. Introduction

Three river catchments were considered, namely those of the Chania River, the Amboni River and the Nairobi River. These are shown on map 4.1. Measurements were made of flows on all these rivers to help confirm calibration of existing rating sections. It was further confirmed that the dry weather flow of the Nairobi river at Kiganjo is effectively zero and that this river without regulation is unsuitable for an urban water source.

The hydrology of the principal river systems were established in terms of expectations of run-off, rainfall and evaporation.

4.2.2. Chania River Catchment

The Chania River catchment has been confirmed as an excellent water source for Nyeri with the major part of the catchment above the existing intake comprising undisturbed forest and bamboo. Sediment loads are low to very low, and likely to remain so providing the catchment cover is not changed.

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The catchment area to the Ihwa raw water gravity intake is 179 km^2 with an estimated mean annual run-off of 644 mm, equivalent to an average flow of 3.7 m^3/sec.

Previous estimates of minimum daily flow at Ihwa <1> of 740 l/sec for a 50 year return period were based on records for the period 1960-1980. The 1960's were an unusually wet period and a revised 98% reliable daily flow of 319 l/sec. is now recommended for design purposes. On a monthly basis, this figure becomes 420 l/sec. At the Nyeri Sewage Works outfall, a 98% reliable daily flow of 319 l/s, less abstraction at the Ihwa and chania intakes, has been estimated.

Should it be found necessary to firm up the daily minimum to a monthly minimum level at Ihwa, a relatively small live storage in the vicinity of the intake of about 250,000 m^3 would be required. Subject to confirmatory detailed survey, such a storage could probably be achieved by constructing a concrete weir (small dam) at the Ihwa Intake site itself. The Council has had the foresight to procure the land that would be inundated.

A 100-year return period maximum daily discharge flood at this site of 39 m^3/sec. has been estimated. The absolute peak from the catchment in its present land use is unlikely to exceed 50 m^3/sec.

Storage/yield characteristics of the Chania River have also been briefly considered based on the data for the period 1982-1994. This suggests that a yield of the order of 1,000 l/sec. would become possible with a live storage in the vicinity of the intake of about 1,150,000 m^3.

It is unlikely that a suitable reservoir site for this could be found at economic cost given the relatively steep gradient of the river. More suitable sites appear to exist upstream of the Chania Falls, within the Abedares National Park. Given the lower mean annual runoff of the order of 400 mm/year in this area it would require appreciably larger storage for similar levels of direct abstraction to be achieved. However, and in terms of firming up dry weather flow for abstraction downstream, such a reservoir site could prove to be economically attractive. Beyond the scope of this present study, it nevertheless needs to be borne in mind for a post 2010 project.

4.2.3 Nairobi River

The Nairobi River is the present source for the Kiganjo Water Supply, however it suffers from excessive upstream abstraction, and therefore often has close to nil flows during dry seasons. The river rises below the snow line on Mt. Kenya and has a long narrow catchment, within which the main vegetation in the significant water yielding higher areas is rain forest and bamboo. Only about 10% of the catchment is forested however, the remainder being largely rangeland with some cultivation. Irrigation in these rangelands is the principal purpose of upstream abstraction.

<1> Gibb & Partners Report, 1980
(Nyeri Water Supply, Preliminary Design Report)

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There is an abandoned gauge on the Nairobi River (RGS 4AA4), where the river has underscored the measuring weir. In the circumstance of almost complete depletion of flow in the dry season by abstraction, much of it unregulated or unauthorised, and therefore of unknown quantities, no meaningful low flow simulation could be done.

4.2.4 Amboni River

The Amboni River at RGS 4AB5 in the vicinity of Kiganjo has a catchment area of about 420 km^2, with an estimated mean annual run-off of 123 mm, equivalent to an average flow of 1.6 m^3/sec. A 50 year monthly minimum flow of about 120 l/sec. is estimated, based on data over the period 1982-1994.

Quantitatively therefore, the Amboni River would be a preferable water source for the Kiganjo area rather than the Nairobi River. However, the catchment has not more than 10% forest cover, the balance being predominantly a mixture of rangeland and cultivation. Qualitatively, it will not be as good a source as the Chania River.

4.3. Raw Water Quality

4.3.1 Amboni River

From the chemical analysis carried out on a sample taken on 12th May, 1995, at the University of Nairobi Public Health Engineering laboratory, the Amboni river raw water can generally be classified as soft, acidic water of low natural and moderate turbidity (36 FTU).

The water has a pH of about neutral and natural alkalinity of 28 mg/l as $CaCo_3$ which with no adjustments may tend to be corrosive.

The bacteriological analysis showed moderate faecal contamination, with a coliform count of 2200/100 ml and E. Coli count of 320/100 ml.

Going by these results the Amboni waters after subjecting it to conventional treatment involving coagulation-flocculation, sedimentation, filtration and disinfection is expected to produce potable water that meets or exceeds the quality specified by WHO (or MOWD).

However it should be noted that if alum or ferric salts are to be used for coagulation, soda ash or lime feed to boost the natural alkalinity in the water prior to coagulation is necessary. This in addition to improving the efficiency of the coagulation process mitigate against a low pH for the final treated water.

4.3.2. Chania Intake

The Chania intake raw water can be described as soft water of low alkalinity (20-36 mg/l as $CaCO_3$), low turbidities and moderate faecal contamination.

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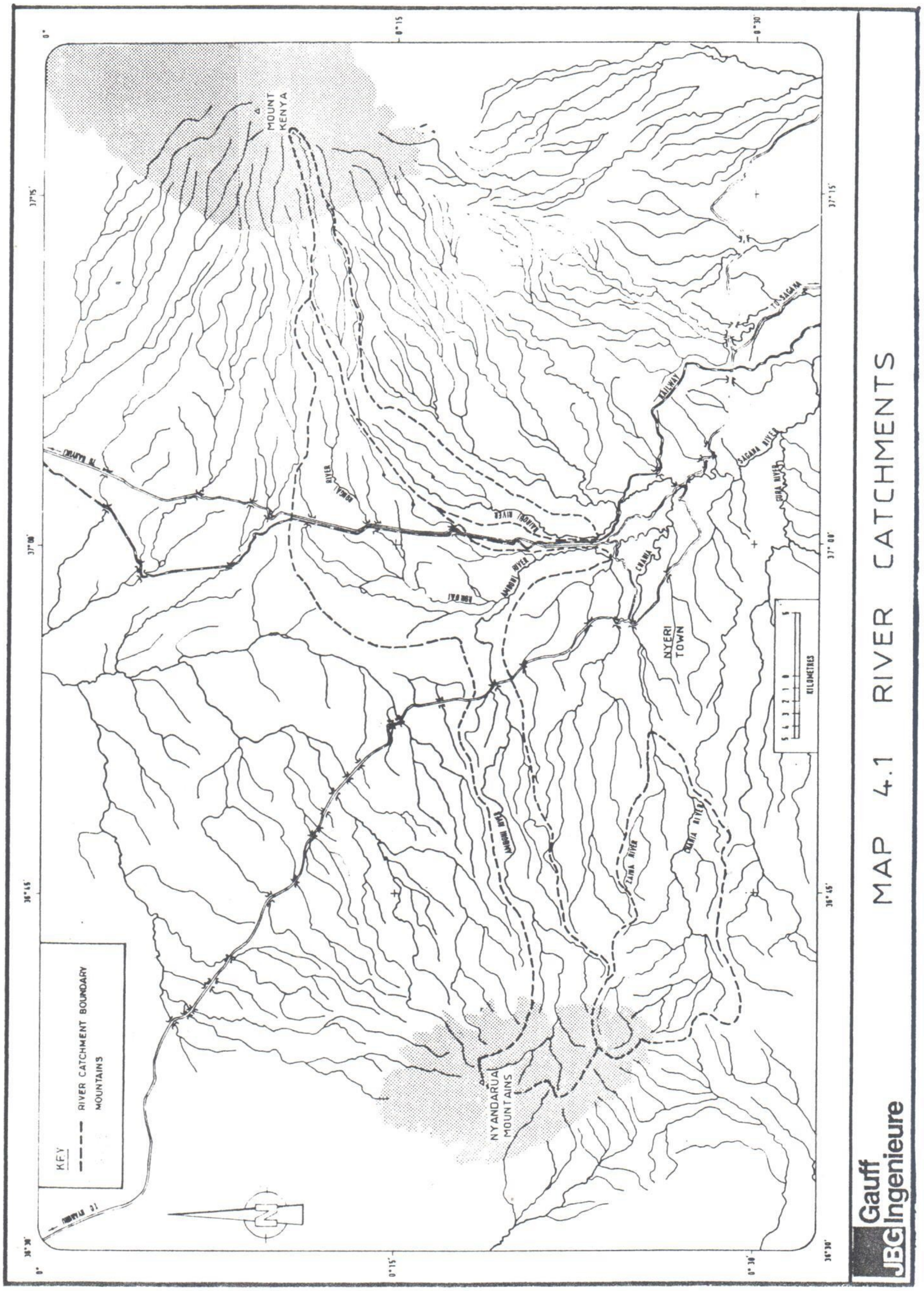

MAP 4.1 RIVER CATCHMENTS

The pH values found to be 7.41 and 7.87 are favourable and would be expected to remain within acceptable levels even after alum addition. However, soda ash or lime addition would be necessary so as to overcome the low natural alkalinity and render the water non-corrosive.

The results from a sample of 7th February, 1995 are of a typical dry spell whilst those of 12th May, 1995 are of a rainy season. It appears that there are no striking quality differences between the two samples. Higher pH values were obtained during the rainy season, accompanied by lower alkalinity values. This may not be explicitly explained but may be an attribute of the characteristic of the catchment area. Faecal pollution as expected is higher during the rainy season.

It will nevertheless be investigated further during the next stage of this Study, and in particular the possibility for gravitating raw water to the Kiganjo Water Treatment Works.

All in all, considering the results of these tests the Chania intake offers an attractive raw water source, which after being subjecting to conventional treatment would produce potable water of acceptable standards.

4.3.3. Ihwa Intake Raw Water

Ihwa water is moderately soft, with low turbidity values, variable alkalinity and moderate faecal contamination.

The results of a sample taken on 12th May 1995 are typical of a rainy season whilst those of 7th February were sampled during a dry season. The results of 7th February shows that with the low turbidity and colour values of 1.9 FTU and <5 Hazens respectively, the raw water could possibly be acceptable for supply to consumers after disinfection only. The results of 17th May, 1995 show a possibility of obtaining water of acceptable standards after only filtration and disinfection. So far Ihwa intake seems to offer the most attractive source of raw water, which would be economical and easy to treat.

The only marked difference between the water quality of the wet season sample and the dry period sample is the observed alkalinity values of 82 mg/l and 17 mg/l $CaCO_3$ respectively. The higher alkalinity observed during the wet season could probably be attributed to the dissolution of minerals by storm water run-off flows. The results further suggest rather strongly that addition of soda ash or lime to boost the natural alkalinity and thereby prevent corrosion, would be necessary only during dry spells.

4.3.4. Kiganjo Intake

Kiganjo intake raw water can generally be classified as soft water of low to moderate alkalinity and moderate faecal contamination.

For the tests carried out on 7th February, 1995 (dry period) and 12th May, 1995 (wet season) the raw water pH was observed to be 8.49 and 7.85 respectively. Alkalinity was

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observed to be as low as 18 mg/l as C_aCO_3 during the dry season. This shows that soda ash addition would be necessary at such times to boost the natural alkalinity.

In comparison to the other sources, the Kiganjo intake raw water characteristics, despite having a different origin from the others considered above, does not seem to have any major deviation, except for a higher iron content (0.4 mg/l) and it's being coloured.

Going by these results, Kiganjo water after subjecting it to conventional water treatment involving coagulation-flocculation, sedimentation, filtration, disinfection and alkalinity correction would be expected to produce potable water of acceptable standards.

5. AERIAL PHOTOGRAPHY, SURVEYS & MAPPING

5.1 Existing Aerial Photography

Controlled aerial photography from 1975 at 1:20,000 and from 1978 at 1:25,000 exists for all but the present north eastern corner and southern part of the Municipality. The flight diagrams for this photography are shown in Fig. 5.1.

Uncontrolled aerial photography from 1991 at a scale of 1:25,000 exists for almost the whole of the Nyeri Municipal area and the Chania River catchment to the west.

A small strip within and close to the western edge of the municipality is not covered as can be seen from the coverage diagram produced as Figure 5.2.

A set of blank and white contact prints of this photography comprising 151 frames was acquired for project planning purposes.

5.2 Mapping

The Municipal area and its surroundings are covered by published mapping at scales of 1:250,000 and 1:50,000.

Approximately 120 km^2 of the 208 km^2 Municipal area was mapped at a scale of 1:5,000 with a 3 m. contour VI during the period 1979-81 based on the 1975 and 1978 aerial photographs.

The mapping was produced as pencilled machine plots only and never formalised onto regular map sheets nor published. The twenty sheets of machine plots were retrieved from Survey of Kenya archives and sepia copies obtained. The location, extent, and sheet reference no's in relation to the Municipal boundary are illustrated on Figure 5.3.

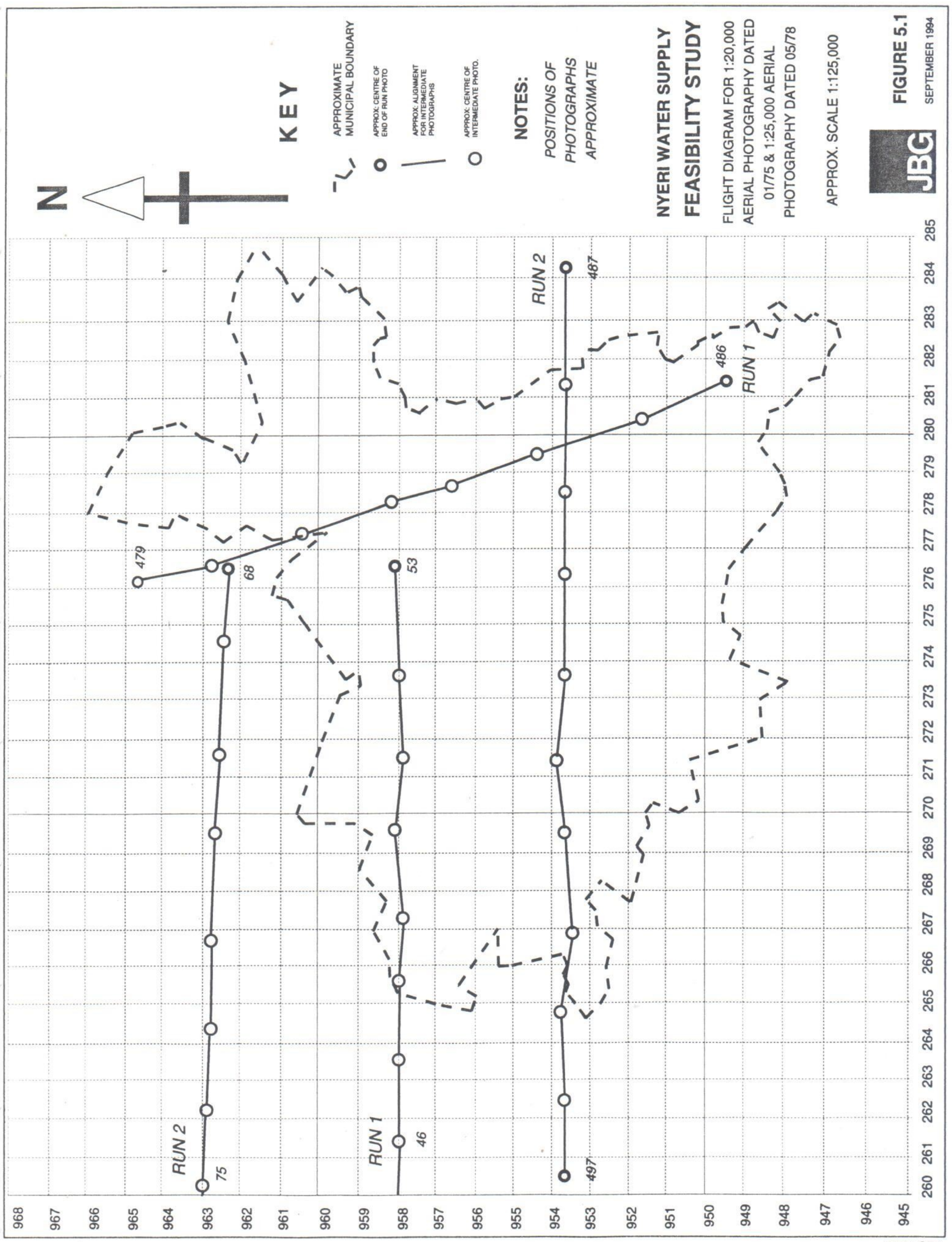
In anticipation of eventual mapping of the entire Municipality at a scale of 1:5,000, a map layout grid was superimposed on the Municipal Area and adjusted to minimise the total no of map sheets. Each sheet would cover an area of 3.25 km by 2.50 km or 8.125 km^2. This proposed map arrangement has been superimposed on the Municipal boundary map together with the outline of the 1:5,000 machine plot coverage as figure 5.4.

Present requirements centre on the Nyeri Urban area and its water and sewerage system and the Kiganjo urban/peri-urban area and its water and sewerage systems.

The extent of mapping that would cover these two areas and the rural area in between is shown on Figure 5.5 in relation to Municipal boundary and 1:5,000 machine plots.

This then involves four complete map sheets and eight part sheets.

Page



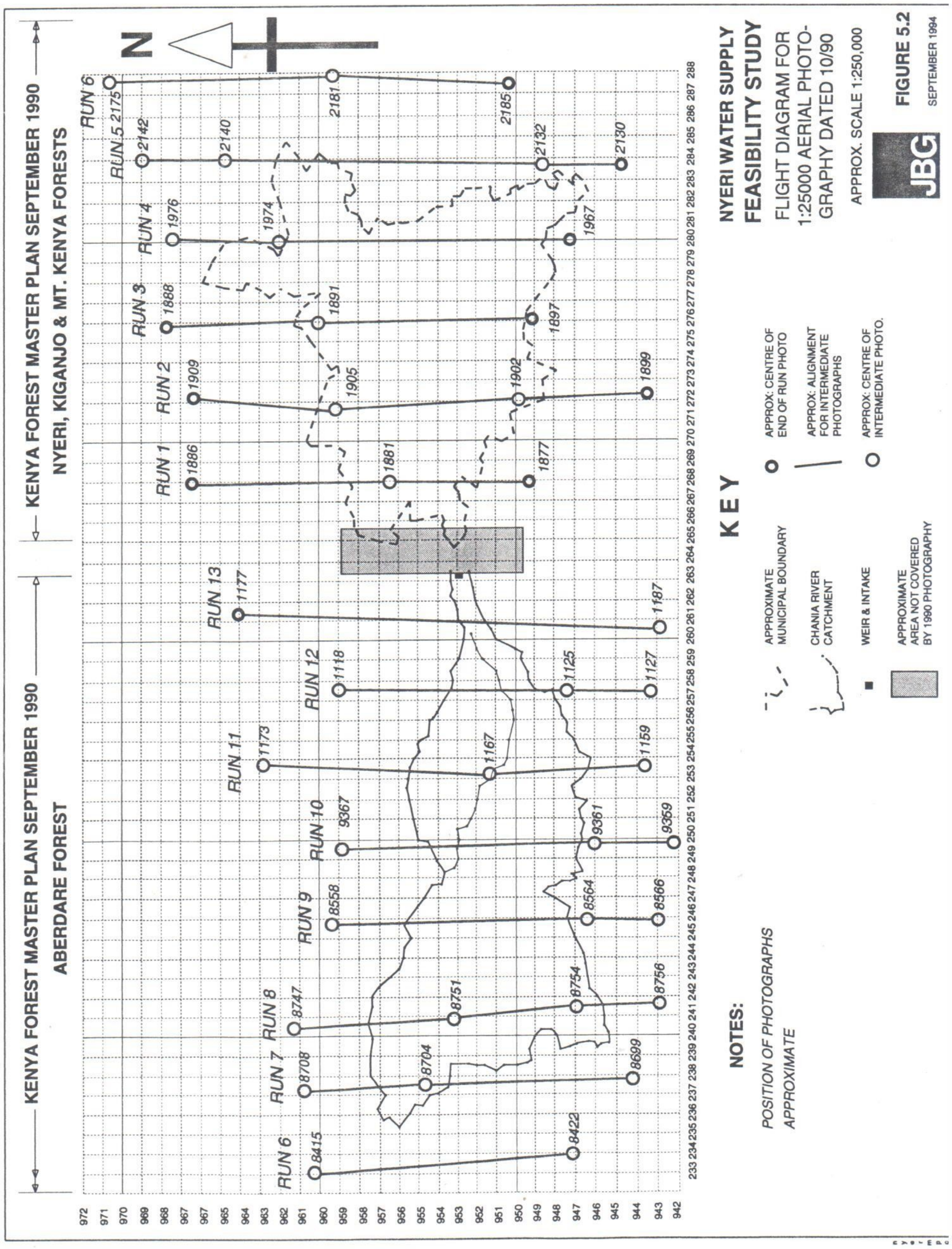
NYERI WATER SUPPLY FEASIBILITY STUDY

FLIGHT DIAGRAM FOR 1:20,000 AERIAL PHOTOGRAPHY DATED 01/75 & 1:25,000 AERIAL PHOTOGRAPHY DATED 05/78

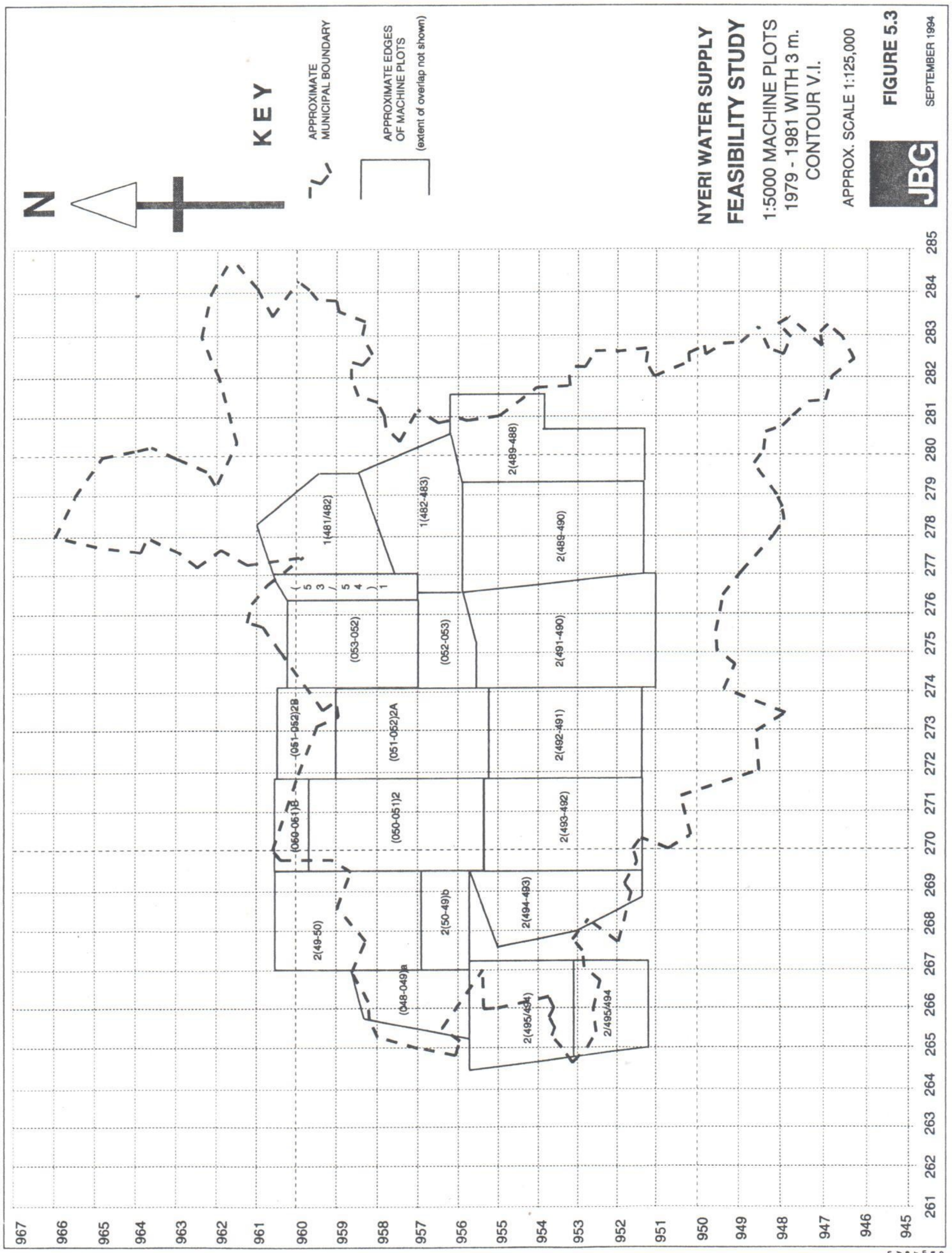
APPROX. SCALE 1:125,000

FIGURE 5.1
SEPTEMBER 1994

Page


KENYA FOREST MASTER PLAN SEPTEMBER 1990
ABERDARE FOREST
KENYA FOREST MASTER PLAN SEPTEMBER 1990
NYERI, KIGANJO & MT. KENYA FORESTS
N
RUN 1
RUN 2
RUN 3
RUN 4
RUN 5
RUN 6
RUN 7
RUN 8
RUN 9
RUN 10
RUN 11
RUN 12
RUN 13
NOTES:
POSITION OF PHOTOGRAPHS APPROXIMATE
KEY
APPROXIMATE MUNICIPAL BOUNDARY
CHANIA RIVER CATCHMENT
WEIR & INTAKE
APPROXIMATE AREA NOT COVERED BY 1990 PHOTOGRAPHY
APPROX: CENTRE OF END OF RUN PHOTO
APPROX: ALIGNMENT FOR INTERMEDIATE PHOTOGRAPHS
APPROX: CENTRE OF INTERMEDIATE PHOTO.
NYERI WATER SUPPLY FEASIBILITY STUDY
FLIGHT DIAGRAM FOR 1:25000 AERIAL PHOTOGRAPHY DATED 10/90
APPROX. SCALE 1:250,000
JBG
FIGURE 5.2
SEPTEMBER 1994

Page


N
KEY
APPROXIMATE MUNICIPAL BOUNDARY
APPROXIMATE EDGES OF MACHINE PLOTS
(extent of overlap not shown)
NYERI WATER SUPPLY
FEASIBILITY STUDY
1:5000 MACHINE PLOTS
1979 - 1981 WITH 3 m.
CONTOUR V.I.
APPROX. SCALE 1:125,000
FIGURE 5.3
SEPTEMBER 1994
JBG
2(489-488)
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2(492-491)
2(493-492)
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1(482-483)
(053-052)
(052-053)
(051-052)2B
(051-052)2A
(050-051)3
(050-051)2
2(49-50)
2(50-49)b
(048-049)a
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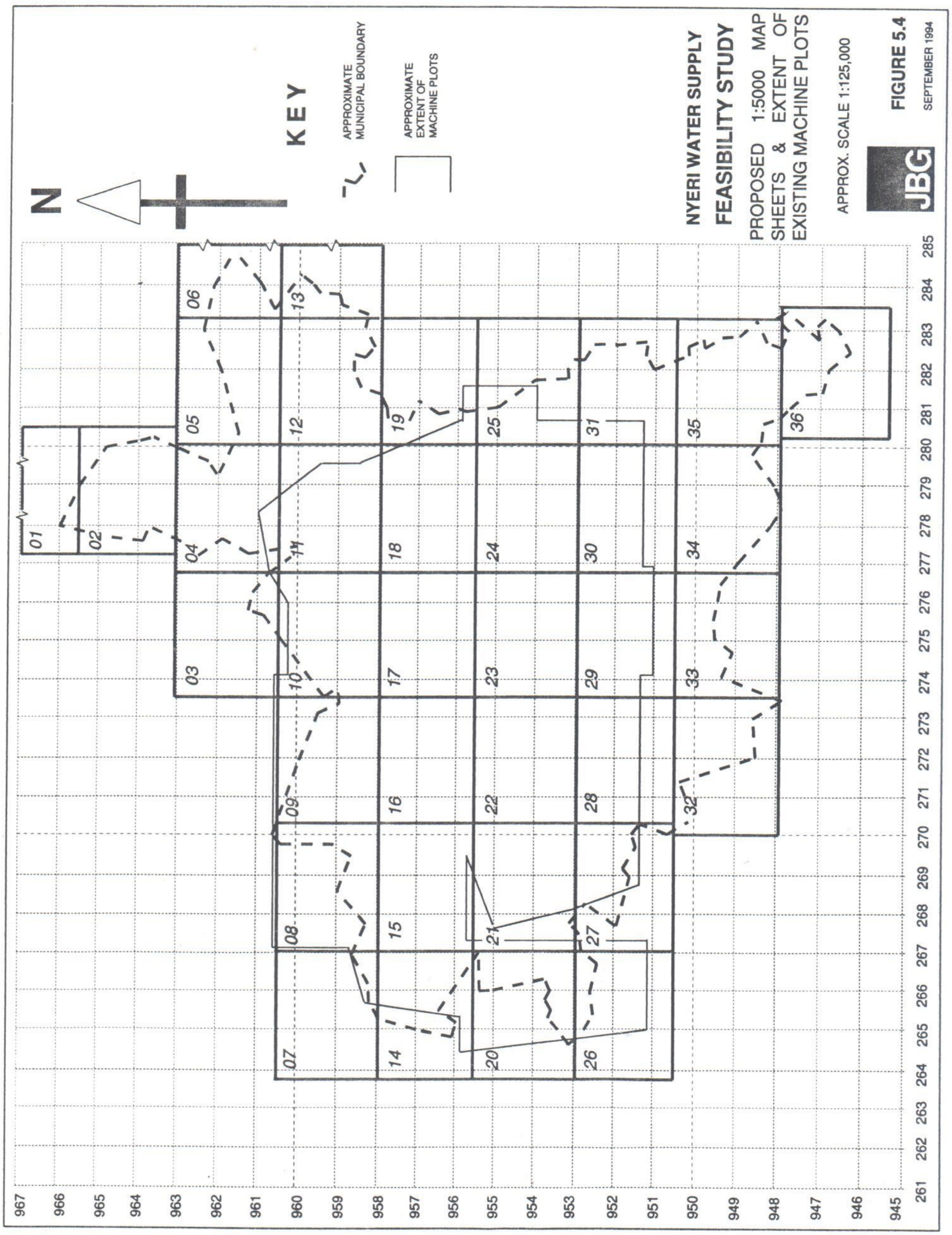
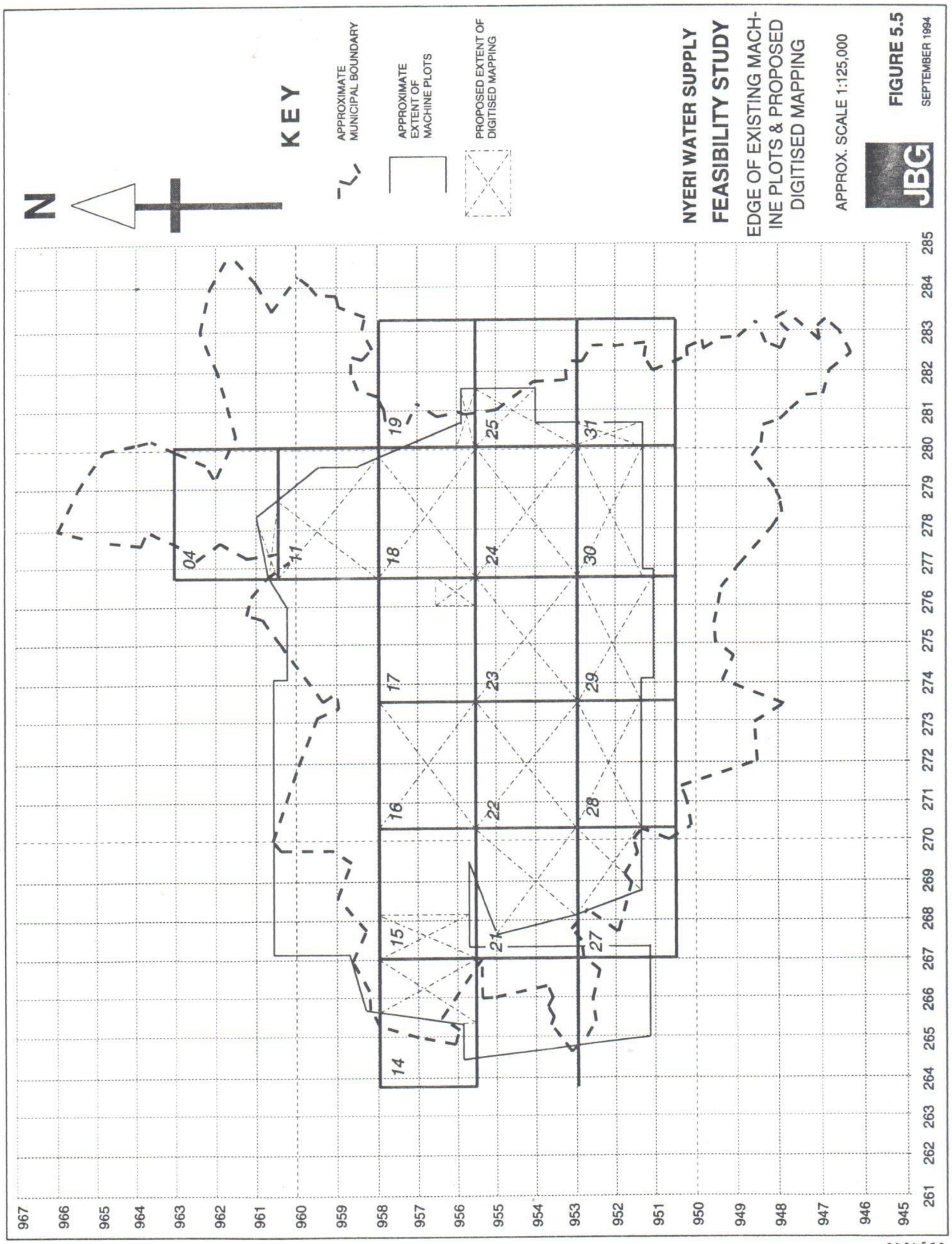
Page


N
KEY
APPROXIMATE MUNICIPAL BOUNDARY
APPROXIMATE EXTENT OF MACHINE PLOTS
NYERI WATER SUPPLY FEASIBILITY STUDY
PROPOSED 1:5000 MAP SHEETS & EXTENT OF EXISTING MACHINE PLOTS
APPROX. SCALE 1:125,000
JBG
FIGURE 5.4
SEPTEMBER 1994

Page


N
KEY
APPROXIMATE MUNICIPAL BOUNDARY
APPROXIMATE EXTENT OF MACHINE PLOTS
PROPOSED EXTENT OF DIGITISED MAPPING
NYERI WATER SUPPLY FEASIBILITY STUDY
EDGE OF EXISTING MACHINE PLOTS & PROPOSED DIGITISED MAPPING
APPROX. SCALE 1:125,000
JBG
FIGURE 5.5
SEPTEMBER 1994

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To facilitate planning, it was decided to digitise the non-topographic information from the 1:5,000 machine plots within this area. Topographic information in areas for future pipelines and sewers can then be digitised and superimposed during the final design stage to produce the necessary plans for plan/profile information for the pipelines/sewers.

The digitised maps so far completed are presented in the book of drawings accompanying this report.

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6. DEMOGRAPHY

6.1 Kenya Population Census

The 1979 census[1], volumes I and II of the 1989 census[2], and the 1994 - 1996 Nyeri District Development Plan were obtained and data for Nyeri District abstracted and studied. The District Development plan being based on the two censii yielded very little additional information in respect of Demography. The census geographic frame, namely Province - District - Division - Location - Sub-location was used in both instances. Detailed information from the 1989 census with regards to households, water supply and sanitation is to be published in a subsequent volume of the 1989 census and could only be made available at Municipal level.

It was noted that in the period between the two censii there had been no boundary changes at Provincial and District level, but considerable change within the more heavily populated Districts due to the creation of more administrative units. Nationwide, this involved the creation of 63 new divisions, 395 locations and 509 sub-locations. In addition a number of urban centres, including Nyeri, increased considerably in size at the expense of adjoining sub-locations.

The introductory pages to volume I of the 1989 census make it clear that the level of mapping undertaken for that census was both extensive and at enumeration area level, to a higher accuracy than previously achieved. Sub-locations were sub-divided into distinctive enumeration areas, each containing between 50 and 150 households, and with boundaries that followed identifiable or visible ground features wherever possible such as roads, footpaths, fences, streams etc.

Where boundary changes occur between censii as is the case for Nyeri, reference to such mapping is invaluable if accurate comparison is to be made between successive census results. Notwithstanding a written request for such maps, and with the support of the Ministry of Local Government, the Director of Statistics has advised that he is unable to sanction the release of such information for either 1979 or 1989. The result is that the comparison and projections made herein are therefore approximate.

At a Municipal level, errors are probably no larger than those inherent in the census exercise as a whole. At and below ward level however, it is not possible to assess population change in a way that is meaningful for water sector infrastructural planning purposes. This is therefore a definite impediment to this project. A decision is therefore required as to whether and how best additional time, cost and effort is to be expended in the detailed planning and sizing of the reticulation network. These circumstances undoubtedly help to confirm that

<1> *Kenya Population Census, 1979; vol I*
Central Bureau of Statistics, Ministry of Planning & Economic Development, June, 1981.

<2> *Kenya Population Census, 1989; vol I & II*
Central Bureau of Statistics,
Office of the Vice-President & Ministry of Planning & National Development, March, 19941.

new aerial photography and a block mapping and consumer survey exercise is an essential pre-requisite for the next stage of this project.

6.2. Nyeri District

According to the National Census, Nyeri District areas were said to be 3,284 km^2 in 1979 and 3,266 km^2 in 1989, although a summation of the divisional census data as published for 1979 did not confirm this. Individual sub-location and ward areas in the 1979 census appear to have been measured to the nearest tenth of a sq. km. However, in the published summation, all values were rounded down to the nearest sq. km. subsequent to computing densities, which accounts for minor differences between the published results and those presented here. In the 1989 census the areas appear to have been up or down rounded to the nearest sq. km. prior to computing densities.

A comparison at locational level between the two censii is presented in table 6.1. In the intervening period, Mathira and Tetu Divisions lost land to Nyeri Municipality, whilst Mukurweini, and Othaya Divisions appear to have remained unchanged except for the creation of new locations and sub-locations. There is however a further anomaly in the area in Mathira Division which is believed to have resulted from a numerical error as quoted for Magutu location in the 1979 census. The major discrepancy in total District area between the 1979 and 1989 censii seems to have resulted from the omission of both Mount Kenya and Aberdare Forest areas from the 1979 census as well as the areas of either forest or large estates in Kieni West and Kieni East Divisions.

At the District level, the 1989 census indicates that the total number of people increased from 486,477 to 607,292, an average annual growth rate of about 2.24%. Households increased from 98,222 to 130,541, an average annual increase of about 2.89%.

The divisions, locations, and sub-locations involved in the transfer of land to Nyeri Municipality between the two censii are indicated in table 6.2.

On the basis of provisional population census figures for 1989 of 613,000, the District Development Plan projected a future annual District growth rate of 2.32%, with the population reaching 718,440 by 1996.

6.3. Nyeri Municipality

In the 1979 census, the Nyeri Municipal area was put at about 72 km^2 with a population of 35,753.

By 1989, the Nyeri Municipal area covered 167 km^2 with a population of 91,539 people. Further boundary changes in 1992 removed some 3.4 km^2 in the south west of the Municipality and added some 32 km^2 in the north west.

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The results of the two censii for the Municipality are summarised in tables 6.3 & 6.4., from which it can be noted that even in those administrative areas where similar names are used, the numeric areas indicated can vary widely.

Without access to the 1979 and 1989 census maps, meaningful comparison at this level is clearly quite impracticable.

Between 1979 and 1989, the expansion to the Municipal area was partly to the southwest, northwest and northern central, but primarily in the southeast and east.

The southern and eastern areas principally effected were the sub-locations of Muthuani, Kiritu and Unjiru of Tetu Location in the southwest and south; the sub-locations of Gatitu, Githiri, Marua, Gaaki and Muruguru of Aguthi Location in the south; and the sub-locations of Gachika and Karuthi of Ruguru Location in Mathira Division in the southeast.

In the northeast, Kihuyo sub-location of Muhoya's Location became a part of the Municipality as did a small part of Kiganjo sub-location of Kaburu Location in the northern central area.

The 1989 Nyeri Municipal area comprises the newly named sub-locations of Mukaro and Kiganjo.

Mukaro comprises all of the 1979 Municipal area apart from the former Kiganjo Ward, together with all the areas acquired from Tetu Location.

Kiganjo (1989) is made up of the 1979 Municipal Kiganjo Ward, and the former sub-locations of Kirichu (Kericho in the 1979 census), and Gachika transferred from Mathira Location. The Nyaribo sub-location (ward) within Kiganjo, is understood to be the north western part of this area that was formerly a part of the 1979 Kiganjo sub-location of Kabaru Location.

From table 6.2, the recorded areas and 1979 populations of the affected areas were abstracted and compared with the new municipal areas as measured from the municipal boundary mapping. These are presented in table 6.5.

In the absence of the 1979 census mapping, this table contains a number of adjustments and approximations to try and "marry" 1979 sub-location names and areas to 1989 Municipal Ward names and areas.

The result suggests that in an area of approximately 91-94 km^2, there was a 1979 rural population of about 32,000 people who by 1989 were within Nyeri Municipality.

On this basis, the number of people living within the 1989 Nyeri Municipal census area in 1979 totalled about 67,900. The average annual increase between 1979 and 1989 was therefore of the order of 3.0%, and not the 9.37% as suggested in the 1989 volume II census report, and in the 1982 Study on the National Water Master Plan.

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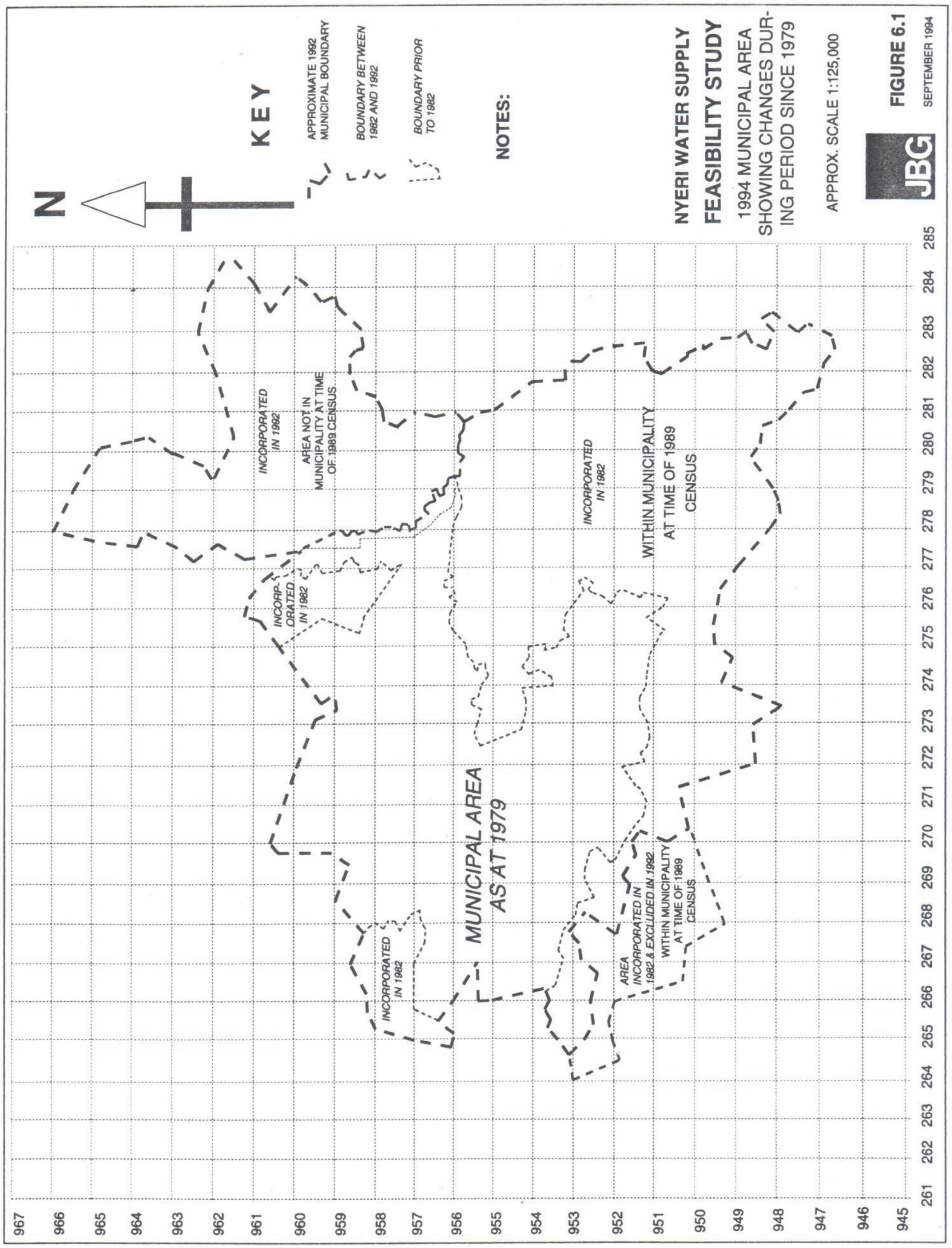
N
KEY
APPROXIMATE 1992 MUNICIPAL BOUNDARY
BOUNDARY BETWEEN 1982 AND 1992
BOUNDARY PRIOR TO 1982
NOTES:
NYERI WATER SUPPLY FEASIBILITY STUDY
1994 MUNICIPAL AREA SHOWING CHANGES DURING PERIOD SINCE 1979
APPROX. SCALE 1:125,000
JBG
FIGURE 6.1
SEPTEMBER 1994
INCORPORATED IN 1982
AREA NOT IN MUNICIPALITY AT TIME OF 1989 CENSUS
INCORPORATED IN 1982
WITHIN MUNICIPALITY AT TIME OF 1989 CENSUS
INCORP-ORATED IN 1982
MUNICIPAL AREA AS AT 1979
INCORPORATED IN 1982
AREA INCORPORATED IN 1982 & EXCLUDED IN 1992
WITHIN MUNICIPALITY AT TIME OF 1989 CENSUS

Page

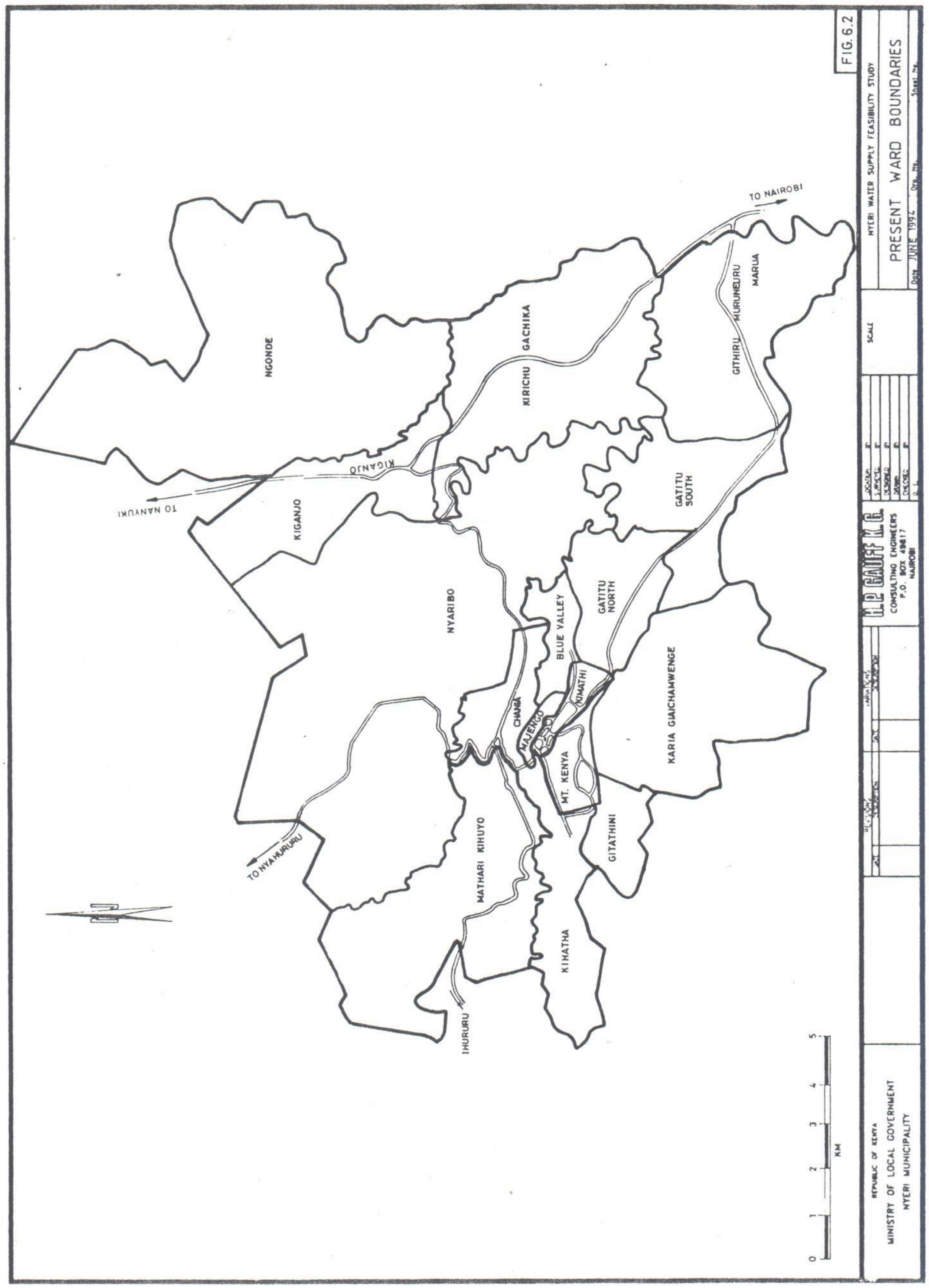
FIG. 6.2
NYERI WATER SUPPLY FEASIBILITY STUDY
PRESENT WARD BOUNDARIES
H.P. GAUFF K.G.
CONSULTING ENGINEERS
P.O. BOX 49817
NAIROBI
REPUBLIC OF KENYA
MINISTRY OF LOCAL GOVERNMENT
NYERI MUNICIPALITY
SCALE
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TO NYAHURURU
NGONDE
KIRICHU
GACHIKA
GITHIRU
MURUNGURU
MARUA
KIGANJO
GATITU SOUTH
GATITU NORTH
NYARIBO
BLUE VALLEY
KIMATHI
CHANIA
MAJENGO
MT. KENYA
KARIA GIAICHAMWENGE
GITATHINI
MATHARI
KIHUYO
KIHATHA
IHURURU

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TABLE 6.1: COMPARISON BETWEEN 1979 & 1989 CENSII FOR NYERI DISTRICT DOWN TO LOCATIONAL LEVEL

ADMINISTRATIVE AREA	1979 CENSUS SITUATION				1989 CENSUS SITUATION				GROWTH RATES
	TOTAL No. no.	H'HOLDS no.	AREA km2	DENSITY p/km2	TOTAL No. no.	H'HOLDS no.	AREA km2	DENSITY p/km2	%
NYERI DISTRICT	**486,477**	**98,222**	***2,092**	****233**	**607,292**	**130,541**	**3,265**	**186**	**2.24%**
KIENI EAST	**38,893**	**8,856**	**488**	**80**	**55,584**	**12,510**	**727**	**76**	
NAROMORU	24,313	5,843	332	73	19,381	4,103	232	84	
KABARU	14,580	3,013	156	93	18,280	3,966	240	76	
GAKAWA					17,923	4,441	255	70	
KIENI WEST	**41,411**	**8,091**	**546**	**76**	**57,636**	**11,844**	**1,051**	**55**	**3.36%**
MWEIGA	26,731	5,347	282	95	22,666	5,095	625	36	
GATARAKWA	14,680	2,744	264	56	13,544	2,637	79	171	
ENDARASHA					21,426	4,112	347	62	
MUKURWEINI	**72,288**	**14,560**	**180**	**402**	**88,838**	**18,370**	**180**	**494**	**2.08%**
GIKONDI	16,967	3,476	38	445	20,710	4,154	39	531	2.01%
GITHII	21,481	4,225	61	353	26,899	5,548	58	464	2.27%
MUHITO	27,651	5,625	49	562	17,380	3,725	28	621	
LOWER MUHITO	6,189	1,234	32	196					
RUTUNE					8,912	1,726	32	279	
GAKINDU					14,937	3,217	23	649	
MATHIRA	**127,359**	**24,753**	**325**	**392**	**145,802**	**31,537**	**389**	**375**	**1.36%**
IRIAINI	21,022	4,039	49	431	25,779	5,442	49	528	2.06%
KONYU	32,181	6,596	58	556	35,411	7,746	55	644	0.96%
KIRIMIKUYU	26,939	5,031	56	485	30,778	6,219	55	560	1.34%
RUGURU	26,408	4,969	90	295	11,590	2,455	65	178	)
MAGUTU	20,809	4,118	73	285	24,216	5,237	131	185	)
NGORANO					12,436	2,462	32	389	1.32%
KARATINA					5,592	1,976	2	2,796	)
TETU (exc. Nyeri Town)	**102,273**	**19,710**	**311**	**329**	**81,391**	**16,279**	**279**	**292**	
AGUTHI	32,622	6,427	74	442	27,865	5,313	48	581	
TETU	21,049	3,949	64	328	11,659	2,231	29	402	
MUHOYA'S	13,679	2,642	73	187	10,686	2,252	93	115	
THEGENGE	34,923	6,692	100	349	31,181	6,483	109	286	
MUNICIPALITY	**35,753**	**9,527**	**72**	**497**	**91,539**	**22,290**	**167**	**548**	
NYERI TOWNSHIP	35,753	9,527	72	497					
MUKARO					78,880	19,366	135	584	
KIGANJO					12,659	2,924	32	396	
OTHAYA	**68,500**	**12,725**	**171**	**402**	**85,141**	**17,398**	**171**	**499**	**2.20%**
CHINGA	16,691	2,920	51	330	20,215	3,943	51	400	1.93%
MAHIGA	18,523	3,516	43	431	22,814	4,633	42	543	2.11%
OTHAYA	33,286	6,289	77	432					)
IRIAINI					22,147	4,495	45	492	2.38%
KARIMA					19,965	4,327	33	605	)
MT. KENYA F./N. P'K					**1,109**	**249**	**111**	**10**	
ABERDARE F./N. P'K					**252**	**64**	**191**	**1**	

Notes: Recorded as 3284 km2 in 1979 Ce ** Recorded as 148 p/km2 in 1979 Census

Sources: Kenya Population Census 1979, Vol. I, pages 42-44 & 49: Kenya Population Census 1989, Vol. I, pages 1-24 to 1-29.

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TABLE 6.2: SUB- DIVISIONS & WARDS INVOLVED IN MUNICIPAL BOUNDARY CHANGES BETWEEN 1979 & 1989

ADMINISTRATIVE AREA	1979 CENSUS SITUATION				1989 CENSUS SITUATION				GROWTH RATES %
	TOTAL No. no.	H'HOLDS no.	AREA km2	DENSITY p/km2	TOTAL No. no.	H'HOLDS no.	AREA km2	DENSITY p/km2	
KIENI EAST	**38,893**	**8,856**	**488.6**	**80**	**55,584**	**12,510**	**727**	**76**	
NAROMORU	24,313	5,843	332.0	73	19,381	4,103	232	84	
KABARU	14,580	3,013	156.6	93	18,280	3,966	240	76	
WARAZO	3,310	695	44.9	74	4,063	865	61	67	
WARAZO JET	2,593	443	8.7	298	3,536	673	19	186	
ISLAND FARMS	2,848	469	13.1	217					
KABARU NDATHI	2,543	699	55.0	46	2,232	578	99	23	
KIMAHURI					3,925	802	13	302	
KIGANJO	3,286	707	34.9	94					
NGONDE					4,524	1,048	48	94	
GAKAWA					17,923	4,441	255	70	
MATHIRA	**153,767**	**29,722**	**414.3**	**371**	**157,392**	**33,992**	**454**	**347**	
IRIAINI	21,022	4,039	48.8	431	25,779	5,442	49	528	
KONYU	32,181	6,596	57.9	556	35,411	7,746	55	644	
KIRIMIKUYU	26,939	5,031	55.5	485	30,778	6,219	55	560	
RUGURU	26,408	4,969	89.6	295	11,590	2,455	65	178	
KARUTHI	*3,200*	*651*	*10.4*	*307*					
GACHIKA	*2,167*	*402*	*8.2*	*265*					
RUTURU	3,474	610	8.4	414					
KIAMARIGA	3,669	703	8.4	437	4,003	868	8	500	
IRURI	2,385	401	7.3	326	3,242	649	7	463	
HOMBE	2,403	493	7.2	332	2,156	520	42	51	
SAGANA	1,943	333	8.8	221	2,189	418	8	274	
CHENI	1,606	287	6.6	245					
GATUNGANGA	2,286	462	6.7	340					
KERICHO	*3,275*	*627*	*17.6*	*186*					
MAGUTU	20,809	4,118	72.9	285	24,216	5,237	131	185	
NGORANO					12,436	2,462	32	389	
KARATINA					5,592	1,976	2	2,796	
TETU (exc. Nyeri Town)	**169,623**	**32,728**	**521.3**	**325**	**131,601**	**26,075**	**449**	**293**	
AGUTHI	32,622	6,427	73.8	442	27,865	5,313	48	581	
GATITITU A	*1,522*	*307*	*5.0*	*304*					
GATITITU B	*2,416*	*475*	*5.4*	*450*					
GITHIRI	1,940	377	5.7	339					
MURUGURU	*2,538*	*492*	*5.4*	*470*					
MARUA	1,550	313	3.7	417					
GAAKI A	3,024	550	6.0	504					
GAAKI B	4,903	930	13.5	364	5,775	1,094	10	578	
MUNGARIA	1,851	390	3.2	580	2,256	462	4	564	
GICHIRA	2,507	507	5.1	489	3,089	582	6	515	
GITITU	2,904	581	5.2	558	3,658	715	7	523	
GATHAITHI	3,353	676	6.4	523	4,121	831	6	687	
ITHEKAHUNO	4,114	829	9.0	457	5,029	964	9	559	
MUTATHIINI					3,937	665	6	656	
TETU	21,049	3,949	64.7	325	11,659	2,231	29	402	
KARAIHU A	1,361	264	3.8	356					
KARAIHU B	1,665	325	5.1	328	1,895	380	5	379	
MUTHUANI A	*2,685*	*540*	*3.9*	*688*					
MUTHUANI B	*2,322*	*424*	*5.6*	*415*					
UNJIRU A	*2,682*	*481*	*5.9*	*456*					
UNJIRU B	*2,514*	*468*	*5.4*	*462*					
ICHAGACHIRU A	1,562	283	4.7	335	1,984	377	5	397	
ICHAGACHIRU B	2,317	391	5.9	394					
KIRITI A	*1,762*	*362*	*3.1*	*568*					
KIRITI B	*1,661*	*314*	*3.5*	*469*					
GAKANGA	518	97	17.9	29					
KIRURUMI					2,867	553	10	287	
KIGOGOINI					3,397	633	6	566	
GATUMBIRO					1,516	288	3	505	
MUHOYA'S	13,679	2,642	72.2	190	10,686	2,252	93	115	**0.23%**
KIHUYO	*2,222*	*407*	*4.9*	*453*					
THATHA A	1,591	290	3.5	459	1,534	311	4	384	
THATHA B	1,876	352	3.3	575					
KABAGE A	1,292	209	3.3	386					
KABAGE B	1,567	316	4.6	340	787	177	34	23	
KABAGE FOREST	1,407	298	34.3	41					
ZAINA (FOREST)	1,075	208	13.3	81	1,116	226	40	28	
NGOORU					1,544	304	4	386	
IHURURU	2,649	562	5.0	530	2,553	577	5	511	
KANJORA					1.807	376	3	602	
KARUNAINI					1,345	281	3	448	
THEGENGE	34,923	6,692	100.1	349	31,181	6,483	109	286	2.06%

Notes: In 1979 census, all decimal places in measured areas were rounded down.

Sources: Kenya Population Census 1979, Vol. I, pages 42-44 & 49: Kenya Population Census 1989, Vol. I, pages 1-24 to 1-29.

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TABLE 6.3: RESULTS OF 1979 CENSUS FOR NYERI MUNICIPALITY

ADMINISTRATIVE AREA	MALE	FEMALE	TOTAL	HOUSE-HOLDS	AREA in sq. kms.	DENSITY
NYERI TOWN	**19,247**	**16,506**	**35,753**	**9,527**	**72**	**497**
MAJENGO WARD	2,489	2,155	4,644	1,646	0.60	7,740
RURINGU WARD	2,214	2,138	4,352	1,161	4.36	998
NGANGARITHI WARD	1,350	1,409	2,759	649	4.16	663
MOUNT KENYA WARD	870	827	1,697	442	2.72	623
CHANIA WARD	2,148	1,071	3,219	928	3.44	935
BLUE VALLEY WARD	1,535	1,645	3,180	775	1.92	1,656
CENTRAL WARD	300	171	471	201	0.96	490
NYARIBO WARD	2,702	1,822	4,524	939	26.15	173
KERICHO WARD	191	202	393	77	1.08	363
KIMATHI WARD	772	708	1,480	458	-	-
KAMAKWA WARD	1,435	1,384	2,819	804	2.72	1,036
MATHARI WARD	1,851	2,130	3,981	740	18.35	217
KIGANJO WARD	1,390	844	2,234	707	5.45	410

Source: Kenya Population Census 1979, vol I, table 1, pages 44 & 49.

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TABLE 6.4: RESULTS OF 1989 CENSUS FOR NYERI MUNICIPALITY

ADMINISTRATIVE AREA	MALE	FEMALE	TOTAL	HOUSE-HOLDS	AREA in sq. kms.	DENSITY
NYERI MUNICIPALITY	**46,405**	**45,134**	**91,539**	**22,290**	**167**	**548**
MUKARO	**39,632**	**39,248**	**78,880**	**19,366**	**135**	**584**
MAJENGO	10,194	8,284	18,478	5,575	7	2,640
RURINGU/THUNGUMA	5,373	5,236	10,609	3,206	20	530
KIHUYO	1,063	1,198	2,261	444	5	452
GITHIRI	1,084	1,289	2,373	473	5	475
MURUGURU	1,154	1,434	2,588	548	6	431
KIHATHA	866	944	1,810	355	4	453
MUNUNGA-INI	1,227	1,302	2,529	530	5	506
GATITU	882	885	1,767	419	5	353
KARIA	1,094	1,158	2,252	459	4	563
RIAMUKURWE	1,339	1,434	2,773	530	6	462
MARUA	1,071	1,050	2,121	461	5	424
KAMAKWA	4,594	4,536	9,130	2,432	7	1,304
MUTHUA-INI	1,727	1,925	3,652	711	6	609
MATHARI	3,847	3,964	7,811	1,480	37	211
GATATHINI	1,196	1,250	2,446	496	3	815
KINUNGA	606	681	1,287	302	2	644
CHORONGI	2,315	2,678	4,993	945	8	624
KIGANJO	**6,773**	**5,886**	**12,659**	**2,924**	**32**	**396**
KIRICHU	1,978	2,154	4,132	868	10	413
KIGANJO	2,284	1,093	3,377	969	5	675
NYARIBO	1,245	1,220	2,465	581	10	247
GACHIKA	1,266	1,419	2,685	506	7	384

Source: Kenya Population Census 1979, vol I, table 1, page 1-24.

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TABLE 6.5: SUB- LOCATIONS INVOLVED IN MUNICIPAL BOUNDARY CHANGES BETWEEN 1979 & 1989

ADMINISTRATIVE AREAS			1979 CENSUS SITUATION				MUNICIPAL WARDS IN 1989		APPROX. AREA IN MUNICIPALITY IN 1989			
DIVISION	LOCATION	SUB-LOCATION	TOTAL No. no.	H'HOLDS no.	AREA km2	DENSITY p/km2	WARD NAME	AREA km2	TOTAL No. no.	H'HOLDS no.	AREA km2	DENSITY p/km2
KIENI EAST												
	KABARU											
		KIGANJO	3,286	707	34.9	94	Kiganjo	4.2	394	99	4.2	94
MATHIRA												
	RUGURU											
		GACHIKA	2,167	402	8.2	265	Gachika	7.8	2,167	402	8.2	265
		KERICHO	3,275	627	17.6	186	Kirichu	21.9	3,275	627	17.6	186
	sub-total							29.7	5,442	1,029	25.8	211
TETU												
	AGUTHI											
		GATITITU A	1,522	307	5.0	304	Gatitu South	4.3	1,522	307	5.0	304
		GATITITU B	2,416	475	5.4	450	Riamukurwe	5.5	2,416	475	5.4	450
		GITHIRI	1,940	377	5.7	339	Githiru	6.0	1,940	377	5.7	339
		MURUGURU	2,538	492	5.4	470	Muruguru	5.1	2,538	492	5.4	470
		MARUA	1,550	313	3.7	417	Marua	3.5	1,550	313	3.7	417
		GAAKI A	3,024	550	6.0	504	Karia	4.4	2,208	550	4.4	504
		GAAKI B	4,903	930	13.5	364	Giachamwenge	7.9	2,844	930	7.8	364
	sub-total							36.7	15,017	3,444	37.4	402
	TETU	MUTHUANI A	2,685	540	3.9	688	Gitathi-ini	2.5	2,067	540	3.0	688
		MUTHUANI B	2,322	424	5.6	415	Muthuani	5.5	2,322	424	5.6	415
		UNJIRU A	2,682	481	5.9	456	Unjiru	4.8	2,172	481	4.8	456
		UNJIRU B	2,514	468	5.4	462	Kihatha	2.8	2,514	468	5.4	462
							Kiriti	3.4				
	sub-total							19.0	9,076	1,913	18.8	483
	MUHOYA'S											
		KIHUYO	2,222	407	4.9	453	Kihuyo	4.7	2,222	407	4.9	453
	TOTAL							94.3	32,151	5,040	91.1	353
	NYERI TOWN (1979)							72.0	35,735	9,527	72.0	497
	GRAND TOTAL							166.3	67,886	14,567	163.1	416

Notes:

Sources: Kenya Population Census 1979, Vol. I, pages 42-44 & 49: Kenya Population Census 1989, Vol. I, pages 1-24 to 1-29.

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Given the predominantly administrative and commercial nature of Nyeri Municipality and the 2.24% average annual increase in the population of Nyeri District as a whole, a 3.0% average annual municipal growth rate is regarded as not unrealistic.

6.4 <u>In and Out Migration</u>

Nyeri Municipality is a Provincial Headquarters and hence an administrative centre of some importance.

Its location, some 2 hrs driving time from Nairobi, off a trunk road that leads only to the scarcely populated North Eastern Province and to southern Ethiopia, has meant that it is not a town which serves as a base for commercial and industrial activities for other than strictly local interests.

As a result, in-migration is a very localised affair except for Provincial administration officials and dependants. On the other hand, out-migration by those seeking jobs in the industrial towns of Thika and Nairobi must be significantly more pronounced.

Such population movements as occur will therefore tend to limit rather than accelerate normal birth rate population increase.

6.5 <u>Selection of Population Projections</u>

Based on the forgoing, it has been necessary to select population projections for urban and rural parts of the Municipality on municipal wide, rather than ward specific data.

This has been done by assuming that the 1979 municipal population was essentially urban, and all subsequently added areas comprise essentially rural people.

In this way it has been possible to compile the following table, and determine an 'urban' growth rate within the overall Municipal growth rate of 3.0%. The resulting 'urban' growth rate of 3.7% will therefore be the basis of all population projections in this study. This figure is also comparable with the 3.7% - 3.75% per annum proposed in the earlier water supply and sewerage design reports for the urban parts of the municipality.

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Table 6.6:

DERIVATION OF POPULATION PROJECTIONS

GROWTH RATE		POPULATIONS 1979 CENSUS	1989 CENSUS
3.70%	urban	35,753	*51,415*
2.24%	rural	32,151	40,124
3.03%	total	67,886	91,539

6.6 Demographic Data from 1989 Census

Demographic data from the 1989 census has only been obtained at Municipal level. In the absence of mapping to which areas can be related more detailed figures were considered unnecessary.

25%

In 1989 there were some 22,245 households within Nyeri Municipality. Approximately one-quarter of all households comprised a single person whilst three-quarters of all households comprised no more than 5 persons. Two thirds of all households were headed by a man and one-third by a woman (Table 6.7). One third of all heads of household were aged between 25 and 34 and $^2/_3$ rds between 20 and 44. (Table 6.8).

The commonest wall materials is wood (45%). followed by stone (28%) and mud and wood (17%). Over 87% of all structures were roofed with iron sheets (Table 6.9). Approximately 50% of all houses had earthen floor with a further 44% having cement rendered floors (Table 6.10).

Paraffin lamps (72%) were the primary source of lighting followed by electricity (25%). Firewood (50%) was the main cooking fuel, followed by paraffin (31%). (Table 6.11). Approximately $^3/_4$rs of all households had access to piped water whilst the vast majority of others used a stream or river. Approximately $^3/_4$rs of all households used pit latrines whilst only 14% were connected to the main sewer and 7% had septic tanks (Table 6.12).

young Employment town core ∴ 1/3 20-34

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TABLE 6.7: NUMBER OF HOUSEHOLDS BY SIZE & SEX OF HEAD OF HOUSEHOLD

Sex of Head of Household	Household Size 1 Person	2 Persons	3 Persons	4 Persons	5 Persons	6 Persons	7 Persons	8 Persons	9 Persons	10 Persons	11 Persons	12 Persons +	Total
Male	4,095	2,033	1,444	1,459	1,313	1,165	962	666	487	359	133	169	14,285
Female	1,762	1,152	1,159	1,126	911	666	492	304	169	124	39	56	7,960
Total	5,857	3,185	2,603	2,585	2,224	1,831	1,454	970	656	483	172	225	22,245

Source: Central Bureau of Statistics, private communication.

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TABLE 6.8: HOUSEHOLDS BY AGE & SEX OF HEAD OF HOUSEHOLD

Age	<15	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+	N.R.
Male	50	299	1,516	2,708	2,208	1,757	1,502	1,158	893	586	427	1,168	13
Female	65	152	1,026	1,426	926	854	718	595	459	345	353	1,030	11
Total	115	451	2,542	4,134	3,134	2,611	2,220	1,753	1,352	931	780	2,198	24

Source: Central Bureau of Statistics, private communication.

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TABLE 6.9: HOUSEHOLDS AND POPULATION IN HOUSEHOLDS BY TYPE OF WALL & TYPE OF ROOF

Type of WALL	Type of ROOF						
	Iron Sheets	Tiles	Concrete	Asbestos Sheets	Grass/ Makuti	Other	Total
STONE							
H'HOLDS	5,136	443	384	310	10	73	6,356
POPUL'N	16,591	2,018	1,033	1,083	38	199	20,962
BRICK/BLOCK							
H'HOLDS	458	59	34	351	5	2	909
POPUL'N	1,716	234	152	943	15	6	3,066
MUD/WOOD							
H'HOLDS	3,217	39	13	10	479	138	3,896
POPUL'N	14,892	201	28	43	1,904	375	17,443
MUD/CEMENT							
H'HOLDS	128	2	2	14	24	5	175
POPUL'N	543	7	12	43	83	14	702
WOOD ONLY							
H'HOLDS	9,903	92	5	16	29	71	10,116
POPUL'N	40,292	444	23	52	86	197	41,094
IRON SHEETS							
H'HOLDS	289	5				5	299
POPUL'N	787	20				15	822
GRASS/REEDS							
H'HOLDS	5			5	8		18
POPUL'N	19			13	20		52
OTHER							
H'HOLDS	320	2	1	2	15	136	476
POPUL'N	1,426	7	3	9	54	421	1,920
TOTALS							
H'HOLDS	19,456	642	439	708	570	430	22,245
POPUL'N	76,266	2,931	1,251	2,186	2,200	1,227	86,061

Source: Central Bureau of Statistics, private communication.

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TABLE 6.10: HOUSEHOLDS AND POPULATION IN HOUSEHOLDS BY TYPE OF FLOOR & TENURE/STATUS OF RESIDENCE

Type of TENURE	Type of FLOOR					
	Cement	Earth	Wood	Tiles	Other	Total
PURCHASED						
H'HOLDS	354	382	18	30	3	787
POPUL'N	1,243	1,608	94	173	20	3,138
CONSTRUCTED						
H'HOLDS	1,990	7,196	119	58	18	9,381
POPUL'N	11,186	36,049	551	386	97	48,269
INHERITED						
H'HOLDS	138	467	9	3	1	618
POPUL'N	595	1,856	28	12	1	2,492
GOVERNMENT						
H'HOLDS	1,494	60	78	45	3	1,680
POPUL'N	4,520	174	322	198	17	5,231
LOCAL AUTH:						
H'HOLDS	277	12	5	5	2	301
POPUL'N	984	34	15	24	9	1,066
PARASTATAL						
H'HOLDS	122	24	2	28		176
POPUL'N	398	56	18	106		578
PRIVATE CO:						
H'HOLDS	629	181	51	27	10	898
POPUL'N	1,884	594	119	74	19	2,690
INDIVIDUAL						
H'HOLDS	4,494	2,575	69	68	14	7,220
POPUL'N	11,948	6,565	236	273	45	19,067
OTHER, RENTED						
H'HOLDS	418	578	23	44	121	1,184
POPUL'N	1,202	1,703	78	161	386	3,530
TOTALS						
H'HOLDS	9,916	11,475	374	308	172	22,245
POPUL'N	33,960	48,639	1,461	1,407	594	86,061

Source: Central Bureau of Statistics, private communication.

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TABLE 6.11: HOUSEHOLDS AND POPULATION IN HOUSEHOLDS BY MAIN COOKING FUEL & TYPE OF LIGHTING

Type of LIGHTING	Main cooking FUEL: Elect-ricity	Paraffin	Gas	Fire-wood	Charcoal	Other	Total
ELECTRICITY							
H'HOLDS	690	3,324	1,044	343	475	84	5,960
POPUL'N	2,728	8,411	4,170	1,696	1,898	207	19,110
PARAFFIN LAMPS							
H'HOLDS	33	3,606	97	10,746	1,299	127	15,908
POPUL'N	102	8,586	437	52,141	3,997	239	65,502
FUEL WOOD							
H'HOLDS	4	20	6	33	3		66
POPUL'N	17	95	21	153	10		296
CANDLE							
H'HOLDS	2	21	31	46	9	18	127
POPUL'N	4	83	161	212	25	52	537
SOLAR							
H'HOLDS		2	6	20	4	1	33
POPUL'N		3	21	82	14	2	122
OTHER							
H'HOLDS	2	4	3	5	3	4	21
POPUL'N	14	7	20	17	8	4	70
TOTALS							
H'HOLDS	731	6,977	1,187	11,193	1,793	234	22,115
POPUL'N	2,865	17,185	4,830	54,301	5,952	504	85,637

Source: Central Bureau of Statistics, private communication.

TABLE 6.12: HOUSEHOLDS AND POPULATION IN HOUSEHOLDS BY MAIN SOURCE OF WATER & SEWAGE DISPOSAL

Type of SEWAGE DISPOSAL	Main source of WATER: Pond	Dam	Lake	Stream/ River	Well	Borehole	Piped	Jabias	Other	Total
MAIN SEWER										
H'HOLDS	101	7	3	16	1		3,212	3		3,343
POPUL'N	322	21	30	49	10		9,114	9		9,555
SEPTIC TANK										
H'HOLDS	48	7	8	41	5	1	1,625	4	2	1,741
POPUL'N	203	19	27	191	25	8	6,132	17	7	6,629
PIT LATRINE										
H'HOLDS	52	35	6	4,476	26	3	11,763	115	110	16,586
POPUL'N	186	125	21	20,785	87	7	45,854	575	370	68,010
BUCKET LATRINE										
H'HOLDS	6	13	18	27			40	1		105
POPUL'N	31	78	85	89			140	2		425
CESS POOL										
H'HOLDS	4	2	1	2			243			252
POPUL'N	19	9	8	7			641			684
BUSH										
H'HOLDS			1	53			16		1	71
POPUL'N			14	190			54		1	259
OTHER										
H'HOLDS	2			3	2		25	1	114	147
POPUL'N	14			13	6		94	10	362	499
TOTALS										
H'HOLDS	213	64	37	4,618	34	4	16,924	124	227	22,245
POPUL'N	775	252	185	21,324	128	15	62,029	613	740	86,061

Source: Central Bureau of Statistics, private communication.

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7. EXISTING WATER SUPPLY SYSTEM

7.1. Nyeri Town

7.1.1. Historical Development

The original water supply facilities for Nyeri town date back to the 1930s, based upon pumped abstraction from the Chania River, at a point below the Outspan Hotel, and treatment at works which were in the area that is now the site of the District Water Office.

The Chania intake is still existing and operational, but the rising mains are more recent (1972), now taking water to the water works presently in use, and the pumpsets were installed between 1972 and 1979.

At the old treatment works site there is no evidence of the treatment facilities which were in use. The five clear water tanks are still there. Although they had not been in use for a long time, the Council has recently re-incorporated them into the present system. There are five ground level tanks, four of them of 135 m^3 capacity each, commissioned between 1946 and 1950, and one of 450 m^3, put into use in 1956. The large tank and two of the small tanks are within the area presently in use for vehicular traffic and parking within the District Water Office, and on several occasions cars were seen parked on tank roof slabs.

In 1959 the water supply system became based on abstraction from a new intake at Ihwa, about 6 kms from Kamakwa, an Asbestos Cement (AC) pipework raw water gravity main, and treatment at a new site at higher elevation but still within Kamakwa, about 250 m from the old site.

These original treatment units (very old works) were augmented in 1968 by a parallel stream of units (old works) and by yet another treatment stream (new works) in 1986. Construction of the new works was accompanied by the installation of a new gravity main from Ihwa.

7.1.2 Ihwa Intake and Raw Water Mains

The Ihwa Intake site is a fenced compound with four buildings: the intake room, a pump house, operator's house, and an external toilet for the operator's house.

A concrete weir is constructed across the Chania river, and the intake house built against it on the south bank. Against the rear wall of the intake house is a river gauging staff.

Abstraction is by a rectangular side entry into the chambers in the intake house. A distribution channel is separated from the individual chambers for the existing and one future raw water main, by fine screens.

A resident attendant also doubles up as the line patroller for the raw water mains.

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The pumphouse was used in 1978 attempts to pump into the raw water main, but these attempts are reported to have been "unsuccessful" and were abandoned.

The old raw water main has the following diameters of AC pipes, the larger pipes being towards the intake:

Diameter	Length
250 mm	995 m
200 mm	2,890 m
150 mm	2,160 m
	6,045 m

The pipework is all of Asbestos Cement (AC) except at the two river crossings on the Chania river, where 200 mm dia cast iron pipes were used. At the road crossing opposite the treatment works, a 100 mm dia. AC pipeline was connecting this main to the old treatment works site. The route of the raw water main follows the Chania river valley for the first 1.5 km, crossing to the north bank and back again at a meander. These crossings are 940 m and 1400 m from the intake. The section of pipework between chainage 1 + 100 and 2 + 100 is only reached by a steep descent through farms into the river valley, whilst that from chainage 4+700 to the treatment works crosses through developed farmland, in a number of instances traversing through homesteads.

The new raw water main is constructed of PVC pipework, except at the river crossings where flanged galvanised steel (GS) pipework was used. GS pipework was also used in some of the pipeline near the intake, where it is in deep excavation, reportedly in rock bottomed trenches. The pipework is of the following chambers and materials:

Material	Diameter	Length
GS	12"	330 m
PVC	280 mm	1,460 m
GS	10"	270 m
PVC	225 mm	4,080 m
		6,140 m

The pipeline essentially follows that of the old raw water main, upto chainage 4+600. From there to the treatment works, the new main was laid along the existing access roads.

One of the principal areas in which it was noted that rehabilitation was needed was at chambers and the fittings within them. A number of chambers on the old raw water main were covered, especially in the sections through farm land, away from the roads. On this main, there is hardly an air valve left. These have been replaced with stopcocks for manual bleeding when necessary. The few remaining air valves were invariably leaking and to a significant extent. On the new main, the valves are in a much better state of repair, but what was of concern was the large number of places where a washout or airvalve would have been expected, but none was in evidence. It is possible that some of the chambers are buried, but in other places this is doubted, especially in pastures where the lack of soil movement would mitigate against this. Considering the means by which the main was constructed (as a joint effort by various government agencies on an emergency basis), it is very probably that these fittings were omitted altogether.

7.1.3. Chania Intake and Raw Water Mains

The Chania Intake is located on the Chania river below the area of the Outspan Hotel, and pumps water to the Kamakwa Water Works through two 150m dia. pipes.

Drawing off is through an unlined channel into a sump chamber equipped with a fine and a coarse screen. This arrangement definitely would need improvement, due to the rapid generation of vegetation in the channel, and the difficulties of drawing off the better quality water with the present channel entry. The latter problem has been addressed in a "temporary" manner by sand-bagging of a channel up the river, but a more effective and more permanent construction is required.

The buildings on the site are one pumphouse and one unipot room. The pumphouse is constructed of masonry to below window level, and the walls finished off with off-cut timber. The building is divided into two rooms, one for the in-operational diesel standby pump, and the other for the two electrically driven pumps.

The two working pumps are operated on an alternating basis, in approximately 12 hour shifts, every day.

7.1.4. Kamakwa Treatment Works

7.1.4.1. Overview

The works consist of very old works (dating from 1959) old works (1968) and new works (1986) The current production capacity of the entire works is estimated at 5580 m^3/day.

The very old and old works comprises of upward flow sludge blanket clarification, and rapid gravity sand filtration with air scour. The new works include hydraulic flocculation, horizontal flow sedimentation, and rapid gravity sand filtration without air scour.

Before the inlet flow is distributed to the new, old and very old works, alum/soda ask dosing is carried out at the Chemical building which houses the inlet works. After filtration the flow converges again at a chlorine dosing chamber before flowing to the clear water tank for onward transmission to the consumers.

7.1.4.2 Inlet Works

The raw water mains from Ihwa intake (gravity) and from the Chania intake (pumping) converge at the alum dosing chambers at the upper floor of the chemical building.

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The water then flows through a channel to the soda ash dosing chambers before being led to raised distribution chambers fixed on the outer side of the chemical building wall. These distribute flow to the various treatment streams.

The distribution chambers measuring 1000 x 1000 x 2000 mm deep were also meant to act as rapid mix units for the works. The channels leading to the chambers are also provided with V-notches meant for flow measurements but no flow measurement are made with these V-notches as the flow is higher than they were designed for.

7.1.4.3. Old/Very Old Works

The old and the very old works together have four upward flow clarifiers constructed of 300 mm reinforced concrete walling. Each unit is 18.49 m^2 (4.25 x 4.25 m) which with a surface overflow rate of 1.25 m/hr can handle 2,170 m^3/day in total.

Two of the clarifiers are for the very old stream and are each provided with 3 No. concrete rectangular surface channels for clarified water collection. The channels are 260 mm wide by 120 mm deep. The channels discharge the clarified water to 150 mm dia. pipes leading to the filters.

The other two clarifiers which are for the old stream are each provided with 3 No. 220 mm wide steel V-notched channels at the surface. Clarified water is evenly drawn off at the surface of the channels and passed into 75 mm dia. settled water pipes connecting to a 100 mm dia. manifold pipe leading to the filters.

Coagulated water from the distribution box enters each clarifier from the bottom through 150 mm dia. pipes equipped with sluice valves. All the four clarifiers are also provided with 100 mm dia. sludge blanket draw-off outlets for maintaining the blanket at an acceptable level. Additionally 150 mm dia. bottom sludge scour pipes are also provided.

Four 3.0 x 2.5 m rapid gravity sand filters are provided. At a surface loading rate of 3.0 m/hr each unit has a nominal capacity of 22.5 m^3/hr. All the four units would then be able to handle 2,160 m^3/day

Each unit is provided with a 150 mm backwash pipe connected with a 150 mm clear water pipe and 2 No. sluice valves. Air scour is through a common 75 mm dia. pipe with 50 mm dia. individual connections. Provision for wash water drainage through 150 mm dia. pipes has been made.

The filter pipework gallery is poorly drained with most of the valves leaking. Each of these valves requires inspection and or replacement as necessary. The filter under drains should also be checked to assess their condition.

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7.1.4.4. New Works

From the distribution chambers outside the chemical house, coagulated water flows through 4 No. 150 mm dia. pipes installed in the bottom of the chambers to converge at 300 mm dia. pipe constituting the inlet to the new works. This pipe is provided with 100 mm dia. washout in a chamber outside the laboratory. Water is led through an inlet valve chamber to the flocculation compartment.

Flocculation is by a series of 9 No. over and under chambers (vertical flow baffled channel). Each chamber is 1250 x 1450 x 2500 mm deep and they are connected to each other by 300 mm dia. openings.

From the last flocculation compartment water flows to a 520 mm wide x 850 mm deep channel which distributes the water to the horizontal flow sedimentation tanks, through a pipe entering from the bottom. The channel is provided with a 150 mm dia. scour pipe draining to a washout chamber adjacent to the flocculation unit.

Three 16000 x 3300 mm horizontal flow sedimentation tanks are provided for the new works. The walls are made of 300 mm wide reinforced concrete and are in structurally sound condition. The inlets to the sedimentation tanks are controlled and isolated by manually closed gates installed along the distribution channel.

The sedimentation tanks slope to the centre, and are provided with a scour pipe and washout chamber. Clarified water is collected through a 500 mm wide x 500 mm deep V-notched channel running along the width of the tanks. The channel is provided with an overflow facility through a 200 mm dia. pipe.

With a surface overflow rate of 0.90 m/hr, each sedimentation tank would have a capacity of 47.5 m^3/hr hence in total can handle 3,420 m^3/day.

From the sedimentation tanks, flow proceeds to three 4500 x 3300 mm rapid gravity sand filters. With surface overflow rates of 3m/hr the filters can handle 3,101 m^3/day in total.

The settled water enters the filters through a 200 mm pipe. The filtered water flows through a 200 mm dia. pipe provided with a first filtrate outlet pipe and valve. The 200 mm dia. filtered water pipes from each filter discharges to a common 250 mm dia. pipe leading to the clear water tank. A 200 mm dia. backwash water pipe to each filter is provided and joins the filtered water pipe. To prevent air binding of the filter sand the backwash water pipe should be interchanged with the clear water pipe. This appears to be necessary due to a construction fault of connecting the backwash water inlet to the elevated collector (above sand level) and the filtered water outlet pipe to the manifold level pipework.

7.1.4.5 Clear Water Tank

An approximately 20 m dia. reinforced concrete circular tank equipped with a float gauge has been provided. The tank cover is a 150 mm reinforced concrete slab with an access to the inside of the tank.

Flow from the old and new works joins before chlorination chamber and then flows through a 300 mm dia. pipe to the tank. Before entering the clear water tank however, a 150 mm dia. branch carries water directly to the Ring Road area, and more recently to Skuta.

7.1.4.6. Chemical Building

The chemical building house the Laboratory/office, the chemical store, inlet works and the alum, soda ash and chlorine storage, mixing and dosing equipment.

Four 1000 x 1000 mm alum solution tanks in groups of two have been provided for the works. Electrical stirrers for alum mixing have also been installed, and are in working condition except that the starters have been disconnected. A 25 mm dia pipe from the elevated tank feeds water to the solution tanks. Four FRO gravity dosers were installed but are out of order.

Four 700 x 800 x 1000 mm deep solution tanks equipped with dissolving baskets and electrical stirrers are provided for soda ash dosing when necessary. The FRO gravity dosers provided for this purpose are also out order.

TCL mixing is in two 1500 x 21500 x 1200 mm deep asbestos cement solution tanks. The dosing rate is determined by timing the flow through the dosing funnel with a stop watch, as no chlorine dosers are available.

The laboratory at the main entrance to the building is poorly equipped. pH determination is by lovibond comparator method, alkalinity test is carried out by the normal titration method using methyl organge, whilst residual chlorine is by the lovibond comparator method using DPD tablets. Colour and turbidity measurements are not carried out in the laboratory as there is no equipment for the tests.

From the records available the raw water pH averages at 7.1, whilst alkalinity is 26 mg/l as calcium carbonate. Alum dosage rate varies between 16 mg/l to 96 mg/l.

A 4.5 x 4.5 m store for alum and TCL is provided at the ground floor of the building. No storage facility is specifically provided for soda ash.

7.1.5 Distribution System

As was mentioned in Section 3 of this report, drawings of the reticulation system, based on what appears to have been an extensive survey of the early 1970's, are known to be in Maji House, but it did not prove possible to have these availed. Neither were the drawings

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done in the 1982 water supply study availed. The Council Engineer has a drawing which he has compiled personally over his stay in Nyeri, and this then was the major available record. In addition, the consultant's staff undertook some confirmatory field investigations, but these were essentially limited.

The resultant presumed distribution network is presented in the drawings accompanying this report. It must be reiterated that the accuracy of these drawings cannot be assessed without executing an exercise of re-constructing as-built drawings from field investigations on a line by line basis.

The basic overall situation is however quite clear.

The only storage is the tanks at Kamakwa and at the District Water Office. All of the distribution is by gravity, save for relatively minor supplies to the Kamakwa area, and to some Government communications facilities at the top of Nyeri Hill.

The main reticulation is in three networks - the central business district (CBD), Ring Road, and Ruringu. Significant extensions off the networks are:

(i) a 90mm dia. PVC branch off the Ring Road network into adjacent areas of mixed urban/rural nature,

(ii) parallel 90mm and 63 m dia. PVC branches off the Ruringu network, down the Nyeri-Nairobi road,

(iii) a 110mm dia. PVC branch from the CBD network into the high density housing area which is rapidly developing on the road to the sewage works (Kangemi area), and

(iv) the northern pipelines, which start from the top of the CBD network.

These latter pipelines are formed by the 100 and 150 mm dia. AC pipe mains into the Kingongo areas, which have been extended in 90 mm dia. PVC along the Nyeri-Kiganjo road; mixed AC/GS/PVC pipework upto 150 mm dia. along the Nyeri-Nyahururu road, upto the Kimathi Institute of Technology; and 160/110 mm dia. PVC along the Kingongo-Mathari road. The last of these branches is also fed by a direct line across the Chania river.

The principal network is constructed in AC pipes, but more recent pipework is in PVC, especially extensions and in-fills. Very few pipelines are galvanised steel (GS). The largest pipe sizes are 200 mm dia., but this is only for the pipework from Kamakwa towards the CBD. Most of the principal pipelines in the main networks are 100 and 75 mm dia., with a few 150 mm dia. lines in the CBD.

7.2 Kiganjo Water Supply

7.2.1 Water Works

Abstraction for the Kiganjo Water Supply is from the Nairobi river, which runs in the valley below and to the north east of the town. There is evidence that the original scheme was based upon treatment at the intake, but these facilities were obviously abandoned in the distant past.

Presently the intake has a concrete weir across the river, a pump room, and a double unit operator's house. The units in the pump hall are three electric driven pumps, and one diesel powered unit. The latter, although a "standby" is of limited emergency usage due to it's relatively low capacity. Data on these pumps and their state of repair is in Annex 7, but suffice it to say that a significant amount of rehabilitation is needed to bring this station into a reliable state.

Pumping is through 4 No. 100 mm dia. GS pipes to the Treatment Works which are at the junction of the Nyeri-Kiganjo link, and the main Nairobi-Nanyuki road.

The inlet works at the water works are on an elevated platform with an underlying chemical store. One tank of 1x1x0.8m is for alum solution, and a similar one for soda ash. After dosing, two channels lead the water to a mixing tank, and the water is then distributed to three circular clarifiers of 4.3 m diameter.

Clarified water is piped through a 100 mm dia. GS pipe to the filters, with off takes from this pipe feeding each of the 4.3 m dia. filters. There is also a 100 mm dia. bypass to allow direct supply of water after clarification.

With optimum, or at least satisfactory operation of the clarifiers and chemical dosing, overflow rates of 1.25 m/hr. for the clarifiers, and 3 m/hr. for the filters would be applicable. This would give capacities of 1,300 m^3/day through the clarifiers, and 3,140 m^3/day through the filters. The relative oversizing of the filters is noteworthy. It should however be noted that when raw water is available, the works are operated at over-capacity, and the resultant inefficient clarification would tend to reduce the rate at which the filters can handle such water.

Clear water storage is in 4 No. 136 m^3 reinforced concrete tanks, which are interconnected by 100 mm dia GS pipework. Chlorine dosing is carried out at tank no. 1, with the dosing tank and day chemicals being on a timber platform on the tank roof.

Additional storage is in elevated pressed steel tanks which, although located within the grounds of the adjacent Police College, are understood by the consultant to be part of the water works facilities. These tanks have nominal capacities of 50 m^3 and 80 m^3.

An approximately 50 m^2 building houses the pump room, laboratory/office, and store. The pump room has 5 No. pumps, 2 of them being diesel powered.

Housing for operators at the water works is limited to 3 units, but the not very distant sewage re-pumping station has more houses, some of which it was understood, are used by water works staff.

7.2.2 Distribution System

The Kiganjo distribution is essentially in two components. There are directly pumped supplies, and those fed off the elevated tanks.

The supply to the town centre and the three major industrial consumers is through three main pipelines; a 150mm dia. AC and a 110 mm dia. PVC pipeline being from the pumphouse, and a 150 mm dia. branch off the Kirichu line from the elevated tanks. The supply to the Police College is directly off the elevated tanks.

The other pipe mains run to the south, feeding the other major institutional consumers, Kirichu trading centre, and rural areas. One is known as the Kirichu line, being a 100 mm dia. AC pipe from the elevated tanks, and the other a 110 mm dia. PVC pipe from the pumphouse, known as the Kagumo line.

The Kagumo line provides a branch to the Kagumo High School, and then immediately after links into the Kirichu line.

The Kirichu trading centre itself is a significant population centre, as it has not only the shopping area, but also an adjacent "village". The village is an area of very small plots (less than 0.1 ha) inhabited by people who were moved there in the 1950s and who are presently more of wage earners than farmers.

The Kiganjo reticulation extends for a considerable distance beyond the Kirichu trading centre into the rural areas bordering the Kiganjo-Nairobi road. For several reasons, the consultant did not attempt to determine the details of that network. Firstly, that pipework does not carry any water and has not done so in the recent past. Significant parts have never actually been wet, having been constructed by potential consumers who's optimism proved unjustified from the start. These rural connections are not presently part of the consumer base. Moreover, as described below, there presently are efforts by several groups to provide those areas with alternative sources of piped, albeit untreated water.

What is of essence is a definition of the area that the Council attempts to serve, and a limitation of Council activity to within such areas. The Kiganjo and Kirichu "towns", and institutions in between are obviously in such an area, and the "tail" end of the reticulation is not seen as being part of the real supply area. In between these two, a boundary of supply needs be delineated.

7.3 Non Municipal Council Water Supplies

7.3.1. General

There are a total 9 No. public water supplies within the Municipal borders in different stages of implementation, excluding the Municipal Council operated supply, as shown in the table below.

TABLE 7.1
NON MUNICIPAL COUNCIL PUBLIC WATER SUPPLIES

Name of Water Supply	Stage of Implementation			Enabling or Undertaking Agency(ies)
	In Operation	Under Imple-menta-tion	Proposed but not Implemented	
Muhoya	✔			EEC & MOLRRWD
Njengu		✔		Canadian High Commission
Wangi			✔	Not yet determined
Aguthi	✔			NWCPC
Nyaribo		✔		RDF, NMC
Ireri-Kirumia			✔	Not yet determined
Kanuna		✔		Catholic Diocese
Ndathi-ini		✔		Catholic Diocese
Tetu-Thegenge	✔			MOLRRWD

Only two of these water supplies, namely Aguthi and Tetu-Thegenge, provide or are designed to provide fully treated water. The rest supply or envisage to supply raw water for domestic and/or minor irrigation purposes.

In addition, there are a number of major consumers who operate their own private water supplies either because they are outside a public supply, or because the public supply in their area is inadequate.

7.3.2 Public Water Supplies in Operation

7.3.2.1. Muhoya Self-help Water Supply

The project is being funded by the European Economic Community (EEC) and the beneficiaries. Commissioning was expected to take place in April/May 1995. The Ministry

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of Land Reclamation and Regional Water Development (MOLRRWD) undertook the design and supervision, whilst construction is being carried out by the local community. The intake is located at Zaina river (Grid ref. 256370°/995388°N- map sheet 120/4). In the early 1980's the area was being served by a 50 mm dia. 2" pipe from the Tetu-Thegenge water supply to a 90 m^3 masonry tank near Kihuyo market but the supply was insufficient. In 1993, construction work commenced to augment the supply. A raw water main, of 225 mm dia. PVC was laid and a 225 m^3 masonry reservoir constructed which will feed the existing reticulation. It is intended to serve approximately 250 No. plots in Kihuyo and Nyarugumu areas within Kihuyo sub-location. It is intended to provide a flow of 4.25 l/s (367.2 m^3/day) for strictly domestic usage. No treatment is intended and supply is by gravity. The beneficiaries will be responsible for operation and maintenance of the system, through a committee they are expected to form.

7.3.2.3. Aguthi Rural Water Supply

This was a Danish funded project which was undertaken in two phases. Phase I was completed in 1983 at a cost of approximately KShs. 29 mio and Phase II in 1989 at a cost of approximately KShs. 24 mio. The project area is approximately 103 km^2. The project is operated by the National Water Conservation and Pipeline Corporation (NWCPC). It serves approximately 7,000 No. consumers in total of which 90% are metered. Of these 500 No. are within the Municipality and are all metered. The intake is located at Gura River (grid reference 259150 E/994540 N - map sheet 120/4), in the Aberdares forest. Average abstraction is 5300 m^3/day. Raw water is conveyed by a 10.6 km long, 300 mm dia pipe to Mathakwa-ini, where full treatment is undertaken. Raw water is used for backwashing and there is no provision for clear water usage within the Treatment Works. From the 2 No. treated water storage tanks, supply is by gravity to the consumers. The supply is adequate in most parts of the supply area, except those on the outskirts of the distribution system such as those bordering the Municipal Council system, and is used for domestic purposes and livestock demand.

7.3.2.3. Tetu-Thegenge Rural Water Supply

The undertaking agency is the Ministry of Land Reclamation Regional and Water Development (MOLRR & WD) and the project was completed in June 1976. The intake is on the Chania river. A 250 mm dia AC 250 m long raw water main with a flow of 46.3 l/s (4,000 m^3/day) to the Treatment Works is used. The project currently serves a total of 3,343 No. consumers by gravity, an unknown number of whom are within the Municipal Council's boundaries. However, distribution within the Municipality extends through and upto parts of Kihatha, Gitathi-ini, part of Karia and Chorongi/Giachamwenge wards. There is a 100 m^3 capacity masonry tank at Kihatha within the Municipality's boundaries. The Treatment Works exist but have proved "ineffective" necessitating a by pass. The actual cause of abandoning the Treatment Works could not be established. Installation of chlorination equipment at the first storage tank in the distribution is presently ongoing, but there is currently no disinfection. The supply is inadequate and water is supplied through rationing. It is reserved strictly for domestic purposes, but consumers are unmetered, and charged on monthly flat rates. There are however proposals to instal consumer meters.

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7.3.3. Water Supplies Under Implementation

7.3.3.1 Njengu Self-Help Water Supply

The project is financed by the Canadian High Commission and is to serve both Njeng'u and Nyaribo sub-locations, part of supply area falling within the Municipality boundaries. The project commenced in 1984 and the intake is on the Muringato river (Grid reference 263800^{O}E/995890^{O}N - Map sheet 120/4). A 5 km long 300 mm dia. PVC raw water main which is already laid is to convey water to a proposed 225 m^3 capacity masonry tank from where supply will be effected without treatment. Abstraction is designed at 71.8 l/s (6,205 m^3/day). The gravity system is envisaged to serve 580 No. plots of average size of 4 acres, for domestic and minor irrigation purposes. A limited distribution system is in place, off the Municipal Council supply, but the supply into the system has been inadequate. The new source is expected to serve these consumers.

7.3.3.2 Kanuna Irrigation Project (Phase I)

The beneficiaries, who are residents of Kanuna in Lower Kirichu sub-location applied for a water permit in 1992 and requested the Ministry of Agriculture, Livestock Development and Marketing (MDALDM) to prepare a design report. The proposed consumers are on the left side the Nairobi-Nanyuki road, and are inside the "dry" parts of the existing Municipal Council Kiganjo system. In 1992 the Ministry prepared a Preliminary Design Report which was forwarded to the project committee and the financier, the Catholic Diocese. The PDR recommended abstraction from river Honi (Q=1140 m^3/day for 10 hr pumping using one pump) and conveyed through a 250 mm dia. rising main 1.7 km long to 3 No. 150 m^3 capacity tanks. The total project area was approximately 200 hectares, and the project was expected to benefit 78 No. households in total.

Upon receiving the PDR, the Catholic Diocese and the beneficiaries went ahead to implement the project from July 1994 to March 1995. They have already laid a 100 mm dia GI raw water rising main and constructed the 225 m^3 capacity masonry tank and the pumphouse at the intake. It may be noted that the sizing of components is different from PDR's recommendations. It is understood that an officer in the MOLRRWD assisted in the revision of the PDR's proposals but no report was prepared. This project (Kanuna) and the Ndathi-ini project described below, have so far resulted in expenditure of KShs.10 mio, and what is remaining is the procurement of the 2 No. pumps, electricity supply to the pumphouse, and laying of the extended distribution networks which is envisaged to cost an additional KShs. 11 mio. The funds are available from the Catholic Church. The supply is for domestic purposes and minor irrigation. No treatment is to be undertaken.

7.3.3.3 Ndathi-ini Irrigation Project - Phase I

The project covers an approximate total area of 232 hectares. Its conception, subsequent design, and construction have been undertaken simultaneously with the Kanuna Irrigation Project, Phase I, by the same agencies.

Abstraction, according to the PDR, was to be from the Honi River, 1.5 to 2 km downstream of the Kanuna intake. An intake and pumphouse, a 250 mm dia pumping main and 4 No. 150 m^3 capacity tanks were to be constructed. The total demand was given as 140 m^3/day, supplying 95 No. households.

Presently, a 225 m^3 masonry tank has been completed, the pumphouse at the intake is in place, and a 100 mm dia GI raw water rising main has been laid.

The supply to Ndathi-ini in Lower Kirichu sub-location is for domestic purposes and minor irrigation. No treatment is undertaken.

7.3.4. Proposed Water Supplies

7.3.4.1 Wangi Self-Help Water supply

This project is part of the larger proposed Gachika rural water supply which split-up into the Wangi and Ireri-Kirumia water supply projects. Much of the intended supply for both projects is within the "dry" part of the Kiganjo (Municipal Council) reticulation.

The Ireri-Kirumia project is described below. The Wangi project is proposed to serve part of Kirichu sub-location with a total supply area capacity of 25.6 l/s (2212 m^3/day) from the Sagana River (Intake grid reference 281650E/995398N - Mapsheet 121/3). The raw water rising main is proposed to be 160 mm dia. PVC feeding 3 No. masonry reservoirs: 2 No. of 136 m^3 capacity and 1 No. of 227 m^3 capacity. The 136 m^3 tank was constructed in the early 1990s and was planned at that time to be served by the Kiganjo water supply, but no water has reached the tank to date. Under the Wangi project, 254 No. consumers are to be served. No treatment is envisaged, and the supply is for domestic and minor irrigation purposes. There is a likelihood of funding by the Kiganjo Parish of the Catholic Diocese, but this has not yet been confirmed.

7.3.4.2. Ireri-Kirumia Self-help Water Supply

This proposed project is intended to serve 400 No. homesteads in Gachika sub-location. Abstraction is proposed to be from the Sagana River and conveyance is to be by pumping through a 160 mm dia. PVC raw water rising main to a 225 m^3 storage tank, where it shall then be boosted to another 225 m^3 storage tank. Supply from the terminal reservoir shall be by gravity. The supply is intended to be for domestic usage and minor irrigation and no treatment is to be undertaken. Kenya Water for Health Organisation (KWAHO) have expressed interest in funding the project but the beneficiaries must raise at least one third the cost of the project.

7.3.4.3. Nyaribo Water Supply Project

The project was financed by the government's Rural Development Fund (R.D.F.), the Nyeri Municipal Council and the beneficiaries. It was implemented in 1986 and was intended to serve 300 No. homesteads in Nyaribo sub-location, part of which is within the Municipality's boundaries. Abstraction was from the Amboni River (Intake grid reference 276900 E/995830 N - Map Sheet 120/4).

The construction was in two components namely:

i) facilities clearly funded and owned by the public (government, Council and consumers), these being an intake structure and pump room, a 136 m^3 masonry tank, a 22 m^3 elevated steel tank, and distribution pipework, and

ii) the intake pump and raw water main, reportedly "contributed" to the project by a local individual.

The works were executed and put into use in 1992. Subsequently however, the individual who contributed the pump and rising main withdrew his goodwill, and stopped the use of the facilities he had "contributed". This caused the closure of the water supply project.

It may be noted that this part of Nyaribo had been included in the design of the Njeng'u water project, but the Nyaribo residents were to instal a trunk gravity main to their area. This remains a viable proposition.

7.3.5 Private Water Supplies

7.3.5.1. General

The organisations below are within the Municipal borders, and have their private supplies, either as the sole source of water, or to supplement the inadequate public supply.

Table 7.2
INDIVIDUALLY OWNED WATER SUPPLIES

Name of Consumer	Location	Treatment		Alternative Public Water Supplies to Which Connected
		Yes	No	
Thunguma Academy	Nyeri-Nairobi Road	✔		
Nyeri High School	Mathari	✔		
St. Paul Seminary	Mathari	✔		
Mathari Mission	Mathari	✔		

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Table 7.2 (cont'd)

Name of Consumer	Location	Treatment		Alternative Public Water Supplies to Which
		Yes	No	
Kamwenja Teachers College	Mathari	✔		
Mount Kenya Bottlers Ltd	Kingongo (Nyeri-Kiganjo Road)	✔		Nyeri Town (Municipal Council) - inactive connection
Kimathi Institute	Nyeri-Nyahururu		✔	Nyeri Town (Municipal Council)

It can be noted that, of the above institutions, four are in the Mathari area and all fairly close together. This is an important consumer base that the Council has been unable to serve.

A further institution worth mention is the Wambugu Farmers Training Institute, on the Nyeri-Nairobi Road. They were once a council water supply consumer, but suffered from severe shortages. They later obtained a connection from the Aguthi system, but this has not solved their problems. They are now considering their own groundwater based system, but have yet to commence implementation.

7.3.5.2. Thunguma Academy

This is a private school with a total resident population of about 1,000 persons, comprising boarding students, staff and dependants of the staff. Water is abstracted from the Thuta river using a pump with a 19 KW motor, and is conveyed to the treatment works by a 50 mm dia. GI raw water rising main. The proprietor did not permit an examination of the treatment works.

Water is stored in 2 No. undergroundwater tanks of 180 m^3 capacity and 2 No. elevated tanks of 18 m^3 capacity each.

Sewerage is disposed of into 2 septic tanks.

7.3.5.3. Nyeri High School

Nyeri High is a government provincial school with a resident student population of 722 pupils. The teaching staff living in the school component are 40 in number with 36 sub-ordinate staff members. Sewerage is disposed of into 4 septic tanks.

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Raw water is extracted from Muraria river through a furrow and is supplied after treatment to the school by gravity. The water treatment is conventional comprising of a screen, alum and soda ash dosing chamber, horizontal flow flocculation basin, 3 m diameter upward flow clarifier, rapid sand filter, chlorination chamber, backwash tank and 2 No. ground level clear water tanks approximately 7 m diameter and 4 m diameter respectively. The nominal capacity of these works is estimated to be about 200 m^3/day, and the supply is adequate for the school.

7.3.5.4 St. Paul Seminary

This is a Catholic Church run school of theology with a resident student population of 350. The teachers and subordinate staff are in 20 number, but there are only 7 houses for staff on the compound. Sewerage is disposed of into septic tanks.

Raw water is abstracted from the Muraria River via the same furrow as is used by Nyeri High School. Treatment is conventional. It consists of a inlet screen alum and soda ash dosing tanks, horizontal flow flocculation chamber, 3 m diameter upward clarification tank, 2 m diameter rapid sand filter and 2 No. ground lever clear water tanks of approximately 5 m diameter. The nominal capacity of this water supply is also estimated to be 200 m^3/day.

7.3.5.5. Mount Kenya Bottlers

The raw water intake for the Coca-Cola bottling plant is located on the Chania river and the abstraction rate is 600 m^3/day. The rising main is 600 m in length and constructed of 75 mm dia. GI pipes. The plant has 210 workers who work for 7 days every week. The production effluent undergoes preliminary treatment in grease traps and through baffle walls after which it is drained to the nearby prison for irrigation. Toilet effluent is disposed of by means of septic tanks.

All of the raw water is treated using conventional methods. This consists of a dosing chamber where soda ash, alum and chlorine are dosed, this being followed by an upward clarification chamber. Next is a tank 8 m^3 in volume, then 2 No. rapid sand filters 2 m diameter and a 636 m^3 clear water tank. The treated water is also stored in 2 No. steel elevated tanks of 30 m^3 and 40 m^3 volume. Water for direct use in bottling (about 10% of total water usage) is also subjected to further treatment as part of the production process.

7.3.5.6. Kimathi Institute

The institute until recently used to pump water from the Muringato river after which chemical dosing would be done in a 20 cm diameter 1 m deep cylinder. The actual chemical which was dosed could not be determined. Water would be then be pumped to an elevated tank from a 5 m^3 underground sump. This water supply is not used at present since the institute has been connected to the Municipal Council water supply system. The institute has a 380 person student and staff body. Sewerage disposal is into waste water ponds. 13 pit latrines are also in use due to the frequent water shortages.

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The connection to the Municipal system is reported to have been carried out due to serious outbreaks of water borne diseases on the campus. Once constructed, the pipeline to the institute has been connected to many other consumers on line. The supply is presently far below the required amounts.

7.3.5.7. Kamwenja Teacher's College

The college abstracts raw water from the Muraria river through the same furrow that serves Nyeri High School and the St. Paul Seminary. The college has a student/staff population of 1,325 persons. Sewerage disposal is through two facultative ponds and one maturation pond in the college grounds.

Raw water is treated using conventional means. Treatment starts with alum and soda ash dosing. This followed by coagulation/flocculation in a horizontal channel with baffle walls. The main treatment unit is one composite filter, which combines sinuous flow sedimentation with rapid sand filtration. Clear water is stored in 2 No. 5 m diameter chlorine contact tanks. The treatment works are also equipped with a pumphouse, housing 2 No. electric pumps, which deliver water to a 50 m^3 elevated tank for storage before distribution.

At the treatment site, the college has a separate system with abstraction, a sump and pumps, for raw water which is used for irrigation on the college farm.

7.3.5.8 Mathari Mission

The Mathari Catholic Mission is a large complex which consists of the following significant institutions:

i) a hospital with a capacity of 600 in-patients

ii) St Teresa's Primary School with 300 boarding students and resident members of staff (other than convent resident staff).

iii) a pastoral (training) centre with 100 resident students and 8 resident workers and staff,

iv) a newly opened nursery school, and an older nursery school with 140 pupils

v) Mary Immaculate Convent, with 300 residents,

and other associated facilities and institutions. The mission is managed by what they call a "procurement section", which has a further 100 resident employees. In addition there is a further institution on mission land which was originally run as an orphanage, but is now a separately managed commercial college with it's own new connection to the Municipal Council water supply.

Regrettably, several visits did not result in full information on the water supply for the mission but indications are that it has a capacity of about 400 m^3/day. The source is the same

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furrow that feeds the Kamwenja, St. Pauls and Nyeri High School water supplies. Conventional treatment is undertaken, and there is elevate storage of about 40 m^3 which services the mission distribution system.

7.4. Public Taps

It was established that within the Municipal Council system, there are only two authorised water kiosks. One is at Mathari, and the other near the densely populated Majengo low cost and informal housing area.

The Mathari structure is well built, being of masonry walls and corrugated galvanised iron (CGI) sheet roofing. The meter is on the wall outside the kiosk, and there is one tap in the front wall for drawing water. The operator has installed a 2.3 m^3 elevated CGI sheeting tank on a wooden platform, about 2 m above ground. The supply is thorough the meter, and into the tank, which then serves the public tap. The operator, Mr. Peter Mwangi, informed that the kiosk itself is owned by the Council, built in 1981, but he has installed the other improvements himself.

The kiosk clearly owes its operation to its location in a depression, lower that the surrounding consumers, who almost all have individual connections. When there is water in the pipeline, reportedly once every week or every fortnight, the pressure is inadequate to reach the surrounding shops and homes, but does fill the tank at the water kiosk. The clientele is however, largely drawn from the shopping centre. This is due to the influence on domestic consumers from

i) the proximity of the Chania River, which is used for water for most purposes,

ii) availability of roof catchment and storage facilities in most homes, which is the source of potable water at most times, and the source of all the water needed during rainy seasons,

iii) the unreliability of supply at the water kiosk, and possibly,

iv) the need to pay for water at the kiosk.

The commercial consumers (including the water kiosk owner) all have roof catchment storage, but this is inadequate. Their large usage of potable water, particularly in the tea houses and other food related business, is what brings them to use the water kiosk. Further, they are better placed to know when water is available at the kiosk, due to their proximity.

The water kiosk operator does not open up the kiosk and await business. The keys are at the operator's nearby tea house, from where any consumer can collect them, help himself at the kiosk, and then return the keys with the appropriate payment. In this fairly close knit community, this seems to work quite well.

Overall however, the usefulness of the water kiosk only seems to arise out of it's location, and thus its ability to tap the low pressure flow in the pipeline. With sufficient pressure of

Page

supply, even if intermittently, it is most probable that its present limited consumer base would disappear.

The other water kiosk is located in the town, just off the main street (Kimathi Way) near its junction with Temple Road. The kiosk is of similar construction - masonry walls and CGI roofing, and owned by the Council.

The surrounding buildings are high density residential housing of permanent construction, however there are temporary construction dwellings in close proximity, as well as informal sector workshops and other commercial activities. The location is therefore one that would be expected to give rise to brisk sales of water.

The water kiosk was found to be locked during the visit, and the meter removed, reportedly for non-payment of bills.

This was the official position. A later visit where no attempt was made to contract the operators was made however, and resulted in witnessing of abstraction of water from the kiosk, through the gate valve at the meter location. A car wash business appears to be operated there.

Although these are the two official water selling points, it became apparent that in the densely populated Majengo area, there were a significant number of people without individual connections. A limited attempt was made to identify sources of water in this area.

Enquiries with passersby and shopkeepers resulted in directions being given to two residences where water could be purchased. At one of these there was no unusual activity to be discerned, but at the other, there were a group of people with water containers, drawing water from an external tap. One woman was in attendance, and clearly in control of the proceedings. The approach of a stranger was clearly seen as an intrusion, leading the group to disperse, and indicating a furtive intent.

It did seem that some, and maybe most of the water needs of the Majengo residents without connections, are met by the Chania river at the bottom of the valley where Majengo is located. On the other hand there was also clear evidence of unauthorised sales of water from individual connections, although this was not being done openly.

7.5 <u>Rehabilitation Requirements</u>

7.5.1. Kiganjo Treatment Works

The Kiganjo treatment works are fed by 4 No. 100 mm threaded GS rising mains. The inlet washouts were on these pipelines could not be located and it is proposed that they be located and a chamber constructed. At present flow measurements to the works are not carried out as the installed V-notch intended for flow measurements is submerged, due to higher flows than it was designed for. A new suitable calibrated V-notch needs to be installed for the purpose.

The FRO gravity dosers are out of order and need replacement for accurate dosing. Provision of only one solution tank for each chemical is not appropriate, and additional solution tanks for each chemical are required, such that when one tank is in service at any given time, the other is either being used to dissolve the chemical, or being cleaned. The existing solution tanks and the dosing channels are badly pitted. They need to be thoroughly cleaned, replastered, and painted with chemical resistant paint.

All the clarifiers were in operation, however clarifiers No. 1 and 2 have developed circular cracks in the concrete walling, and this is causing leaking. The structures may have reached the end of their useful life, after having been in use for a period of 50 years. Whereas there is the possibility of repair, it may be found that they should, in the not very distinct future, be brought down and new ones constructed, as they are becoming structurally unsafe.

Before this longer term solution is achieved, the plaster within 0.5 m of cracks should be removed, the surface cleaned thoroughly and the plaster renewed. Further work would be to water proof the leak sites with an appropriate water proofing slurry such as "Vandex" or similar material.

The inlet piping to the clarifiers from the mixing tank lacks a flow control valve, hence it is not possible to isolate any of the clarifiers for cleaning or repair. Valves should be introduced before any repair on the clarifiers commences.

The timber access bridge connecting the units is also structurally unsafe and requires replacement.

The drainage valves for the clarifiers are located at a common place. These are buried and cannot be accessed easily for operation and maintenance. A common valve chamber for them should be constructed to enable frequent desludging of the clarifiers.

The overflow for clarifier No. 3 was observed to be at a higher level than for the rest of the clarifiers. This means that at instances of higher flows, this clarifier is likely to be overloaded. This needs to be levelled with the others.

A 100 mm dia filter bypass pipe equipped with appropriate valves for the clarified water is provided. The bypass valve for clarifier No. 1 is leaking seriously and needs replacement, and a chamber constructed for it. The bypass valve for clarifier No. 3 is also leaking and needs repair.

At the pipework leading clarified water to the filters, the valve to filter No.1 is leaking and it's chamber collapsed, whilst the valve to filter No. 2 is leaking and its spindle out of order.

Filters No. 1 and filters 2 have developed circular cracks similar to those of the clarifiers. These also seem to be reaching the end of their useful life. In the long term, they require to be brought down and new ones built in their place. In the meantime they need to be renovated in a similar manner to that described for the clarifiers.

The filtration rate was observed to be very low and the operators are usually forced to bypass some of the clarified water to the storage tanks. The low rate of filtration was attributed to the poor backwashing carried out currently, as a result of the breakdown of specific items of the backwash system. Whilst the air blower is in working order, the air valves to filter No. 1 and 2 are out of order, hence, no air scour is currently being carried out in those filters, and the third filter is not connected to the air scour system. The valves should be replaced and possibilities of introducing air scour to the third filter looked into. The filter media has an accumulation of mud balls and therefore needs to be removed, washed, sieved, replaced and topped-up.

The backwash water valve for filter No.1 is functioning but leaking and needs repair. On the other hand, the backwash water valve for filter No. 2, is not only out of order, but is also is corroded and leaking. It is proposed that it should be replaced and the chambers for all these valves rehabilitated.

The washout valve chamber for filter No. 2 has also collapsed and needs reconstruction.

All the four storage tanks were observed to be in structurally sound condition. They do need to be thoroughly cleaned on the inside however, and any internal faults repaired.

To enable the operators to know whether there is sufficient water in the tank for pumping, a visual tank level indicator should be installed in any of the tanks, preferably that nearest the pumphouse.

The inlet and outlet valves to and from storage tank No. 3 and 4 are out of order and need replacement. The outlet valve from storage tank No. 4 is also leaking seriously and needs repair.

Chlorine for disinfection is dosed from a 1.0 x 1.0 x 0.8 m fibre glass solution tank placed on a raised timber platform on top of storage tank No. 1. The dosing is done manually without a doser. Whereas it is most appropriate that a separate facility for the chemical mixing and dosing be available, it may be found that only limited measures are appropriate. In such a case, a chemical resistant lining should be provided over the tank roof to mitigate against the severe corrosive effects of chlorine. A simple shade over the dosing position should also be provided. Further, for more accurate and efficient dosing, an FRO gravity doser should be installed for the purpose.

The 2 No. elevated steel tanks located within the adjacent police college were also inspected. The 6.0 x 6.0 x 2.4 steel tank seemed to be in structurally sound condition, except that the inspection timber platform surrounding the tank requires rehabilitation, as it looks unsafe. The older 4.8 x 4.8 x 2.4 m elevated steel tank is partially corroded and leaking at the joints, but otherwise the tank and tower appear structurally sound. The tank would need repair, possibly by the insertion of a waterproof liner, and replacement of internal stays by external members. The timber platform providing access around the tank should also be repaired.

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All the electrical driven motor pumps were in working order, however, the diesel engines have been out of order for the last eight years.

The approximately 12 m^2 office cum laboratory room seems just adequate for the purpose, but the laboratory barely functions, as only residual chlorine and pH testing using the lovibond comparator can be carried out. The laboratory is definitely lacking in equipment, but that which is most critical is the equipment for jar tests.

7.5.1. Kamakwa Treatment Works

The raw water mains from the Ihwa Intake (gravity) and the Chania Intake (pumping) converge at the alum dosing chambers at the upper floor of the chemical building. The 150 mm dia. inlet pipework to the alum dosing points is corroded and should be replaced. The rest of the pipework inside the chemical building seems in sufficiently good order but should be repainted.

The 4 No. alum solution tanks are in structurally sound conditions, except the apparent need for painting with chemical resistant paint. The electrical stirrers for each of the solution tanks are believed to be in working order, however the starters for each tank are missing. These should be replaced. The 4 No. FRO dosers provided for each solution tank are all out of order, hence the amount of alum dosed is based on guess work. All the dosers need to be replaced with new ones.

The 4 No. soda ash solution tanks are also in good condition, but also need chemical resistant paint. Soda ash is currently dosed manually as there are no dosers provided for the purpose. Each of the soda ash solution tanks should be provided with an FRO doser.

The amount of chlorine dosed is determined by timing flow through a dosing funnel with a stop watch. 2 No. FRO gravity dosers for chlorine dosing should be provided. The on-line chlorine dosing practiced for the Mumbi Line is not appropriate as there is no provision for contact time. This pipeline should be modified to commence after, rather than before, the contact tank.

The 25 mm dia pipework network feeding the solution tanks with clear water is partially corroded, and leaking in many parts. The pipework could be rehabilitated in parts, but significant sections need to be replaced altogether. The floor of the dosing room is badly pitted and should be renovated and the walls painted. The door, leading to the old clarifiers from the dosing room is in poor condition and should be replaced.

The water, after dosing is led through a channel to the 2 No. deep steel distribution chambers, fixed on the outer side of the chemical building. Both the channels leading to the chambers are equipped with a V-notch meant for flow measurements. No flow measurements can be made with these devices, however, as the current flow through the notch exceeds the design flow and is submerged. The V-notches should be replaced with calibrated larger ones which will enable flow measurements to be made.

Considering the current flow to the works estimated at 5800 m^3/day, the mixing chambers seem inadequate. The estimated mixing time with the estimated current flow is less than 1 minute, whilst the recommended time is 2 minutes. The possibilities of improving the mixing process either by adding on to the mixing chambers or replacing them with new larger ones should be looked into.

The clarifier structures, though old, seem structurally sound, except for the apparent need for cleaning. All the four clarifiers should be emptied each at a time, thoroughly cleaned and any pitting refilled. The 0.5 m dia. centre feed inlet cores to each of the clarifiers are seriously corroded and should be replaced. The I-sections (beams) supporting the central core are also corroding, but only appear to need cleaning and painting.

The concrete collector channels for the very old works are badly pitted and need to be refurbished. The channels seem not to be level, which can cause short circuiting or the creation of undesirable dead zones. These should be levelled out. The V-notched collector channels for the old works should also be painted to prevent corrosion. The 100 mm dia. sludge bleeder pipes and all the air-vent pipes provided for each of the clarifiers are corroded and need to be replaced.

The old and very old filters at Kamakwa, like the clarifiers, though old, seem structurally sound.

The inlet pipework and valves to the filters seem satisfactorily, however, the pipe gallery is in a very poor state, as it is poorly drained. The 150 mm dia. pipework for filtered and backwash water is corroded in parts, needing replacement, and their respective valves have seized and also require replacement. To ease operation the valves should be provided with spindles reaching to the top of the filter walkway to enable the operator to open and close the valves without having to go down the ladder. Provision for draining and paving the area around the pipe-gallery should be made, as flooding of the gallery is contributing greatly to the corrosion of the pipework and valves, and in addition resulting in poor working conditions for the operators.

The new works flocculation chambers are in structurally sound conditions, but the slot widths seem to be inadequate for the current flow to the works. The velocity through the slots should be kept below 0.6 m/s, as recommended, by enlarging the size of the slots. Such an improvement would help prevent breakage of formed flocs. The free board allowed is also inadequate and small increases in the incoming flow causes overflowing. This should be rectified by raising the flocculation chambers' walls.

The three horizontal flow sedimentation tanks at the new works appear to be structurally sound and there was little to note in need of refurbishment here.

It was noted from the operators that each of the new works filters are backwashed 4 to 6 times in every 24 hours. Such a high frequency of backwashing is not really economical. The high rate of filter clogging could be attributed to formation of mud balls in the filter media, insufficient backwashing over a long period, and/or inadequate under drains. It is proposed that the filter media be removed, washed, filtered and replaced. At such a time, the filter under drains should be inspected, and if seen to have shortcomings, the necessary modifications or repairs be carried out.

In the design of rapid gravity sand filters, it is normal practice to have the filtered water outlet pipe raised to a level slightly above the filter media in order to prevent air binding of the media. In the new works, this is not the case. On the contrary, the backwash water pipe seems to have taken the position of the filtered water pipe. It is proposed that the pipe work be interchanged for efficient functioning of the filters.

The filtered water valves for filter no. 1 and 3 are leaking and should be repaired. Otherwise, the filter gallery is well drained and easily accessible.

The elevated steel tank which serves the areas upstream of Kamakwa treatment works is rusty and unsightly, hence should be painted both on the inside and outside. Additionally, a thorough check should be carried out to identify any areas of potential leaks and approved water proof sealant applied.

The reinforced circular tank seems satisfactory.

Clearly the Kamakwa treatment works laboratory is under-equipped, lacking even essential items like a turbidimeter and jar test stirrer. The only tests carried out are residual chlorine and pH using a lovibond comparator, and alkalinity measurements. Essential tests like turbidity measurements and colour are not carried out.

Stirring for the jar test is done manually by hand, which is inappropriate, as it cannot give results of any acceptable degree of accuracy.

It is therefore necessary that to serve the intended purposes, the laboratory should at the very least be equipped with the following most basic equipment:

- turbidimeter
- standard jar testing electrically driven stirrer
- conical flasks, burettes and pipettes
- pH meter
- Lovibond comparators for residual chlorine and colour measurements.

The above equipment is necessary for daily routine measurements. Other tests which are not done on a daily basis can be contracted out to other laboratories when necessary.

7.5.3 Raw Water Mains

The raw water mains from Ihwa to Kamakwa have different aspects of rehabilitation and improvement that are required.

The old main no longer has pipe markers, which made identification of it's route difficult, in some cases even to the line patroller. It is understood the markers existed, but being within farmland, have been removed or become dislodged with time. Throughput the pipeline, air valves need to be installed, washout valves serviced and/or replaced, and in some cases chambers need to be uncovered, reconstructed, or just provided with covers.

On the new main, the major concern is with the failure to find air valves and washouts at some points where these would be expected. This is considered an aspect of importance, in maintaining the quantity and quality of raw water.

The principle area of improvement required on the rising mains from the Chania intake is on the steep ascent from the intake, where the surrounding material is showing signs of being eroded and slipping away. The slopes need to be stabilised by a combination of vegetative protection and erosion barriers, however a principle concern here will be that the land is privately owned and the pipework is there by by virtue of wayleave.

7.5.4. Reticulation

A reconnaissance of the distribution network in Nyeri Town was undertaken between 13th and 16th March, 1995. This involved an assessment of the state of valves and other fittings on pipelines over 50 mm in diameter.

Only one significant point of leakage on a main pipeline was found, and this was immediately attended to when reported. This by itself does not present a full picture, since the deep permeable soils in the distribution system will soak up leakage, and mitigate against such being easily identified. This is what was the case on the old raw water main near the Ihwa intake, where as reported by the Council, a major leak had existed for a long time without surface indications, and only became apparent after major subsidence of the surrounding area.

On minor pipework especially in the central business district, quite a number of points of leakage were found, but again they were attended to upon being reported. It may be noted that the small diameter pipework between consumer locations tends to be closer to the surface and therefore it is easier to have the leagues being evident.

Other principal findings were:

i) many missing valves, especially air valves,

ii) frequent cases of buried valves

iii) lack of marker posts along pipelines, also lacking at almost all valves, and

iv) lack of valve chambers, collapsed chambers, and where there were chambers, lack of chamber covers.

In most places in the reticulation, air valves which have malfunctioned or been vandalised have been replaced with stopcock for manual air bleeding.

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A summary of the findings of inspecting 53 sluice valve locations, 14 air valves, 10 washouts and 6 fire hydrants is as follows:

i) Sluice valves

a) Valves

- in good condition	78%
- leaking	9%
- missing	4%
- buried	9%

b) Chambers

- in good condition	27%
- needing refurbishment	7%
- needing total reconstruction	17%
- no chamber	49%

ii) Air Valves

a) Valves

- in good condition	29%
- replaced with stopcock	43%
- inoperational	7%
- no valve	21%

b) Chambers

- in good condition	Nil
- in need of reconstruction	29%
- no chamber	64%

iii) Washouts

a) Valves

- in working order	60%
- valve not working	20%
- buried valve	20%

b) Chamber and Outfall

- in adequate condition	50%
- in need of rehabilitation	50%

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iv) Hydrants

a) valve in working order 100%

b) chamber

- in good condition 67%
- in need of rehabilitation 33%

The above does not indicate a satisfactory state of repair of fittings and their chambers.

One further aspect of note is the absence of bulk meters within the distribution system. Considering the significant loss of water especially in the Nyeri town system, and the indication that the majority of loss is physical rather than administrative, this is then an area where attention is required.

7.5.5 Electrical Mechanical Aspects

Annex 7 in volume II of this report contains the detailed findings with respect to the mechanical and electrical installations in the water supplies and sewerage systems.

With regard to the water supply systems, a general summary would be that the mechanical/electrical equipment is overall in need of renewal. The Nyeri town system, due to its low mechanisation, does not suffer that greatly from defects, except in chemical mixing/dosing, air scour and back washing, and the reliability of the Chania pumping source. Much of the equipment at the water works needs replacement, including the backwash pumps which are operational but old and unreliable. The two Weir pumps at the Chania intake are working and save for some maintenance (leaking glands, check on motor/pump alignments and improvement to cable connections) can be said to be in adequate condition.

The Kiganjo system had the principal problems. At the intake, none of the pumps were in service in December 1994, but by January, one pump had been procured. The station should have three operational electrical driven pumps. The diesel unit, due to its limited capacity, is of little use as a standby. This whole station is in need of basic re-equipping. At the treatment works, the electric pumps were operational, but were not very reliable; frequent attention to them was said to be necessary to keep them working. The two diesel units had been inorperational for some time.

The Kiganjo system also has problems with lack of dosers and no chemical mixing equipment.

Page

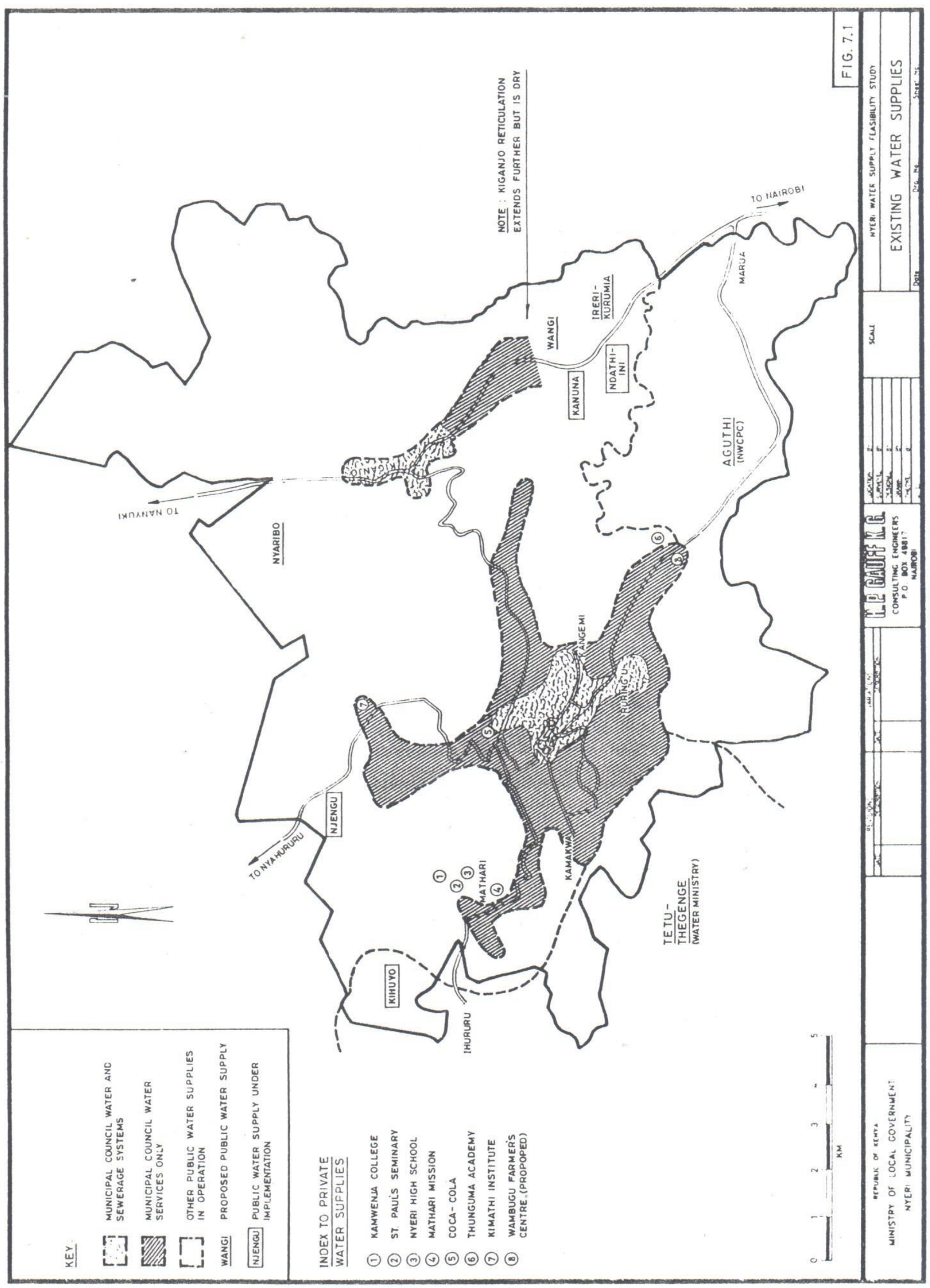
FIG. 7.1
NYERI WATER SUPPLY FEASIBILITY STUDY
EXISTING WATER SUPPLIES
NOTE : KIGANJO RETICULATION EXTENDS FURTHER BUT IS DRY
TO NAIROBI
TO NANYUKI
TO NYAHURURU
WANGI
IRERI-KURUMIA
NDATHI-INI
KANUNA
MARUA
AGUTHI (NWCPC)
NYARIBO
NJENGU
MATHARI
KAMAKWA
TETU-THEGENGE (WATER MINISTRY)
KIHUYO
IHURURU
KEY
MUNICIPAL COUNCIL WATER AND SEWERAGE SYSTEMS
MUNICIPAL COUNCIL WATER SERVICES ONLY
OTHER PUBLIC WATER SUPPLIES IN OPERATION
WANGI PROPOSED PUBLIC WATER SUPPLY
NJENGU PUBLIC WATER SUPPLY UNDER IMPLEMENTATION
INDEX TO PRIVATE WATER SUPPLIES
1 KAMWENJA COLLEGE
2 ST. PAUL'S SEMINARY
3 NYERI HIGH SCHOOL
4 MATHARI MISSION
5 COCA-COLA
6 THUNGUMA ACADEMY
7 KIMATHI INSTITUTE
8 WAMBUGU FARMER'S CENTRE.(PROPOPED)
0 1 2 3 4 5
KM
REPUBLIC OF KENYA
MINISTRY OF LOCAL GOVERNMENT
NYERI MUNICIPALITY
L.P. GAUFF K.G.
CONSULTING ENGINEERS
P.O. BOX 49817
NAIROBI

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8. WATER CONSUMPTION

Do they [illegible] water

8.1 Zones

The Nyeri Municipal Council has divided the water supplies into a number of zones, 18 in Nyeri and 3 in Kiganjo. All meter reading and billing is organised on a zonal basis, and it is therefore possible to break down consumption and billing on a zonal basis. Hence the data in this section which shows the current picture of distribution/consumption of water in different parts of the town is presented by zone. Table 8.1 presents a brief description of the different zones, the location of the largest consumers, and the number of connections in every zone, while Figure 8.1 presents a map of the zones.

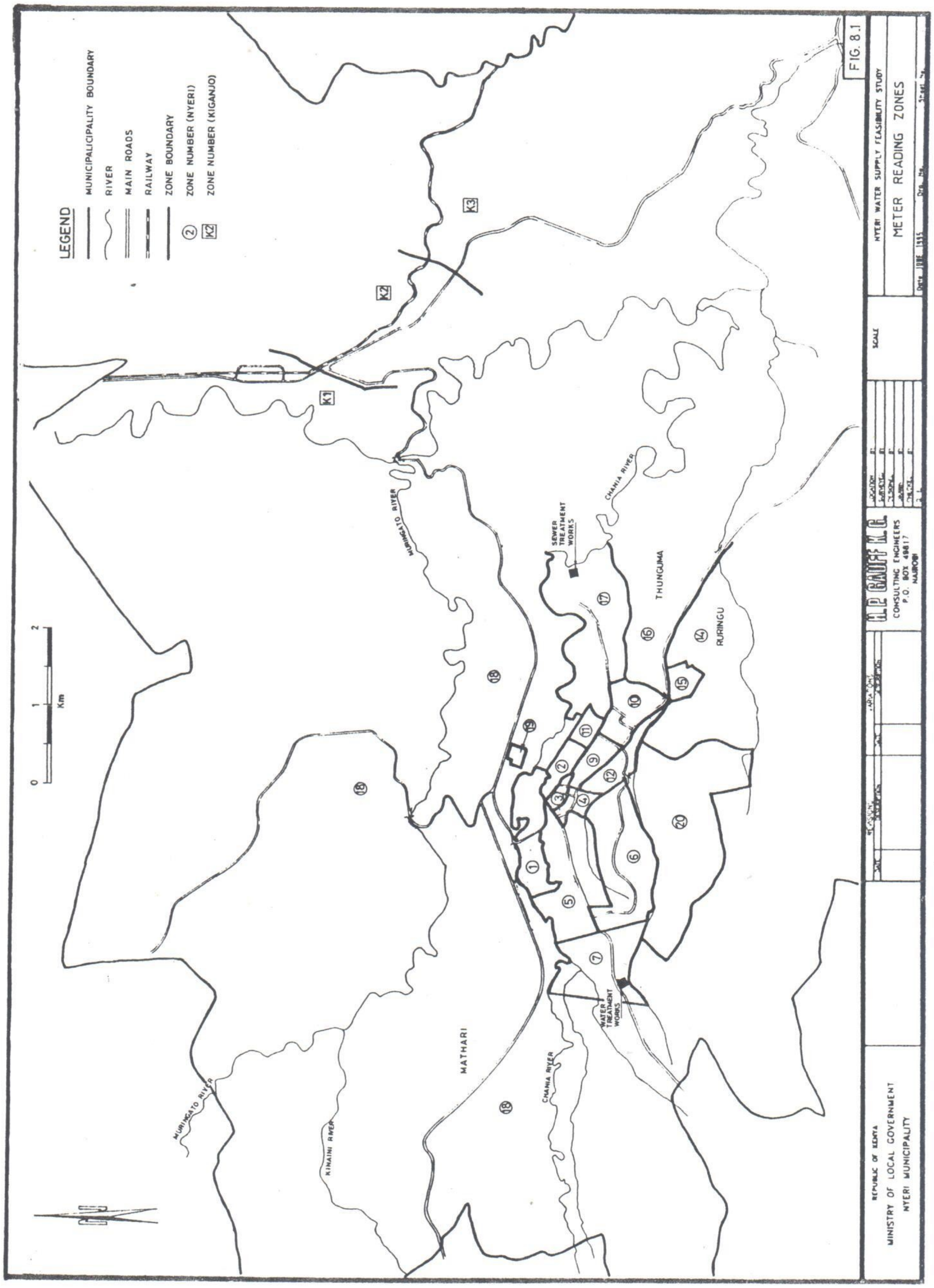
Two sets of numbers of connections are presented. Firstly the total number of connections in each zone in September 1994 provided by the Municipal Council's Engineer. This was the total number of connections regardless of whether or not the consumer was currently active. It can be seen that the total was 4577 in the two supplies. Since in Section 10.2.1 it is shown that of the total number of connections which were closed in September was 550, the number of active connections from this estimate was 4027 in both Nyeri and Kiganjo.

The second set of numbers shows the number of active connections based on enumerators going through all the meter books. The connection had to be receiving water at the time of the exercise, and hence could slightly under-estimate the number of active connections. It should be noted that the number for zone 20 was not counted and the figure in the table was estimated on a pro-rata basis. It can be seen that the total number of connections was 3884. This is just over 7% fewer than that indicated above. However for the purposes of the present exercise, the figure is sufficiently accurate. Furthermore the small difference between the two estimates shows that the Council records are good, and that the enumeration exercise although rapid provided a reasonable estimate of the number of currently active connections by zone.

8.2 Water Consumption and Billing by Zone

In order to examine the composition of consumption and water charges by zone, the consultants examined the billing control sheets for the period July-December 1994. The complete figures for the six month period are presented in Table 8.2. While these records are an accurate reflection of the amounts actually billed, they contain a few errors. For example in some months there was a failure to bill one or two zones. Furthermore the variation in consumption between months means that there were special factors in play during some months or that there are errors. Hence the consultants have attempted to estimate the typical current situation for an average month, taking into account all these factors. Where month to month variations are small the estimated consumption is based on the calculated average. Where there were large variations however, it has been necessary to use a judicious estimate. The figures are presented in Table 8.3.

Page


LEGEND
MUNICIPALICIPALITY BOUNDARY
RIVER
MAIN ROADS
RAILWAY
ZONE BOUNDARY
ZONE NUMBER (NYERI)
ZONE NUMBER (KIGANJO)
K1
K2
K3
Km
MURINGATO RIVER
CHANIA RIVER
SEWER TREATMENT WORKS
WATER TREATMENT WORKS
THUNGUMA
RURINGU
MATHARI
FIG. 8.1
NYERI WATER SUPPLY FEASIBILITY STUDY
METER READING ZONES
CONSULTING ENGINEERS
REPUBLIC OF KENYA
MINISTRY OF LOCAL GOVERNMENT
NYERI MUNICIPALITY

Page

Low Cost/Rural Areas Connection/Population Rat

Area	Connections Gauff	Pop. 89
1. Kamakwa	205	9130
2. Majengo	129	18478
3. Ruringu Town	169	10609 Ruringu/Thug
4. Ruringu Rural	321	
5. ~~Skuta~~ Blue Valley	300	
6. Kiganjo Rural	195	
7 Ngangarithi	254	

Source: HP Gauff + Census 89

$\frac{2}{5} \times \cancel{100}^{20}$ -

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Table 8.1
DESCRIPTION OF ZONES & NUMBER OF CONNECTIONS

Zone No.	Area	Characteristics of Supply Area	No.of Conns NMC	Gauff
	NYERI TOWN			
1	Bondeni	Medium Cost Housing	117	111
2	St Peters	Mix - Govt Offices, Light Ind. Shops, Low Cost Housing	155	146
3	Labour	Same as 2	135	124
4	DC's	Offices, Shops, Hotel, MC Housing.	129	119
5	Baden Powell	HC/MC Housing, Outspan&Golf Club	87	85
6	Mumbi	Mainly domestic. Mixed LC/MC/HC Nyeri Tech Inst, Mt Kenya Hosp. Green Hills	296	268
7	Kamakwa	Low Cost Housing, Shops	258	205
9	Town Centre	Compete Mix, Div Police HQ	382	371
10	Asian Quarters	Only domestic - mix HC/MC/LC	198	172
11	Majengo	Low Cost Housing/Shops	142	129
12	Kimathi Estate	MC Housing	207	178
14	Ruringu Rural	Mixed Housing	450	321
15	Ruringu Town	Commercial. LC Housing, Few HC	222	169
16	Skuta	Domestic HC/MC	199	145
17	Blue V/Kangemi	Domestic LC/MC P.G.Hospital	362	300
18	King'ong'o Rrl	LC/MC Housing, Industry, Prison, Nyeri P.School, Kimathi Institute	233	195
19	King'ong'o Est.	MC Housing	336	*276
20	Ngangarithi	LC/MC/HC Housing	299	*254
	Sub-Total		4207	3568
	KIGANJO			
K1	Town	Police College, KCC	107	91
K2	Kericho	Kangumo H.S.	180	154
K3	Kanuna		83	71
	Sub-Total		370	316
	TOTAL		4577	3884

* *pro-rata estimate, actual count not done*

Analyse Numbers vs Conne
Compre with

C

TABLE 8.2 SUMMARY OF CONTROL SHEETS SHOWINGBILLING BY ZONE JUL - DEC 1994 in KShs

November-December 1994

ZONE	1	2	3	4	5	6A	6B	7A	7B	9A	9B	10A	10B	11	12	14A	14B & C
Water Charges	194,600	154,857	164,399	232,097	214,021	181,040	95,249	75,772	31,631	313,570	168,201	76,528	29,483	138,500	103,090	85,915	64,997
Meter Rent	1,669	2,006	1,801	1,821	1,212	2,620	1,261	1,997	835	2,866	2,441	1,872	663	1,862	2,714	2,020	2,307
Sewerage	47,973	97,220	92,749	197,379	27,175	111,798	3,908	0	0	275,014	135,487	67,667	27,075	101,745	91,324	1,766	7,803
Conservancy	5,390	5,742	5,038	4,902	3,190	7,040	3,344	2,222	682	9,178	6,734	5,148	1,870	5,192	7,326	1,254	440
Total	249,632	259,825	263,987	436,199	245,598	302,498	103,762	79,991	33,148	600,628	312,863	151,215	59,091	247,299	204,454	90,955	75,547
Volume (m3)	10,349	8,407	8,831	12,013	10,801	9,885	5,429	4,887	1,874	16,227	8,933	4,687	1,738	7,752	14,286	4,902	3,741

September-October 1994

ZONE	1	2	3	4	5	6A	6B	7A	7B	9A	9B	10A	10B	11	12	14A	14B	14C
Water Charges	150,959	82,117	157,468	140,288	79,482		83,315	57,618	28,214	412,485	230,802	11,025	25,900	129,479	113,708	76,202	27,341	17,629
Meter Rent	1,746	1,833	1,841	1,680	1,107		1,343	1,794	798	3,262	2,652	398	593	1,667	2,660	1,919	1,349	833
Sewerage	16,586	41,991	89,621	124,333	244		1,930	660	447	359,358	177,746	10,032	23,967	91,089	102,958	0	3,376	2,660
Conservancy	5,630	4,902	5,104	4,528	2,948		3,686	1,822	692	10,160	7,530	1,122	1,672	4,458	7,503	902	44	264
Total	174,921	130,843	254,034	270,829	83,781		90,274	61,894	30,151	785,265	418,730	22,577	52,132	226,693	226,829	79,023	32,110	21,386
Volume (m3)	8,332	5,008	8,519	17,566	4,599		4,901	3,718	1,659	21,096	12,176	753	1,484	7,176	6,831	6,395	1,536	948

July-August 1994

ZONE	1	2	3	4	5	6A	6B	7A	7B	9A	9B	10A	10B	11	12	14A	14B	14C
Water Charges	43,371	33,751	43,908	43,138	52,106	59,263	30,067	26,724	9,583	215,303	55,162	25,042	10,236	43,545	39,998	25,251	14,058	5,692
Meter Rent	1,358	1,638	1,371	1,479	958	2,041	1,046	1,781	637	224	2,067	1,547	514	1,495	2,085	1,786	1,092	657
Sewerage	4,877	14,286	24,749	35,188	342	31,089	534	90	0	161,679	44,062	23,079	9,109	29,781	36,291	262	985	887
Conservancy	4,116	4,389	3,798	4,014	2,610	5,463	2,772	1,818	504	2,598	5,724	4,284	1,422	4,104	5,604	897	36	216
Total	53,722	54,064	73,826	83,819	56,016	97,856	34,419	30,413	10,724	379,804	107,015	53,952	21,281	78,925	83,978	28,196	16,171	7,452
Volume (m3)	7,487	5,767	7,378	7,373	8,903	10,000	5,167	4,490	1,573	36,022	8,964	4,104	1,677	7,412	6,853	4,215	2,212	892

TABLE 8.2 (cont'd)

November-Dec

ZONE	15A	15B	16A	16B	17A	17B	18A	18B	19A	19B	20A	20B	Nyeri Total
Water Charges	76,570	2,524	12,606	15,230	342,336	47,533	807,758	134,082	26,675	65,848	49,130	27,353	3,931,595
Meter Rent	2,067	156	671	796	2,532	1,645	1,805	1,172	632	2,059	1,934	1,521	48,957
Sewerage	35,828	1,815	0	0	248,303	240	350,684	5,818	23,371	55,037	0	1,561	2,008,740
Conservancy	5,390	440	0	0	3,256	770	1,122	660	1,782	5,768	0	44	93,924
Total	119,855	4,935	13,277	16,026	596,427	50,188	1,161,369	141,732	52,460	128,712	51,064	30,479	6,083,216
Volume (m3)	4,829	167	777	832	16,162	3,105	44,863	6,979	1,700	4,093	3,034	1,798	223,081

K1	K2	K3	Kiganjo Total
693,647	43,688	16,579	753,914
940	1,256	725	2,921
616,312	3,248	0	619,560
3,370	506	0	3,876
1,314,269	48,698	17,304	1,380,271
32,055	2,344	2,261	36,660

September-Oct

ZONE	15A	15B	16A & B		17A	17B	18A	18B	19A	19B	20A	20B	Nyeri Total
Water Charges	93,661	1,797	25,627		64,953		325,563	14,640	87,648	64,925	42,137	27,089	2,572,072
Meter Rent	2,145	117	1,564		1,521		2,439	304	2,004	2,138	1,412	1,380	42,499
Sewerage	36,119	1,456	1,221		7,098		25,345	734	73,423	56,308	0	160	1,248,862
Conservancy	5,522	330	154		1,298		1,503	282	5,566	6,178	88	132	84,020
Total	137,447	3,700	28,566		74,870		354,850	15,960	168,641	129,549	43,637	28,761	3,947,453
Volume (m3)	10,592	103	1,786		3,901		20,768	833	8,035	3,863	2,814	1,717	167,109

K1	K2	K3	Kiganjo Total
838,342	89,753	46,111	974,206
1,510	2,224	983	4,717
735,779	23,437	160	759,376
4,886	990	44	5,920
1,580,517	116,404	47,298	1,744,219
39,125	4,989	2,684	46,798

July-August 19

ZONE	15A	15B	16A	16B	17A	17B	18A	18B	19A	19B	20A	20B	Nyeri Total
Water Charges	30,539		7,832	4,937	34,058	18,710	218,344	43,703	26,077	19,560	26,944	10,172	1,217,074
Meter Rent	1,826		761	642	1,956	1,397	1,703	846	1,579	1,599	1,800	1,085	38,970
Sewerage	13,946		101	7	9,927	240	73,963	902	22,600	17,272	0	0	556,248
Conservancy	4,608		162	0	2,628	684	1,098	342	4,374	4,410	0	0	72,675
Total	50,919		8,856	5,586	48,569	21,031	295,108	45,793	54,630	42,841	28,744	11,257	1,884,967
Volume (m3)	5,110		1,034	524	5,759	3,471	36,652	7,365	4,407	3,025	4,389	1,425	203,650

K1	K2	K3	Kiganjo Total
196,966	33,717	12,554	243,237
1,173	2,010	851	4,034
147,603	5,210	0	152,813
4,128	1,008	0	5,136
349,870	41,945	13,405	405,220
32,848	5,405	2,013	40,266

Table 8.3
CONSUMPTION AND CHARGES BY SUB-ZONE (NYERI TOWN)

Meter Book Sub-Zone	Av.Billed Consump. (m3/month)	Meter Rent	Water Charge	Sewerage Charge	Cons. Charge
		------------ Shs/month -----------			
1	4,360	850	80,660	19,900	2,750
2	3,200	950	57,600	36,200	2,650
3	4,120	900	76,630	43,200	2,550
4	6,160	900	110,880	94,300	2,350
5	4,050	600	74,920	9,500	1,650
6A	5,000	1,300	91,500	59,500	3,500
6B	2,580	650	44,640	1,800	1,750
7A	2,180	950	33,800	N	1,000
7B	850	400	14,450	N	350
9A	12,000	1,500	233,400	204,700	4,500
9B	5,010	1,250	94,700	76,300	3,550
10A	1,600	900	25,600	22,600	2,000
10B	820	300	14,100	12,900	900
11	3,720	900	66,960	49,200	2,500
12	4,660	1,350	65,240	57,800	3,700
14A	2,590	1,000	45,320	930	550
14B	1,100	750	19,360	2,400	50
14C	460	400	8,600	1,300	150
15A	2,500	1,050	40,000	18,700	2,750
15B	70	70	1,190	870	200
16A	450	400	7,200	N	100
16B	340	350	6,120	N	0
17A	4000*	1,200	72,000	?	1,500
17B	1,640	800	25,100	N	400
18A	17,000	1,100	293,500	97,700	600
18B	3,500	550	64,400	2,000	250
19A	2,360	1,000	37,050	32,500	1,500
19B	1,830	1,050	30,010	25,100	3,000
20A	1,700	950	26,530	0	0
20B	820	750	12,710	N	50
Total	100,670	25,120	1,774,170	869,400	46,800

Notes: * = unreliable due to large periodic differences
N = small but the data does not permit a sound estimate

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In estimating meter rents, the actual average monthly income since the September 1994 tariff increase was used. In estimating average water charges the estimated consumption was multiplied by the estimated revenue per cubic metre for the particular zone, since the tariff was increased. The sewerage income was calculated on a pro-rata basis using the estimated average water charges and the recent ratio of sewerage to water charges. Conservancy charges were estimated based on the actual average since the tariff was increased.

The total revenue from the Nyeri town system based on the above table is just over KShs 2.7 million/month. This figure is in line with the expected annual income of around KShs 40 million/annum under the current tariff of which just over 80% is expected from Nyeri. Hence the figures in Table 8.3 which were estimated individually for every zone appear to cross check with the overall position.

The figures in Table 8.3 apart from showing the present distribution of consumption within the town, also provide some guidance for designing the future distribution system.

Although Table 8.3 shows the distribution of charges between zones, there is no information available regarding the distribution of revenue collected, since all revenue data is based on the total supply.

8.3 Water Consumption by Volume of Individual Consumer Use

Based on consumption in early 1994, the Municipal Council's Engineer has made an analysis of the distribution of water consumption between consumers by the level of their consumption. The results are presented in Table 8.4. The data is useful inasmuch as the number of consumers in every consumption range were counted, however the total resulting consumption is over 10% higher than the average monthly use in Nyeri, hence the individual figures should be treated as indicative only, although the pattern is sound.

Table 8.4
PATTERN OF WATER CONSUMPTION

	Volume of Monthly Consumption (m3)					
	0-6	7-10	11-20	21-40	41-100	>100
Number of Connections	410	1334	696	529	250	119
Percentage of Conns(%)	12.3	40.0	20.9	15.8	7.5	3.5
Total Consumed (m3)	1640	10762	10388	15822	17086	61086
Percentage Consumption	1.4	9.2	8.9	13.6	14.6	52.3
Average/Connection	4.0	8.0	14.9	29.9	68.3	513.3
Average Revenue/Conn.	75.0	103.0	199.6	449.2	1213.6	11003.6
Total Revenue	30750	137402	138922	237627	303400	1309428
Percentage of Revenue	1.4	6.4	6.4	11.0	14.1	60.7
Volume of Water	19208	9044	12390	13117	14125	49183
% of Water	16.4	7.7	10.6	11.2	12.1	42.0

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The consumption figures for the top four categories have been taken from the Engineer's estimate, however small modifications have been made to the use of the lowest two categories, since the original figures were considered to be slightly erroneous. Furthermore the consumption of the lowest category has been assumed to be 4 m^3/month since the original data was missing. It is to be noted however that the resultant overall consumption and conclusions are not sensitive to this assumption. Table 8.4 shows that:

(i) although those consumers who use over 100 m^3/month only constitute 3.5% of the total number of consumers, they account for nearly half of all the water billed.

(ii) in addition due to the increasing stepped tariff, they contribute around 60% of all water revenue.

(iii) at the other end of the scale, approximately 52% of the total number of consumers use 10 m^3 or less per month, but they only account for a quarter of the water billed, and then they only contribute under 9% of water revenue.

This analysis shows the great importance of the large consumers and fully endorses the policy of the Nyeri Municipal Council and the Engineer in Charge of concentrating on the large consumers in metering and billing.

The percentages in the last row of the table will be utilised in examining the effects of alternative tariffs during the financial analysis of the proposed new Nyeri water supply in the Feasibility Report.

8.4 Consumption by Large Users in Nyeri

The consultants examined the meter reading books and identified all consumers with an average monthly consumption in excess of 100 m^3/month. These consumers are listed in Table 8.7. The consumption of these 96 identified consumers is summarised in Table 8.5 by consumer category.

Table 8.5
CONSUMPTION BY LARGE USERS IN NYERI BY CATEGORY

Consumer Category	Consumption Av. m^3/month
Domestic	3,100
Institutions	32,590
Commercial	12,230
Industry	1,500
Total	**49,420**

It can be seen that institutional consumption accounts for approximately two thirds of consumption by large consumers. Since continuity of supply to institutions such as schools, hospitals, prisons and the like is an issue of public concern, and thus can affect action to enforce payment, this is significant, and would be even more significant in the event that payment by government institutions were to deteriorate.

It is noted that there is a minor inconsistency between the data collected by the consultants and the figures appearing in the Municipal Council's Engineer's analysis in Section 8.3. Firstly the consultants only counted 96 consumers with average monthly consumption in excess of 100 m^3/month, while the Engineer counted 119. The difference is in part explained by the fact that the consultants only counted a consumer if his consumption averaged over 100 m^3/month, while the Engineer's figures were based on a single month. The inclusion of a few additional large consumers would close the already small gap between the two different estimates that 48.8% and 52.3% of all consumption is used by "large" consumers.

8.5 Consumption by Large Users in Kiganjo

In Kiganjo there were seven identified consumer with an average monthly consumption of 100 m^3/month or more, these consumers are listed in Table 8.7 and their consumption is summarised in Table 8.6 by consumer category.

TABLE 8.6
CONSUMPTION BY LARGE USERS IN KIGANJO BY CATEGORY

Consumer Category	Consumption Av. m^3/month
Institutions	12,200
Industry	5,600

It can be seen that institutional consumption accounts for approximately two thirds of the consumption by large consumers. The total average consumption of the large consumers during 1994 was 17,800 m^3/month. This represents approximately 91% of average monthly consumption in Kiganjo in 1994. Hence consumption in Kiganjo is dominated by the few large consumers. In fact the two largest consumers alone (Police College and milk processing factory) account for almost 80% of all consumption in Kiganjo. This pattern will be taken into account later when the appropriate tariff for the proposed new water scheme is examined.

What also will need to be taken into account is the degree of satisfaction of demand that the consumption figures represent. The large consumers are all concentrated near the water works, and thus tend to be availed of their needs more readily. Suppressed demand has a higher effect on the consumption by small consumers especially in the more densely populated area around Kirichu.

8.6 Consumer Categories

For the purposes of estimating consumption by consumer category, four broad groups of consumers have been considered. Firstly institutional consumers. During the survey of large consumers almost 40 institutional consumers were identified, and institutional use in Nyeri is very important. However according to local officials, there are only a limited number of additional institutions which use less than 100 m^3/month. Hence most institutional use is accounted for by the major consumers.

Nyeri has a narrow industrial base and even some of the existing "wet" industries do not use the municipal water supply. There are less than 10 significant industrial consumers using the Nyeri and Kiganjo water supplies. Furthermore the only very large industrial consumer KCC is located in Kiganjo, and in Nyeri the largest potential industrial user is the Coca-Cola factory, but they have found it necessary to make their own, more readily assured arrangement for water. Within the Nyeri water supply, industrial use is of very minor importance.

There are over 30 commercial consumers who use in excess of 100m3/month. In addition there are a many commercial users amongst the large number of smaller consumers.

Most of the smaller consumers are either domestic or commercial, but it is not easy to sub-divide them between the two categories accurately, since it is often not possible to tell the category of a consumer from the name in the meter books. Council officials do however estimate that around 85% of them are domestic.

8.7 Breakdown of Consumption in Nyeri by Consumer Category

Due to the difficulty of categorising all consumers, precise division of the remaining consumption between consumer categories is not possible, but an estimate can be made based on the assumption that 85% of the smaller consumers are domestic.

Industrial and institutional consumption by consumers using less than 100 m^3/month is very small. Based on discussions in Nyeri, it is assumed that they represent 2% and 5% of the remaining consumption. Although these figures are highly subjective, the overall breakdown in not sensitive to the figures used. It is also assumed that the average consumption of the smaller commercial consumers is similar in rough terms to that of the average domestic consumer. Based on these assumptions the breakdown of the remaining 50% of the water would be:

Domestic	39%
Institutions	3%
Commercial	7%
Industry	1%

When these figures are added to the known breakdown of the 50% of the water used by the largest consumers, the breakdown of consumption in Nyeri is:

Domestic	42%
Institutions	36%
Commercial	19%
Industry	3%

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Table 8.7
MAJOR CONSUMERS

8.7.1 NYERI TOWN

Connection Number	Name of Consumer	Consumer Category	Zone	Average Consumer (m3/mth)
22	Provincial Water Office	1	1	400
23	MOW Yard	1	1	300
1646	Slaughterhouse	2	1	400
1778	Chief Mat. Engineer	1	1	100
1833	Kimani Onyando & Co.	3	1	400
1923	MOW Staff Quarters	1	1	250
39	Administration Police	1	2	300
104	Kenya Posts & Telecomm.	1	2	400
586	Controlling Postmaster	1	2	500
929	Thegenge Trading Co.	3	2	100
1767	Gachuhi Ngaranda	4	2	100
4464	St Peters Church	1	2	100
77	Nyeri Municipal Council	1	3	400
166	Marshalls E.A.	3	3	100
1169	Master Hotel	3	3	300
1222	KP & L	3	3	200
1381	Muhotetu Farmers	3	3	100
1885	Joseph Wahome	3	3	200
1918	Central Hotel	3	3	300
1962	Nyeri Plot Owners	3	3	150
2116	Geoffrey Gathii	3	3	100
17	White Rhino Hotel	3	4	450
150	DC's Office	1	4	400
263	CID HQ	1	4	150
341	Elijah Murithi	4	4	150
355	Duncan Ndegwa	3	4	100
389	Post Office	3	4	100
971	Nyeri Golf Club	3	4	100
1289	Kenya Commercial Bank	3	4	100
3633	Green Hills Hotel	3	4	2000
11	PC's Residence	5	5	400
105	Mt. Kenya Hospital	1	5	700

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Table 8.7.1 (cont'd)

Connection Number	Name of Consumer	Consumer Category	Zone	Average Consumer (m3/mth)
128	Outspan Hotel	3	5	2000
177	Nyeri Golf Club	3	5	600
967	Nyeri Golf Club	3	5	100
1775	Provincial HQ	1	5	700
2223	Provincial Water Office	1	5	200
4813	Nyeri Golf Club	3	5	10
119	Kartar Singh Ltd	4	6	100
1128	Green Hills Hotel	3	6	300
1714	Nyeri Technical Institute	1	6	2000
2788	John Kariuki	4	7	100
60	Nyeri Plot Owners	3	9	200
154	Div.Polic HQ	1	9	200
480	Div. Police HQ	1	9	4000
961	Mutune Trading Co.	3	9	300
1123	Nyeri Municipal Council	1	9	100
1743	Mutune Trading Co.	3	9	550
2433	Maru "A" Hotel	3	9	550
2560	Macharia Rungare	3	9	400
3294	Nyeri Star Hotel	3	9	300
3879	Diana Centre	3	9	200
3951	Joseph Njagi	4	9	150
4072	Maru "C" Hotel	3	9	350
4532	NMC New Market	3	9	180
4563	Edward Weru	3	9	100
332	St. Marys Sec. School	1	10	100
383	Municipal Rental Houses	4	11	100
417	NMC Blue Valley Estate	4	11	1500
513	Municipal Rental Houses	4	11	100
529	Municipal Rental Houses	4	11	250
4788	Nyeri Muslim Assoc.	1	11	100
256	Cathedral Sec. School	1	12	200
408	Our Lady's Cathedral	1	12	140
856	Temple Road Service Station	3	12	250
2515	Inslamic Foundation	1	12	300

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Table 8.7.1 (cont'd)

Connection Consumer Number	Name of Consumer	Category	Zone	Average Consumer (m3/mth)
366	ASK showground	3	14	600
426	Juvenile Remand Home	1	14	100
510	Ruringa Girls Home	1	14	100
533	Caltex Children's Home	1	14	200
980	Admin. Police Quarters	1	14	200
3577	S.N. Gitahi	4	14	100
2269	Provincial General Hospital	1	17	50000
184	Nyeri Primary School	1	18	5000
208	William Kimaru	4	18	150
227	Baptist Mission	1	18	100
271A	Prison	1	18	7000
489	Ministry of Nat. Resources	1	18	900
714	Tropical Trading Co.	3	18	200
764	Baptist Mission	1	18	250
937	Game Department	1	18	250
1286	Kimathi Institute of Technology	1	18	1500
1521	Kirimaru Farm	2	18	150
1578	Baptist Mission	1	18	400
1652	Highland Mineral	2	18	150
1696	Kenya Posts & Telecom.	3	18	250
2812	VOK	1	18	250
2891	Highlands Mineral	2	18	300
3690	North Tetu Timber	2	18	100
3730	Baptist Mission	1	18	1000
4286	Wananchi Sawmills	2	18	150
4340	David Waigi	3	18	200
4363	Sisters of St. Joseph	1	18	100
4411	J. Sembhi	4	18	200

8.7.2. KIGANGJO

Connection Number	Name of Consumer	Consumer Category	Zone	Average Consumer (m3/mth)
1	Kiganjo Police College	1	K1	10000
4	Police College Junior Mess	1	K1	100
54	KCC Milk Factory	2	K1	5500
16	Kagumo High School	1	K2	1600
158	CCM Primary School	1	K2	100
406	Sacred Heart School	1	K2	400
417	Wheat Millers	2	K2	100

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9. PRESENT WATER DEMAND AND SUPPLY

9.1 Demand Estimation

In February and March, 1995, the consultant undertook a field survey involving door to door visits to 513 representative consumers, and all 96 major consumers. The representative consumers were selected more on the basis of giving information on diverse areas and different types of consumers, rather than being a purely random sample. The survey covered both the Nyeri town and Kiganjo areas.

The information collected related to the type of premises, metering, number of inhabitants and sewage disposal. The consumption records for the previous three months were also abstracted from Council records, and filled in on each form.

It had been hoped that this survey would yield real figures on consumption patterns, but this was not to be the case, due to the depressed supply situation in almost all areas of the reticulation. The overall results are in Table 9.1. It can be seen that the average per capita consumption billed to residential high cost properties is 173 l/cap/day which is not in itself very low, because the main high cost residential area is near the water works. The low cost housing consumers appeared most affected, with some being billed at levels down to 7 l/cap/day. Of note however, is the "occupancy" rates. Those for high and medium cost housing are within expectation. The high figures for low cost residential and commercial residential premises reflect the common incidence of several residences being fed off one meter, rather than actual households having that high a number of persons.

For present purposes of reviewing the supply situation, it has been necessary to then adapt assumed figures based on common expectations. The figures chosen have been conservative, illustrated by the comparison with the Water Development Ministry's recommendations, but they will serve to illustrate the situation. A more comprehensive assessment of design demand parameters will be undertaken in later stages of this study.

For the major consumers, each was considered on individual basis, although their consumption records were also collected and averaged. The overall situation was one where the major consumers have a less depressed supply situation than the small consumers. There can be several reasons for this. Firstly, major consumers will often receive consideration during rationing (e.g. hospital, prison, etc.) due to the public health implications. They will also be in a better position to construct adequate storage and hence abstract more during low demand periods. Some of the principal major consumers are located in areas where they are better assured of at least an intermittent supply. Lastly a major consumer who does not obtain at least an intermittent supply, or who must have a reliable supply, is likely to resort to his own devices (Coca Cola, Thunguma Academy, and Wambugu Farmers Centre)

Computation of the present average demand by other consumers has been done on the basis of the number of consumers, and the per consumer demand which was adopted in Table 9.1.

These demands were then distributed into the various zones on the basis of each major consumer being attributed to the respective zone, and assumptions being made on the distribution of numbers of consumers of various types in each zone. This is of course an exercise which involves a fair element of approximation, but which is of adequate accuracy for the present illustrative purposes. It can also be noted that the distribution by consumer types is by numbers of consumers, which gives a different result from the evaluation earlier in this report of the distribution of proportion of total water consumption attributed each consumer group. The resultant demands for each zone are in Table 9.3.

The overall average demand arrived at is 6,800 m^3/day for the Nyeri town system.

This figure does need some expounding on. Firstly, this is the "past the meter" demand which does not take into consideration losses in distribution. From the analysis of water losses, it was concluded that 37% of water put into the system is lost, thus an average supply rate from the treatment works of 10,800 m^3/day would be necessary to meet this average demand. The present supply capacity from the Kamakwa Treatment works can only meet 52% of this.

A further consideration is the fluctuation in water usage during the year, which is linked to rainfall patterns and the increased usage during dry months of the year. A commonly applied factor in this regard is 30%, increasing the average daily demand in such periods to 14,040 m^3/day, and in such periods only 40% of the average requirements could be met from Kamakwa. Such periodic demand fluctuations can not be met by storage, unless this were in wholly uneconomic proportions.

The Nyeri town system does not have balancing storage of significant proportions. The tanks at the treatment works and the district water office total only 2,125 m^3 which is about 9 hours storage at the treatment works capacity, but only 3.6 hours storage at the average demand in dry seasons. This would mean that the distribution system would be expected to cater for a proportion of the daily demand peaking, were the supply capacity high enough.

One further comment in this respect is the manner of deriving these demand figures, which is based on the active consumers. The inactive consumers are essentially those who, although connected to the distribution, have not found it of any practical purpose to maintain an account, since no water comes their way. In the event of an improvement in the supply situation, such consumers would be likely to reactivate their connections, and exert a demand which is not reflected in the above figures.

A brief look at the 1993 demand projections by Sir Alexander Gibb & Partners (1982) is appropriate.

Table 9.1
DEMAND PER CONSUMER

NOTE: The field data below is for consumers currently being billed at an average of less than 100 m3/month

Consumer Type	Sample Size	Av. No.of Residents	Consumption Billed [m3/mth]			Per Cap. Consump. Billed [l/cap/d]			Demands Assumed		Maji Design Recomm. [lit/cap/day]
			Max.	Average	Min.	Max.	Average	Min.	Per Consumer [m3/day]	Per Capita [lit/cap/day]	
Residential - High Cost	56	5.8	63	**30**	7	556	**173**	44	**1.22**	**210**	250
Residential - Medium Cost	60	6.1	59	**18**	4	363	**97**	29	**0.76**	**125**	150
Residential - Low Cost [P]	21	16.7	83	**17**	3	96	**33**	7	**1.09**	**65**	75
Residential - Low Cost [T]	53	19.8	78	**17**	3	194	**29**	7	**1.09**	**55**	75
Commercial/Residential	18	21.5	99	**40**	8	164	**62**	19	**1.83**	**85**	
Other [non residential]	79		99	**37**	2				**1.60**		

← *Data From Field Survey* →

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Table 9.2
MAJOR CONSUMERS' DEMAND - NYERI TOWN

CONS-UMER ID	ZONE	CONNEC-TION NO.	TYPE OF PREMISES	METER LOCA-TION	LEAK. AT METER?	OCCUPANTS		AV. CONS. BILLED [M3/DAY]	PER CAP. CONS. BILL. [l/cap/day]	DESIGN DEMAND [m3/day]
						RESID.	VISIT.			
300	18	271	PRISON	?		6000		237.0	39	390
276	17	2269	PROV. GEN. HOSPITAL	M		800	2000	162.4	203	469
	9	154, 480	DIV. POLICE HQ.					140.0		140
310	19	184	NYERI COMPLEX [SCH.]	A		600	1000	102.7	171	105
381	4	1128, 3633	GREEN HILLS HOTEL	A		150	100	77.0	513	96
392	5	128	OUTSPAN HOTEL	M		80	150	66.6	833	70
469	11	417	RESID. LOW COST BLOCK	B				58.7		60
573	6	1714	NYERI TECHNICAL SCH.	M		700		50.0	71	75
316	18	227, 3730	BAPTIST HIGH SCHOOL	M		600		39.4	66	50
336	18	1286	KIMATHI INST. OF TECH.	M		800	30	31.3	39	70
396	5	177, 971, 967, 4813	GOLF CLUB	A		10	15	30.0	3000	27
	18	489	MIN. NAT. RESOURCES					30.0		30
572	6	105	MT. KENYA HOSPITAL	M		50		23.8	476	25
389	5	1775	P.C.'s OFFICE	M		500		22.7	45	28
135	1	1645, 4275	ABATTOIR	A				22.6		35
152	2	586	RESID. LOW COST 18 NO.	G		100		21.0	210	21
313	18	1652, 2891	HIGH LANDS WATER	A			100	20.1		200
	14	366	SHOW GROUND					20.0		20
	9	2433	MARU A HOTEL					18.0		18
562	1	22	M.O.W. STAFF HOUSES	G				15.3		16
326	18	1302	MT. KENYA ACADEMY	G		500	20	15.2	30	43
380	4	389	POST OFFICE [GPO]	G			185	14.0		15
379	4	17	WHITE RHINO HOTEL	A	L	30	100	13.9		15
151	2	104	RESID. LOW COST BLOCK	M	Y	80		13.7	171	15
	4	150	DC'S OFFICE					13.0		14
	3	77	NYERI MUNICIPAL COUN.					13.0		14
	9	2560	MACHARIA RUNGARE					13.0		13
390	5	11	PC'S RESIDENCE	G				12.5		14
	9	4072	MARU "C" HOTEL					12.0		20
160	3	1918	CENTRAL HOTEL	G		30	60	11.2	375	12
200	12	856	PETROL STATION	M				10.8		12
	3	1169	MASTER HOTEL					10.0		10
	9	961	MUTUNE TRADING					10.0		18
	9	3294	NYERI STAR HOTEL					10.0		10
223	12	2515	MOSQUE/ ISLAM. FOUND.	A	L			9.8		10
340	18	955, 4286	WANANCHI SAWMILLS	A				9.7		8
134	1	1833	OFFICE & SHOPS	?				9.6		14
575	9	3374	HOTEL/LODGING	?		18	100	9.5	525	10
339	18	2812	VOK RADIO	G		180	20	9.4	52	10
184	14	980	ADMIN. POLICE LINES	G		200		9.4	47	13
330	18	937	GAME DEPARTMENT	B		220		9.1	41	15
137	1	23	M.O.W. YARD	G				8.8		10
76	9	1743	GRAND BATIAN	?		30	150	8.5	282	15
467	11	529	RESD. MEDIUM 8 NO.	?		40		8.3	208	11
329	18	4411	RESID. HIGH COST	M		6		8.0	1328	8
564	2	39	ADM. POLICE LINES	A		120	0	8.0	66	10

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Table 9.2 [contd]

CONS-UMER ID	ZONE	CONNEC-TION NO.	TYPE OF PREMISES	METER LOCA-TION	LEAK. AT METER?	OCCUPANTS RESID.	OCCUPANTS VISIT.	AV. CONS. BILLED [M3/DAY]	PER CAP. CONS. BILL. [l/cap/day]	DESIGN DEMAND [m3/day]
333	18	208	RESID. HIGH COST	B		6	10	7.5	1253	8
161	3	1222	KPLC OFFICES	A		200		7.5	38	8
	5	2223	PROV. WATER OFFICE					7.0		7
318	18	764	RESID. HIGH COST	G		5		6.8	1358	7
121	1	1923	MOW STAFF QUARTERS	B		60		6.6	110	9
464	11	513	RESD. MED COST 8 NO.	B				6.2		7
322	18	714	TROPICAL TRADE CO.	A		15	7	6.1	407	7
	9	4532	NEW MARKET					6.0		6
320	18	4340	ROCK HOTEL	A		10	70	6.0	595	6
382	4	1289	KCB BANK	M				5.9		6
78	10	3575	RESID. MEDIUM COST	G		15		5.8	389	6
168	3	1885	COMMERCIAL	G		30		5.8	192	7
402	10	3879	OFFICES [DIANA CENTRE]	A		2	50	5.7	2863	6
212	12	408	CATHEDRAL	G		100		5.4	54	6
317	18	1578	BAPTIST FARM	B		25		5.4	217	9
222	12	3494	THINGIRA GUEST HOUSE	A	Y	25		5.3	212	6
323	18	1521	KIRIMARA FARM	A		7	10	5.3	756	6
167	3	1962	COMMERCIAL/RESIDEN.	B	Y	80		5.3	66	7
65	7	4653	COMMERCIAL/RESIDEN.	G		30		4.9	163	5
400	10	332	ST.MARY'S SCHOOL	G		400	450	4.9	12	22
301	18	1696	K P T C DEPOT	?		10	300	4.8	476	5
183	14	533	CHILDREN'S HOME	?		60		4.1	69	5
213	12	256	CATH. SECRETARIAL C.	A		100		4.0	40	9
185	14	3577	COMMERCIAL/RESIDEN.	A		30		4.0	132	4
468	11	383	N M C HOUSES	G		20		3.9	195	4
466	11	4788	MAJENGO MOSQUE	M			200	3.9		4
77	10	95	SHOP	G		5		3.9	770	4
154	2	929	COMMERCIAL	A		100		3.8	38	4
375	4	341	COMMERCIAL/RESIDEN.	A				3.8		14
559	1	60	COMMERCIAL BLOCK	A				3.7		4
311	18	3690	NORTH TETU SAWMILL	A	Y	50		3.5	70	8
	18	4875	ST. TERESA COM. COLL.			45	150	3.5		16
579	14	3038	NURSERY SCHOOL	G	Y	0	170	3.5		4
165	3	1382	COMMERCIAL/RESIDEN.	G		100		3.4	34	9
79	10	91	RESID. MEDIUM COST	A		6		3.4	558	4
337	18	4363	SISTERS OF ST. JOSEPH	A		70		3.3	48	13
68	7	2788	RESID. MED COST 4 NO.	G		16		3.2	201	4
	14	426	J. REMAND HOME					3.0		6
	14	510	RURINGA GIRLS HOME					3.0		13
370	4	692	MUNICIPAL FIRE SERVICE	G		18		2.7	150	6
328	18	1409	RESIDEN. HIGH COST	B		5		2.1	420	3
164	3	166	MARSHALLS GARAGE	G				1.8		4
416	20	2820	RESIDEN. HIGH COST	G	L			1.6		2
					TOTALS			1665.8		2604.0

Key:

A = Above ground
B = Buried below ground
G = At or below ground but NOT buried
M = In a meter box
W = On a wall

Y = A lot of leakage around the meter
L = A little leakage around the meter

Table 9.3
DEMAND ESTIMATION

Note: Distribution losses and seasonal/daily demand peaking are not considered in the figures below

ZONE	NO. OF CONSUMERS			DISTRIBUTION OF "OTHER" CONSUMERS						DEMAND [M3/DAY]		
	Major Consu-mers	Other Consu-mers	TOTAL	RESIDENTIAL High Cost	Medium Cost	Low Cost Perm.	Low Cost Temp.	COMM/ RESID-ENTIAL	COMM-ERCIAL ETC.	Major Consumers	Other Consumers	TOTAL
NYERI												
1	7	104	111	25%	60%	8%	3%	2%	2%	88	99	187
2	4	142	146			20%	25%	5%	50%	50	196	246
3	8	116	124					45%	55%	71	198	269
4	8	96	104		30%			40%	30%	166	138	304
5	8	77	85	50%	45%	3%			2%	146	78	224
6	2	266	268	40%	45%	10%			5%	100	271	371
7	2	203	205	2%	10%	35%	30%	8%	15%	9	243	252
9	10	373	383					45%	55%	250	635	885
10	5	167	172	7%	40%	33%		5%	15%	42	180	222
11	5	124	129			50%	34%	10%	6%	86	148	234
12	5	173	178		30%	45%	5%	5%	15%	43	191	234
14	7	314	321	4%	12%	30%	40%	9%	5%	65	360	425
15		169	169		10%	25%	20%	25%	20%	0	227	227
16		145	145	3%	17%	38%	40%		2%	0	152	152
17	1	299	300		2%	40%	45%	8%	5%	469	349	818
18	24	194	218		25%	45%	17%	5%	8%	912	211	1123
19	1	275	276		22%	65%	3%	5%	5%	105	297	402
20	1	201	202	2%	8%	40%	45%		5%	2	219	221
TOTALS	98	3438	3536							**2604**	**4194**	**6798**

Demand per Consumer [m3/day]	**1.22**	**0.76**	**1.09**	**1.09**	**1.83**	**1.60**

OVERALL DISTRIBUTION OF OTHER" CONSUMERS	6%	17%	29%	18%	13%	17%

Their projections were based upon the demand for the whole municipal area of that time, except for the area served by the Kiganjo system. A comparison can only therefore be made by removing the areas in their projection which are outside the present Nyeri town supply. This applies to Kamuyu, Gitathi-ini, Karinga-ini, Nyaribu, and the area they called the "Eastern Extension", all of which accounted for 20.4% of the Gibb demand estimation. The Thunguma and Mathari areas were also included, and gave 14% of the demand. Whereas these latter two areas are in the large part reticulated, they are the areas in which inactive connections are concentrated, due to the lack of water. A fair estimate is that only one quarter of the demand in those two areas would be as a result of presently active consumers. Overall, therefore, about 69% of the Gibb demand estimates would fall within the area of the present Nyeri town consumer base.

The Gibb projections for 1993 were 11,193 m^3/day, and therefore 69% of this would be an average demand of 7,723 m^3/day.

To be comparable to the figures in this report, that would need further adjustment. Firstly, Gibb allowed a total of 2,434 m^3/day for industrial usage. This was based on two major consumers (soft drink bottlers), and applying industrial use demands over all areas zoned for industrial development whether such development was to be expected or not. This expected development has not occurred. Of the two bottlers, Coca-Cola now have their own supply and are not an active consumer (they had been allocated 500 m^3/day) and Highlands had been allocated 590 m^3/day, but their management at present estimates their needs at 200 m^3/day. A reduction of 890 m^3/day in the Gibb projections is warranted for these two consumers. For the general industrial demand allowed (1,344 m^3/day), one would need to analyze the physical planning for industrial sites to distribute it, but most of it is not within the reticulated area. Large areas of the industrial zoning were within the Nyaribo Plains.

Another reduction which is justified is the 80 m^3/day allowed for Wambugu Farmers Centre, as they are not presently an active consumer.

Overall, the adjusted Gibb projection which can be compared with the estimation done for this report, would be of the magnitude of 6,200 m^3/day, about 90% of the result obtained by this consultant. This is within a fairly good level of compatibility.

9.2 Reticulation Capacity

The capacity of the distribution system was also examined with respect to the demand estimated. The following scenarios were considered:

i) reasonably secure supply - distribution losses taken into account, and some seasonal variation (25%) such that only in short periods of the year would the supply be less than the average daily demand.

ii) fair supply - only distribution losses considered, during peak use seasons there would be intermittent supply

iii) intermittent supply - areas within about 75% of the average daily demand plus losses at average use seasons, and about 50% of this in peak use seasons.

iv) occasional or no supply - areas outside the above categories.

The distribution network was modelled based on the available information, which as has been noted is not precise. Demands were distributed to pipe nodes as follows:

a) major consumers according to actual location, and

b) other consumers by attributing to each node a representative proportion of the demand of "other" consumers within the meter reading zone.

These nodal demands and other relevant data were processed in the consultant's REHM network analysis software. The resultant situation obtained is illustrated in Figure 9.1.

It can be seen that only a very small area can be said to have a reasonably secure supply, based on the reticulation capacity. This is just around the Kamakwa area. Some parts of Ring Road (high cost housing) have a fair supply.

The bulk of the reticulation system area has varying degrees of insufficiency, ranging from areas of intermittent and inadequate supply, to occasional or no water availability. The latter applies largely to the eastern part of the distribution, covering the lower parts of the CBD, Asian Quarter, Ruringu, Kangemi, Skuta and Thunguma. The western part of the reticulation around Mathari is in the same situation.

Clearly the distribution system is far below the capacity necessary for the present demand.

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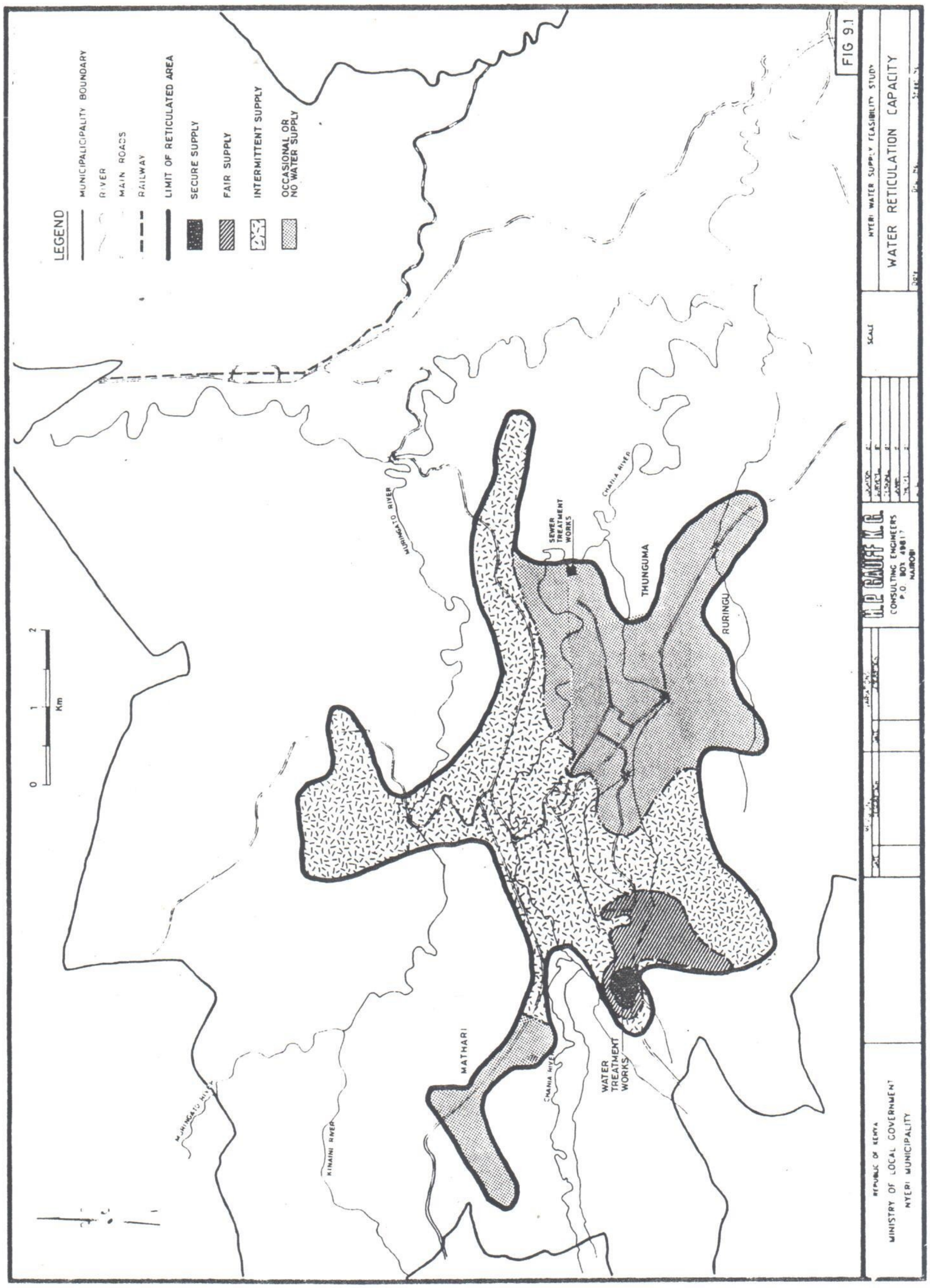
LEGEND
MUNICIPALICIPALITY BOUNDARY
RIVER
MAIN ROADS
RAILWAY
LIMIT OF RETICULATED AREA
SECURE SUPPLY
FAIR SUPPLY
INTERMITTENT SUPPLY
OCCASIONAL OR NO WATER SUPPLY
0
1
2
Km
SEWER TREATMENT WORKS
THUNGUMA
RURINGU
MATHARI
WATER TREATMENT WORKS
FIG 9.1
NYERI WATER SUPPLY FEASIBILITY STUDY
WATER RETICULATION CAPACITY
SCALE
CONSULTING ENGINEERS
NAIROBI
REPUBLIC OF KENYA
MINISTRY OF LOCAL GOVERNMENT
NYERI MUNICIPALITY

10. WATER PRODUCTION AND ADMINISTRATION

10.1 Water Production and Losses

10.1.1 Estimates of Water Production

Data on the volumes of raw water abstracted from the intakes at Nyeri and Kiganjo in recent years are not available, however historic figures for the volumes of water leaving the treatment works and for the volumes of water billed to consumers in Nyeri on a monthly basis are maintained by the Municipal Council's Engineer and are shown in Table 10.1 for the five year period February 1990 to December 1994. Figures for Kiganjo are also shown in that table, but on annual basis. It should be noted that whenever the term production is used in the following sections, it refers to water leaving the treatment works, and not to the water being abstracted from the source.

The average daily production over the five year period January 1990 to December 1994 was 5,555 m^3/day. Furthermore there was no evident long term change in production trends. While there were considerable monthly differences in production, (the maximum and minimum monthly production during the period from January 1990 to November 1994 ranged from 140,000 m^3 to 184,000 m^3), these differences related to short term factors, and the difference between the highest and lowest production years was only 5%.

A leak on the raw water main close to the Ihwa intake was however detected and repaired in November 1994, and it is claimed by the Council that this has resulted in a significant increase in the water available for treatment and would permit total production to increase to 6,500 - 7,000 m^3/day, when there are no problems, and possibly with a daily average production, to take account of short term problems, of around 6,200 m^3/day. While it is possible that average production may in future exceed the last five years' average figure, the estimates of current unit costs in this report will be based on the historic term figure. During December and January 1995 production averaged just over 6,200m3/day, but in February 1995 fell back to under 6,000 m^3/day. Clearly if this increased production potential is regularly realised, the overall financial situation could be slightly better than shown in this report, but the overall financial conclusions would not be changed significantly. Revenues could increase by 12%, but costs would also increase significantly, since short term variable costs are shown later in this report to represent around half of the total production costs. (c.f. Section 11.4).

The daily average production leaving the Kiganjo treatment works over the last five years is 914 m^3/day, but there has also been a deterioration in production since 1991. In that year average daily production was 1,020 m^3/day, but this figure fell steadily over the following years and in 1994 the average daily production was down to 765 m^3/day. There is a serious problem especially during periods of low flow and daily production is sometimes extremely low. In November 1994 average daily production was only 540 m^3. A feature of Kiganjo is that the bulk of the water is supplied to a small number of large consumers, but on average even the demand of these consumers is not fully satisfied.

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Table 10.1
WATER PRODUCED AND BILLED 1990 - 94

10.1.1. Nyeri town

Period	Treated Water Produced (m^3/month)	Volume Billed (m^3/month)	Accounted for Water (%)
1990			
February	154,000	88,095	57.2
March	171,337	91,300	53.3
April	176,551	104,044	58.9
May	183,477	90,815	49.5
June	172,591	115,847	67.1
July	172,900	102,738	59.4
August	167,503	106,085	63.3
September	140,761	114,530	81.4
October	179,917	108,619	60.4
November	163,290	111,150	68.1
December	161,392	87,114	54.0
Annual Total	2,011,330	1,222,186	60.8
1991			
January	165,252	118,160	71.5
February	160,486	113,126	70.5
March	175,181	109.998	62.8
April	166,876	109,690	65.7
May	180,324	107,362	59.5
June	171,680	105,995	61.7
July	177,083	106,600	60.2
August	171,461	127,765	74.5
September	168,271	113,664	67.5
October	172,542	110,851	64.2
November	172,829	117,829	68.2
December	175,923	110,020	62.5
Annual Total	2,057,858	1,351,060	65.7
1992			
January	177,659	111,668	62.8
February	163,646	114,082	69.7
March	176,013	103,569	58.8
April	161,050	104,955	65.2
May	173,362	102,957	59.4
June	173,326	112,335	64.8
July	177,107	103,633	58.5
August	174,262	112,351	64.5
September	171,135	105,522	61.7
October	175,183	104,467	59.6
November	165,458	109,163	66.0
December	184,085	107,896	58.6
Annual Total	2,072,286	1,292,598	62.4
1993			
January	178,328	114,466	64.2
February	161,487	107,544	66.6
March	171,100	119,038	69.6
April	163,779	109,767	67.0
May	162,490	101,043	62.2
June	153,907	107,313	69.7
July	162,349	114,096	70.3
August	159,866	107,684	67.4

Table 10.1 (cont'd)

Period	Treated Water Produced (m^3/month)	Volume Billed (m^3/month)	Accounted for Water (%)
September	155,793	108,055	69.4
October	165,072	107,914	65.4
November	160,857	90,696	56.4
December	166,106	110,140	66.3
Annual Total	1,961,134	1,297,756	66.2
1994			
January	163,794	96,406	58.9
February	155,793	89,482	57.4
March	172,776	103,130	59.7
April	167,197	120,800	72.3
May	163,348	96,755	59.2
June	165,159	102,535	62.1
July	169,742	105,461	62.1
August	175,438	98,698	56.3
September	160,697	101,240	63.0
October	168,622	96,408	57.2
November	176,719	95,627	54.1
December	195,454	120,947	61.2
Annual Total	2,034,739	1,227,489	60.3

10.1.2. KIGANJO

Period	Treated Water Produced (m^3/annum)	Volume Billed (m^3/annum)	Accounted for Water (%)
1990	*357,300	*292,736	81.9
1991	372,475	311,833	83.7
1992	349,215	271,504	77.7
1993	309,812	274,514	88.6
1994	279,164	234,269	83.9

** Based on 11 months figures, increased to 12 months on a pro-rata basis.*

10.1.2 Comparison of Production and Volume Billed (Nyeri Town)

In Nyeri town over the five year period January 1990 - December 1995, the average daily billing has been 3,502 m^3/day, and since average production has been 5,555 m^3/day, on average 63% of all water leaving the treatment plant has been billed, leaving an average of 37% unaccounted for. Furthermore it is noticeable that the annual percentages of water billed and accounted for do not vary greatly between years. Every year the percentage is within 3% of the five year average. There are however significant differences between months. It is probable that while this reflects greater real "between month" differences in the percentage of water which is actually consumed/lost, part of the difference is related to the fact that there are small errors in the monthly billing figures compared to actual bona fide consumption, and these cancel out between months. In other words if some consumers are not billed during a particular month, that missed consumption would then be billed in a subsequent month. For that reason, it is probable that annual percentages of unaccounted for water are more accurate than monthly percentages.

10.1.3 Apportioning Unaccounted For Water

There is no available data which would enable one to accurately apportion the total loss of treated water between leakage in the distribution system and administrative losses. Firstly no check has been made recently regarding the accuracy of the master meters. There is definite need for these to be checked regularly. Assuming that the 37% figure is reasonably accurate, the engineer in charge estimates that physical losses are around 20%. As will become apparent from the sections hereunder, it would be fair to consider that figure to be an under estimate, since this means that administrative losses are around 17%. The level of administrative concern with revenue collection would mitigate against such a rate of loss. The sources of such losses include:

(i) use by unregistered, i.e. illegal consumers. There is no data on this source of loss, although local officials estimate that it could account for around 5% of production. Efforts to reduce this loss are currently being planned for later in the year. During that programme, improved data on such losses could emerge.

(ii) under-billing of bona fide consumers due to under-billing, meter malfunction, or a lapse in the meter reading/billing procedures. This whole question is discussed below in Section 10.1.4, however losses from these sources are not high. It is believed that all the sources of under-billing could not account for as much as 10% of production.

(iii) free use of water for public purposes. This accounts for very little unaccounted for water in Nyeri, since public taps are metered. The use from hydrants is insignificant as a percentage of total use.

It is concluded that administrative losses are not unreasonable. Firstly an examination of the potential sources of such losses suggests that they are limited. Secondly given that total water unaccounted for after the treatment plant totals 37%, the age and condition of the system is such that leakage losses would account for a significant proportion of total unaccounted for water.

10.1.4 Under-Billing of Consumers

A significant number of meters are known to be malfunctioning, (c.f. Section 10.2.1), but as far as under-billing due to stopped meters is concerned, the two key factors are involved namely:

(i) emphasis is put on major consumers, and virtually all known non functioning meters are located at small consumers' properties,

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(ii) in such cases consumers are billed on the basis of the last six months consumption, in the last period during which the meter was working.

Losses from properties with known malfunctioning meters will thus only occur at small consumers properties, and only where the consumers have increased their average consumption since the meter stopped functioning. Such losses are only likely to occur where consumers realise that they can take advantage of the situation, and there are some such properties where the meter has been stopped for a long time due to lack of funds to purchase sufficient replacement meters. Since it is claimed that these long term stoppages are only allowed to occur where the previously metered use was very limited, the total of such losses, although unknown, is unlikely to be a significant proportion of the total system consumption.

Losses due to under-registration of water flows by meters cannot be estimated, since they are by definition unknown. Indeed if such an under-registration is occurring at a major consumer the losses could be significant. Fortunately the engineer in charge takes a personal interest in large consumers and arranges for such meters to be read in between the standard meter reading exercises. He also regularly checks the consumption of all consumers, especially the large ones, by going through the meter reading books every month, to pick up significant falls in measured consumption so that he can arrange to have such meters checked. The cases which would not be picked up would be where a consumer increased consumption during a period when his meter started to under-register, which seems to be an unlikely occurrence on a significant scale.

Losses arising from billing errors due to the bill under-stating the most recent reading are unusual and insignificant. The billing procedure is discussed in Section 10.3.2, where it is pointed out that it is possible that a consumer does not get billed in a particular month, but that this would normally be rectified subsequently. The real potential for losses arises from the loss of a ledger card which would result in that consumer no longer being billed. No data is available on lost ledger cards, but there is no evidence that it is significant or that it occurs.

All of the above tend to lead to a conclusion that the 37% loss of water can in the large part be attributed to distribution losses.

10.1.5 Production and Unaccounted for Water in Kiganjo

Table 10.1 presents the annual production and volumes billed in Kiganjo over the last five years.

The annual average percentage of unaccounted for water in Kiganjo over the five year period 1990-94 is 17%. It is again difficult to allocate this figure between leakage and administrative losses. The losses are far lower than in Nyeri since it is probable that both physical and administrative losses are lower. A large proportion of the water is delivered to a few large consumers and in the case of one such consumer the meter is actually at the treatment plant. Hence as regards this consumer who accounts for around 20-25% of billing in Kiganjo, there are no unbilled leakage or administrative losses. The main difference with Nyeri is the resulting overall lower level of losses, due to physical factors, and the fact that

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the large portion of billed water is captured in just three bills. Otherwise similar comments as presented in Sections 10.1.3 and 10.1.4 apply to Kiganjo.

10.2 Administration of Consumption and Related Issues

10.2.1 Current Metering Situation

Nearly all water consumption by bona fide consumers is metered, or would be if all meters were working accurately, since non metered use only occurs at a very few outlets such as hydrants and at a limited number of very low use domestic premises. According to Nyeri Municipal Council records for September 1994, there were a total of 4207 consumers in Nyeri and 370 in Kiganjo, giving a total of 4577 of whom 550 were currently closed, leaving 4027 potentially active connections. In total there were 3086 operational meters, i.e. almost 77% of connections were equipped with functioning meters, but the remaining 23% of meters combined meters that were not functioning, properties where access to read meters was difficult, buried meters, and a few premises with no meter at all. Based on the longer term records this figure was slightly below the longer term monthly average of functioning meters which was normally over 80%. The percentage fluctuated depending upon various factors including whether or not spare meters or money to purchase spare meters were available. In September 1994, meters at 385 of the 941 "unmetered" connections were known to be non functioning, 398 were classified as "problematic", needing to be checked, 56 as locked/inaccessible, and 9 as being covered. There were only 92 connections without meters at all. The fact that at any time, reliable meter readings are only available for approximately 80% of consumers means that approximately 20% of bills are based on estimates of the last six months' known consumption.

10.2.2 Meter Reading

All meters are supposed to be read once a month and during the monthly meter reading exercise most meters are read. It was reported that the larger consumer's meters are supposed to be checked weekly but although extra emphasis is placed on reading these meters, the weekly check could not be confirmed. The major consumers records of meter readings in between the monthly exercise appear to be very patchy. Until February 1995 Nyeri Municipal Council employed six meter readers. They report to a water foreman, who although not having the title metering foreman, acts in that capacity. In theory the meter foreman should report to the water superintendent, but in practice he often reports directly to the Engineer, since the latter involves himself in efforts to ensure that the whole metering and reading exercise is efficient. The meter section has a total of four motor cycles which are used by the meter readers and plumbers repairing meters.

The time taken for meter reading depends upon the characteristics of different parts of the supply area and on the varying competence of the individual readers. In some areas it is possible to read 150 meters per day, but elsewhere the number can fall to around 40/day. Meter reading is organised on a zonal basis and there is a monthly schedule, which although not rigidly followed, provides a framework for the monthly exercise. The approximate current schedule which is shown below is based on five meter readers, since there will often be one who is unavailable for reading for various reasons, such as leave or sickness. The number of days shown for every zone is the minimum time requirement. When problems occur the

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number of days required for a zone can increase by up to 50%. In addition 5 days are required to read meters in Kiganjo, giving a minimum of 52 man-days. In practice the total time involved may be as much as 60 man-days, but even then most readings should be completed within a 15 day period, i.e. within 11 working days. On occassion there can be one or two staff members continuing with reading until around the 22nd of the month.

Meter Reader	Zone Read on Working Day: 1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	5	5	12	12						
2	7	17	17	4	9	9	9	10	10	11	11	
3	4	14	14	14	20	20	20	20	16	16	16	
4	5	15	6	6	7	7						
5	19	19	19	18	18	18	18					

There is at least one meter book per zone in which the meter readers record all their readings. In every book there is a page for every consumer and the reader records the latest reading under the previous one. Due to the number of consumers and/or geography, most zones are sub-divided with a specific meter book for every sub-zone. Zones 1, 2, 3, 4, 5, 11 and 12 are not sub-divided, zones 9 and 14 are divided into three parts/books, (A, B, & C), while the remaining 9 zones are divided into two (A and B).

When the meter readers are allocated their days work, they take the relevant meter reading book from the meter section where they are stored by the meter foreman. At the end of their days work they must return the book either to the Engineer or to the meter foreman. The readings may be initially checked, by the meter foreman looking through the returned meter reading books for apparent anomalies, but the key check is undertaken by the Engineer who personally goes through each and every book both checking the work, giving any necessary follow up instructions, and proposing figures where new estimates are required.

It is clear that the figures recorded in the meter books are an accurate reflection of the actual recordings. Meter readers are rotated between zones to help ensure that there is no collusion between the readers and consumers, and the Municipal Council Engineer keeps a very tight personal control on all aspects of meter reading.

10.2.3 Follow-Up of Problems

Where meter readers meet problems they report them to the meter foreman, for example the discovery of a suspect meter or finding that they cannot get access to the meter. He may subsequently despatch a plumber or meter reader to fix the meter, and may arrange for them to carry a spare in case they cannot fix it on the spot, or he may see the consumer to arrange access. Where he cannot deal with the matter himself he should refer it to the superintendent, or to the Engineer who usually follows up difficult cases himself.

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10.2.4 Responsibility

It is reported that in the past, meter readers came under the Treasurer's Department, but now they are responsible to the Engineer. This arrangement works well given the latter's interest in metering. Once the meter books have been filled, including any necessary estimates, the administrative responsibility passes to the Treasurer's Department although the Engineer's Department retains the technical responsibility for sorting out related problems.

The meter books are collected by the billing staff from the meter section as and when they are required for bill preparation. When they have finished with a book they return it to the same place. There are no specific controls on the books, and at any time a particular book could be on the meter room desk, with one of the meter readers, with the Engineer for checking, with billing staff, or with the revenue accountant. The foreman does however seem to know where the books which are currently out are located. It is reported that no book has ever been lost in recent years, but if a loss were to occur it would create a problem, although it should be manageable by tediously retrieving figures from the ledger cards.

10.2.5 Meter Servicing

The meter readers' time remaining after meter reading is complete, is spent servicing meters, and making disconnections and reconnections. The meter readers themselves reported that this time is split roughly 60/40 in favour of servicing, although this is only an average figure since servicing is a continuous activity as compared to disconnecting which occurs in "lumps". Meters are mostly serviced on site and usually only involves cleaning. In addition to the meter readers, there are two plumbers who are trained on meter servicing, who tend to deal with the meters which the meter readers cannot fix by simply washing out the silt.

10.2.6 Increased Meter Readers

It is claimed that the work involved in reading and servicing meters and in disconnecting and reconnecting was greater than could be handled by the existing six meter readers and two plumbers. The result was that, with the emphasis on reading and servicing, insufficient time was available for disconnections and none for detecting illegal connections. It is probable that most illegal connections result from disconnected consumers who have reconnected illegally rather than consumers undertaking new connections in secret. Hence it should be possible to detect most illegal connections by periodically visiting every closed or non active connection. Also although disconnection is a regular feature of the Nyeri water supply, normally only some of the disconnections which have been authorised are actually implemented due to a lack of manpower. This is despite the fact that the new approach to disconnection involving wiring and sealing has made disconnection easier.

Consequently in February 1995, the Council employed four additional meter readers in order to increase its ability to disconnect consumers, to detect illegal connections and for any other related activities in order to increase administrative efficiency. The effective capacity for some time may not be increased significantly since the new recruits are currently under-going on the job training with existing meter readers and will not be able to operate on their own until they know the location of all meters in their assigned zones. The future arrangements once the four trainees are able to work by themselves has not yet been determined, but it is possible that some readers will be occupied full time on servicing and disconnection, and will be able to spend a significant amount of time tracing illegal connections.

10.2.7 Procedure for Disconnection

Inasmuch as water and sewerage are billed together there is no differentiation made between not paying for water and not paying for sewerage. After the bills have been produced, the Revenue Accountant or his clerks are supposed to identify those consumers with more than two months arrears. This seems to be a rather informal process and it appears that the "flagging" of any consumer who fails to meet the payment criteria is not automatic, but depends on spotting by an individual. Based on this exercise the revenue accountant prepares a list of those due for disconnection in the Disconnection Orders Book, and after checking the names against recent payments, he sends it to the Chief Accountant/Municipal Treasurer for his signature which authorises the disconnections. A copy of the disconnection list is then sent to the Engineer's Department where it is given to the meter section for implementation. The meter foreman issues specific disconnection instructions to the meter readers who effect the disconnections. Once the disconnection has been made it is recorded in the "Disconnection Register". Due to lack of manpower, only some of the authorised disconnections are actually implemented the same month, and in some cases the same names have appeared on the disconnection list several times. Hence there are large differences between the list of names in the Disconnection Orders Book and the Disconnection Register. This is one of the problems that can be expected to be solved when the new meter readers are fully trained.

10.2.8 Procedure for Reconnection

In order to be reconnected a consumer has to pay all his arrears and his reconnection fee, except in very occasional special cases, where the Municipal Treasurer/Chief Accountant gives specific approval for a lesser sum to be paid initially. The consumer receives two receipts from the cashier, one for his arrears and one for the reconnection fee. He then takes these receipts to the Revenue Accountant's office where the receipt number is written on the accountants copy of the disconnection list. Three copies of a reconnection notice which represents the authorisation to reconnect are prepared by the Revenue Accountant, one remaining in the reconnection notice book and two being sent to the Water Section. These are received by the meter section foreman who gives the original to the meter reader/plumber allocated to the job. When the worker has returned from making the reconnection he fills in his copy, and returns it to the meter foreman for filing.

10.2.9 Appraisal of the Disconnection Procedure

Despite the delays which sometimes occur before a consumer is disconnected, the system basically works and results in most consumers paying off their arrears. The delays caused are normally not of very significant financial impact.

Although in theory all consumers can be disconnected, in practice the municipal water staff cannot disconnect "essential" consumers such as the prison, hospitals, police, and Provincial Commissioner's and District Commissioner's offices. However there are only a few consumers who cannot be disconnected, and officials reported that they can, for example, disconnect schools. When the special consumers show up on the major defaulters list, they have to be dealt with by the Town Clerk. He has meetings with the head of the institution concerned and/or with the Provincial Commissioner who assists in solving the problem. If at any time the problem persists, the Town Clerk may write to the relevant Permanent Secretary. Every indication is that these approaches to the authorities have kept the outstanding payments from such consumers in check. In time most such debts are paid by the responsible government department, and the overall revenues do not seem to have been seriously affected, although late payment by the largest consumers can affect the short term cash flow position of the Water and Sewerage Fund.

It can be concluded that until now the inability to disconnect sensitive connections has not been a serious impediment to the financial position of the water supply operation, and until the last tariff increase arrears were not mounting. Government arrears have increased dramatically since the price increase. At one time last year they were only KShs 1.7 million, but within four months of the tariff increase in September 1994, they reached KShs 5 to 6 million.

The large increase in the arrears of those consumers who cannot be disconnected should not give immediate cause for concern, and the increase in the tariff could have been expected to increase the arrears of government institutions in the short run, since there is usually a time lag until a department organises itself to deal with a dramatically increased financial liability. The inability to disconnect these large consumers is not a problem today, but it does have the potential for a serious financial problem. Potentially it could lead to mounting arrears if the relevant ministry had a very serious cash flow problem and did not put Nyeri Municipal Council high on its priority list of creditors.

10.2.10 Cost of Metering

It is difficult to estimate the cost of metering at present since the price of new meters and spares has been very unstable in the recent past, partially due to the strengthening of the Kenyan shilling. It is reported that over a relatively short period in 1994 the price of meters increased dramatically, although in 1995 the price has fallen slightly. The Council has recently purchased a small batch for KShs 2,500 each. An additional 50% is assumed to cover the cost of installation and other fittings. The Engineer reported that he obtains an average meter life of 15 years, but since this seems to be rather optimistic, a figure of 12 years is assumed. This means that the annual depreciation cost would be KShs 312.50.

The average cost of each meter reader and plumber, taking their basic salary, housing allowance and NSSF into account is around KShs 5,000/month. In addition the cost of the meter foreman is around KShs 100,000 per year. Hence the total annual labour cost associated with reading, servicing and other activities is around KShs 580,000, with another KShs 200,000 for the new trainees (from early 1995), giving a total annual cost of KShs 780,000. This works out at just under KShs 200/meter/year. Including a further allowance, (40-50%), to cover other costs such as spares and transport, and adding the cost of the

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meters and fittings, the approximate annual direct cost is estimated at around KShs 600/meter/annum.

10.2.11 Complaints

Complaints can basically be divided into two categories, technical and commercial. The chief accountant or his staff are supposed to deal with commercial complaints while the engineer and his staff deal with technical complaints. There is no set complaints procedure and while most complaints are dealt with rapidly, the fact that consumers initially complain to different people means that they are often passed on to someone other than the person to whom they have complained.

The main commercial complaint since the tariff increased last September is that people believe that their bill is too high. This usually only requires an explanation of the tariff increase, from either the meter reading foreman or accountant depending on whether the consumer has gone to the Treasurer's or Engineer's Department.

Another complaint occurs if the meter reading interval is longer than normal, so that the billed consumption is higher than usual. Again staff have to see that the consumer understands. Sometimes consumers complain that they did not receive a bill, in which case the chief accountant investigates. Another complaint is that someone is still receiving an estimate when they are no longer using the water, for example in constructing a building. Other complaints include that they have paid their arrears but this is not reflected on the bill. Commercial complaints take up the time of senior as well as junior staff, but the staff are aware that consumer relations should not be ignored, and complaints are generally dealt with to the consumers satisfaction, where this is possible. Clearly this may not always be possible, where for example, the tariff is the source of the complaint.

Technical complaints cover the aspects of about; (i) meters, either the consumer believes that it is over-reading, or it has stopped working and he believes that his estimate is higher than actual use, (ii) leakages, or (iii) they are not receiving water.

Technical complaints are normally initially handled by the meter section foreman, who refers the case to the superintendent if he is not able to handle it himself. Similarly the superintendent refers some difficult cases to the Engineer.

If a leakage is reported and is found to be located on the consumer's side of the meter, he is informed that he is responsible for fixing it, and given appropriate advice, but if it is simple to fix, the plumber/meter reader investigating may do so on the spot. If the leakage is on the other side of the meter, the Nyeri Municipal Council staff repair the leakage. If there is a meter complaint a plumber/meter reader is sent to identify the problem and fix it. He may carry a spare meter in case the existing meter needs to be replaced. Sometimes meter complaints arise from a leakage on the premises, and this is explained to the consumer.

As mentioned above, although at present most complaints are dealt with satisfactorily, there is no set complaints procedure. Attempts to introduce a standard procedure are said to have failed in the past, however, a single complaints contact point for consumers should be possible.

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10.2.12 Recent Measures to Reduce Losses

The main effort recently to reduce losses has been the recruitment and training of four additional meter readers. This should; (i) improve the metering situation and slightly reduce unbilled water by bona fide consumers, (ii) accelerate disconnections and hence improve the cash flow and (iii) have a significant effect on reducing illegal consumption. The majority of illegal connections would be expected to be from illegal reconnection of disconnected premises, who have for example removed the sealed wires which closed the connection or who have removed plugs; rather than the connection by the consumer of a completely new connection. Consequently tracing a high percentage of illegal connections, and reducing illegal consumption only requires more time and effort to be devoted to a simple detection exercise, using existing information. It is reported that disconnected consumers who are found taking water illegally are charged KShs 2,000 plus an estimate of use since they were disconnected.

The other losses which might be reduced are physical and billing losses. No significant effort other than the normal on-going leakage reduction activities are being made to reduce distribution losses, although as mentioned in Section 10.1.1 recently a major leakage on the raw water main which had presumably existed for a long time was repaired, with a potential financial benefit. One is lead to the expectation that similar problems in the distribution system, if rectified could yield consequential results.

As was discussed in Section 10.1.4, it is believed that billing losses due to under-billing accurate meter readings are very small. Non-the-less, the lack of cross checking in the present system means that small losses could exist. The computerisation of the whole billing exercise and associated accounting should eliminate any such losses.

10.3 Billing and Revenue Collection

10.3.1 Billing

Consumers are billed for water, sewerage and conservancy charges on a single bill. The billing system used by Nyeri Municipal Council, although sound in administrative principle, is archaic in technology, due to the old fashioned billing machines used. The machines are used for three functions: bill production, recording of payments on individual ledger cards and for salaries. There are basically two problems:

(i) the age of the machines means that they regularly break down. This has two effects, the annual maintenance cost is extremely high, as is the cost of stationary, and the production of bills is inefficient. In February 1995, one of the two machines broke down and since then all work has been concentrated on one machine. During the week when it is used for salaries, no machine is available for billing or recording of payments. Hence in March 1995 billing was falling well behind schedule. Council officials are rightly hesitant to have the machine repaired since the repair costs are high compared to the cost of procuring a new computer system.

(ii) even when both machines are operating as well as they can, bill production is inefficient. Firstly they have to be programmed every day to undertake the specific operation for which they will be used that day. The programming activity which consists of feeding an old fashioned paper based programme through the machine can take some time before success is achieved. Secondly there is a very limited carry forward of information and the time required for data input is very high compared with that required in modern billing systems. Thus billing is slow and laborious at the best of times, and the work of the staff involved is extremely tedious. They work inefficiently due to the equipment which they have to operate, and billing can sometimes fall behind even when there is no major breakdown.

The only storage of information is on the consumers' ledger cards on which the latest meter readings, billing details and payments are recorded. In order to demonstrate the weaknesses of the system the steps involved are detailed below:

1. The operator puts the paper for the bill into the machine.

2. He then types in:
   (i) account number
   (ii) connection number
   (iii) balance
   (iv) check total

3. If the check total does not equal the sum of (i) to (iii) the operator has made an entry error and must cancel and start again (the check total which consists of the addition of (i) to (iii) was calculated the last time that the ledger card was used). This ensures that no data entry errors are made, but the need to feed in historic data anew every time a bill is prepared is inappropriate in the 1990s.

4. The operator inputs the consumer's name and address. These are typed directly onto the bill.

5. Operator now strikes the ENTER key and the machine from memory fills in: account number, connection number, and the date (the latter is set every morning).

6. The current and past meter readings are then inputed from the meter book.

7. The machine then computes the volume of consumption, and the amount.

8. The meter rent is typed in, as are the sewerage and conservancy charges. The operator reads off the sewerage charged from a table against the metered consumption.

9. The machine now adds the different monthly charges.

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10. It then adds them to the previous balance to produce the current balance.

11. The bill is now taken out of the machine

12. The corresponding ledger card is now put in the machine.

13. A single instruction results in the latest billing information being entered on the ledger card.

The bills are produced on a zonal basis and the operator goes through all the ledger cards for a zone and the corresponding meter book. When he has finished the billing for a zone/sub zone, he is able to request the machine to print a "Billing Control Sheet" which shows the total amount billed by service for that zone. This information is passed to the revenue accountant, so that calculations of total billing can be made for each billing period. Subsequently the figures are transferred to the Water Control Register. Most bills are then sent by mail, although some are retained for collection by the consumer.

In order to record payments, the appropriate programme must be fed into the machine. The operator uses the daily sheets from the Water Fund Receipt Journal to extract the payment information which he/she types onto the relevant ledger card. Each ledger card has to be found individually before an entry can be made. The machine subtracts the payment from the latest balance to compute the current balance.

Ledger cards are never thrown away. All current cards are kept in one location, and when a card is filled, that card is kept in another box, and the new card goes into the current section. When a property is vacated, the card is put into another box. Whenever a connection is disconnected, it's card is not removed from the current section, since the assumption is it is likely to be reconnected. Billing operators reported that there are 5,091 cards for Nyeri and 539 for Kiganjo, giving a total of 5,630. This compares well with the figure of 4,576 connections in September 1994 reported by the engineer.

10.3.2 Assessment of the Billing System

It appears that for the most part, the present billing system is no quicker than a completely manual system would be. The main advantage is that the total amount billed for each zone is produced by the machine on the request of the operator, thus the Council knows the total billing without additional calculations.

Billing in Nyeri is reasonably accurate in spite of the billing system, due to the fact that senior staff use their initiative. Administrative losses from inefficient billing are probably very limited but cannot be quantified. Junior staff seem to be doing their jobs reasonably well given the inherent problems. It was reported that the problem of non functioning machines is partially countered by ensuring that all large consumers' bills go out on time, even if they have to be manually computed and hand written.

The main weakness is that there is very little if any cross checking in the system, for example there is no cross checking that all consumers are actually billed every month. The

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number of bills sent out each month are not counted, although a sensible emphasis is put on the large consumers' bills and a check is made that these have been dispatched.

In preparing the bills the clerks go through the ledger cards one by one and find the relevant page in the meter reading book and copy the figure onto the bill/ledger card. If in the very unlikely event a page were missing from the meter reading book, it would be picked up, but if a ledger card is missed, it would not be picked up immediately. In most cases it would then be picked up at the next billing. It is however possible that a low use consumer would escape paying the correct amount of minimum charges, but the exact situation could not be ascertained. Since there is no cross checking, if a group of consumers were not billed in a particular month, there would be no systematic method of alerting the responsible persons to this fact.

If a ledger card went missing, it is probable that consumer would not be billed. It is therefore suggested that if the present system is not changed in the near future, the clerks should go through the meter books and identify any active consumers for whom no ledger card exists, on possibly an annual basis. The figure is probably very low and there may not be any missing cards, but no one knows and this is one possible source of administrative water losses.

The monthly billing figures are routinely compared with production figures for the month, but sometimes a complete zone/sub zone is omitted from the billing exercise, and hence the billing/production ratio will be incorrect. Omissions in one month will generally be included in the following month, however, and so the longer term billing/production ratio will remain reasonable.

10.3.3 Revenue Collection

Payments for water bills are received by the cash office in the municipal building. Consumers can pay by cash or cheque as long as they bring their bill or provide their connection/account number. The cashier writes on a carbonised receipt so that after the receipt is given to the consumer, the data is shown on the Water Fund Receipt Journal. The information consists of the name, the account and connection numbers, the amount paid and the receipt number. The cashier then ticks a cash or cheque column. During the day the cashier totals the completed journal pages and at the end of the day the value of all payments is added, and the total recorded. The value of the cash collected is added as well as the value of cheques held. Normally there is no problem in balancing the amounts. The auditor then checks the figures and the cash/cheques. The cash is banked by the banking cashier the following morning. The auditor keeps the journal pages for further checking.

When the daily totals from the Water Fund Receipt Journal have been fully reconciled with the cash/cheques and have been checked by the Internal Auditor, the pages of the Water Fund Receipt Journal are passed to the Chief Accountant. The revenue figures are then recorded in the Income Analysis Book. Later the same pages are passed to the billing machine operators for the payments to be entered on the individual consumers ledger cards.

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10.3.4 Revenue Collection Performance

At present the overall revenue collection performance is best measured by the percentage of the billings which are successfully collected, without considering the time lag involved between an amount being billed, and actually being paid. Even those who pay on time, normally pay a bill in the period following that in which it is presented, and some consumers such as large government institutions may actually pay a bill several periods later than that which it is sent out; hence in the short term the percentage of total billing actually collected may not represent a good indicator of collection performance. Despite this, and over a period of a year or so in which tariffs remain unchanged and were not increased towards at the end of the previous year, a direct comparison of billings and revenues is a valid measure of performance. Table 10.2 below presents the figures for billings and collection for the period January 1991 to December 1994.

Table 10.2

TOTAL CHARGES AND OUTSTANDING BALANCE IN NYERI AND KIGANJO

	Total Charges	Total Receipts	Credit Notes	------ Balance ------ B/f	C/f
1990-91					
Jan/Feb	1,813,158	1,035,077	-	7,150,394	7,928,475
Mar/May	2,593,453	2,702,114	-	7,928,475	7,819,813
June	878,612	873,390	20,273	7,819,813	7,804,764
1991-92					
Jul/Aug	1,761,740*	2,343,249	-	7,804,764	7,223,255
Sep/Oct	1,761,740*	1,103,380	-	7,223,255	7,881,615
Nov/Dec	1,642,625	1,522,585	-	7,881,615	8,001,655
Jan/Feb	2,000,209	2,391,047	-	8,001,655	7,610,817
Mar/Apr	2,274,662	1,154,418	-	7,610,817	8,731,061
May/Jun	2,166,825	2,754,995	-	8,731,061	8,142,891
SUB-TOTAL	11,607,801	11,269,674			
1992-93					
Jul/Aug	2,142,663	2,556,834	-	8,142,891	7,728,720
Sep/Oct	2,113,600	2,421,824	-	7,728,720	7,420,496
Nov/Dec	2,039,670	767,800	-	7,420,496	8,692,366
Jan/Feb	2,145,680	2,130,344	168,498	8,692,366	8,539,204
Mar/Apr	2,140,491	1,790,733	-	8,539,204	8,888,962
May/Jun	2,103,116	2,158,690	-	8,888,962	8,833,388
SUB-TOTAL	12,685,220	11,826,225			
1993-94					
Jul/Aug	2,182,356	3,694,774	-	8,833,388	7,320,970
Sep/Oct	2,138,761	3,159,481	-	7,320,970	6,300,250
Nov/Dec	1,962,853	1,371,004	-	6,300,250	6,892,099
Jan/Feb	1,769,773	1,456,030	-	6,892,099	7,205,842
Mar/Apr	2,600,932	2,392,365	-	7,205,842	7,414,409
May/Jun	2,241,311	2,077,060	-	7,414,409	7,578,660
SUB-TOTAL	12,895,986	14,150,714			
1994-95					
Jul/Aug	2,290,161	3,513,599	-	7,578,660	6,355,222
Sep/Oct	5,691,677	2,401,905	-	6,355,222	9,644,994
Nov/Dec	7,458,648	4,275,884	-	9,644,993	12,827,758

It can be seen that over the period up to August 1994, just prior to the implementation of the large tariff increase, the balance outstanding, despite oscillating, did not increase at all over preceding 44 month period. In fact it decreased slightly.

During the last three complete financial years the percentages of billings collected were:

1991-92	97.1%
1992-93	93.2%
1993-94	109.7%

Clearly the collection in all years contained an arrears component, but this is always a feature of water rate collection. The key test is whether or not the balance outstanding is increasing over time. It has clearly not been doing so in Nyeri, since 1991, and it can be stated unequivocally that the revenue collection performance has been outstanding during the 1990s.

Superficially the large increase in the outstanding balance during the last four months of 1994, after the tariff increase, gives cause for concern. This is not necessarily the case. If throughout the period all arrears were of relatively recent origin, i.e. there were no arrears which had been kept on the books for some years, one would expect the balance in the next few months to increase to a figure of around Shs 24 million, if revenue performance was unchanged, i.e. just under 4 months billings, as before. The greater the long term arrears component, the less should the balance increase. Although the long term arrears component could not be established quantitatively, it is clear that recent bills represent the major component of the arrears. Hence it cannot be said that revenue performance is deteriorating until the arrears are on a regular basis well in excess of Shs 24 million. If the performance is similar to that over 1991-94 one might expect the balance to oscillate between Shs 20 and 30 million with billing on the current tariffs.

10.3.5 Large Consumers Debts

Table 10.3 shows the sums owed by the largest debtors on 31st December 1994. Since the figures include the December 1994 bills they are not arrears in the true sense of the word, although that is what they are termed by Nyeri Municipal Council. In some cases such as most of the commercial enterprise, the debts mainly represent recent bills, but in the case of some government consumers, the figures include some longer standing debt. A comparison of the total of the sum owed by the 14 largest debtors of KShs 6.57 million with the reported total outstanding balance of all consumers at the same date of KShs 12.83 million shows that these 14 consumers accounted for over 50% of the sum owed for water and sewerage. Furthermore whilst the KShs 6.57 million is a reasonably reliable figure, the KShs 12.83 million figure could very well be an over-estimate of the current debt of all consumers as discussed below, hence the percentage of total debt owed by the 14 large consumers could be considerably in excess of 50% of all debt.

Table 10.3
MAJOR DEBTORS AT NYERI AND KIGANJO WATER SUPPLIES

Consumer	Sum Owed (Shs)
Police Training College - Kiganjo	1,976,999
G.K.Prison	1,073,121
Provincial General Hospital	922,046
Divisional Police HQ	654,658
Nyeri District Commissioner	401,541
KCC Kiganjo	380,235
Nyeri Primary School	290,435
Nyeri Technical School	284,325
Outspan Hotel	194,133
Green Hills Hotel	183,356
Mt Kenya Hospital	96,061
Golf Club	47,215
Mutune Trading Co.Ltd	43,686
Thingira Hotel	21,432
TOTAL (Rounded)	**6,570,000**

By the end of January 1995, the total sum owed by the above 14 consumers had increased by a further Shs 2 million. Although this need not give rise to immediate concern, it does emphasis the importance of council officials putting special efforts into communicating with, and following up, the debts of these consumers, especially the top four in the list which accounted for 36% of the money owed to the council on 31st December 1994.

10.3.6 Comment on Outstanding Debt

There is a lack of cross checking related to the origin of the balance outstanding (arrears) and hence there is some uncertainty as to how accurate the figures are. The balance outstanding figure is kept in the Water Billing Control Account Book. The figure is estimated at the end of every month, (currently at the end of every second month), by adding the total billed in the last billing period to the previous outstanding balance and subtracting the revenue received during the last period. If a mistake were to be made at any point in time, it would be carried forward permanently, hence the total could contain a series of errors.

At present only the amount of the balance outstanding is known, but there is no information on the length of time that the debts have been outstanding, how much of the total debt relates to consumers who are no longer supplied, or any other parameter. On the other hand, the amount which is owed by the largest consumers is known, since it is computed manually.

As mentioned above the current balance outstanding is based on the previous figure, amended to take account of the most recent billings and receipts. There is no direct tie up with the ledger cards, and if it had not been for a recent exercise organised by the Chief Accountant, in which the balances on all the ledger cards were totalled as at 31st December 1994, no one would know how that total compares with the figure appearing in the Water Billing Control Account Book. The total resulting from the addition of all the cards, both active and those which are no longer active was Shs 8.03 million. This is well below the total

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outstanding balance figure for the same date, of Shs.12.83 million, reflected in the account book.

10.3.7 Linkage Between Billing and Revenue Collection

The linkage between billing and revenue collection is inadequate. The only comparison which can be made between collection and billing is a comparison of independently calculated totals. It is not possible to see how the collection relates to recent, and to long past, billing. Furthermore although billing is broken down into components such as meter rent, water charges and sewerage charges, the revenues cannot be broken down by service. The basic breakdown of revenue is by total daily collection. It can only be assumed that the proportions of revenues for individual services are in the same ratio as in the recent billing.

Whilst the system ensures that the total amount collected is properly checked and the revenue is controlled and properly accounted for, the posting of individual payments to the relevant consumer's records depends upon staff efficiency since they have to be transferred one by one onto the ledger cards. Any omissions would in any case normally be picked up following a consumer complaint.

It is concluded that little measured consumption escapes being billed and the estimates of the total amounts billed are reasonably accurate. There is no question as to the total amount of money collected, and the overall level of payment is good. The billing system is however slow, laborious and costly. There is no automated system for highlighting individual non payment, which is undertaken on an ad hoc basis.

10.3.8 Cost of Billing and Revenue Collection

The cost of billing and revenue collection cannot be obtained directly from the estimates or expenditure records since they are part of the Water Administration costs, thus the costs have been estimated based on the cost of inputs and on the current salaries of the staff involved.

Five clerks are involved in water and sewerage billing. Billing together with entering payments on the ledger cards takes approximately 75% of their time. There is also one cashier receiving water and sewerage payments, and three clerks plus the revenue accountant involved with water and sewerage revenues. It is reported that water and sewerage takes up two thirds of their time. In addition the chief accountant spends nearly half of his time dealing with water and sewerage revenue activities.

An approximate estimate of the cost of the wage bill, housing and other allowances and NSSF for the billing and revenue clerks and cashier, together with the appropriate part of the salaries and benefits of the Chief and Revenue Accountants is estimated at around Shs 650,000 per annum, although before the mid 1994 salary increase the estimated cost was around Shs 400,000.

The Chief Accountant reported that the annual maintenance charge for the billing machines is around Shs 400,000. (Note that a new PC of standard usage costs about Shs.150,000). In addition the total stationary cost including machine requirements is Shs 220,000 with an additional Shs 60,000 for postage.

Hence it is estimated that billing and revenue collection currently cost the Treasurers Department at around Shs 1.33 million per annum in direct inputs.

10.3.9 Computerisation

The examination of the current method of billing and revenue collection conclusively shows that the council is in need of a new simple computerised system. Not only would this improve efficiency and information, but it should reduce costs. To this end, the council had gone through a tendering process for the hardware and software for a new billing system at the time this study commenced. It is to be hoped that the present methods will soon be replaced. There were however two constraints:

(i) some of the Councillors had opposed the acquisition of a new billing system on the grounds of expense. Whether or not they were correct regarding the quotations which had been obtained by the Council, it was important that they be made aware of the costs of not modernising billing so that they appreciate the need. It is understood the Town Clerk had this in hand.

(ii) it is important that the new billing system is the most appropriate for Nyeri. Whilst cost is very important it is also important to ensure that the most appropriate system is selected. The most appropriate system is likely to be the most cost effective unless it is considerably more expensive than the alternatives. In fact the most appropriate system could be a relatively cheap system, since the most appropriate for Nyeri may be quite simple. The key factors are simplicity of use, and achieving the billing objectives to the maximum degree possible.

Computerising the billing and other water supply operations in Nyeri will have a number of advantages. Firstly the long run cost will definitely be less than that associated with the existing billing machines in both direct costs and in terms of staff time involved. Secondly it would contribute to increased financial control and to dramatically improved availability of management information.

At present although all consumers have both an account and a connection number, the available figures themselves provide no consumer management information. It is suggested that when the billing of consumers is being computerised information on a consumer's location, the consumer category, and other data such as whether or not a consumer is sewered should be included. It may even be appropriate to allocate consumers numbers which immediately identify some of these parameters. Whatever coding structure is adopted, it should permit various levels of account/consumption analyses, for example (i) analysis of metered consumption by various criteria, and sub-analyses, such as by consumer category within a zone, (ii) analyses of billings by various parameters, and (iii) the allocation of cash receipts against type of service, by time, by area, and by type of consumer. In addition the arrears situation would be kept up to date and there would be a direct comparison between billing and collection. Automatic flagging of required disconnections combined with the current efforts to increase disconnection capability would assist efficient disconnection.

As a result of the initial examination of the billing system and the problems which it has been creating for the council, the consultants have examined alternative billing systems available in Kenya and have proposed a simple system which would meet the council's needs. If any new system is to be adopted successfully, it is important that all staff who will be involved are well trained.

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11. COSTS, REVENUES AND TARIFFS

11.1 Total Production Costs

Table 11.1 presents the costs incurred by the Nyeri/Kiganjo water and sewerage schemes over the period 1991-94. The first part of the table presents the figures for the sewerage, Nyeri water, Kiganjo water and water administration, extracted from subsequent estimates for 1991-2 and 1992-93, and from the general ledger for 1993-4. The latter parts of the table show the combined water supply expenditures for both supplies including the costs of administration and Nyeri Municipal Council's total water supply and sewerage expenditures.

In order to obtain an estimate of the total expenditures incurred by each water supply, the water administration costs have been allocated to the two schemes using a ratio of 6:1. This figure was derived from discussions with officials in Nyeri. Table 11.2 presents the resulting costs for the two water supplies.

11.2 Unit Production Costs of Water

Table 11.3 presents the annual expenditure on the Nyeri and Kiganjo water supplies, together with the volumes of production and billed consumption, and the unit cost calculations based on such expenditure.

That table shows that the unit cost of water produced at Kiganjo has been more than double that in Nyeri, but the difference in the cost per unit consumption is lower (40% to 75% higher at Kiganjo compared with Nyeri) due to a higher level of losses in Nyeri.

In order to estimate the current unit costs, one must estimate current costs relative to those in 1993-4. Based on the 1994-5 estimates presented in Section 11.12, the total cost in Nyeri is just under 46% higher than in 1993-94. Production during the first half of the current financial year was running at around 7% higher than during 1993-94. Hence the current unit production cost in Nyeri is estimated at around 36% higher than in 1993-94, i.e. at KShs 7.97/m^3, say KShs 8/m^3. However the volume of consumption was running at a similar level to that in 1993-94 and the cubic metre cost consumed is estimated at around KShs. 13.4/m^3.

Similar modifications to the 1993-4 unit cost of production in Kiganjo suggest that the current cost of production is around KShs 18.4/m^3 and that the current unit cost of consumption is around KShs 20.5/m^3. All these costs are however based on the 1994-5 estimates, and actual expenditures and unit costs are likely to be somewhat lower than the above figures.

11.3 Unit Sewerage Costs

Table 11.4 presents the combined annual costs of the Nyeri and Kiganjo sewerage schemes, since the costs are not separated in the Nyeri Municipal Council accounts. The volume of consumption shown is the volume consumed by all sewered consumers in both Nyeri and Kiganjo. The figure is based on the estimate that 60% of all water consumed is used by consumers connected to a sewerage system. The last row shows the unit cost based on the total recurrent sewerage cost divided by the total consumption of sewered consumers.

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Table 11.1
COST BREAKDOWN OF WATER SUPPLY AND SEWERAGE EXPENDITURES
1991-94

	1991-92	1992-93 (KShs)	1993-94
Sewerage			
Employees	1,368,960	1,523,420	1,641,885
Repairs and Maint.	93,400	231,160	337,692
Electricity	400,000	355,100	638,717
Transport	120,000	134,020	181,314
Office/Overhead	166,360	88,720	29,795
Loan Charges	500,000	200,000	-
Renewals	0	99,500	-
Other	41,820	40,300	15,205
Total	2,690,540	2,672,220	2,844,608
Nyeri Water Supply			
Repairs & Maint	449,420	622,540	1,086,730
Electricity	600,000	600,100	1,579,107
Chemicals	640,900	1,479,920	3,336,585
Fuels and Oils	152,000	25,280	98,422
Meters,Spares,Boxes	254,500	196,220	368,684
Renewals Provision	180,000	180,000	180,225
Office	0	43,680	47,933
Other	23,800	4,760	15,310
Total	2,300,620	3,152,500	6,712,996
Kiganjo Water Supply			
Repairs & Maint	251,200	322,660	149,372
Electricity	750,000	519,100	1,310,800
Chemicals	316,000	743,560	837,310
Fuels and Oils	100,000	16,860	83,578
Meters,Spares,Boxes	117,200	46,500	70,000
Renewals Provision	90,000	81,300	-
Office	5,000	30,520	30,305
Other	6,720	11,260	2,050
Total	1,636,120	1,771,760	2,483,415
Administration			
Employees	1,520,900	2,709,180	2,579,450
Office/Overheads	566,300	654,000	615,082
Renewals Fund (Veh)	150,000	50,000	-
Loan Charges	500,000	200,000	-
Establishment Chrgs	700,000	500,000	600,000
Transport	320,000	325,500	565,808
Minor Capital Works	346,880	373,680	1,177,648
Total	4,104,080	4,812,360	5,537,988

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Table 11.2

WATER SUPPLY SCHEME EXPENDITURE (INCL ADMINISTRATION)

	1991-92	1992-93 (KShs)	1993-94
Nyeri			
Direct Costs	2,300,620	3,152,500	6,712,996
Administration	3,517,783	4,124,880	4,746,847
Total	5,818,403	7,277,380	11,459,843
Kiganjo			
Direct Costs	1,636,120	1,771,760	2,483,415
Administration	586,297	687,480	791,141
Total	2,222,417	2,459,240	3,274,556

Table 11.3

UNIT PRODUCTION COSTS IN NYERI AND KIGANJO

	1991-92	1992-93 (KShs)	1993-94
Nyeri Water Supply			
Total Cost (KShs)	5,818,403	7,277,380	11,459,843
Volume of Production (m^3/annum)	2,063,163	2,038,400	1,958,110
Volume of Consumption (m^3/annum)	1,336,295	1,302,200	1,245,693
Unit Cost KShs/m^3 Prod.	2.82	3.57	5.85
Unit Cost KShs/m^3 Cons.	4.35	5.59	9.20
Kiganjo Water Supply			
Total Cost (KShs)	2,222,417	2,459,240	3,274,556
Volume of Production (m^3/annum)	358,184	327,462	283,046
Volume of Consumption	293,772	264,720	253,562
Unit Cost KShs/m^3 Prod.	6.20	7.51	11.57
Unit Cost KShs/m^3 Cons.	7.57	9.29	12.91

Table 11.4

UNIT RECURRENT SEWERAGE COSTS IN KIGANJO/NYERI COMBINED

	1991-92	1992-93 (KShs)	1993-94
Total Cost (KShs)	2,690,540	2,672,220	2,844,608
Volume of Consumption (m^3/annum)	978,040	940,152	899,553
Unit Cost (KSh/m^3)	2.75	2.84	3.16

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Table 11.4 shows that the unit recurrent sewerage costs are, as one would expect, far lower than the unit recurrent water supply costs. For example the unit sewerage cost was KShs 3.16/m^3 consumed by sewered consumers in 1993-4 compared with recurrent water supply costs of approximately three times that in Nyeri, (KShs 9.20/m^3 consumed), and approximately four times greater in Kiganjo, (KShs 12.91/m^3 consumed). Based on the 1994-5 estimates the unit recurrent sewerage cost for this period, (using the same approach as that used for water in Section 11.2 and with the same reservations about the resulting figures), would be KShs 4.99/m^3 consumed by sewered consumers.

11.4 Breakdown of Unit Costs

Since the 1993-94 costs are more reliable than the 1994-5 costs, the breakdown of the unit cost is based on the actual 1993-4 expenditure figures. Tables 11.5 and 11.6 present the unit costs of consumption and production broken down into the main cost elements for the Nyeri and Kiganjo water supplies.

Table 11.5
UNIT COST OF PRODUCTION IN NYERI BY COST ELEMENT 1993-4

Cost Element	Annual Cost (KShs)	Breakdown (%)	Unit Cost of: Prod (KShs/m^3)	Cons
Staff Costs	2,210,957	19.3%	1.13	1.78
Repairs and Maintenance	1,086,730	9.5%	0.55	0.87
Electricity	1,579,107	13.8%	0.81	1.27
Chemicals	3,336,585	29.1%	1.70	2.67
Fuels and Oils	98,422	0.9%	0.05	0.08
Meters & Spares	368,684	3.2%	0.19	0.30
Renewals	180,225	1.6%	0.09	0.14
Contribution to Establishment	514,286	4.5%	0.26	0.41
Transport	484,978	4.2%	0.25	0.39
Office and Overhead	590,456	5.1%	0.30	0.47
Capital Cost	1,009,412	8.8%	0.52	0.82
Total	11,459,842	100.0%	5.85	9.20

It can be seen that in Nyeri, electricity and chemicals together constitute almost 43% of the total cost. These elements plus staff constitute well over 60% of total production cost.

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Table 11.6

UNIT COST OF PRODUCTION IN KIGANJO BY COST ELEMENT 1993-4

Cost Element	Annual Cost (KShs)	Breakdown (%)	Unit Cost of: Prod (KShs/m^3)	Unit Cost of: Cons (KShs/m^3)
Staff Costs	368,493	11.3%	1.31	1.46
Repairs and Maintenance	149,372	4.6%	0.53	0.59
Electricity	1,310.800	40.0%	4.63	5.16
Chemicals	837,310	25.6%	2.96	3.30
Fuels and Oils	83,578	2.6%	0.30	0.34
Meters & Spares	70,000	2.1%	0.24	0.27
Renewals	-	-	-	-
Contribution to Establishment	85,714	2.6%	0.30	0.34
Transport	80,830	2.5%	0.29	0.32
Office and Overhead	120,224	3.7%	0.43	0.48
Capital Cost	168,235	5.0%	0.58	0.65
Total	3,274,556	100.0%	11.57	12.91

Table 11.6 shows that the unit cost of production in Kiganjo is far higher than in Nyeri. However it also shows that the higher costs for electricity and chemicals accounts for the major part of the difference. The total unit cost of production in Kiganjo is KShs 5.72 higher than that in Nyeri, however electricity and chemicals account for KShs 5.08 of this difference. Thus the current very high power and chemical costs, which in 1993-4 accounted for over 65% of all production costs in Kiganjo, would be a key factor in the future design decisions.

It can also be seen that due to the higher losses in Nyeri, the unit costs of consumption at the two schemes are not as different as the costs of production. In fact when the costs of power and chemicals are excluded, the unit cost of production of other inputs in Kiganjo is lower than that in Nyeri.

Table 11.7 presents the unit cost breakdown of the recurrent sewerage costs. It can be seen that staff costs account for approaching 60% of all sewerage recurrent costs.

Table 11.7

UNIT COST OF SEWERAGE IN NYERI/KIGANJO BY COST ELEMENT 1993-4

Cost Element	Annual Cost (KShs)	Breakdown (%)	Unit Cost (KShs/m^3)
Staff Costs	1,641,885	57.7%	1.82
Repairs and Maintenance	337,692	11.9%	0.38
Electricity	638,717	22.5%	0.71
Transport	181,314	6.4%	0.20
Office and Overhead	29,795	1.0%	0.03
Other	15,205	0.5%	0.02
Total	2,844,608	100.0%	3.16

11.5 Operation and Maintenance Costs

Although Nyeri Municipal Council has not been making significant repayments on its water supply and sewerage loans, the figures in Sections 11.1 to 11.4 do include some capital cost elements such as expenditures on minor extensions for the water supply. Thus although the above costs are basically for operation and maintenance, they do include some capital cost elements. Table 11.8 presents the total costs incurred over 1991-4 with those cost elements which are basically of a capital nature eliminated, i.e. it shows the costs of operation, maintenance and administration, but also includes the very minor replacement costs which have been incurred.

Table 11.8

WATER AND SEWERAGE OPERATION AND MAINTENANCE COSTS

	1991-92	1992-93 --------------- (KShs) --------------	1993-94
Nyeri Water Supply (KShs)	5,092,506	6,785,654	10,450.430
Production (m^3/annum)	2,063,163	2,038,400	1,958,110
Consumption	1,336,295	1,302,200	1,245,693
O&M Cost KShs/m^3 Prod.	2.47	3.33	5.34
O&M Cost KShs/m^3 Cons.	3.81	5.21	8.39
Kiganjo Water Supply(KShs)	2,101,434	2,377,286	3,106,321
Production (m^3/annum)	358,184	327,462	283,046
Consumption (m^3/annum)	293,772	264,720	253,562
O&M Cost KShs/m^3 Prod.	5.87	7.26	10.97
O&M Cost KShs/m^3 Cons.	7.15	8.89	12.25
Sewerage (KShs)	2,190,540	2,472,220	2,844,608
Consumption (m^3/annum)	978,040	940,152	899,553
Unit Cost (KShs/m^3)	2.24	2.63	3.16

A comparison of the figures in Table 11.8 with those in Tables 11.3 and 11.4 shows that the unit O&M costs are only just below the unit total expenditure incurred by Nyeri Municipal Council due to the very low capital expenditures/loan repayments being made. Based on the logic used in Section 11.2 to update to 1994-95, the 1994-5 unit operation and maintenance costs would be:

	Cost of Water Produced (KShs/m^3)	Cost of Water Consumed (KShs/m^3)
Nyeri Water Supply	7.26	12.25
Kiganjo Water Supply	17.44	19.48
Sewerage	-	4.99

11.6 Assets and Depreciation

Any estimate of the current value of assets of the Nyeri and Kiganjo water supply schemes would be unlikely to be very accurate. For example, the book value of the Nyeri water supply when taken over from MoWD in 1982 was KShs 3.66 million but the figure was doubtful, even at that time. Given that the total capital expenditure on water supply since then has probably been around KShs 20 million, the major part of which was incurred 5-8 years ago, the current book value of water supply assets would probably be around KShs 15 million if such records were kept.

Even the sewerage scheme does not appear in the assets register of the Council since it is still maintained in the category of 'work in progress'. In order to obtain an order of magnitude estimate of the current value of the system, the value of the original loan of KShs 170 million could be depreciated linearly by 2.5% per annum over the interim six year period. This suggests a current 1995 value of around KShs 145 million. However given;

(i) the uncertainty surrounding any current asset values, and,

(ii) the fact that any annual depreciation estimate of the water supply system would have little effect on any future financial calculations, since the value of those assets would be insignificant compared to the probable cost of any future major augmentation of the water supply.

(iii) sewerage loan repayments are a reasonable proxy for the current financial costs of the sewerage system,

the current repayments which the Council should be making on its water and sewerage loans will be used as a proxy for the annual capital costs of existing assets in estimating total current production costs.

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11.7 Water Supply Costs Including Capital Costs

The current production costs shown in Sections 11.1 - 11.4 included small capital costs elements but far higher capital costs should have been incurred. Firstly existing loans should have been repaid, and secondly larger allowances should have been made for replacements.

Table 11.9 presents the annual costs of the Nyeri water supply, shown in Table 11.2 together with an assumed annual capital cost of KShs 1.5 million for Nyeri. This is based on a sum of just over KShs 1 million per annum which is the current loan repayment liability, and KShs 0.5 million for renewals and replacements. It can be seen that in 1993-4 the total unit cost of production including capital costs was KShs 6.6/m^3, while the total cost of water consumed was KShs 10.4/m^3. These costs are only 13% higher than the unit costs actually incurred, and is a reflection of the low capital costs in Nyeri due to low historic costs of an aging scheme. The corresponding figures for 1994-95 would be around KShs 8.7/m^3 production and KShs 14.6/m^3 consumption.

Table 11.9
UNIT PRODUCTION COSTS FOR NYERI WATER SUPPLY 1993-4

Recurrent Cost (KShs)	11,459,843
Annual Capital Cost (KShs)	1,500,000
Total Annual Cost (KShs)	12,959,843
Volume of Production (m^3/annum)	1,958,110
Volume of Consumption (m^3/annum)	1,245,693
Unit Cost KShs/m^3 Prod.	6.6
Unit Cost KShs/m^3 Cons.	10.4

As regards Kiganjo, annual capital costs are extremely low, since there are no significant outstanding loans for that supply. Furthermore any annual depreciation estimates would be very low since the book value of the supply, if it could be established, would be extremely low, since the historic costs involved in its construction are in today's terms relatively insignificant.

11.8 Sewerage Costs including Capital Costs

Although the total production costs of water are not much higher than the recurrent costs due to low capital costs, the total costs of sewerage including capital costs are far higher than the recurrent costs due to the relatively recent expensive construction. Table 11.10 presents the recurrent costs incurred in 1993-4 together with the loan repayment which should have been made. It can be seen that the inclusion of the capital costs increases the total cost and unit costs by over 386%.

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Table 11.10
CAPITAL AND RECURRENT SEWERAGE COSTS IN KIGANJO/ NYERI COMBINED IN 1993-4

Recurrent Cost (KShs)	2,844,608
Annual Capital Cost (KShs)	11,000,000
Total Annual Cost (KShs)	13,844,608
Volume of Consumption (m^3/annum)	899,553
Unit Cost (KShs/m^3)	15.39

Based on the 1994-95 recurrent estimates the total cost for that year would be KShs 15.4 million and the unit cost would be just over KShs 17/m^3.

Hence whilst the combined unit recurrent costs of sewerage are only one third, and one quarter respectively of the recurrent costs of water in Nyeri and Kiganjo, the total unit costs for sewerage are higher than the total unit production costs of water in both Nyeri and Kiganjo.

11.9 Water Supply and Sewerage Income

Table 11.11 summarises the NMC's income from water supply and sewerage over 1991-4. The figures for 1991-2 and 1992-3 were extracted from subsequent budget estimates, while the 1993-94 figures were taken from the general ledger.

Table 11.11
SUMMARY OF ANNUAL WATER SUPPLY & SEWERAGE INCOME

Actual Income	1991-92	1992-93	1993-94
		(KShs)	
Sewerage Charges			
Nyeri	2,892,000	3,096,280	3,019,691
Kiganjo	727,400	864,220	809,954
Other	0	195,700	21,455
Sub-Total	3,619,400	4,156,200	3,851,100
Water Charges			
Nyeri	6,981,800	6,746,900	7,141,349
Kiganjo	1,200,000	1,469,540	1,424,206
Misc Income	148,900	169,040	444,665
Sub-Total	8,330,700	8,385,480	9,010,220
Total	11,950,100	12,541,680	12,861,320

However it should be noted that the council regards charges raised rather than cash received as the income figure, which they compare with expenditures in their budgets. This definition of income will, unless otherwise stated, be used in this report for two reasons. Firstly although it is possible to allocate the charges raised to water and sewerage, it is not possible with existing book-keeping practices to allocate cash collected to water and sewerage separately. Secondly in the medium term, cash received is very similar to charges levied, i.e. collection has been almost 100% in recent years. The relevant figures are presented in Table 11.12.

Table 11.12
TOTAL CHARGES COMPARED TO INCOME (KSHS MILLION)

	Income for Water and and Sewerage from Subsequent Estimates /General Ledger*	Water Income Control Book	
		Total Charges incl. Conservancy	Cash incl. Conservancy
1991-92	11.95	11.61	11.27
1992-93	12.54	12.69	11.83
1993-94	12.86	12.90	14.15
Total	37.35	37.20	37.25

Table 11.12 demonstrates that over a three year period the charges levied are a reasonable proxy for the cash collected. Given that conservancy charges are approximately 4% of all charges and revenues, it appears strange that the figures for water and sewerage incomes in subsequent estimates are so similar to known charges including conservancy. However even if this does represent an error it is a maximum of 4%.

11.10 Comparison of Budget and Subsequent Expenditures and Incomes

Table 11.13 presents the approved budget figures for the years 1991-2 to 1993-94 and the subsequent expenditures/incomes. It should be noted that the figures are presented in Kenyan Pounds since all budget figures are presented in this way. The Kenya pound is equivalent to 20 Kenya Shillings. It can be seen that generally expenditure falls short of the approved expenditure. This is caused by the council not needing the approved funds for various reasons, and to the approved funds not being available when required. It is not possible to quantify the relative importance of these factors, but officials insisted that the lack of liquidity at times prevents them from spending their full approval.

It can also be seen that income falls well short of that appearing in the estimates, although in two years out of three it did not lead to a deficit. However in 1994-95 actual income far exceeded that appearing in the estimates since the latter did not take full account of the tariff increase.

Table 11.13
RELATIONSHIP BETWEEN BUDGET AND ACTUAL EXPENDITURES
(KENYA POUNDS)

	Sewerage	Nyeri Water	Kiganjo Water	WS&S Admin	RCTCO	Total
	---------------- Kenya Pounds ----------------					
Expenditure						
Approved 1991-2	227,561	80,700	66,100	260,764	87,000	722,125
Actual 1991-2	134,527	115,031	81,806	187,860	17,344	536,568
Income				Misc.		
Approved 1991-2	297,000	400,000	84,000	30,000		811,000
Actual 1991-2	180,970	349,090	60,000	7,445		597,505
Expenditure						
Approved 1992-3	179,166	113,600	73,500	265,192	40,550	672,008
Actual 1992-3	133,611	157,625	88,518	221,934	18,684	620,442
Income				Misc.		
Approved 1992-3	297,000	400,000	84,000	30,000		811,000
Actual 1992-3	207,810	337,345	73,477	8,452		627,084
Expenditure						
Approved 1993-4	183,325	213,000	139,850	267,203	165,500	968,878
Actual 1993-4	142,230	335,650	124,171	218,017	58,882	878,950
Income				Misc.		
Approved 1993-4	342,000	465,000	90,000	38,000		935,000
Actual 1993-4	192,555	357,068	71,210	22,233		643,066

11.11 Financial Position of the Nyeri Sewerage and Water Supply Operations During 1992-94

This Section examines the financial position of Nyeri sewerage and water supply operations for the period 1992-94, and subsequently comes to conclusions about the adequacy of the current tariff. The main analysis is in terms of the overall sewerage and water supply operations, but the financial positions of the individual components (Sewerage, Nyeri Water Supply and Kiganjo Water Supply) are also examined.

In breaking down expenditures by component, small errors could occur since it is possible that some expenditures slip into a different budget heading from that which actually incurs the expenditure. For example minor elements of the Administration costs may be incurred by the sewerage operation. Secondly the division of Administration costs between Nyeri and Kiganjo water supplies, is based entirely on judgement, since there is no other way to make the allocations. A ratio of 6:1 has been assumed. Any errors involved will however be minor and would not affect any of the conclusions.

Table 11.14 presents a comparison of the costs and revenues of the water and sewerage operations of Nyeri Municipal Council.

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Table 11.14

COMPARISON OF COSTS AND INCOME OVER 1991-94 (KSHS)

	1991-92	1992-93	1993-94
Nyeri Water Supply			
Costs	5,818,403	7,277,380	11,459,843
Income	6,981,800	6,746,900	7,141,349
Surplus/Deficit	1,163,397	- 530,480	-4,318,494
Kiganjo Water Supply			
Costs	2,222,417	2,459,240	3,274,556
Income	1,200,000	1,469,540	1,424,206
Surplus/Deficit	-1,022,417	-989,700	-1,850,350
Sewerage			
Costs	2,690,540	2,672,220	2,844,608
Income	3,619,400	4,156,200	3,851,100
Surplus/Deficit	928,860	1,483,980	1,006,492
Water Supply Combined			
Costs	8,040,820	9,736,620	14,734,399
Income	8,330,700	8,385,480	9,010,220
Surplus/Deficit	289,880	-1,351,140	- 5,724,179
Water Supply and Sewerage			
Costs	10,731,360	12,408,840	17,579,007
Income	11,950,100	12,541,680	12,861,320
Surplus/Deficit	1,218,740	132,840	-4,717,687

It should be noted that there is a minor inconsistency in the Table arises because, although the miscellaneous income is included in the combined water supply figures, there was no sound basis for allocating this income between the two water supplies, so the individual figures for the individual water supplies appear to be marginally worse than they actually were.

In 1991-92 it can be seen that for the entire water supply and sewerage operations, income covered all costs and generated a surplus of KShs 1.2 million. Whilst both Nyeri water supply element and the Nyeri/Kiganjo sewerage element each produced surpluses of around KShs 1 million, Kiganjo water supply produced a loss of a similar magnitude.

In 1992-93 the entire water supply and sewerage operation just about covered its costs. Whilst sewerage generated a surplus approaching KShs 1.5 million, both water supplies incurred deficit, the Kiganjo deficit at almost KShs 1 million being approximately double that of Nyeri. In this period Nyeri recovered almost 95% of its costs, but the corresponding figure for Kiganjo was only 60%.

In 1993-94 the water supply and sewerage operation went seriously into overall deficit. The sewerage continued to generate a surplus of around KShs 1 million, but Nyeri water supply produced a deficit of over KShs 4 million, and the deficit in Kiganjo was approaching KShs 2 million. The overall deficit was approaching KShs 5 million or approximately 27% of costs, i.e. only 73% of costs were recovered. Despite the larger deficit incurred by the Nyeri water supply, it still covered a higher proportion of its costs than Kiganjo, 62% compared to 43%.

The reason for the dramatic shift into deficit in 1993-94 is clear. Income remained almost static but costs increased considerably following the "economic dislocation" of 1993. While the cost increases in sewerage and water supply administration only increased moderately, the direct water supply costs increased dramatically. In Nyeri the direct water supply costs more than doubled from KShs 3.15 million to Kshs 6.71 million, while in Kiganjo they increased from KShs 1.77 to KShs 2.48 million. Furthermore the cost increase was concentrated in a few items, notably chemicals. While sewerage and administration expenses were kept under the approved estimates, water supply expenditures exceeded approvals. Kiganjo just exceeded the approved budget but Nyeri water supply exceeded the budget by KShs 2.67 million. Chemical expenditures exceeded the approved sum by KShs 1.46 million while electricity exceeded the approved budget line by over KShs 0.81 million.

The total expenditure in chemicals and electricity was KShs 7.7 million in 1993-94 compared to KShs 3.7 million in 1992-93. This increase in the cost of chemicals and power accounted for the major part of the deficit in 1993-94.

11.12 Current Year 1994-5 Income and Expenditure

The only figures which exist for 1994-95 are the estimates of expenditure and income, expenditure incurred to date in the ledger and income to date. The general ledger was examined to determine expenditures during the first half of 1994-95, but it is clear that the expenditures recorded to date are in some cases not properly representative of costs incurred. For example the expenditure recorded on electricity is based on the payment of a few small power bills only.

Similarly expenditures on items such as transport clearly do not represent costs incurred to date. Hence in the analysis below, the following estimates will be used, despite their being only indicative of the actual expenditure. The summary figures are as follows:

Sewerage	KShs 4,487,820
Nyeri Water Supply	KShs 16,711,380
Kiganjo Water Supply	KShs 5,208,900
Total	KShs 26,408,100

Normally the actual expenditures fall well short of the estimates, on the other hand it appears that the July 1994 salary increases have not been fully taken account of in the estimates and rather than make an attempt at what would be spurious accuracy the figures are used as they are. Given the large salary increases and some inflation in other cost elements, the overall increase over 1993-94 estimates by approximately 50% does not seem unreasonable.

On the other hand the income figures in the estimates are clearly inappropriate, since they do not take full account of the tariff increase of September 1994.

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Given that the tariff increase in September 1994 increased most prices by a factor of approximately three, one would expect the billings for a full year at the new tariff to be around KShs 40 million, and since the increase only became effective in September, the probable billing for 1994-95 will be around KShs 36 million.

The combination of the current expenditure estimate with the projected income for 1994-95 would give a surplus of KShs 9.6 million, but the surplus of cash revenue over expenditure is likely to be far lower and cash received may not even cover expenditures due to the payment time lag subsequent to any tariff increase.

Nevertheless given the fact that in recent years Nyeri Municipal Council's actual revenue collection has matched income as defined by billing, the required tariff analyses will be based on Nyeri Municipal Council's definition of income.

In order to determine the financial situation of sewerage and water supply operations under the current tariff, the projected future income will be allocated to the each utility in the same ratio as that of recent income. Using the 1993-94 figures in Table 11.14 the split is sewerage 31%, Nyeri Water Supply 58%, and Kiganjo Water Supply 11%. Since the percentage increases in the water and sewerage tariff are similar, there is unlikely to be any major changes in the revenue split in the near future. Hence the 31%/58%/11% figures are applied to the estimated annual income of KShs 40 million representing a full year at the current tariff, and to an income of KShs 36 million representing expectations for 1994-95. The results are shown in Table 11.15.

Table 11.15
COMPARISON OF PROJECTED COSTS AND PROJECTED INCOME UNDER THE CURRENT TARIFF. (KSHS MILLION) FOR 1994 - 95.

	Expend -iture	Income		Surplus	
		10 mths	12 mths	10 mths	12 mths
Sewerage	4.49	11.16	12.40	6.67	7.91
Nyeri Water Supply	16.71	20.88	23.20	4.17	6.49
Kiganjo Water Supply	5.21	3.96	4.40	-1.25	-0.81
Total	26.41	36.00	40.00	9.59	13.59

It can be seen that in 1994-95 the total surplus should be KShs 9.59 million, but if the tariff increase started from July 1994, the total surplus would have been over KShs 13.5 million. Despite the overall surplus it can be seen that Kiganjo water supply is still in deficit, albeit a much reduced one of KShs 1.25 million in 1994-95.

11.13 Adequacy of the Current Charges

Based on a full year at the new tariff and with projected 1994/95 costs, the last column of Table 11.15 shows that the overall surplus is in excess of KShs 13.5 million, with Kiganjo water supply still causing a small deficit, and with Nyeri water supply and sewerage producing surpluses of almost KShs 6.5 million and KShs 8 million respectively.

These promising figures which are based on the recent pattern of expenditure do not however present the full picture. Firstly in recent years contributions to renewals and replacement, and loan repayments have been very low. The result is that inadequate allowance has been made for replacement and arrears on outstanding loans have been increasing. Any estimate of the tariffs required for cost recovery should take these factors into account. In round figures the repayments due on the sewerage and water loans are KShs 11 million and KShs 1 million respectively. It is difficult to determine whether a further allowance should be made for arrears on the loan and for an uncertain increase in the payment on the sewerage loan when the housing element is paid for. As a compromise, an annual sum for the sewerage loan of KShs 13 million will be assumed. Further, a sum of KShs 0.5 million will be allowed for water supply renewals and replacements in Nyeri and KShs 0.1 million in Kiganjo.

In addition all costs will be subject to inflation, but due to the large salary increase in 1994, it is assumed that an overall cost increase of 10% would be sufficient between 1994-5 and 1995-6. It is assumed that the volume of sales will be similar in 1995-6 to that in 1994-5. Based on these assumptions, the 1995-6 expenditure/income positions is presented in Table 11.16.

Table 11.16
COMPARISON OF PROJECTED COSTS AND PROJECTED INCOME UNDER THE CURRENT TARIFF IN 1995-6. (KSHS MILLION)

	Expend -iture	Income	Surplus/ Deficit
Sewerage	17.94	12.40	-5.54
Nyeri Water Supply	19.88	23.20	3.32
Kiganjo Water Supply	5.83	4.40	-1.43
Total	43.65	40.00	-3.65

It can be seen that, based on the assumptions outlined above, the total deficit during 1995-96 would be KShs 3.65 million, with deficits from sewerage and Kiganjo water, and surplus from Nyeri water. Despite that, it is not recommended that the tariff is increased before July 1996 because:

(i) the deficit is relatively small when considered as a percentage of total projected expenditure, (8%), and is sensitive to a number of the assumptions on which the above estimate was made, some of which are subject to considerable uncertainty, and thus it is possible that break even could be achieved.

(ii) the figures assume that the Nyeri Municipal Council meets its water and sewerage loan obligations in full; even if a potential deficit is generated, break even would be achieved by making slightly reduced loan repayments,

(iii) consumers should be allowed a breathing space after the last very large tariff increase, and

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(iv) even if a tariff increase was implemented, it would at present only be possible to publicly justify a small increase.

It can be concluded that current rates could be held steady until July 1996, but definitely no longer than this, if the water and sewerage operations are to cover their costs, and fulfill their loan obligations.

Thereafter, and from July 1996, the Nyeri Municipal Council should institute regular annual increases in the tariffs. This would enable income to remain in line with inflation and it would mean that huge percentage increases such as that in September 1994, should not have to be repeated.

Assuming that the increase in 1996 was to enable the council to break even on its water supply and sewerage operations during 1996-7, and to pay its loan obligations in full, but without paying towards the arrears built up in recent years, and that it was intended to implement a further increase in July 1997, the average increase from the present tariff would still be quite limited. In very approximate terms, it would be moderately higher than the rate of inflation between 1995-6 and 1996-7, since although the projected 1995-96 deficit would have to be covered, the KShs 14 million of annual costs, i.e. loan repayments, would not be subject to inflation.

It would be pre-mature at this stage to recommend the actual tariff increase which would be appropriate in July 1996. This is because it will be necessary to take account of the capital costs, which will result from the Consultant's short term augmentation recommendations, together with the resulting increases/decreases in operational costs and any increase in the volumes of water available. These costs have not yet been established and a decision on such measures has not been taken.

When the costing of the prospective situation, after the implementation of any recommended physical rehabilitation and administrative improvements, have been determined, the appropriate overall increase in the average revenue per cubic metre will be calculated.

This information will be presented in the Feasibility Report. Given that the Nyeri Municipal Council is currently billing for 63% of water produced and is collecting most of the revenue due, the scope for increasing revenues from reducing administrative losses is very limited. The main improvements would probably relate to the effects of any proposed physical rehabilitation to reduce distribution losses.

The resulting average revenue required to cover costs will be used to recommend cost covering tariffs, with and without, the proposed rehabilitation. The exercise will include an examination of which tariff structure would have the optimum socio-economic impact for a given level of income.

11.14 Current Nyeri Water and Sewerage Tariff

Table 11.17 presents the current tariff for water and sewerage in Nyeri and Kiganjo which was introduced in September 1994 and table 11.18 the tariff which was in force from January 1992 until then.

It can be seen that the tariff was increased by a factor of around three, although the increase for consumption above 50m^3/month was 267%. These represented high increases, but were appropriate since the rates had fallen seriously behind costs.

Table 11.17
NYERI WATER AND SEWERAGE TARIFF

Monthly Water Consumption	Water Charges	Sewerage Charges	
0- 6 m^3	Kshs 75/mth	KShs 80/mth	(fixed minimum charges)
6-20 m^3	KShs 14/m^3	KShs 12/m^3	
20-50 m^3	KShs 18/m^3	KShs 15/m^3	
Above 50 m^3	KShs 22/m^3	KShs 20/m^3	
Kiosk Users	KShs 20/m^3		

Table 11.18
PREVIOUS TARIFF

Monthly Water Consumption	Water Charges	Sewerage Charges	
0- 6 m^3	Kshs 39.90/mth	KShs 45/mth	(fixed min.charges)
6-20 m^3	KShs 4.50/m^3	KShs 4.00/m^3	
Above 20 m^3	KShs 6.00/m^3	KShs 4.50/m^3	
Kiosk Users	KShs 10.00/m^3		

When considering the future tariff in Nyeri, the rates charged by the National Water Conservation and Pipeline Corporation will be one reference point. NWC&PC's current tariff is shown in Table 11.19. It can be seen that at the lower levels of use, the rates are not very different from those in Nyeri, but the NWC&PC rates are significantly higher for large consumers. Recalling that the large consumers (over 100 m^3 per month) consume more than half of the water sold, this is an aspect of great significance.

Table 11.18
NWCPC CURRENT WATER TARIFF

Monthly Water Consumption	Water Charges
0-10 m^3	Kshs 90/mth (minimum charge for 10m^3/month)
10-30 m^3	KShs 15/m^3
30-60 m^3	KShs 20/m^3
60-100 m^3	KShs 30/m^3
Above 100 m^3	KShs 40/m^3

The only other regular monthly charge in Nyeri relates to meter rents. These range from KShs 7.80/month for 1/2" and 3/4" connections up to KShs 42/month for 4" connections. These charges only represented small increases over the previous tariff. The meter rent currently accounts for only 1% of total water supply and sewerage income.

11.15 Connection and Reconnection Fees

In order to be connected a consumer must sign a Water Agreement and pay the connection fee and deposit. In the case of a sewer connection there is only a connection fee. Although the water charges were increased very significantly in September 1994, the increases in the connection and reconnection fees were very limited. Connection fees are based on distance from the distribution pipe to the consumers premises, and increased from a minimum charge of KShs 300 for the first 30 metres to KShs 360. The rate per metre for connections exceeding 30 metres increased from KShs 4 to KShs 5/metre. The reconnection fee was only increased from KShs 120 to KShs 150. The charges for turning on and turning off at the consumer's request, and for a special meter reading or meter testing at the consumer's request all increased from KShs 50 to KShs 60. It is suggested that all these fees should be substantially increased and proposals will be presented in later reports. If the consumer is shown to have made a justifiable request, for example, to have his meter tested and then it is found the meter was faulty, it is proposed that his fee should be refunded.

11.16 Deposits

Currently deposits required from new consumers range from KShs 600 for most consumers, up to KShs 3,000 for the largest consumers. The only increase in September 1994 was for the largest consumers where the previous charge had been KShs 2,400.

These deposits, especially for large consumers are considered much too low and should be significantly increased. The level of deposit should be such as to provide security against a consumer withdrawing the service without meeting outstanding payments.

Since the cost of meters increased dramatically in the period before the September 1994 rate increase, a water meter deposit of KShs 2000 for new consumers was introduced. This was based on an initial deposit of KShs 1000 plus 10 monthly payments of KShs 100.

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11.17 Ability to Pay

At this stage it is not possible to quantify the ability to pay, although it is suggested that a minimum charge of more than KShs 100 may be difficult for some consumers to afford. This is based on the criterion that consumers should not be expected to pay more than 5% of their cash income for water from their own connection. Discussions in Nyeri suggested that few of those households, who already have their own connection, have a monthly income of much less than KShs 2,000.

At present the minimum monthly charge is KShs 75/month and although there are a considerable number of people who are being, and should be, disconnected, water supply staff report that this is rarely due to consumers being unable to afford the current rate. In addition the majority of consumers who are disconnected, rapidly reconnect. Furthermore it was reported that there is no evidence that the recent large increase in the tariff, involving an increase in the minimum charge from KShs 39.50 to KShs 75 per month, has lead to a significant increase in the number of consumers liable for disconnection.

At this stage, it is suggested that the minimum monthly water tariff should not exceed KShs 100/month in 1995 values. If cost recovery requires a rate higher than KShs 17/m^3, it would be possible to reduce the quantity of water consumption at which a consumer remains in the minimum charge bracket currently (6m^3/month), since 10% of consumers use less than that minimum volume. This proposal will be taken into account in the discussion of the proposed tariff in the Feasibility Report.

11.18 Appraisal of the Current Tariff

The present tariff has a number of sound features; there is a clear relationship between the service received and the charge, all consumers are subject to the same tariff, and it is simple to understand and easy to administer.

Table 11.17 showed that the current water tariff is based on an increasing unit charge as consumption increases. This is an appropriate trade off between social criteria which require that rates for low use are not so high as to discourage use for basic needs, and financial criteria which require that revenues cover costs. Furthermore under the current situation in which demand exceeds supply, an increasing incremental tariff is appropriate, although given the current supply situation and consumption patterns, larger differentials for the higher levels of use would probably be appropriate.

One inequitable element of the current tariff is the minimum charge. This means that very low consumption users, who are also likely to be poor, could be being charged a high unit rate if they are using less than 6m^3/month. The field investigations indicated that around 10% of consumers are using less than the minimum volume. The two usual arguments in favour of a minimum charge are (i) when the metering situation is unsatisfactory a minimum charge is necessary, but this is not the case in Nyeri, where most meters are working, (c.f. Section 10.2.1), and (ii) a minimum charge is necessary for safeguarding income. If it is assumed that the average volume of those using less than the minimum volume is only half that quantity, (a

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pessimistic assumption which would tend to exaggerate the financial loss of scrapping the minimum volume), then the financial loss of eliminating the minimum charge on the Nyeri supply would be 400 consumers by KShs 37.5/month, (assuming that the charge for the first 6m^3 was KShs 12.5/m^3), which is KShs 15,000 per month. This is the equivalent to far less than 1% of the current income from the Nyeri supply. Hence consideration should be given to eliminating such charges in Nyeri. If this is done, implementation could be undertaken at the time of the next tariff increase to show that management has the interest of the smallest consumers in mind.

In 1994 the rate charged to water kiosk operators increased from KShs 10/m^3 to KShs 20/m^3. Before the tariff increase the charge was more than double that paid for basic consumption by other consumers and was 66% higher than the highest rate paid by other consumers. Since the financial effect will be very limited, there is a strong case for giving high weight to equity considerations. Even the new rates mean that kiosk operators are paying considerably more than the basic rate and almost as much as the top rate for other consumers.

The structure of the current sewerage tariff is similar to that of the water tariff. Given the large excess capacity in the sewerage system at the moment, the structure totally contradicts any economic criterion. On the other hand the increasing incremental rates do meet social and financial criteria, and the current structure is endorsed. Here a minimum charge is in line with both financial and economic criteria, but again conflicts with social criteria. The majority of low water use consumers are not connected to the sewerage system however, so only a limited number of consumers would be affected.

In conclusion it is believed that the overall tariff structure is reasonably appropriate for the Nyeri situation. The main requirement is that the levels of the tariff are sufficient to cover the Council's water and sewerage costs and any associated financial obligations. Section 11.11 showed that the existing tariff is high enough to meet this requirement in the very short term, but not in the medium to long term.

11.19 Uniform Tariff

Given that the Nyeri and Kiganjo water supplies are physically independent schemes, it would be possible to develop different tariffs for the two supplies. The main case for doing so is that the unit costs at Kiganjo are far higher than those on the Nyeri scheme. Kiganjo's direct unit costs are between three and four times higher than those at Nyeri, because total direct costs are approaching half of those at Nyeri, while production is only around 1/8th of that at Nyeri. Even when administration costs are included, the unit cost of water is still well in excess of double that at Nyeri.

The case for the same tariff at both supplies relates to the fact that both supplies are operated by the same agency and it could face difficulties in charging consumers different rates. Furthermore the Kiganjo supply is less reliable than the Nyeri supply. The main reason why the consultants cannot at this point in time recommend on whether it is best to have the same or different tariffs is that the most appropriate time to consider any tariff differentials, would be when the probable relative future costs of the two schemes, based on the proposed scheme augmentation, have been established.

12. ORGANISATION OF NYERI MUNICIPAL COUNCIL

12.1 Legal Base and Relationship with Government

12.1.1 Legal Base of the Council

Nyeri became a Municipality in 1971 based on a Legal Notice that Nyeri Urban Council was being elevated to Municipal status. The Council is constituted under the Local Government Act - Chapter 265 of the Laws of Kenya - LGA. The Act was passed in 1978 and was based largely on the Local Government Regulations of 1963. In fact the 1978 Act only contained minor amendments. The main significance was the legal basis was now an Act, rather than regulations. For the most part, the previous regulations simply became sections of the Act. Amendments since 1978 have had little effect on the municipality's legal standing and its operations. For example in 1992 there were significant amendments to the LGA but they concerned the election laws. The Act devolves powers and responsibilities to councils, and provides the legal framework within which local authorities may function as corporate bodies, explicitly indicating the fields within which they may operate. The Act covers their constitutions, proceedings, staffing matters, financial provisions and accountability.

The Council's Standing Orders and Financial Regulations govern the procedures to be followed by officers in the pursuance of their duties. The Council's Standing Orders are based on the Local Government Act, but are those which after examination, Nyeri Municipal Council has specifically adopted to govern the actions of its own officers. The Financial Regulations, (which are in effect the financial standing orders), of Nyeri Municipal Council are based on regulations prepared by the Ministry of Local Government, which were approved with minor amendments by the Council's Finance, Staff, and General Purpose Committee in December 1986, and adopted by the Council in the same month. They cover budget preparation, financial monitoring, charges and revenue collection, procurement, expenditure, and the renewals fund.

12.1.2 Legal Base for Water Supply and Sewerage

The Ministry responsible for water development (c.f. Section 3.2) is the principle agency in Kenya with the mandate for management, development, operation and maintenance of water supplies, sewage disposal and pollution control. However, the Ministry of Local Government, through the municipal councils is responsible for water supply and sewerage in most of the major urban centres. Thus in Nyeri, the Council is responsible for the water supply and sewerage schemes.

Nyeri Municipal Council is an appointed water undertaker, under Section 124 (2) of the Water Act, and has a statutory obligation to provide a water supply service. It is empowered to make by-laws relating to tariffs, supply management, and prevention of waste and pollution of the supply under 143 (3A) with the right to disconnect under circumstances stated in Section 143 (4).

A code of conduct for water undertakers is provided under the Water Undertakers Rules which, cover the appointment of water undertakers, works and land used, provision of services, metering, illegal connections, charges, circumstances for disconnection etc. There

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is a degree of overlap between this Act and the water supply related provisions of the LGA. The Council operations have largely been based on the water undertakers rules, but the Engineer reported that recently the Council has also been following the standard water supply by-laws circulated by MOLG. These cover the council's ability to charge rates which reflect the real cost of Operation and Maintenance and replacement and to disconnect late payers, consumers' responsibility not to interfere with meters and to inform council of necessary repairs, entry and inspection by officials, illegal use of water, pollution of the system, provision of service connections, deposits, unauthorised connections, council's ability to prohibit the use of water for specified purposes, and maximum penalties for contravention of the by-laws.

Although Nyeri Municipal Council is not a local health authority it is still subject to the Public Health Act whose regulations cover the protection and prevention of pollution dangerous to public water supply (Sections 129 & 130). Much of the Act and its subsidiary legislation is related to sanitary services of local authorities, including the disposal of offensive liquids and other waste matters both within the town and from any sewage works, (Section 126).

As regards sewerage, Nyeri Municipal Council has had its own by-laws for a considerable time. These are the Nyeri Municipal Drainage and Sewerage By-Laws approved in 1979. These cover (i) the ability to require that owners of buildings where the plot boundary is within 70 yards of a sewer to connect to that sewer, even if an existing septic tank/cesspool is already being used, (ii) to examine wastewater facilities and require the owner to carry out necessary repairs, (iii) to prevent injurious matters from entering sewers, (iv) the ability of the Council to make charges to cover costs of work undertaken in accordance with the by-laws, and (v) the penalties applicable for offences under the by-laws, (maximum KShs 1,000 or two months imprisonment). In addition the Nyeri Municipal Council (General) By-Laws deal with some aspects of water and sanitation.

Although under the existing Acts and by-laws, the Council has the powers to prosecute consumers who contravene water supply and sewerage regulations, the financial penalties have not kept up with inflation. On the other hand imprisonment would rarely be appropriate. Furthermore officers often feel that the effort involved in going to court is such that it may not be justified when the fines are so low, thus at the moment the Council's main interest is often to rectify the situation without recourse to the law. If the fines were far higher on the other hand, the Council could find it appropriate to pursue legal action in some instances, and a few successful cases might act as a major deterrent to all other consumers.

12.1.3 Council's Relationship with Ministry of Local Government

Nyeri Municipal Council is an administrative unit operating at the local level on authority delegated to it by Central Government. The latter is supposed to provide (i) guidance and advice, and (ii) supervision and control. The key ministry involved is the Ministry of Local Government which is responsible for overall direction, management, supervision and control on the administrative, and to a lesser extent, technical matters.

The relationship with the Ministry of Local Government is largely one of constraint by the Ministry. The main link is the Provincial Local Government Officer who reports to Ministry headquarters. The MoLG's high level of control over councils was established at a time

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when central government gave councils a reasonable level of financial support which no longer exists. Since the 1970s it has not provided any recurrent funds, and the limited capital funding it has provided has been on a loan basis, often the local matching contribution demanded by project donors.

Council staff feel that there are too many controls, and that the problem stems from the Local Government Act which limited decentralisation by its over-riding concern that councils should be subject to very tight control by MoLG in raising, administering, and spending public funds. Hence Nyeri Council has little financial freedom, and the framework within which it must operate each year is closely controlled by MoLG through its approval of the annual estimates. Even minor decisions, other than those which are entirely routine, may require MoLG approval. For example, if the Council's bank agrees to a temporary limited overdraft of say KShs 1 million, the Council cannot use such a facility until the approval of the Ministry is given.

All loans to the Council have to be approved by MoLG and pass through its Loans Authority, (Section 222 of LGA). This applies to both loans from the Government and to any external loans, which have to be channelled through Treasury and MoLG for onward lending to the municipality. MoLG also controls tenders, inasmuch as where the Council wishes to select any but the lowest tender, however obvious the case for doing so, they need MoLG approval.

While the structure and level of charges such as licence fees, water rates or any other charges which it levies, are decided by resolution of the Council, the Council must under Section 148 of the LGA, obtain approval from MoLG if the Council wishes to increase any of its charges. Frequently this is done as part of the approval of the annual budget, although it can be given separately.

Despite exercising a high level of control, the Ministry has sometimes not performed its responsibilities in a timely way. For example, the Council only received the approval of its 1994/5 budget estimates three quarters of the way through the financial year. This meant the Council was not able to exceed the 1993/94 approved limits for any budget heading. On the other hand MoLG did approve the September 1994 water rate increase separately and did so quickly, thereby giving good support to the Council.

There as been no recent role played by the of Central Government in providing councils with the necessary resources to meet the responsibilities which have been devolved to local authorities. Councils are responsible for the provision of a large range of community services which target the improvement of the social and economic welfare of their inhabitants. In order to discharge their functions they are empowered to raise funds to cover their expenditures. However Nyeri Municipal Council's financial base has been weakened over the years both by various government decisions, and by the difficulties which have been associated with setting tariffs which allow for the full recovery of all recurrent and capital costs. At the same time the Municipal area and the number of inhabitants to whom it should be supplying services has increased significantly.

As a result, the Council's greatest problem has been inadequate finance. One consequence is that despite the large recent tariff increase in water and sewerage rates, which currently

12.2 Current Organisation of the Council

12.2.1 Council

The Council currently consists of 15 elected councillors and 5 nominated councillors. The mayor, his deputy and the chairmen of the Council committees are elected from amongst the Councillors.

The full council and the council committees are the main decision making bodies of the Council. There are only the four council committees: Finance Staff and General Purposes (FSGP), Town Planning and Works, Education Housing and Social Services, and Public Health and Environment. The controlling committee is that of Finance, Staff and General Purposes. There are no standing sub-committees. Some functions which might be considered as appropriate for a sub-committee are dealt with by a full committee, for example the full FSGP committee considers tenders. Sub-committees are formed on an ad hoc basis, as and when the need arises, for example for the allocation of plots.

Water supply and sewerage are the responsibility of the Town Planning and Works Committee, to which the Engineer reports, but under the proposed new departmental arrangements, (c.f. Section 12.2.5), the new Water and Sewerage Department will report to a new committee, the Water Supply and Sanitation Committee.

The internal administrative and executive organisation headed by the Town Clerk is based on three departments, (with a fourth currently being set up), which are responsible for the day to day activities of the Council and for the provision of services.

12.2.2 Council Departments

Until now there have been three departments in the Council: the Town Clerk's, Treasurer's and Engineer's Departments. A fourth department, Water Supply and Sewerage, is currently being established. Including the new department, the Councils current organisation is based on the chart shown in Figure 12.1. This shows the four departmental heads and the main responsibilities of their departments.

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Figure 12.1

ORGANISATION AND RESPONSIBILITIES OF THE COUNCIL'S DEPARTMENTS

```
                        Full Council/Committees
                                  |
                              Town Clerk
                                  |
   ----------------------------------------------------
   |                  |                |                |
 Municipal        Deputy Town     Municipal        General
 Treasurer        Clerk           Engineer         Manager
   |                  |                |              W&S
   |                  |                |                |
Accountancy        General Admin   Fire Service    Water Supply
Internal Audit     Personnel       Roads           Sewerage
Service Charge     Legal           Parks
Financial Control  Cleansing       Survey/Buildings
Expenditure        Cemeteries      Elect/Mech.
Revenue Collection Social Services Garage
Central Stores     Housing
                   Markets
                   Inspectorate
```

Until the Water and Sewerage Department starts operation the Engineer's Department is still responsible for water supply and sewerage. Furthermore until a new municipal engineer is appointed, the position will be vacant, if as anticipated, the Engineer moves to the General Manager Water and Sewerage post.

In addition to the senior posts shown above, there are approved posts for a Municipal Education Officer and for a Chief Public Health Officer, but these posts have never been filled since they were approved some years ago, and at present there are no Education and Health Departments. Currently the Council's main education role is the running of two nursery schools. These currently come under Social Services, in the Town Clerk's Department. The only current public health role played by the Council is that of cleansing, this again comes under the Town Clerk's Department and is handled by a Cleansing Supervisor who is responsible to the Deputy Town Clerk.

The individual heads of department are responsible for the overall organisation, administration, and management of their department, for attending and advising all relevant council, committee and sub-committee meetings, for coordinating the activities of their departments with that of other departments, and representing the Council on relevant matters involving other parties. The Town Clerk tries to ensure a reasonable level of coordination between the different departments, through a weekly heads of departments meeting. It is probably easier for smaller councils such as Nyeri to avoid the problem of minimum contact between departments than it is for larger councils. The organisation of the two departments relevant to this study are discussed in Sections 12.2.3 and 12.2.4.

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12.2.3 Treasurer's Department

Figure 12.2
ORGANISATION OF MUNICIPAL TREASURER'S DEPARTMENT

```
                      Municipal Treasurer
                            |
                            |
    ------------------------------------------------------
    |                        |                   |          |
    |                        |                   |          |
 Internal          Chief Accountant              |          |
 Auditor                     |                   |          |
                             |                   |          |
                  -------------------        Principal      |
                  |                  |       Revenue        |
                  |                  |       Officer        |
               Acct I             Acct I     (Acting)*      |
             (Revenue)        (Expenditure)     |           |
                  |              (Acting)       |         Chief
                  |                  |          |         Store
              ---------              |          |         Keeper
              |        |         Clerical       |         (Acting)
         Billing    Clerical      Staff         |
          Staff      Staff                      |
                                          ------------
                                          |           |
                                      Cashiers    Outside
                                                  Collectors
```

The existing structure of the Treasurer's Department is shown in Figure 12.2 above. Although all the positions shown are currently filled, a number of the posts are held be officers who are only in an acting capacity. The acting Provincial Revenue Officer (PRO) will revert to his permanent position as Accountant I (Expenditure) when a new PRO is appointed.

The chart shows the theoretical organisation of the Treasurers Department. Whilst the PRO is theoretically responsible for all cash and banking, in practice, the cashiers within the municipal office actually report to the Chief Accountant rather than to the Principal Revenue Officer.

The Treasurer reported that his Department does not have a series of distinct sections and the above chart is therefore only an illustration of how the department operates in practice. In effect there could be said to be five sections: Expenditure, Revenue Accounting (both under the Chief Accountant), Internal Audit, Revenue Office and Stores. These are closely linked to the main functions of the Department for which the Treasurer has overall responsibility. These functions with the person directly responsible are:

Page

Audit	- Chief Internal Auditor
Accountancy/Financial Control	- Chief Accountant
Expenditure	- Accountant I (Expenditure)
Revenue	- Accountant I (Revenue)
Service Charges	- Principal Revenue Officer
General Stores	- Chief Store Keeper

Water and sewerage bill payments as well as land rates, service charges, and house rents are received from the consumers/tenants etc at the cash office. Market fees etc are collected by Municipal collectors and paid by them into the cash office. The Revenue Accountant is responsible for all revenue book-keeping including that for water supply and sewerage, but he has no responsibility for cash.

12.2.4 Engineer's Department

The Engineer's Department is currently divided into the following sections; administration, water supply, sewerage, parks, roads, building, fire, electrical/mechanical, and garage. These sections, other than water and sewerage, have limited resources, responsibilities, and finance. The funding for water and sewerage has been approximately three times that for the other sections combined. The Department is also responsible for supervising the design of septic tanks, although emptying is left to the private sector. Although the current organisation charts for the water and sewerage sections are about to become redundant, they are shown in Figures 12.3 and 12.4 so to lay the basis for the discussion in Section 12.3.3 of the serious technical staff shortages in the Council's water and sewerage operations.

12.2.5 Proposed Water and Sewerage Department

The Council is in the process of establishing a separate Water and Sewerage Department. In 1994 it passed a resolution for the establishment of the new Department, which was approved by the Minister for Local Government through his approval of the 1994-95 estimates. In addition the full Council has passed a resolution for the establishment of a Water and Sanitation Committee. This will start functioning as soon as a Chairman is appointed, early in the 1995-96 financial year.

The new departmental posts included in the 1994-5 estimates were for the General Manager, a Deputy General Manager and a secretary. For the most part, other staff are already occupying approved posts in the water and sewerage sections and will be transferred to the new Department. There will however be some new posts including a Deputy General Manager (Commercial), and laboratory staff. The former is considered to be a key post in the new Department. Plans for these are being finalised and all proposed posts in the new Department will be included in the 1995-96 estimates. Further, the unofficial appointment of the present Council Engineer to the post of General Manager must be formally approved so that the Council can go ahead with the recruitment of a new Municipal Engineer, although it is not certain whether council finances would immediately allow such an expenditure.

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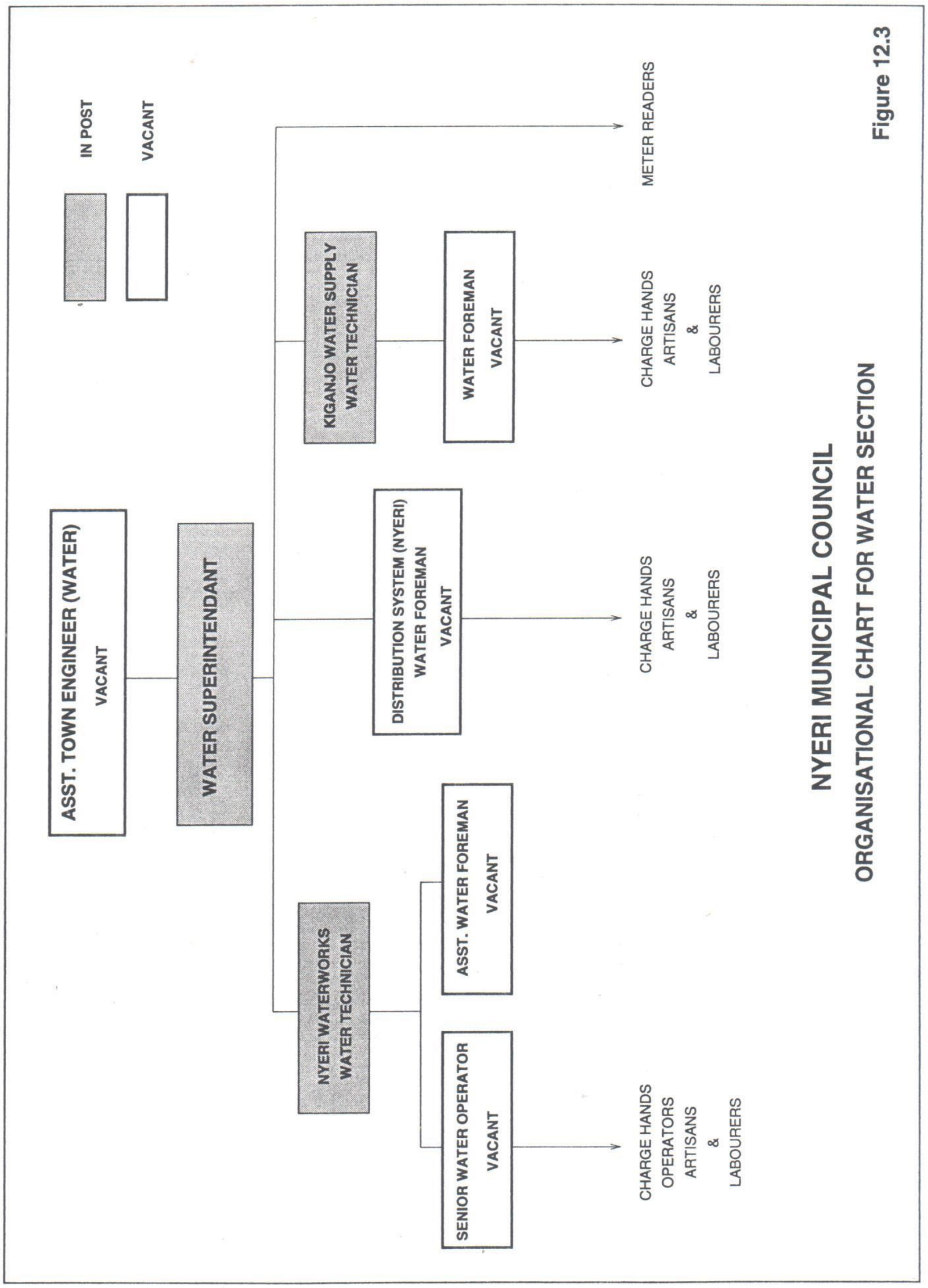
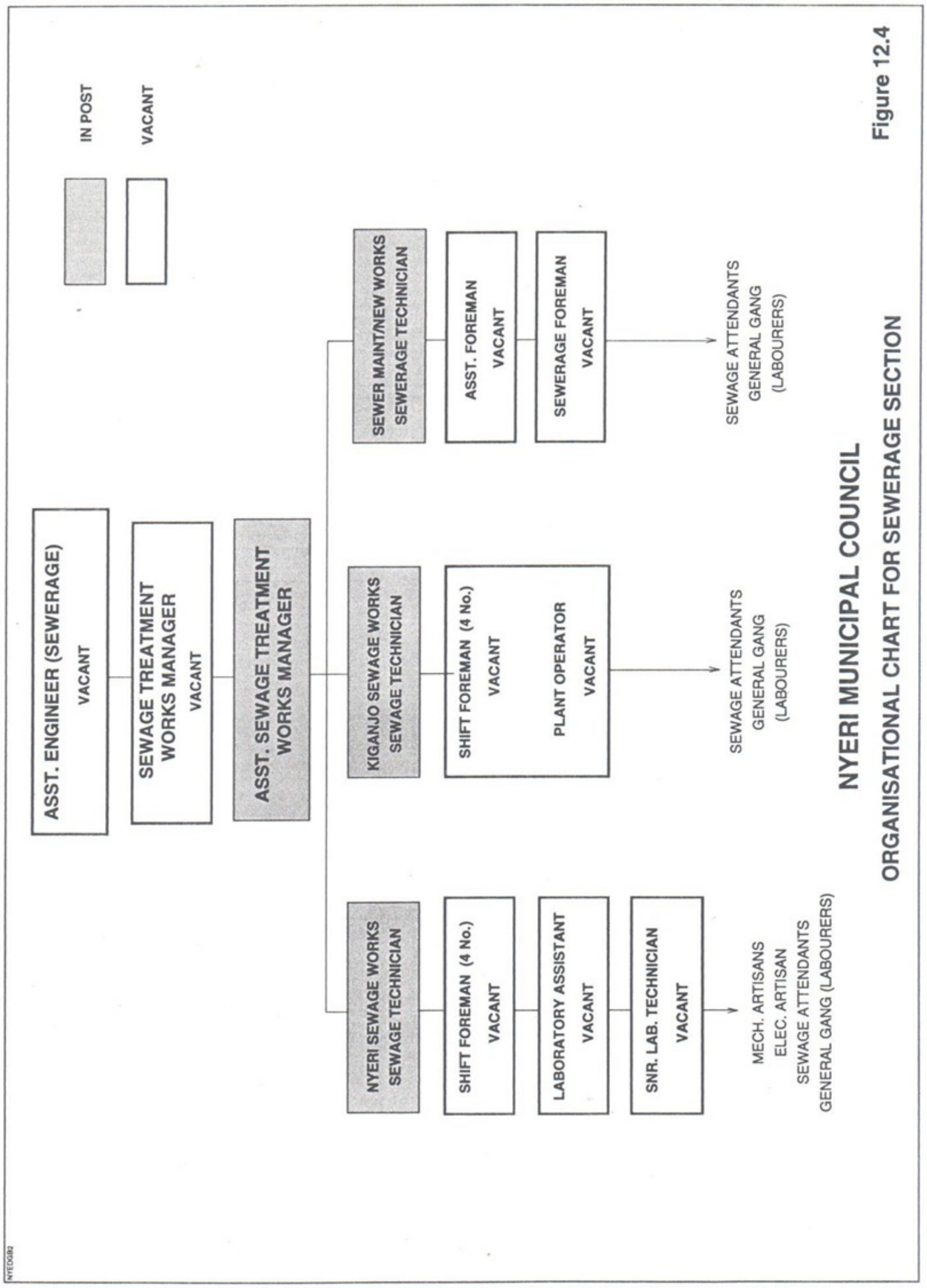


NYERI MUNICIPAL COUNCIL
ORGANISATIONAL CHART FOR WATER SECTION

Figure 12.3

Page



NYERI MUNICIPAL COUNCIL
ORGANISATIONAL CHART FOR SEWERAGE SECTION

Figure 12.4

In addition to all technical aspects of water supply and sewerage, the new Department will be responsible for all its own cost accounting, and will hold its own Vote Book, all billing, revenue collection and revenue accounting, and its own stores. Hence all billing staff, some revenue accounting clerks, and some stores staff will need to be transferred to the new Department. It will also need its own accountant, although one person should be able to oversee both cost and revenue accounting.

The Council argues that the new head of department, the General Manager for Water and Sewerage will be able to devote all his time to water and sewerage. This argument only exposes a limited potential for improvement, since the Engineer, due to the financial importance of these activities, already spends over 80% of his time on them.

The efficiency of the water supply and sewerage operation depends more on the competence of key individuals, than on the organisational set-up. Whilst this is not an argument against implementing the best system, sight should not be lost of the fact that it is more important to fill the existing vacancies in the water and sewerage sections, than it is to change the set-up.

One potential advantage of the creation of a department is that it may improve the efficiency of consumer management. The combination of the engineering, consumer service, and financial control in the one department should provide an increased opportunity for; a more commercial approach, and an integrated management information system covering costs, revenues, consumer information etc, which would provide the data for improved planning.

The General Manager will ultimately be in charge of all billing, revenue collection and banking, and will report the revenue figures to the Treasurer for incorporation in the Council's accounts. In addition the Department will be responsible for its own accounts and the General Manager will have cheque signing powers for departmental accounts which will be separate from Council's other accounts. While this will rectify the inappropriateness of the Engineer currently not having cheque signing powers for water supply expenditures, it will only provide limited financial control to the General Manager, since the Treasurer will remain ultimately responsible for expenditure approvals. In addition the Department will be subject to the normal financial controls of reporting to the relevant committee, (Water and Sanitation Committee), and to checking by the Internal Auditor.

A key financial advantage of having a separate department will depend upon the extent to which it is possible to isolate the finances of water and sewerage from the rest of the Council's finances. As is discussed in Section 13.9, a complete separation is far from assured.

The ability to carry out its own purchasing should increase procurement efficiency since the Department's own staff will be looking for the required items. In addition the increased control over expenditure may enable the General Manager to better spend in line with priorities.

It has also been suggested that a separate department should enable more appropriate accounting policies, for example with regard to depreciation, and provisions for renewals and replacements, to be adopted. This argument has some merit, but the main requirements for effective implementation of such policies are an adequate revenue margin over immediate operational costs, and Councillors who are prepared to forbid water supply and sewerage surpluses, other than real ones, (i.e. those remaining after all capital cost liabilities have been met and adequate allowances for replacements have been set aside), being used for other purposes.

It has also been claimed that a General Manager would be in a better position to organise training programmes, the case for this is again not clear. His ability to organise training would best be strengthened by having the currently vacant professional posts in the water and sewerage sections filled.

The case for a separate department would be strongest if the creation of such a department bringing responsibility under one person was combined with a series of performance indicators for all departmental staff. It would be even stronger if it could be shown that having a separate department will make it easier to fill the professional vacancies in the water and sewerage sections, and result in a cost effective water supply and sewerage undertaking.

The proposed organisation for the Water and Sewerage Department has not yet been approved, but a comparison of the professional/technical staff currently available in the water and sewerage sections with the proposals shows that there will be a large proportion of vacancies in key positions in the new Department unless the Council is able to recruit additional well qualified staff. Furthermore the filling of all the proposed posts is likely be hindered by financial constraints, unless the Department's finances are isolated from those of the Council's other activities.

12.3 Staffing

12.3.1 Council's Overall Staffing

Nyeri Municipal Council's last staff list was compiled in the middle of 1994 and is dated 1st July. A summary of the staffing at that time is presented in Table 12.1. This is taken from the 1994-95 Estimates and a comparison with the staff list shows that the numbers in Table 12.1 represent the numbers of post filled, rather than the established posts.

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Outside the water and sewerage sections a high proportion of posts are filled. At June 1994 there were approximately 20 salaried positions vacant in all other sections, i.e. approximately 80% of posts were filled. In the water section 18 out of 24 positions were filled but in the sewerage section only 5 out of 20 positions were filled. These figures reflect two factors. Firstly the maintenance of the sewerage system is not being given high priority and falls well short of that required for keeping deterioration at a satisfactory level. Secondly the shortage of qualified technicians is one of the Councils bigger problems.

The overall level of non salaried vacancies within the Council is low, but again the water and sewerage sections with nine and seven vacancies respectively had the main shortfalls, although it is not clear whether all these additional staff are really necessary.

12.3.2 Salaried Staff in the Treasurer's Department

Within the Treasurer's Department there are five staff with CPA II including the three senior staff Treasurer, Chief Accountant, and Chief Internal Auditor. The Certified Public Accountant (CPA) qualifications start from CPA I, to the fully qualified CPA III or CPA (K). It was reported that the other two staff with this qualification were the Acting PRO and the Acting Accountant I Expenditure. In addition based on the June 1994 staff list there are four staff who have passed CPA I. One has CPA (K) and there are four accounts clerks who have the Account Clerks National Certificate. Approximately half of the 29 salaried staff in the Treasurer's Department only have secondary school or secretarial qualifications. The Department was almost fully staffed, and as at June 1994 there were only two vacancies and these were for relatively low positions.

12.3.3 Salaried Staff in the Engineer's Department

Of the five most senior posts in the Engineers Department, only the head of department post is filled. This alone demonstrates the very limited technical staffing level of the Council.

Of the eight staff in the Administration Section of the Engineer's Department only the head of department is a professionally qualified engineer, and three others hold technician qualifications (Ordinary Diploma). There were three vacant posts at June 1994, unfortunately these included the three most senior posts immediately below the Engineer, namely Deputy Municipal Engineer, Assistant Engineer, and the Works Superintendent. The lack of professional support staff means that the Engineer has insufficient time for planning since he is attending to day to day problems. The appointment of a Deputy Municipal Engineer would therefore significantly strengthen the planning capability of the Department.

In all the other sections of the Engineer's Department, excluding Water and Sewerage which are discussed below, there are only nine staff, of whom none are professionals and only three are qualified technicians.

The quality of the water and sewerage technical staff is limited both by their training and by what was perceived as less than full dedication on the part of a few members of staff. The result is that their performance often falls well short of that which could be expected from a good technician, and that the Engineer has to spend most of his time on day to day operations. This means that he has had to give planning low priority in order to give more time to supervision than would be necessary if he had a reasonable level of assistance. Whilst the lack of staff below the Engineer who can, for example, interpret pressure tests, can be attributed to the lack of engineers, there is also an inability to interpret results to a level that can reasonably be expected of a technician, for example, being able to relate an increase in unaccounted for water to obvious factors.

According to the June 1994 staff list, none of the five staff in the Sewerage Section are highly qualified. The Sewerage Superintendent has a technical diploma, while the others have undergone training at the Ministry of Water Development's training school (now Water Institute). There are 15 vacant posts (75% of all salaried posts in the section), including the two most senior posts, the Sewerage Works Manager and the Assistant Engineer (Sewerage). The only two professional posts are both vacant. Furthermore all the posts immediately below the three technicians are vacant. Figure 12.4 above demonstrates the large gaps which currently exist in staffing the Sewerage Section. The saving factor in this situation is the apparent dedication of some key sewage works staff members.

Again based on the staff list, most of the 18 staff members in the Water Section have no post school qualification, although a few have passed artisan tests, and a number have attended courses at the Water Institute. In total there are six vacant posts according to the staff list and nine according to the organisation chart. Based on the staff list this is only 25% of the total posts and is not serious. What is more important is that they include the only professional post, that of Assistant Town Engineer (Water). Furthermore the organisation chart (c.f. Figure 12.3) shows that four of the six posts just below the Water Superintendent are vacant, although only one of these posts appears in the staff list.

It is concluded that the shortage of well qualified technicians is a major problem for the Council. The lack of well qualified technicians is manifest in the large number of vacancies throughout the sewerage section, and at the foreman level in the water section. In addition both sections have some technical staff whose training is below the desirable level for the post which they hold.

Taking the low level of qualified staffing into account, the performance of the Engineer's Department in operating the water supply and sewerage schemes is better than might have been expected. This is clearly attributable to the personal commitment and dedication of the Engineer. Nevertheless, there is a clear need for additional professional staff within the water and sewerage sections in order to free the Engineer from mundane activity, and allow him time for managerial functions.

In particular there should be one professional whose is employed full time on the water supply. It is also desirable that there should be at least one professional employed full time on sewerage, such as an assistant engineer (sewerage) or a well qualified works manager. Other than that, it is not clear whether it is necessary to fill all the professional posts in the Engineer's and Water and Sewerage Departments. When the Engineer's Department having responsibility for water, sewerage and all other engineering functions did function, albeit rather inadequately, with only one professional, one has to ask whether more than three professionals are required by the Council for the same tasks now being executed by one person.

12.3.4 Recruitment and Terms of Service

The Service Commissions Act (Cap 185) 1984 containing the Public Service Commission (Local Authority Officers) Regulations and applies to all local authorities. It covers appointments, promotions, transfers, and termination of appointments. The Act allows the delegation of staffing matters for posts in scale 15 and below to local authorities. This cut-off point is reported to be under amendment to a higher scale, but it has not yet been reflected in the recruitment process.

If the Council wishes to recruit for a post that is to be created, or if it is a vacant post covered by the current freeze on recruitment, the Council needs MoLG's approval for filling the position. The inclusion of a post in the annual budget is the main way of obtaining approval for a post, since approval means that expenditure on the post can be incurred. In fact when the MoLG approves the budget, it includes a paragraph on the establishment and personnel budget and comments on what has, and has not, been approved. In very special urgent cases, the Council can ask for specific approval for a post within the year, and this happened when the sewerage scheme was about to be commissioned.

In order to recruit a person for an approved post, the Council advises the PSC, through MoLG, that a person should be recruited for the post. The PSC advertises the post and in time compiles a short list of the best candidates. This is produced at a pre-selection meeting which the Nyeri Municipal Council Town Clerk or his representative attends, possibly accompanied by the head of the relevant department. The PSC ultimately determines the short list, but normally gives considerable weight to the views of the NMC representative.

The Town Clerk or his representative is again present at the interviews, and is able to put any technical or other questions which he wishes to the candidates. All those present, the NMC, MoLG, and PSC representatives all rank the candidates individually. The PSC then make the final selection after the sub-committee reports to a full meeting of the PSC. In practice this means that in the vast majority of cases the selection coincides with the NMC's own choice, but this is not guaranteed.

If the Council has a potential candidate within its existing staff for the post it advises the PSC at an early stage. The Council and MoLG may both recommend to the PSC that such a person is an appropriate person for the post. The PSC normally insists that the post should be filled competitively and should be advertised, although occasionally it may accept that the case for the proposed person is overwhelming.

Nearly all posts in the NMC, both salaried and non-salaried are on permanent terms. Normally the only reasons for dismissal are related to misconduct. Even this involves a lengthy process. Initially the section head, department head and town clerk must endorse the case for dismissal, which must be approved by the Council's Finance, Staff and General Purposes committee. For posts below level 14, the Council's decision is final, other than for any actions arising from any involvement of the Local Government Workers Union.

In order to be able to dismiss staff in scale 14 and above, the Council has to obtain PSC approval, and until such approval is granted, the Council can only suspend the individual concerned. Retirement for all staff is compulsory at the age of 55.

The current terms and conditions of service were agreed in July 1994 between the Association of Local Government Employers and the Kenya Local Government Workers' Union, and approved by the Industrial Court. The most senior NMC staff (grades 3 & 4) are now paid within the salary range of KShs.15,485 to KShs.23,935 per month depending upon their years of service. The new salary scale for the lowest grade (20) of salaried worker is now KShs. 2,020 to KShs. 3,940 per month. The median salary of NMC salaried staff is now estimated to be over KShs. 5,000 per month. In addition staff receive housing allowances which are reported to typically represent 20-30% of the basic salary. Despite the recent large salary increases, local government will still have a problem in competing with the private sector for high calibre staff at such pay levels.

12.3.5 Training

The Council does not have any officer responsible for training and staff development, and there has been no overall needs assessment of training requirements. In general apart from on the job training provided by senior staff and/or experienced staff to junior/recently recruited personnel, and occasional staff seminars for senior staff, training within the Council is very limited.

Training in the Nyeri Municipal Council and in other local authorities has serious limitations. There is a limited amount of programmed training each year which is initiated by the Office of the President and which coordinates training at government training institutes. If a local authority has a suitable candidate it can forward the name and the person may or may not be accepted depending , on the ratio of candidates to places. This training tends to be related to accounts and administration staff.

There are also some short courses organised by the Federation of Kenyan Employers in supervisory and management skills. Council officials still felt that there is a large group of personnel who are not catered for, especially where specialised training is required. Computer training is widely available in the private sector, but it tends to concentrate in a few limited areas. Some senior officials felt that there is insufficient emphasis on training within the Council and even within the whole local authority sector. It is claimed that the manpower planning department in MoLG does not deliver the services which councils require.

Donors are another source of training but this is often done on an ad hoc basis, although it can be extremely useful. A training component within the proposed water supply project would be welcomed by Council officials.

12.4 Physical Resources

12.4.1 Offices

The Municipal offices are not fully adequate for present requirements and, for example, sometimes there are three clerks working in a small room. Officials claim that they need to expand the existing Municipal building especially if a Water and Sanitation Department is to be created. Although the creation of the Water and Sanitation Department should only increase the office requirement for a few senior staff, current space is inadequate.

On the other hand, there is little room within the existing Municipal Hall compound for further construction. The Council also has offices and housing at the sewerage treatment plant at Kangemi, and at the sewerage plant at Kiganjo. There is a small office at the water supply at Kiganjo and an office and housing at the Kamakwa waterworks.

12.4.2 Vehicles

The transport situation facing the Council is poor. At present the Council has 23 vehicles but all are old, no vehicle has been purchased since 1986, and some are non operational. The details are shown below together with allocations to water and conservancy activities:

Type of Vehicle	Number	Operational	Allocation of Operational Veh.
Saloon Cars	4	3	Pool
Pick-Ups	4	2	WS&S
Landrover	1	0	
Lorries	10	4	2 - Refuse
Tractors	2	2	Refuse
Grader	1	1	
Cat: Shovel/Exc	1	1	

While the saloon cars are pooled all other vehicles are allocated to specific functions. Water supply and sewerage has a lorry but it is non operational.

Although it can be seen that the vehicle situation is grim, the Council is unable to allocate funds for the purchase of new vehicles due to financial constraints. Even the main civic vehicle is over 20 years old, and while it is a public embarrassment when it breaks down, it cannot be replaced.

The main hope for new vehicles has been as part of major projects but Nyeri has not had one recently. Clearly transport is a necessary operations expenditure, which should be incorporated adequately in calculations of required costs.

12.4.3 Garage

Although the garage space is limited, and some equipment and tools could be provided/replaced, the garage is reported to be adequate for the demands made upon it. In fact the key constraints on the efficiency of vehicle repair are the lack of cash for speedy acquisition of spares, and possibly in the performance of some staff, which even allowing for the working conditions are seen as indifferent. There is a need for a competent person in charge who would thereby improve the performance of existing staff. Consequently the Council hopes to fill the vacant mechanical superintendent post in the near future.

12.4.4 Stores

To date, the Council does not have a specific store for water and sewerage, but has a single central store which is responsible for supplying all departments with their requirements. It is however intended that the new Water and Sewerage Department will have its own store.

The existing store which is located close to the town centre only has very limited storage facilities. Local staff reported that a larger store is required, but the case for additional storage space is not overwhelming. While the stores facilities are very limited, they only stock a small number of items and do not appear to be grossly inadequate.

At the time of the Consultant's visit, they could have held considerably more stock than was actually held. As regards space for water supply and sewerage items, the space for most small items does not appear to be a constraint. More space would be required if larger volumes of pipes and chemicals were to be carried, however some additional chemicals could be stored in the roofed but open part of the store, especially if they were stored neatly. Storage space for pipes is very limited, but these could be stored in the open if necessary, possibly under tarpaulins, but at present there is no indication, that pipe stocks will be increased dramatically.

It is more important that stores procedures are efficient than that storage space is increased. A rapid assessment suggests that limited storage space does not seriously hinder efficiency.

It was also reported that the calibre of stores staff is not high and their qualifications are very limited. They do seem to fulfill their main tasks non the less, and the stores record keeping appears to be reasonably accurate inasmuch as a few sample checks showed that the stock coincided with the bin cards. Clearly the system needs to be improved from the point of view of improved management information. This could be achieved by computerisation if accompanied by adequate training.

12.5 <u>Procurement</u>

12.5.1 Procurement Procedure

The basic stores procedures follow standard government procedures.

A user requiring an item from stores, fills out a requisition form and if in stock, the item is issued. If it is not in stock, a purchase requisition has to be made out, and a requisition note is attached. These are then sent to the Accounts Section for checking that a sufficient balance exists in the Vote Book, and if necessary quotations are obtained. The item is then posted in the Vote Book.

Subsequently the Chief Accountant authorises the purchase and an LPO is drawn up, which must be signed by the Treasurer or Chief Accountant. The LPO is then returned to the storekeeper, and taken to the supplier. In urgent cases it is possible for the Council to make cash purchases, in which case the supplier is given a cheque at the time of collection/delivery. In most cases however the supplier submits an invoice and this is processed before payment is made. The delivered/collected items are received by the storeman, and where appropriate the quality is assessed. A receipt voucher is issued and the item is recorded on the bin and stock cards.

12.5.2 Procurement Regulations

Procurement is an important area covered by the Council's Financial Regulations. These are based on Section 133 of the Local Government Act and include the requirements that tenders should be advertised and should only be awarded to the lowest tenderer unless approval is sought from MoLG. The latter requirement can cause delays while approval is obtained, even when it is clear that the lowest tender is not the optimum one.

The Council is supposed to go to open tender for any expenditures above KShs 10,000. In practice since inflation has rendered this figure far too low, KShs 10,000 is used as a cut off point for obtaining three quotations. There is no new updated specific figure above which the Council is obligated to go to open tender, but it always goes to open tender when the expenditure involved is considered high.

12.5.3 Annual Tenders

For the most commonly required items an annual tendering process is followed in which the supply of items for a financial year are tendered. These tenders are usually requested very near the end of the previous financial year, and the evaluation and award usually occurs after the financial year has started. In the interim, the previous year's contract remains in force.

Within the water supply operation, annual tenders are awarded for chemicals, pipes, fittings, meters, stationary etc. When inflation is low the system works well since as long as there is money still available on the appropriate budget line, and cash is actually available, there is no hindrance to procurement. During periods of significant unexpected inflation the annual supplier may refuse to supply at the tendered price, since he would make a loss by doing so.

When an annual tenderer refuses to supply, the Council may approach the second and third placed tenderers. If they are still unable to obtain their requirements at the acceptable price and are forced to pay a higher price, they will obtain quotations. Since the system is based on individual items, Nyeri Municipal Council currently has a wide range of suppliers under the annual tender system, for example currently there are nine different suppliers of water supply fittings alone.

The annual tendering process for frequently required items is considered a satisfactory arrangement by the officers interviewed, especially if the winning tenderer is located in Nyeri. Whilst some are based in Nyeri or at least have a representative there, some suppliers are located in Embu and/or Nairobi. Fortunately the suppliers of both the main chemicals used, alum and chlorine, are located in Nyeri.

The annual tender system means that the Council is able to use the suppliers as their stores and only keep a very limited supply themselves. For example the deliveries of chemicals usually only cater for around two weeks requirements. This arrangement also prevents the Council's cash flow from being stretched, as they pay in accordance with deliveries.

12.5.4 Assessment of Procurement and Effect on Operations

Generally, officials felt that the purchasing regulations and procedures do not constitute a major operational bottleneck. Nevertheless it was reported that although the stores are supposed to keep adequate stocks of fast moving items, there is often a failure to maintain appropriate minimum stocks and the stores sometimes run out of commonly required items.

When the stores run out of an item, it may occasionally be due to stores staff failing to place an order in time, but more frequently the reason may not be related to stores staff/procedural inefficiency but to other factors. Sometimes suppliers may fail to meet delivery dates, although the most common problem relates to orders being postponed to the last minute due to a lack of liquidity rather than to inefficiency.

The effect of the Council's cash flow problems on procurement is exacerbated by the fact that higher priority is given to paying salaries, so that budget lines for spares and materials take the brunt of any cash flow problem. Hence even if the overall problem is not severe, it may reflect seriously on the ability to fulfill purchase requirements. Consequently even though money has been allocated in the budget to a particular budget line, it will not necessarily be available in the account at the actual time when the Engineer or his staff require it.

The lack of funds can result in long delays in carrying out routine work. In particular it sometimes restricts the provision of new connections so that consumers have to wait to see their application implemented. Such delays can also have revenue implications. In addition liquidity can have an effect on Council's ability to undertake proper repairs, inasmuch as a temporary but not fully satisfactory repair may be made, for example in case of a leak.

It is emphasised, however, that the combination of factors which may reduce the operational efficiency of stores and the water supply is not allowed to have serious consequences for operation. For example the lack of an item in the store is unlikely to significantly delay a serious need, since when an emergency occurs, a funding solution is found and neither a lack of liquidity nor the procurement procedures are allowed to seriously hinder the rapid acquisition of the required item.

As an example, it was reported that although normally only two 12" pipes are kept in stock, if there was to be a burst requiring more than two lengths, the stores staff would rush to Nairobi or borrow from the Water Ministry stocks in Nyeri, and the cost would be met. In any real emergency the Town Clerk or Treasurer would intervene and if necessary give instructions for immediate payment, and regularise the transaction later, since the Council has passed a general resolution to cover emergency purchases.

Furthermore while finance does act as a constraint on bulk purchasing, the stores are not allowed to run out of chemicals. If they run out of key fittings, they can make cash purchases if the cost is less than KShs 10,000, and if the purchase is considered important.

On the other hand senior staff who appreciate the need for planning and who wish to carry out their jobs in the most efficient way, find the financial limitations frustrating.

For example, they would like minimum stocks of every item to be determined and re-ordering to be automatic whenever the stock of an item falls below this pre-determined level. Cash flow considerations currently prevent such an approach. Although calculations have not been made, it would appear that the additional funds required to maintain stocks at an acceptable level are very small compared to Council's overall expenditures, hence it is suggested that the Council should estimate the cost in order to strengthen the case for adequate stock holding.

13. FINANCE

13.1 Budgeting Procedures

Local authorities are obliged under section 212 (1) of the Local Government Act to prepare an annual budget for each financial year (July 1st - June 30th), comprising the budget estimates and a list of staff. The Estimates show the proposed detailed estimates of the Council's income and expenditure both recurrent and capital for the coming year, as well as the actual figures for the previous year and anticipated figures for the current year. Since they are prepared some time before the end of the current year, the latter figures are always contain a significant element of estimation.

The figures are broken down into individual activities each with its budget code, such that the Water and Sewerage is divided into four main budget codes for Sewerage, Nyeri Water Supply, Kiganjo Water Supply, and Water Supply Administration. Under every expenditure code there is a division into sub-codes for specific cost items, such as electricity, chemicals etc.

The budgets also show the combined figures for each of the four funds operated by the Council. These funds cut across departments and committees, for example the activities covered by the Water and Sewerage Fund only comprise part of the activities of the Engineer's Department, and also just part of the activities overseen by the Town Planning and Works Committee. On the other hand the activities paid under the General Fund include some activities of most departments and committees.

The draft annual budgets are prepared by the responsible head of department in consultation with the Treasurer. The fact that experience shows that most budgets will be cut at some stage or other during the budget approval process means that it is tempting for officers to pad their budgets, and this happened in the past when budgets tended to be based on the previous year's budget, simply amended for inflation. Budgets are now supposed to built up from an assessment of requirements for each and every activity, and it is claimed that padding is not included, due to the serious financial position of the Council in which the fulfillment of all real needs would produce a huge budget deficit.

The draft estimates are submitted to the relevant committee who after discussion and amendment forward them to the Treasurer who consolidates the different estimates into a single budget for presentation to the Finance, Staff and General Purposes Committee (FSGP). At around the same time, the Town Clerk discusses the draft with the Provincial Local Government Officer (PLGO) so that the final estimates are likely, for the most part, to be acceptable to MoLG. After the FSGP committee has approved the draft, if necessary after referral and modification, it submits it to the full Council for approval, at least 14 days prior to the commencement of the financial year.

The Council may further modify the estimates before approving them and forwarding them to MoLG for approval by the Ministry. In recent years this approval has taken several months. In 1993-94 approval which is sent via the PLGO was not received by the Council until February 1994, and in 1994-95 it was not received until late March 1995. In the meantime the Council can incur recurrent expenditures up to the level approved for the previous year.

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As regards capital expenditure, the Council it can continue with on-going projects as long as expenditure remains within the already approved frame. New projects cannot commence until the budget is approved. Further while inclusion in a budget approval provides sufficient authority for the Council to proceed with expenditure on some projects, for example those externally funded, for those projects financed by the Service Charge Fund, specific approval is required.

13.2 Tariff Increases

If a tariff increase is to be effected, it must first be approved by the FSGP Committee. In order to obtain approval a very convincing case has to be presented since the Councillors are very aware that they must look after the interests of their residents as well as the interests of the Council operations. Similarly once the increase is approved locally, it must be approved by the MoLG. Again a convincing case must be presented if it is to be approved.

13.3 Financial Management

Raising, administering and disbursing funds for the provision of municipal services is the main purpose of Nyeri Municipal Council's financial management for which the main responsibility rests with the Treasurer and the FSGP committee. Funds are raised through (i) fees and charges levied for services provided such as water supply and sewerage rates and housing rents, (ii) issuing licences for premises and activities, (iii) property rates, (iv) bank loans and (v) loans from Central and foreign governments.

As discussed in Section 12.1.3, the Council needs MoLG approval for increasing charges or raising loans.

The administration of a council's funds is governed by sections 215 to 221 of the Local Government Act. Under Section 216 a council has to establish a general rate fund into which receipts are paid and from where liabilities have to be discharged. Under Section 218, a local authority has also to create a general reserve fund so as to provide a sufficient working balance and be able to meet unforseen contingencies. End of year surpluses of the general revenue accounts are transferred to/from this fund, and monies in the fund may be temporarily invested. Nyeri does not operate a Reserve Fund.

Councils have the authority under Section 219 to create renewals funds to provide for replacement of assets. Capital funds for the purpose of defraying capital expenditure and/or reducing outstanding debt can be created (Section 220), whilst a consolidated loan fund in which all or part of any loan transaction can be centralised is also permissible. The Nyeri Council does not have any such funds.

Although it did operate a renewals fund in the past, this has been defunct for several years due to a lack of any available money which could have been placed in such a fund. It is hoped to revive a renewals fund in the near future, and it would be appropriate for the Water

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and Sewerage Department to operate such a fund, if that fund could be protected from borrowing by other departments.

Expenditures can only be incurred if provided for in the approved estimates and only if they are approved by the Treasurer, although the imprest system allows other senior staff to make small expenditures and to account for them retro-actively.

Control of finances is provided by the Internal Audit Section of the Treasurer's Department, by MoLG through its approval of estimates, charges and loans, and by external audit which is regulated by the Controller and Auditor General. In theory the external audit should be undertaken within six months of the end of the financial year, but in practice the final accounts are only available up to 1992, and the last audited accounts are for 1988.

Financial monitoring is the responsibility of the Municipal Treasurer, notably to ensure that expenditure does not exceed the approved budgeted amounts. He is supposed to alert heads of departments where expenditure may have to be restricted to remain within the approved amounts and/or where income is likely to fall short of the estimates. He also prepares quarterly reports to the Finance Committee on expenditures and income, and on variances from the approved figures.

In addition he is supposed to prepare revised estimates in the middle of the financial year for recommendations by the FSGP Committee for any action to prevent deficits. In practice this would be a rather pointless activity given that the Ministry has not approved the original estimates by this time. Financial monitoring tends to be rather informal, the main tool being restricting the approval of expenditure to that for which funding still exists in the Vote Book.

If income is likely to fall short of the proposed funding there is no direct mechanism for reducing expenditure, other than the fact that a lack of liquidity prevent all but the most urgent expenditure under a particular fund.

13.4 Accounting

Section 228(3) of the LGA requires that accounts are kept on a payments and receipts basis, and that at the end of the year they are put on an accruals (expenditure and income) basis, thereby providing a financial accounting/financial management system.

This results in final accounts and an annual balance sheet. The objective is to show clearly and publicly that the funds administered have only been used for the purpose for which they have been provided. They must relate all expenditure and revenue to the approved estimates. They are also supposed to provide the necessary information needed for resource management and for setting appropriate charges, and to provide a clear permanent record of all financial transactions. The main problem relates to the fact that most stages of accounting up to external audit are so far behind in time, that management information is poor.

The accounting system is built on an expenditure analysis based on individual payment vouchers/cheques by code, an income analysis based on revenue journals, the salaries and wages ledger, the petty cash book and bank accounts. All these come together in the

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General Ledger which is the key accounts record and which contains the principal accounts and the totals from subsidiary ledgers. These cover debtors/creditors, capital accounts, revenue and expenditure accounts, provision accounts, fund revenue and reserve accounts. The four service oriented accounts are described below.

13.5 Annual Budgets

The budgets of Nyeri Council are based on four funds, these are the General Fund, the Housing Fund, the Water and Sewerage Fund and the Service Charge Fund. The General Fund covers all the overall administrative costs of the Town Clerk's and Treasurer's Departments, the Engineers Department except for water and sewerage, and social services, public health, education and markets. Its main sources of income are various rates, fees and licences which the Council is able to levy. Over recent years, the General Fund has accounted for approximately half of Council's expenditure and income.

The Housing Fund covers all expenditure on Council properties and derives it income from rents. This normally only accounts for around 6-8% of the Council's annual budget.

The Water and Sewerage Fund covers the expenditures on the Nyeri and Kiganjo water and sewerage schemes and derives it income from water and sewerage charges. It typically accounts for around one third of the total Council budget.

The Service Charge Fund is financed by service charges levied on Nyeri residents to cover services such as street lighting. The budget for this fund typically accounts for around 10% of the Council's overall budget.

Table 13.1 presents the budget estimates for the last three years. It should be noted that the budgets are presented in terms of Kenya Pounds (KP), and hence the figures in Table 13.1 are expressed in these units, (1KP = KShs 20). The figures represent the approved budgets, except for 1994-95 figures which at the time that the data was collected, had not been approved and hence the figures were still initial estimates.

It should be noted that actual expenditures can vary considerably from the approved budgets, but it was not possible to establish actual expenditure and income for the individual funds without going into ledgers etc, since annual accounts past June 1992 are not finalised and summaries are not presented in subsequent budgets. Hence this has only been undertaken for the Water and Sewerage Funds. The budgets do however give a reasonable picture of the order of magnitude of the different funds and of total Council expenditure. Furthermore the impression given by the budgets, that the overall annual surplus/deficit expressed as a percentage of the overall budget is small, is also true.

Expressed in KShs the annual budget from 1992-93 to 1994-95 has increased from around KShs 50 million to KShs 75 million.

In practice, over recent years, the Council has managed to balance its income and expenditure. Although individual funds do have significant deficits in some years and the latest estimates suggest that the General Fund should have a deficit approaching KShs 8 million by June 1995, overall the four funds, up to 1994, usually managed to remain in surplus.

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Table 13.1
ANNUAL APPROVED BUDGET ESTIMATES - (KENYA POUNDS)

	Expenditure	Income	Surplus/Deficit
General Fund			
1992-93	1,312,934	1,156,007	-156,927
1993-94	1,393,745	1,240,456	-153,289
1994-95*	1,780,715	1,566,123	-214,592
Housing Fund			
1992-93	147,352	172,586	25,234
1993-94	236,300	292,030	55,730
1994-95	257,875	322,212	64,337
Water & Sewer.Fund			
1992-93	675,046	811,000	135,954
1993-94	968,878	935,000	-33,878
1994-95	1,320,405	1,311,500	-8,905
Service Charge Fund			
1992-93	272,765	350,000	77,235
1993-94	288,057	350,000	61,943
1994-95	348,966	400,000	51,034
TOTAL BUDGET			
1992-93	2,408,097	2,489,593	81,496
1993-94	2,886,980	2,817,486	-69,494
1994-95	3,707,961	3,599,835	-108,126

13.6 Financial Constraints

The Council has nevertheless faced serious financial problems for several years now. The central government has given local authorities responsibilities, but the opportunities for the councils to raise adequate revenue are not commensurate with the obligations, and the government has not provided grants for recurrent expenditure for some considerable time. Nyeri, as with other councils, has a relatively narrow income base which includes rates and licence fees, service charges and water rates. A holistic approach to local government finance is required if the services provided by councils are to be improved.

In recent years, Nyeri Council has only managed to balance its books by restricting expenditures in some areas, to less than the desirable level, with an inevitable deterioration in some areas of its activities. Both capital expenditures (other than those funded by loans), and financial provisions for renewals and replacements have been extremely low. As an illustration, there has been a significant deterioration in the transport fleet, since as mentioned in Section 12.4.2, no new vehicle has been purchased since 1986. In addition inadequate funding has been provided for preventive maintenance of water supply and sewerage works. This means that an increasing proportion of what should be done under routine maintenance is postponed with an inevitable deterioration until replacement or major repair will eventually be required, which may only be affordable if external funds are available.

The second means of balancing the books has been to delay the repayment of outstanding loans when payments have been due. This has particular relevance for the Water and Sewerage Fund. In the very provisional 1995-96 estimates an item of KShs 11 million has been included under sewerage for loan repayment. This was also included in the 1994-95 estimates but it was taken out by the Finance Committee against the advice of the senior professional staff. Councillors argued that if it was included, the Council would not be able to balance the budget.

13.7 Over-Expenditure and Moving Funds between Budget Lines

In principle it is not possible to over-spend and expenditure for every budget line should be kept within the budget for that particular line. Over expenditure on major budget headings is certainly not allowed There is a provision for supplementary expenditures but due to approval delays, it would rarely be worthwhile to try to obtain additional recurrent finance, since it is very unlikely that the approval would be granted in time, hence in practice it does not happen for O&M expenditure. Where necessary over-expenditure will be very minor, it may be overcome by charging the costs to a sub-heading budget line within the same budget which is aimed at similar expenditures. Supplementary requests for project expenditure are possible, where funds are inadequate due to special or unforseen expenditure, but since the approval process has to be followed, it is only worthwhile doing for large additions. Where there is an urgent need and with special attention to the matter, it may be possible to obtain approval reasonably quickly.

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13.8 Financial Provision for Replacements and Renewals

Senior Council staff are well aware of the insufficiency of the funds set aside for any repair and renewal funds. There are two main reasons for this.

Firstly the finance is not usually available for the Council to be able to set aside money for such funds, as is in fact required in the Local Government Act. The Act says that councils should contribute money from revenues for the future acquisition of necessary assets although it does not lay down any quantified guidelines, and these funds should be invested in the interim. In practice where the cost of a replacement is limited, these costs are sometimes charged under the renewal and replacement provision budget line rather than under a capital expenditure heading.

The second reason is that any money put into such funds is unlikely to be available, for the expenditures for which they were intended, at the time they are required. Such money would only be there as a book-keeping entry and the actual cash would have been spent on something else. In recent years all Council money has expended as it is collected, hence senior staff say that under existing circumstances there is little point in putting any money aside for such funds. Instead it is better to buy replacement components under the capital expenditure as and when required.

If a large replacement/renewal fund was built up, it is most probable that the Council staff would be under pressure from Councillors to spend it on some other immediate requirement. In other words in the present situation it would not be possible in practice to protect such funds for the purpose for which they are intended. It therefore would not be wise to put significant sums into such funds until either the finances of the Council are far sounder than at present, or the attitudes of the key actors are changed, or systems are in place which prevent such funds from being put to usage other than that for which they are intended.

13.9 Council "Funds"

As mentioned in Section 13.5, the Council's finances are based upon four funds: General Fund, Housing Fund, Water Fund, and Service Charge Fund. These funds are operated separately, and the corresponding bank accounts are held in different banks in Nyeri.

The Water Fund derives its income from water and sewerage rates, from connection fees and from a few minor related income heads. It only finances water and sewerage related expenditures, which fall under budget codes 090-093. This includes capital expenditure which is financed by the Council's own revenues, and termed "Revenue Contribution to Capital Outlay". The latter are generally relatively minor due to the financial constraints faced by the Council. Conservancy charges are levied together with water and sewerage rates but the estimated conservancy revenue is allocated to the General Fund which meets conservancy expenditure.

Due to the constant cash flow problems which face the Council, lending by one fund to another is a regular feature of day to day Council operations. Strictly all borrowing by any fund from another fund should be repaid, and for the most part the inter-fund loans are repaid. It is however reported that repayment is not fully assured and that if one fund was to develop a good financial position, it could not be certain that its surpluses would not be permanently lent to another fund. Even if it had an asset in the other fund's debt to it, it may be unable to actually recover the cash.

In recent years the Water Fund has not generated any substantial surpluses and has therefore not been a major lender to other fund, in fact it has sometimes been a borrower. As recently as July - November 1994 it was unable to pay all its salary obligations and borrowed from the General Fund. As a result of the September tariff increase which is now being reflected in higher revenues, it has repaid most of the amount borrowed and should have fully repaid its "loan" before the end of the current financial year.

Over the next year the Water Fund should be in surplus, although that surplus will be sensitive to the extent to which it meets its loan obligations. If it does generate a significant surplus, it could result in the Fund being under pressure to lend to other funds to "temporarily" finance non water activities. The establishment of a completely separate Water and Sewerage Department could reduce this pressure. The new Department's General Manager by being a signatory to all cheques would have a significant say over the Water Fund. Hence in theory he could refuse to endorse a loan to another fund. Furthermore he may decide to use any surplus to repay water and sewerage loans. But if other funds face serious cash flow problems, it is possible that the Council would order him to delay such repayments. The position of an independent department is yet to be seen, but given the past actions of the Council in financial management, the General Manager would need to be extremely forceful if the Department was to achieve real financial independence.

13.10 Loans

The Council is able to finance development costs with loans provided that the full council passes a resolution to accept the loan, and the approval of the Local Government Loans Authority is obtained.

According to information provided by the Treasurer's Department, as at June 1992, the outstanding loans at that time included the following:

	(KShs million)
Principal Outstanding	
Sewerage Scheme	133.98
Land Acquisition for Sewerage	2.09
Sewerage Study	3.07
Water Supply	12.96
Sub-Total	152.10
Interest Arrears for Sewerage Scheme	75.16
Total Outstanding for Water and Sewerage	227.26

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Other long term liabilities included in the latest NMC final accounts (June 1992) accounts were:

	(KShs million)
New Town Hall	1.163
Council Office	0.055
Abbatoir	0.828
Market Kiosks	1.400
Gakere Rd	0.219
National Housing Corporation Loans	16.877
Total	20.542

Hence as at June 1992, NMC owed approximately KShs 250 million, of which over 85% was for sewerage, and only 5% was for water supply. Since no later accounts are available the Consultant has tried to build up a reasonably accurate picture for 1995 by using the 1992 figures as a reference point, and by discussing every major loan with Council officials.

The Sewerage Loan which was funded by the African Development Bank with a local element provided by the Kenya Government is the Council's largest outstanding loan, by far. Construction was completed in 1988/89, although some expenditure for staff housing has been incurred until very recently. The original loan was for around KShs 170 million but only around KShs 155 was spent initially. Recent expenditure on housing has increased the total loan significantly above the original KShs 170 million figure, although the final figure is not yet known. It was reported that the there was no grace period, that the loan should be repaid over 30 years at an interest rate of 6.5% and that annual repayments are supposed to be KShs 11 million, (although this would only appear to fund the interest on KShs 170 million). To date, no significant repayments have been made, in fact since most of the interest has not been paid, arrears have built up. Whilst precise current figures could not be identified, based on the 1992 arrears, total arrears are probably something over KShs 100 million; this figure would include some non payment of capital as well as interest. Based on a six year period since repayment should have commenced, and an annual sum due of KShs 11 million, the greater part of which is interest, it would appear likely that unpaid interest is around KShs 70 million. Hence including recent expenditure on housing, the total liability could be something over KShs 250 million. It was reported that NMC has been negotiating with MoLG concerning the repayment.

The second largest loan liability is to National Housing Corporation and comprises a number of different loans - firstly a number of loans mainly for housing at rates of interest of, or around, 6.5%, secondly a USAID loan at 9% interest and thirdly the largest component, the IBRD Third Urban loan for urban infrastructure/upgrading of squatter areas at 11.25% interest. Repayment of the latter loan was due to commence in 1992, but the Council has not met repayments, in part due to defaulting by the plot beneficiaries.

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As at 30th June 1994, the total sum outstanding on these housing loans was KShs 37.96 million. It comprised the following:

	Principal Outstanding	Interest Arrears
	--- (KShs million) ---	
General NHC Loans	11.97	5.03
USAID	1.41	0.49
Third Urban	13.81	5.25
Total	27.19	10.77

Current annual repayments should be over KShs 3.2 million, and repayments due at 31st December 1994 totalled KShs 1.61 million. The latest arrears are shown as KShs 12.33 million however, suggesting that only minor payments have been made in the interim.

Loans for water supply are very limited, the main component being for extensions to the Kamakwa waterworks. This is reported to be just under KShs 13 million, with an annual repayment of around KShs 1 million. The Council has tended to fund more recent minor works out of revenues, for example, the Kamakwa extension undertaken during May to August 1994 at a total cost of KShs 3.5 million. When the raw water parallel mains was constructed some years ago using direct labour, the Council funded 60% of the KShs 5 million from its own resources. The remaining KShs 2 million was provided by MoLGLA and it is assumed that this figure is included in the Kamakwa waterworks figure.

The total of current loans to NMC including outstanding arrears, based on the figures presented above is estimated to be something over KShs 300 million. The current annual sums due on the loans, (excluding consideration of arrears) are reported to be:

Sewerage	KShs 11.0 million
Kamakwa	KShs 1.0 million
N.H.C incl Third Urban	Kshs 3.2 million

Given that the Treasurer reported that the repayment of all other liabilities is under KShs 0.6 million per annum, the total annual repayment should be under KShs 16 million/annum. This does not take account of the repayment of the outstanding arrears, notably on the sewerage loan. If annual repayments were made on all outstanding arrears, it is estimated that the annual repayments may increase by over KShs 6 million, although the figures on which this calculation are based are imprecise.

Hence the loan burden which the Council is currently carrying is high, but it is not totally unreasonable compared to its overall annual expenditures, inasmuch as annual repayments would represent around 22% of its total budget, or just over 30% if it not only met its original liabilities, but also started repaying accumulated arrears.

In practice the financial situation with regard to repayment of loans has been very poor in recent years, due to the Council's limited financial resources relative to its necessary recurrent expenditure. The Council had a reasonable history of loan repayment at one time, but repayments since 1988 have been very low. Any repayments of loans to the Local

Government Loans Authority since then, other than a few payments to NHC, have usually been money owed by government to the Council for rates etc, which has been withheld. Indications are however that the Council is now making an effort to obtain payments from the beneficiaries of NHC loans in order to improve its own performance on that aspect of debt.

75%

Nearly three-quarters of the premises surveyed are served by 'on-site' or 'on-plot' facilities, that is, by pit latrines or septic tanks. Excluding the non-residential premises, about two in five premises use pit latrines and two in five use septic tanks.

40% 40%

Throughout the area both pit latrines and septic tanks have, on average, large numbers of users. Pit latrines are often shared by a dozen or more families living in rural areas or urban rows of single rooms. Whilst the majority of septic tanks are used by one or two families living in high-cost dwellings, the average number of users per tank is boosted by a few tanks for multi-storey buildings shared by large numbers of individuals or families.

On the whole the condition of septic tanks is satisfactory. For high-cost dwellings the standard single-chamber design appears to work well. The difficulties with drainfields experienced in many countries (notably the United States) are avoided because of the use of deep soakpits penetrating soil which accepts infiltration of tank effluent. One common difficulty currently being experienced in Nyeri is failure of the piped water supply, which necessitates the flushing of WCs with buckets. This is inconvenient for householders, but does not influence the operation of lightly-loaded septic tanks. A few enterprising owners of high-cost dwellings have preempted any trouble from lack of water by making a form of pit latrine over the soakpit by building a 'little room' and by forming a squat hole in the soakpit cover.

The few instances of serious trouble with septic tanks were observed where systems are overloaded. Some big tanks of ample capacity have been built, such as at the Classic Court Hotel. Elsewhere the tanks provided for some dozens of users are little larger than those that are usual for one or two families. The difficulties with some multi-user septic tanks are compounded by inaccessibility. In some cases the tanks are well below street level, making it unlikely that vacuum tankers could empty overflowing tanks.

Another major trouble with the septic tank systems is primarily concerned with the water closets rather than the tanks or soakpits. Some WCs in appalling condition are connected to septic tanks; others to municipal sewers. In several communally-used WC toilets (particularly those for junior government staff quarters) the pans were full, blocked, filthy dirty, or broken. In many of these unhygienic situations, the water supply has been disconnected, the cistern is broken, the flushing system is inoperative or the down-pipe has become disconnected. Incidentally it is worth pointing out that some excellent examples of well-kept communal WCs were found during the survey

The majority of the 'normal' domestic septic tanks in Nyeri rarely, if ever, require desludging. This convenient phenomenon is common in many parts of Africa. It is likely that in climates with uniform high temperature throughout the year sludge decomposition matches the addition of fresh solids in domestic sewage. This is different from the situation in temperate climates, for which a desludging interval of less than a year is often stipulated.

Overall, where premises are served by septic tanks, it was found that:

i) The usual design for domestic septic tanks is satisfactory, provided they serve not more than three families, and the effluent is discharged to deep soakpits.

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ii) From an environmental health point of view, urgent improvement is required to many communal water closets, particularly those in government quarters.

iii) Before approving the occupation of large premises whose sanitation is by septic tanks, the municipal authorities should try to ensure that the facilities are of sufficient capacity for the anticipated number of users and that adequate accessibility is available for desludging septic tanks by vacuum tankers when required.

Compared with other regions, East Africa is remarkable for the size of pits used as latrines. Pits over six metres deep are usual from Sudan southwards through Kenya and to Uganda and Tanzania, whereas a depth of two to four metres is common in Asia, in West Africa and further south in Zimbabwe, Botswana and Lesotho.

In Nyeri pits of great depths have been dug. During the survey six recently-excavated pits were inspected. According to the owners or contractors, three were 6 metres deep, one was 9 metres deep, another 15 metres and the last was 18 metres deep. In all cases the excavators confirmed the depths after they had been greeted with some skepticism. In particular, the men responsible for the 18 metres depth were absolutely adamant that they had dug to this depth.

The majority of the shelters (or 'superstructures') that were examined were low-cost do-it-yourself affairs, mostly made of timber. Most of the slabs are also made of timber.

Nearly half of the pits that were examined were unsatisfactory in some respect, however, few were really bad. None suffered from the smell by which pit latrines in some countries may be located from a distance, none was surrounded by a cloud of houseflies, and no cockroach was seen in any latrine.

A very few shelters ('superstructures') and floor slabs were dilapidated and in imminent danger of collapse. Otherwise, most of the trouble is due to dirty slabs. Cleanliness is difficult where the floor is made of untrimmed logs, and there seems to be an awareness of the advantages of concrete slabs. One owner displayed ingenuity by studding his timber floor with substantial protruding nails and twisting barbed wire to provide reinforcement for concrete he was to lay 'that very night'.

Nevertheless, many concrete floor slabs were as dirty as those made of timber. This may indicate the desirability of an hygiene promotion programme pointing out the disease transmission possibilities (or probabilities) of dirty latrines. The programme should be directed at both men and women, giving different and appropriate emphasis.

Of course the shortage of water, which is a recurring complaint throughout the municipality, adds to the difficulty of keeping slabs clean. Water already used for washing clothes is however suitable for cleaning slabs, and ash is also an effective cleaning agent.

Such a hygiene promotion programme should encourage the fabrication, installation and use of well-designed and well-made concrete slabs. Footrests could be incorporated. They assist in squatting at a position which reduces fouling of slabs, and are particularly useful at night. Only two pit latrines with footrests were noticed in the Nyeri survey. The shape and size of squat holes might also receive attention. Considerable variation was found during the survey, although rectangular holes are favoured in timber floors. No keyhole-shaped slabs were noted, but several well-made slabs had triangular shaped holes about 400mm long, 180mm wide at the base and with the apex rounded with 50mm diameter. This might be selected as a 'standard' shape for Nyeri.

One concrete slab noted in Nyeri was about 20 mm thick, which is economical in materials (and hence cost) but is only sufficient because it is supported by a timber floor. The same idea is used with 'San Plat' slabs. One type of San Plat is 600mm square with a keyhole-shaped squat hole and footrests. Individual concrete covers are cast in individual San Plat slabs, making a perfect fly-proof seal. SanPlats were developed in Malawi, have been widely adopted in Uganda and other African countries and are manufactured in Kenya. Their main purpose is control of flies, but San Plat lids are also claimed to control smell.

As already noted, the survey indicated that fly nuisance in latrines is not a serious problem in Nyeri, but the possibility of seasonal increase of fly population and fly nuisance should be investigated. It is recommended that some of the latrines where some evidence of fly nuisance was found should be inspected regularly in the coming months to discover whether there is any such seasonal variation. Table 14.2 lists the latrines which might be investigated.

The lack of a serious fly problem also reduces the need for widespread adoption of ventilated improved pit (VIP) latrines. Possibly this accounts for the very few attempts at building VIPs in Nyeri, in spite of efforts by some international organizations to propagate this form of sanitation throughout Africa during the past twenty years. None of the pseudo-VIPs at Nyeri appeared to have fly-proof netting. The most extraordinary example of failure to understand the purpose of the vent pipe was seen in a very well-built school latrine with a tiled ridge roof. The vent pipe from the pit reached as high as the space above the walls and underneath the roof.

A secondary advantage of ventilation should not be ignored. In addition to controlling flies, vent pipes (if of sufficient height and properly located) remove malodorous gases from latrines. In view of the number of latrines at Nyeri with a (slightly) unpleasant smell, attempts might be made to at least explain the correct operation of VIP latrines.

The summary of findings with respect to pit latrines were that:

i) The usual practice of digging pits to depths greater than six metres should be continued. It probably accounts for the small number of pit latrines in Nyeri which create really bad fly and smell nuisance.

ii) A hygiene education programme should be instituted, dealing with the transmission of faecal-derived disease and stressing the importance of latrine cleanliness. This might usefully be centered on schools in the first instance, although of course this would require the bringing of school latrines up to an acceptable standard and then maintaining this standard.

iii) Provision of concrete slabs should be encouraged, possibly by arranging for the manufacture and sale of San Plat slabs or by loaning moulds for squat holes and footrests.

iv) A leaflet describing the purpose, construction, operation and maintenance of VIP latrines should be prepared and made available as appropriate to household heads and builders.

v) Slabs with triangular shaped squat holes about 400mm long, 180mm wide at the base and with the apex rounded with 50mm diameter might be selected as a 'standard' shape for Nyeri.

vi) Some latrines where flies were noticed during the survey should be inspected regularly in the coming months to discover whether there is any seasonal variation in fly nuisance.

The waste from about a quarter of the premises surveyed is discharged to public sewers. With the concentration of sewerage in the central business district, it is not surprising that compared with the municipal area as a whole there is a high proportion of non-residential premises amongst those that are sewered. These make up 42 per cent of sewered premises surveyed, whereas non-residential premises comprise only 20 per cent of all surveyed properties. It is also not surprising that the average number of users per connection (18 individuals) is larger than in the whole sample.

Of those who commented on the water situation, three quarters of those connected to sewers complained about the unsatisfactory water supply, very little different from the proportion of all users who reported difficulties with water. Difficulties with blocked sewers were the reverse of the water situation. Only a quarter of those connected to sewers who were asked about blockage reported trouble yearly or more frequently. There was no correlation between difficulties with water supply and difficulties with blocked sewers.

The number of sewer connections is reported to be as follows:

	Nyeri	**Kiganjo**
Sewer connections for private properties	1610	99
Sewer connections from government and public institutions	68	10

From a public health point of view, significant extensions to the sewerage system are not seen as being justified in the short term. Some 'infilling' is desirable to provide complete coverage in some central business district streets and in a few other areas with high population density, but soil conditions are ideal for septic tank soakaways and pit latrines, and most outlying residential areas have a low density or a rural nature, so it might be unwise (and is certainly unnecessary) to extend sewerage in most areas. The appalling condition of many water closets in sewered low-cost building development, such as government staff quarters, strengthens the argument for the existing system of sanitation.

Table 14.1

SUMMARY SANITATION FIELD DATA

No.	Zon	Details	Type of building					Type of sanitation				No of users		Condition of sanitation			Water supply		Other information
			Hi	Md	Lo St	Lo W	Ind	P	ST	MS	Cp	Fam	Ind	OK	Bd	Why bad	Gd	Bd	
1	6		1						1										
2	6	Bishop's house	1						1										
3	6		1						1										
4	6					1		1											
5	6		1						1										
6	6	Nathoo	1						1										
7	6		1						1										
8	6		1						1										
9	6	Judge's residence	1						1										
10	6	Senior Police Offr's reside	1						1										
11	6		1						1										
12	6		1						1										
13	6		1						1										
14	6			1					1										
15	6		1						1										
16	6		1						1										
17	6		1						1										
18	6	"Emming"	1						1										
19	6	Bishop Gatimu Rd	1						1										
20	5		1						1										
21	6	New Apolostic Church					1			1									
22	17	KANGEMI			1			1											
23	17			1						1									
24	17			1						1									
25	17					1		1											
26	17					1		1											Poorly maintained mud house
27	17				1			1											
28	17					1		1											
29	17	near Mukui bar			1					1									
30	17			1															Listed as "private sewage works"
31	17	nr Kenya Brew bott plant		1						1									
32	10	Asian Quarters		1						1									
33	10			1						1									
34	10		1							1									
35	10		1							1									
36	10			1						1									
37	10			1						1									
38	10			1						1									
39	10			1						1									
40	10			1						1									
41	15	RIRINGU		1					1										
42	15	Dr J K Githae		1					1										
43	15	Q Posho Mill					1		1										
44	15				1				1										
45	15				1				1										
46	15	Bar & restaurant					1		1										
47	15	opp Neema Enterprises shop			1			1											
48	15	Nursery school					1		1	1									
49	15	Shop					1		1			7							Four WCs to ST
50	15	YMCA Community Centre					1		1										
51	15			1					1										
52	15				1					1									
53	15			1					1										
54	15			1					1										
55	15			1					1										

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Table 14.1 (Contd.)

			Type of building					Type of sanitation				No of users		Condition of sanitation			Water supply		Other information
No.	Zon	Details	Hi	Md	Lo St	Lo W	Ind	P	ST	MS	Cp	Fam	Ind	OK	Bd	Why bad	Gd	Bd	
56	15			1					1										
57	15				1				1										
58	15						1		1										
59	16	SKOTA		1				1	1										
60	16			1					1			2							Internal WCs
61	16					1		1				5							Inadequate vent
62	16		1						1										
63	16					1		1											
64	16					1		1				7							
65	16		1						1										
66	16		1						1										Two WCs
67	15		1						1										
68	16			1				1				3						1	WCs but no water
69	16	Tea shop			1			1											
70	16	Salama Timber Company				1		1											
71	16	Caltex petrol stn					1		1										
72	16	Murunguru Estate	1					1	1			8						1	
73	16	Mrs Mugo's residence	1					1	1										
74	11	MAJENGO				1		1										1	Pit 20ft deep
75	11					1		1											
76	11	Mosque				1				1							1		Six WCs
77	11				1					1									
78	11					1		1				1			1	see Note			Dilapidated
79	11	Kiosk and residential			1			1											WC being built
80	11					1		1											
81	17	BLUE VALLEY		1						1									
82	17					1				1									
83	17				1					1								1	Three WCs
84	17				1			1											
85	17	Government qtrs			1					1									
86	17				1					1							1		
87	17				1					1							1		
88	6	RING ROAD	1						1										ST shared
89	6		1						1										
90	6		1						1										
91	6		1						1										
92	19	NYERI MORTGAGE	1						1										
93	19	Kingo'ngo Prison					1	1	1	1									
94	19			1						1								1	
95	19	Riverside cafe				1		1											Sullage connected to sewer; pit 30ft deep
96	18	Muitung'u Building	1							1									Post Office and 4-story appartments
97	18	Midland bar/restaurant	1						1						1	blocked		1	WCs blocked; ST full
98	18					1		1							1	full	1		Two men digging new pit for 2000/-; to be 20ft deep, about 3ft sq
99	18	P&T office	1							1				1					
100	18	UNGA Trade Centre	1						1	1									ST no longer in use
101	18	Makotano T Kiosk				1		1						1					Sullage to latrine pit
102	18				1			1	1	1				1					
103	18	Site & services		1						1				1					
104	18	S&S		1						1									
105	18	S&S		1						1		12							Two WCs
106	7	KAMAKWA	1						1										Nursing Home
107	7			1					1			2							STs emptied once
108	7				1				1			15	80						Six WCs for 14 units
109	7					1		1				25			1	Smell		1	Two pits nearly full
110	7					1		1				7	20						

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Table 14.1 (Contd.)

			Type of building					Type of sanitation				No of users		Condition of sanitation			Water supply		Other information
No.	Zon	Details	Hi	Md	Lo St	Lo W	Ind	P	ST	M S	Cp	Fam	Ind	OK	Bd	Why bad	Gd	Bd	
111	7			1					1			3	13						Internal WCs
112	7	Waterwks staff qtrs			1				1						1	See Note			Two WCs out 1 filthy
113	9	CBD - petrol stn					1			1								1	Sewer blocks yearly
114	9	Wachura tailoring shop					1			1									Blocks 3-4 months
115	9	Dignity hair saloon					1			1									
116	9	Wandeto's tailor					1			1									Blocks 4 per year
117	9	Beer depot					1			1									
118	9	Grand Batian Hotel					1			1									No blocking
119	9	Kaka garage					1												No sanitation
120	9						1												No sanitation
121	9	Wazee Hukumbuka					1			1									Rarely blocked
122	9	Green Leaf Hotel					1			1								1	No sewer problem
123	9						1			1								1	No blocking
124	9	BP petrol					1			1								1	Blocks 3 per year
125	9	Paresia Hotel					1			1								1	No blocking
126	9	Maki building					1			1								1	Blocks 1 per year
127	9						1			1									
128	9	New Munyaka Hotel					1			1								1	No blocking
129	9	Chloride-Exide					1			1									No blocking
130	9	Batian beer garden &tc					1			1									No blocking
131	9	United African Baker					1			1									
132	9	Stallion Insurance					1			1									No blocking
133	3	Oriental Lab Suppliers					1		1										ST recently emptied
134	3	Joanns House					1		1										
135	3	Business Machines Ltd					1			1									No blocking
136	3	High rise building					1		1										ST & Soakpit full
137	3	Caltex petrol stn					1			1									Blocks 3 monthly
138	3	PCEA Church					1	1						1					
139	3	Kenya Power & Lighting					1			1									No blocking
140	3	Consolidated Bank					1			1									
141	3	Kona Trrading Co					1			1									Rare blockage
142	3	Central Plaza					1			1									No blocking
143	4	Town Health Centre					1	1							1	smell			ST not in use
144	4	KP&LC Residence		1						1									No blocking
145	4	Mr Mawcru		1					1	1									
146	4			1						1									No blocking
147	4	Pastor Macharia	1						1										
148	4	Mr Julius Muriuki		1						1									Block once in 3 yrs
149	4			1						1									Abandoned ST
150	4	P C headquarters					1			1									No blocking
151	4	District headquarters					1			1									
152	4	Lenana grocers					1			1									No blocking
153	4	DP offices					1			1									No blocking
154	4						1			1									Blocks every year
155	12	Temple Road petrol stn					1			1									No blocking
156	12	Kimathi Estate - D6		1						1									No blocking
157	12	Kimathi Estate - D16		1						1									No blocking
158	12	Kimathi - MG/41		1						1									No blocking
159	12	Kimathi - MG/42		1						1									No blocking
160	12	Seventh Day Advent Ch					1	1						1					WC being built
161	12	Kimathi - LG/204		1						1									
162	12	Thingira Guest House					1			1									Blocks 1 per year
163	12			1							1								WC to cesspit
164	12	Mosque					1		1										
165	12	Mosque								1									
166	12	Assemblies of God school					1		1										
167	12	Labrary					1			1									
168	12			1															Blocks 2 per year
169	7	Nursery School					1		1				80	1					Five WCs + urinal

Table 14.1 (Contd.)

			Type of building					Type of sanitation				No of users		Condition of sanitation			Water supply		Other information
No.	Zon	Details	Hi	Md	Lo St	Lo W	Ind	P	ST	MS	Cp	Fam	Ind	OK	Bd	Why bad	Gd	Bd	
170	7	Shops	1						1			4		1					Four internal WCs
171	7	Road Side Hotel					1	1	1						1	ST full			Pit latrine used now
172	7			1					1				20						Two STs
173	7	Shops and rooms				1		1					10	1					Timber latrine slab
174	7	Shops and rooms				1			1			4			1	no water		1	No water; unpaid bill
175	7	Shop and rooms			1				1			6			1	no flush	1		cistren needs repair
176	7	Shops & rooms (4 floors)	1						1			40			1	ST overflow			
177	7	Bar, restaurant & rooms			1				1			12			1	no flush			Cisterns not work
178	7		1						1					1			1		Internal WC
179	7	Two semi bungalows	1					1	1			2		1					Internal WCs
180	7					1		1				12			1	dilapidated			Next plot to 180
181	7					1		1				9		1					
182	20	Mt KENYA WARD				1		1											
183	20					1		1											
184	20				1			1											
185	20					1		1										1	
186	20				1			1											
187	20		1					1	1										
188	20				1			1											
189	20				1			1											
190	20					1		1											
191	20				1			1											
192	14	RURINGO		1					1				5	1			1		Internal WCs
193	14					1		1				5			1	Dirty; flies	1		
194	14					1		1					20		1	Dirty			Sq hole 400 x 100
195	14		1					1	1				4	1				1	Sq hole 150 dia
196	14	Govt staff qtrs		1				1	1						1	See Note		1	WC pans broken
197	14	Govt Junior Staff Qtrs			1			1	1			17			1	See Note			Two WCs very dirty
198	K	KIRICHU		1				1						1					Vent UNDER roof
199	K					1		1					5		1	Flies			
200	K	Charcoal sellers				1		1							1	Smell		1	Sq hole 270x130
201	K	Classic Hotel & shops				1		1											Two pit latrines
202	K	Kirichu Market Clinic		1					1			4		1					Two WCs; 8 y old
203	K	Cafe & rooms			1			1							1	See Note			Sq hole tri 360x180
204	K	Cafe & rooms		1					1			11		1				1	Three WCs to ST
205	K		1						1				6	1					Inside WC to ST
206	K	KIGANJO MORTGAGE		1					1	1									Sewer to comm STs
207	K			1					1	1									as 208
208	K			1					1	1									as 208
209	K	Bar					1	1										1	
210	K					1		1										1	
211	K	School					1	1											
212	K	Youth Training Centre					1	1	1										
213	K				1			1										1	
214	K					1		1										1	
215	K	Health Centre					1	1											
216	K	Primary School					1	1										1	
217	K			1				1										1	
218	K				1			1										11	
219	K	KIGANJO TOWN			1					1									No blocking
220	K					1		1							1	Flies			
221	K	Shops & rooms			1					1					1	Dirty			
222	K						1			1									Often blocks
223	K	Health centre etc					1		1						1	No soakpit			Pit latrine being dug
224	K	Commercial					1		1										ST emptied 3 times
225	K	Institution					1			1				1					
226	K				1				1										Soakpit floods
227	K	Railway qtrs			1				1					1					
228	K	NCPB					1		1	1									

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Table 14.1 (Contd.)

			Type of building					Type of sanitation				No of users		Condition of sanitation			Water supply		Other information
No.	Zon	Details	Hi	Md	Lo St	Lo W	Ind	P	ST	MS	Cp	Fam	Ind	OK	Bd	Why bad	Gd	Bd	
288	1					1		1					7		1	Dirty	1		Sq hole tri 400 x 180
289	1		1						1				6	1			1		
290	1	Good quality timber			1				1										
291	1	Katerina House 4 floors	1						1			30							ST often emptied
292	5	Baden Powell Road	1								1		9						C/pit emptied 2/yr
293	5	Kenya Commercial Bank	1						1				1						
294	5	MOW low-grade staff			1			1				100			1	Smell,flies			Two pits; 1 no door
295	5	MOW higher-grade		1					1										Internal WCs
296	20	RURINGU		1						1		4						1	Internal WCs
297	20		1					1			1	8							Two WCs to cesspit
298	20	Classic Hotel		1					1									1	Large ST - 30 WCs
299	20	Nganga Rithi				1			1			15			1	very dirty		1	Two WCs
300	20	Kanoga River area				1		1					10		1	slight smell		1	No piped water
301	20					1		1					6	1				1	No piped water
302	20					1		1				9	25		1	dirt sml flies		1	
303	20	Ngangarutti [??]	1					1	1				8	1				1	Lid for sq hole
304	20	Shamba				1		1					20	1				1	New pit to be 30ft
305	20	House being built	1					1	1					1				1	Lat over 60ft s'pit
306	20	Scattered dwellings				1		1					30	1	1	See note	1		Three pit latrines
307	20	Nursery School			1			1							1	Very dirty		1	No water supply
308	20	Charcoal seller				1		1							1	dirt sml flies			One pit full; one bad
309	20	V posh house being built	1					1	1					1					Lat over 50ft s'pit
310	2	Church					1		1										
311	2	Gichuhi Building [??]					1		1										
312	2	Single room rental				1		1											
313	2					1		1											
314	2				1														
315	2	Central Drug Co					1			1									
316	2	Commerce & Resid					1												
317	2	MAJENGO				1		1											
318	2				1					1									
319	2					1		1											
320	2					1		1											
321	2					1		1											
322	2	Hotel, 2 shops, rooms					1			1		18	25	1			1		WC reported ok
323	2	Pentecostal Primary School		1				1					75						Pit for 71 children
324	2	Hotel + rooms			1			1	1				20		1	WC filthy		1	One pit lat; 2 WCs
325	2	Sweet water mum cafe				1		1							1	Smelly, flies			Wood shelter bad
326	2	GK No 3 Bdg & Lodging			1					1			10	1					WC tiled to 1.5m
327	14	RURINGU - cafe				1		1							1	Dirty, smelly		1	Sq hole 800 x 400
328	14	Hotel & bar			1			1						1			1		Sq hole 400x200
329	14	Mixed type housing				1		1					15	1		See Note		1	Sq hole tri 400x180
330	14					1		1				12	25	1			1		Sq hole 300x200
331	14	Silent Sea Hotel				1		1				14						1	Vent, no flyproof
332	14	Survivor General shop				1		1	1			2	5	1				1	
333	14	Moslem owner				1		1					10		1	smelly, wet		1	Sq hole 250x150
334	14					1		1					20		1	dirty, smell		1	Sq hole 300x150
335	14					1		1					12		1	dirty, flies			Timber & mud floor
336	14			1				1					1	1					Sq hole 220x150
337	2	MAJENGO - mosque					1												Mosque being built
338	2					1		1											
339	2					1		1											
340	2					1		1											
341	2					1		1											
342	2	Church compound					1		1										
343	2					1		1											
344	2					1		1											
345	2					1		1											
346	2				1			1											

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Table 14.1 (Contd.)

			Type of building					Type of sanitation				No of users		Condition of sanitation			Water supply		Other information
No.	Zon	Details	Hi	Md	Lo St	Lo W	Ind	P	ST	M S	Cp	Fam	Ind	OK	Bd	Why bad	Gd	Bd	
347	17	Dr Jane Wambui		1						1								1	No blocking
348	17	Church day nursery				1		1						1					
349	17				1			1										1	No standpipe
350	17	Mr Gitonga		1					1									1	
351	17	Mr Kanja			1			1					11					1	Two toilets
352	17				1			1										1	
353	17				1			1					5					1	
354	17	BlockH				1		1					5					1	
355	17					1		1					9				1		Two toiletes - timber
356	17	Mr Rukwaro		1				1											
357	14	RURINGU		1					1				6	1				1	Three inside WCs
358	14		1						1				8	1			1		Internal WCs
359	14		1						1				5	1			1		ST for 3 bungalows
360	10	ASIAN QUARTER		1						1								1	
361	10			1						1									No blocking
362	10			1						1								1	No blocking
363	10			1						1									No blocking
364	10			1						1								1	No blocking
365	K	KIRICHU				1		1											
366	K			1				1											
367	K					1		1											
368	K					1		1											
369	K	PCEA Church					1	1											
370	K					1		1											
371	K			1				1	1										
372	K					1		1											
373	K					1		1											
374	K					1		1											
375	K					1		1											
376	K					1		1											
377	K			1				1											
378	16	SKUTA	1						1									1	
379	16			1					1									1	
380	16			1				1	1										
381	16						1	1										1	
382	16					1		1										1	
383	16			1					1									1	
384	16	Secondary School					1		1									1	
385	16			1					1										
		% of totals	18	24	15	22	21	35	37	27	1			54	46		26	74	
		Averages										11	16						

Table 14.2

PIT LATRINES FOR INVESTIGATION OF FLY NUISANCE

Premises No	Zone	Description and location of premises	Fly situation during February survey
195	14	Timber houses near Ruringu Stadium	Fly nuisance
201	K	Plot next to Catholic Church at Kirichu	Fly nuisance
222	K	Chief's Camp next to Police Station at Kiganjo	Flies
296	1	Latrines near low grade Ministry of Works staff houses near Hindu cemetery	Flies
304	20	Latrine used by about 25 people near Kanuga stream	Flies

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14.2. Nyeri Town Sewage Works

14.2.1. Introduction

Nyeri Sewage Works is a sophisticated sewage treatment system involving both physical and biological waste water treatment. Physical treatment includes screening, grit removal, and primary, intermediate and tertiary settlement, whilst biological treatment is by both high rate and low rate filters, and maturation ponds. Aerobic sludge digesters and sludge drying beds are also employed in the works.

The works were put into operation in 1988 and most of the flow to the works is of domestic origin, emanating mainly from the central business district, the Chania valley, Ruringu area and Kimathi housing area.

The flow to the works is currently estimated at 2,100m^3/day, which is far below the capacity of the works which is 6,000 m^3/day, hence recirculation pumping geared towards providing enough flow to turn the arms of the high rate filters is carried out.

The works have a significant number of electrical/mechanical installations which are expensive in operation and maintenance.

This section outlines of the existing facilities and their condition, and highlights some of the apparent problems experienced in the works, as well as possible remedies.

14.2.2 Volumes of Treatment

The ultrasonic flow measurement equipment installed at the inlet works functioned upto May, 1991`, thus complete flow records were only existing for the months between and including September 1988 and April 1991. When this study commenced, a V-notch was installed, and readings taken five times daily between 8 a.m and 6 p.m, over a three month period. These readings allow an estimation of monthly flows in the months of February to April 1995. The old records and the estimates based on the new measurements are in Figure 14.1.

Save for the expected low flow into the new commissioned works (September 1988), the flows in the works varied from a low of 958 m^3/day to a high of 2,135 m^3/day, upto when the measurement equipment stopped working. The annual fluctuation pattern from these figures is not immediately discernible. The November to January period does seem to represent a peak period, but the highest flows were recorded in March to May 1990. The June/July period also appears the low flow time, but January/February 1990 breaks this trend. Overall the time over which the data is spread is insufficient for such an analysis to be conclusive.

The 1995 figures are based on the average of flow readings during a day, discounted to 70%. The rationale for that is that the readings would be fairly representative of the main water usage time of say 16 hours, but omit an 8 hour period of virtually no sewage output by consumers. On that basis, current sewage inflows to the works are about 2,100 m^3/day.

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NYERI SEWAGE TREATMENT WORKS - MONTHLY FLOWS

YEAR	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1988									20752	36965	46068	41005
1989	55461	26999	36835	36384	33806	28750	36530	46790	34555	41398	43777	52299
1990	39668	35984	53057	64043	52093	43160	42890	39982	42480	48737	45933	45696
1991	43949	40464	48068	44429								
1995		50490	44414	39627								

Note: The 1995 flows are derived from instantaneous V-notch readings.

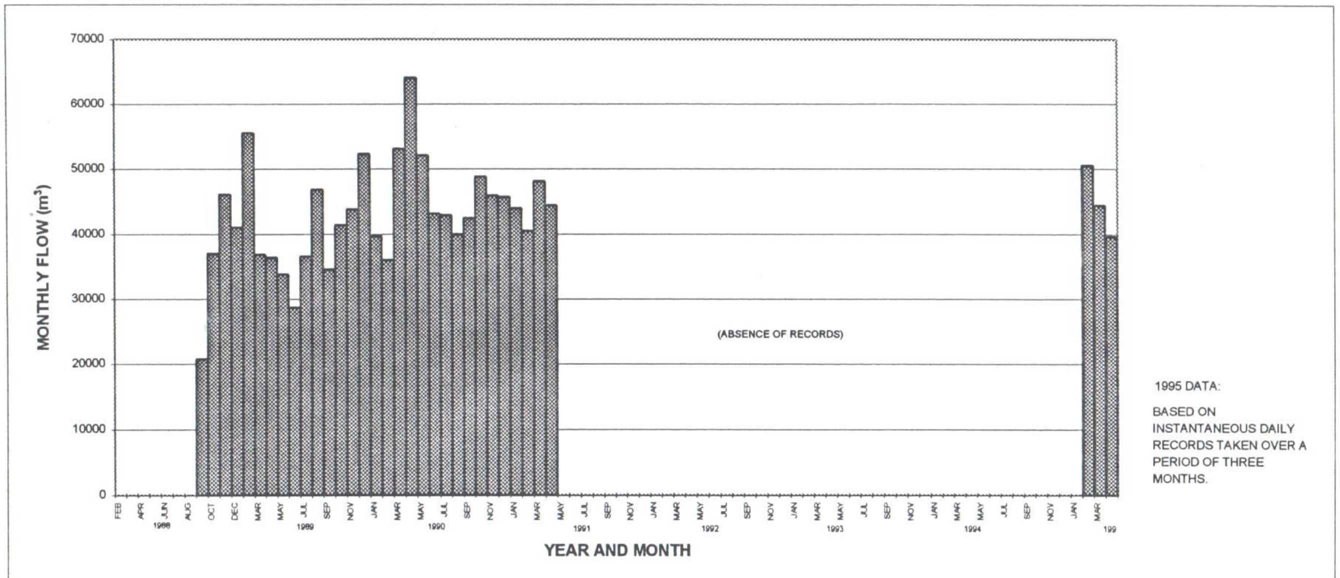

Figure 14.1

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14.2.3 Treatment Process

Flows from the two trunk sewer lines on either side of the town converge at a chamber near the inlet works. The sewage then flows through 600 mm dia. concrete pipe to the screening area.

The 600 mm dia. concrete pipe opens to 500 mm wide by 1000 mm deep open channel provided with 2 No. hand-cleaned bar racks in series, both slanting at 30° to the vertical. The first of the two is a coarse screen with 40 mm spacing between bars, and the second one is a fine screen with 25 mm spacing between bars. A rectangular channel is provided at the top of each screen where the rakings are temporarily stored before being loaded to a wheelbarrow for incineration or burying. The rectangular channel is not perforated to allow draining of the screenings before they are taken away, and this tends to make the carting away more difficult and less pleasant a task than would otherwise be the case. An overflow channel connected to the maturation ponds is provided to cater for storm water flows.

From the screens the sewage flows through the 500 mm wide channel to the 2 No. aerated grit chambers. Aeration is by 2 No. air compressors adjacent to the chambers. Air distribution is via a 25 mm dia. pipes connecting to the 50 mm dia. pipe from the compressors.

The grit chambers were said to be designed such that grit could gravitate to the loading bay beneath the chamber where it could be collected by a truck for disposal. This does not function as intended, and hence grit is manually pushed down through the outlet pipes provided. The grit outlet pipes are severely corroded and need replacement and the design of the bottom of the chamber requires to be checked, to see whether there is a possibility that, with minor modification there would be the possibility of self cleansing of the chamber.

The effluent from the grit chamber flows through a channel provided with an ultrasonic flow meter which is not functional at present. In the next channel section, the recirculation flow is introduced and the whole is then piped to a square shaped distribution box provided with manually closed gates.

The flow is distributed to the 2 No. centre feed circular clarifiers each equipped with an electrically driven rotating bridge structure which hosts the sludge scraper and scum skimming blades. Peripheral scum baffles, scum collector troughs, and scum outlet pipes are also provided.

The effluent flows over the peripheral V-notched weir plates to the 500 mm collector channel, and is led to a common outlet chamber through 500 mm dia. concrete pipe. This then leads to a second distribution chamber (1.2 x 3 m) which provides head to the high rate percolating filters.

2 No. high rate percolating filters have been provided for the works. Each filter is equipped with 4 No. 150 mm nominal bore rotary distributor arms with protruding 20 mm dia. openings which evenly distribute the waste water over the filter surface.

The distributor arms are mounted on a central pivot and revolve in a horizontal plane. A clearance of about 200 mm has been allowed between the bottom of the arms and the top of the bed. The filter media is of crushed stones with an average aggregate size of approximately 100 mm. The depth of the media is estimated to be 3 m.

Excessive biological slime is naturally sloughed off together with the effluent for settlement in the intermediate clarifier. Provision has been made for air vents at the bottom of the filters.

Currently only one filter at a time is put to use, as the flow through the works, even with recirculation, is only adequate to cause arm rotation of one of the filters. The filter being used is however changed periodically.

It was noted that the area surrounding the percolating filters is poorly drained and this may cause problems during rainy seasons by flooding the air vents.

The effluent from the high rate filters flows to a sump provided with 3 No. automatic submersible pumps for raising the sewage to a head chamber adjacent the single intermediate clarifier. The control panel for the submersible pumps is on a raised open platform adjacent to the sump.

The mode of construction of the intermediate clarifier is similar to the primary clarifiers, except that no scum facility has been provided. At the head chamber provision is made for connection to future clarifiers. A differential head bellmouth adjusted by means of spindle is used to reduce sludge in the tank. A gate valve is also provided in the sludge sump for fully draining the clarifier.

The effluent flows by gravity to a distribution box in between the two low rate bio - filters. These are shallower than the high rate filters (about 2 m deep) and have smaller aggregate size (approx. 50 mm dia.). Each rotary arm is provided with 60 No. 20 mm dia. openings with rubber flaps for even flow distribution.

From these filters, the effluent flows to a 3 m deep heptagonal reinforced concrete chamber for onward transmission to the two circular reinforced concrete clarifiers of approximately 15 m diameter. These clarifiers are of similar design to the intermediate clarifier.

From there, the effluent flows to a sump at the drainage pumping station from where some is pumped back to the high rate filters and the rest flows to the maturation ponds for final treatment.

The sludge from the final clarifiers is collected in a sludge sump adjacent to them. The sump also holds the sludge from the intermediate clarifier, all of which pumped to the sludge digesters.

Three maturation ponds in series are provided for final effluent treatment. These ponds are of irregular trapezoidal shapes, to fit into the limited flat area available. The first pond is approximately 72 x 48 m wide. The deep green colour shows algal growth which is essential for pond aeration. The second pond measures approximately 80 x 24 m, whilst the third is 80 x 30 m . The intensity of algal growth diminishes as the effluent passes from one pond to the next.

Pipework and chambers with handstops, have been provided to allow any or all of the ponds to be by-passed.

The embankment to the last two ponds has failed in many parts and requires rehabilitation. The embankment lined with 600 x 600 mm precast concrete paving slabs, which in some places have fallen into the ponds.

The final clear effluent from the last maturation pond flows through an approximately 1000 mm dia concrete pipe to Chania river. 3 No. 2 x 2 x 3 m deep inspection chambers are provided for the pipe but the chambers have no covers. This may pose a dangerous to children and animals, as the pipeline passes through private land between the ponds and the outfall point.

Four 25 x 25 m sludge digesters have been provided for sludge stabilization. These are well over 6 m deep and have a retention period of about 120 days. After digestion, the sluge is emptied into one of the thirteen 20 x 24 x 0.5 m deep open sludge drying beds, equipped with 200 mm dia. central sludge inlet and manually operated draining gates. The beds are partitioned by 150 mm thick reinforced concrete walls which are in good condition. The bed floor is laid with precast concrete slabs with sand filled spacing, to allow for percolation of water to the ground.

14.2.3. Treatment Problems and Constraints

Inadequate flow to the works was identified as one of the major problems of the sewage works. This was mainly realised in the high rate filters where despite using only one of them, the incoming flow was not enough to rotate the distributor arms. Recirculation of effluent from the final clarifiers has proved expensive both in operation costs, and in the maintenance of the pumps.

To overcome this problem four solutions whose viability and applicability should be looked into in detail are proposed:

- i) trim the distributor arms;
- ii) remove two of the four arms;
- iii) construct sewer extensions to increase flow into the works; and
- iv) bypass the high rate filters

The third alternative is an attractive as a long-term option, since the municipal council would benefit from increased revenue collection. In the short term however, the first two alternatives should be given consideration. The fourth alternative should be looked into in light of the waste water characteristics and the efficiency of the various units.

Analysis of samples taken at points in both works during eary February show that the raw sewage is very stong considering its largely domestic origin. This is likely to be due to the inadequate water supply situation discussed above. A more normal strength may resut from imprements to the water supply.

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A second feature of the analysis is the seeming deterioration of standard in the ponds at the Nyeri works. This requires surther investigation and probably split sampling for confirmatory analysis. The situation may be improved by harvesting algae with nets, or by introduing algae-eating fish, or by converting some or all of the poinds into constructed wetlands.

The embankment failures at the maturation ponds do not present an immediate notable problem, however rehabilitation is necessary to prevent future costly and extensive repair.

Corrosion of the grit outlet pipes in the grit chamber and the failure of grit removal by gravity as intended should be given due consideration. Possibilities of replacement of the steel pipes with uPVC pipes and improvement to the slope at the bottom of the grit chamber should be looked into.

The most serious constraint is the mechanical/electrical maintenance of submersible sewage pumps at the drainge pumping station (and at the Kiganjo re-pumping station). The mechanical seals are reported to have commenced being preblematic within a few years of commissioning, and have caused trouble since. A major problem seems to be the ability to obtain genuine spare parts, and have these installed at regular preventive maintenance periods. Presently, the seals are replaced regularly, but at very short intervals, and with fabricated imitiations. The repercusions are a short period cycle of maintenance. Where the seals do not last until replaced, the consequence is leakage of corrosive liquid into the motors, causing burn-out.

Although this was the most recurrent problem, the Council was quite clearly struggling to keep the electrical/mechanical plant operational. During the consultant's inspection, a large number of items were found inoperational (see details in Annex 7).

The outstanding feature of both the Nyeri and Kiganjo sewage works is that they cannot be said to be appropriate for tropical African conditions. In particular, the use of pumping plant appears to have been maximized rather than minimized with the resultant excessive operational costs and likelihood of breakdown. At the Nyeri works the extensive use of pumping is particularly noteworthy as the outfall sewers from the sewerage system to the works are steeply inclined, so that plenty of head is available and could have been utilized. It is also difficult to understand the basis of pumping all the Kiganjo sewage to another area for treatment in ponds, when there did not seem to be total lack of space for development in areas where sewage could have gravitated.

14.3 Kiganjo Sewage Works

The sewage works at Kiganjo are in two components namely:

i) a sewage reception, physical treatment and pumping station, located on the Nairobi-Kiganjo road, and

ii) the main works which are about 2 km north of Kagumo High school in the plains across the Nairobi River.

The two stations are linked by a 200 mm dia. bitumen lined steel pipeline.

The rationale for this arrangement is not clear, and is definitely not lack of space at the pumping station site. In fact the tender drawings show the sewage works being where there is now only the physical treatment and pumping. The consideration could also not have been the availability of a suitable discharge point.

What can be discerned is the comparison put forward between the sites. The PDR stated that where the present pumping station now is (referred to in that report as Site I) would be unsuitable for ponds "due to the steeply sloping nature of the site". The site slopes at a roughly 10% gradient but there could have been the consideration of the adaptation of pond shapes to suit the existing ground profile. For this site, single stage biofiltration was proposed, but with "a high rate of recirculation", due to "the strong nature of the wastes and high milk waste contribution". The milk factory was expected to contribute 37% of the sewage flow and 54% of the BOD load. The presently existing system, with ponds at what was referred to as Site III, was noted to involve pumping.

In the PDR comparisons, the treatment systems considered were ponds, biofiltration and activated sludge. The latter requires a very high level of technical competence in day to day running and is therefore unusual in developing countries. Oxidation ditches were not considered.

The most likely explanation for the decision to adopt the existing system, is that the Client preferred the single pumping option (from site I to site III) rather than the treatment option recommended for site I, involving recirculation pumping, four mechanised scraper bridges, and pumping of sludge to drying beds on the other side of the Kiganjo-Marua road.

The present system therefore has inlet works with coarse screening (40 mm spacing) and fine screening (25 mm bar spacing). Next is a grit compartment of 2 No. 900 mm wide by 700 mm deep channels, and 150 mm dia. grit removal outlets underneath. A throated flume section follows for flow measurement. Form these inlet works the sewage is conveyed by a 500 mm dia. concrete pipe to a sump equipped with 3 No. submersible pumps, for pumping to the main sewage works. An emergency overflow stone pitched pond is also provided, with a capacity of about 2,000 m^3, which retains sewage during periods when the pumps cannot operate either due to failure or due to power outages.

The main sewage works are divided into two parrallel systems of ponds, each stream having one anaerobic, two facultative and one maturation pond, all in series.

The anaerobic ponds are 30 x 20 m in plan, and are equipped with differential head bellmouths for emptying sludge, and a bottom outlet for fully emptying the ponds. The sludge is then led to 4 No. sludge drying beds. These drying beds were constructed in a swampy area, thus no drying can take place. The anaerobic ponds are therefore not desludged.

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The facultative ponds are 135 x 60 m for the first in series, and 65 x 35 m in plan for the secondary ponds. The effluent from the maturation ponds is conveyed to a tributary of the Nairobi river in a 450 m dia. concrete pipe.

The significant problems at these sewage works are the high cost of sewage pumping, and the maintenance of the sewage pumps. These pumps have the same problem with mechanical seals as are experienced at the Nyeri sewage works.

14.4 Sewers

The sewers in Nyeri were constructed in two different times, the old sewers in 1958-1960 and the new sewers in 1985-1987.

The old sewers essentially covered the central business district, to within 100 m of Kimathi Way, as well as the Blue Valley housing area and the Provincial Hospital. The only extension off this network was a branch along Temple Road, upto the Nyeri-Nairobi road, and then to the Police Divisional Headquarters.

The sewer trunk main terminated at the old sewage works, in the Chania Valley between the prison and Provincial General Hospital.

The new arrangement was for two trunk mains, terminating at the new sewage works.

The northern system closely follows the Chania river, serving the Kingongo area (including the site and service scheme and the prison) and there is a line at the lower part of the CBD and Majengo. It then picks up the flow from the old sewers before continuing along the river to the Sewage Works.

The new southern system serves the areas into which the CBD had expanded, as well as the Green Hills Hotel/Nyeri Golf Club area, Nyeri Technical, Kimathi Estate, Asian Quarter, Ruringu and parts of Kangemi.

The sewer lines are mainly of concrete and uPVC pipework, with diameters from 250 to 600 mm diameter, although some of the old branch sewers are reported to be of 150 mm diameter. All of the Nyeri system is by gravity.

The Kiganjo system (under the same contract as the new Nyeri sewers) was the first sewer network for that area, and consists of two mainlines which converge at the sewage repumping station.

The western line (Line Y) has no branches; it commences at the Police College and the only other significant consumers on that line are the CCM Kiganjo Primary School and Sacred Heart secondary school. This line is indicated on the available drawings as being 250 mm dia. PVC.

The principal sewer (Line X) is to the north of the pumping station, and covers the Kiganjo "urban" centre. The main line starts at 250 mm dia. PVC but after only 200 m changes to

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400 mm dia. at the milk factory, and stays at that diameter. There is only one short branch (260 m long) within the central Kiganjo area, in 250 mm dia. PVC (Line XA).

The original preliminary design called for one further line to the south (Line Z), serving Kagumo High School and the Kirichu area. The sewer was to be by gravity to a location near the Kirichu shopping area, and the sewage then pumped to near Kagumo High School, before gravitating to where the existing pumping station is. This sewer appears to have been omitted from the final scope of works for financial reasons.

Overall, there is presently no evident difficulty with regard to sewer coverage. Those areas covered are essentially in a depressed water supply situation, and so cannot exert the sewage flow loads that the sewers can cope with.

The principal reticulated areas which do not have sewers are:

i) Kamakwa and areas towards Kamakwa from the Golf course area

ii) Ring Road and adjacent low density housing,

iii) northern areas towards Mathari and along the Nyeri-Nyahururu road,

iv) areas in Kingongo along the Nyeri-Kiganjo road, past Nyeri Primary School,

vi) the Kirichu area in the Kiganjo system.

Most of these are areas where space will be readily available for on-plot systems. The only exceptions to this will be the industrial park on the Nyeri-Kiganjo road, and the trading centres of Kamakwa and Kirichu.

The latter, it has been noted, would have required an additional sewer pumping station, if it were to be served.

14.5 Solid Waste Disposal

The responsibility for solid waste disposal falls under cleansing section of the Town Engineer's Department. This section has five sub-sections dealing with

i) refuse collection
ii) street cleaning
iii) Kiganjo general gang
iv) mosquito control, and
v) cemetery

The section has two supervisors, who oversee headmen in charge of each sub-section. Staff in the refuse collection sub-section consists of 5 drivers and 23 crew members, whilst there are 30 street sweepers.

Solid waste collection is carried out largely within the more densely built up areas, and in the rest of the municipal area, on-plot disposal is carried out. In Nyeri Town, the central business district and nearby Ruringu commercial centre are serviced, as are residential and commercial/residential areas such as Ring Road, Kimathi, Blue Valley, Asian Quarter, Kangemi, Kingongo, and Chania Estate. Away from Nyeri town, the other areas within which refuse collection is expected to be carried out are Kiganjo, and the nearby Kirichu trading centre. This area of intended coverage, is on the most part, the area in which such services need to be provided. All other parts of the Municipality are essentially of low population density and of predominantly rural nature, thus there is adequate space for on-plot disposal of solid waste. Some areas are developing fairly rapidly into an urban nature, particularly along the road to Nairobi, and thus may soon warrant being incorporated into the area for solid waste collection arrangements.

The waste collected is predominantly domestic in nature, with packaging materials largely being from the commercial areas. It comprises mainly of organic domestic wastes, broken glass, paper, plastics and metal cans and containers.

There is no separate provision for industrial or hazardous waste collection.

The industries in Nyeri which generate waste other than paper packaging or similar materials in significant quantities are the two bottling firms (Coca-Cola and Highlands) and the saw mills. The bottlers re-cycle much of the broken glass, and it is understood they have in-house waste reduction equipment, but the residual goes to the Municipal dump. The saw mills burn waste within their premises, but also transport residues and some waste to the Municipal dump.

Hazardous waste is mainly from hospitals and health centres. This is collected together with all other wastes with no attempt at segregation or separate disposal.

Although some premises have and use officially issued solid waste containers of about 0.1 m^3 capacity, these are few and far in between. The majority use a variety of containers and storage means. Sawn off drums are common, and in some affluent neighbourhoods, polythene bags are used. In low cost housing areas, dumping in "dark spots" - hidden, or out of the way areas, is common. Council employees then sweep the waste together and shovel it into collection vehicles.

The Council presently has five collection vehicles.

- i) one refuse collection vehicle with compactor
- ii) two lorries fitted with semi-cylindrical covers with side doors (side loader)
- iii) one tractor with a side loader trailer, and
- iv) one tractor with an open trailer.

One lorry and one tractor were found out of service due to mechanical faults, leaving three serviceable vehicles. This number of vehicles was clearly insufficient for the task in hand.

Dumping is carried out at a site below the Blue Valley high density housing estate, in the Chania river valley. The site is an abandoned quarry. This dumping areas is only 50 m from the nearby housing, and 20 m from a nursery school. As the dumping is uncontrolled, there arises a nuisance problem, particularly smell, flies and vermin. The area is not fenced and accessed by neighbourhood children, as well as waste collectors (scavengers)

This site is however already full. A new dumping area will therefore need to be identified.

The two immediate possibilities under consideration are both abandoned queries, one at Kabiru-ini, and the other at Kangemi.

The Kabiru-ini site is on government land, about 89 km from the town, near the Kimathi Institute of Technology off the Nyeri-Nyahururu road. The area is forested and the quarry depressions fairly extensive. The disadvantages of this site are the distance from town, and the poor state of the access road off the main road. On the other hand, the site is within forest, away from habitation, and will be easy to reinstate such as to blend in with the surroundings, once it is full.

The Kangemi site is near the sewage works and only about 2 km from the Central business district. The areas is however private land, which would necessitate the expense of procurement. The quarry is smaller, and urban development is rapidly expanding in it's direction, leading to it being considered a shorter term solution than the Kabiru-ini site.

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15 URGENTLY REQUIRED MEASURES

15.1 Billing

Chapter 10 includes an analysis of the billing methods employed by the Nyeri Municipal Council, and concludes that the present billing machines are both very expensive to run, and also not far removed from manual bill preparation. The present set-up does not have scope for the production of meaningful management information, nor does it allow for automated routines such as identifications of defaulters.

Due to their age, the machines' maintenance has with time become unrealistically expensive, and spares difficult to come by. By February 1995, it was no longer practicable to repair the machines, and the Council had to result to purely manual bill preparation.

In discussions between the Council, MoLG and the consultant, the Council indicated that they had the intention of computerising the billing systems, and had invited proposals from several firms. Thereafter the Consultant analysed these proposals, and sought further information on what was available, and the agreement of the Client sought for the inclusion of billing improvements in the services, as an Addendum. Agreement in principal was given by MoLG letter of 11th April, 1995.

The consultants submitted an analysis of the offers previously obtained by the Council, and recommendation on the most appropriate system, under cover of the letter of 15th May, 1995. The proposed hardware consisted of two networked PC units, one with a 1080 Mb and the other with a 256 Mb hard disk. The software was proposed as being DOS, Windows, MS Office, and networking packages. The relational database would be based on MS Access.

At the time of this report, arrangements to proceed with the execution of these measures were being finalised, and the financier's approval had been sought.

15.2 Block Mapping and Consumer Survey

As indicated in Chapter 6, it has not and will not be possible to obtain copies of the mapping associated with the 1989 population census.

This mapping is said to have been very detailed and in urban areas that were enumerated in groupings of not more than 100 households the combination of mapping and detailed census data would have provided a possible alternative to a specific water oriented block mapping and consumer survey.

Knowledge of the present reticulation system has also been limited due to the Water Development Department's unwillingness to release a number of 'as-built' drawings known to be in their possession. It is also not clear how accurate those drawings are. Drawings which have also not been availed are those of the 1982 water supply study.

Under these circumstances and although an attempt has been made to model the existing reticulation system on computer this is unlikely to be of sufficient accuracy for reticulation expansion purposes without the gathering of further field data.

To facilitate detailed planning of the distribution network expansion and to provide the basis for improved metering, meter reading, billing and revenue collection, a block mapping exercise Is considered essential and a consumer survey desirable. This would require the updating of the digitised mapping already being undertaken and would best and most cost effectively be achieved by aerial photography.

A consumer survey and block mapping exercise would thus be aimed at mapping the service area, confirming the details of the existing reticulation, and providing a new and reliable consumer database to accompany the proposed new billing arrangements.

It is proposed that such an exercise would have the following components:

i) aerial photography of the service area
ii) digitised mapping
iii) field confirmation of the reticulation and junction details
iv) re-checking and expansion of the existing consumer database and information on connections through field investigations.

This information is considered essential for detailed and conclusive reticulation analysis, providing a realistic basis for the computerised billing, and laying the groundwork for possible future improvements in consumer management by use of geographic and information management systems.

15.3. Leakage Detection

Chapter 10 above has illustrated that the loss of about $^{1}/_{3}$rd of the water produced in Nyeri can only be attributed, in the large part, to leakage in the distribution system. This is presently difficult to control, as pointed out, due to the soil conditions, which will not give surface indications of even major leakage, and the absence of bulk metering within the distribution, and therefore absence of a means of determining the areas prone to leakage.

The analysis of management capability as at present indicates an ability within the Council to put information to use in reaching appropriate decisions, when such information is available.

In view of this, it is considered that leak detection and containment measures are urgently required within the Nyeri town distribution.

Installation of bulk meters are an obvious component of such measures. These would need to be installed in such a way as to segregate supply areas, and there would need to be a parallel exercise of putting into place the routine generation of data on the ratio between in-coming water and billed consumption in these segregated areas.

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This would identify areas of concern, but would not give immediate indication of the areas where the leaks are located, so that corrective action can be initialled. The council would, in the existing physical circumstances, need to have devices for leak detection. A wide range of equipment of varying complexity, accuracy, reliability and cost exist on the market, and it would be necessary to examine the available equipment, and arrive at a suitable choice.

It is recommended that analysis of appropriate leak detection and containment measures is undertaken, and the manner in which these measures can be implemented be investigated.

15.4 Immediate Works

An Immediate Works programme would comprise two distinct components, one aimed at containing or improving the operation and maintenance of the existing systems, and the other at a cost effective uprating in supply to reduce the shortfall in supply prior to a major new project. These two components are presented below.

The recommended immediate refurbishment measures are almost exclusively electro/mechanical and mechanical in nature involving pumps and motors, air blowers, stirrers, chemical dosers and pipeline valves.

Detailed assessments of both the prevailing mechanical situation and of the electro-mechanical situation have been made and are presented in Annex 7. Comprehensive refurbishment requirements are addressed in chapter 7, whilst only the most essential are suggested for an immediate works programme, and included here.

i) Ihwa Gravity Intake

No measures proposed

ii) Kamakwa Pump Intake

No refurbishment measures proposed, but see below for other Immediate Works proposals.

iii) Kamakwa Treatment Works

Replace electrical stirrers to alum mixing tanks.
Replace chlorine room extraction fan.
Replace air blower and backwash pumps.
Replace water level indicator to elevated tank.
Replace all Old/Very Old Works filter valves (inlet, drainage, backwash and outlet).

iv) Kiganjo Intake & Treatment Works

At the present time, it is unclear as to whether both units will be phased out or the treatment works at least retained. Any units to be retained are in need of extensive refurbishment to give them an acceptable future life. A decision on refurbishment should however await the decision on the future of these works. In the meantime, it is considered that NMC themselves should attend to the most serious problem which is the lack of operational raw water pumping capacity.

v) Nyeri Sewage Works

Replace all lost electrical components and introduce enhanced security to reduce the risk of repetition.

- Replace the submersible recirculation pumps with a more rugged type less prone to mechanical seal wear. The replacements should have double seals with a suitable warning/protection device associated with the intermediate space within the seal.

vi) Kiganjo Sewage Pumping Station

Replace all lost electrical components, introduce enhanced security to reduce the risk of repetition, and return submersible pumpsets to site and recommission them as and when sewage flow rates justify this.

vii) Kiganjo Waste Stabilisation Ponds

No measures proposed

As detailed in chapter 7, the water supply for Nyeri town is largely obtained by gravity from the Ihwa intake on the Chania River, just outside the Municipal border. There is in addition a pumped intake on the Chania River at near Kamakwa, within close proximity to the commercial centre. The treatment works at Kamakwa, currently comprise:

i) very old works (dating from the 1950's)
ii) old works (1960's), and
iii) new works (1980's)

all of which together have a theoretical output of about 5,580 m^3/day. About 60% of this is produced through the new works, and the other components account for approximately 20% each. Mechanical/electrical equipment is limited to two backwash pumps and an air compressor, and two booster pumps to the elevated tank for the Kamakwa area.

Based on the figures in chapter 9, the present production capacity is far below demand.

Based on upgrading works previously undertaken at Kisumu and Kericho it would be practicable at relatively small investment cost, to increase supply through the treatment works units as follows:-

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Table 15.1
UPRATING OF KAMAKWA WATER TREATMENT WORKS

COMPONENT	APPROX. CURRENT THROUGHPUT m^3/day	UPRATING METHOD	INCREASE ATTAINABLE %	FINAL OUTPUT m^3/day
Very Old Works	1,080	Dispersion cone in clarifier + change in filter media	44	1,560
Old Works	1,080	media	44	1,560
New Works	3,420	Lamella plates in sed.tank + change in filter media	72	5,880
TOTAL	5,580			9,000

The details for the sedimentation units and the filter units are summarised in table 15.2

In the absence of the as built drawings, a detailed resurvey of the raw water mains between the Ihwa Intake and Kamakwa treatment works was undertaken. This confirmed that the head available is approximately 44.30 m, and the distance about 6,200 m. Two gravity mains exist, the second of which was completed in 1986. The initial routes are generally similar but deviate at about chainage 4 + 400

The old gravity main comprises 995 metres of 250 mm dia. AC pipe; 2,890 metres of 200 mm dia. AC pipe and 2,160 metres of 150 mm dia. AC pipe. The capacity of this main is calculated to be about 24 l/sec. (2,070 m3/day). The pipeline was laid to achieve this flow taking into account topography along the route with a relative high point at chainage 2 + 060 being such that the hydraulic gradient comes within about 2 metres of the pipe overt. It is not practicable to increase the gravity flow along this pipeline.

The new gravity main comprises a mixture of 300 mm dia. galvanised steel, 280 mm dia. uPVC and 225 mm dia. uPVC.

In the first 2,060 metres, the mix of 300 mm and 250 dia. GS and 200 mm dia. uPVC is such that GS is used for the initial 315 m and then at road and river crossings and short lengths of deep excavation.

Total length of 300 mm dia. GS is estimated at about 330 metres, together with about 270 m of 200 mm dia. GS, and 1,540 m of 280 mm dia uPVC. The final 4,080 m are in 225 mm dia. uPVC.

At present there is a constraining high area on this pipeline at chainage 5 + 480 which limits flow to about 41 l/sec. Re-routing this pipeline between chainage 5 + 050 and 5 + 680 would enable a 27% increase in along this pipeline from about 41 l/sec. to 52 l/sec. (3,540 m^3/day to 4,410 m^3/d).

Table 15.1

DETAILS OF UPRATING POSSIBILITIES FOR KAMAKWA TREATMENT WORKS

					Current Situation				Modified Situation					
Units	length m	breadth m	depth m	no.	overflow rate m3/m2.h	outflow l/s	outflow m3/hr	outflow m3/day	adjusted equivalent length m	Modified overflow rate m3/m2.h	outflow l/s	outflow m3/hr	outflow m3/day	limiting flow after modification m3/day
Sedimentation														
very old	4.25	4.25	6.1	2	1.25	12.5	45	1,084	-	1.8	18.1	65	1,561	1,561
old	4.25	4.25	6.1	3	1.25	12.5	45	1,084	-	1.8	18.1	65	1,561	1,561
new	16.00	3.3	2.7 - 2.9	3	0.90	39.6	143	3,421	28	0.90	69.3	249	5,988	-
					TOTALS	65	233	5,589		TOTALS	105	380	9,109	
Filtration														
Units	length m	breadth m	depth m	no.	overflow rate m3/m2.h	outflow l/s	outflow m3/hr	outflow m3/day		Modified overflow rate m3/m2.h	outflow l/s	outflow m3/hr	outflow m3/day	
very old	3.00	2.5	-		3	12.5	45	1,080		4.5	18.8	68	1,620	-
old	3.00	2.5	-		3	12.5	45	1,080		4.5	18.8	68	1,620	-
new	4.50	3.30	-		3	35.9	129	3,101		5.5	68.1	245	5,881	5,881
					TOTALS	61	219	5261		TOTALS	106	381	9121	9,003

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Details are summarised in table 15.3.

Screened raw water can be pumped from the Chania river some 800 m from the treatment works via two 150 mm dia. uPVC pipelines to the Kamakwa treatment works. According to Gibb, 1980, the capacity of this system with appropriate pumps is about 3,300 m^3/day (38 l/sec). Currently it is only about $^1/_3$rd of this.

The existing and possible raw water supply situation is therefore as indicated in the following table:

Table 15.3

RAW WATER SUPPLY UNDER AN IMMEDIATE WORKS PROGRAMME

Type	Main	Existing l/s	Supply m^3/d	Possible l/s	Supply m^3/d
Gravity	AC.	24	2,070	24	2,070
Gravity	GS/uPVC	41	3,540	52	4,490
Pumping	uPVC (2No.)	12	1,040	38	3,280
			6,650		9,840

This would be adequate to supply an uprated water works capable of treating about 9,000 m^3/day. With a pumped supply of about 40 l/sec, the re-alignment of the 630 m of raw water gravity main would not be necessary.

The primary pipelines leading from the treatment works into town comprise 2 No. 8" (200 mm) dia. pipes. To increase the ability of the network to absorb and distribute approximately 60% more than currently designed for, a new trunk main approximately 4 km long would be required from the treatment works as far as the western corner of the Central Business District and then along the Kenyatta Highway. At some as yet to be confirmed location, but probably in the vicinity of Temple Road school, the new pipeline would be connected into the eastern end of the present CBD distribution network.

Final sizing and extent of the new main needs to await the projections of future demand, as it should probably be sized for the future water requirement rather than for the fairly modest increase intended now.

As discussed in chapter 14, a number of modifications at the Nyeri Sewage Works are under consideration so as to both make them less technologically inappropriate and to reduce the reliance on electro-mechanical components which will also reduce operational costs.

Only one modification is proposed as part of an immediate works programme, namely the introduction of an intermittent dosing syphon to the high rate biological trickling filters. This will help ensure that the feeding arm of the operational filter successfully rotates without the need for the present pumped recirculation of sewage from a subsequent treatment stage.

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An immediate works programme of direct beneficial purposes would therefore comprise of the following basic components:

a) Replacement/ refurbishment of electro/mechanical and mechanical components at the Kamakwa Treatment Works and the Nyeri Sewage Works as enumerated above,

b) Water supply expansion aimed at increasing treatment works output from a design discharge of 5,800 m^3/d to 9,000 m^3/day to comprise:

   i) Raw Water Pumping Mains

   Install new pumpsets capable of pumping about 40 l/sec. through a head of approximately 110 m. via existing twin 150 mm dia. uPVC pipes.

   ii) Treatment Works - Sedimentation

   Install dispersal cones in old and very old units (4No.), modifying pipework and collector troughs as necessary. Install lamella plates in last third of horizontal sedimentation tanks (3No.), modifying inlet/outlet pipework as necessary.

   iii) Treatment Works - Filtration

   Remove and replace all filter media utilising coarser grained sand. Modify inlet and outlet pipework as necessary.

   iv. Reticulation - Trunk Main

   Duplicate initial 4,000 m of primary reticulation trunk main, utilising pipework of a diameter to be confirmed.

c) Nyeri Sewage Works

Construct dosing syphon to high rate trickling filters

Table 15.4

NYERI WATER SUPPLY, RAW WATER GRAVITY MAINS; CURRENT & POSSIBLE MODIFIED SITUATION

Section	Chainage	AVERAGE FLOW in l/s	AVERAGE FLOW in m3/hr	AVERAGE FLOW in m3/d	Pipe Wall Material	Pipe ND mm	Length m	Friction Kb mm	Head Loss m	Minor Losses at 5%	Velocity (v) in m/s	Exit Losses 1+20v2/2g	Start level masl	Hydraulic Head m	Static Head m	Head m
	0-939	24.00	86	2,074	A.C.	250	939	0.15	0.930	0.05	0.489		1931.30			
Existing	939-2060	24.00	86	2,074	A.C.	200	1,121	0.15	3.408	0.17	0.764		1913.00	1930.32	17.32	
Situation	2060-3885	24.00	86	2,074	A.C.	200	1,825	0.15	5.548	0.28	0.764		1924.50	1926.75	2.25	
Old	3885-5250	24.00	86	2,074	A.C.	150	1,365	0.15	17.963	0.90	1.358		1905.00	1920.92	15.92	
Pipeline	5250-6200	24.00	86	2,074	A.C.	150	950	0.15	12.502	0.63	1.358		1894.00	1902.06	8.06	
	6200							-			-		1887.00	1888.93	1.93	
							6,200	-	40.351	2.02	-	2.88	-44.30			0.95
	0-330	41.00	148	3,542	GS	300	330	0.1	0.279	0.01	0.533		1931.30			
	330-495	41.00	148	3,542	uPVC	280	165	0.06	0.295	0.01	0.734		1913.00	1931.01	18.01	
Existing	495-695	41.00	148	3,542	GS	250	200	0.1	0.41	0.02	0.760		1924.00	1930.70	6.70	
Situation	695-955	41.00	148	3,542	uPVC	280	260	0.06	0.465	0.02	0.734		1924.00	1930.27	6.27	
New	955-1075	41.00	148	3,542	GS	250	120	0.1	0.246	0.01	0.760		1912.00	1929.78	17.78	
Pipeline	1075-2060	41.00	148	3,542	uPVC	280	985	0.06	1.760	0.09	0.734		1911.00	1929.52	18.52	
	2060-5480	41.00	148	3,542	uPVC	225	3420	0.06	18.133	0.91	1.138		1924.00	1927.67	3.67	
	5480-6150	41.00	148	3,542	uPVC	225	670	0.06	3.552	0.18	1.138		1908.00	1908.63	0.63	
	6150						-	-			-		1887.00	1904.90	17.90	
							6,150	-	25.140	1.26	-	2.32	-44.30			-15.58
	0-330	52.00	187	4,493	GS	300	330	0.1	0.436	0.02	0.676		1931.30			
	330-495	52.00	187	4,493	uPVC	280	165	0.06	0.460	0.02	0.932		1913.00	1930.84	17.84	
Modified	495-695	52.00	187	4,493	GS	250	200	0.1	0.644	0.03	0.965		1924.00	1930.36	6.36	
Situation	695-955	52.00	187	4,493	uPVC	280	260	0.06	0.725	0.04	0.932		1924.00	1929.68	5.68	
New	955-1075	52.00	187	4,493	GS	250	120	0.1	0.386	0.02	0.965		1912.00	1928.92	16.92	
Pipeline	1075-2060	52.00	187	4,493	uPVC	280	985	0.06	2.748	0.14	0.932		1911.00	1928.52	17.52	
	2060-5480	52.00	187	4,493	uPVC	225	3420	0.06	28.458	1.42	1.443		1924.00	1925.63	1.63	
	5480-6150	52.00	187	4,493	uPVC	225	670	0.06	5.575	0.28	1.443		1908.00	1895.75	-12.25	
	6150						-	-	-		-		1887.00	1889.9	2.9	
							6,150	-	39,432	1.97	-	3.12	-44.30			0.23

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MUTISO

DRAFT

REPUBLIC OF KENYA

HARAMBEE

MINISTRY OF LOCAL GOVERNMENT
ON BEHALF OF
NYERI MUNICIPAL COUNCIL

KfW Kreditanstalt für Wiederaufbau
(KfW ASSISTED)

NYERI WATER SUPPLY FEASIBILITY STUDY

SITUATION ASSESSMENT REPORT

Volume II :
Annexes

JBG Gauff Ingenieure

FRANKFURT AM MAIN, GERMANY
AND
NAIROBI, KENYA

JULY 1995

NYERI-A2

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NYERI WATER SUPPLY FEASIBILITY STUDY

ASSESSMENT OF SITUATION

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ANNEX 1

NYERI WATER SUPPLY FEASIBILITY STUDY

I. INTRODUCTION

Nyeri town is the Provincial Capital of Central Province and the Municipality is one of the six administrative divisions of the Nyeri District. The Municipality covers an area of 176 sq.km and has 14 elected wards with 21 councillors representing the Government as a nominated councillor.

Nyeri can be described as an urban/rural town as more than 60 % of its present area is rural in nature with rich agricultural hinterland owned and managed by small scale farmers growing tea, coffee as cash crops etc..

The Municipality operates two water supplies one serving the Town centre and the surrounding areas at Kamakwa and the other Kiganjo. The two water supplies with daily productions of 5.5 million litres and 1.1 million litres respectively are only able to meet some of the town's daily water demands estimated at 11.0 million litres for Nyeri and 3.0 million litres for Kamakwa. The most recent study on Nyeri Water Supply was prepared in 1982 by Sir Alexander Gibbs and partners.

Nyeri town and Kiganjo are served by two recently commissioned sewage treatment works which are currently under-utilized due to the inadequate water supply in the areas. Some densely populated areas e.g. Kangemi, Kamakwa and parts of Ruringu might require sewer extensions once an adequate water supply is available.

A full scale feasibility study shall be elaborated for the extension of the Nyeri water supply system while part A of the ToR shall also include the existing facilities in Kiganjo.

II. TERMS OF REFERENCE

A. Assessment of Situation

Collect, review and summarize information on development and present situation of water supply covering technical, financial, organizational and socio-economic aspects, i.a.:

1. Raw water source, water works facilities, distribution network, number of yard/house connections and of public taps; urgent rehabilitation requirements by components (production, storage, transmission).

2. Water consumption by various consumer groups (households, by living standards and income groups, public taps, industries, schools, hospitals, administration etc.).

3. Theoretical water demand (according to supply standards) compared to present water supply capacity; assessment of suppressed demand, if any.

4. Raw and clear water production over the last 3 years, sales (m^3), billing (m^3; KShs), revenue collection (KShs), metering, physical and administrative water losses, necessity for block mapping and consumer survey.

5. Present cost of water supply (running, maintenance, depreciation), required cost-covering tariff versus existing tariff.

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6. Overall budget of the Municipality (description and interpretation), indebtedness (total amount and yearly budgeted vs. effective debt service), budget for water supply and sewerage, effective payments for water supply and sewerage.

7. Organization chart for Council's administration, Engineer's Department, Water and Sewerage Section; establishment for Water and Sewerage Section incl. vacant positions; qualification of personnel.

8. Brief description of sanitary facilities (solid and liquid waste disposal, on-lot systems, percentage of households connected to sewers, responsibilities for operation and maintenance, necessity for expansion of sewer network and sewage treatment plant, if any).

B. P R E - F E A S I B I L I T Y

1. Determine water consumption and project future demand of the various consumer groups to the years 2010 and 2015. Apply using minimum, average and maximum assumptions. Discuss in detail the need for a project (major problems and bottlenecks of the existing supply situation, main objectives to be achieved by a project).

2. Define suitable alternatives for individual and integrated systems for the 2 design periods. Pay special attention to the raw water source(s) and consider possibilities how to optimize the use of existing system components.

3. Prepare engineering layouts and preliminary quantities and cost estimates for all works proposed.

4. Recommend optimum solutions for the two specified periods by technical and economical evaluations of investments and operation costs.

5. Review possible implications of the water supply proposals on sanitation and outline possible solutions. Include details in feasibility study.

6. Assess environmental and socio-economic impacts of the project (on health, standard of living, women, urban poor etc.).

7. Identify project objectives and objectively verifiable indicators to measure project achievements. Justify proposed measures and their relevance to the intended achievements. Prepare a logical framework matrix.

C. F E A S I B I L I T Y

The technical alternative selected by Client and KfW shall be investigated to feasibility level:

1. Elaborate engineering preliminary designs including preliminary quantities and cost estimates (by years of construction/investment) with breakdown of
   - construction cost based on unit rates and preliminary quantities
   - equipment and material
   - consulting services
   - physical and price contingencies
   - local and foreign currency components.

2. Elaborate in detail on annual operation and maintenance costs up to the final stage of the project, specify foreign currency component.

3. Prepare economic and financial analysis of the project including present value (unit water cost method), cash-flow and sensitivity analysis; effects on the population regarding health, social benefits, income, women, etc.).

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4. Propose tariff structure (assuming realistic collection rate) to achieve operating cost coverage, total cost coverage (real and nominal calculations); elaborate on affordability and willingness to pay.

5. Give guidelines for staffing and qualification of operation and maintenance services, propose necessary establishment (Water and Sanitation Departement/autonomous Water and Sanitation Company) and compare with the present situation, elaborate on additional costs involved.

6. Make detailed proposals for improved meter reading, billing and collection, for minimization of technical and administrative water losses.

7. Make proposal for new organisational set up (e.g. water and sewerage department). Assess necessity for training programme and elaborate terms of reference, man-month input and cost estimate for such programme.

D. REPORTING

The following reports are to be submitted to ministries/authorities involved and to KfW for comments and approval prior to the start of the next study stage:

- inception report (8 copies)
- pre-feasibility report (8 copies)
- feasibility report (10 copies).

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LOGFRAME MATRIX

	Indicators	Assumptions	Indicators
I Goal:			
II Objectives:			
III Results:			
IV Activities:			

ANNEX 2

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LIST OF REFERENCE DOCUMENTS

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11. Nyeri District Development Plan 1994 - 1996
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12. Monthly Rainfall data, Kiandogoro & Nyeri MOW Station 1981 - 1994
Consultants Records & MOLRR & WD Nyeri District Office.

13. Summaries of Measurement Discharges & Velocities.
RGS 4AC3, 4AC4, 4AC5, 4AC6, 4AB5, 4AB6 between 1947 and 1993 Consultants Records & MOLRR & WD Nyeri District Office.

14. Daily River Gauge Heights
RGS 4AC3, 4AC4, 4AC5, 4AC6, 4AB5, between 1980 and 1994
Consultants Records and MOLRR & WD, Nyeri District Office

15. Aerial Photography at 1:25,000 scale dated October 1990
Aerial Photography at 1:20,000 & 1:25,000 scale
dated January, 1975 and May 1978

16. Mapping:

1:250,000 scale sheet	SOK Publication
1:50,000 scale sheets	SOK Publication
1:5,000 scale pencil plots with 3 m contour VI based on 1975 and 1978 photography	SOK Archives

17. Local Government Act Cap 265 - rev 1986

18. Water Act Cap 372 - rev 1972

19. NMC Estimates for the years 1992/93, 93/94, 94/95

20. NMC Staff List dated 1st July 1994

21. NMC General Ledger for years 1993/94 and 94/95

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22. NMC Water & Sewerage Fund Rate & Charges - Sep. 1994

23. NMC Water Billing Control Sheets & Control Account Book

24. NMC Income Analysis Book

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C.A. Dutto; 1975

30. Economic Survey 1992
Ministry of Planning and National Development; May, 1992

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ANNEX 3

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Gauff Ingenieure

Beratende Ingenieure
Consulting Engineers
Ingénieurs Conseils

H P GAUFF KG – CONSULTING ENGINEERS – P.O. BOX 49817 NAIROBI/KENYA.

Branch Office

NAIROBI
EAST CHURCH RC
WESTLANDS
TEL: 445288
FAX: 446124

JBG

5th October, 1994
DB/bn/K1083/915

Mangat IB Patel & Partners
P.O. Box 48674
NAIROBI

Attn: Mr. H.S. Mangat

RE: NYERI WATER SUPPLY – FEASIBILITY STUDY
NYERI FOUL SEWERAGE SCHEME

Dear Mr. Mangat,

We have been appointed by MOLG for the KfW funded Nyeri Water Supply Feasibility Study. The consultancy requires a review of present and past sanitation and sewerage in the town.

We have been unable to locate design documents and 'as built' drawings etc. of the Nyeri Foul Sewerage Scheme for which your firm were the Consultants.

Kindly confirm that documents and drawings are with you so that we can obtain the necessary authorisation letter from MOLG to acquire copies from you.

Yours Sincerely,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

Page

MANGAT, I.B. PATEL & PARTNERS – CONSULTING ENGINEERS

H.S. MANGAT	BE (Civil), REng, CEng, Eur Ing, FIEK, FIET, MAAK(E), FICE, FIMunE, FIWEM
ISHWAR B. PATEL	BE (Civil), MS (Illinois) REng, CEng, FIEK, MAAK (E), FIStructE, FICE
M.S. BHACHU	BEng, MSc (Lond), DIC, REng, CEng, Eur Ing, FIEK, MICE, FIWEM
T.S. MANGAT	BSc (Hons), CEng, Eur Ing, MICE, MIWEM, MAWWA

Associate:
R.M. HIRANI — B Tech (Civil) Hons, REng, CEng, MAAK(E), MIStructE

BISHOP'S GARDEN TOWERS, BISHOPS ROAD P.O. BOX 48874, NAIROBI, KENYA
TEL: CIVILS 710500/1 STRUCTURES 710546/7 FAX: 710549

MIBP
PARTNERS
CONSULTING ENGINEERS

H.P. GAUFF KG
EINGEGANGEN AM
11 OCT 1994 / G
NAIROBI

Ref. No. 1399/94/1002/HSM/EME — 7th October, 1994

Gauff Ingenieure,
P.O. Box 49817,
NAIROBI.

→ Dg

Dear Mr. Baker,

NYERI WATER SUPPLY

Congratulations on your appointment as Consultants for above Project.

This is to confirm that we have the documents referred to in your letter. However, it will be necessary to make photocopies and the prints of the plans. This will involve some costs.

Yours sincerely,

H.S. MANGAT

Page

Gauff Ingenieure

Beratende Ingenieure
Consulting Engineers
Ingénieurs Conseils

Branch Office

NAIROBI
EAST CHURCH R
WESTLANDS
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FAX: 446124

JBG

H P GAUFF KG – CONSULTING ENGINEERS – P.O. BOX 49817 NAIROBI/KENYA

27th October, 1994
DB/bn/K1083/1009

The Director
Survey of Kenya
P.O. Box 30046
NAIROBI

thru The Director
Department of Urban Development
P.O. Box 30004
NAIROBI

RE: NYERI WATER SUPPLY - FEASIBILITY STUDY

1:50,000 Map Sheets

Dear Sir,

We have been appointed by MOLG to undertake a Feasibility Study for the supply of water to Nyeri.

To facilitate our work we require to purchase two sets of the following map sheets:

120/1	120/2	121/1
120/3	120/4	121/3
134/1	134/2	135/1

Kindly authorise us to do so.

Yours faithfully
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

Page

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H P GAUFF KG — CONSULTING ENGINEERS — P.O. BOX 49817 NAIROBI/KENYA.

26th January, 1995
IK/bn/K1083/66

The Director,
Central Bureau of Statistics
P.O. Box 30266,
NAIROBI

RE: NYERI WATER SUPPLY
FEASIBILITY STUDY

Dear Sir,

We have been retained as consultants for the above project by the Ministry of Local Government, and part of our work includes projection of the future population, and hence the future demand for water.

In order to fully appreciate the available national census data, it is necessary to take into account any variations in census boundaries between the censuses of different years.

We therefore request that you provide us with maps of the 1979 and 1989 census areas within Nyeri Municipality, showing both words and enumeration areas.

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

cc: Permanent Secretary - MOLG
Attn: Eng. Mwaura

Page

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FAX: 446124

JBG

27th January, 1995

H P GAUFF KG – CONSULTING ENGINEERS – P.O. BOX 49817 NAIROBI/KENYA.

IK/bn/80

Permanent Secretary
Ministry of Local Government
P.O. Box 30004
NAIROBI

Attn: Eng. Mwaura

RE: NYERI WATER SUPPLY
FEASIBILITY STUDY

Nyeri Municipality - 1979 and 1989 Censii Maps

Dear Sir,

For the above study, we require to analyse population growth in Nyeri Municipality, for which the national census figures will be primary data. To fully analyse the figures, we need to compare the areas used in the different censii and therefore need the maps of wards and enumeration areas.

We would be pleased if you could provide a letter to the Central Bureau of Statistics, in line with the enclosed draft.

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

D J Baker

L. Laubert
GENERAL MANAGER

D J Baker

D. Baker
HEAD, WATER SECTION

File

Page

DPD/158/A/III/8

30th January, 1995

Sir Alexander Gibb & Partners (Africa)
P.O. Box 30020
NAIROBI

(Att. Dr. S.T. Avery)

RE: NYERI WATER SUPPLY - FEASIBILITY STUDY

M/s. H.P. Gauff have been appointed by this Ministry of carry out the Feasibility Study for Nyeri Water Supply.

You are herewith authorised to make available to them at cost copies of all reports, documents and drawings to assist them in the above mentioned feasibility study as they may require.

Thanking you for your cooperation in this matter.

Yours faithfully

ENG. F.N. MWAURA
DEPUTY DIRECTOR TECHNICAL SERVICES
for: PERMANENT SECRETARY

Page

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H P GAUFF KG – CONSULTING ENGINEERS – P.O. BOX 49817 NAIROBI/KENYA.

15th February, 1994
KW/bn/K1083/155

The Director,
Ministry of Land Reclamation
Regional and water Development
P.O. Box 30521
NAIROBI

Attn: Eng. J. Maina

RE: NYERI WATER SUPPLY – FEASIBILITY STUDY

Feasibility Study

Dear Sir,

We have been appointed by Ministry of Local Government as the Consultant for the above project, and are now compiling the available past records.

The Ministry of Local Government had requested Sir Alexander Gibb & Partners to release to us the drawings associated with the Design that they executed in 1982, however they have stated that as the Water Department was the Client when they carried out the design, your consent is required before they provide us with these drawings.

Please therefore give your consent for Sir Alexander Gibb to provide us with the drawings they have for Nyeri Water Supply.

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

cc: MOLG – Attn: Eng. Mwaura

Page

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TEL: 445288
FAX: 446124

JBC

H P GAUFF KG — CONSULTING ENGINEERS — P.O. BOX 49817 NAIROBI/KENYA.

20th February, 1995
KW/bn/K1083/167

Mangat IB Patel
P.O. Box 48674
NAIROBI

RE: NYERI WATER SUPPLY - FEASIBILITY STUDY
Nyeri Foul Sewerage Scheme

Dear Sirs,

By our letter DB/bn/K1083/915 of 5th October, 1994, we informed you of our appointment as the Consultants on the above study, and requested that you confirm the availability of the design documents, "as built" drawings and the like for the Nyeri Foul Sewerage Scheme, in your possession, pending authorisation from MOLG for us to acquire them from you.

Your letter 1399/94/1002/HSM/EME of 7th October, 1994 confirmed that you had the documents and drawings, and the MOLG letter DPD/158/A/III/7 of 30th January, 1995 has authorised you to release them to us.

We therefore request that you provide the bearer of this letter the necessary assistance in carrying out the acquisition of the documents and drawings.

May we express our appreciation for the expeditious co-orperation that we confidently anticipate, and remain,

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

cc: Ministry of Local Government - Eng. Mwaura

Page

MINISTRY OF LAND RECLAMATION, REGIONAL AND WATER DEVELOPMENT

Telephone: Nyeri 4331 and 4333
If calling or telephoning please ask for
....
When replying please quote
Ref. No. CP/HYDRO/23/15
and date

OFFICE OF THE
PROVINCIAL WATER ENGINEER
CENTRAL PROVINCE
P.O. Box 1343
NYERI

14th February, 1995

H. P. GAUFF
EINGEGANGEN
27 FEB 1995
NAIROBI

The Head of Water Section,
H.P GUFF CONSULTANT ENGINEERS,
P.O. Box 49817,
Nairobi.

ASSESSMENT OF NYERI WATER SUPPLY

Thanks for the above exercise being carried out for the Nyeri Municipality by your firm.

However due to the poor state of the river gauging stations at Nairobi and Chania rivers intakes, you are humbly requested to consider the rehabilitation of the same and where possible you modernise the water level (in the rivers) monitoring devises for easy and continuous assessment data in future.

Maitima S. M'Mukindia
for: PROVINCIAL WATER ENGINEER, CENTRAL PROVINCE

CC: Permanent Secretary,
Ministry of Land Reclamation,
Regional and Water Development,
P.O. Box 30521,
NAIROBI.
(Att: DWD)

The Town Clerk,
Nyeri Municipal Council,
P.O. Box 180,
Nyeri.
(Att: Municipal Engineer)

Page

—>DAS -> L108 S

MANGAT, I.B. PATEL & PARTNERS – CONSULTING ENGINEERS

H.S. MANGAT BE (Civil), REng, CEng, Eur Ing, FIEK, FIET, MAAK (E), FICE, FIMunE, FIWEM
ISHWAR B. PATEL BE (Civil), MS (Illinois) REng, CEng, FIEK, MAAK (E), FIStructE, FICE
M.S. BHACHU BEng, MSc (Lond), DIC, REng, CEng, Eur Ing, FIEK, MICE, FIWEM
T.S. MANGAT BSc (Hons), CEng, Eur Ing, MICE, MIWEM, MAWWA

Associate:
R.M. HIRANI B Tech (Civil) Hons, REng, CEng, MAAK(E), MIStruct E

BISHOP'S GARDEN TOWERS, BISHOPS ROAD P.O. BOX 48674, NAIROBI, KENYA.
TEL: CIVILS 710500/1 STRUCTURES 710546/7 FAX: 710549

MIBP + PARTNERS CONSULTING ENGINEERS

Ref. No.181/95/1002/MPP/SA 27th February, 1995

H.P. Gauff,
P.O. Box 49817,
Nairobi.

? As constructed drawings?

FOR THE ATTENTION OF MR BAKER

Dear Sirs,

SUB: NYERI SEWERAGE PROJECT -DOCUMENTS COPIES

As requested we enclose herewith one set of the following documents:-

1. Nyeri Sewerage Project - Master Plan & Preliminary Design Report - Volume I - Report

2. Nyeri Sewerage Project - Master Plan & Preliminary Design Report - Volume II - Appendices

3. Nyeri Sewerage Project - Master Plan & Preliminary Design Report - Volume III - Drawings (as per attached Appendix "A").

4. Nyeri Sewerage Project - Final Design Drawings - (As per attached Appendix "B").

Please arrange to forward the payment as per invoice attached.

Yours faithfully

T.S. MANGAT

Encl.

Page

Gauff Ingenieure

Fio

Beratende Ingenieure
Consulting Engineers
Ingénieurs Conseils

H P GAUFF KG — CONSULTING ENGINEERS — P.O. BOX 49817 NAIROBI/KENYA.

2nd March, 1995
KW/bn/K1083/208

Branch Offi
NAIROBI
EAST CHURCH
WESTLANDS
TEL: 445288
FAX: 446124

JBC

The Director,
Ministry of Land Reclamation
Regional and Water Development
P.O. Box 30521
NAIROBI

RE: NYERI WATER SUPPLY - FEASIBILITY STUDY

Dear Sir,

We have been appointed by the Ministry of Local Government as Consultants for the above study, and would request that you avail to us copies of the drawings listed in the enclosed sheet, which are in your possession.

We will be calling upon your officers for further arrangements in this regard.

In anticipation of your kind cooperation, we remain,

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

cc: Ministry of Local Government - Eng. Mwaura
Nyeri Municipal Council - Eng. Nguiguti

Encl.

Page

DRG. NO.	TITLE OR DESCRIPTION
2.05-H072-001	Nyeri Water Supply - Intake at Ihwa
2.05-H072-002 2.05-H072-003	Nyeri Water Supply - Layout of (old) Raw Water Main
2.05-H072-004	Nyeri Water Supply - Plan of (Kamakwa) Treatment Works
2.05-H072-005	Nyeri Water Supply - Plan of Former Treatment Works
2.05-H072-006 to 2.05-H072-010	Nyeri Water Supply - Reticulation Survey 1979 (layouts)
2.05-H072-011 to 2.05-H072-015	Nyeri Water Supply - Old Raw Water Main Profiles
2.05-H072-016 to 2.05-H072-048	Nyeri Water Supply - Distribution Main Profiles
2.05-H072-049	Nyeri Water Supply - Treatment Works Layout
2.05-H003-001	Kiganjo Water Supply Layout (showing plan of Intake and RWM alignment)
2.05-H063-001 to 2.05-H063-005	Tetu Thegenge Water Supply - Layouts
2.05-H043-001	Kimathi Institute of Technology Water Supply
2.05-H069-001	Aguthi Water Supply Phase I General Layout of Supply Area

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H P GAUFF KG – CONSULTING ENGINEERS – P.O. BOX 49817 NAIROBI/KENYA.

13th March, 1995
DB/bn/K1083/233

Permanent Secretary
Ministry of Local Government
P.O. Box 30004
NAIROBI

Attn: Eng. F.N. Mwaura

RE: NYERI WATER SUPPLY – FEASIBILITY STUDY
Water Supply Immediate Works Programme

Dear Sir,

We forward herewith a brief report, outlining possibilities for the uprating of the Kamakwa Water Works from a theoretical 5,200 m3/day, (actual 6,000 m3/day) to about 9,000 m3/day, which figures should be compared to a present (1995) water demand of about 12,000 m^3/day.

Works would include the refurbishment of the raw water pump intake system for short term use; uprating of the old/very old sedimentation tanks by use of dispersal cones and of the new sedimentation tanks by installation of lamella plates; changing filter media; associated pipework modifications; and the laying of about 4,000 m of new trunk main to the south-eastern corner of the Central Business District.

We would also propose that such a programme should include minor alterations at the sewage works to facilitate operation of one high rate trickling filter without the need of recirculation, and other measures aimed at an overall reduction in use of electro-mechanical plant.

Should the above measures be of interest, we would prepare a budget cost estimate for the Works involved.

It will then be necessary for these measures to be presented to MoF as a priority requirement to enable the item to be introduced at the next Kenya-German Government discussions for funding in 1996-1997.

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

Page

MINISTRY OF LAND RECLAMATION, REGIONAL AND WATER DEVELOPMENT

Telegrams: "WATER", Nairobi
Telephone: Nairobi 716103
If calling or telephoning ask for

DIRECTOR OF WATER DEVELOPMENT
MAJI HOUSE
NGONG ROAD
P.O. Box 30521
NAIROBI

When replying please quote
Ref. No. WD/2/5/1 76 Vol IV/128.
and date

H. P. GAUFF KG
ZING-...
15 MAR 1995
NAI...

1st March, 1995

M/S H. P. Gauff KG
Consulting Engineers,
P. O. Box 49817,
NAIROBI.

→ DD/WW

Attn. D. Baker

Dear Sir,

REF: NYERI WATER SUPPLY FEASIBILITY STUDY

Your letter ref. No. KW/BN/K1083/155 dated 15th February, 1995 dwelling on the above subject hereby refers.

At this juncture, we're sorry to inform you that we cannot honour your request as we are not involved as the Engineer in this current project.

It is therefore hereby advised that you explore any other means necessary and possible as you liase with the local government Ministry and M/S Sir Alexander Gibbs and Partners towards facilitating the release of the same.

ENG. J. N. MAINA
FOR: DIRECTOR OF WATER DEVELOPMENT.

Page

Gauff Ingenieure

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FAX: 446124

JB[G]

H P GAUFF KG – CONSULTING ENGINEERS – P.O. BOX 49817 NAIROBI/KENYA.

20th March, 1995
DB/bn/K1083/244

Permanent Secretary
Ministry of Local Government
P.O. Box 30004
NAIROBI

Attn: Eng. F.N. Mwaura

RE: NYERI WATER SUPPLY - FEASIBILITY STUDY

Meter Data Capture + Billing

Dear Sir,

The present system of meter data capture and billing used by Nyeri Municipal Council is both antiquated, time consuming and cumbersome. One result is that there are significant delays between meter reading and billing and/or bills have to be hand prepared.

The project financier has indicated that they would have no objection to an addendum to our Consultancy to enable the procurement of appropriate computer and printer hardware and meter data capture and billing software plus training to replace the present system.

Subject to your agreement in principle to this, there are several ways of putting together the most appropriate package depending on whether you wish to transfer software from another local authority, utilise new software etc.

We would therefore propose an early meeting to discuss and agree on this.

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

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H P GAUFF KG – CONSULTING ENGINEERS – P.O. BOX 49817 NAIROBI/KENYA.

Branch Office
NAIROBI
EAST CHURCH R
WESTLANDS
TEL: 445288
FAX: 446124

JBG

22nd March, 1995
KM/bn/K1083/262

Mangat I.B. Patel & Partners,
P.O. Box 48674
NAIROBI

Attn: Mr. H.S. Mangat

RE: NYERI WATER SUPPLY - FEASIBILITY STUDY

<u>Nyeri Foul Sewerage Scheme - Documents and 'As Constructed' Drawings</u>

Dear Sir,

Reference is made to your letter dated 7th October, 1994 ref. No. 1399/94/1002/HSM/EME where you confirmed having the above mentioned drawings and documents. In a subsequent letter ref. No.181/95 the forwarded documents as listed out in the Appendices excluded the sewerage treatment design and 'as-built' drawings (FDR).

We hereby request you to avail these documents and drawings soonest to enable us proceed on schedule with the Nyeri Water Supply Feasibility Study.

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

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H P GAUFF KG — CONSULTING ENGINEERS — P.O. BOX 49817 NAIROBI/KENYA.

23rd March, 1995
DB/bn/K1083/282

JBG

RE: NYERI MUNICIPAL COUNCIL
NYERI WATER SUPPLY - FEASIBILITY STUDY

Procurement of Meter Data Capture/Billing Equipment

Dear Sirs,

You recently provided Nyeri Municipal Council with an offer for the supply, delivery and installation and commissioning of a computer network and water billing software.

We have now been charged with reviewing the offers made and with procurement of both hardware and software for the Municipal Billing System.

Could you please therefore confirm to us the hardware specification as offered by yourselves together with as much detail as possible of the software package(s) you proposed.

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. J Baker

D. Baker
HEAD, WATER SECTION

Page

American Communication Technologies
P.O. Box 52250
NAIROBI

New Rehema House, Rapta Road Westlands

Kirumba Mwaura & Co. Associates
P.O. Box 50515,
NAIROBI

Agip House, 1st floor, Haile Selassie Ave.

AT & T Global Information Solutions (K) Ltd
P.O. Box 30217
NAIROBI

Agip House, Grd Floor, Haile Selassie Ave.

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H P GAUFF KG — CONSULTING ENGINEERS — P.O. BOX 49817 NAIROBI/KENYA.

27th March, 1995
KW/bn/K1083/287

Permanent Secretary
Ministry of Local Government
P.O. Box 30004
NAIROBI

Attn: Eng. F.N. Mwaura

RE: **NYERI WATER SUPPLY - FEASIBILITY STUDY**

Request for release of documentation
from Sir. A. Gibb & Partners and from MOLRRWD

Dear Sir,

The Director of Water, Ministry of Land Reclamation, Regional and Water Development has requested that as the technical department for Water Development in Kenya, they be appraised of the situation vis a vis our consultancy for Nyeri so that they can then consider our request for release of documents and drawings in connection with this project.

Copies of earlier relevant correspondence are enclosed.

Your early attention would be much appreciated as this information is required to enable us to proceed with our Consultancy.

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

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H P GAUFF KG — CONSULTING ENGINEERS — P.O. BOX 49817 NAIROBI/KENYA.

29th March, 1995
KW/bn/K1083/304

Permanent Secretary
Ministry of Local Government
P.O. Box 30004
NAIROBI

RE: NYERI WATER SUPPLY - FEASIBILITY STUDY

Record of Discussions

Dear Sir,

We enclose herewith a record of the discussions held during a courtousy call on 21st March, 1995 on His Worship the Mayor of Nyeri Muncipality.

Yours faithfully,
H.P. GAUFF KG
Consulting Engineers

L. Laubert
GENERAL MANAGER

D. Baker
HEAD, WATER SECTION

cc:	MOLG	-	Eng. Mwaura
	MOLG	-	Mr. Muriuki
	His Worship the Mayor	-	Nyeri
	Nyeri Municipal Council	-	Mr. Gikuhi
	Nyeri Municipal Council	-	Eng. Nguiguti

Encls

Page

Gauff Ingenieure (JBG)

KENYA

Project

NYERI WATER SUPPLY
FEASIBILITY STUDY

Project No.

Meeting No.:

Date : 21/03/95
Place : TOWN HALL,NYER
Minuted by: K.B. WANGOMBE

Present:

For Nyeri Municipal Council

1.	H.W. Cllr.J. Wanjage	The Mayor	NMC
2.	Mr. R.K. Gikuhi	Town Clerk	NMC
3.	Mr. J. Nguiguti	Engineer	NMC
4.	Mr. G. Maina	Treasurer	NMC

For Ministry of Local Government

1. Mr. E. Muriuki

For H.P. Gauff Consulting Engineers

1. Mr. D. Baker
2. Mr. K.B. Wangombe

Copies to:

H.W. the Mayor, Nyeri
Town Clerk
Town Engineer
PS - MOLG
Eng. Mwaura - MOLG
Mr. Muriuki - MOLG

Preliminary Matters

The meeting was held as a courtesy call upon the Mayor, in order to introduce the Consultants and provide a briefing on the work they are to execute.

Item	Minutes	Action
1.	**INTRODUCTION BY MR. BAKER** Subsequent to introductions of the persons present, Mr. Baker apologised to H.W. the Mayor for activity on site having started prior to formal introductions being made. This had arisen because the official start was only now coming into effect, but despite this the Consultants had made an early start on some activities. Now that the Consultancy contract was formally to commence, it had been deemed an appropriate time to make a call on H.W. the Mayor.	

Page

Item	Minutes	Action
	The study was to be in three stages, each stage being reported on before proceeding to the next. The first step was to assess the current situation, followed by development of various project alternatives, and lastly to detail the selected alternative to an extent that would allow the preparation of cost estimates which can be used in finalising financial arrangements for the project final design and construction.	
	So far, the Consultants had had the best of co-operation from the Council's officers, for which gratitude was expressed.	
	Going by past experience, then any project which may result from the study could be expected to be completed in a minimum of 8 years if good progress was made, however it was quite evident this was too long a period given the critical present situation.	
	Alleviation of the present situation within the not very distant future could therefore only be achieved through an Immediate Works programme, if such a programme were put forward through the Ministry of Local Government (MOLG) and accepted for financing by Kreditanstalt fuer Wiederaufbau (KfW).	
	If a main project is to be executed, then the Nyeri Municipal Council (NMC) would need to prepare themselves to meet the expectations of KfW. There had been a change in the KfW approach in recent years, and they now require project packages to be economically viable. Thus the donor would need to see that NMC are meeting todays costs, first and foremost, prior to being able to demonstrate ability to meet projected costs inclusive of a proposed project.	
2.	**<u>REMARKS BY H.W. THE MAYOR</u>**	
	H.W. the Mayor thanked Mr. Baker for his kind remarks.	
	He pointed out that although the Council had a number of pressing problems, the water supply situation was the most critical of them. Some areas were not getting water more than once a week. Fortunately natural water sources were close to the built-up areas, however there were obvious consequences of wide spread use of untreated water.	
	His Worship understood the need for consumers to pay for services rendered, and appreciated the need for NMC to meet its commitments.	
	It was noted that in the previous year, Shs.5.6 mio had been obtained from the government for improvements to the water supply, however this amount of money had only been adequate for limited improvements.	
	H.W. the Mayor invited the Consultants to liaise with NMC officials for all the information they may need in their work. He wished to see local officials fully involved in the decision making process.	

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	He further was very anxious that measures to alleviate the currently critical situation be taken.	
3.	**REMARKS BY THE TOWN CLERK**	
	The Town Clerk also requested full involvement of NMC officials in decision making, and that the views of councillors, which will be channelled through the NMC Engineer, be given full consideration.	
	It was not however clear what the relationships were between KfW, MOLG, NMC and the Consultants, within the Consultancy Agreement.	
	Further, there had been discussions within NMC of the areas which could be addressed in an immediate works programme. In particular it had been noted that:	
	(i) rehabilitation of the existing works was needed,	
	(ii) the possibility of procuring vehicles for the water and sanitation section and motorcycles for meter readers needed to be explored,	
	(iii) the present metering situation was unsatisfactory, and meters were expensive, so this aspect was considered worthy being pursued, and	
	(iv) distribution system improvements were needed.	
	In the long term, NMC felt it may be considered necessary to have a dam at Ihwa to regulate low flows.	
	With regard to the municipal area, the Town Clerk wished to know how the study will address the Kiganjo area, and those areas served by National Water Conservation and Pipeline Corporation (NWCPC), Water Department, and locally constructed water supplies.	
	Another area of constraint was the constant breakdown of the old accounting machines in present usage, with very high maintenance costs. It was considered that manual bill preparation may even be preferable.	
4.	**EXPLANATIONS BY MR. MURIUKI**	
	Mr. Muriuki expressed gratitude for H.W. the Mayor having availed himself for the discussions, and apologised for the lack of an earlier visit, due to the contractual aspects not being fully in place previously. Whilst these aspects were being tied together, the Consultants had been familiarizing themselves with the site and had not officially commenced work.	

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	Going into past developments, Mr. Muriuki noted that in the ADB funded project of the early 1980's, the water supply was also to be addressed, but eventually only the sewerage scheme was constructed. A study of the water supply was however done by Sir Alexander Gibb and Partners. Subsequently, the Government of Germany agreed to look into financing a water project, and as a precursor to this a consultant, H.P. Gauff (HPG) had been jointly appointed by the Kenyan and German governments to assess the scope of such a project. Contractual arrangements in that regard had gone through KfW in Germany, and MOLG and the Treasury in Kenya. The Council had not been involved as the money to be expended was German grant funds. In executing the services however, the Consultants were expected to work closely with the Council. After the study is completed, then the project will be appraised by the German government. The monies mentioned recently in the press as having been committed by the German government would only be made available if a positive appraisal were arrived at. Such monies would be provided to the Kenya Government, and there would subsequently be on-lending to the Council through the Local Government Loans Authority (LGLA). There was need for the Council to prepare for the appraisal of the project if the project is to be expected to proceed. The particular aspects to be addressed are: (i) definite progress towards a cost covering tariff (ii) a sustainable management system to be in place, and (iii) the Council to have an organisational set up with qualified staff who had proper tools for their work NMC should prepare themselves to be able to demonstrate that they meet the conditions which can be expected to be set. Mr. Muriuki said MOLG will give all necessary support for an Immediate Works programme provided the Council showed such to be warranted. The recent German water sector paper required water projects to target the urban poor thus the proposals in this regard should be aimed at heavily populated areas. The Council was requested to give HPG all possible assistance and access to information possible, during the study.	
5.	**QUESTION BY H.W. THE MAYOR** H.W. the Mayor wished to know the physical area to be covered by the project.	

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6	**RESPONSE BY MR. MR. MURIUKI**	
	It was explained that the study being carried out by HPG would include the entire Municipal Area.	
	It was however to be noted that the donor's principal interest was in a smaller area.	
7	**FURTHER REMARKS BY H.W. THE MAYOR**	
	H.W. the Mayor agreed that the Council needed to improve on revenue collection, and on cost recovery. He had no doubt that consumers would appreciate that services had to be paid for, and would be more than willing to pay what was needed, if only they could be provided with the much needed water supply. He said that the councillors would be appraised of the situation, and they would then explain to the populace the justification and necessity for tariff increases.	
	H.W. the Mayor also noted that during the study, negative aspects regarding the Council's operations will come to light and would of course be reported on. He however requested that the Council be given prior information on such aspects, so that the report can, as well, include the Council's views and explanations. This he felt would enable the reports to present balanced views.	
8	**ADDITIONAL EXPLANATIONS BY TOWN CLERK**	
	The Town Clerk informed that NMC have already started preparing for gradual tariff increases, to be effected each year. He was glad to report that the councillors had been very supportive in these efforts.	
	The sewerage project repayments were noted to be exerting a distorting effect on the present expenditure financial picture, as the repayments on the high capital cost were not balanced out by any appreciable increased revenue. Further, some branch sewers had been constructed in areas with few potential consumers, whilst leaving out prime areas such as the area near the post office.	
	The Town Clerk reported that they had received MOLG approval for the establishment of a Water and Sewerage Department in the previous week.	
	Further, all top council officers had been attending workshops organised by the Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) on water and sanitation systems operation and management. The workshops were found very useful.	
	Whereas the present emphasis on the urban poor was appreciated, the Town Clerk pointed out that large consumers formed the revenue base and the contribution to revenue by the very small consumers was nominal, despite their large numbers and thus high revenue collection costs. In this regard he wished to dispel the notion which he heard being expressed, to the effect that the Kenya Police College, Kiganjo, did not pay their water bills. The Town Clerk pointed out that whereas they may	

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	on occasion delay for some months in making payment, they then paid all their arrears, and unlike many other consumers never had long term debts on their account.	
9.	**ENQUIRY FROM NMC ENGINEER**	
	Eng. Nguiguti emphasised the NMC desire for short term measures to improve the water supply situation.	
	He also enquired into the past experience of other towns during project appraisal.	
10.	**REPLY BY MR. MURIUKI**	
	Mr. Muriuki said there was no intention of implying that NMC would fail to meet the needs for positive appraisal and could be expected to do so given adequate commitment. It was to be noted however that some recent projects, such as the Nairobi Wholesale Market, had failed to secure financing at the appraisal stage.	
	Further, the German government sector paper on water and sanitation was being revised, and this paper would give indication of the German priorities in that field.	
11	**FINAL REMARKS BY TOWN CLERK**	
	The Town Clerk re-iterated the view that Nyeri Town residents were very willing to pay for services such as water supply, provided that they could in return obtain a reliable service.	
	NMC had started preparing for the anticipated project. As urgent measures to ensure that such a project was not hampered, the Council had already acquired the land which Sir Alexander Gibb & Partners had indicated as being required for expansion of the Kamakwa Treatment Works. In addition, the Council had foreseen that there might be need for land for expansion at the Ihwa Intake, and had already acquired the necessary land.	
	Other preparations in hand included the starting up of a Water and Sanitation Department, as recently approved, tariff increases as part of a planned and sustained plan, and the planned improvements in billing.	
	The Town Clerk expressed the Council's full commitment to the development of an efficient and sustainable service organisation and it's management.	

Table 5.1.2 (cont.) Monthly flow data

Amboni River at RGS 4AB5, catchment 420 sq km
Monthly catchment runoff (mm):

	1	2	3	4	5	6	7	8	9	10	11	12	Ann
1982	5.3	2.7	2.1	17.2	50.1	12.6	4.6	5.7	4.6	13.5	40.6	23.4	182
1983	4.8	3.6	3.3	14.1	24.0	5.2	9.9	17.0	11.0	19.9	18.6	15.5	147
1984	6.0	3.0	2.9	3.4	2.6	2.1	2.6	1.9	2.5	10.9	17.2	8.7	64
1985	2.8	3.1	2.9	29.4	17.6	5.3	4.5	3.4	5.3	9.6	8.2	5.3	97
1986	2.4	1.8	2.3	11.9	17.3	10.4	6.7	6.3	13.1	12.5	12.1	20.4	117
1987	4.3	2.9	3.2	7.7	6.1	20.3	4.4	4.0	2.6	3.0	20.9	8.9	88
1988	5.6	2.7	3.7	51.7	23.0	7.4	7.4	10.3	13.4	11.6	16.7	11.6	165
1989	9.0	6.0	4.1	19.6	13.0	4.8	6.2	8.2	20.9	19.8	28.5	26.5	166
1990	26.6	5.8	28.1	59.7	17.5	5.6	4.4	4.8	3.0	4.5	9.3	10.5	180
1991	4.3	2.3	2.4	5.4	14.5	6.9	4.1	5.3	3.5	5.4	5.9	3.9	64
1992	2.6	1.8	1.9	6.8	17.6	6.8	3.3	5.3	5.0	13.3	11.8	21.1	97
1993	31.3	37.2	6.1	8.0	10.1	6.4	3.2	3.2	3.1	4.0	4.4	5.5	122
1994	2.0	1.5	2.0	15.1	20.9	9.2	6.9	12.2	5.3	6.5			
1995		2.3											
Mean	8.2	5.7	5.0	19.2	18.0	7.9	5.3	6.7	7.2	10.3	16.2	13.4	123

Amboni River at RGS 4AB5
Mean monthly discharge (cu m/sec):

1982	0.83	0.42	0.32	2.69	7.86	1.98	0.72	0.90	0.72	2.11	6.36	3.67	2.43
1983	0.76	0.63	0.52	2.28	3.76	0.84	1.56	2.67	1.78	3.12	3.01	2.44	1.96
1984	0.94	0.51	0.46	0.55	0.41	0.33	0.41	0.29	0.41	1.70	2.78	1.36	0.85
1985	0.43	0.54	0.45	4.77	2.76	0.86	0.70	0.54	0.85	1.51	1.32	0.84	1.30
1986	0.38	0.31	0.36	1.94	2.71	1.69	1.06	0.99	2.12	1.96	1.96	3.20	1.56
1987	0.68	0.50	0.50	1.25	0.96	3.28	0.69	0.63	0.42	0.47	3.39	1.40	1.18
1988	0.87	0.45	0.58	8.38	3.60	1.20	1.16	1.62	2.17	1.82	2.71	1.82	2.20
1989	1.41	1.05	0.64	3.17	2.04	0.77	0.97	1.29	3.39	3.10	4.62	4.15	2.22
1990	4.18	1.01	4.41	9.67	2.74	0.91	0.70	0.76	0.49	0.71	1.50	1.65	2.40
1991	0.67	0.39	0.37	0.88	2.27	1.13	0.65	0.83	0.56	0.84	0.96	0.61	0.85
1992	0.42	0.30	0.29	1.10	2.76	1.10	0.52	0.83	0.81	2.09	1.91	3.31	1.30
1993	4.91	6.46	0.95	1.29	1.58	1.04	0.51	0.50	0.51	0.63	0.71	0.85	1.63
1994	0.32	0.26	0.31	2.44	3.28	1.49	1.07	1.91	0.86	1.01			
1995		0.41											
Mean	1.29	0.94	0.78	3.11	2.83	1.28	0.82	1.06	1.16	1.62	2.60	2.11	1.64

Statistical summary of logarithms of monthly discharge data:

Mean	-0.06	-0.24	-0.27	0.35	0.37	0.05	-0.11	-0.05	-0.04	0.14	0.34	0.25
SD	0.352	0.337	0.296	0.353	0.296	0.226	0.158	0.249	0.293	0.254	0.264	0.264

Expected minimum monthly discharge, assuming Log-Normal distribution:

10-yr	0.31	0.21	0.22	0.78	0.97	0.57	0.48	0.43	0.38	0.65	1.00	0.81
14.9-yr	0.24	0.17	0.18	0.60	0.78	0.49	0.43	0.36	0.31	0.54	0.82	0.67
20-yr	0.23	0.16	0.18	0.58	0.76	0.47	0.42	0.35	0.30	0.53	0.80	0.65
29.4-yr	0.20	0.14	0.15	0.50	0.67	0.43	0.40	0.31	0.26	0.48	0.72	0.58
50-yr	0.16	0.12	0.13	0.42	0.57	0.38	0.36	0.28	0.23	0.42	0.62	0.51

Source: Spreadsheets with Ministry of Water Development gauge heights converted to daily discharge using rating equations given in Appendix I.

Note: minimum daily flows for various return periods can be derived from mean monthly baseflow by allowing for 15 days recession, equivalent to a factor of 0.76 for the Chania River at 4AC5.

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Table 5.1.3 Annual series of minimum recorded daily flows, RGS 4AC5

Year	Daily flow (l/s)	Log(flow)
1960	1030	3.013
1961	960	2.982
1962	1440	3.158
1963	1520	3.182
1964	1400	3.146
1965	1180	3.072
1966	1400	3.146
1967	1010	3.004
1968	1330	3.124
1969	1160	3.064
1970	1170	3.068
1971	840	2.924
1972	1440	3.158
1973	1270	3.104
1974	920	2.964
1975	860	2.934
1976	880	2.944
1977	1170	3.068
1978	1440	3.158
1979	1590	3.201
1980	900	2.954
1981	(missing)	
1982	590	2.771
1983	1270	3.104
1984	590	2.771
1985	900	2.954
1986	890	2.949
1987	550	2.740
1988	990	2.996
1989	1190	3.076
1990	1270	3.104
1991	990	2.996
1992	360	2.556
1993	940	2.973
1994	890	2.949
1995	940	2.973
Statistics of 1960-95 data:-		
Mean	1065	3.0081
SD	289	0.1369
10-yr	695	680
14.9-yr	604	616
20-yr	590	607
29.4-yr	538	573
50-yr	472	533
Statistics of 1982-95 data:-		
Mean	883	2.922
SD	265	0.151
50-yr	340	409

Source: Reference 1 for 1960-80 data;
Consultant's files for rest.

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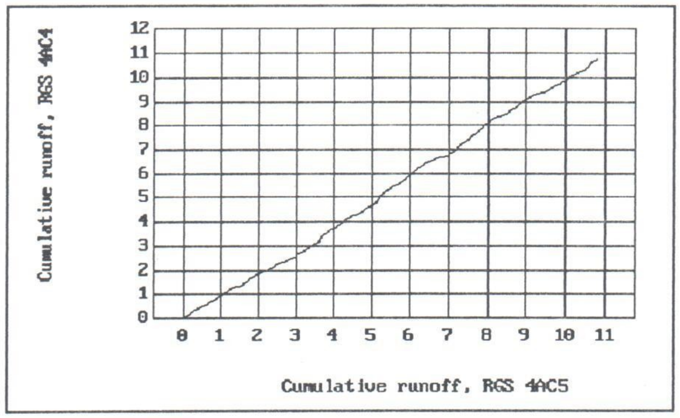
Fig 5.1.1 Double mass plot of Chania River runoffs (plotted in units of mean annual runoff)



5.2 Dry weather recession of flow

The dry season flows are characterized by a recession of flow after the rainy seasons have ended. For perennial rivers that are not subject to significant fluctuating abstractions upstream, the recession of flow is often found to be quite steady and, if expressed as the ratio of the flow on any particular day to the flow of the preceding day, it is found to be much the same from year to year. In respect of monthly flows, this similarity is observed in the logarithmic plots (Appendix III), where recession limbs of the hydrographs for the Chania River can be compared from year to year.

Inspection of the daily flow records for the periods of steady recession (identifiable on the logarithmic plots, Appendix III), indicates a daily recession of 0.9822, equivalent to a monthly recession of 0.579.

This pattern of flow recession can be described mathematically as

$$Q_1 = Q_0 \times Kr_1$$

where Q_0 is the flow at any time and Q_1 is the flow one unit of time later.

Inspection of the Chania River RGS 4AC5 hydrographs (Appendices II & III) indicate that baseflow recession on average starts when the river discharge is 4.1 cu m/sec, this event having a return period of 2 years, or a probability on an annual basis of 50 %. This discharge is equivalent to a monthly catchment runoff of 60 mm, or about 11 Mcm.

Assuming the catchment behaves as a linear reservoir, then the water in storage, S_t, at time t is given by

$$S_t = - Q_t / \ln Kr$$

This relationship gives an estimate of 20 Mcm in groundwater storage in the catchment when baseflow recession starts at the end of the rainy season in average conditions .

At 80 percent reliability (that is conditions expected in at least 4 years out of 5, on average), the number of consecutive dry months is not expected to exceed 3.9 months (see discussion at end of section 3.4 above). The reliable daily flow is then calculated as:

$$\begin{aligned} Q10 &= 4.1 \times 0.579^{3.9} \\ &= 0.487 \text{ cu m/sec} \end{aligned}$$

Where Q10 is the 10-year return minimum daily flow (ie 90% reliable), since the probability of the flow being at least 4.1 is 50% and the probability of at least 3.9 consecutive dry months is 80 %, and the probability of the two events occurring together is obtained by multiplying the separate probabilities. In similar fashion the expected minimum flow at the intake site at RGS 4AC5 can be estimated for various return periods (Table 5.2.1). The significance of the various return periods for the Nyeri water supply design project is explained in a subsequent section of this Annex.

Table 5.2.1 Minimum flows estimated from baseflow recession characteristics

Return period for dry spell (T, years)	Duration of dry spell (D, months)	Return period for minimum flow event (2xT, years)	Minimum daily flow for 2T-yr event (Q2T, l/s)
5	3.9	10	487
7.45	4.3	14.9	392
10	4.6	20	333
14.7	4.8	29.4	298
25	5.0	50	267

Source: Q2T = 4100 x 0.5793^{D} l/s, as explained in text; D is read off Fig 3.4.1.

5.3 Flood flows

The records for RGS 4AC5 have been inspected to give a series of annual maximum discharges for 1981-94. The analysis of the statistics for the mean daily discharge indicates a maximum daily discharge of 39 cu m/sec for a 100-yr return period event. The peak discharge might be somewhat higher, but not much, as the main volume of water is runoff from climax tropical forest and bamboo.

Tentatively, a design figure of 50 cu m/sec is proposed.

Table 5.3.1 Annual maximum daily discharge at RGS 4AC5

Year	Daily flow (cu m/s)	Log(flow)
1960	12	1.079
1961		
1962		
1963	25	1.398
1964	25	1.398
1965	20	1.301
1966	25	1.398
1967	23	1.362
1968	25	1.398
1969	23	1.362
1970	20	1.301
1971	16	1.204
1972	19	1.279
1973	10	1.000
1974	11	1.041
1975	18	1.255
1976	10	1.000
1977	21	1.322
1978	21	1.322
1979	19	1.279
1980	10	1.000
1981	10	
1982	25	1.398
1983	16	1.204
1984	6	0.778
1985	15	1.176
1986	18	1.255
1987	14	1.146
1988	12	1.079
1989	12	1.079
1990	16	1.204
1991	12	1.079
1992	7	0.845
1993	15	1.176
1994	27	1.431
Mean	17	1.205
SD	6	0.166
10-yr	24	**26**
50-yr	29	**35**
100-yr	31	**39**

Source: Reference 1 for 1960-80 data;
Consultant's files for rest.
Note: values in **bold type** are recommended as a basis for design.

5.4 Storage/yield characteristics

River flows fluctuate with time. Seasonal variation means that, where water supplies are taken directly from river intakes, the reliable yield is determined by the minimum expected flow. This yield can be called the run-of-river yield, and is usually some quite small proportion of the mean annual flow. If seasonal fluctuations are regulated by storage of the river flows, then the reliable yield can be increased to a large proportion of the mean annual flow if sufficient storage is available. The relationship between storage and yield is determined entirely by the temporal distribution of the river flows. If both storage and yield are expressed as percentages of the mean annual runoff (MARO), then the relationship is dimensionless, that is independent of the size of the river or stream or of the amount of rainfall that appears as streamflow.

A convenient procedure for estimating the storage/yield relationship is provided by the sequent peak algorithm, where the cumulative sum of inflow minus demand is calculated. This cumulative sum fluctuates seasonally, with peaks and troughs. The first peak is located and the next larger peak (sequent peak) is identified. The storage required is the difference between the initial peak and the subsequent lowest trough in the interval preceding the sequent peak. The largest storage required during the whole sequence of flows is the storage needed to satisfy the demand during that period.

This algorithm has been applied to the runoff records for the Chania River at RGS 4AC5 (Table 5.1.2) for the period 1982 to 1994. Although this period of continuous river records does not give a direct estimate of yield at 98 percent reliability, it indicates the order of improvement of yield if storage is available.

Table 5.4.1 Storage/yield relationship for Chania River, 1982-94

Chania River at RGS 4AC5:

Yield as % MARO	Storage as % MARO
10	0.0
20	0.6
30	2.2
40	6.1
50	12.4
60	21.5
70	34.0
80	46.9
90	72.2
100	115.6

Source: computer printout, with runoff input from Table 5.1.2 .

6 ESTIMATION OF RELIABLE YIELD

6.1 Method

For this project the present hydrological study gives estimates of reliable dry weather flow at the water intake, RGS 4AC5, by analyzing:

i) the record of monthly discharges 1981-1995 (Table 5.1.2);

ii) the pattern of occurrence of dry spells (Fig 3.4.1) together with the baseflow recession characteristics of the river (Table 5.21);

iii) the annual series of minimum daily discharges.

The return periods chosen for the analysis are 10-yr, 14.9-yr, 20-yr, 29.4-yr and 50-yr (Table 6.4.1).

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - INFLUENT - MID-DAY

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	900	
COD, mg/l	1200	
SOLIDS-SUSPENDED, mg/l	320	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION LIST		
1.		
2.		
3.		

GENERAL REMARKS

SIGNED [signature] CHAIRMAN DEPARTMENT OF CIVIL ENGINEERING DATE February 9, 1995

6.4 Presentation of results

Table 6.4.1 Estimates of reliable flow at Nyeri w/s intake

Return period	< Minimum daily flow l/s >		
Method:-	(i)	(ii)	(iii)
10-yr	**532**	487	695
14.9-yr	**433**	392	604
20-yr	**418**	333	590
29.4-yr	**372**	298	538
50-yr	**319**	267	472

Source: for i) Table 5.1.2; for ii) Fig 3.4.1 & Table 5.2.1;
for (iii) Table 5.1.3.
Note: values in **bold type** are recommended as a basis for design.

6.5 Alternative Sources

6.5.1 Kiganjo w/s

The Kiganjo water supply source is presently from the Nairobi River. The river flows are often insufficient to maintain supply at the design level during the dry seasons. The Amboni River dry weather flows (Table 5.1.2) are sufficient to provide an alternative source. Amboni River water in the vicinity of the weir at RGS 4AB5 is expected to be of better quality than the present source from the Nairobi River, which includes effluent from the town. Water quality would not however be as good as from the Chania River due to the relatively large area of rangeland and cultivated land within the catchment.

6.5.2 Nyeri w/s

For the present planning horizon, the Chania River at the intake is expected to provide adequate quantities of water at an acceptable level of risk of failure.

Beyond this planning horizon, consideration may be given to impounding wet weather flows of the Chania near the source within the boundaries of the National Park. Assuming that the seasonal distribution of flow at the source is similar to that at RGS 4AC5, then the storage/yield relationship (Table 5.4.1) can be used to give an order of magnitude of the augmentation of yield that would be practicable.

From the measurements made by the Consultant (Table 5.1.1), the mean annual runoff (MARO) above, say, the Chania Falls would be expected to be at least 400 mm, equivalent to 18 Mcm. Live storage of 12.4 % of MARO, that is 2.2 Mcm would allow a gross steady yield of 9 Mcm per year, equivalent to 285 l/s. Assuming a surface area of the reservoir of 1 sq km, then evaporative losses would be of the order of 1250 mm/yr, equivalent to 40 l/s, giving a nett steady yield of about 245 l/s. Other levels of augmentation of yield can be roughly estimated in similar fashion using the storage/yield relationship (Table 5.4.1).

Conceptually, such an impoundment could better augment the Chania River dry season baseflow by controlled releases from a possible reservoir above the Chania Falls. Such a scheme would involve an artificial lake within the Park, which might include some negative environmental impact, but would enhance the dry weather flows and probably be acceptable in respect of fishing, wildlife and maintenance of the aesthetic attractions of the river.

7 SEDIMENT YIELDS

7.1 Records

There are no systematic records of sediment yields for the rivers of interest.

The water samples taken at low flow from the Chania intake and from the river at I..., had very low suspended levels of suspended solids of 15 mg/l and 5 mg/l respectively, and cannot be taken as representative for flow conditions at other times.

7.2 Estimates

Sediment production from a catchment varies with climate, soil type, land use and topography. Two studies that take account of climate and vegetal cover can be used to give estimates for catchments were records are not available:

i) Langbein and Schumm (Reference 3) related mean annual sediment production to mean annual precipitation. Using this relationship, the sediment yields for the Chania River above the intake (mean annual rainfall 1300 mm), and for the Amboni River above RGS 4AB5 (mean annual rainfall 700 mm), are 16,000 and 50,000 tons respectively.

ii) Fleming (Reference 4), using data from many catchments over the world, derived relationships between the mean annual sediment load and the mean annual discharge for various vegetal covers, which can be described as forest cover for the Chania River and as a mixture of forest, scrub and grasslands for the Amboni River. Applying this relationship gives an annual discharge for the Chania River as for i) above, equivalent to a very low average suspended sediment concentration of 120 mg/l. This estimate is in line with anecdotal evidence that the river discharge is rather free of sediment. The Fleming relationship for the Amboni River, gives a result about three times greater than from i) above, equivalent to a rather high suspended sediment concentration of 3 g/l.

8 REFERENCES

1. Sir Alexander Gibb & Partners: Nyeri Water Supply, Preliminary Design Report, 1980.

2. T.Woodhead: Studies of Potential Evaporation in Kenya, E.A.A.F.R.O., 1968.

3. W.B.Langbein and S.A.Schumm: Yield of sediment in relation to mean annual precipitation, Trans Am Geophys Union, vol 39, pp 1076-1084, December 1958.

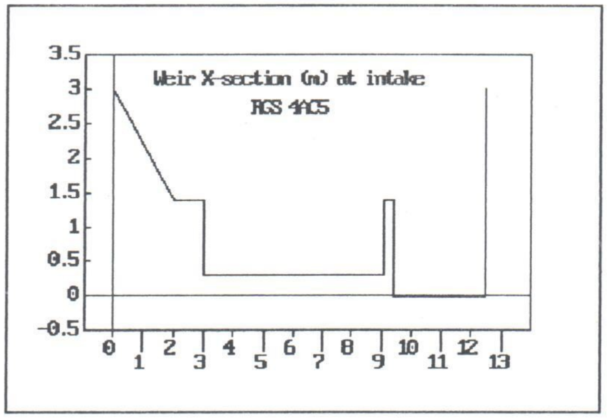
4. G.Fleming: Design curves for suspended sediment estimation. Proc Inst Civ Eng., vol 43, pp 1-9, 1969.

Rating curves

RGS 4AC5 - Chania River at intake

The weir was surveyed and a rating developed from a compound weir formula.

Cross-section at weir:



Formulae (h in m, q in cumec)

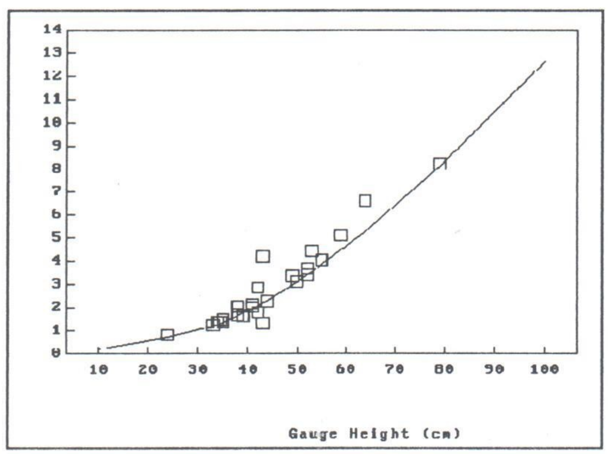
for h=0 to 0.3

$$q = 1.9 \times 3.06(h+0.007)^{1.5}$$

for h=0.3 to 1.1

$$q = 1.9[3.06(h+0.007)^{1.5} + 6.1(h-.302)^{1.5}]$$

Rating curve showing current meter measurements of discharge (cu m/sec), 1975 to date. The unbroken line is the discharge computed from the formula.



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RGS 4AB4 - Amboni River

The weir was surveyed and a rating developed from a compound weir formula.
Rating curve showing current meter measurements of discharge (cu m/sec). The unbroken line is the discharge computed from the formula. The MOWD rating is shown for comparison.

Formulae (h in m, q in cumec).

for h = 0 to 0.16

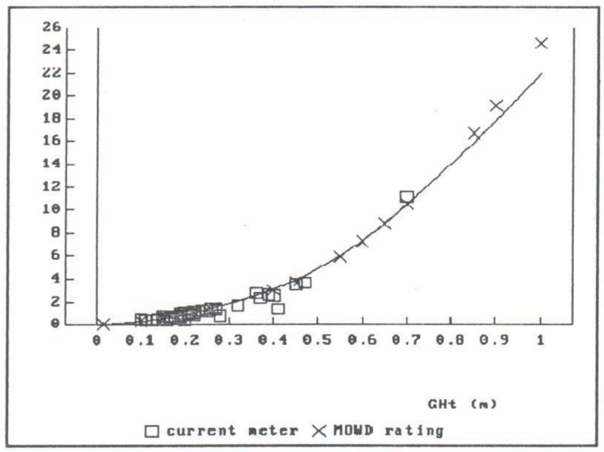
$$q=2.2[4.6-.2(h-.02)](h-.02)^{1.5}$$

for h = .16 to 0.46

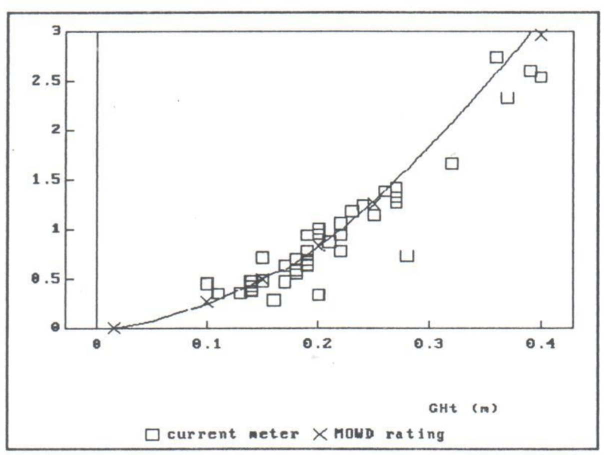
$$q=2.2[(4.6-.2(h-.02))(h-.02)^{1.5} + (3.05-.2(h-.16))(h-.16)^{1.5}]$$

for h = 0.46 to 1.1

$$q=2.2[4.6(h-.02)^{1.5} + 3.05(h-.16)^{1.5} + 8(h-.46)^{1.5}]$$



The lower part only of the above graph:

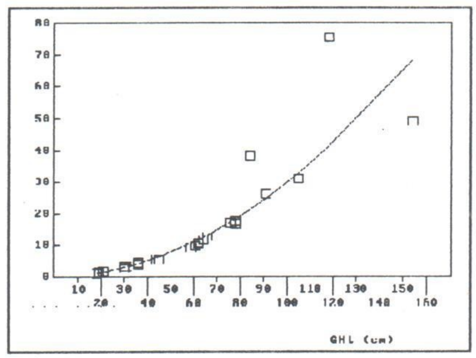


RGS 4AC4 - Chania River near the Prison

The first graph is for 1958-61:

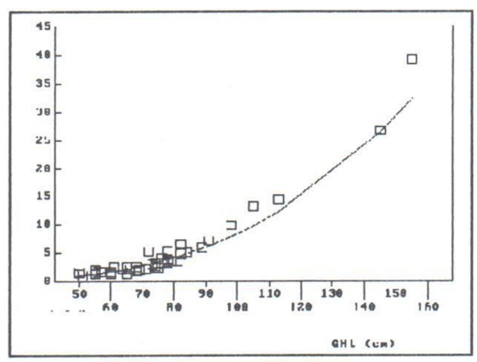
Formulae (q in l/s, h in cm)

$$q = 4.133\ h^{1.929}$$



1962-85:

$$q = 0.00515\ h^{3.104}$$



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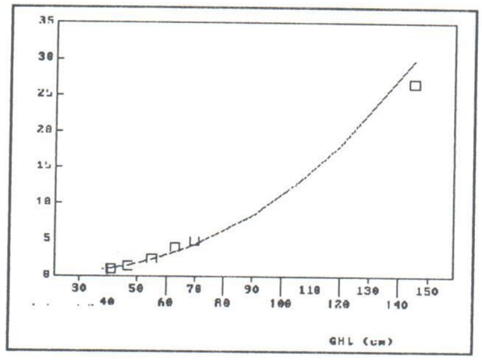
Rating curves

1985 to date:

$q = 0.0594\ h^{2.637}$



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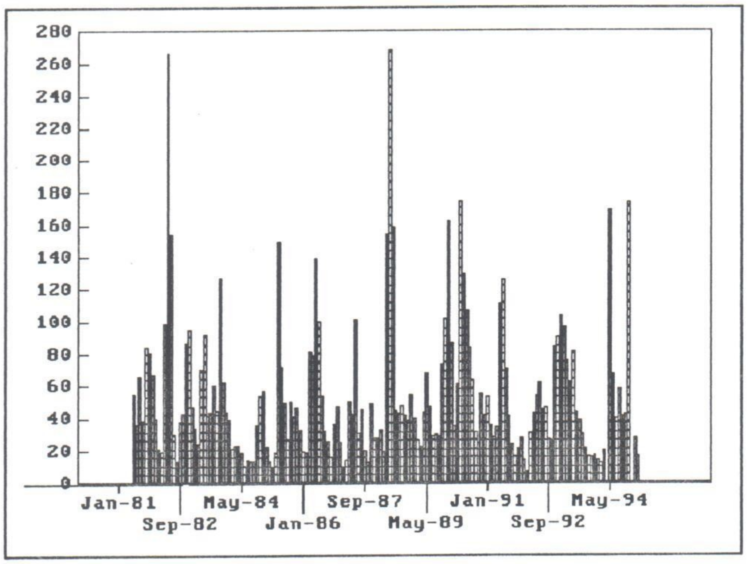
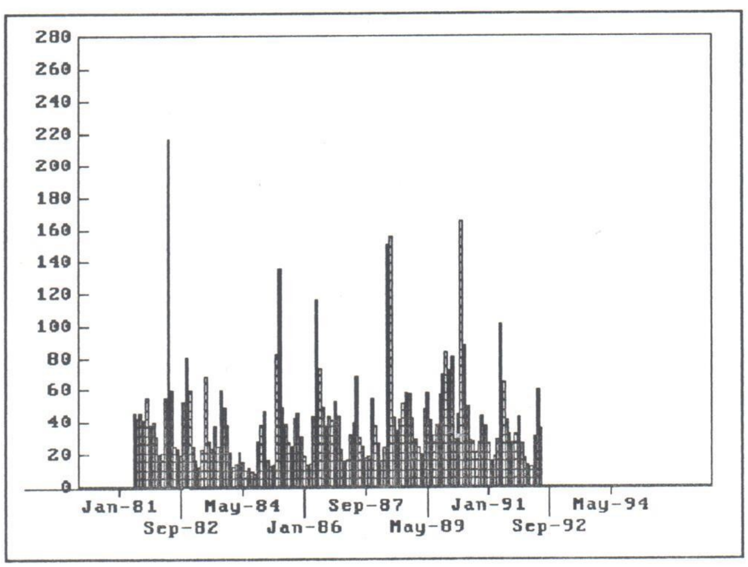
Chania River at 4AC5
catchment runoffs in mm



Chania River at 4AC4
catchment runoffs in mm



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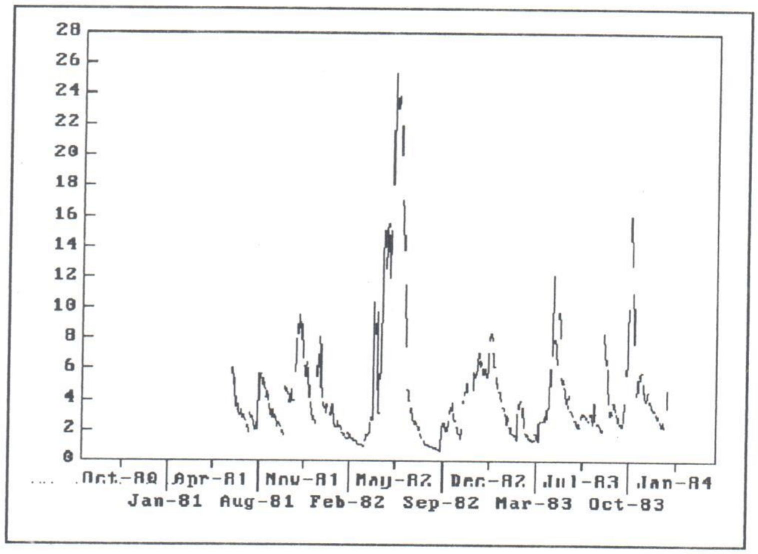
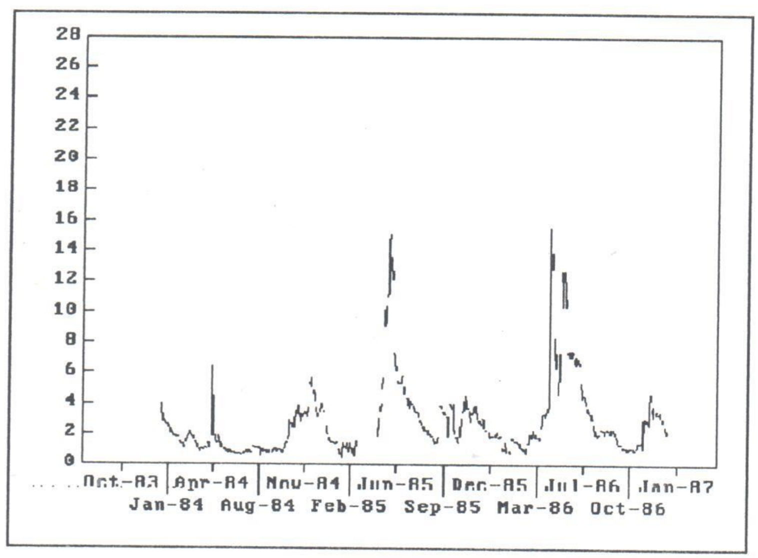
Chania River at 4AC5
Daily discharge in cu m/sec





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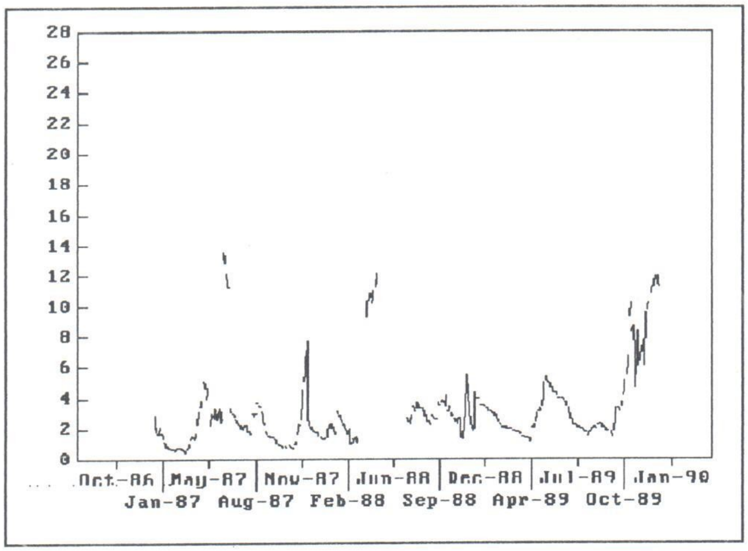
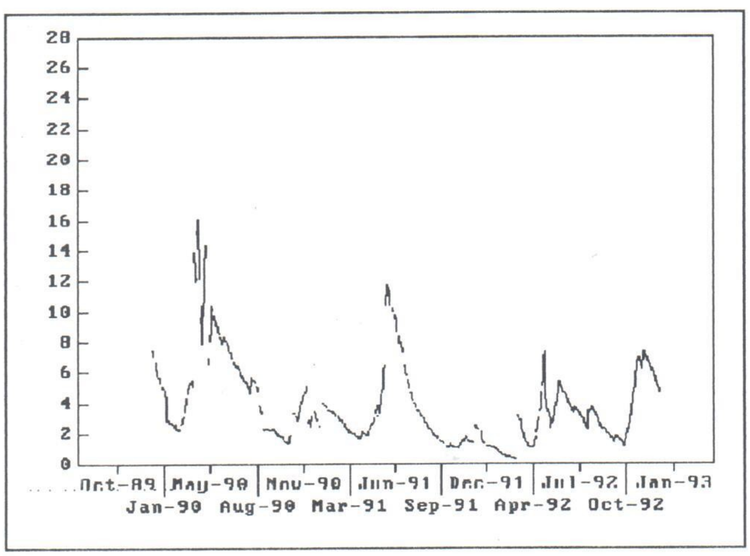
Hydrographs

Chania River at 4AC5

Daily discharge in cu m/sec





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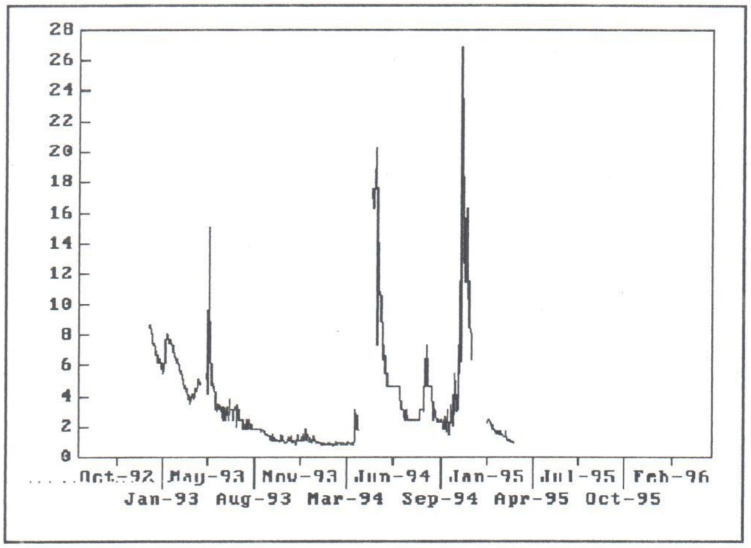
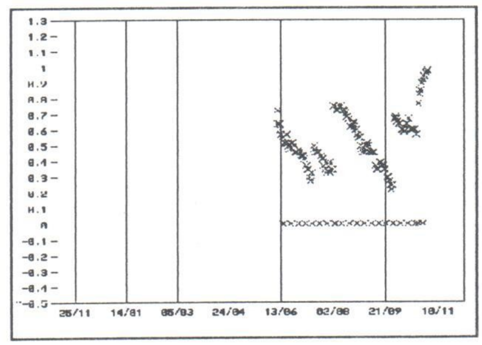
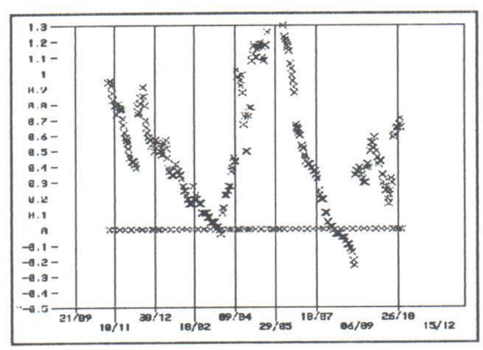
Chania River at 4AC5
Daily discharge in cu m/sec



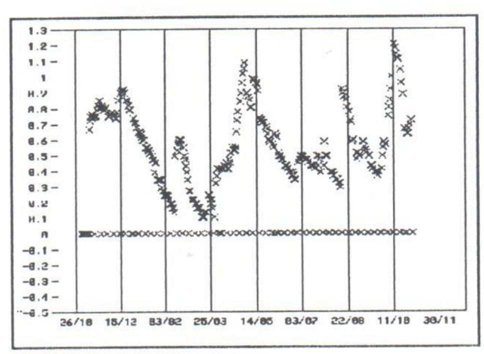
Logarithmic plots of river discharge for Chania River RGS 4AC5



1980 1981

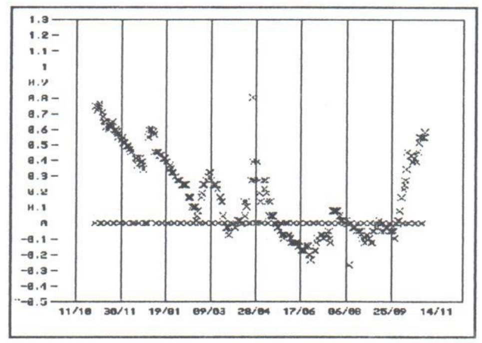


1981 1982

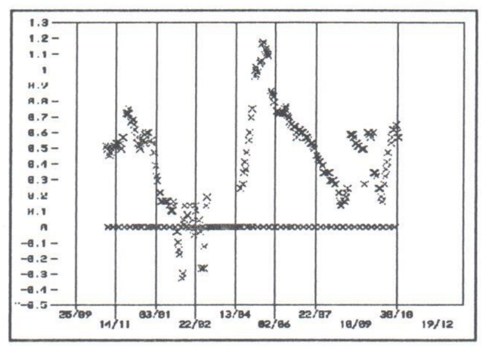


1982 1983

Logarithmic plots of river discharge for Chania River RGS 4AC5



1983 1984



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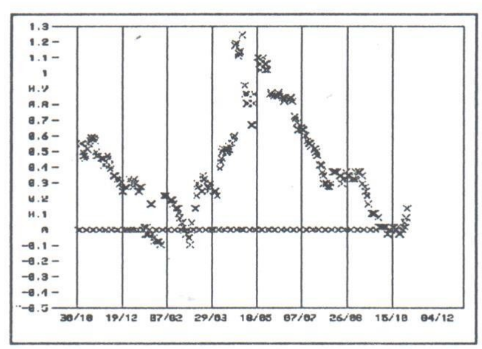

1985 1986

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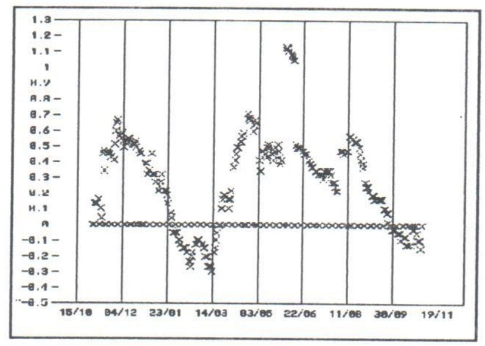
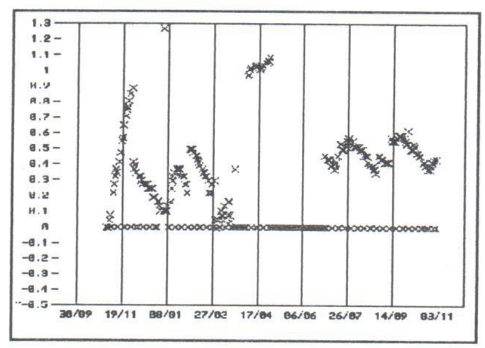
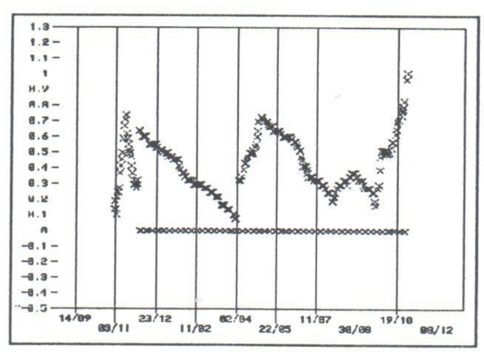
Logarithmic plots of river discharge for Chania River RGS 4AC5



1986 1987



1987 1988



1988 1989

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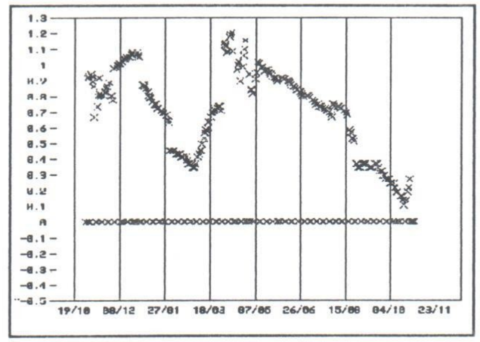
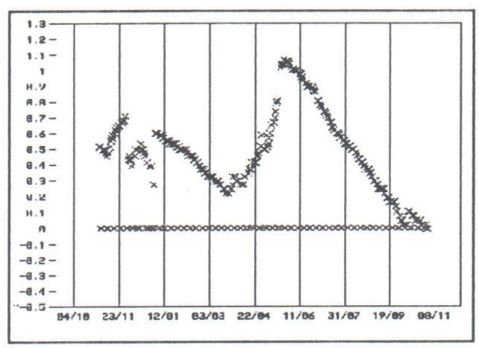
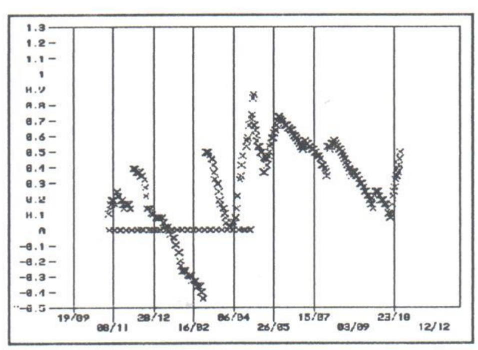
Logarithmic plots of river discharge for Chania River RGS 4AC5



1989 1990

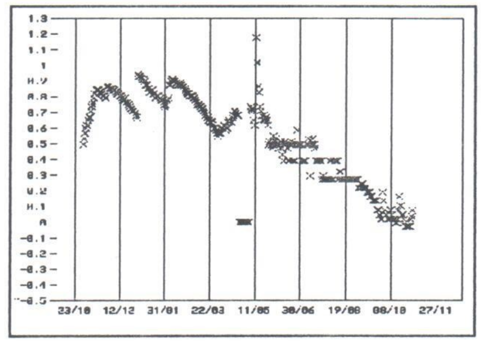


1990 1991

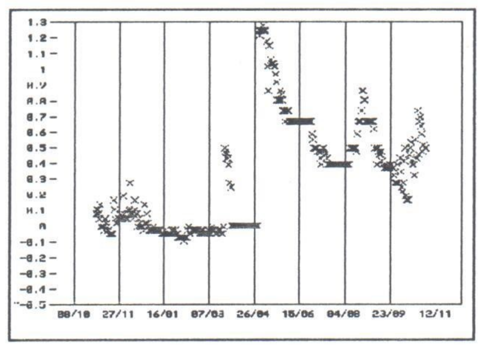


1991 1992

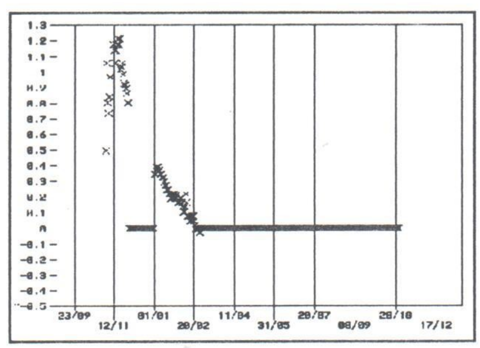
Logarithmic plots of river discharge for Chania River RGS 4AC5



1992 1993



1993 1994



1994 1995

ANNEX 5

Page

1. PREVIOUS REPORTS RELEVANT TO POPULATION & WATER DEMAND

Four sectorial reports have been obtained that are relevant to this study. These are:

1. National Master Water Plan Stage 1
   Tippetts-Abbett-McCarthy-Stratton, September 1980
2. The Study on the National Water Master Plan
   Japanese International Cooperation Agency July 1992
3. Nyeri Sewerage Scheme, Final Design Report
   Mangat, I.B. Patel September, 1978
4. Nyeri Water Supply, Preliminary & Final Designs
   Alexander Gibb & Partners, December, 1980 & 1982

The two National Water Plans give somewhat generalised information but are useful in putting the Municipality into a District and water catchment setting. Relevant information, mainly in tabular form has been abstracted and is summarised here.

The specific water supply and sewerage reports largely were produced prior to issuance of the 1979 population census although the preliminary water supply report had access to a 1978 population survey that gives it a reasonable base for projections of population and water demand, and the final water supply design report had access to raw data from the 1979 census.

1.1. <u>Nyeri and the National Water Master Plan Stage 1</u>

a) <u>Introduction</u>

Under the National Water Master Plan (NMWP) stage 1, population projections and demands were calculated and summarised on a river catchment by river catchment basis.

The catchments of interest are that of 4A and 4BA, the Sagana River, comprising four sub-basins, 4AA the Sagana River, 4AB the Muringato River, 4AC the Chania River, 4BA the Sagana River and 4AD the Gura River, although to a lesser extent.

The total catchment area covers some 2366 sq. km sub-divided as indicated in table 1.1:

TABLE 1.1: RIVER CATCHMENTS IN THE NYERI AREA

Catchment Ref	Principal River	Catchment Areas in sq. km			
4AA	SAGANA	507			
4AB	MURINGATO	698	1620		
4AC	CHANIA	415		1923	
4BA	SAGANA		303		2366
4AD	GURA			443	

Source: NMWP stage 1, Table B., Appendix II., Volume V

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b) Population Projections and Water Demand

Population projections and water demands were summarised in a number of tables, relevant information from which has been brought together here in the following table.

TABLE 1.2: POPULATION & WATER DEMAND PROJECTIONS FOR CATCHMENT 4A IN m^3/d

Category	1998	2000 (by interpolation)	2008
RURAL			
Population (no.):			
rural	588,712		798,703
rural centre	11,940		19,500
Total	600,652		818,203
Water Demand (m^3/d):			
Traditional	904		-
CWP's	8,685		11,562
Individ. Connect'ns	16,466		33,671
Institutions	8,575		14,904
Rural Centres	1,205		1,945
Livestock	26,274		39,397
Rural Total	62,109		101,479
URBAN			
Population (no.):			
principal towns	110,740	(123,372)	190,047
other urban	7,970		17,213
Total	118,710		207,260
Water Demand (m^3/d):			
Principal town	**15,507**	**(16,367)**	**26,602**
Other Urban	1,123		2,411
Urban Total	16,630		29,013
CATCHMENT TOTAL	78,739		130,492

Source: NMWP. Stage 1, Vol. III, Tables 10-15, 10-16, 14-5, & 14-6

The only principal town is Nyeri and population and water demand figures for year 2000 have been obtained by interpolation as indicated above. Per capita demand for year 2000 would be 133 l/p/d.

By extrapolation, figures for year 2010 would be 211,725 persons requiring 29,634 m^3/day, or 140 l/p/d.

c) Water Availability

Estimates of river flow were made as follows for catchment 4A

TABLE 1.3: FLOW ESTIMATES FOR CATCHMENT 4A IN mm

Mean Annual		50% Annual		80% Annual		95% Annual	
RAINFALL	RUNOFF	RAINFALL	RUNOFF	RAINFALL	RUNOFF	RAINFALL	RUNOFF
1,112	345	1,103	322	910	250	735	195

Source: NWMP, Stage I, Volume II, Table 3-9

The catchment area to the intake site which is also the location of river gauging station (RGS) 4AC5 is computed to be 174 km^2.

Based on 45 years of synthesised record for catchment 4AC with an area of 415 km^2 the following was given:

TABLE 1.4: SYNTHESISED RUNOFF FOR CATCHMENT 4AC - MEAN FLOW IN mm

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Mean	19.3	14.2	18.4	52.0	69.4	28.5	18.7	15.5	13.6	25.4	34.8	25.9	337.6
St. Dev.	6.5	3.5	11.7	43.1	38.9	9.5	4.3	3.3	3.1	30.7	45.1	10.8	107.4

Source: NMWP, Stage 1, Volume V, Report Appendices, Page II-53

Assuming that this data has a log-normal distribution with 50% probability at the mean value, then the frequency factor for a 95% low flow probability would be 1.65, and in the month of lowest expected flow, February, the low flow would therefore be 14.2 - (1.65 x 3.5), that is it would be approximately 8.4 mm/month or 52,000 m^3/day on a 174 km^2 catchment.

1.2 Nyeri and the Study on the National Water Master Plan

a) Introduction

The study on the National Water Master Plan (NWMP) was published in July 1992 but only made public in 1994.

Data was primarily compiled on a District basis. Limited cross-referencing to river catchments was made, mainly in final summary form.

As a part of the Study, a Water Resources Development and Use Plan towards 2010 was produced. The following data regarding Nyeri has been abstracted from that Plan.

b) Population and Industrial Growth

TABLE 1.5: INTERCENSAL COMPARISON OF 1979 CENSUS WITH 1989 CENSUS (PROVISIONAL RESULTS) FOR NYERI DISTRICT

1979 Census (1,000's)			1989 Census (1,000's)			Intercensal Growth Rate (%)		
TOTAL	URBAN	RURAL	TOTAL	URBAN	RURAL	TOTAL	URBAN	RURAL
486	41	446	613	98	515	2.34	9.16	1.45
POPULATION DENSITY IN 1989: 409 persons/sq. km.								
Source: Study on NWMP, Vol.1., July 1992, Table 2.5.1.								

TABLE 1.6: URBAN POPULATION OF MAJOR URBAN CENTRES : NYERI, 1979 AND 1989

Census Population		Change of Urban Population between two Census	
1979	1989	INCREMENT	ANNUAL GROWTH (%)
35,753	88,600	52,847	9.5
Source: Study on NWMP, Vol.1, July 1992, Table 2.5.2.			

Based on the NWMP countrywide evaluation, in 1979, Nyeri had 1.5% of the country's urban population of 2,315,696. By 1989, this had grown to 2.4% of the then urban population of 3,735,900.

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For Nyeri District the following were projected for the period up to year 2010.

TABLE 1.7.: POPULATION PROJECTED FOR NYERI DISTRICT 1990-2010 ('000)

1990			1995			2000			2005			2010		
TOT.	URB.	RUR.	TOT.	URB.	RUR.	TOT.	URB.	RUR.	TOT.	URB.	RUR.	TOT.	URB.	RUR.
647	107	540	706	162	544	804	243	561	929	318	611	1,084	412	673
Source: Study on NWMP, Vol 1, July 1992, Table 4.1.1.														

For the towns in Nyeri District, the Study predicted the following:

TABLE 1.8.: PROJECTED URBAN POPULATION BY TOWN: 1990-2010 ('000)

Town Name	Location	Projected Urban Population				
		1990	1995	2000	2005	2010
Naro Moru	Kamburaini	0.0	0.0	0.6	0.8	0.9
Mweiga	Mweiga	0.0	0.0	0.4	0.5	0.6
Karatina	Kirimukuyu	5.4	8.2	12.2	16.0	20.6
Ihururu	Muhoya	0.0	0.0	0.3	0.4	0.4
Othaya	Karima	4.8	7.3	10.8	14.2	18.3
Nyeri	Nyeri Municipal	97.0	146.7	218.6	286.7	370.7
Note:	Zero figures in 1990 and 1995 mean that these rural centres are assumed to be raised to the status of urban centres by year 2000.					
Source: Study on NWMP, Vol 1., July 1992, Table 4.1.2.						

The Study also made projections on likely value of manufacturing on a District basis. For Nyeri District this was as follows:

TABLE 1.9.: DISTRICT DISTRIBUTION OF VALUE ADDED BY MANUFACTURING INDUSTRY AT 1988 CONSTANT PRICES : 1988-2010 (K.Shs x 10^6)

1988	1990	1995	2000	2005	2010
361.6	417.9	600.0	861.2	1097.1	1397.3
Source: Study on NWMP, Vol.1., July 1992, Table 4.1.5.					

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Land use in Nyeri District was considered, and the following projected:

TABLE 1.10.: LAND USE IN NYERI DISTRICT IN sq. km.

YEAR	TOTAL AREA	LAND AREA	WATER AREA	FOREST & PARK	SWAMP	TOWN SHIP	BARREN	AGRI-CULTURAL	OTHER
1990	3,284	3,284	0	1,526	0	60	5	1,104	589
2010	3,284	3,284	0	1,526	0	80	5	1,299	374

Source: Study on NWMP, Vol.1, July 1992, Tables 5.3.1., and 6.3.3.

c) Water Demand

National guidelines for water supply are published in the Design Manual of the former Ministry of Water Development (MOWD). The following tables have been abstracted from the Study on the National Water Master Plan, and are based on this.

TABLE 1.11.: CONNECTION RATE BY SERVICE TYPE IN %

Type	Indiv. Connection Rate			Non Indiv. Connection Rate		
	Initial	Future	Ultimate	Initial	Future	Ultimate
URBAN						
High and medium Class House	100	100	100	0	0	0
Low Class Housing	10	30	50	90	70	50
RURAL AREA						
High Potential	20	40	80	80	60	20
Medium PotentiaL	10	20	40	90	80	60
Low Potential	5	10	20	95	90	80

Source: Study on NMWP, MOWD Design Manual; Table 4.1 (Table 4.2.1), Vol.1., July 1992

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TABLE 1.12.: UNIT CONSUMPTION RATES

Consumer	Unit	Rural Areas			Urban Areas		
		HIGH POTENTIAL	MEDIUM POTENTIAL	LOW POTENTIAL	HIGH CLASS HOUSING	MEDIUM CLASS HOUSING	LOW CLASS HOUSING
People w/IC	l/c/d	60	50	40	250	150	75
People w/o IC	l/c/d	20	15	10	-	-	20
Livestock Unit	l/LU/d	50	50	50			
Boarding Schools	l/c/d	50	50	50	50	50	50
Day Schools w/WC	l/c/d	25	25	25	25	25	25
Day Schools w/oWC	l/c/d	5	5	5	5	5	5
Hospitals							
Regional	l/bed/d	400	plus 20 litre per outpatient per day (minimum 5,000 l/day)				
District	l/bed/d	200					
Others	l/bed/d	100					
Dispensary and Health Centre	l/d	5,000	5,000	5,000	5,000	5,000	5,000
Hotels							
High Class	l/bed/d	600	600	600	600	600	600
Medium Class	l/bed/d	300	300	300	300	300	300
Low Class	l/bed/d	50	50	50	50	50	50
Administrative Offices	l/c/d	25	25	25	25	25	25
Bars	l/d	500	500	500	500	500	500
Shops	l/d	100	100	100	100	100	100
Unspecified Industry	l/ha/d	20,000	20,000	20,000	20,000	20,000	20,000
Coffee Pulping Factories	l/kg coffee	25	25	25	25	25	25

NOTES: w/ = with w/o = without
IC = Individual Connection WC = Water Closet LU = Livestock Unit

Source: Study on NWMP, Vol.1.July 1992, MOWD Design Manual, (Table 4.2.2)

TABLE 1.13.: UNIT WATER CONSUMPTION RATE BY INDUSTRIAL TYPE: 1989-2010

ITEM		FOOD BEVERAGES & TOBACCO	TEXTILE APPAREL & LEATHER	WOOD & WOOD PRODUCTS	PAPER PRODUCTS & PRINTING	CHEMICALS & PETROLEUM PRODUCTS	NON-METALIC MINERAL PRODUCTS	BASIC METAL INDUSTRIES	MACHINERY & EQUIPMENT	OTHERS	MANUFACT-URING INDUSTRY
1. Value Added in 1988 (K.£ 1,0000)		321,164	81,511	22,892	61,902	132,129	37,175	47,438	76,372	16,978	797,561
2. Total Units of Manufacturing Establishment (Nos)		678	398	442	283	211	98	19	304	94	2,527
3. Value Added per Establishment (KShs.1,000)		9,474	4,096	1,084	4,374	12,524	7,586	49,934	5,024	3,612	6,312
4. Unit Water Consumption Rate per Value Added (c.m./day/KShs.billion(at 1989 prices *1))		5,617	8,443	732	19,471	26,521	8,561	51,738	3,654	1,360	13,015
5. Unit Water Replenishment (Raw Water) Rate per Value Added (c.m./day/KShs.billion (at 1989 prices *1))		3,300	6,794	655	11,394	5,295	2,327	6,211	698	568	3,287
6. Unit Water Replenishment Rate in the Projection (cu.m./day/KShs.billion (at 1989 prices *1))											
a.	1989 *2	5,617	8,443	732	19,471	26,521	8,561	51,738	3,654	1,360	13,015
b.	1990	5,562	8,404	730	19,279	26,015	8,413	50,654	3,584	1,341	12,784
c.	1995	5,286	8,207	721	18,317	23,489	7,671	45,234	3,232	1,247	11,626
d.	2000	5,010	8,011	712	17,356	20,962	6,928	39,814	2,880	1,153	10,468
e.	2005	4,734	7,815	703	16,394	18,435	6,186	34,394	2,528	1,058	9,309
f.	2010 *2	4,459	7,618	694	15,433	15,908	5,444	28,974	2,176	964	8,151
REFERENCE:	Unit Rates for Industrial Development in Japan (1986)										
1. Number of Samples		7,479	7,460	2,303	4,582	5,847	2,898	2,206	24,312	1,262	58,349
	Numbers of Firms (Nos.)										
2.Unit per Firm											
	Employees	97	80	72	98	129	88	197	151	86	122
	Production (Million Yen)	3,116	931	1,397	2,757	5,956	1,916	8,192	4,248	1,994	3,605
	Value Added (Million Yen)	903	350	511	1,146	2,178	893	2,294	1,368	774	1,195
	Yard Area (sq.m)	14,048	9,391	16,721	13,526	46,430	35,927	103,232	18,025	9,360	22,776
	Water Consumption (cu.m./day)	762	444	56	3,351	8,674	1,148	17,823	751	158	2,336
	Water Replenishment (cu.m./day)	448	357	50	1,961	1,732	312	2,140	143	66	590
3. Water Recovery Rate (%)		41	20	11	42	80	73	88	81	58	75
4. Drained-to-Replenished Rate (%)		36	38	51	84	7	22	9	29	16	21
5. Unit Rate (cu.m./KShs.billion(at 1989 prices)) *3											
	Water Consumption per Production	1,628	3,177	268	8,094	9,700	3,991	14,491	1,177	528	4,316
	Water Consumption per Value Added	5,617	8,443	732	19,471	26,521	8,561	51,738	3,654	1,360	13,015
	Water Consumption per Yard Area (cu.m./day/ha)	542	473	34	2,477	1,868	320	1,727	416	169	1,026
	Water Replenishment per Production	957	2,556	240	4,737	1,937	1,085	1,740	225	220	1,090
	Water Replenishment per Value Added	3,300	6,794	655	11,394	5,295	2,327	6,211	698	568	3,287

Remarks:

*1 Refer to the below REFERENCE

*2 Whole water consumed in processing is assumed to be supplied by a water supply system. However, a water recirculation system will be introduced into the manufacturing process, though its recirculation rate is assumed to be a half of volume mentioned in Row 5 by the year 2010.

*3 To convert the 1986 value to the 1989 value in Japan, the overall wholesale price index of manufacturing industry products was applied, with was 0.994 between the years. the foreign exchange rate in 1989 was K.Shs.21.6/US$ and JY143/US$

Source: Study on NWMP, Vol 1., July 1992, Table 4.2.3.

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Based on earlier projections and the estimated breakdown of water consumption by industrial type and probable location, industrial water demands were computed on a District basis. For Nyeri they were as follows:

TABLE 1.14.: DISTRIBUTION OF INDUSTRIAL WATER REQUIREMENT: 1989-2010 IN m^3/day IN NYERI DISTRICT

1989	1990	1995	2000	2005	2010
2,361	2,521	3,380	4,570	5,417	6,407

Source: Study on NWMP, Vol.1., July 1992, Table 4.2.4.

It was then possible to summarise water demand projections for the entire District as follows:

TABLE 1.15.: DOMESTIC & INDUSTRIAL WATER DEMAND IN NYERI DISTRICT

Category	1990	2000	2010
RURAL			
Population (no)	540,096	560,697	672,814
Residential Demand (m^3/d)	13,540	17,832	30,458
Non Residential Demand (m^3/d)	4,484	4,656	5,583
Total Rural Water Demand (m^3/d)	18,024	22,488	36,041
URBAN			
Population (no)	107,200	242,904	411,536
Residential Demand (m^3/d)	13,279	30,758	53,242
Non Residential Demand (m^3/d)	2,221	5,034	8,529
Total Urban Water Demand	15,500	35,792	61,771
OTHER			
Livestock Water (m^3/d)	3,916	4,427	5,989
Industrial Water (m^3/d)	2,521	4,570	6,407
Total Demand (m^3/d)	39,961	67,277	110,208
PER CAPITA DEMAND (l/p/d)	62	84	102

Source: Study on NWMP, Vol.1., July 1992, Tables 4.2.5., 4.2.6., & 4.2.7

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Specific figures for Nyeri Municipality as presented are as follows:

TABLE 1.16.: NYERI MUNICIPALITY WATER DEMAND PROJECTIONS

PRESENT RAW WATER SOURCE	PRESENT W/S CAPACITY m^3/d	POPULATION			DEMAND			1990 COVERAGE
		1990	2000	2010	1990	2000	2010	%
Chania R.	5,890	97,000	218,600	370,700	15,559	35,042	59,718	37.86

Source: Study on NWMP, Vol.1., July 1992, Table 3.1.

c) **Water Availability**

The catchment areas recorded by the NWMP for the five sub-basins comprising the 4A and 4BA Sagana River catchment are as follows:

TABLE 1.17.: NYERI CATCHMENTS AND AREAS

Catchment Ref	Principal River	Catchment Areas in sq. km			
4AA	SAGANA	519	1632	1949	2390
4AB	MURINGATO	684			
4AC	CHANIA	429			
4BA	SAGANA		317		
4AD	GURA			441	

Source: Study on NWMP, Vol.1., July 1992, Table 5.5.4.

According to the NWMP Study, the balance between water demands and potential available water is as follows for the Sagana River system.

TABLE 1.18.: WATER BALANCE FOR CATCHMENTS IN NYERI AREA IN m^3/day

SUB DRAIN-AGE AREA	WATER DEMAND			SAFE YIELD SURFACE WATER	SAFE YIELD GROUND WATER	TOTAL	DEFICIT		
	1990	2000	2010	(10% PROB)			1990	2000	2010
4AA	2,905	3,768	5,866	42,336	217	42,553			
4AB	12,070	25,947	44,069	25,056	451	25,507	-	-440	-18,562
4AC	10,133	17,674	29,295	203,040	184	203,224			
4AD	6,661	9,321	14,793	864	316	1,180	-5,481	-8,141	-13,613
TOTAL 4A	31,769	56,710	94,023	271,296	1,168	272,464	NIL		
4BA	6,265	8,406	12,892	27,648	405	28,053			

Source: Study on NWMP, Vol.1., July 1992, Table 4.7.2.

It is believed that the water demand shown in table 1.18 for Nyeri Municipality is spread between sub-drainage areas 4AB and 4AC.

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The 1 in 10 year flow for catchment 4AC of 203,040 m^3/day would seemingly apply to the entire 429 km^2 catchment, compared to the 174 km^2 of the present, and probable, future water source. The figure is equivalent to 14.2 mm/month, or 82,000 m^3/day at the present intake site.

d) **Cost Estimates**

Implementation plans giving cost and recommended construction periods are also given. For Nyeri they are as follows:

TABLE 1.19.: NWMP COST ESTIMATES FOR WATER, SEWERAGE & DRAINAGE FOR NYERI MUNICIPALITY

Scheme	Cost US$	Implementation Period	Water Source
Nyeri Water Supply	50,300,000	1996-97	Chania River gravity, run-of- river
Nyeri Sewerage	23,740,000	1996-97 & 2005-06	
Nyeri Drainage	13,100,000	2002-04	

Source: Study on NWMP, Vol 2., July 1992, Tables 3.3, 3.6, & 3.13.

1.3 Nyeri Sewerage - Report of 1979

a) Introduction

The Nyeri Sewerage Scheme report was not directly concerned with water demand but had to evaluate Municipal population and in order to estimate sewage flows had to make demand estimates for certain areas within the Municipality.

b) Population and Institutions

Population projections made for this sector were as follows:

TABLE 1.20.: POPULATION ESTIMATES - NYERI SEWERAGE SCHEME FOR NYERI MUNICIPAL AREA AS AT 1979

Location	Year					
	1978	1980	1985	1990	1995	2000
Urban	11,563	12,446	14,961	17,985	21,620	25,990
Future Urban Centres	11,122	11,972	14,391	17,300	20,796	25,000
Rural	14,440	15,314	17,759	20,587	23,867	27,668
Totals	36,786	39,366	46,672	55,344	65,649	77,894

Source: Nyeri Sewerage Scheme, Final Design Report, Table 3.1.

For the phase I Sewerage Scheme (1990) the following was computed, together with estimated saturation populations for these planned areas.

TABLE 1.21.: POPULATIONS IN PLANNED PARTS OF MUNICIPALITY

Planned Area	1990 Pop.	2000 Pop.	Ultimate Population
Nyeri Urban	17,985	25,990	25,995
Kamakwa	2,768	4,000	4,000
Ruringu	5,882	8,500	8,500
Total	26,635	38,490	38,495
Kiganjo Urban	1,799	2,600	
GRAND TOTAL	28,434	41,090	

Source: Nyeri Sewerage Scheme, Final Design Report, Table A & Table 3.4.

Estimates of population densities at ultimate land capacity for formalised residential development were also made:

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TABLE 1.22.: ULTIMATE RESIDENTIAL LAND CARRYING CAPACITY

Classification	Density (persons/ha)
Low Density	40
Medium Density	130
High Density	300
Source: Nyeri Sewerage Scheme, Final Design Report, Table 3.3.	

A detailed assessment for formal development areas and residential populations in Nyeri Town and Ruringu was also made based on these densities:

TABLE 1.23.: DEVELOPMENT AREAS AND RESIDENTIAL POPULATIONS

DURPP Ref.	Description	Ultimate Pop. Dens. (p/ha)	Area (ha)	Population in 1980	Ultimate Population Capacity
0_{1}	Site & Services Scheme	300	8.3	1,070	1,079
0_{2}	Medium Density Residential	130	1.1	143	143
0_{3}	High Density Residential	300	1.1	330	330
0_{4}	M.O.W. staff housing	-	2.0		
0_{5}	M.O.W. staff housing	-	1.6	870	870
0_{6}	M.O.W. staff housing	-	0.7		
0_{7}	Liable to flooding	-	-	-	-
0_{8}	High Density Residential	300	6.1	1,500	1,830
0_{9}	Medium Density Residential	130	12.1	1,300	1,573
0_{10}	Low Density Residential	40	14	500	576
0_{11}	Low Density Residential	40	3.1	76	124
0_{12}	Low Density Residential	40	1.6	60	64
0_{13}	Low Density Residential	40	12.8	500	512
0_{14}	Low Density Residential	40	4.4	100	176
0_{15}	Low Density Residential	40	4.0	100	160
0_{16}	Low Density Residential	40	1.6	50	64
0_{17}	Low Density Residential	40	4.7	100	188
0_{18}	Low Density Residential	40	13.8	200	552
0_{19}	Low Density Residential	40	33.2	500	1,328
0_{20}	Medium Density Residential	130	7.7	500	1,000
0_{21}	Medium Density Residential	130	4.0	260	520
0_{22}	Medium Density Residential	130	1.1	120	143
0_{23}	Medium Density Residential	130	2.2	260	286
0_{24}	Kimathi Estate (med. den. res.)	130	5.1	350	663
0_{25}	Police staff housing	-	2.6	342	350
0_{26}	Low Density Residential	40	13.4	400	536
0_{27}	Medium Density Residential	130	5.2	-	676
0_{28}	Low Density Residential	40	1.6	48	48
0_{29}	Medium Density Residential	130	5.4	650	702
0_{30}	High Density Residential	300	12.1	3,630	3,630
0_{31}	High Density Residential	300	5.1	500	1,530
0_{32}	High Density Residential	300	5.2	-	1,560
0_{33}	High Density Residential	300	8.6	-	2,580
0_{34}	High Density Residential	300	5.3	-	1,590
0_{35}	Medium Density Residential	130	9.7	-	1,261
0_{36}	Medium Density Residential	130	2.0	150	260
0_{37}	Medium Density Residential	130	2.0	200	260
0_{38}	Low Density Residential	40	6.2	50	248
0_{39}	Medium Density Residential	130	1.4	50	182
0_{40}	High Density Residential	300	3.2	200	960
	TOTAL RESIDENTIAL		235.7	15,109	28,554

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TABLE 1.23. (cont'd)

DURPP Ref.	Description	Ultimate Pop. Density (p/ha)	Area (ha)	Population in 1980	Ultimate Population Capacity
1_{1}	Mt. Kenya Bottlers	-	9.1	-	-
1_{2}	Industrial	-	11.1	-	-
1_{3}	Small Scale Industrial	-	4.3	-	-
1_{4}	Industrial	-	4.1	-	-
1_{5}	Sawmill	-	1.9	-	-
1_{6}	Workshops	-	1.0	-	-
1_{7}	Workshops	-	5.2	-	-
1_{8}	Workshops	-	0.8	-	-
1_{9}	Workshops	-	0.5	-	-
1_{10}	Workshops	-	1.1	-	-
	TOTAL INDUSTRIAL		39.1	-	-
4_{1}	Prison	-	26.6	700	1,200
4_{2}	Masonic Lodge, Bar & Restaurant	-	2.9	20	20
4_{3}	Ministry of Works	-	1.2	-	-
4_{4}	Future Public Purpose	-	0.2	-	-
4_{5}	Future Public Purpose	-	1.9	-	-
4_{6}	Outspan Hotel (100 beds)	-	19.6	295	300
4_{7}	Mt. Kenya Hospital (17 beds)	-	3.2	76	80
4_{8}	Future Public Purpose	-	1.1	-	-
4_{9}	Future Public Purpose	-	0.5	-	-
4_{10}	Traditional Village	-	1.9	-	60
4_{11}	White Rhino Hotel (40 beds)	-	1.1	75	75
4_{12}	Public Purpose	-	1.0	-	-
4_{13}	Fire Station, Church & Mosque	-	2.1	-	-
4_{14}	Future Public Purpose	-	3.4	-	-
4_{15}	Cathedral	-	2.2	-	-
4_{16}	Future Public Purpose	-	4.4	-	-
4_{17}	Provincial Hospital	-	10.1	732	1,600
4_{18}	Future Public Purpose	-	1.7	-	-
4_{19}	Baptist Mission	-	1.0	-	-
4_{20}	Cemeteries	-	5.0	-	-
4_{21}	Veterinary Department	-	0.4	-	-
4_{22}	Church & Cemetery	-	2.1	-	-
4_{23}	Provincial. Police HQ & Law Courts	-	7.1	-	-
4_{24}	Provincial Administration	-	1.6	-	-
4_{25}	Provincial Administration	-	1.3	-	-
4_{26}	Town Hall	-	1.4	-	-
4_{27}	Municipal Administration	-	0.7	-	-
4_{28}	Police	-	2.0	-	-
4_{29}	Temple	-	0.5	-	-
4_{30}	Temple	-	1.2	-	-
4_{31}	Future Public Purpose	-	0.8	-	-
4_{32}	Cemetery	-	1.7	-	-
4_{33}	Future Public Purpose	-	4.4	-	-
4_{34}	County Council, Library, Public Purpose	-	5.6	-	-
4_{35}	Future Public Purpose	-	5.6	-	-
4_{36}	Ministry of Works Camp	-	1.1	250	250
4_{37}	Hostel, Police Lines	-	3.3	224	250
4_{38}	Tetu Divisional HQ	-	1.5	-	-
4_{39}	Juvenile Remand Home	-	0.6	50	50
4_{40}	Police Training School	-	1.7	50	50
4_{41}	Future Public Purpose	-	0.5	-	-
4_{42}	Community Development Centre	-	0.9	-	-
4_{43}	Children's Home	-	1.2	25	25
4_{44}	Stadium	-	5.5	-	-
	TOTAL PUBLIC PURPOSES		143.8	2,497	3,960

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TABLE 1.23. (cont'd)

DURPP Ref.	Description	Ultimate Pop. Density (p/ha)	Area (ha)	Population in 1980	Ultimate Population Capacity
2_1	Government Primary School	-	28.4	310	515
2_2	Future Primary and Nursery School	-	1.9	-	-
2_3	Future Nursery School	-	0.6	-	-
2_4	Future Primary School	-	1.9	-	-
2_5	Nursery School	-	0.4	-	-
2_6	Secondary Technical School	-	19.0	770	770
2_7	Prim. & Tech. School, Temple Rd.	-	2.8	-	-
2_8	Future Secondary School	-	4.4	-	-
2_9	Medical Training College	-	3.0	-	-
2_{10}	D.E.B. Pr.Sch. & St. Mary's S. Sch.	-	5.0	-	-
2_{11}	Nursery School	-	0.2	-	-
2_{12}	Primary Nursery School	-	2.2	-	-
2_{13}	Future Nursery School	-	0.2	-	-
2_{14}	Future Nursery School	-	0.4	-	-
2_{15}	Future Primary School	-	2.2	-	-
2_{16}	Future Nursery School	-	0.3	-	-
2_{17}	Future Nursery School	-	0.3	-	-
2_{18}	Primary School,(future housing)	(130)	2.6	-	338
2_{19}	Sec. Sch, & Future Pr. Sch. (Ruringu)	-	2.1	-	
2_{20}	Federal High School (Kamakwa)	-	-	170	170
	TOTAL SCHOOL		77.9	250	2,123
5_1	Business cum Residential	73	0.5	-	36
5_2	Business cum Residential	73	0.2	-	15
5_3	E.A.P. & L & Future Commercial	73	0.5	-	37
5_4	Bank	73	0.4	-	29
5_5	Bank	73	0.8	-	58
5_6	Business cum Residential	73	6.8	306	496
5_7	Business cum Residential	73	0.5	23	36
5_8	Business cum Residential	73	3.3	149	241
5_9	Market	73	0.4	18	29
5_{10}	Commercial	73	0.7	-	51
5_{11}	Business cum Residential	73	0.3	14	22
5_{12}	Business cum Residential	73	1.3	58	95
5_{13}	Future Business cum Residential & Car Park	73	0.7	32	51
5_{14}	Future Business cum Residential	73	1.4	-	102
5_{15}	Future Business cum Residential	73	2.4	-	175
5_{16}	Business cum Residential	73	3.2	144	234
5_{17}	Future Business cum Residential	73	0.7	-	51
5_{18}	Commercial	73	0.3	-	22
5_{19}	Future Business cum Residential	73	2.4	-	175
5_{20}	Future Market and Commercial	73	0.7	-	51
	TOTAL BUSINESS & COMMERCIAL		27.5	744	2,006
	Areas noted in the Advisory Plan as Deferred but since allocated or for which uses have been re-allocated.				
8_1	Site & Services	300	4.7	600	1,410
8_2	Industrial	-	8.5	-	-
3_9 (part)	Youth Hostel	-	not known	-	150
3_9	PCCA Hostel	-	not known	-	150
3_{12}	KIGWU Housing (Medium Density)	130	1.1	-	142
	TOTAL ADDITIONAL AREAS		14.3	600	1,852
	TOTALS		538.3	20,200	38,495

Source: Nyeri Sewerage Scheme, Final Design Report, Table 3.4.

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School and day schooling estimates were made on the assumptions as indicated below:

TABLE 1.24.: SCHOOL SIZES

School Type	
Nursery School	420 pupils/ha
Primary School	420 pupils on 1.6 ha
Secondary School	720 - 1200 pupils on 6 ha

Source: Nyeri Sewerage Scheme, Final Design Report, Section 3.2.2.

Existing schools were listed, together with details of pupils and staff

TABLE 1.25.: SCHOOLS IN NYERI IN 1980

Name	Day Pupils	Boarders	Staff
Nyamachaki Primary School	655		17
Temple Road Primary School	517		15
Githwariga Primary School	724		21
D.E.B. Muslim Primary School	451		13
Ngangarithi Primary School	430		13
Riamukurwe Primary School	683		20
Thunguma Primary School	592		17
Kiganjo Primary School	455		13
Muringato Primary School	180		8
Kamuyu Primary School	472		13
Nyeri Primary School	380	250	70
Kerichu Primary School	920		24
St. Theresa's Primary School		197	9
Kamwenja Primary School	390		11
Hillfarm Primary School	516		18
Nyaribo Primary School	583		15
<u>Secondary Schools</u>			
Kagumo High		760	55
Nyeri High	518		21
Thunguma	438		13
Temple Road	300		11
St. Mary's	288		5
Nyeri Baptist		150	9
Federal	180	120	9
Ruringu	172		7
St. Paul's Seminary	108		7
Kirichu	78		3
Nyeri Sec. Technical School		600	

Source: Nyeri Sewerage Scheme, Final Design Report, Table 3.5.

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Projections for commercial area requirements were also made:

TABLE 1.26.: COMMERCIAL AREA REQUIREMENTS IN NYERI

Area	1978	1980	1985	1990	1995	2000
Nyeri Town + Ruringu	15. 9	17.8	21.4	25.1	30.2	36.4
Kamakwa + Kamuyu	5.7	6.2	7.5	9.0	10.8	13.1
Thunguma	3.3	3.6	4.3	5.0	6.1	7.4
Kiganjo	3.5	3.9	4.8	5.7	6.8	8.0
Kirichu	2.3	2.5	3.0	3.7	4.4	5.4
TOTALS	30.7	34.0	41.0	48.5	58.3	70.3

Source: Nyeri Sewerage Scheme, Final Design Report, Table, Section 3.2.3.

A range of possible industrial development was projected:

TABLE 1.27.: DEMAND FOR INDUSTRIAL LAND IN NYERI

Area (ha)	1978	1980	1985	1990	1995	2000
Low Estimate	17	21	28	37	52	72
High Estimate	34	42	56	74	104	144

Source: Nyeri Sewerage Scheme, Final Design Report, Table Section 3.2.4.

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1.4. Nyeri Water Supply - Report of 1982

a) Introduction

Estimates of population and its projection were made as part of the Nyeri Water Design study in 1980-1982.

b) Population and Institutions

The report quoted the results of the 1979 census on a ward basis and totalling to 35,316 persons as follows:

TABLE 1.28.: RESULTS OF 1979 CENSUS

Ward	1979 population
Kimathi or Central	1,853
Ngangarithi	2,525
Kamakwa	2,812
Chanya	3,223
Mathari	3,977
Ruringu	4,313
Majengo	4,663
Nyaribu	4,521
Kiganjo	2,625
Mt. Kenya	1,691
Blue Valley	3,109
Source: Nyeri Water Supply, Preliminary Design Report, 1980; Table, Section 4.3.2	

Ultimate land carrying capacities for residential populations were given for formal areas as follows:

TABLE 1.29.: ULTIMATE LAND CARRYING CAPACITIES

Area	Ultimate Population
Nyeri Town	25,515
Thunguma	6,000
Ruringu	8,500
Kiringaini	400
Kamuyu	3,500
Kamakwa	4,000
Total (exc. Kiganjo)	47,915
Source: Nyeri Water Supply, Preliminary Design Report, 1980; Section 4.6.2.	

Land Use was estimated to be as follows:

TABLE 1.30.: LAND USE IN NYERI MUNICIPALITY IN 1979 IN ha

YEAR	TOTAL AREA	FOREST & PARK	SWAMP	URBAN	IDLE	BUSH	AGRICULTURAL		
							PAST-URE	INT-ENSIVE	EXT-ENSIVE
1978	5242.6	115.5	0	979.7	159.9	595.6	743.2	2140.7	508.0

Source: Nyeri Water Supply, Preliminary Design Report, 1980; Table 4.1.

Existing schools were listed, together with details of pupils and staff

TABLE 1.31.: PRIMARY SCHOOLS IN NYERI IN 1978

Name	Present No's	By year 2000
PRIMARY BOARDING SCHOOLS		
Nyeri Primary	743	1,714
St Terezas	236	544
Sub- total	979	2,258
PRIMARY DAY SCHOOLS		
Temple Road	529	1,220
Muslim	454	1,047
Nyamachaki	849	1,958
Githwariga	806	1,859
Muringato	217	500
Nyaribu	664	1,531
Kiganjo	484	1,116
Hill Farm	615	1,418
Kamwenja	411	948
Mwenji	545	1,257
Kamuyu	511	1,179
Kanoga	374	863
Ngangarithi	484	1,116
Riamukurwe	767	1,769
Thunguma	652	1,504
Mt. Kenya	33	76
Sub- total	8,395	19,361

Note: All projections at 3.7% p.a.

Source: Nyeri Water Supply, Preliminary Design Report, 1980; Table 4.11.

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TABLE 1.32.: SECONDARY SCHOOLS IN NYERI IN 1978

Name	Present No's	By year 2000
SECONDARY BOARDING SCHOOLS		
Nyeri High	800	2,000
St Pauls Seminary	400	800
Thunguma	1,000	2,000
Ruringu High	500	1,200
Nyeri Technical	400	850
Kamakwa	400	900
Baptist	160	300
Kamwenja T.T.C.	660	1,522 *
Kimathi Inst. of Technology	300	692 *
Sub- total	4,620	10,264
SECONDARY DAY SCHOOLS		
St Mary High	400	800
Temple Road	400	800
Sub- total	800	1,600

Note: * Projections at 3.7% p.a.

Source: Nyeri Water Supply, Preliminary Design Report, 1980; Table 4.11.

Medical facilities were reported as follows:

TABLE 1.33.: MEDICAL FACILITIES IN NYERI

Facility	Beds or Outpatients Authorized	Beds or Outpatients Unauthorized.	Planned Future
Provincial Hospital			
Adults	249	61	
Children	8	68	
Totals	257	129	800
Mt. Kenya Hospital			
Adults	17	-	17
Children	4	-	4
Mathari Mission Hospital			
Kiganjo Health Centre	200 per day		
Municipal Health Centre	500 per day		2000 per day

Source: Nyeri Water Supply, Preliminary Design Report, 1980; Table 4.12. and Section 4.6.6.

Other Institutions noted were the G.K. Prison and the Wambugu F. T. C.

Four major industries were noted namely, Mt. Kenya Bottlers, Highland Mineral Water, Wananchi Saw Mills, and the KCC Plant at Kiganjo.

The Physical Planning Department had reportedly projected industrial area rerquirements for year 2000 as follows.

TABLE 1.34.: INDUSTRIAL AREAS BY YEAR 2000

Area	Extent in hectares
Thunguma	10
Ruringu	15
Kamuyu	7
Kamakwa	8
Nyeri Town	60
Estates in rural areas	40
Kiganjo	12

Source: Nyeri Water Supply, Preliminary Design Report, 1980; Table, Section 4.6.3.

For commercial purposes, a total year 2000 requirement of 57 hectares was estimated against a 1987 set aside area of 53 hectares.

c) Population Projections

Population projections made for the sector were:

TABLE 1.35.: POPULATION PROJECTIONS

Location	Year 1980	1985	1990	1995	2000	2005
Urban	18,000	22,592	28,356	35,591	44,671	53,570
Rural	18,000	20,579	23,415	26,494	29,781	35,714
Mathari(part)	1,240	1,459	1,717	2,021	2,378	2,798
TOTALS	37,240	44,630	53,488	64,106	76,830	92,082

Source: Nyeri Water Supply, Draft Final Design Report, 1982; Table 3.1.

The sub-division for year 2003 on a ward basis is given in table 1.36.

TABLE 1.36.: PROJECTED POPULATIONS BY WARD FOR YEAR 2003

Ward	2003 Population (projected)		
	Urban	Rural	Total
Nyeri & Blue Valley	26,527	1,179	27,706
Kamuyu	3,639	1,571	5,210
Kamakwa	4,159	786	4,945
Gitathi-ini	-	800	800
Karingaini	416	3,143	3,559
Ruringu	8,837	1,180	10,017
Thunguma	6,238	2,356	8,594
Easter-ext	-	9,843	9,843
Nyaribu	-	8,907	8,907
Mathari	-	6,067	6,067
TOTALS	49,816	35,832	85,648

Source: Nyeri Water Supply, Draft Final Design Report, 1982, Table 3.3.

d) Water Demand

Average annual water demands were computed based on the following assumptions and data:

TABLE 1.37.: WATER DEMAND FOR URBAN AND RURAL AREAS

Consumers	Units	High Potential Rural Areas	Urban Area	Remarks Areas
Overall Consumption Rates	l/h/d	50	135	Urban Centres
	l/h/d		110	Rural Centres
	l/h/d		70	Local/Market centres
People with individual connections	l/h/d	50	300	High Class Housing
	l/h/d		150	Medium Class Housing
	l/h/d		75	Low Class Housing
People using CWP's, kiosks	l/h/d	25	25	
Livestock Units	l/LU/day	75	75	
Hospitals	l/bed/d	200	400	High Class
	l/bed/d		200	Medium Class
	l/bed/d		100	Low Class
Health Centres, Dispensaries	l/patient/d	10	10	
Hotels	l/bed/d	600	600	High Class
	l/bed/d	300	300	Medium Class
	l/bed/d	50	50	Low Class
Administrative Offices	l/h/d	25	25	
Boarding Schools	l/pupil/d	50	50	
Day Schools	l/pupil/d	25	25	With W.C.'s
	l/pupil/d	10	10	Without W.C.'s

Source: Nyeri Water Supply, Preliminary Design Report, 1980, Appendix B, Table B.1.

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Housing category data was used to convert per capita figures into areal demand as shown in the following table:

TABLE 1.38.: WATER DEMAND BY HOUSING CATEGORY

Housing Category	Population Density (persons/ha)	Per capita Consumption (l/d)	Areal Water Demand (m^3/ha/d)
Low Density	40 *	300	12.0
Medium Density	100 *	150	14.9
High Density	75 *	75	13.1

* Said to be typical Physical Planning Dept. figures for Nyeri

Source: Nyeri Water Supply, Preliminary Design Report, 1980, Appendix B, Table B.1.

Peak Factors proposed were derived from an earlier study for the town of Kitale, and as follows:

Maximum monthly rate of consumption = 1.25 times the ave. annual rate
Maximum weekly rate of consumption = 1.34 times the ave. annual rate
Maximum daily rate of consumption = 1.56 times the ave. annual rate

Due to the suppressed demand situation, it was not possible to measure peak hourly demands, and for design purposes, a peak rate demand of 2.5 times maximum daily rate for a continuous period of 2 hours was assumed.

To allow for fire fighting, the MOWD Design Manual criteria was adopted, namely:

In high value commercial areas, minimum main diameter 100 - 150 mm.
Pressure at hydrants to be not less than 15 m.
Every hydrant site to be capable of providing 10 l/s for at least 2 hours.

Service Reservoir Capacity was fixed at one days peak day demand equivalent.

The proposed limits for the augmented supply were:

1. The Municipal area as it was in 1980 except for Kiganjo
2. Part of the area which may be included in he future eastward extension of the Municipality
3. The village of Gathi-ini, south of Kamakwa.

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Projected flows for year 2003 were computed and tabulated by area and zone:

TABLE 1.39.: WATER DEMAND BY AREA IN YEAR 2003

Demand type	Nyeri & Blue Valley	Kamuyu	Kamakwa	Gitathi-ini	Karingaini	Ruringu	Thunguma	Easter ext	Nyaribu	Mathari	TOTAL
DOMESTIC											
Urban Population	26,527	3,639	4,159	-	416	8,837	6,238	-	-	-	49,816
Rural Population	1,1797	1,571	786	800	3,143	1,180	2,356	9,843	8,907	6,067	35,832
Demand in m^3/day	3,637	566	599	38	205	1,249	954	468	423	288	8,427
INDUSTRIAL											
Area in hectares	60	7	8	-	-	15	10	20	20	-	140
Demand in m^3/day	1,500	175	200	-	-	375	250	500	500	-	3,500
COMMERCIAL											
Area in hectares	24.5	6.55	6.55	-	-	11.9	7.4	-	-	-	56.9
Demand in m^3/day	594	159	159	-	-	289	179	-	-	-	1,380
EDUCATIONAL											
Demand in m^3/day	424	29	47	-	28	60	182	15	35	346	1,166
HEALTH											
Hospitals in m^3/day	472	-	-	-	-	-	-	-	-	-	472
Outpatients, m^3/day	9	2	2	-	1	4	3	3	2	2	28
Demand in m^3/day	481	2	2	-	1	4	3	3	2	2	500
GOVT ADMIN.											
Demand in m^3/day	172	-	-	-	-	77	-	-	-	-	249
LIVESTOCK											
Livestock Units	124	166	83	84	331	124	248	1,037	663	640	3,500
Demand in m^3/day	9	12	6	6	25	9	20	78	50	48	263
OTHER											
Demand in m^3/day	662	-	-	-	-	115	-	-	-	-	777
TOTAL DEMAND	7,479	943	1,013	44	259	2,178	1,588	1,064	1,010	684	16,262
Percentage of Total	46.0	5.8	6.2	0.3	1.6	13.4	9.8	6.5	6.2	4.2	100.0
PEAK MONTH DEMAND	9,348	1,179	1,266	55	324	2,723	1,985	1,330	1,263	855	20,328
PEAK WEEK DEMAND	10,022	1,264	1,357	59	347	2,919	2,128	1,425	1,353	917	21,791
PEAK DAY DEMAND	11,667	1,471	1,580	69	404	3,398	2,477	1,660	1,576	1,067	25,369
PEAK HOUR DEMAND	29,167	3,678	3,951	172	1,010	8,494	6,193	4,150	3,939	2,668	63,422

Source: Nyeri Water Supply, Preliminary Design Report, 1980, Table 5.6.

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TABLE 1.40.: WATER DEMAND BY SERVICE ZONE IN YEAR 2003

Service Zone	Areas	Average Demand	Peak day demands m3/day Month	Week	Day	Hour
Upper Central	Nyeri & Blue Valley					
	Sector 1	1,142	1,427	1,530	1,781	4,453
	50% sector 2	1,111	1,388	1,488	1,732	4,331
	Sector 3	2,107	2,634	2,824	3,288	8,217
	Sector 4	1,300	1,625	1,742	2,028	5,070
	20% Kamakwa	203	253	271	316	790
	Part Mathari	104	130	139	162	406
	50% Karingaini	129	162	174	202	505
	SUB TOTAL	6,096	7,619	8,168	9,509	23,772
Lower Central	Nyeri & Blue Valley					
	50% sector 2	1,110	1,389	1,488	1,732	4,331
	Blue Valley	709	886	950	1,106	2,765
	SUB TOTAL	1,819	2,275	2,438	2,838	7,096
Ruringu	Ruringu	2,178	2,723	2,919	3,398	8,494
	Thunguma	1,588	1,985	2,128	2,477	6,193
	25% Karingaini	65	81	87	101	253
	SUB TOTAL	3,831	4,789	5,134	5,976	14,940
Western	Kamuyu	943	1,179	1,264	1,471	3,678
	80% Kamakwa	810	1,013	1,086	1,264	3,161
	Gitathi-ini	44	55	59	69	172
	25% Karingaini	65	81	86	101	252
	SUB TOTAL	1,862	2,328	2,495	2,905	7,263
Mathari	Mathari	580	725	778	905	2,262
Northern	Nyaribu	1,010	1,263	1,353	1,576	3,939
Eastern	Eastern	1,064	1,330	1,425	1,660	4,150
	TOTALS	16,262	20,328	21,791	25,369	63,422

Source: Nyeri Water Supply, Preliminary Design Report, 1980, Table 5.6.

1.5. <u>Comparison of Population Projections</u>

As would be expected given the similarity in timing, the population projections made in the Nyeri Water and the Nyeri Sewerage Scheme studies are very similar. They are however at variance to those made in the two National Water Master Plans, and particularly so to those made in the NWMP Study, 1992.

Differences arise as a result of

i) different starting figure
ii) different annual growth rates

What is not stated, but has a clear bearing on selection of annual growth rate is the area to which the baseline figure relates, and what is then used to estimate annual growth rate.

The pre-1982 Nyeri Municipal area, and hence that in place at the time of the 1979 population census covered approximately 72 sq. km.

In 1982, this was revised to 204 sq km, the situation at the time of the 1989 census. A further revision in 1992 reduced the 1982 area by about ... sq.km in the south west of the Municipality but increased the overall area, adding an additional ... sq. km in the north east.

TABLE 1.41.: COMPARISON OF BASIS OF POPULATION PROJECTIONS

Study	Date of Base Data	Area of Municip-ality at Base Data Date	Base Pop. ulation	Growth Rate(s) Used	Remarks
NMWP Stage 1 1969-78 of	1969 project'n	1978	24,300	1978-88 7.05% 1988-98 6.30% 30,400	Based on 1969 with District growth 1998-08 5.50% 3.48% p.a.
Nyeri Sewage	1978 Survey		36,786	urban 3.75% rural 3.00%	
Nyeri Water PDR	1979 census		35,316	3.81%	Based on 1969 - 79 census period
Nyeri Water FDR	1980 compromise		37,240	3.70%	
Study on NWMP	1979 census 1989 census		35,753 88,600	9.5%	The difference in Municipal area not taken into account in obtain-ing pop. project'n for 1989-2010

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ANNEX 6

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - POND 2. INFLUENT, MORNING

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	60	
COD, mg/l	80	
SOLIDS-SUSPENDED, mg/l	25	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST		
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BACTERIOLOGICAL EXAMINATION LIST		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - POND 3, INFLUENT, MORNING

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	30	
COD, mg/l	40	
SOLIDS-SUSPENDED, mg/l	30	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - POND 1. INFLUENT, MID-DAY

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	60	
COD, mg/l	80	
SOLIDS-SUSPENDED, mg/l	35	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - POND 1. INFLUENT, MORNING.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	35	
COD, mg/l	48	
SOLIDS-SUSPENDED, mg/l	20	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - POND 2. INFLUENT, MID-DAY.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	12	
COD, mg/l	16	
SOLIDS-SUSPENDED, mg/l	35	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST		
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SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - POND 3. INFLUENT, MID-DAY

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	30	
COD, mg/l	48	
SOLIDS-SUSPENDED, mg/l	25	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST		
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SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - INFLUENT, MORNING

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	1020	
COD, mg/l	1360	
SOLIDS-SUSPENDED, mg/l	760	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST		
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SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - EFFLUENT, MORNING

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	48	
COD, mg/l	64	
SOLIDS-SUSPENDED, mg/l	20	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - SECONDARY BIO-FILTER-INFLUENT, MORNING.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	130	
COD, mg/l	160	
SOLIDS-SUSPENDED, mg/l	25	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - SECONDARY BIO-FILTER - INFLUENT, MID-DAY.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	115	
COD, mg/l	152	
SOLIDS-SUSPENDED, mg/l	30	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - PRIMARY BIO-FILTER - INFLUENT, MORNING.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	480	
COD, mg/l	640	
SOLIDS-SUSPENDED, mg/l	240	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - PRIMARY BIO-FILTER - INFLUENT, MID-DAY

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	540	
COD, mg/l	720	
SOLIDS-SUSPENDED, mg/l	160	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - EFFLUENT - (FILTERED) MID-DAY

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	50	
COD, mg/l	64	
SOLIDS-SUSPENDED, mg/l	25	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - RECIRCULATION FLOW - EFFLUENT (HUMUS TANKS) - MORNING.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	30	
COD, mg/l	40	
SOLIDS-SUSPENDED, mg/l	20	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - RECIRCULATION FLOW - MID-DAY.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	30	
COD, mg/l	40	
SOLIDS-SUSPENDED, mg/l	25	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI SEWAGE - NYERI - KIGANJO

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	1270	
COD, mg/l	1696	
SOLIDS-SUSPENDED, mg/l	240	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION KIGANJO SEWAGE - MATURATION PONDS - INFLUENT

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	65	
COD, mg/l	88	
SOLIDS-SUSPENDED, mg/l	40	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION KIGANJO SEWAGE - EFFLUENT.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	90	
COD, mg/l	120	
SOLIDS-SUSPENDED, mg/l	60	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION KIGANJO SEWAGE - FACCULTATIVE PONDS - INFLUENT

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	600	
COD, mg/l	800	
SOLIDS-SUSPENDED, mg/l	200	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION KIGANJO SEWAGE - EFFLUENT - FILTERED.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	430	
COD, mg/l	560	
SOLIDS-SUSPENDED, mg/l	40	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION KIGANJO SEWAGE - PUMP STATION - INFLUENT.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l	1380	
COD, mg/l	1840	
SOLIDS-SUSPENDED, mg/l	280	
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
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CHEMICAL ANALYSIS FOR WATER SAMPLES

SAMPLE DESCRIPTION KAMAKWA T.W. SED. TANK EFFLUENT

PARAMETER	RESULT	REMARKS
pH	6.95	
APPARENT COLOUR, °H	15	
TRUE COLOUR, °H	<5	
CONDUCTIVITY, µS/cm	118	
TURBIDITY, F.T.U.	0.6	
CALCIUM HARDNESS as $CaCo_3$, mg/l	4	
TOTAL HARDNESS as $CaCo_3$, mg/l	12	
TOTAL ALKALINITY as $CaCo_3$, mg/l	12	
CARBONATE ALKALINITY, mg/l	0	
IRON, mg/l	0.2	
FLUORIDES, mg/l	0.91	
SULPHATES, mg/l	36	
PHOSPHATES, mg/l	0.04	
SILICA, mg/l	45	
DISSOLVED OXYGEN, p.p.m.	6.4	
NITRATES, mg/l	0.01	
MANGANESE, mg/l	0	
CHLORIDES, mg/l	14	
CHROMIUM, mg/l	0.02	
COPPER, mg/l	0	
TOTAL COLIFORM/ml	-	
TOTAL FAECAL COLIFORM/ml	-	
DISSOLVED SOLIDS, mg/l	355	
SUSPENDED SOLIDS, mg/l	5	
TOTAL SOLIDS, mg/l	360	
BIOCHEMICAL OXYGEN DEMAND, mg/l	-	
CHEMICAL OXYGEN DEMAND, mg/l	-	

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CHEMICAL ANALYSIS FOR WATER SAMPLES

SAMPLE DESCRIPTION KAMAKWA T.W. INLET WORKS

PARAMETER	RESULT	REMARKS
p^H	8.07	
APPARENT COLOUR, °H	10	
TRUE COLOUR, °H	<5	
CONDUCTIVITY, µS/cm	90	
TURBIDITY, F.T.U.	0.8	
CALCIUM HARDNESS as $CaCo_3$, mg/l	4	
TOTAL HARDNESS as $CaCo_3$, mg/l	14	
TOTAL ALKALINITY as $CaCo_3$ mg/l	30	
CARBONATE ALKALINITY, mg/l	0	
IRON, mg/l	0.3	
FLUORIDES, mg/l	0.94	
SULPHATES, mg/l	38	
PHOSPHATES, mg/l	0.04	
SILICA, mg/l	44	
DISSOLVED OXYGEN, p.p.m.	6.3	
NITRATES, mg/l	0.01	
MANGANESE, mg/l	0	
CHLORIDES, mg/l	12	
CHROMIUM, mg/l	0.02	
COPPER, mg/l	0.01	
TOTAL COLIFORM/ml	-	
TOTAL FAECAL COLIFORM/ml	-	
DISSOLVED SOLIDS, mg/l	335	
SUSPENDED SOLIDS, mg/l	5	
TOTAL SOLIDS, mg/l	340	
BIOCHEMICAL OXYGEN DEMAND, mg/l	-	
CHEMICAL OXYGEN DEMAND, mg/l	-	

GENERAL REMARKS

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CHEMICAL ANALYSIS FOR WATER SAMPLES

SAMPLE DESCRIPTION KAMAKWA T.W. CLARIFIER EFFLUENT

PARAMETER	RESULT	REMARKS
p^H	7.22	
APPARENT COLOUR, °H	10	
TRUE COLOUR, °H	<5	
CONDUCTIVITY, µS/cm	133	
TURBIDITY, F.T.U.	0.5	
CALCIUM HARDNESS as $CaCo_3$, mg/l	6	
TOTAL HARDNESS as $CaCo_3$, mg/l	16	
TOTAL ALKALINITY as $CaCo_3$ mg/l	18	
CARBONATE ALKALINITY, mg/l	0	
IRON, mg/l	0.3	
FLUORIDES, mg/l	0.81	
SULPHATES, mg/l	40	
PHOSPHATES, mg/l	0.03	
SILICA, mg/l	39	
DISSOLVED OXYGEN, p.p.m.	6.5	
NITRATES, mg/l	0.02	
MANGANESE, mg/l	0	
CHLORIDES, mg/l	14	
CHROMIUM, mg/l	0.01	
COPPER, mg/l	0	
TOTAL COLIFORM/ml	-	
TOTAL FAECAL COLIFORM/ml	-	
DISSOLVED SOLIDS, mg/l	310	
SUSPENDED SOLIDS, mg/l	10	
TOTAL SOLIDS, mg/l	320	
BIOCHEMICAL OXYGEN DEMAND, mg/l	-	
CHEMICAL OXYGEN DEMAND, mg/l	-	

GENERAL REMARKS

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CHEMICAL ANALYSIS FOR WATER SAMPLES

SAMPLE DESCRIPTION KAMAKWA T.W. CLEAR WATER

PARAMETER	RESULT	REMARKS
p^H	7.60	
APPARENT COLOUR, °H	<5	
TRUE COLOUR, °H	<5	
CONDUCTIVITY, µS/cm	116	
TURBIDITY, F.T.U.	0.7	
CALCIUM HARDNESS as $CaCo_3$, mg/l	6	
TOTAL HARDNESS as $CaCo_3$, mg/l	14	
TOTAL ALKALINITY as $CaCo_3$, mg/l	22	
CARBONATE ALKALINITY, mg/l	0	
IRON, mg/l	0.2	
FLUORIDES, mg/l	0.93	
SULPHATES, mg/l	33	
PHOSPHATES, mg/l	0.04	
SILICA, mg/l	40	
DISSOLVED OXYGEN, p.p.m.	6.6	
NITRATES, mg/l	0.02	
MANGANESE, mg/l	0	
CHLORIDES, mg/l	10	
CHROMIUM, mg/l	0.02	
COPPER, mg/l	0.02	
TOTAL COLIFORM/ml	-	
TOTAL FAECAL COLIFORM/ml	-	
DISSOLVED SOLIDS, mg/l	325	
SUSPENDED SOLIDS, mg/l	5	
TOTAL SOLIDS, mg/l	330	
BIOCHEMICAL OXYGEN DEMAND, mg/l	-	
CHEMICAL OXYGEN DEMAND, mg/l	-	

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CHEMICAL ANALYSIS FOR WATER SAMPLES

SAMPLE DESCRIPTION KIGANJO INTAKE

PARAMETER	RESULT	REMARKS
p^H	8.49	
APPARENT COLOUR, °H	50	
TRUE COLOUR, °H	20	
CONDUCTIVITY, µS/cm	351	
TURBIDITY, F.T.U.	4.1	
CALCIUM HARDNESS as $CaCo_3$, mg/l	8	
TOTAL HARDNESS as $CaCo_3$, mg/l	22	
TOTAL ALKALINITY as $CaCo_3$ mg/l	80	
CARBONATE ALKALINITY, mg/l	8	
IRON, mg/l	0.4	
FLUORIDES, mg/l	0.77	
SULPHATES, mg/l	55	
PHOSPHATES, mg/l	0.02	
SILICA, mg/l	38	
DISSOLVED OXYGEN, p.p.m.	6.0	
NITRATES, mg/l	0.03	
MANGANESE, mg/l	0	
CHLORIDES, mg/l	40	
CHROMIUM, mg/l	0.02	
COPPER, mg/l	0.02	
TOTAL COLIFORM/ml	-	
TOTAL FAECAL COLIFORM/ml	-	
DISSOLVED SOLIDS, mg/l	340	
SUSPENDED SOLIDS, mg/l	10	
TOTAL SOLIDS, mg/l	350	
BIOCHEMICAL OXYGEN DEMAND, mg/l	-	
CHEMICAL OXYGEN DEMAND, mg/l	-	

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CHEMICAL ANALYSIS FOR WATER SAMPLES

SAMPLE DESCRIPTION KIGANJO CLEAR WATER

PARAMETER	RESULT	REMARKS
p^H	7.81	
APPARENT COLOUR, °H	40	
TRUE COLOUR, °H	20	
CONDUCTIVITY, µS/cm	346	
TURBIDITY, F.T.U.	5.0	
CALCIUM HARDNESS as $CaCo_3$, mg/l	6	
TOTAL HARDNESS as $CaCo_3$, mg/l	14	
TOTAL ALKALINITY as $CaCo_3$ mg/l	70	
CARBONATE ALKALINITY, mg/l	0	
IRON, mg/l	0.4	
FLUORIDES, mg/l	0.91	
SULPHATES, mg/l	40	
PHOSPHATES, mg/l	0.05	
SILICA, mg/l	44	
DISSOLVED OXYGEN, p.p.m.	6.0	
NITRATES, mg/l	0.03	
MANGANESE, mg/l	0	
CHLORIDES, mg/l	34	
CHROMIUM, mg/l	0.01	
COPPER, mg/l	0.01	
TOTAL COLIFORM/ml	-	
TOTAL FAECAL COLIFORM/ml	-	
DISSOLVED SOLIDS, mg/l	310	
SUSPENDED SOLIDS, mg/l	10	
TOTAL SOLIDS, mg/l	320	
BIOCHEMICAL OXYGEN DEMAND, mg/l	-	
CHEMICAL OXYGEN DEMAND, mg/l	-	

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CHEMICAL ANALYSIS FOR WATER SAMPLES

SAMPLE DESCRIPTION CHANIA INTAKE

PARAMETER	RESULT	REMARKS
pH	7.41	
APPARENT COLOUR, °H	25	
TRUE COLOUR, °H	5	
CONDUCTIVITY, µS/cm	120	
TURBIDITY, F.T.U.	2.2	
CALCIUM HARDNESS as $CaCo_3$, mg/l	8	
TOTAL HARDNESS as $CaCo_3$, mg/l	24	
TOTAL ALKALINITY as $CaCo_3$ mg/l	36	
CARBONATE ALKALINITY, mg/l	0	
IRON, mg/l	0.2	
FLUORIDES, mg/l	0.85	
SULPHATES, mg/l	29	
PHOSPHATES, mg/l	0.03	
SILICA, mg/l	40	
DISSOLVED OXYGEN, p.p.m.	6.3	
NITRATES, mg/l	0.02	
MANGANESE, mg/l	0	
CHLORIDES, mg/l	14	
CHROMIUM, mg/l	0.02	
COPPER, mg/l	0	
TOTAL COLIFORM/ml	-	
TOTAL FAECAL COLIFORM/ml	-	
DISSOLVED SOLIDS, mg/l	325	
SUSPENDED SOLIDS, mg/l	15	
TOTAL SOLIDS, mg/l	340	
BIOCHEMICAL OXYGEN DEMAND, mg/l	-	
CHEMICAL OXYGEN DEMAND, mg/l	-	

GENERAL REMARKS

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CHEMICAL ANALYSIS FOR WATER SAMPLES

SAMPLE DESCRIPTION IHWA INTAKE

PARAMETER	RESULT	REMARKS
p^H	8.52	
APPARENT COLOUR, °H	20	
TRUE COLOUR, °H	<5	
CONDUCTIVITY, µS/cm	88	
TURBIDITY, F.T.U.	1.9	
CALCIUM HARDNESS as $CaCo_3$, mg/l	4	
TOTAL HARDNESS as $CaCo_3$, mg/l	12	
TOTAL ALKALINITY as $CaCo_3$ mg/l	82	
CARBONATE ALKALINITY, mg/l	8	
IRON, mg/l	0.2	
FLUORIDES, mg/l	0.90	
SULPHATES, mg/l	32	
PHOSPHATES, mg/l	0.02	
SILICA, mg/l	45	
DISSOLVED OXYGEN, p.p.m.	6.2	
NITRATES, mg/l	0.02	
MANGANESE, mg/l	0	
CHLORIDES, mg/l	12	
CHROMIUM, mg/l	0.02	
COPPER, mg/l	0.02	
TOTAL COLIFORM/ml	-	
TOTAL FAECAL COLIFORM/ml	-	
DISSOLVED SOLIDS, mg/l	305	
SUSPENDED SOLIDS, mg/l	5	
TOTAL SOLIDS, mg/l	310	
BIOCHEMICAL OXYGEN DEMAND, mg/l	-	
CHEMICAL OXYGEN DEMAND, mg/l	-	

GENERAL REMARKS

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI CLEAR WATER

Date Collected 2.2.95 . Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE CLEAR

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST 1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION LIST 1. TOTAL COLIFORM/100 ml	13	
2. E. COLIFORM/100 ml	5	
3.		

GENERAL REMARKS

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION KIGANJO CLEAR WATER

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE CLEAR

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. TOTAL COLIFORM/100 ml	15	
2. E. COLI/100 ml	7	
3.		

GENERAL REMARKS

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION KIGANJO INTAKE

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE CLEAR

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. TOTAL COLIFORM/100 ml	25	
2. E.COLI/100 ml	14	
3.		

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE-SOURCE & DESCRIPTION CHANIA INTAKE

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE CLEAR

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES LIST 1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION LIST 1. TOTAL COLIFORM/100 ml	35	
2. E.COLI/100 ml	20	
3.		

GENERAL REMARKS

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION IHWA INTAKE.

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE CLEAR

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. TOTAL COLIFORM/100 ml	30	
2. E.COLI/100 ml	13	
3.		

GENERAL REMARKS

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE-SOURCE & DESCRIPTION KIGANJO INFLUENT SEWAGE

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. TOTAL COLIFORM/100 ml	350,000	
2. E.COLI/100 ml	170,000	
3.		

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI EFFLUENT SEWAGE

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. TOTAL COLIFORM/100 ml	230,000	
2. E.COLI/100 ml	127,000	
3.		

GENERAL REMARKS

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI INFLUENT SEWAGE

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. TOTAL COLIFORM/100 ml	360,000	
2. E.COLI/100 ml	195,000	
3.		

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION NYERI EFFLUENT SEWAGE

Date Collected 2.2.95 Date Analysed 3.2.95 By PHE

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. TOTAL COLIFORM/100 ml	270,000	
2. E.COLI/100 ml	134,000	
3.		

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Nyeri water Supply

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION AMBONI RIVER

(H.P. GAUFF)

Date Collected 11.5.95 Date Analysed 12.5.95 By P.H.E.

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. COLIFORM/100ML	2200	
2. E. COLI/100ML	320	
3.		

GENERAL REMARKS

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION CHANIA INTAKE

(H.P. GAUFF)

Date Collected 11.5.95 Date Analysed 12.5.95 By P.H.E.

GENERAL APPEARANCE OF SAMPLE CLEAR

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. COLIFORM/100 ML	80	
2. E. COLI/100 ML	25	
3.		

GENERAL REMARKS

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION IHWA INTAKE

(H.P. GAUFF)

Date Collected 11.5.95 Date Analysed 12.5.95 By P.H.E.

GENERAL APPEARANCE OF SAMPLE CLEAR

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/1		
BOD5, mg/1		
COD, mg/1		
SOLIDS-SUSPENDED, mg/1		
-DISSOLVED, mg/1		
-SETTLEABLE, mg/1		
-TOTAL, mg/1		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. COLIFORM/100 ML	350	
2. E. COLI/100 ML	90	
3.		

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ANALYSIS ON WASTEWATER SAMPLES

SAMPLE SOURCE & DESCRIPTION KIGANJO INTAKE

(H.P. GAUFF)

Date Collected 11.5.95 Date Analysed 12.5.95 By P.H.E.

GENERAL APPEARANCE OF SAMPLE TURBID

PARAMETER	RESULT	REMARK
pH		
COLOUR APPARENT H		
TRUE H		
TURBIDITY, F.T.U		
DISSOLVED OXYGEN (SITE), mg/l		
BOD_5, mg/l		
COD, mg/l		
SOLIDS-SUSPENDED, mg/l		
-DISSOLVED, mg/l		
-SETTLEABLE, mg/l		
-TOTAL, mg/l		
OTHER SPECIFIC SUBSTANCES		
LIST		
1.		
2.		
3.		
4.		
BACTERIOLOGICAL EXAMINATION		
LIST		
1. COLIFORM/100 ML	180	
2. E. COLI/100 ML	40	
3.		

GENERAL REMARKS

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CHEMICAL ANALYSIS FOR WATER SAMPLES

DESCRIPTION CHANI INTAKE

METER	RESULT	REMARKS
	7.87	
RENT COLOUR, °H	50	
COLOUR, °H	20	
CTIVITY, µS/cm	98	
BIDITY, F.T.U.	7	
CIUM HARDNESS as $CaCo_3$, mg/l	8	
AL HARDNESS as $CaCo_3$, mg/l	2	
AL ALKALINITY as $CaCo_3$ mg/l	20	
BONATE ALKALINITY, mg_3/l	0	
, mg/l	0.2	
ORIDES, mg/l	0.70	
PHATES, mg/l	35	
SPHATES, mg/l	0.05	
ICA, mg/l	45	
SSOLVED OXYGEN, p.p.m.	6.4	
RATES, mg/l	0.01	
NGANESE, mg/l	0	
LORIDES, mg/l	16	
ROMIUM, mg/l	0.02	
PPER, mg/l	0.01	
OTAL COLIFORM/ml	-	
TAL FAECAL COLIFORM/ml	-	
ISSOLVED SOLIDS, mg/l	350	
USPENDED SOLIDS, mg/l	40	
OTAL SOLIDS, mg/l	390	
IOCHEMICAL OXYGEN DEMAND, mg/l	-	
HEMICAL OXYGEN DEMAND, mg/l	-	

GENERAL REMARKS

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CHEMICAL ANALYSIS FOR WATER SAMPLES

SAMPLE DESCRIPTION KIGANJO INTAKE

PARAMETER	RESULT	REMARKS
pH	7.85	
APPARENT COLOUR, °H	80	
TRUE COLOUR, °H	50	
CONDUCTIVITY, µS/cm	86	
TURBIDITY, F.T.U.	20	
CALCIUM HARDNESS as $CaCo_3$, mg/l	6	
TOTAL HARDNESS as $CaCo_3$, mg/l	2	
TOTAL ALKALINITY as $CaCo_3$ mg/l	18	
CARBONATE ALKALINITY, mg/l	0	
IRON, mg/l	0.2	
FLUORIDES, mg/l	0.81	
SULPHATES, mg/l	45	
PHOSPHATES, mg/l	0.04	
SILICA, mg/l	40	
DISSOLVED OXYGEN, p.p.m.	6.5	
NITRATES, mg/l	0.01	
MANGANESE, mg/l	0	
CHLORIDES, mg/l	16	
CHROMIUM, mg/l	0.02	
COPPER, mg/l	0.02	
TOTAL COLIFORM/ml	-	
TOTAL FAECAL COLIFORM/ml	-	
DISSOLVED SOLIDS, mg/l	340	
SUSPENDED SOLIDS, mg/l	30	
TOTAL SOLIDS, mg/l	370	
BIOCHEMICAL OXYGEN DEMAND, mg/l	-	
CHEMICAL OXYGEN DEMAND, mg/l	-	

GENERAL REMARKS

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ANNEX 7

Page

PART I:

MECHANICAL INSTALLATIONS

1. INTRODUCTION

The survey was conducted at the following water works during December 1994:

(a) Ihwa Gravity Intake;
(b) Kamakwa Intake;
(c) Kamakwa Water Treatment Works;
(d) Kiganjo Intake; and
(e) Kiganjo Water Treatment Works.

and at the following sewage works :

(a) Nyeri Sewage Works;
(b) Kiganjo Sewage Pumping Station, and
(c) Kiganjo Sewage Ponds

The purpose of the survey was to obtain details of the state of the mechanical installations in the above stations, and to recommend the level of attention or replacement considered desireable in relation to the operation of the works.

2. CONDITION OF PLANT

The situation is presented in tabular form on the following pages:

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
1	RAW WATER MAINS		
1.1	Ihwa Gravity Main - dia. 150 mm.		
	- 3 no. sluice valves, dia 150 mm	all operational and in reasonably good condition; no damage or leakage observed	basic maintenance and testing required
1.2	Ihwa Gravity Main - dia. 200 mm.		
	- 1 no. sluice valve, dia 200 mm	operational and in reasonably good condition; no damage or leakage observed	basic maintenance and testing required
1.3	Kamakwa Pumping Main - dia. 150 mm.		
	- 1 no. sluice valve, dia 150 mm	operational and in reasonably good condition; no damage or leakage observed	basic maintenance and testing required
1.4	Raw Water Bypass to CWT - dia. 200 mm.		
	- 1 no. sluice valve, dia 200 mm	operational and in reasonably good condition; small leakage from gland observed	basic maintenance and testing required
1.5	New Raw Water Connection- dia. 200 mm. from bypass to treated water chamber from old works to CWT - the connection made so as to enable disinfection (with chlorine) of the bypass water		
	- 1 no. sluice valves, dia 200 mm	operational and in good condition	basic maintenance and testing required

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	proposed steps - remarks
2	CHEMICAL DOSING		
2.1	Inlet collector pipe from:		
	- Ihwa gravity main dia. 150 mm - Kamakwa pressurised main dia. 150 mm		
	- 1No. sluice valve dia. 150 mm isolating both mains)	operational and in good condition	basic maintenance + test required
2.2	Inlet to Alum mixing chambers - Dia. 100 mm		
	- 4Nos. sluice valves dia. 100 mm	operational, but deteriorated and rusty; leakages from the glands (2Nos)	maintenance + test - and probable replacement
2.3	Alum tanks electric stirrers		
	- 4Nos electrical stirrers with reduction gears	4Nos - non-operational	
	- 2Nos. - manuf: East African Chains Ltd. Type : NO14512/25 P = 1.5 HP rpm 1425, output rpm 62-65) (approx.)	stirrers operational and in good condition, no leakages found.	stirrers - maintenance + test required. electrical starters - replacement alternative option
	- 2Nos - manuf: VEB ElectromotorenWerke Type : 2G2 KMRB 80 G 4/320 P = 1.5 Kw output rpm = 63, marked for Y-Δ starter but believed to be of DOL type.	starters out of order; partly dismantled (components were taken to sewage works)	set of new stirrers with electrical starters the existing stirrers after maintenance should be taken to the W.P. store as spare equipment.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
2.4 (cont'd)	Inlet to Alumn mixing chambers-dia. 150 mm (from IHWA gravity dia. 200)		
	- 4Nos. sluice valves Dia. 150 mm	operational and in relatively good condition	basic maintenance + test required.
2.5	Soda ash tanks electric stirrers		
	- 4Nos. electric stirrers with reduction gears - 1No.electrical motor - manuf: Brook Crompton Parkinson	4 Nos. - operational and in relatively good condition; small leakage from the gear (1No.)	maintenance + test required
	Electrical Motor Type : D90LD P = 1.5 KW rpm = 1420 marked for Y-Δ starter	no problem with starters and electrical installation reported	
	Gear : David Brown Helicom Type : MHD 335 P = 2HD output Rpm 58.2 Ratio : 24.78/1		
	- 3 Nos. - Manuf : VEB ElectromotoremWerke Type : 2G2 KRMB 80 G 4/320 P = 1.5 kW 50 Hz output Rpm = 63 market for Y-Δ starter		
Note:	existing starters most probably of the D.O.L. type?		

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	proposed steps - remarks
2.6	Chlorine tanks electric stirrers		
	- 2Nos. electric stirrers with reduction gears the nameplates are not accessible. both of them the same type; probably VEB ElectromotoremWerke equipment, data as above	2Nos. operational slightly deteriorated, starters reportedly in good condition.	maintenance & test required or replacement with the set of new equipment after maintenance, should then be treated as a spare equipment.
2.7	Chlorine extraction fan	operational but obsolete	to be replaced

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
	OLD WORKS		
3	CLARIFIERS		
3.1	Inlet valves dia. 150 mm		
	- 4Nos. sluice valves Dia. 150 mm	operational and in good condition	test & ev. basic maintenance required
3.2	Outlet collector valve dia.150 mm		
	Note- there is only 1 valve installed separating outlet of clarifier No.1 from the others		
	- 1No. sluice valve dia. 150	operational and in good condition	test + ev. basic maintained required
3.3	Desludging and drain valves dia.100 mm		
	- 4 Nos. sluice valves dia. 100 mm	operational and in good condition	test + ev. basic maintenance required
3.4	Desludging valves. dia. 100 mm (in concrete underground channel)		
	- 4Nos. sluice valves dia. 150 mm	operational in poor condition; not reliable (at least 3 Nos.)	check-up + test; most likely replacement

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
4	FILTERS		
4.1	Inlet Valves Dia. 150 mm		
	- 4Nos. sluice valves dia. 150 mm	operational,; serious gland leakages (2Nos.)	maintenance + test; replacement of 1 or 2 Nos. probable
4.2	Outlet valves dia. 150 mm		
	- 4Nos. sluice valves dia. 150 mm	operational; in poor condition; very rusty; leakages from the glands outlet pipework from the filters needs excavation and carefully checking	replacement of the valves recommended. replacement of at least part of outlet pipework very likely
4.3	Backwash valves dia. 150 mm		
	- 4Nos. sluice valves dia. 150 mm	3 Nos. operational /1No. not - reported. all of them in poor or very poor condition very rusty with leakages from the glands. backwash pipework needs exposing and carefully checking.	replacement of backwash valves recommended replacement of at least part of backwash pipe collector very likely
4.4	Drainage valves dia. 200 mm		
	- 4Nos. sluice valves dia. 100 mm	all of them operational - but; in very poor condition; rusty with leakages.	replacement of drainage valves recommended
4.5	Air scouring valves dia. 100 mm		
	- 4Nos. sluice valves dia. 100 mm	operational and in reportedly condition	basic maintenance + test

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
5	PUMP & COMPRESSOR ROOM		
5.1	Air scourer - 1No. Manuf: HAMMOND ENGINEERING Type : RAL 13 Serial No. 7805 El motor: THOMSON-HUTON Type : KNX - C 2/3 Serial No. 790.46 H2 P = 5HP; rpm = 1420	air scourer with associated M/E (starters) equipment operational but old technical efficiency deteriorated electrical installation have been repaired several times since commissioning. It does not look reliable	replacement of air scourer with associated M/E equipment recommended
5.2	Backwash pumps - 2Nos. Pump: Manuf: SIGMUND PUMPS Type : N-NG4 Serial No.: 915306-1;2 Electrical Motor Manuf: Metropolitan VICKERS Type : K4126 P = 10HP; rpm = 1450 400/440v;15A	- both operational with small leakages from the glands; noisy (Electrical motor side); old electrical installation + starters operational but old, to be checked and tested.	replacement of backwash pumps with associated M/E equipment recommended.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
5.3	Backwash pump valves - suction sluice valves dia. 150 mm - 2Nos.	operational ; no faults found; no problems reported	basic maintenance & test recommended
	- discharge non-return valves; Dia. 150mm-2Nos. Note: There is no discharge sluice valve	operational ; no faults found; no problems reported	basic maintenance + test recommended
Note to items 5.2 and 5.3 General policy decision is required if the backwash pumps are to be replaced with associated M/E equipment. If so, the pumps, starters and associated items to store and treated as spare, emergency equipment.			
5.4	Treated water pumps - 2Nos. (to elevated steel tank) Pump : Manuf. AJAX PUMPS. Size : 1l/2 KV Serial : C (indicipherable)	1No. - removed 1No. - operational; in poor condition with leakage, noisy, old	replacement of treated water pumps with associated M/E equipment recommended
	Electrical motor: 3HP - nameplates removed	Electrical installation does not look reliable	

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
5.5	Treated water pump valves - suction sluice valve dia. 38 mm ($1^1/_2$") - 1No. - discharge sluice valve dia.50mm (2")-1No. - discharge non-return valve dia.50mm (2") 1No.	operational; no problems reported operational; no problems reported operational; no problems reported Note: All valves look brand new and probably have been replaced recently.	} basic maintenance + test recommended
Note: set of suction and discharge valves for the removed pump set is generally OK General note as for items 5.2 and 5.3			

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
6	NEW WORKS WATER SUPPLY LINE dia. 300 mm (from chemical building to new works)		
6.1	Inlet valve to flocculation chamber. dia.300mm		
	- 1No. sluice valve (gate type) dia.300 mm	operational in good condition reported; no leakages found	basic maintenance + test recommended
6.2	Washout valve. dia. 100 mm (to dia.300 mm main		
	- 1No. sluice valve dia.100 mm	operational in good condition reported; no leakages found	basic maintenance + test recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
7	NEW WORKS FLOCCULATION CHAMBER		
7.1	<u>Washout valve Dia. 150 mm</u> (to flocculation chamber) - 1No. sluice valve Dia.150 mm	operational and reportedly in good condition ; no faults or leakages found	basic maintenance & test recommended
8	NEW WORKS SEDIMENTATION TANKS - 3NOS.		
8.1	<u>Washout valves dia. 200 mm</u> - 3Nos. sluice valves Dia. 200 mm	operational and reportedly in good condition; no faults or leakages found.	basic maintenance + test recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
9	NEW WORKS FILTERS - 3NOS.		
9.1	Inlet valves dia. 200 mm (from sed. tanks to the filters)		
	- 3Nos. sluice valves dia. 200 mm	operational and in good condition	basic maintenance & test recommended
9.2	Outlet valves Dia. 200 mm		
	- 3Nos. sluice valves dia. 200 mm	operational in good condition	basic maintenance & test recommended
9.3	Backwash valves dia. 200 mm		
	- 3Nos. sluice valves dia. 200 mm	operational and in good condition	basic maintenance & test recommended
9.4	Drain valves dia. 200 mm		
	- 3Nos. sluice valves dia. 200 mm	operational and in good condition	basic maintenance and & test recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
10	TREATED WATER TANK (concrete structure)		
10.1	T.W.T. drain valve dia. 250 mm (or 300 mm) (the drain chamber was covered with soil)		
	- 1No. sluice valve dia. 250 (or 300 mm)	operation and in good condition	excavation of drain chamber to T.W.T. basic maintenance & test recommended
10.2	T.W.T. level indicator	in operational condition but not reliable	replacement is recommended

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NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
11	ELEVATED TREATED WATER TANK (steel tank)		
11.1	Drain and washout valve dia.50 mm		
	- 1No. sluice valve dia. 50 mm	operational and in good condition small leakage from the gland	basic maintenance & test recommended
11.2	Tank water indicator	Not operational	replacement is recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
12	RISING MAINS		
12.1	Isolating valve dia. 200 mm (from concrete T.W.T)		
	- 1No. sluice valve dia. 200 mm	operational, no faults found; small leakage from the gland	maintenance + test recommended
12.2	Main water meter		
	- 1No. type KENT 6" (150 mm) 0-1000 l/rev - to be confirmed	operational; no faults or leakages found	calibration test recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
14	SKUTA MAIN DIA. 100 MM		
14.1	<u>Isolating valve dia. 100 mm</u>		
	- 1No. sluice valve dia. 100 mm	operational and in good condition reportedly (but covered with soil so the real condition is uncertain)	excavation; basic maintenance test recommended.
14.2	<u>Main water meter</u>		
	- 1No. - type KENT 4" (100 mm) 0-100 l/rev.	operational and in good condition (but covered with soil so the real condition is uncertain)	excavation; calibration test recommended
15	KAMAKWA MAIN DIA. 75 MM (from elevated steel tank)		
15.1	<u>Isolating valve dia. 75 mm</u>		
	- 1 No. sluice valve dia. 75 mm	operational and in good condition no faults and leakages found	basic maintenance + test recommended.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI WATERWORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
16	ELECTRIC POWER SUPPLY		
16.1	Main transformer		
	- 1No. - Manuf: STROMBERG 3.3 KV/415V; 200 KVA	operational and in good condition reported	detailed electrical check-up recommended
16.2	Main circuit breaker		
	- 1No. - 63A	operation and in good condition reported	detailed electrical check-up recommended.

Note to items 16.1 and 16.2:

The figures were obtained from the local staff, so that the detailed electrical check-up is required to state the real technical value of the above equipment for scheduling any further steps to be undertaken

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KAMAKWA RAW WATER PUMPING STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
1	INTAKE		
	2Nos. suction pipes 6" (dia.150 mm) with foot valves	both foot valves in operation, good condition reported.	
	thereafter, the dia. of the suction pipes is reduced from 6" (150 mm) to 5" (125 mm)	however: the intake screen is rusty and partly broken, the intake concrete chamber is choked with sediment, so the real condition of both foot valves is to be confirmed	both foot valves are to be checked to estimate their technical condition.
2	RAW WATER PUMPS - 3NOS		
2.1	Electrical driven raw water pumps - 2Nos. Pump: WEIR PUMPS LTD Type/Frame : DQA 100/125 Unit No. : 568 11/405; 406 Electrical Motor: Manuf: CELMA Type : Se 280 M2 P = 90 KW (125 HP); rpm = 2965 400-440V; 50 H_Z	both of them in operational condition; leakages from the glands; small vibration in the couplings area (alignment) cable connections to motors to be improved	mechanical maintenance to the pumps and motors electrical check-up to motors and starters improvement of existing cable connection to motors
	Starter: Y-Δ starters	starters operational; one is brand new	

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KAMAKWA RAW WATER PUMPING STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
	Associated equipment to above pumps		
2.2	Suction valves	there are no suction valves installed, only intake foot valves	
2.3	Discharge isolating valves		
	- 2Nos.sluice valves dia. 100	operation and in good condition, no leakages found	basic maintenance + test recommended
2.4	Discharge non-return valves		
	- 2Nos. non return valves (swing type) dia. 100 mm	operational and in good condition reported; no leakages found.	basic maintenance & test recommended
2.5	Discharge bleeding valves.		
	- 2 Nos sluice valves dia. 50 mm	operational and in good condition	basic maintenance + test recommended
2.6	Diesel driven raw water pump - 1No. No technical details	pump unit - dismantled and removed diesel unit - u/s partly dismantled, name plate removed associated mechanical equipment out of order; partly dismantled.	new arrangement of diesel driven pump unit with associated equipment required with removal of existing one.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KAMAKWA RAW WATER PUMPING STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
3	DRAINAGE SYSTEM (of raw water pipeline to Nyeri Waterworks) - 1No sluice valve dia. 100 mm	operational and in good condition reported	the real function of existing drainage system is to be clarified. New arrangement of drainage pipe with sluice valve is required to avoid flooding of Raw Water Pumping station area when the system in use

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KAMAKWA RAW WATER PUMPING STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
4	ELECTRIC POWER SUPPLY - INSTALLATION <u>No technical details of existing equipment available</u> <u>The existing electrical installation:</u> - main transformer 3.3/415V; 50100 kVA - ?(to be confirmed - main isolating switch - electric meters - distribution panel - isolating switch } for 1st pumping uint - starter panel with Y-Δ starters - isolating switches 2Nos. } for 2nd pump unit - starter panel with - Y-Δ starters - Power factor correction unit Manuf : MICAFIL Type : 6D1-971-3 Q_m = 30 kVar; 420V	operational and in good condition reported; power cables are to be reconnected. all existing equipment is operational and reportedly in good condition. However, the installation has been repaired and changed several times since commissioning.	detailed electrical check-up of existing equipment is highly recommended. The results of the check-up shall be used as a basis for scheduling of any further action to be undertaken.
<u>Note to 2nd pump unit equipment</u> the starter panel looks brand new. most likely the new starter panel has been installed together with new isolating switch without removal of the existing one			

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI SEWAGE WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
1	INLET WORKS		
1.1	Ultrasonic measuring equipment (measuring the sewage flow to grit chamber)	Non-operational; the equipment failed and was dismantled and removed.	replacement with new measuring equipment complete. Note: it is recommeded that less sophisticated equipment be installed.
2	GRIT CHAMBER		
2.1	Air compressors (Roots type) - 2Nos	operational; but the technical efficiency of both of them has deteriorated; small oil leakages from the bodies.	mechanical maintenance + M/E tests recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI SEWAGE WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
3	SLUDGE PUMPING STATION		
3.1	Sludge pumps - 3Nos (1OP/2NOP)	No.1 - operational; in poor condition with serious leakages; technical efficiency deteriorated.	full range mechanical maintenance to the pumpset + M/E' tests recommended
		No.2 - operational & in good technical condition from mechanical point of view	provision of all necessary electrical components to MCC panel to restore its techn. efficiency based on detailed electrical check-up.
	Note: Item 3.1 shall be read together with item 7.1	Out of operation due to the lack of certain number of electrical components in MCC panel, which have failed or have been dismantled and removed.	
3.2	Sump pump - 1No. (located in sludge pit)	operational; not reliable due to some mechanical or electrical problems reported.	full range M/E tests + necessary maintenance recommended or replacement if necessary

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI SEWAGE WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
	INTERMEDIATE PUMPING STATION		
4.1	Intermediate (booster) Pumps - 3Nos. (1 operational, 2 non operational) Note: Item 4.1 shall be read together with item 7.1	No. 1 - operational in good condition No. 2 - out of operation due to the lack of certain number of important electrical components in MCC panel (in Sludge Pumping Station) which have failed or have been dismantled and removed.	basic maintenance to the pumps + tests recommended. provision of all necessary electrical components to MCC panel to restore its tech. efficiency based on detailed electrical check-up.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI SEWAGE WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
5.	DRAINAGE PUMPING STATION		
5.1	Drainage Pumps - 3Nos (1OP/2NOP) (1 operational, 2 non-opertional)	No.1 - operational in good condition reported No. 2 & 3 non-operational; dismantled and removed due to serious tech. problems with mechanical seals. Also, serious electrical problems with electrical motors as a consequence of above mentioned.	full range M/E overhaul to two pumpsets with replacement of existing mech. seals with new, proper type. (problem best solved in cooperation with mech. seals manufacturer or supplier). M/E maintenance to pumpset No.1 with replacement of mech. seal + test. or replacement of existing equipment with new pumps is to be considered.
	Note: Item 5.1 shall be read together with item 7.2	In addition, the lack of great number of important electrical components in MCC panel which have failed or have been dismantled and removed.	provision of all necessary electrical components to MCC panel to restore its tech. efficiency based on detailed electrical check-up

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI SEWAGE WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
6.	WORKS (RETICULATION) PUMPING STATION		
6.1	Recirculation Pumps - 3Nos. (1 OP/2NOP)	No. 1 - operational and in good condition	basic maintenance to the pumps + tests recommended
		No. 2 & 3 - operational in good technical condition; but out of operation due to the lack of great number of important electrical components in MCC panel which have failed or have been dismantled and removed.	provision of all necessary electrical components to MCC panel to restore its tech. efficiency based on detailed electrical check-up.
Note: Item 6.1 shall be read together with item 7.2			

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

NYERI SEWAGE WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
7.1	ELECTRIC POWER SUPPLY		
7.1	MCC Panel (for sludge and intermediate pumps located in Sludge Pumping Station) The panel consists of: - main circuit-breaker 200A - control panels for sludge pumps with isolating switches; starters etc. - control panels for intermediate pumps with isolating switches, starters etc. - control and monitoring devices for above - power factor correction unit "MICAFIL"	only - 1 of 3Nos. sludge pumps and only - 1 of 3Nos. intermediate pumps can be operated from the panel due to the lack of great number of important electrical components. The component have failed or have been dismantled and removed	detailed Electrical check-up + tests provision of all necessary electrical components to MCC to restor its technical efficiency based on above.
7.2	MCC panel	Note: Item 7.2 shall be read together with items 5.1 and 6.1	

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO RAW WATER PUMPING STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
1.	INTAKE - 4Nos. suction pipes dia. 75 mm - 1No. penstock gate - for washout of the intake chamber	operational and in good condition reported. however looks very old and obsolete.	maintenance + test recommended or replacement to be considered.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO RAW WATER PUMPING STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
2.	RAW WATER PUMPS - 4Nos. with their M/E equipment	both pumps and diesel engine operational reportedly and in good condition.	
2.1	Diesel driven pump unit - 1No. Pump: K.S.B. Type: MOVI 40/5 Prod. No.: 403007060121.0110. Order: 6-174-293202/1 Year 1984 Diesel Engine: LISTER P = 39.5 HP. rpm = 1800	Note: there was no possibility to switch the pumpset on due to the lack of diesel fuel The pumpset looks old and poorly maintained so that the mechanical maintenance will be necessary.	mechanical maintenance to the pump and diesel engine & test recommended.
2.1.1	Suction valve		
	- 1No sluice valves	operational and reportedly in good condition	basic maintenance + test recommended
2.1.2	Discharge isolating valve		
	- 1No. sluice valve dia. 75 m	operational and reportedly in good condition	basic maintenance + test recommended
2.1.3	Discharge non-return valve		
	- 1No. non-return valve dia. 75 mm	operational and reportedly in good condition	basic maintenance + test recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO RAW WATER PUMPING STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
2.2	<u>Electrical driven pump units - 3Nos</u>		
	No technical details of existing equipment available.		
	All the pumps were dismantled and removed due to mechanical failures.		
	Also 2 out of 3No. electrical motors were dismantled and removed.		
	<u>Note:</u> Advised that 1 No. of replacement pumpset (pump + electrical motor) had been already ordered.		
2.2.1	<u>Suction valves</u>		
	- 3Nos. sluice valves, dia. 75 mm	operational and reportedly in good condition	basic maintenance + test recommended
2.2.2	<u>Discharge isolating valves</u>		
	- 3 Nos. sluice valves dia. 75 mm	operational and reportedly good condition	basic maintenance + test recommended.
2.2.3	<u>Discharge non-return valves</u>		
	- 3Nos. non-return valves dia. 75 mm	operational and in reportedly good condition	basic maintenance + test recommended.

<u>Note to items 2.2.1, 2.2.2, 2.2.3 -:</u>
All the valves look brand new and they must have been installed recently.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANGO RAW WATER PUMP STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
3	ELECTRIC POWER SUPPLY (installation) No technical details of existing equipment available at the moment The existing electrical installation comprises: - main transformer - main isolating switch - electrical meters - 3Nos. - distribution panel - isolating switches - 3Nos (per each starter) - starter panels - 3Nos. (most probably with Y-Δ starters) - power factor correction unit - 1No.	all existing electrical equipment is operational and reportedly in good condition. Detailed tech. evaluation shall be carried out to find out the real value of existing equipment.	Detailed electrical check-up of existing equipment is recommended. The results of the check-up shall be used as a base for scheduling of any further action to be undertaken.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO SEWAGE PUMPING STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
1	Sludge pumps 3Nos. (1 operationa, 2 non-operational)	No.1 - operational and reported to be in good condition. No.2 & 3- non-operational; dismantled and removed due to serious technical problems with mechanical seals. Also serious electrical problems with motors as a consequence of above mentioned mechanical failure.	full range M/E overhaul to pumpsets No.2, 3 with replacement of existing mech. seals with new proper type (type problem is to be solved in cooperation with mech. seals manufacturer or supplied). M/E maintenance to pumpset No.1 with replacement of mech. seal + test or replacement of existing equipment with new pumps is to be considered.
2	Discharge isolating valves		
	- 3Nos. sluice valves (wedge type) Dia.200mm	operational and in good technical condition reported.	basic maintenance + test recommended
3.	Discharge non-return valves		
	- 3Nos. non-return valves Dia.200 mm	operational and in good technical condition reported leakage from the cover of valve No.2 (broken gasket)	basic maintenance + test recommended
4.	Discharge by-pass valve		
	- 1No. sluice valve (wedge type) Dia.150 mm	operational and in good technical condition reported.	basic maintenance + tests recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO SEWAGE PUMPING STATION

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
5	MCC PANEL <u>The panel consists of:</u> - main circuit breaker 100A (or 150 A) - control panels for sewage pumps with isolating switches; starters etc. - control and monitoring equipment for above - control and indication devices for the control electrodes system	all the equipment operational and reportedly in good technical condition.	basic electrical maintenance + tests recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
1	RAW WATER WORKS		
	- 2Nos. pipelines dia.100 mm from KIGANJO RAW WATER PUMPING STATION - interconnecting pipe dia. 100 mm. - 3 Nos. sluice valves dia. 100 mm	all of them operational in good condition; but very old	basic maintenance + test recommended
2	CHEMICAL DOSING		
	Chemical gravity dosers	operational	Routine maintenance and cleaning could be improved.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
3	SEDIMENTATION TANKS - 3NOS		
3.1	Drain and washout valves (the same)		
	- 3Nos sluice valves. dia. 100 mm	operational and reportedly in good condition; but very old; & partly covered with soil	maintenance - test recommended replacement of at least 1No. very likely
3.2	Separation valves		
	(the valves separate water flow from different sed. tanks to different filters)		
	- 2Nos. sluice valves. dia. 150 mm	operational - reportedly; in poor condition; covered with soil	test + evaluate maintenance recommended replacement of at least 1 No. very likely.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
4	FILTERS - 3NOS.		
4.1	Outlet valves		
	- 3Nos sluice valves dia. 150 mm	1 No. - Non-operational 2 Nos. - operational and reportedly in relatively good condition; very old; covered with soil	excavation; maintenance + test for 2Nos. replacement of 2Nos. shall be considered) (1NOP - 1 additional)
4.2	Backwash valves		
	3Nos. sluice valves dia. 150 mm	2 Nos. - non-operational 1 No - operational but in poor condition; very old covered with soil	replacement of drain valves is recommended.
4.3	Drain valves		
	- 3Nos. sluice valves. dia. 150 mm	1 No. - Non-operational 1 No. - operational but in very poor condition; usually not used 1 No. - operational in relatively good condition but very old.	replacement of air scouring valves is recommended.
4.4	Air scouring valves		
	- 3Nos. sluice valves dia. 75 or 100 mm	2 Nos - non-operational 1 No. - operational but reportedly in poor condition there is very limited access to the valves they are in narrow concrete chambers partly covered with soil.	replacement of air scouring valves is recommended.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
5	AIR SCOURER The air scourer is Roots type driven by electrical motor (18 HP or 18 KW) with V-belts. Power output of 18 HP - most likely. The nameplates from the scourer unit and electrical motor are removed.	operational - but the tech. condition is so poor that it cannot be considered for any repair. electrical installation - starter in very poor condition as well	replacement of air scourer complete with associated M/E equipment is recommended.

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NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
6	TREATED WATER TANKS - 4NOS.		
6.1	Water main to T.W.Ts (collector pipe)		
	- 1No. sluice valve dia. 150 mm	operational and in good condition reported	maintenance + test recommended
6.2	Inlet valves (to each T.W.T.)		
	4 Nos sluice valves dia. 100 mm	1 No. - non operational 3 Nos - operational; but at least 2 of them in poor condition; very old	maintenance + test to 2Nos of inlet valves replacement of remaining 2Nos. or replacement of 4Nos. sluice valves is to be considered.
6.3	Drain and washout valves (the same)		
	- 4Nos sluice valves dia. 100 mm	all of them operational in relatively good condition reported.	maintenance + tests to all of them recommended.
6.4	Outlet valves (from each T.W.T)		
	- 4Nos. sluice valves dia. 150 mm	1 No - Non operational 1 No. - operational, reportedly in poor condition reported. 2 Nos - operation in relative good condition. very old	maintenance + tests to 2Nos of outlet valves replacement of 2Nos. outlet valves
6.5	Water main to Pumping Station (collector pipe)		
	1 No. sluice valve dia. 150 mm	Non-operational reported; constantly open	replacement of 1 No. sluice valve

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NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
7	TREATED WATER PUMPING STATION Pumps with associated M/E equipment		
7.1	Treated Water Pump - 1No.		
	Pump: WORTHINGTON - SIMPSON Type 2 DD4 Serial No. 5140086	pump unit operational and reportedly in good condition	M/E maintenance to pump unit (pump electrical motor) + test
	Electrical motor: BROOK CROMPTON-PARKINSON MOTORS	Note Actually out of operation due to the lack of enough water	
	Type D6J4K P = 15 KW; rpm = 1440 starter: Y-Δ type individual isolating switch installed	Y-Δ starter and isolating switch + electrical installation operational in relatively good condition.	electrical maintenance to Electrical installation + test.
7.1.1	Suction valve		
	- 1No. sluice valve dia. 75 mm	operational and in good condition	maintenance + test recommended.
7.1.2	Discharge non-return valve		
	1 No. sluice valve dia. 75 mm	operational and in good condition	maintenance + test recommended.
7.1.3	Discharge non-return valve		
	1 No. non-return valve (swing type) dia. 75 mm.	non-operational with serious internal leakage reported	replacement of valve necessary

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
7.2	Treated Water Pumps - 2Nos		
	Pump: WORTHINGTON-SIMPSON Type: $2^1/_2$" D4 Serial No. 513.3110	both pump units operational and reportedly in good condition. they look old; slightly worn-out.	M/E maintenance to pumps and electrical motors + test
	El motor: BROOK CROMPTON-PARKINSON MOTORS Type: P = 5HP; Rpm = 1440 400/440v $50H_Z$ Starters: D.O.L type	Note: there was no possibility to switch them on due to lack of water electrical installation + starters. it looks old but is operational in relatively good condition.	Electrical maintenance to electrical installation + test
7.2.1	Suction valves		
	- 2Nos. sluice valves dia. 75 mm	operational and in good condition reported.	maintenance + test recommended.
7.2.2	Discharge isolating valves		
	- 2 Nos. sluice valves dia. 65 mm ($2^1/_2$")	operational and in good condition reported	maintenance + test recommended.
7.2.3	Diesel driven treated water pumps - 2Nos.		
	- 2 Nos. - non return valves (swing type) dia. 6.5 m ($2^1/_2$")	Both units: - pump dismantled and removed - diesel unit partly dismantled	replacement of 2Nos. diesel driven pump units if necessary
7.3	No technical details available. The pumps the same type as described under item 7.2	Associated mech. equipment partly failed, partly, dismantled and removed.	new, rearranged installation with associated equipment

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
	RISING MAINS		
8	KAGUMO HIGH SCHOOL MAIN		
8.1	Isolating valve		
	- 1No. sluice valve dia. 100 mm	operational and reportedly in good condition	excavation; maintenance + test recommended.
8.2	Main water meter		
	- 1 No. type KENT 4" (100 mm) with counter only	operational and reportedly in good condition . fully covered with soil	excavation; calibration + test recommended.

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
9	TOWN MAIN (dia.100 mm)		
9.1	Isolating valve		
	- 1No. sluice valve dia. 100 mm	operational and reportedly in good condition	excavation; maintenance + test recommended
9.2	Main water meter		
	- 1No. - type KENT 2" (75 mm) 1-100 l/r	operational and in good condition reported.	excavation; maintenance + test recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
10	MILK FACTORY MAIN DIA. 100 MM		
10.1	Isolating valve		
	- 1No. sluice valve Dia. 100 mm	operational and reportedly in good condition	excavation; maintenance + test recommended
10.2	Drain and Washout valve (the same)		
	- 1No. sluice valve Dia. 100 mm	operational and reportedly in good condition	excavation; maintenance + test recommended
10.3	Main water meter		
	- 1No. - type KENT size 3" or 4" - with counter only	operational and reportedly in good condition	excavation; maintenance + test recommended

NYERI WATER SUPPLY - MECHANICAL STATUS REPORT AS AT DECEMBER 1994

KIGANJO WATER WORKS

ITEM	EQUIPMENT - TECHNICAL DATA	TECHNICAL CONDITION	PROPOSED STEPS - REMARKS
11	**WATER MAIN** (to Police Training School elevated tank All the main equipment (valves; water meter) located, near tank		
12	**ELECTRIC POWER SUPPLY -** (installation) No technical details of existing equipment currently available.	all existing equipment is reported to be in operation condition. however, it must be checked and specified in details once again	detailed electrical check-up of existing equipment is required. the results of the check-up shall be used as a base for scheduling of any further action to be undertaken.

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PART II

ELECTRICAL INSTALLATIONS

1. INTRODUCTION

The survey was conducted at the following water works during April 1995:

(a) Kamakwa Intake;
(b) Kamakwa Water Treatment Works;
(c) Kiganjo Intake; and
(d) Kiganjo Water Treatment Works.

and at the following sewage works :

(a) Nyeri Sewage Works;
(b) Kiganjo Sewage Works; and
(c) Kiganjo Sewage Ponds

The purpose of the survey was to obtain details of the state of the electrical installations in the above stations, their effect on the working of the stations and how they could be improved.

2. CONDITION OF PLANT

(a) KAMAKWA INTAKE

No.	ITEM	EFFECT ON OPERATIONS		
		SEVERE	NOMINAL	NONE
1	Pump Hall lighting unsatisfactory		√	
2	Diesel Pump Hall lighting unsatisfactory			√
3	No socket outlet provided			√
4	Diesel pumpset : pump removed and engine has not been run for a long time so unlikely to operate again		√	

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(b) KAMAKWA WATER TREATMENT WORKS

No.	ITEM	EFFECT ON OPERATIONS		
		SEVERE	NOMINAL	NONE
1	Office wall socket outlet not functional			√
2	Filter area spotlights not functional		√	
3	Chemical Stores lighting not functioning			√
4	Dosing room lighting not satisfactory			√
5	Only 1 out of 4 Alum stirrers are functioning		√	
6	Ring Road Chlorine dosing room lights and electric fittings not functional and badly corroded			√
7	Only 1 out of 2 Booster Pumps is functional but leaking badly		√	

(c) KIGANJO INTAKE

No.	ITEM	EFFECT ON OPERATIONS		
		SEVERE	NOMINAL	NONE
1	Pump Hall lighting fittings missing		√	
2	No socket outlet provided in the Pump Hall			√
3	Security lighting not provided			√
4	Pumpset No. 1 Ammeter range high at 0 - 200 A. Suggested to be 0 - 60 A			√
5	Pumpset No. 1 removed	√		
6	75 Hp pumpset removed	√		
7	75 Hp motor faulty		√	
8	75 Hp Pumpset cooling window should be fitted with insect proof wire gauze			√
9	Diesel pumpset Lister engine leaking oil excessively		√	

(d) KIGANJO WATER TREATMENT WORKS

No.	ITEM	EFFECT ON OPERATIONS		
		SEVERE	NOMINAL	NONE
1	Pump Hall lighting fittings missing		√	
2	No socket outlet provided in the Pump Hall			√
3	Outside luminares not provided			√
4	Lighting fittings in store removed			√
5	Socket outlet not provided in store			√
6	Security lighting broken down			√
7	Pump Nos. 1 & 2 power isolating switches still mounted on old un-used starters. New isolators should be provided		√	
8	Pumpset Nos. 3 & 4 (diesel engines) aged and damaged beyond repair. Pump No. 3 is in good condition but No. 4 has been taken out		√	
9	Pumpset No. 5 (ex-Kamakwa) with 1 spare pump is not run as it creates air lock in the pipe	√		
10	Spare pump similar to No. 3 not functioning due to broken end cover			√
11	Pumpsets have no electrical instruments eg Ammeters and Voltmeters			√
12	Filter Air Blower located in the chemical storage room corroding	√		
13	Main isolator switch and blower motor isolator switch are completely corroded and in-operable	√		
14	Lighting bulb missing in the chemical storage room. Conduits and fittings require painting to stop further corrosion			√

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(e) KIGANJO SEWAGE PUMPING STATION

No.	ITEM	EFFECT ON OPERATIONS		
		SEVERE	NOMINAL	NONE
1	Pump No. 1 panel has a loose terminal block, wires are disconnected, fuses other than HRC are in use and running lamp (red) not functional	√		
2	Pumpset No. 2 main starter relay removed. Panel not in use		√	
3	All control relays and wiring for Pumpset No. 3 panel were burglarised. Panel not in use		√	
4	Fittings and wiring for Distribution feeder were burglarised. Panel not in use		√	
5	Fittings and wiring for Distribution Board were burglarised. Panel not in use		√	
6	Control Panel - Pump duty selector switch to be re-positioned correctly			√
7	Incoming Panel - rodents entering through cable entry. Should be sealed			√
8	Incoming panel - voltmeter glass broken. Should be replaced			√
9	Incoming panel - voltmeter needle vibrates when voltage selector switch is in positions R-B, Y-B and R-Y. The relevant resistors to be replaced			√
10	Indoor lighting not functioning but the fittings are in good condition. Lighting bulbs to be installed			√
11	Submersible pumpsets - only No. 1 is available and operating. Nos. 2 & 3 have been removed for safe keeping after the respective control panels were burglarised	√		
12	Pump Nos. 2 & 3 control panels which were burglarised should be refurbished to restore the operations of the respective pumpsets	√		

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(e) NYERI SEWAGE WORKS

No.	ITEM	EFFECT ON OPERATIONS		
		SEVERE	NOMINAL	NONE
1	Site (street) lighting time switch faulty. To be replaced with a photocell or ripple receiver switch. Flood lights to be added to improve on the site security lighting			√
2	Aerator Blower No. 1 motor removed for repairs. Should be re-instated since it has already been repaired		√	
3	One Aeration Diffuser has been removed following failure. It should be re-instated		√	
4	Pressure gauge for the Aerating Blower not functional. To be replaced			√
5	Ultra Flow Measuring Unit faulty			
6	Fluorescent tubes removed at the main switchgear room			√
7	0-800 A ammeter on the Incoming Panel indicates very low current. Should be replaced with a 0-200 A ammeter			√
8	Voltmeter on Incoming Panel shows is poorly damped at some positions of the voltmeter selector switch			√
9	Incoming panel - voltmeter needle vibrates when voltage selector switch is in positions R-B, Y-B & R-Y. The relevant resistors to be replaced			√
10	Works Control Board 0 - 400 A ammeter displays very low value. Should be replaced with 0 - 50 A ammeter			√
11	Control Panel for Intermediate Lift Pump No. 1 had some installations removed to replace burglarised parts in other panels. It should be re-furbished	√		
12	Ammeter in Sludge Pump No. 1 range 0 - 40 A should be replaced by 0 - 20 A ammeter	√		

No.	ITEM	EFFECT ON OPERATIONS		
		SEVERE	NOMINAL	NONE
13	Control Panel for Intermediate Lift Pump No. 2 had some installations removed to replace burglarised parts in other panels. It should be re-furbished	√		
14	Control Panel for Sludge Pump No. 2 had some installations removed to replace burglarised parts in other panels. It should be re-furbished	√		
15	Ammeter glass for Intermediate Lift Pump No. 3 broken			√
16	Control Panel for Sludge Pump No.3 had some installations removed to replace burglarised parts in otherpanels. It should be re-furbished			√
17	Intermediate Pumping Station panel 0 - 40 A ammeter reading low. To be replaced with 0 - 10 A ammeter			√
18	Blower Feeder panel 0 - 40 A ammeter reading low. To be replaced with 0 - 10 A ammeter			√
19	Annunciator does not function. Should be repaired and re-commissioned		√	
20	Pressure Gauges for Sludge Pump Nos. 1, 2 & 3 not functioning		√	
21	Drainage Pumping Station Incomer ACB ammeter range 0 - 400 A should be replaced by 0 - 100 A ammeter			√
22	Recirculation Pump No. 1 panel burglarised. Pump is functional	√		
23	Recirculation Pump No. 2 burglarised. The pump is functional.	√		
24	Works Drainage Pump No. 1 panel burglarised. The pump is also faulty	√		
25	Works Drainage Pump No. 2 Ammeter faulty and should be repaired. The pump is functional			√

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No.	ITEM	EFFECT ON OPERATIONS		
		SEVERE	NOMINAL	NONE
26	Works Drainage Pump No. 3 panel burglarised. Pump is also faulty	√		
27	Final Humus Tank Scraper No. 1 panel burglarised of some control fittings		√	
28	Final Humus Tank Scraper No. 2 panel burglarised of some control fittings		√	
29	Works Drainage Pumps Control selector not functional		√	
30	Raw Sewage litres/sec gauge and flow meter chart are not functional			√
31	Recirculation Pumps Control selector not functional		√	
32	Recirculation Pump Nos. 1, 2 & 3 gauges (m of H_2O) not functional			√
33	Works Drainage Pump Nos. 1, 2 & 3 gauges (m of H_2O) not functional			√
34	Fluorescent lighting tubes removed			√
35	Lagoon Nos. 1, 2, 3 & 4 inspection chambers lights stolen or faulty			

3. SITE STUDIES

2.1 WATER TREATMENT WORKS

(a) KAMAKWA INTAKE

Lighting

In the electric driven pump hall, a bulkhead type fitting has been dismantled but the bulb holder still functions satisfactorily. A fluorescent lamp fitting does not function.

In the diesel driven pump hall the bulb holder functions but it needs to be replaced with a new one for safety reasons.

All the outdoor lighting luminares are functioning satisfactorily.

Pumpsets

There are two directly-coupled electric motor driven pumpsets of similar characteristics. One pumpset is run during the day and the other at night so that each pumpset runs for 12 hours and remains at rest for a similar length of time.

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Pump No. 1

The pump is controlled by a star-delta starter on which is installed a 0 - 300 Ampere ammeter and 0 - 450 Volt voltmeter with selector switch. At the time of investigation this pump was at rest.

Motor

Make : ELMA made in Poland
3-phase
type: Se 280 M2
Ser. No : EK 157856
Power : 90 kW 125 HP
Work : S1
RPM : 2965
Starter : 400 - 450 V Δ 156 - 142 A 50 Hz
Cosφ : 0.92 η : 91%
PHE : VOE0530 Δt : 40^{0}C Cu : 80^{0}C
Climate : TH Year : 1977 625 kg
Insulation Class : B

Pump

Weir Pumps Ltd, Scotland
Unit No. 56811 / 406
Frame DOA 100 / 125

Pump No. 2

The pump is controlled by a star-delta starter on which is installed a 0 - 300 Ampere ammeter and 0 - 450 Volt voltmeter with selector switch. At the time of investigation the pump was running and the ammeter reading was 90 Amps which is within the expected loading.

Motor

Make : ELMA made in Poland
3-phase
type: Se 280 M2
Ser. No : EK 157853
Power : 90 kW 125 HP
Work : S1
RPM : 2965
Starter : 400 - 450 V delta 156 - 142 A 50 Hz
Cosφ : 0.92 η : 91%
PHE : VOE0530 Δt : 40^{0}C Cu : 80^{0}C
Climate : TH Year : 1977 625 kg
Insulation Class : B

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Pump

Weir Pumps Ltd, Scotland
Unit No. 56811 / 405
Frame DOA 100 / 125

Diesel Pump

The diesel engine has not been run for several years while the pump has been removed. The set is, therefore unlikely to be operable again.

Engine

Ruston & Hornsby (India) Ltd under licence from Ruston & Hornsby Ltd, Lincoln - England

Engine No : 784D113
Mark : 4YDA
Full load speed : 1800
No load speed : 1860
Rated load : 63.8
Rating : Cont.

(b) KAMAKWA WATER TREATMENT WORKS

General

All the cables in this station have been run inside steel pipe conduits.

An indication panel consisting of 10 pairs (green and red) indication lamps exists on one wall of the office. These are for indicating whether any of the 10 dosing chemical stirrers (4 alum, 2 chlorine and 4 soda ash) are on (green) or tripped (red). Below each pair of indication lamp is a reset push-button.

Lighting

The lighting installations within the office are in satisfactory condition and functional. 2 wall-socket outlets are not functional. 3 floodlights for lighting the filters area are not functional but outdoor luminares mounted on steel posts are functioning satisfactorily.

Lighting fittings installed within the chemical storage room are not functional . Only one fluorescent tube inside the second chemical storage room is operational. In the first chemical storage room only one lighting bulb exists but it was found to be non-functional.

In the chemical dosing room up-stairs, all the fluorescent tubes are not functional but on one of them a bulb holder and bulb have been temporarily installed and provides the only lighting point.

Inside Mumbi Estate (Ring Road) chlorine dosing room, the lighting fittings are not functioning. The split unit is completely corroded and needs to be changed. The wall socket outlet is damaged.

In the Backwash / Booster room below the Mumbi Estate chlorine dosing room, the lighting fittings are functioning well.

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Dosing Chemicals Stirrers

(i) Alum stirrers

There are 2 Alum mixing tanks each containing 2 stirrers. Viewing the stirrers from left to right, stirrers No. 1, 2 and 3 are non-functional but No. 4 is operational.

All the stirrers are driven by single-phase motors through speed reducing gears.

<u>Motors</u>

<u>No. 1</u>

NECO Normand Electrical Ltd, Norwich, England

HDM5 Part No. 170075

Motor No. D90LH R931275 Class: F Rise: B

kW : 1.5

Motor RPM : 1420

Rating : MCR

Voltage : 220 - 240 / 330 - 415 Δ / Y

Ser. No : WV121426

Type : 2H200

output speed : 1425 / 52

<u>No. 2</u>

East African Chains Ltd

Ser No : 14512 / 25

Frame : 2H200D90

Power : 1.5 kW

Volts : 220 / 330 / 440

Ph : 3

Hz : 50

Amps : 6.2 / 3.6

Rating : CCT

Type : SC

<u>No. 3</u>

VEB Electremotorenwerks Thurm DDR / GDR

7G2 KMDB RD G 4 / 220

363239 /12 1985

IP : 54

U / min (RPM) : 53

G : 110 kg : 31.5

kW : 1.5

F - B rise

M: 220 Nm

220 - 240 Δ / 380 - 420 YN

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No. 4

VEB Electremotorenwerks Thurm DDR / GDR
7G2 KMDB RD G 4 / 220
363244 /12 1985
IP : 54
U / min (RPM) : 53
G : 110 kg : 31.5
kW : 1.5
F - B rise
M : 220 Nm
220 - 240 Δ / 380 - 420 YN

(ii) Chlorine stirrers

There are 2 chlorine mixing tanks each containing 1 stirrer both of which are functioning. All the stirrers are driven by single-phase motors through speed reducing gears.

Motors

viewing the stirrers from left to right, the following are the details on the name plates

No. 1

VEB Electremotorenwerks Thurm DDR / GDR
7G2 KMDB RD G 4 / 220
363237 /12 1985
IP : 54
U / min (RPM) : 53
G : 110 kg : 31.5
kW : 1.5
F - B rise
M : 220 Nm
220 - 240 Δ / 380 - 420 YN

No. 2

VEB Electremotorenwerks Thurm DDR / GDR
7G2 KMDB RD G 4 / 220
363236 /12 1985
IP : 54
U / min (RPM): 53
G : 110 kg : 31.5
kW : 1.5
F - B rise
M: 220 Nm
220 - 240 Δ / 380 - 420 YN

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(iii) Soda Ash Stirrers

There are 4 Soda Ash mixing tanks each containing 1 stirrer all of which are functioning. The stirrers are driven by single-phase motors through speed reducing gears.

Motors

No. 1

VEB Electremotorenwerks Thurm DDR / GDR
7G2 KMDB RD G 4 / 220
363234 /12 1985
IP : 54
U / min (RPM) : 53
G : 110 kg : 31.5
kW : 1.5
F - B rise
M: 220 Nm
220 - 240 Δ / 380 - 420 YN

No. 2

VEB Electremotorenwerks Thurm DDR / GDR
7G2 KMDB RD G 4 / 220
363238 /12 1985
IP : 54
U / min (RPM) : 53
G : 110 kg : 31.5
kW : 1.5
F - B rise
M: 220 Nm
220 - 240 Δ / 380 - 420 YN

No. 3

VEB Electremotorenwerks Thurm DDR / GDR
7G2 KMDB RD G 4 / 220
363232 /12 1985
IP : 54
U / min (RPM): 53
G : 110 kg : 31.5
kW : 1.5
F - B rise
M: 220 Nm
220 - 240 Δ / 380 - 420 YN

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No. 4

Hawker Siddley Brook Crompton Parkinson Motors
Frame No. D90LD 142739Q Class F B rise
kW : 1.5 rev / min : 1420 Rating : MCR
415Y 3 - phase 50 Hz 3.55 A
Made in England

Stirrer

David Brown
Helicon Series
Size MHD 335
Order H111382 / 8
Rating HP : 2
Output RPM 58.5
Ratio 24.79 / 1
An extractor fan at the Chlorine dosing area is functional.

(iv) Booster and backwash pumpsets and blower

In the backwash / booster room there are 2 booster pumpsets in which only one is functional and the other has been removed. There are 2 backwash pumpsets both of which are fully functional. There is also one blower unit which is operational.

The main isolator and distribution panel with associated conduits need to be re-painted due to corrosion.

Booster Pumpsets

No. 1

These are directly coupled pumpsets having the following characteristics

Motor - No name-plate

Pump - Ajax Pumps
Size: 11 / 1K
Series : C
Assembled : FS

This pump leaks water onto the floor causing the room to be flooded all the time.

Backwash Pumpsets

These are belt drive type.

Page

No. 1 Motor

Metropolitan Induction Motor Type : K4126
HP : 10
V : 400 / 440
A : 13
Freq : 50
ph : 3
No. SW 14356B

No 1 Pump

Sigmund Pumps Ltd Gateshed, England Type: N - NG4
Ser. No. 915306 - 2

No. 2 Motor

Metropolitan Induction Motor Type : K4126
HP : 10
V : 400 / 440
A : 13
Freq : 50
ph : 3
No. SW 14356B

No 2 Pump

Sigmund Pumps Ltd Gateshed, England Type : N - NG4
Ser. No. 915306 - 3

Blower unit

This is directly - coupled.

Compressor

The Hammond Engineering Co. Ltd Enfield - middx - England
Type : RAL 13
Ser. No. 7805

Motor

The British Thomson - Houston Co. Ltd Rugby, England

Type : KNX - C2 / 3 No. 79046H2
Volts : 415
Phase : 3
Cyc : 50
HP : 50
HP : 5 cont rpm : 1420

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(c) KIGANJO INTAKE

Lighting

In the pump hall lighting fittings, originally bulkhead type, have been removed and instead temporary ceiling rose with bulb have been installed. All the outside luminares are functional. There are no plug outlets installed. All the lighting cables are installed in steel pipe conduits.

Pumpsets

There are positions for 3 pumpsets comprising of 2 No. 30 kW pumps (Nos. 1 & 2) and a 75 Hp pumpset. Pump No. 1 and its drive motor have been removed for repairs. Pumpset No. 2 is now operated by No. 1 pump starter.

The starter for No. 1, 30 kW pump has a 0 - 200 A ammeter whose range is too high for the motor sizes. Subsequently under normal operating condition, the ammeter reading is in the non-linear range between 0 - 50 A (30 A). No. 2, 30 kW unit starter has a 0 - 120 A ammeter.

Power cables for pumpsets No. 1 & 2 are in poor condition and need to be replaced but power cables for the 75 Hp pumpset are in acceptable condition.

A rectangular hole cut on the wall for the purpose of cooling the 75 Hp motor should have a wire mesh installed in it to keep off insects and other venoms.

A diesel pumpset is functional but is aged and leaking oil excessively.

<u>No. 1</u>

<u>motor</u>

Hawker Siddley Electric Motors Ltd, Guiseley, Leeds, England

7B - D200	D7BM2K	
30	415 Δ volts	
2945 rev / min	52Δ Amps	3-phase
50 Hz		
Isol F	IP 54	MC
Temp. rise 80 °C		
IEC 34 - 1		

<u>Pump</u>

Ajax - Elite to DIN 24255
Item No. 210715
Size 50 - 26 - Axoc
Ser. No. 93 / 0173 IMP DIA
Supplied by KSB Ajax Pumps PTY Ltd
Melbourne - Australia

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No. 2

Not available

75 Hp Pumpset

This unit has been removed for pump repairs but 2 similar motors (one of them damaged) are kept in the pump hall.

Telemecanique 3-phase Δ - Y starter with a 0 - 15 A ammeter which is too small for that size of motor and 0 - 600 V voltmeter.

Motor

Made in Poland
3-phase motor
Type : Sem 250M2
No. : Ee 130155

Power : 55 kW75 Hp	Work : S1		2945 rpm
Stat : 400 - 440 V Δ	94 - 86 A	50 Hz	
Cos φ : 0.93	η : 91.8%		
PNE : VDE 0530	40°C Δt cu		
Climate : TH	Year : 1977	440 kg	Ins. cl : B

Damaged Motor

Made in Poland
3-phase motor
Type : Sem 250M2
No. : Eh 139199

Power : 55 kW75 Hp	Work : S1		2945 rpm
Stat : 400 - 440 V Δ	94 - 86 A	50 Hz	
Cos φ : 0.93	η : 91.8%		
PNE : VDE 0530	40°C Δt cu		
Climate : TH	Year : 1977	440 kg	Ins. cl : B

Pump

Removed for repairs.

Diesel Pumpset

Engine

Lister
No. 3401175HR3401
Output 39.5 Hp
rev / min 1800

Pump

KSB Klein Schanzlin & Becker Ag.
Type MOVI 40/5 N/A
Prod No. 4030070601210110
Ord No. 6 - 174 - 293 202 / 1
Year 1984

(d) KIGANJO TREATMENT WORKS

(i) Pump Hall

Lighting

All the lighting wiring is run through steel pipe conduits.

Lighting fittings within the pump hall have been removed.

There are no plug outlets provided.

The street lighting which was controlled from the office is not functional. The street lighting consists of luminares mounted on 4 poles such that 3 of them have one luminare each and 1 pole at the residential quarters has 3 luminares mounted on it.

The lighting fittings in the office are functioning well.

The lighting fittings in the equipment store are functioning well. There is a socket outlet which seems to be in good working condition.

Pumpsets

There are a total of 5 pumpsets 2 of which are functional, 1 standby and 2 which are powered by diesel engines but both engines are damaged beyond repair. All the electric motor pumpsets are belt drive coupled type.

For the 3 electric motor driven pumpsets, they were initially controlled by starters manufactured by Allen West & Co. Ltd, Brighton, England. The starters are aged and have been replaced by Telemecanique direct-on-line (DOL) starters but the isolating switches in the old starters are still used for isolation of supplies to the individual pump motors. The starters have no electrical instrumentsprovided. All the electric motor supplies have been installed inside steel pipe conduits.

No. 1

This unit is functional.

Motor

Crompton Parkinson Ltd
5 Hp 1430 rpm 50 cycles No. 4EN
400 / 440 V 7 Amp
continuous rating

Pump

Worthington Simpson
Newark - Notts - England
21/2D4 No. 5133110

No. 2

This unit is functional.

Motor

Crompton Parkinson Ltd
5 Hp 1430 rpm 50 cycles No. 4EN
400 / 440 V 7 Amp
continuous rating

Pump

Worthington Simpson
Newark - Notts - England
21/2D4 No. 5133115

No. 3

Diesel Engine

The diesel engine is damaged beyond repair and has no name-plate.

Pump

The pump is functional.

No. 4 Diesel Engine

The diesel engine is damaged beyond repair and has no name-plate.

No 4 Pump

The pump has been removed and its whereabouts was not known to the operators on duty at the time of the study.

No. 5

The pumpset was transferred from Kamakwa and although it is in good working condition it is not used since, according to the operators, it pumps air through the pipe causing air-lock.

No 5 Motor

Guselex Motors Hawker Siddley Model HB6J4K
15 kW 20 Hp M.C. Rating
1440 RPM 28 Amps Delta
415 V 3-ph 50 Hz
Class 'B' insulated BS 2610

The name-plate does not give the frame or serial number.

(b) KIGANJO SEWAGE WORKS

Lighting

The indoor lighting is not functional due to lack of fluorescent tubes although the wiring and fittings seem to be in good condition.

Outdoor lighting is functional.

Control Board

The control board consisting of feeder control panels and pump control panels were supplied by BIWATER Pumps & Controls, Wallwin Pumps, Warwick, England. The panel arrangement is as follows:

Pump No. 1

mounted on the swing-door are the following items:

- 0 - 60 A Ammeter which is in good working condition;
- hour-run counter which is in good working condition;
- running lamp (red) whose bulb has burnt out;
- supply on lamp (colourless) which is in good working condition;
- failed lamp (amber) which is in good working condition; and
- automatic pump control is functioning well

a terminal block has been unfastened and lies loose inside the panel;

control wiring has been disconnected at certain terminals and the general condition of the wiring rendered untidy; and

fuses other than HRC have been utilised in motor power supply.

All the above should be rectified.

Pump No. 2

The timer on the main pump starting relay has been removed.

Pump No. 3

The swing-door, control wiring, control relays and instruments were all burglarised. The panel will need to be re-furbished in whole.

DISTRIBUTION FEEDER

All the fittings, wiring and control relays were burglarised.

CONTROL PANEL

The panel is in good condition and the wiring has not been disturbed much. The pumps automatic control electronics seems to be in good working condition but the pump duty selector switch which has been positioned wrongly needs to be corrected.

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INCOMING PANEL

The outside and inside appearance of the panel is good. The cable entry was left unsealed hence rats have been entering the panel. Although the rats have not damaged the electrical parts they have left the panel quite dirty. The cable entry should be covered with plastic compound.

mounted on the swing-door are the following items:

- 0 - 200 A Ammeter which is in good working condition;
- 0 500 V Voltmeter which is in good working condition but the glass is broken; and
- Voltage selector switch is in working condition but the voltmeter needle vibrates when the voltage selector switch is at positions R-B, Y-B and R-Y.

Submersible Pumps

No.1

This is the only functioning pump and although it is automatically controlled by the electrodes which sense the sludge level, the pump runs for many hours in a day since the original design was for 2 duty pumps and 1 standby pump. To extend the pump's life, the maintenance personnel have had to carry out the servicing of the pumpset every two weeks.

No.2

The pumpset went faulty and was removed for repairs.

No.3

The pumpset went faulty and was removed for repairs.

(c) NYERI SEWAGE WORKS

Lighting

All the lighting fittings and socket outlets in the office area are functioning satisfactorily.

The site (street) lighting is functional but it is manually operated after the failure of the time switch which controlled the lights. The effectiveness of the site lighting is low due to the few number of installed lights. In future flood lights should be installed in various points in the Works to light the entire area within the Works.

Aerating Blowers

No. 1

Motor

Removed for re-winding.

Blower

Hick Hargreaves, Bolton, England
Size 2032
Ser. No. V16807
A Bundenberg pressure gauge range 0 - 15 lb / in^2 does not function.

No. 1 Motor

Hawker Siddley Brook Crompton Parkinson Motors
Make : IP55
Frame : D90S
No. : 0499645
kW : 1.1
Rev : 1420
Rating : MCR
Voltage : 240 / 415 Δ Y
Ph : 3
Hz : 50
Amp : 5.2 / 30

Blower

Hick Hargreaves, Bolton, England
Size 2032
Ser. No. V16808

one of the four aeration defusers on one bank (out of 2) is damaged and has been removed and the pipes shut-off.

Blower Control Panel

The control panel for the aeration blowers and the ultra-flow monitoring instrument in the yard the following indicating lamps which are all functional :

Supply on	White
Running	Red
Failed	Amber

and the following push-buttons which are also functional :

Stop	Red
Start	Green
Reset	Black

The hour-run counters for the aeration blowers are both functional.
Off - Hand - Auto switch is functional.
Heater Off - Auto switch is functional.
The main isolator switch is operational.

Ultra-Flow Monitoring Instrument

Arkon Instruments Ltd
Unit C3 Liddington Trading Estate
Ser. No. UF 5219
Supply : 240 vac

Scraper Bridge Drives

No. 1

Hawker Siddley Brook Crompton Parkinson Motors
Frame : D71FD R817404
Class : F B Rise
kW : 0.25
Rev / Min : 1380
Rating : MCR
Voltage : 415 Y
Ph : 3
Hz : 50
Amp : 0.77
Gear - Radicon

No. 2

Hawker Siddley Brook Crompton Parkinson Motors
Frame : D71FD R817406
Class : F B Rise
kW : 0.25
Rev / Min : 1380
Rating : MCR
Voltage : 415 Y
Ph : 3
Hz : 50
Amp : 0.77
Gear - Radicon

Main Switchgear Room

Lighting

All the fluorescent tubes have been removed but the other lighting fittings are in good condition.

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Main Power Distribution Board

The board was supplied by BIWATER Pumps & Controls, Wallwin Pumps, Warwick, England and comprises the following panels :

1. Meter Board

The following KP&LC meters are installed inside :

KWh, KVAh, and KVA demand instrument.

2. Incoming ACB

Installed Ammeter with range 0 - 800 A but shows no reading because of the low load. The ammeter should be replaced with a 0 - 200 A range ammeter.

Ammeter Selector Switch

Voltmeter with range 0 - 500 V

Voltage Selector Switch, the voltmeter vibrates at positions R-B, Y-B, R-Y and the voltmeter displays low damping at positions R-N, Y-N, B-N.

3. Works Control Board Feeder ACB

The installed kilowatt-hour meter is functioning well.

Installed Ammeter with range 0 - 400 A shows no reading because of the low load. The ammeter should be replaced with a 0 - 50 A range ammeter.

Ammeter Selector Switch is functioning well.

Voltmeter with range 0 - 500 V.

Voltage Selector Switch is functioning well.

4. Intermediate Lift Pump No. 1

The ammeter and control relays have been removed and utilised for replacement of burglarised ones at the Works Pumping Station leaving the panel non-operational.

Sludge Pump No. 1

All the controls are functioning well.

The Ammeter Selector Switch functions at all the positions except R.

The Ammeter with a range 0 - 40 A is too high to show accurate readings. It should be replaced with an Ammeter having a range 0 - 20 A.

Scraper No. 1

All the control installations function well.

Page

Future (scraper)

Only the main isolator switch has been installed. The wiring and other installations to be put in depending on the intended scheme of control of the future scraper.

5. Intermediate Lift Pump No. 2

The ammeter and control relays have been removed and utilised for replacement of burglarised ones at the Works Pumping Station leaving the panel non-functional.

Sludge Pump No. 2

The ammeter and control relays have been removed and utilised for replacement of burglarised ones at the Works Pumping Station leaving the panel non-functional.

Scraper No. 2

All the control are functioning well.

Future (scraper)

Only the main isolator switch has been installed. The wiring and other installations to be put in depending on the intended scheme of control of the future scraper.

6. Intermediate Lift Pump No. 3

All the control installations are functioning well but the Ammeter has a broken glass and its damping is poor. The ammeter should be replaced.

Sludge Pump No. 3

The ammeter and control relays have been removed and utilised for replacement of burglarised ones at the Works Pumping Station rendering the panel non-functional.

Site lighting

The time switch controlling the site lighting went faulty and since then the site lighting is controlled by the main isolator switch. A new time switch, photocell or ripple receiver should be installed.

7. Controls

Intermediate Lift Pumps - the selector switch functions well.

Sludge Pumps - the selector switch functions well.

All the common control circuits are functioning well.

Intermediate Pumping Station

Ammeter shows no readings with range 0 - 40 A due to low load. It should be replaced with a 0 - 10 A ammeter.

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Blower Feeder

Ammeter shows no readings with range 0 - 40 A due to low load. It should be replaced with a 0 - 5 A ammeter.

Distribution Feeder

Only the isolator switch has been installed on the swing-door and wired to the fuses. The switch is functional.

Distribution Feeder

Only the isolator switch and heater control have been installed on the swing-door and wired to the fuses. The switches are functional.

8. Instrumentation

Alarm Annunciator

After installation, the Contractor was unable to make it work and so it has never functioned.

The indications on the Alarm Annunciator are listed as :

Intermediate Lift Pump No. 1 Failure
Intermediate Lift Pump No. 2 Failure
Intermediate Lift Pump No. 3 Failure
Sludge Pump No. 1 Failure
Sludge Pump No. 2 Failure
Sludge Pump No. 3 Failure
Works Drainage Pump No. 1 Failure
Works Drainage Pump No. 2 Failure
Works Drainage Pump No. 3 Failure
Recirculation Pump No. 1 Failure
Recirculation Pump No. 2 Failure
Recirculation Pump No. 3 Failure
Intermediate Lift Pump Sump Low Level
Sludge Pump Sump Low Level
Recirculation Pump Sump Low Level
Drainage Pump Sump Low Level
Intermediate Lift Pump Sump High Level
Sludge Pump Sump High Level
Recirculation Pump Sump High Level
Drainage Pump Sump High Level
9 spare indicator windows
Power Monitor
Reset push-button
Lamp Test push-button
Accept push-button

Pressure Gauges

Sludge Pump No. 1 gauge range 0 - 25 metres of water range is too high since it reads approximately 7 metres of water.

Sludge Pump No. 2 gauge range 0 - 25 metres of water range is too high since it reads approximately 7 metres of water.

Sludge Pump No. 3 gauge range 0 - 25 metres of water range is too high since it reads approximately 7 metres of water.

Power Factor Correction Panel

This is a switched Power Factor Correction system manufactured by MICAFIL. It achieves a maximum power factor of 0.8 as measured by the maintenance personnel.

Outdoor Installations

Intermediate Scrapper Junction Box

The Junction Box contains the following :

Distribution Board Feeder main isolator switch

Distribution Board isolator switch

Scraper isolator switch

Future

Intermediate Pumps controls

There are 3 Intermediate Pumps but only 1 (No. 3) is operational since the control panels for the other two were burglarised and have not yet been replaced.

Intermediate Humus Scraper Motor

Hawker Siddley Brook Crompton Parkinson Motors

Frame : D71FD R817408

Class : F B Rise

kW : 0.25

Rev / Min : 1380

Rating : MCR

Voltage : 415 Y

Ph : 3

Hz : 50

Amp : 0.77

Gear - Radicon

Final Humus Scrapers No. 1

Hawker Siddley Brook Crompton Parkinson Motors

Frame : D71FD R817405

Class : F B Rise

kW : 0.25

Rev / Min : 1380

Rating : MCR

Voltage : 415 Y

Ph : 3
Hz : 50
Amp : 0.77
Gear - Radicon

Final Humus Scrapers No. 2

Hawker Siddley Brook Crompton Parkinson Motors
Frame : D71FD R817407
Class : F B Rise
kW : 0.25
Rev / Min : 1380
Rating : MCR
Voltage : 415 Y
Ph : 3
Hz : 50
Amp : 0.77
Gear - Radicon

Radicon Gear

David Brown
Order No. R162451 / 86
Class 237 - 1200 / 1

Works Pumping Station

Lighting

All the lighting fluorescent lamps have been removed otherwise the electrical fittings including the socket outlet (1 No.) are in good condition.

Control Board

At the Works Pumping Station the Control Board comprises the following panels.

1. Incomer ACB

   The installed Ammeter with a range 0 - 400 A is too high to read accurately the low load and should, therefore, be changed to 0 - 100 A range.

2. Recirculation Pump No. 1

   The panel was burglarised of all the installations and wiring.

   Recirculation Pump No. 2

   The panel was burglarised of all the installations and wiring.

Recirculation Pump No. 3

On the panel is mounted a 0 - 100 A ammeter which does not show accurate reading since the range is too high for the load and would be preferred an ammeter with a range 0 - 40 A. The pump is manually operated since the automatic control system is not functional.

3. Works Drainage Pump No. 1

The panel was burglarised of all the installations and wiring.

Works Drainage Pump No. 2

The panel is functional but the ammeter on it is faulty.

Works Drainage Pump No. 3

The panel was burglarised of all the installations and wiring.

4. Final Humus Tank Scraper No. 1

Some control items in the panel were burglarised.

Final Humus Tank Scraper No. 2

Some control items in the panel were burglarised.

Future (2 No.)

Only isolator switches have been installed in both.

Distribution Feeder

Only isolator switch is installed on the swing-door and fuses inside.

Works Control Pumps Control Selector

Not functioning

5. Recirculation Pumps Control and Instrumentation

Raw sewage litres / second (l /s) gauge range 0 - 210 l /s and a flow meter chart recorder are not functional.

Recirculation Pumps Control Selector not functioning.

Recirculation Pump No. 1 gauge (in metres of water) does not function correctly.

Recirculation Pump No. 2 gauge (in metres of water) does not function correctly.

Recirculation Pump No. 3 gauge (in metres of water) does not function correctly and is stuck on position 9 m of H_20.

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Pumps

Raw Sewage Pumps (Sludge Pumps)

These pumpsets are direct coupled dry well type.

No. 1

Ser. No. R8002
Type VP3 - 175 - 4
27.7 metre Head 22 litres / sec.
RPM (@ Full load) 1450
17.5 kW 35 Amp
Insulation Class F 415 V 3 ph 50 Hz

No. 2

Ser. No. R8003
Type VP3 - 175 - 4
27.7 metre Head 22 litres / sec.
RPM (@ Full load) 1450
17.5 kW 35 Amp
Insulation Class F 415 V 3 ph 50 Hz

No. 3

Ser. No. R8004
Type VP3 - 175 - 4
27.7 metre Head 22 litres / sec.
RPM (@ Full load) 1450
17.5 kW 35 Amp
Insulation Class F 415 V 3 ph 50 Hz

Effluent Recirculation Pumps

No. 1

The submersible pumpset is in good condition.

Ser. No. R7996
Type VP6 - 300 - 6
7.5 metre Head 34 litres / sec.
RPM (@ Full load) 1000
30 kW 57 Amp
Insulation Class F 415 V 3 ph 50 Hz

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No. 2

The submersible pumpset is in good condition.

Ser. No. R7997
Type VP6 - 300 - 6
7.5 metre Head 34 litres / sec.
RPM (@ Full load) 1000
30 kW 57 Amp
Insulation Class F 415 V 3 ph 50 Hz

No. 3

The submersible pumpset is operational.

Ser. No. R7998
Type VP6 - 300 - 6
7.5 metre Head 34 litres / sec.
RPM (@ Full load) 1000
30 kW 57 Amp
Insulation Class F 415 V 3 ph 50 Hz

Intermediate Lift Pumps

All the Intermediate Lift Pumps are in good working position but only No. 3 is operational due to canibalisation of Nos. 1 & 2 control panels.

No. 1

Ser. No. H2898
Type HOMA A 150 - 380K 37.0 / 6C
8.3 metre Head 96 litres / sec.
RPM (@ Full load) 960
37 kW 68 Amp
Insulation Class F 415 V 3 ph 50 Hz

No. 2

Ser. No. H2899
Type HOMA A 150 - 380K 37.0 / 6C
8.3 metre Head 96 litres / sec.
RPM (@ Full load) 960
37 kW 68 Amp
Insulation Class F 415 V 3 ph 50 Hz

No. 3

Ser. No. H2900
Type HOMA A 150 - 380K 37.0 / 6C
8.3 metre Head 96 litres / sec.
RPM (@ Full load) 960
37 kW 68 Amp
Insulation Class F 415 V 3 ph 50 Hz

Works Drainage Pumps

The submersible pumpset is faulty and has been removed.

No. 1

Ser. No. R7999
Type VP6 - 300 - 6
16 metre Head 30 litres / sec.
RPM (@ Full load) 1440
15 kW 28 Amp
Insulation Class F 415 V 3 ph 50 Hz

No. 2

The submersible pumpset is functional.

Ser. No. R8000
Type VP6 - 300 - 6
16 metre Head 30 litres / sec.
RPM (@ Full load) 1440
15 kW 28 Amp
Insulation Class F 415 V 3 ph 50 Hz

No. 3

The submersible pumpset is faulty and has been removed for repairs.

Ser. No. R8001
Type VP6 - 300 - 6
16 metre Head 30 litres / sec.
RPM (@ Full load) 1440
15 kW 28 Amp
Insulation Class F 415 V 3 ph 50 Hz

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Sampler

Sampler type SIRCO is damaged and inoperable.

Model X - SAME / 24 R
Volts 240 50 Hz
Amps 3.15 max.
Ser. No. 8 / 1086
Date of manufacture October 1986

SIRCO CONTROLS Ltd

Lagoons

There are four lagoons and each of them has an inspection chamber in which is installed an inspection lamp.

Lagoon No. 1 lamp stolen;
Lagoon No. 2 lamp stolen;
Lagoon No. 3 lamp stolen; and
Lagoon No. 4 lamp faulty.