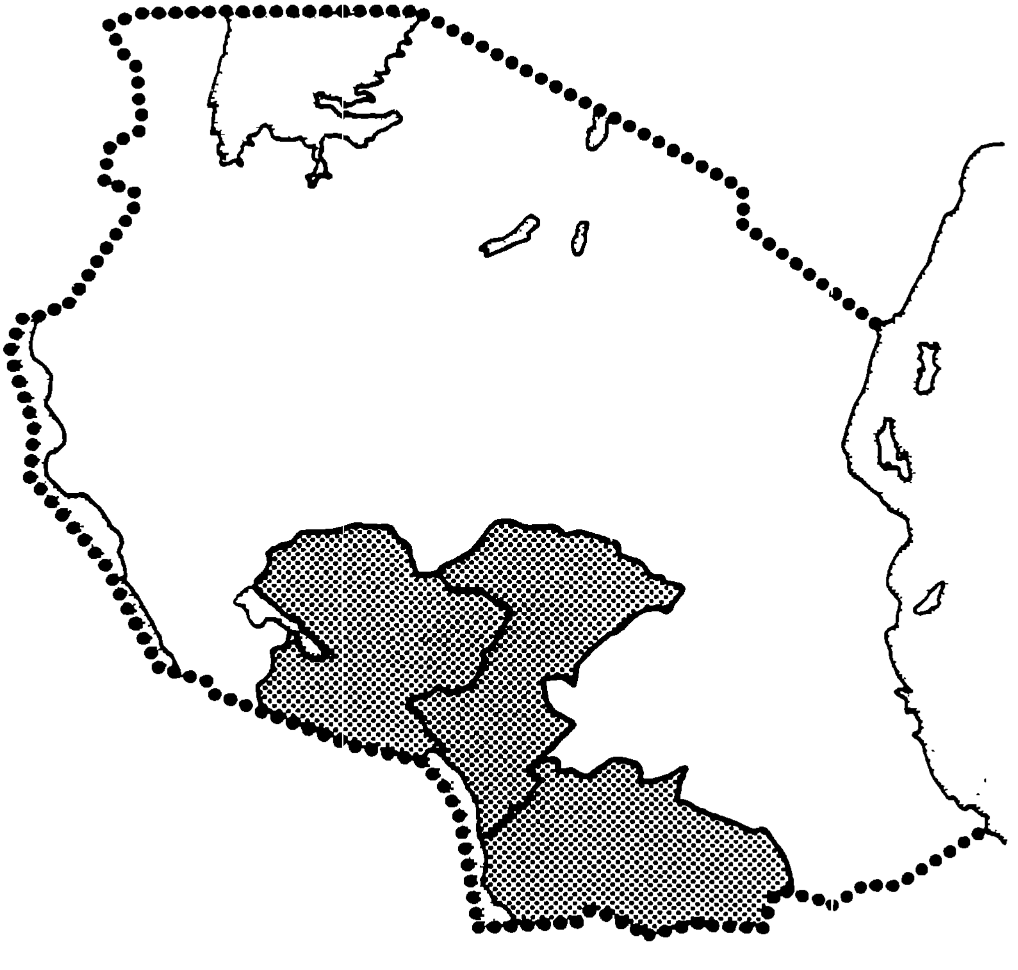
UNITED REPUBLIC OF TANZANIA

INTERNATIONAL DEVELOPMENT AGENCY • DANIDA

IMPLEMENTATION OF WATER MASTER PLANS FOR IRINGA, RUVUMA AND MBEYA REGIONS

WATER CONSUMPTION IN SIX VILLAGES 1987



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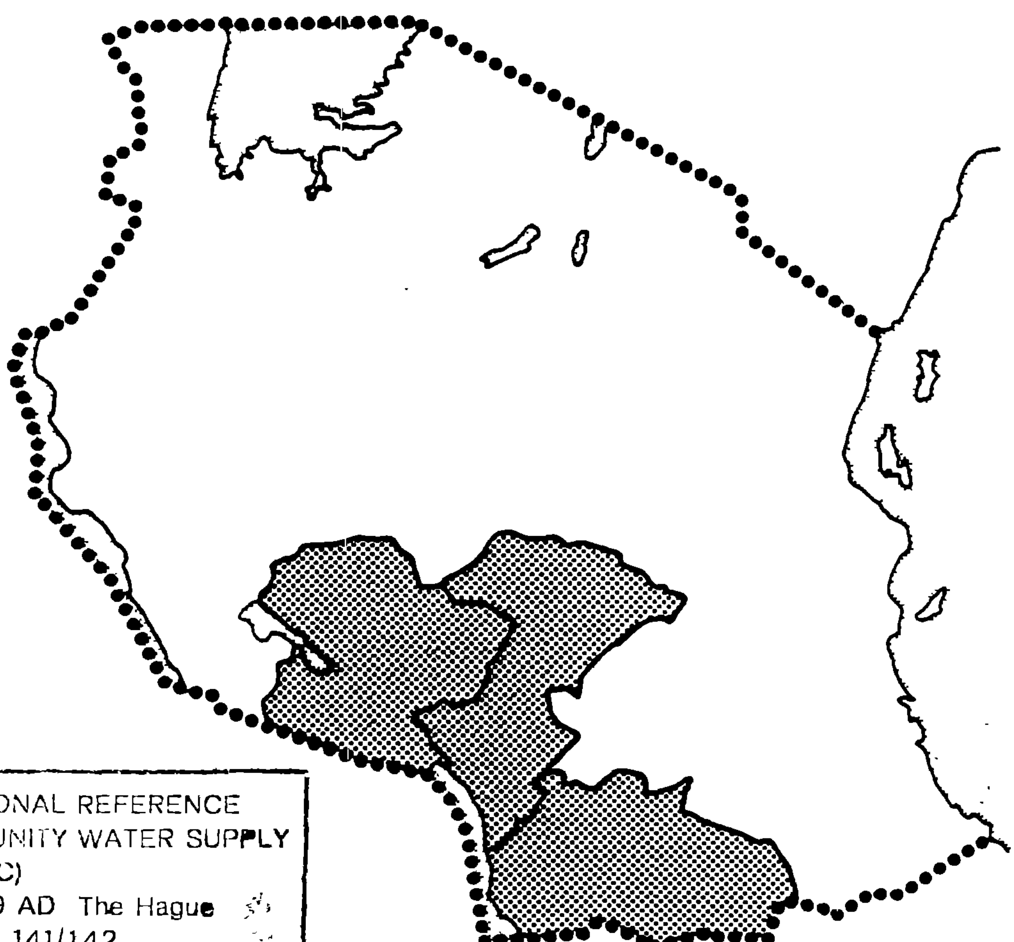

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APPENDICES

1. INTRODUCTION

1.1 Background

The first phase of the DANIDA/MAJI sponsored Water Master Plans in Iringa, Ruvuma and Mbeya Regions commenced in 1980 with the preparation of Water Master Plans covering both engineering and socio-economic aspects. Concurrently with preparations of the plans construction of a few water supply schemes was commenced in 1982, and the last volumes of the plans were completed early 1983.

The second phase of the project, comprising implementation of water supplies in selected high priority villages in the three regions, took off late 1983 and was planned to cover a 5-year period. So far (late 1987) approximately 170 villages have been supplied with water under the programme either by means of gravity supply or handpumps.

As a prerequisite for another implementation phase the project was evaluated during May 1987, and in connection with the evaluation, it was decided to carry out a study on water use in the villages. The first part of the study was carried out in the rainy season during February/March 1987 in order to provide data for the Evaluation Mission. Additional data collection was made towards the end of the dry season during September/October 1987, and the present report is covering both data collection periods although the last period covering 6 villages is analysed in greater detail than the first, which only covered 4 villages.

1.2 Objectives of the Study

There were two major objectives of the study:

- To establish reliable figures for actual water use in villages supplied in accordance with the criteria of the Water Master Plans.

- On the basis of findings of the study to comment on present design criteria and make recommendations for changes if required.

The design criteria recommended in the WMPs deal with per capita water demand, Nos. of users per DP (Domestic Water Point), maximum walking distances to fetch water, capacity of DPs, peak factors, allowance for losses and storage demands.

1.3 Study Team and Acknowledgements

The field work of the study was executed by staff attached to the implementation phase either by means of employment in the Regional Water Engineers' offices or by employment in the Regional DANIDA Implementation Offices. A complete list of team members is given in Appendix I. The design of the study, supervision of field and computation work , the final processing of data and reporting was done by Hans Egerrup, Resident Representative of the engineering consultants to the project.

The assistance and support to the study team provided by Regional Water Engineers, staff of Implementation Offices and DANIDA Steering Unit is greatly appreciated, and special thanks goes to all the field staff, who fulfilled their tasks in the most excellent way despite long working hours and frequent unpleasant weather conditions. Especially, the services of four Iringa team members, who formed the backbone of the field teams both during the rainy and the dry season in all three regions, and who did most of the computation work, have been extremely valuable for the successful completion of the study.

Last, but not least, the villagers should be mentioned. Without the full support and collaboration of Village Chairmen, Village Water Committees, Village Secretaries and Balozis, the study could not have been carried out, and the performance of the many villagers reading meters was commendable.

1.4 Guidance to the Reader of the Report

It is hoped that the report will be studied by both engineering and socio-economic staff of the project, and that the report would be of interest to people outside the project with an interest in rural water supplies. The report is predominantly directed towards engineering aspects, however, other subjects of more common interest are also included.

To facilitate the understanding of technical aspects in particular, explanations are given, which for many readers might seem unnecessarily detailed, however, many such explanations have been added during the drafting of the report as a result of discussions held with project staff and others.

Consequently, the report has become quite voluminous and guidance to selected chapter reading is therefore given below.

The summary should be read by everybody and could be supplemented with the following chapters according to interest of the reader.

- Interest in per capita water consumptions:
  Chapters 6, 7 and 12 supplemented with Chapters 5 and 8 if variations in consumption are of interest too.

- Interest in engineering design aspects:
  Chapters 6 to 12 and 14 to 16.

- Interest in individual villages, service levels (walking distances, Nos. of users, etc) and collectors of water:
  Chapters 5, 7, 11, 13 and 14.5.

- Interest in "design" of study:
  Chapters 3 and 4

- Interest in cost implications:
  Chapter 16.

2. SUMMARY

2.1 Summary of Findings

The study was carried out in 4 villages in the rainy season and 6 villages in the dry season of 1987. The villages have all had piped water supply for more than a year and were selected so as to represent, as good as possible, the variations in climatic and other conditions of the 3 regions Iringa, Ruvuma and Mbeya.

The water consumptions of the villages were measured by use of water meters fitted to all domestic water points (DPs) and master meters covering the complete villages for a period of 9 to 10 days in each village. The meters were read on a continuous basis from 6 am to 9 pm and data was obtained for calculation of per capita consumption, peak factors, losses, waste and storage demand.

Household interviews were carried out at all households using the water supplies in order to collect data on population and use of alternative water sources. The study covers a total population of more than 10,000 people, and 2 days of observations were included to obtain data on collectors of water.

The results of the metering showed average per capita water consumptions in the dry season ranging from 20 l/day to 30 l/day, with a weighted average of some 26 l/day. It was also found that timing of measuring water consumption is very important, the rainy season average consumption being only 2/3 of the dry season consumption.

It is necessary to design water supplies for maximum consumption, so further analyses and recommendations are based on the dry season data only.

There appears to be a tendency towards lower consumption with increased walking distances when looking at individual DPs, however, when considering complete villages the tendency is not clear.

The number of users per DP is found to affect the actual amount of water drawn per capita. When number of users exceeds some 150 people per tap a decline in rate of consumption from the water supply of up to some 20% was found, but there is not found any proof of increases in consumption, when number of users are say below 100.

The study does not show any correlation between water consumption and socio-economic conditions of the villages.

During the study considerable variations in daily consumptions occured. The variations were biggest during the rainy season (up to ± 32% from average), but during the dry season the variations ranged from 8% to 14% only with an average of 12%. It is most common that high consumptions take place on Fridays, Saturdays and Sundays, with Saturdays having the highest consumption. The effect of the daily variations is that per capita consumption on Saturdays is some 3 l higher than the weekly average (dry season).

Water not being used (for instance from taps left open at night) appear not to be a major problem. The water wasted in this way only amounts to about 1 l/c/d on average, but large variations occured from village to village.

The loss of water through leakages in pipes also varied considerably from village to village, however, on average the findings indicate that the normal allowance of 20% for losses appears reasonable.

Adding up the different components of water use a total demand of 36 litres per capita per day is found, based on the service level recommended in the Water Master Plans. This is considerably higher than the 25 litres provided for in WMP. The proposed higher per capita demand is not due to increase in consumption from 1981 to 1987, but is mainly caused by the study based on interviews during WMP not taking seasonal and daily variations in consumption into account.

There are also strong indications of villagers underestimating the volumes of water collected by children. In WMP the volumes collected by children were estimated at 22% based on household interviews, whereas the present study, in which all DPs were under observation for 2 days, showed that some 40% of the water is collected by children.

The master meters were read every quarter of an hour in order to provide data for calculation of peak factors. It was found that the present design flow of 10 l/min per tap is sufficient for design of pipelines leading to DPs and that the overall peak factor can be reduced from the 3.0 presently in use to 2.5 for villages with a future population above 2,000. For smaller villages the peak factor of 3.0 should continue to apply.

It was found to be economically advantageous to provide extra storage to compensate for daily variations in consumption within the week. The transmission system therefore needs to be designed for weekly average only, which also reduces the requirements to minimum flow at water sources. The total demand for storage to balance both daily and hourly variations has been estimated at some 60% of the daily design capacity of the schemes.

Finally the cost implications of the above findings/recommendations have been evaluated, and it is found that construction cost will increase with approximately 11% from the present level of expenditures. This equals some DKK 35.- (US $ 6.-) per capita.

2.2 Summary of Proposed Design Criteria

Based on the findings of the present study the following design criteria are proposed. For comparison the WMP design criteria are shown in brackets.

- Daily per capita demand (inclusive of losses and waste etc): 36 litres (25);

- Design flow to DPs: 10 l/min per tap (same);
- Peak factor for villages with more than 2000 inhabitants: 2.5 (3.0);
- Peak factor for villages with less than 2000 inhabitants: 3.0 (same);
- Storage demand in percent of daily design capacity: 60% (50%);
- Maximum Nos. of users per tap: 200 (same);
- Maximum walking distance to DP: 400 m (same).

2.3 Recommendations for Further Studies

Although the amount of data collected and evaluated in the present study is very extensive and provides reliable information on water use during the metering periods, it cannot be stated that the week chosen in the dry season had maximum or near maximum consumption. Further data on seasonal variations is therefore required. Collection of data in this respect commenced in the beginning of January 1988 with the installation of a master meter in one village in Iringa Region. The meter is being read once a day and days with rainfall are recorded. Data processing should be made after about a year.

The recommendations of the present study are based on the present (WMP) service level, however, it is not known whether a new phase of the project will include changes in service levels. Before such possible changes are introduced it is important to evaluate the technical, social and economical consequences.

The extensive workload put on children with collection of approximately 40% of all water drawn from DPs is a possible social consequence of providing water nearer to the housestead than it was before.

The present study does not reveal whether children were contributing equally much with collection of water from traditional sources, but it is recommended that the matter be looked into and also whether the practice has any health implications on the children.

The time of the highest water consumption coincides with the time of the lowest flow in surface water sources. Many existing and proposed surface water sources are small mountain streams with only marginal extra capacity at the end of the dry season. The findings of the present study therefore place increased emphasis on the ongoing low flow gaugings and the analyses of minimum flows and also on environmental control of catchment areas.

It is considered likely that a number of proposed surface water sources will have insufficient capacity to meet the increased demand, so intensified use of groundwater sources will be necessary. It might also be advantageous in some cases to supply some villages both with surface and groundwater, particularly where settlements are scattered.

3. SELECTION OF SAMPLE VILLAGES

3.1 Study Area

The study area is the three Regions where the MAJI/DANIDA sponsored water project is operating namely Iringa, Ruvuma and Mbeya Regions. The three regions are of approximately same size and covers a total area of some 180,000 sq. km. with great variations in altitude and climate. Altitudes range from some 500 metres to about 2,500 metres above sea level, and mean annual rainfall from 400 mm to 2,500 mm.

The present population (1987) of the three regions is approximately 3 million people. The population density is relatively low in Ruvuma Region (some 50% of the density of the other two regions), but large variations occur from the semi-arid areas in northern Iringa and Mbeya Regions to the fertile highlands and lake shore areas in Mbeya Region.

For the purpose of preparing the Water Master Plans the 3 regions were sub-divided in a total of 18 Agro-Ecological Zones, which are described in Volume 12, Ch. 2.

3.2 Village Selection Procedures

The rainy season metering took place concurrently with a "Pre-Evaluation Study" on water use, participation in operation and maintenance of water schemes and functioning of village water committees, so the village selection procedures had to take both technical and sociological factors into account. Senior staff from all 3 regions were taking part in the selection, which was based on the following criteria:

- Villages from all 3 regions to be represented;
- As many different climatic and agro-ecological conditions as practically possible to be represented;

- Different settlement patterns should be considered;

- The villages should have well established Village Water Committees;

- Both single village supplies and group scheme supplies to be included;

- Reasonably easy access to the villages (rainy season);

- The villages have had a piped water supply for more than 1 year;

- The water supply is reliable;

- The water quality is good;

- Preferably a clear separation of distribution and transmission systems of the water supply;

- Possibility of establishing reliable population figures.

Although approximately 60 villages had a functioning gravity water supply by mid-1986, most of them could not fulfill the majority of the above criteria, and some criteria had to be relaxed for a few of the six selected villages. In fact so few villages complied with the criteria that there was practically no choice in Iringa and Ruvuma Regions and effectively only a choice between villages in 2 group schemes in Mbeya Region.

The situation of the six selected villages is shown in Figure 3.1, and a good variety of climatic, ecological and socio-economic conditions of the 3 regions are represented by the selected villages as shown in Table 3.2.

More detailed description of the selected villages are to be found in Chapter 5.

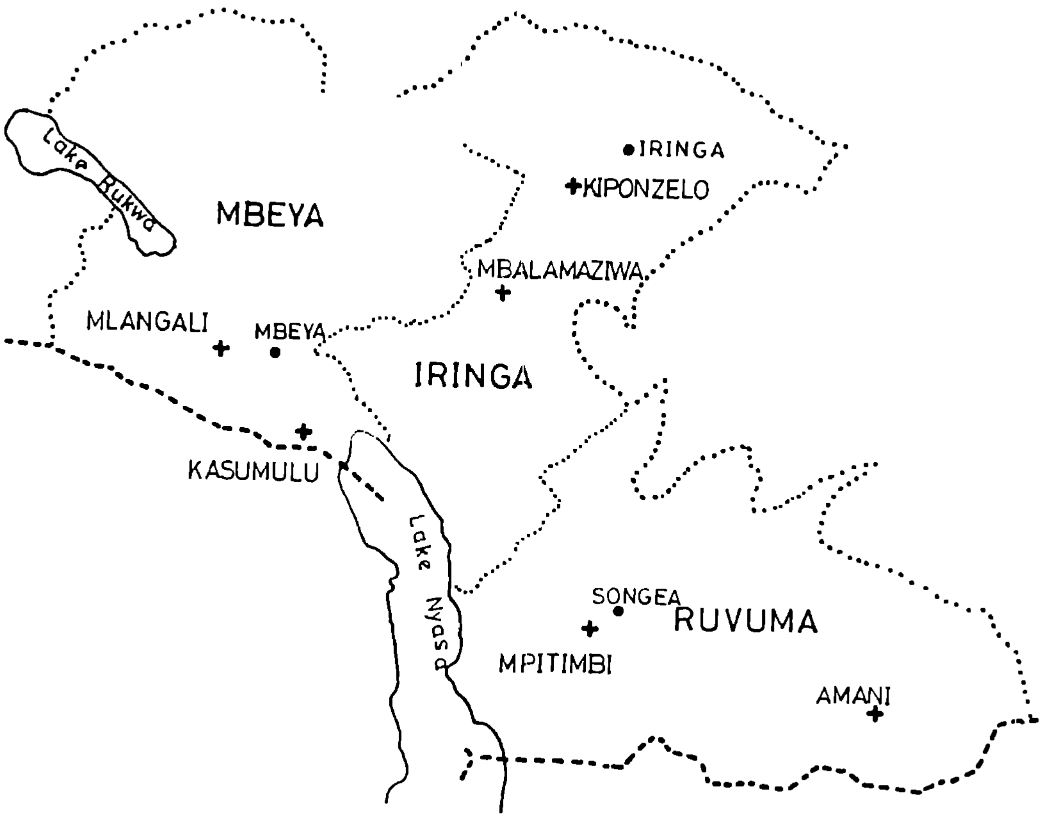

Figure 3.1 - Situation of sample villages

Name of Village	Region/District	Agro Ecolo-gical zone	Settlement pattern	Type of water scheme	Separation of distribution & transmission systems
Kasumulu	Mbeya /Kyela	Lake shore	Scattered	Group (large)	Yes
Mlangali	Mbeya /Mbozi	Wet highlands	Fairly dense	Group (small)	Yes
Kiponzelo	Iringa/Iringa	Mixed zone	Fairly dense	Single	No
Mbalamaziwa	Iringa/Mufindi	Upper plateau	Dense	Group (medium)	Yes
Mpitimbi "B"	Ruvuma/Songea	Intermediate	Scattered	Group (small)	Yes
Amani	Ruvuma/Tunduru	Dry eastern	Dense	Group (small)	No

Table 3.2 - Particulars of selected villages

3.3 Statistical Considerations

The selection procedure described in Chapter 3.2 above did not leave any possibility for random selection of villages. However, it is questionable whether random sampling would have given results, which would reasonably cover the large variations in both climatic and other conditions of the study area without the sample being very large. The most appropriate sampling technique for this particular case appears therefore to be stratified sampling, and the selection procedures followed comply quite well with the requirements for such sampling.

Stratified sampling should give comparatively small sampling errors, but how big these errors are cannot be stated due to the limited knowledge of all the villages, from which the sample was selected (approximately 60 villages).

Provided variations in average per capita water consumption in villages in the 3 regions are somehow following the normal distribution function it can be worked out that the sample of six villages will provide an estimated average per capita water consumption that is less than 10% wrong in 90 out of 100 villages (or in other words the estimate is correct within ± 10% with 90% confidence). If the confidence should be increased to 95% the margin of error would increase to some ± 15%. The size of the sample (6 villages) would not increase even if the sample should represent all 1500 villages in the three regions, if the same margin of error and level of confidence is maintained.

The water consumption studied in the six selected villages was for the entire population of the villages and consumption figures are therefore the actual water consumption at the time of the study and no statistical errors refer to the recorded consumptions. The above mentioned margin of error and level of confidence do only apply if the results from the six villages are taken to represent other villages in the regions.

Measures taken to reduce inaccuracies of individual village results (non-sampling errors) are described in Chapter 4.

4. METHODOLOGY

4.1 Design of the Study

From the initial discussions on the possibility for conducting a study on water consumption, it was concluded that the study should be based on water meters in order to provide as exact data as practically possible. It was further decided that water consumption should be metered for the complete villages (master meters), and supplemented with meters at individual DPs.

It was not known during the planning of the study, how the villagers would react to the installation of meters, therefore, it was decided to install meters at all DPs to avoid getting biased results due to the possible effect of villagers avoiding (or prefering) DPs with meters installed. It was further decided that the reading of meters should be done by villagers, so as to avoid possible changes in water using habits (e.g. laundrying at DPs etc.) due to the presence of "foreigners" observing activities at DPs (the purpose was to measure actual water consumption, and not only water consumption complying with the agreement between the villages and MAJI/DANIDA).

Additional advantages of metering all DPs were that the rate of water losses in the distribution systems could be established and possible effects on the water consumption of variations in physical and other conditions within a village evaluated.

Before the actual study commenced, a pilot study was carried out at 2 DPs over a period of 4 days at Kiponzelo Village. The main objectives of the pilot study were to test the villagers' ability to read the meters, to observe the reaction of the villagers to the metering and to test the accuracy of the proposed meter installation. (The accuracy of the meter installation is reported on in Chapter 4.3).

The villagers selected as meter readers (one per DP) performed very well and the forms for recording readings proved useful for the purpose. Furthermore, no adverse effects of the meter installations were observed, so it was decided to carry on with the study as planned.

4.2 Activities in the Villages

In this chapter a brief description of typical activities taking place in the selected villages during the study is given.

After studying drawings of the water supplies recognaissance visits were made to the villages and agreements were made with village chairmen and water committee chairmen on an introductory meeting to the programme. At the same time the chairmen were asked to select meter readers, who preferably should be young people having completed standard 7, not having any employment and living near the DP. The actual selection of meter readers turned out to comprise mainly of young people and about one third of them were females.

The meetings were normally held in the morning with village governments and water committees represented and most 'balozis' (10 cell leaders) present together with other interested villagers. The purpose of the study was explained to the meetings and it was stressed that there were no intentions of changing their water supply, nor of collecting any charges for the water, therefore they should continue using the water as usual.

A team of plumbers was in the meantime installing the master meter at the storage tank, and after the meeting, small meters were installed at all DPs and meter readers instructed by staff from RWE's office. Each meter reader was issued with a digital watch, a torch, ballpen and forms for recording meter readings. Readings would then commence the next morning at 06.00 hours and continue every hour until 21.00 hours for the next 9 to 10 days. Only the results from 7 days out of the 9 or 10 days of metering were used for computations, and the first day of metering was not used in any case in order to allow people to get used to the meters.

The master meter was read by staff from RWE's office every quarter of an hour during the day and every 3 hours during a few nights to check on system losses. The RWE staff also supervised the DP meter readers and collected forms every day for checking and computation of consumptions. Supervision by senior personnel was carried out 3 to 4 times in each village.

The household interviews were normally performed over a period of two weeks either before or during the actual metering, by staff from the village participation section of the project.

At the completion of the metering period, meters were dismantled and meter readers paid for their service.

During the dry season metering, the study was supplemented with two days of observations at each DP for the purpose of counting people of different categories collecting water (see Chapter 13).

4.3 Meters and Meter Installations

The meters used were ordinary house installation meters with a nominal capacity of 2.5 m^3 per hour, showing cubic metre readings with digits, and fractions (down to 0.0001 m^3) on 4 "clock type" counters. The meter readers (villagers employed by the project for that purpose) should not interpret the readings, but only copy the m^3 reading and the position of the arms on the "clock" counters (copy of form for meter readers is enclosed in Appendix IV). The meter readers were issued with forms, ball pen, torch and digital watch, and recorded readings every hour from 06.00 hours to 21.00 hours. The meter readers performed well and only a few readings could not be used.

Before commencing the actual programme, a pilot study was carried out in Kiponzelo village (see chapter 4.1 above). It was the intention to install the small meters immediately before the tap on the DPs, so both installation and reading would be easy, but such an installation would not fulfill technical requirements to certain lengths of straight pipes before and after the meters.

The effect on the accuracy by installing meters at the taps was tested at 2 DPs (one with many users and one with few users) for a period of 4 days. At each of the 2 DPs one meter was installed at the tap and one on the straight pipe in the ground before the DP. By comparing the readings of the meters it was found that differences were less than 0.5%. Consequently, the meter installation at the tap was considered acceptable for the purpose of the study.

The master meters used are 50 mm Meinecke meters with a capacity range from 1.5 to 35 m^3/hour and with readings down to 0.01 m^3 (Accuracy $\pm$ 5% from 0.18 m^3/hour to 1.5 m^3/hour and $\pm$ 2% above 1.5 m^3/hour). The master meters were read every quarter hour from 06.00 to 21.00 hours and at 3 hour intervals for some nights to determine system losses. (copy of form for master meter recording is enclosed in Appendix IV).

The master meters were in all cases installed on straight pipes.

Further data on the meters used are enclosed in Appendix III.

Comparisons of total water use at DPs (recorded with small meters) and the recorded total flow at the master meters over periods of 9 to 10 days showed differences of less than 2% (in villages without losses), which proves that possible errors caused by meters are marginal and of no significance to the result of the study.

Computations of results were made partly in the villages and partly back in office. Copies of forms used are enclosed in Appendix IV.

4.4 Household Interviews

It is equally important to get reliable population figures as reliable water consumption figures. The last population census was in 1978, so census figures are not applicable. It was therefore decided to carry out household interviews at all households using water from the system investigated, so as to establish total population using the water supply, and also how the population is distributed on various DPs. At the same time people were asked whether or not they used water for other than domestic purposes and if they use other water sources (traditional sources).

In some villages, population figures were also obtained from the village registry, but in most cases these figures were outdated and large differences between registry figures and figures from household interviews were found. In all cases with large differences, the household interviews resulted in larger population figures than the ones obtained from the village.

The results of the household interviews are considered the most reliable, and comparisons of total number of children obtained from interviews and actual number of children in primary schools gave reasonable results. Comparisons with the 1978 census showed large variations in population growth rates, but good similarities of ratios between children and adults.

The form used for the household interviews is enclosed in Appendix IV.

A second purpose of the household interviews was to obtain information on use of water for non-domestic purposes (proved insignificant), and for supplementary use of traditional sources. Sporadic observations were made at traditional sources, which were mainly used for personal hygiene, laundrying and cleaning utensils. Since the purpose of the study was to provide basis for revision of (or to confirm) design criteria, it was important to record the use of traditional sources, so compensation for such usage could be made when estimating per capita water demand. No study of quantities used from traditional sources was made, nor for water volumes used for different purposes when collected from DPs, as such information is available from the Pre-Evaluation Study and Water Master Plan Studies.

From WMP Volume 12, Table 8.19 and Pre-Evaluation Study, Table 8.2, it can be seen that approximately 60% of the water collected is being used for personal hygiene, cleaning and laundrying. Assuming that some 20 litres are used per capita per day (see Chapter 7), it appears appropriate to make an allowance of 12 litres per day for each person using traditional sources for supplementing the water supply (see also WMP Volume 5A, Table 4.3). The average per capita consumption is not very sensitive to the allowance as shown in Chapter 7.

4.5 Definitions

The definitions of various terms used in this report are given in Appendix II. A few of the terms related to per capita water consumption are explained below.

- Actual consumption excluding losses (total or per capita).

  This is the total amount of water flowing through DPs, or in other words the amount of water, which could have been effectively used by consumers.

- Actual consumption excluding losses and estimated waste.

  This is the above amount of water after deduction of estimated waste, which in turn is defined as water not put into use (e.g. water wasted from taps left open). Water used at DPs for cleaning buckets etc. is not waste.

- Estimated net water consumption if supply from water supply only.

  This is the estimated water consumption (excluding losses and waste) if all villagers were using the water supply only. The figure therefore contains an allowance for use of traditional sources (if any).

- Average consumption
  When the term "average" is used in connection with consumption figures, it means average of consumption during the respective metering period (7 days) and not annual average.

- Maximum day consumption
  With the term "maximum" is meant the maximum consumption recorded during the respective metering period, and not annual maximum.

In addition to the definitions given in Appendix II most terms are explained in the text too.

5. WATER CONSUMPTION IN SAMPLE VILLAGES

5.1 General

The present chapter contains information on the six villages about climatic conditions, population, settlement pattern and use of traditional sources. Furthermore, the water supply systems are described and data given on water consumption both during the rainy and the dry season for the individual villages.

Summary of water consumptions, losses, waste, peak factors, etc. based on data from all villages are dealt with in Chapters 6 to 15.

5.2 Kasumulu Village

5.2.1 Background information

Kasumulu village is situated in Kyela district on the plains between the Kiwira and Songwe Rivers some 20 km from Lake Nyasa. The altitude is slightly above 500 metres and the mean annual rainfall is 2400 mm. The agro-ecological zone (Lake Shore) is described in WMP, Vol. 12 Ch. 2.3.4. The climate is hot and humid most of the year, and temperature measurements during the dry season metering of water use ranged between 24^{o} and 38^{o} Centigrade during daylight hours. The minimum temperature was $18^{o}C$.

The new Mbeya - Malawi road is passing through the lower part of the village (see village layout Figure 5.1),but has so far not resulted in significant commercial developments in the village.

There is no health centre or dispensary, but two primary schools in the village.

Most of the available land is used for agricultural purposes and most people are living on their land, resulting in a very scattered settlement pattern with no concentration of dwellings. Due to the scattered settlement and the situation between two perennial rivers a large number of the villagers are using the traditional sources or only using the water supply for drinking and cooking. A certain part of the village is

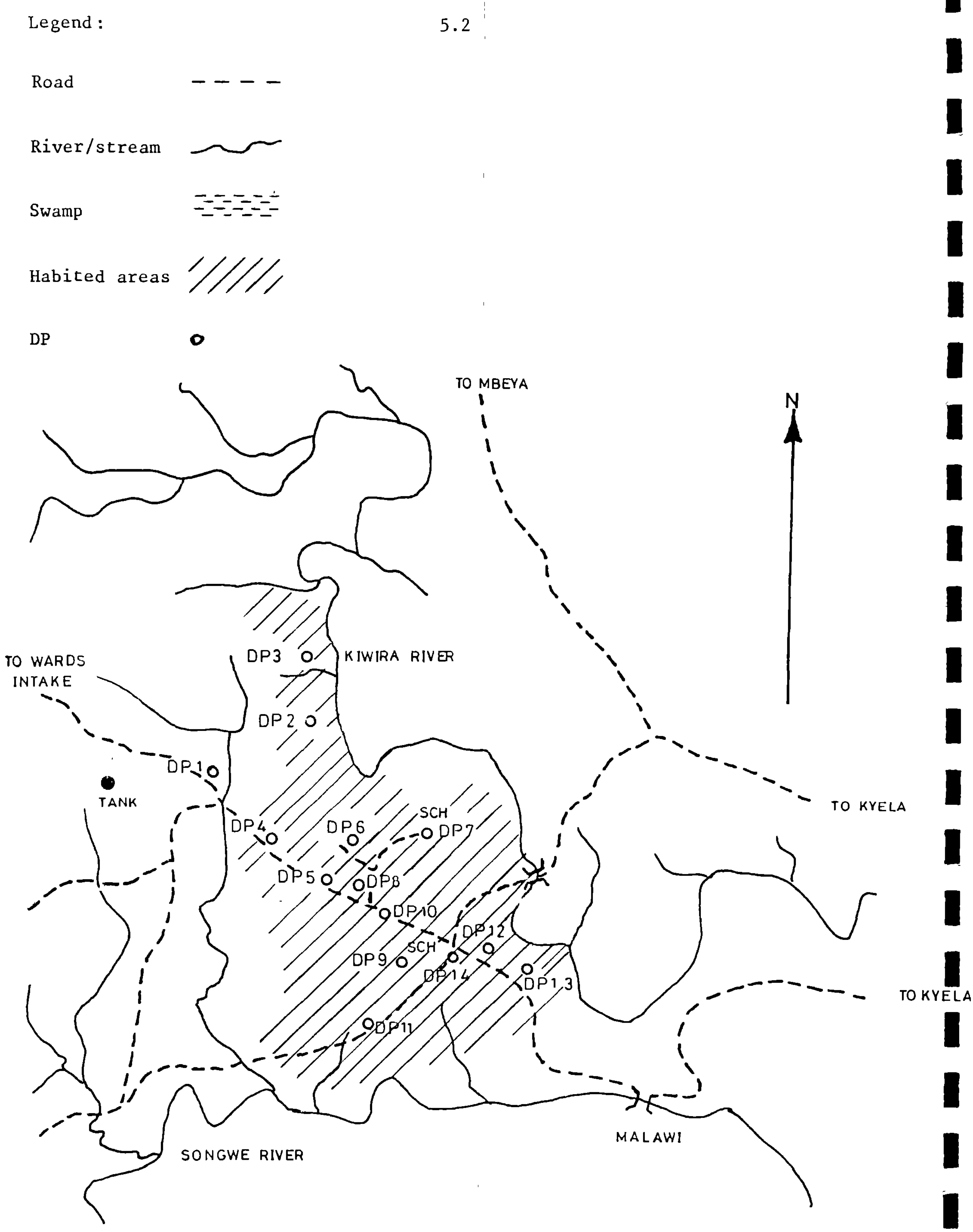

Figure 5.1 - Kasumulu village layout

Scale 1 : 50,000

supplied with water from another village water supply system and has therefore for the purpose of this study been excluded from the calculations. Furthermore, a contractor had a temporary camp in the village supplied from the water supply system. The water use at the camp was metered separately and has been excluded from the calculations, with the consequence that the few villagers using water from the camp are excluded from the study too.

A summary of the results of the household interviews is given below. Details are given in Appendix V.

Use of water	Population	%	Households
For domestic purposes only and entirely from the water supply	1,160	53%	258
As above but also for garden watering	183	8%	33
From water supply but supplemented with traditional sources	386	18%	73
Total using water supply	1,729	79%	364
From traditional sources only (or from other system)	473	21%	114
Grand Total	2,202	100%	478

Table 5.2 - Kasumulu Village: Summary of household interviews

5.2.2 Description of water supply system

Kasumulu village water supply is part of a large group scheme, which is still under construction. The supply to Kasumulu was completed in 1985 and since then there has only been one major interruption to the supply caused by a landslide near the intake. The supply is by gravity from a mountain stream and the water quality is good. Water is conveyed through the transmission system to village storage tanks and all DPs in Kasumulu are supplied from such a tank through the distribution system.

The master meter was installed on the outlet pipe from the tank and small meters were installed on all 14 DPs and at the contractor's camp (see layout).

Due to the scattered settlement walking distances are relatively long and some 20% of the villagers are not using the water supply. There were no interruptions to supply during the two metering campaigns.

5.2.3 Metering of water consumption

The water consumption was metered both towards the end of the rainy season and towards the end of the dry season during the last week of March and the second week of September respectively. There was no rain during any of the two periods, but, there are some small water streams in the village during the rainy season, so more use of traditional sources should be expected during the rainy season.

The water consumptions at individual DPs are shown in Appendix VI, pages 1 and 2, both for rainy and dry seasons. Summaries are given in Tables 5.3 and 5.4.

There is a remarkably large difference between the rainy season and dry season consumption, the average rainy season consumption being only 61% of the dry season consumption. It is stressed that the presented results are actual measurements at that specific time and they might neither reflect the lowest nor the highest consumption of the village.

Type of Consumption		Wed.25/3	Thu.26/3	Fri.27/3	Sat.28/3	Sun.29/3	Mon.30/3	Tue.31/3	Overall average per day
Actual consumption excl. losses	Total	25,440	25,674	23,468	25,945	29,863	28,284	29,762	26,919
	Per Capita	14.7	14.8	13.6	15.0	17.3	16.4	17.2	15.6
Estimated Waste		0	500	100	0	950	0	600	307
Actual consumption excl. losses and estimated waste	Total	25,440	25,174	23,368	25,945	28,913	28,284	29,162	26,612
	Per Capita	14.7	14.6	13.5	15.0	16.7	16.4	16.9	15.4

Table 5.3 - Kasumulu Village: Water consumption March 1987 (rainy season) in litres per day

Note: Maximum and average figures are underlined.

Type of Consumption		Wed.9/9	Thu.10/9	Fri.11/9	Sat.12/9	Sun.13/9	Mon.14/9	Tue.15/9	Overall average per day
Actual consumption excl. losses	Total Per Capita	43,701 25.3	49,872 <u>28.8</u>	48,416 28.0	41,109 23.8	34,421 19.9	46,543 26.9	45,072 26.1	44,162 <u>25.5</u>
Estimated Waste		0	1,400	700	400	0	2,600	500	800
Actual consumption excl. losses and estimated waste	Total Per Capita	43,701 25.3	48,472 <u>28.0</u>	47,716 27.6	40,709 23.5	34,421 19.9	43,943 25.4	44,572 25.8	43,362 <u>25.1</u>
Compensation for use of traditional sources (386 people)		-	-	-	-	-	-	-	4,632
Estimated net water consumption if supply from W/S only	Total Per Capita	-	-	-	-	-	-	-	47,994 <u>27.8</u>

Table 5.4 - Kasumulu Village: Water consumption September 1987 (dry season) in litres per day
Note: Maximum and average figures are underlined.

The estimated waste is insignificant, but the use of traditional sources is likely to account for 10% or more of the total water consumption.

An analysis of per capita water consumption at individual DPs is shown in Table 5.5, which also gives comments and possible explanations to the variations in per capita use. The information on use of traditional sources and garden watering is from the household interviews. During the dry season metering, brickmaking was ongoing at several places in the village. The bricks were (according to the village chairman) almost entirely for use in the village, so it is not a commercial activity, and it is a common activity for that time of the year. The extensive brick-making at DP 14 and the water consumption at a bar and at the small market brings the per capita consumption based on people living nearby up to a very high figure. This is because the non-domestic consumption is added to the consumption of relatively few people (39 only). The average per capita consumptions at DPs not affected by use of traditional sources, garden watering, etc. varies from 20.3 l/day to 26.5 l/day only. The number of users per DP does not appear to influence the per capita water consumption, but there seems to be a tendency to lower per capita consumption at DPs placed in the outskirts of the village, where walking distances are relatively long (DP nos. 1, 3, 7 and 11).

Figure 5.6 shows the daily variations in consumption for the whole village. For individual DPs, the variations are much higher (see Appendix VI) and it is worth noticing that peak days at individual DPs are scattered over the whole period of metering and that no more than 5 DPs out of the 14 have maximum consumption on the same day. Water use in the village is thus not following a common pattern.

The hourly variations in consumption over the day are also quite different from day to day. These hourly variations as recorded by the master meter are shown in Appendix VII pages 1 to 4, for the dry season metering. (Since it is records from the master meter, losses and waste are included, amounting to some 8% on average).

DP NO.	Average per capita consumption excl. losses and waste	Nos. of people per DP	People supplementing with water from trad. sources	Estimated net water consumption if supply from W/S only	Comments
1	12.3	118	52	17.6	Relatively long distances
2	20.4	98	6	21.1	
3	16.2	101	0	16.2	Many staying near river. Relatively long walking distances
4	18.8	83	22	22.0	
5	20.3	103	0	20.3	
6	24.0	128	0	24.0	
7	15.7	227	114	21.7	Many staying near river
8.	23.6	86	0	23.6	
9	41.4	121	0	41.4	Some garden watering
10	48.1	106	0	48.1	Some garden watering
11	18.4	163	61	22.9	Near river
12	11.5	222	131	18.6	Near river
13	26.5	134	0	26.5	
14	172.6	39	0	172.6	At market. Extensive brickmaking
Total	25.1	1729	386	27.8	

Table 5.5 - Kasumulu Village: Estimated per capita consumption at individual DPs

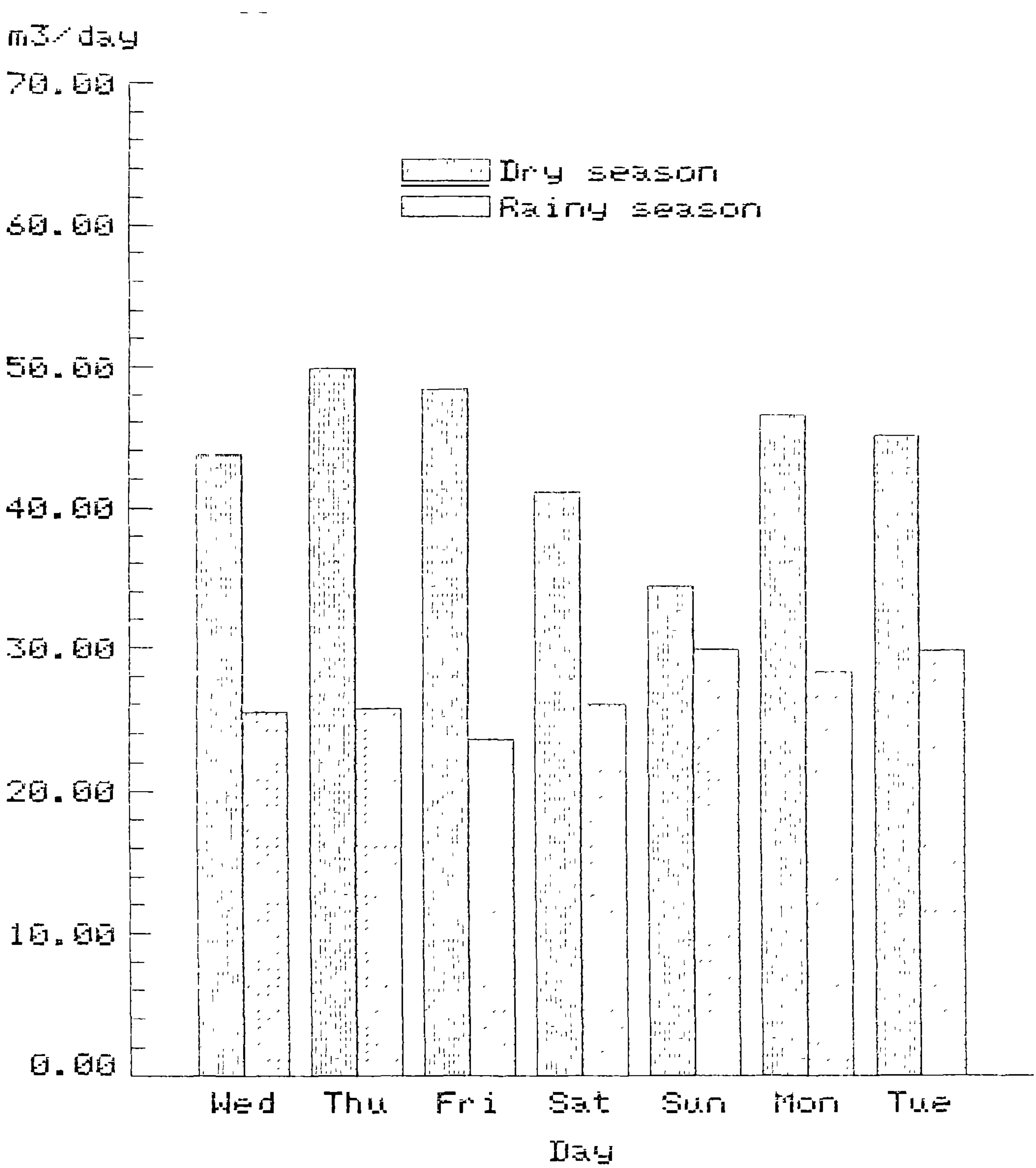

Figure 5.6 - Kasumulu Village: Actual daily consumption excl. losses

Figure 5.7 shows average hourly consumption over 7 days of metering. It can be seen from the figure that almost all water is collected between 6 am and 8 pm, that water is collected throughout the day and that major peak hours occur from 7 to 9 am and from 6 to 7 pm.

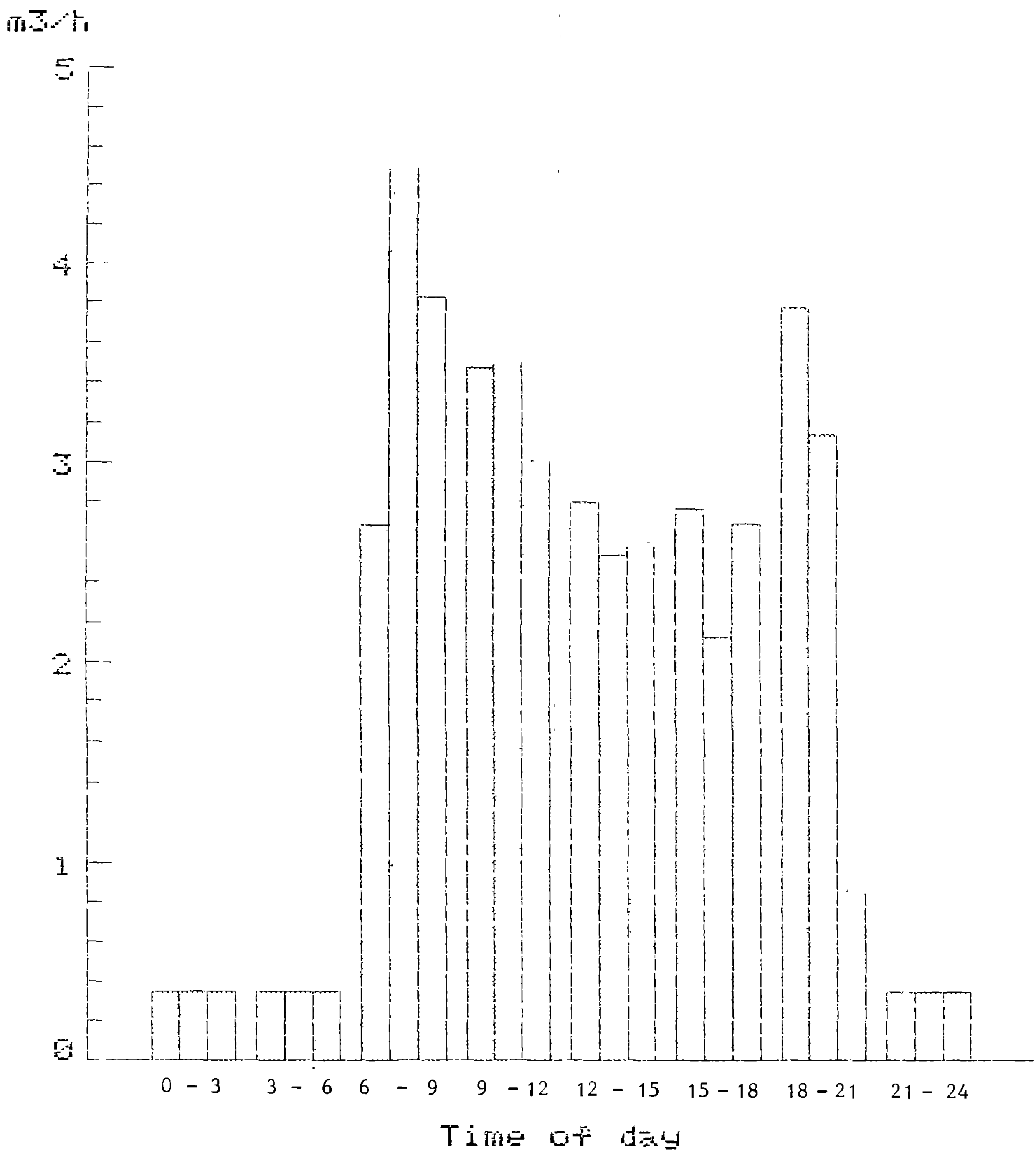

Figure 5.7 - Kasumulu Village: Hourly consumption, average over 7 days

5.3 Mlangali Village

5.3.1 Background information

Mlangali village is situated in Mbozi district some 1½ km south of the Tanzania - Zambia highway and some 40 km from Mbeya. The altitude ranges from 1240 m to 1300 m and the mean annual rainfall is around 1000 mm. The agro-ecological zone (wet-highlands) is described in WMP, Vol. 12 Ch. 2.3.3.

The climate is hot towards the end of the dry season, but is otherwise relatively cool, and temperature measurements during the dry season metering of water use ranged between 16^o and 37^o Centigrade during day-light hours. The minimum temperature was 15^oC.

The village is situated along the old murram road to Zambia over a distance of some 3 km and most families have small fields near their houses and other fields outside the inhabited area. The settlement pattern is denser than in Kasumulu village and might be characterised as being of medium density compared to other villages of the study. There is a primary school and a dispensary in the village, but no market or other major commercial developments.

Water from a perennial river south-west of the village is led into ditches along the old main road from where it is diverted at several places to the fields for irrigation. There is also a large man-made pond in the village, so water (although of poor quality) is available at short distance almost everywhere in the village (see village layout Figure 5.8). Consequently, cleaning utensils and laundrying with water from the ditches is quite common, but as there is no privacy at the ditches, personal hygiene is mainly at home.

A summary of the result of the household interviews is given in Table 5.9. Details are given in Appendix V.

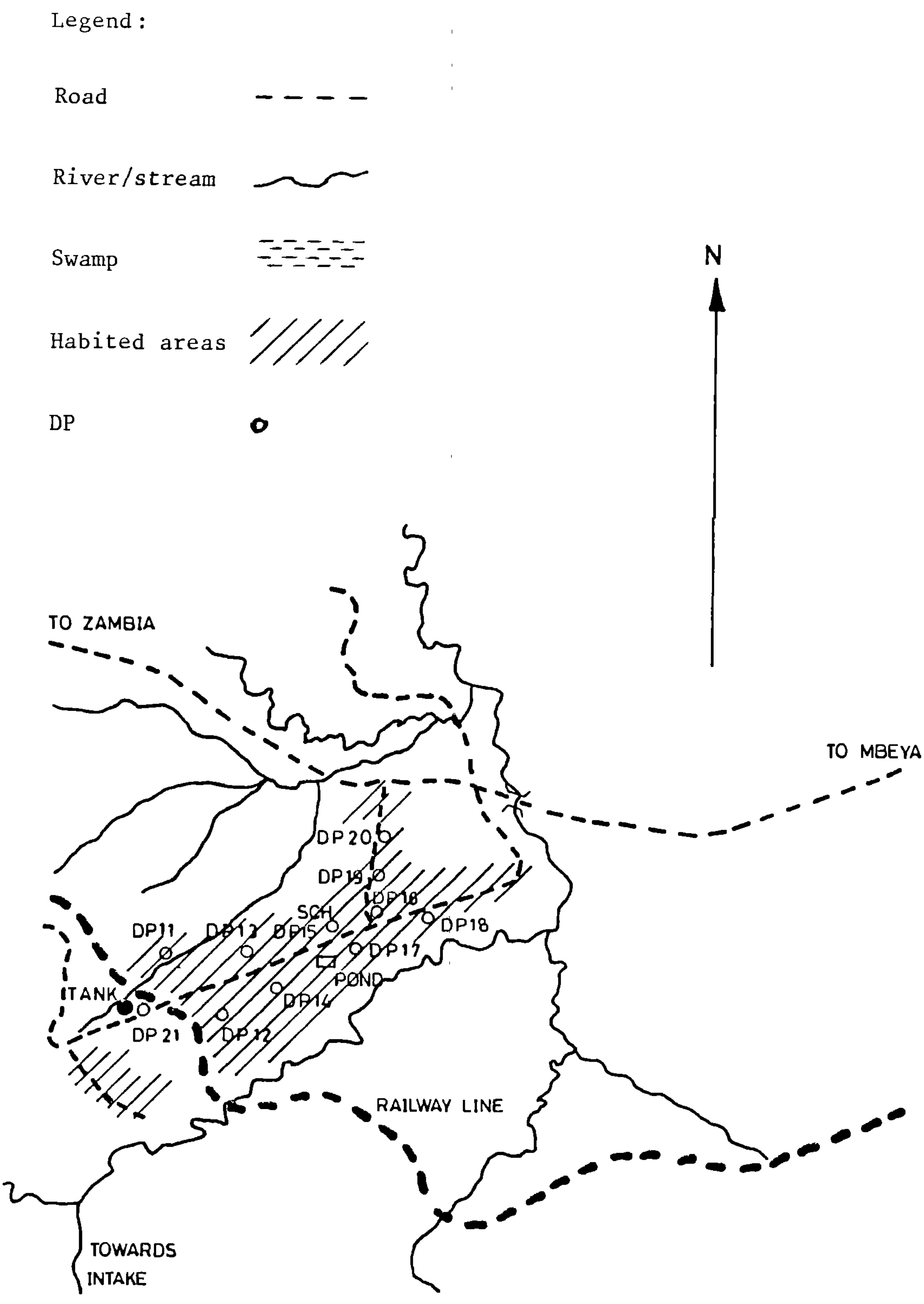

Figure 5.8 - Mlangali village layout

Scale 1 : 50,000

Use of water	Population	%	Households
For domestic purposes only and entirely from the water supply	985	77%	235
As above but also for garden watering	16	1%	4
From water supply but supplemented with traditional sources	185	15%	39
Total using water supply	1186	93%	278
From traditional sources only	95	7%	20
Grand total	1281	100%	298

Table 5.9 - Mlangali Village: Summary of household interviews

5.3.2 Description of water supply system

Mlangali village water supply is part of a group scheme covering 5 villages, and the village has received water since 1984. The supply is by gravity from a river in the mountains south of the village, which has a high silt load during the rainy season. Interruptions to the supply do occur basically due to siltation of the intake, and the water supplied to the village is coloured and has a relatively high turbidity during the rainy season. The only treatment provided is plain sedimentation. No interruptions to the supply occured during the two metering periods reported on.

Water is branched from the common transmission system to the village storage tank via a sedimentation tank situated near the tank, and all DPs are supplied from the tank through the distribution system.

One DP is situated so near the tank, that it was not possible to install the master meter between the tank and the DP due to insufficient head available. The readings of the master meter is therefore only covering 10 DPs, but all 11 DPs have been metered with small meters (see Figure 5.8).

5.3.3 Metering of water consumption

The water consumption was metered both towards the end of the rainy season and towards the end of the dry season during the last week of March and the second week of September respectively. There was some rain on most days during the metering in March, but no rain during September.

The water consumption at individual DPs are shown in Appendix VI pages 4 and 5 for both rainy and dry seasons. Summaries are given in Table 5.10 and 5.11.

The average consumption from the rainy season metering is some 75% of the dry season average, however, the actual results are from that specific time and should not be understood as absolute maximum and minimum consumptions.

The estimated waste is 12% and 8% for rainy and dry season respectively, and the use of traditional sources is likely to account for some 3% only of the total domestic water consumption.

An analysis of per capita water consumption at individual DPs is shown in Table 5.12, which also gives comments and possible explanations to the variations in per capita use. The information on use of traditional sources and garden watering is from the household interviews.

Type of Consumption		Tue.24/3	Wed.25/3	Thu.26/3	Fri.27/3	Sat.28/3	Sun.29/3	Mon.30/3	Overall average per day
Actual consumption excl. losses	Total	22,557	26,388	32,251	28,008	33,380	32,962	32,322	29,695
	Per Capita	19.0	22.2	27.2	23.6	<u>28.1</u>	27.8	27.3	<u>25.0</u>
Estimated Waste		400	2,500	5,100	1,000	1,600	6,100	8,500	3,600
Actual consumption excl. losses and estimated waste	Total	22,157	23,888	27,151	27,008	31,780	26,862	23,822	26,095
	Per Capita	18.7	20.1	22.9	22.8	<u>26.8</u>	22.6	20.1	<u>22.0</u>

Table 5.10 - Mlangali Village: Water consumption March 1987 (rainy season) in litres per day

Note: Maximum and average figures are underlined

Type of Consumption		Wed.9/9	Thu.10/9	Fri.11/9	Sat.12/9	Sun.13/9	Mon.14/9	Tue.15/9	Overall average per day
Actual consumption excl. losses	Total	35,489	35,584	40,293	40,527	40,079	34,673	36,769	37,631
	Per Capita	29.9	30.0	34.0	34.2	33.8	29.2	31.0	31.7
Estimated Waste		2,600	2,400	3,700	3,000	7,600	300	1,100	2,957
Actual consumption excl. losses and estimated waste	Total	32,889	33,184	36,593	37,527	32,479	34,373	35,669	34,674
	Per Capita	27.7	30.0	30.9	31.6	27.4	30.0	30.1	29.2
Compensation for use of traditional sources (185 people)			(Basically Laundrying and Cleaning only)						1,176
Estimated net water consumption if supply from W/S only	Total								35,850
	Per Capita								30.2

Table 5.11 - Mlangali Village: Water consumption September 1987 (dry season) in litres per day

Note: Maximum and average figures are underlined

DP No.	Average per capita consumption excl.losses and waste	Nos. of people per DP	People supplementing with water from trad. sources	Estimated net water consumption if supply from W/S only	Comments
11	34.0	167	10	34.3	
12	16.8	181	49	18.4	
13	21.7	164	0	21.7	
14	36.6	119	46	38.9	Some garden watering
15					School and dispensary and some garden watering
16*	47.4	153	36	48.8	
17					
18	23.4	113	26	24.8	
19	43.3	94	2	43.4	Beer brewing at local bars
20	30.2	113	5	30.4	
21	8.1	82	11	9.7	Long walking distances
Total	29.2	1186	185	30.2	-

Table 5.12 - Mlangali Village: Estimated per capita consumption at individual DPs

Note: * DP 16 was not functioning at time of household interview. Water was at that time drawn from DP 15 and 17 nearby.

DP nos. 15, 16 and 17, which are situated near each other, are combined in the analysis, because DP no. 16 was not functioning at the time of the household interview.

Some brickmaking was observed during the dry season metering, but the water used was taken from the irrigation ditches and not from the water supply. No other exceptional water using activity was observed.

The average per capita consumption at DPs with domestic use only and "normal" walking distances (normal for that village) ranges between 18.4 l/day and 34.3 l/day. The large difference could be due to different usage of water, but could also be due to inaccuracies in determining number of users per DP. The average per capita consumption for the 5 normal DPs (nos. 11, 12, 13, 18 and 20) was 25.6 l/day during the dry season metering.

The number of users per DP is probably not influencing the per capita consumption, although the per capita consumption at DP nos. 15, 16, 17 and 19 might indicate that. However, the same DPs are used for other than purely domestic purposes. People using DP no. 21 have considerably longer walking distances than the other villagers and it is likely that a larger proportion of them use traditional sources than the results from the household interviews indicate.

Figure 5.13 shows the daily variations in consumption for the whole village. For individual DPs the variations are much higher (see Appendix VI pages 3 and 4) and peak days for individual DPs can occur on any day during the week. For instance during the dry season metering, only one DP had peak day on Saturday, which was the peak day for the entire village. Also in this village, there appears to be no common water use pattern, which can apply to most DPs.

The hourly variations in consumption over the day are also differing from day to day as illustrated in Appendix VII. The variations are as recorded by the master meter and are therefore for only 10 out of the 11 DPs. For the same reason water waste amounting to some 8% is included in the figures.

The average hourly consumption over a period of 7 days (dry season) is shown in Figure 5.14. It can be seen from the figure that water use is fairly evenly distributed over the daylight hours and that there are no distinct morning or evening peak hours. This is more an effect of the figure showing the average than an illustration of the actual consumption pattern. Water use in Mlangali village is fairly even over the day, but when looking at individual days, it is found that within the week investigated, 3 days had morning peaks, 2 days midday peaks and 2 days evening peaks.

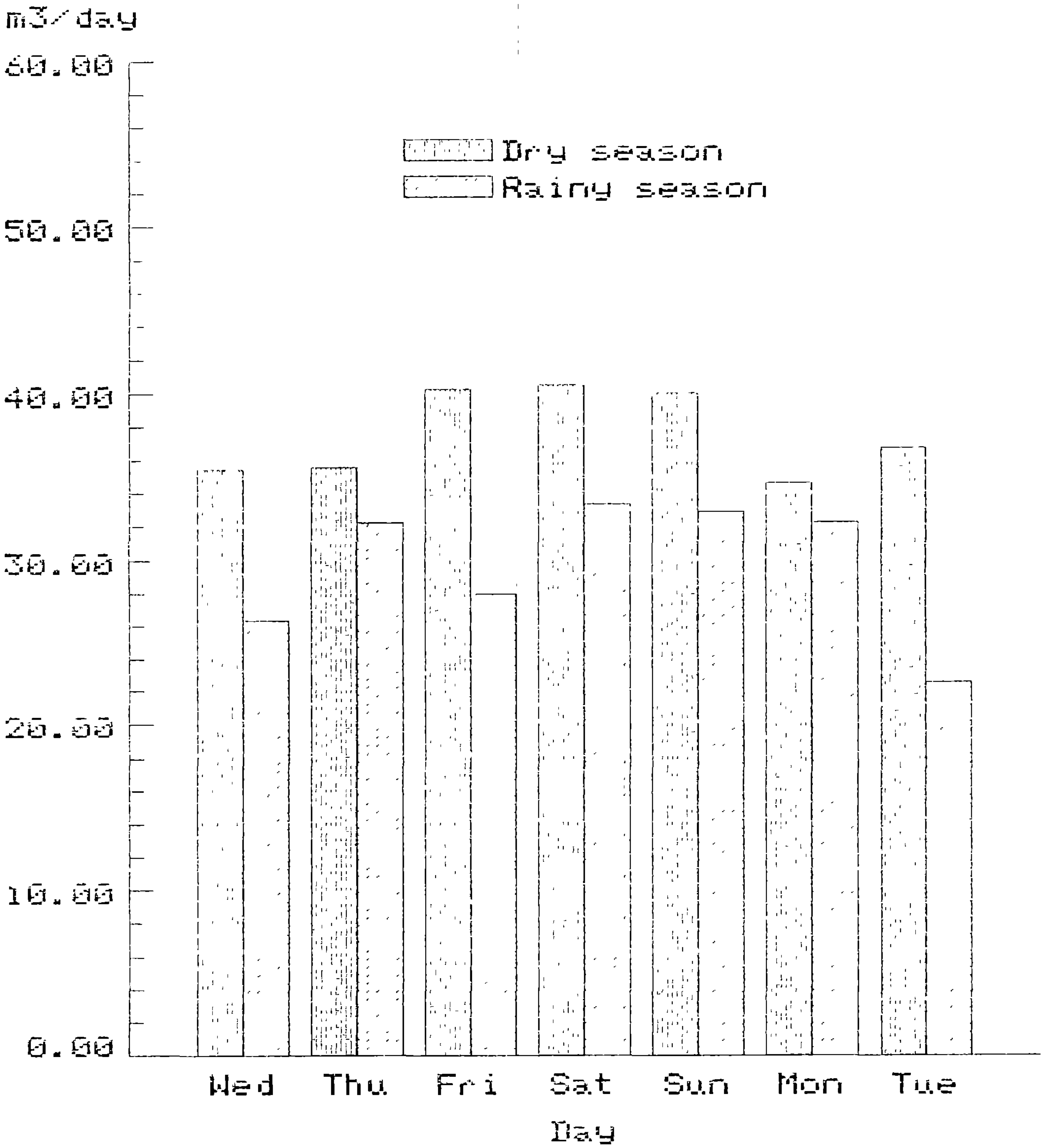

Figure 5.13 - Mlangali Village: Actual daily consumption excl. losses

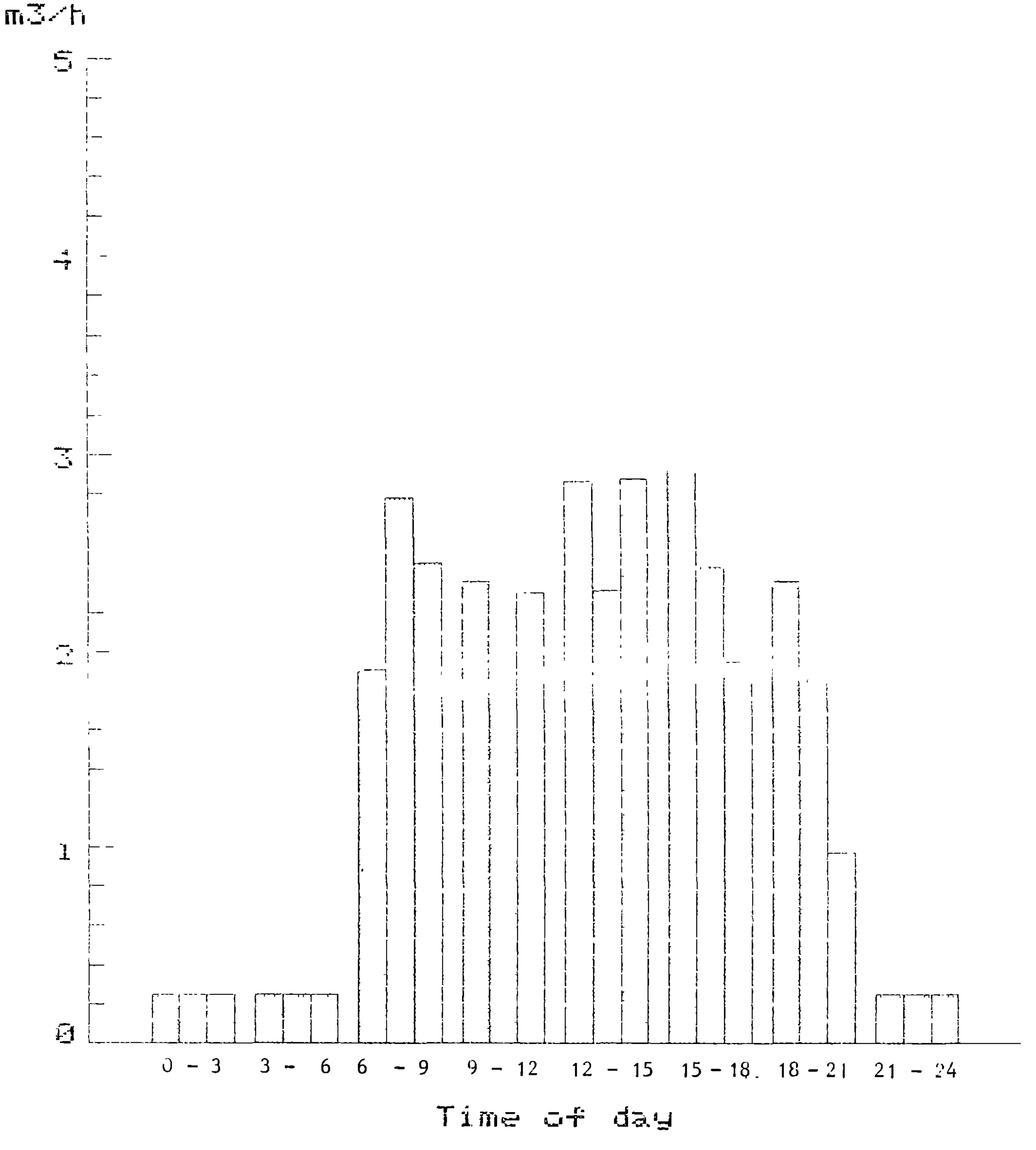

Figure 5.14 - Mlangali Village: Hourly consumption, average over 7 days

5.4 Kiponzelo Village

5.4.1 Background information

Kiponzelo village is situated in Iringa district, west of Iringa town some 15 km from the main Iringa - Mbeya road. The Divisional Secretary has office in the village and a relatively large health centre and the related staff quarters have been constructed in the village. There is also a post office, so the village is a service centre for a number of surrounding villages.

The altitude ranges from 1700 m to 1760 m and the mean annual rainfall is 800 to 900 mm. The agro-ecological zone (transition zone) is described in WMP, Vol. 12 Ch. 2.2. The climate is relatively cool most of the year, and temperature measurements during the dry season metering of water use ranged between 20^{o} and 36^{o} Centigrade during daylight hours. The minimum temperature recorded was $8^{o}C$.

The old part of the village is densely populated and people have their fields away from the village, whereas the more recent village settlers are living more scattered in the outskirts of the village.

There is a swampy area close to the village from where some 10% of the villagers using the piped supply obtain water as a supplement to the piped supply. Interviews of households not using the supply were not performed. (See village layout Figure 5.15).

The supply to the above mentioned health centre and the staff houses was metered separately and is dealt with in Chapter 5.4.4.

A summary of the results of the household interviews is given in Table 5.16. Details are given in Appendix V.

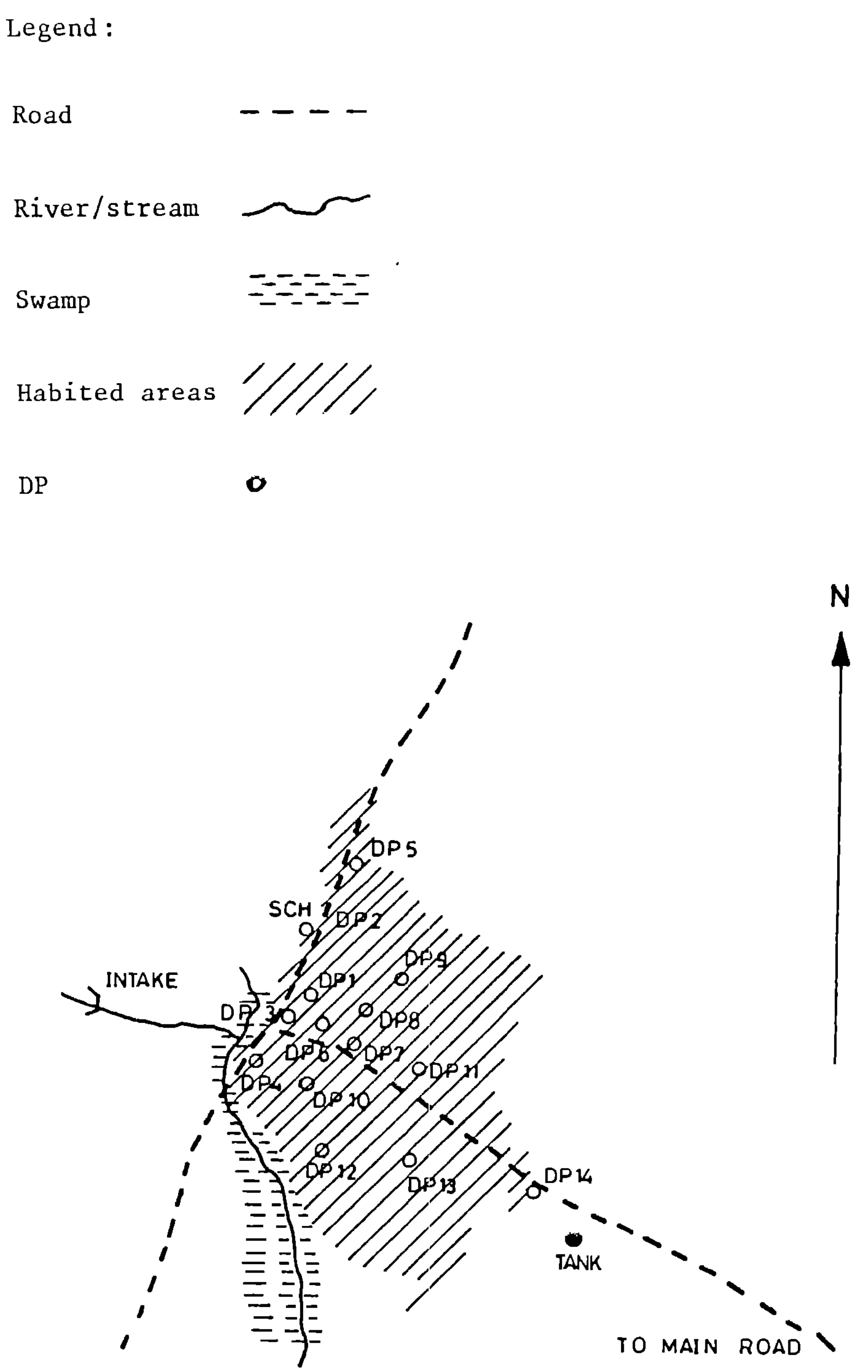

Figure 5.15 - Kiponzelo village layout

Scale 1 : 50,000

Use of water	Population	%	Households
For domestic purposes only and entirely from the water supply (A)	1979	88%	403
As above but also for garden watering (B)	117	5%	27
From water supply but supplemented with traditional sources (C)	193	9%	37
Both (B) and (C)	(52)	(2%)	(11)
Total using water supply	2237	100%	456

Table 5.16 - Kiponzelo Village: Summary of household interviews

5.4.2 Description of water supply system

The water supply for Kiponzelo village was originally constructed in the early seventys as a pumped supply using a nearby swamp as source. In 1984, a new intake was constructed on a small stream in the mountains north-west of the village, so as to supply the village by gravity, and at the same time additional branches were laid to the distribution system to supply new DPs. The water quality is good, and the supply has been well functioning despite many leaks in the old pipe system.

There is no separate transmission system. From the new source water enters the supply system in the lower part and the existing tank in the opposite end of the village is balancing peak flows through a combined inlet and outlet pipe. Temporary closure of the tank during the rainy season measurements caused some pipe bursts in the old system, so it was decided for this particular village to rely on meters installed on all 14 DPs only.

The misleading result of the household interviews could have its origin in dissatisfaction on the part of some villagers with the service level (walking distances) of the new water supply system. Part of the village had an old water supply, where DPs were situated quite close to each other. As part of the agreement with the village for a new water supply covering the whole village, some of these existing DPs were taken out of service, thereby reducing the service level. Negotiations between the village and MAJI on the matter has been ongoing for a long time, and it is felt that this "dispute" might have biased the result of the household interviews, and the observations are considered more realistic.

A summary of the corrected/repeated household interviews is given in Table 5.32 below. Details are given in Appendix V page 5.

Use of water	Population	%	Households
For domestic purposes only and entirely from the water supply	1,304	84%	308
From water supply but supplementing with traditional sources	228	15%	38
Total using water supply	1,532	99%	346
From traditional sources only	22	1%	5
Grand total	1,554	100%	325

Table 5.32 - Mpitimbi "B" village: Summary of household interviews

Legend:

Road - - - -

River/stream

Swamp

Habited areas

DP o

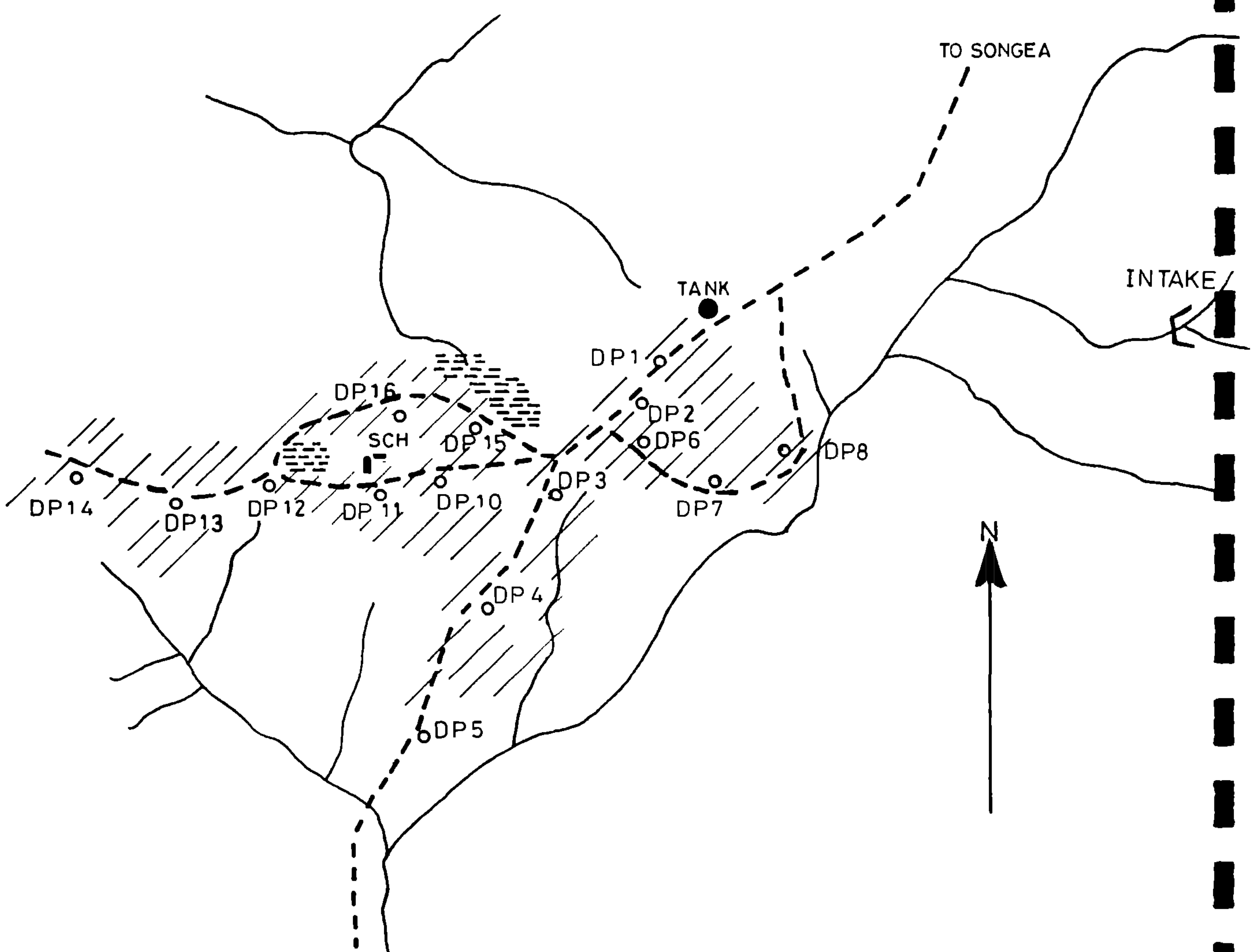

Figure 5.31 - Mpitimbi "B" village layout

Scale 1 : 50,000

5.6 Mpitimbi "B" village

5.6.1 Background information

Mpitimbi is situated in Songea district and is a large settlement some 25 km South-West of Songea town, with a Mission station having some health services, schools, etc. centrally placed in the village. Due to the size of the village it was some years ago divided into two villages, Mpitimbi "A" and Mpitimbi "B". Mpitimbi "A" covers the old part of the village with the Mission, old schools, godowns, market, etc. whereas Mpitimbi "B" covers more recent settlements of scattered nature with a primary school as only communal facility of importance.

The altitude range from 970 m to a little above 1000 m and the mean annual rainfall is around 1200 mm. The agro-ecological zone (intermediate zone) is described in WMP Vol. 12 Ch. 2.4.4.

The climate is moderately hot and temperature measurements during the dry season metering of water use ranged between 18° and 36° Centigrade during daylight hours. The minimum temperature was 17° C.

As mentioned above the settlement pattern in Mpitimbi "B" is scattered with most people living on their land, and no sizeable concentration of dwellings occur. There are perennial traditional sources (swamps and small streams) on all sides on the village, but people using the traditional sources are estimated at less than 20%, based on household interviews and sporadic observations at such sources. (See village layout Figure 5.31).

The household interviews performed during September 1987 showed that 60% of all households were using traditional sources to supplement the water supply, however, that figure has been considered most unlikely by community development staff with extensive knowledge of the village and is also contradicted by observations. Consequently interviews were repeated early 1988 with the result that only 16% of the population were using traditional sources.

The hourly variations in consumption over the day are differing considerably from day to day (See Appendix VII pages 13 to 16). Of the seven days metered, 3 have peak hour consumption in the morning, 3 in the afternoon and 1 in the evening. Figure 5.30 shows the average hourly consumption over the 7 days of metering. Like in Kiponzelo village almost all water (96%) is collected between 06.00 hours and 19.00 hours, and the consumption is fairly evenly distributed over the day.

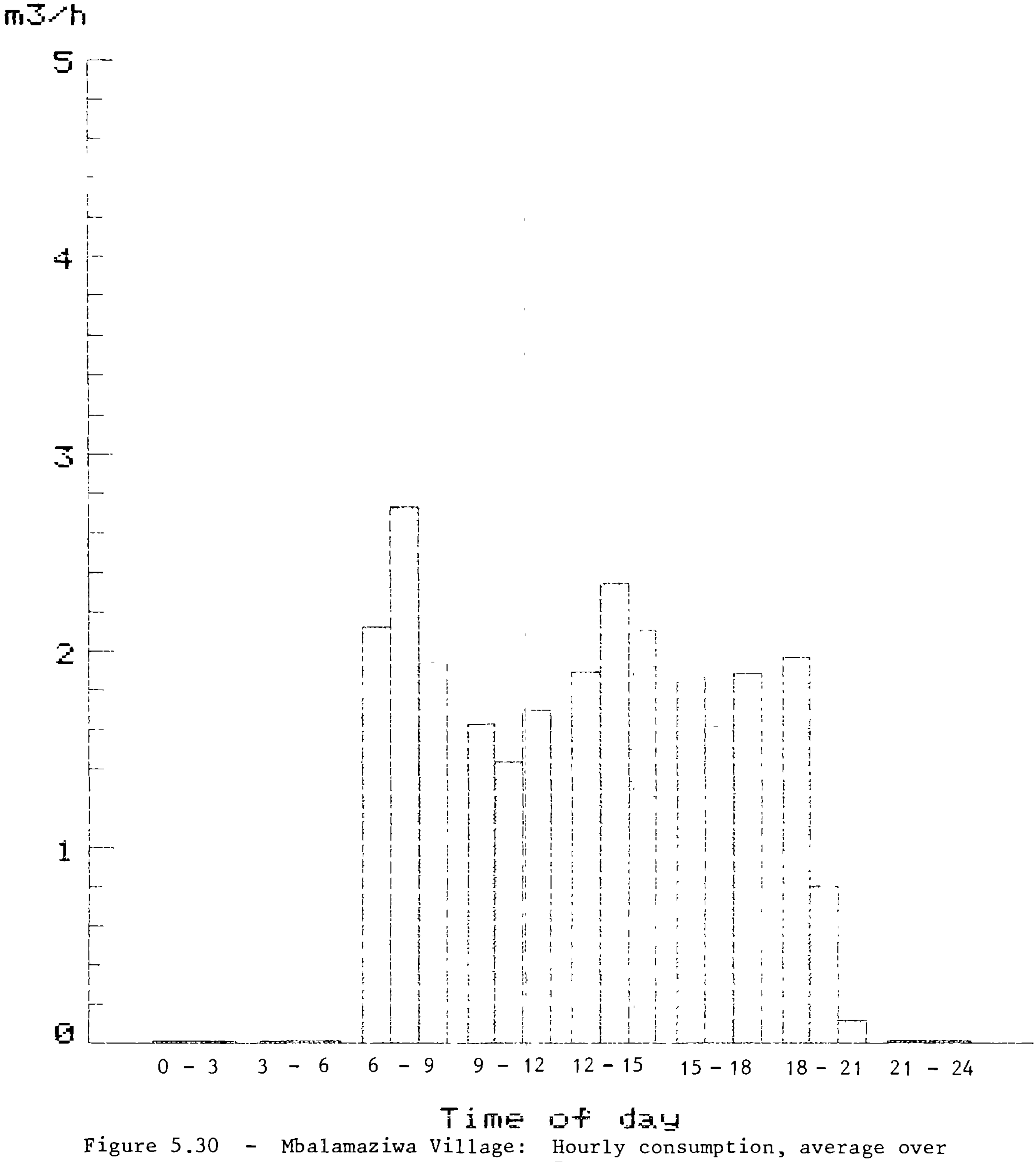

Figure 5.30 - Mbalamaziwa Village: Hourly consumption, average over 7 days

Figure 5.29 shows the daily variations in consumption for the whole village. The variations for individual DPs can be seen in Appendix VI pages 7 and 8. Also for this village the maximum consumption at individual DPs are scattered over the whole week and no more than 3 DPs have maximum consumption on the same day (dry season).

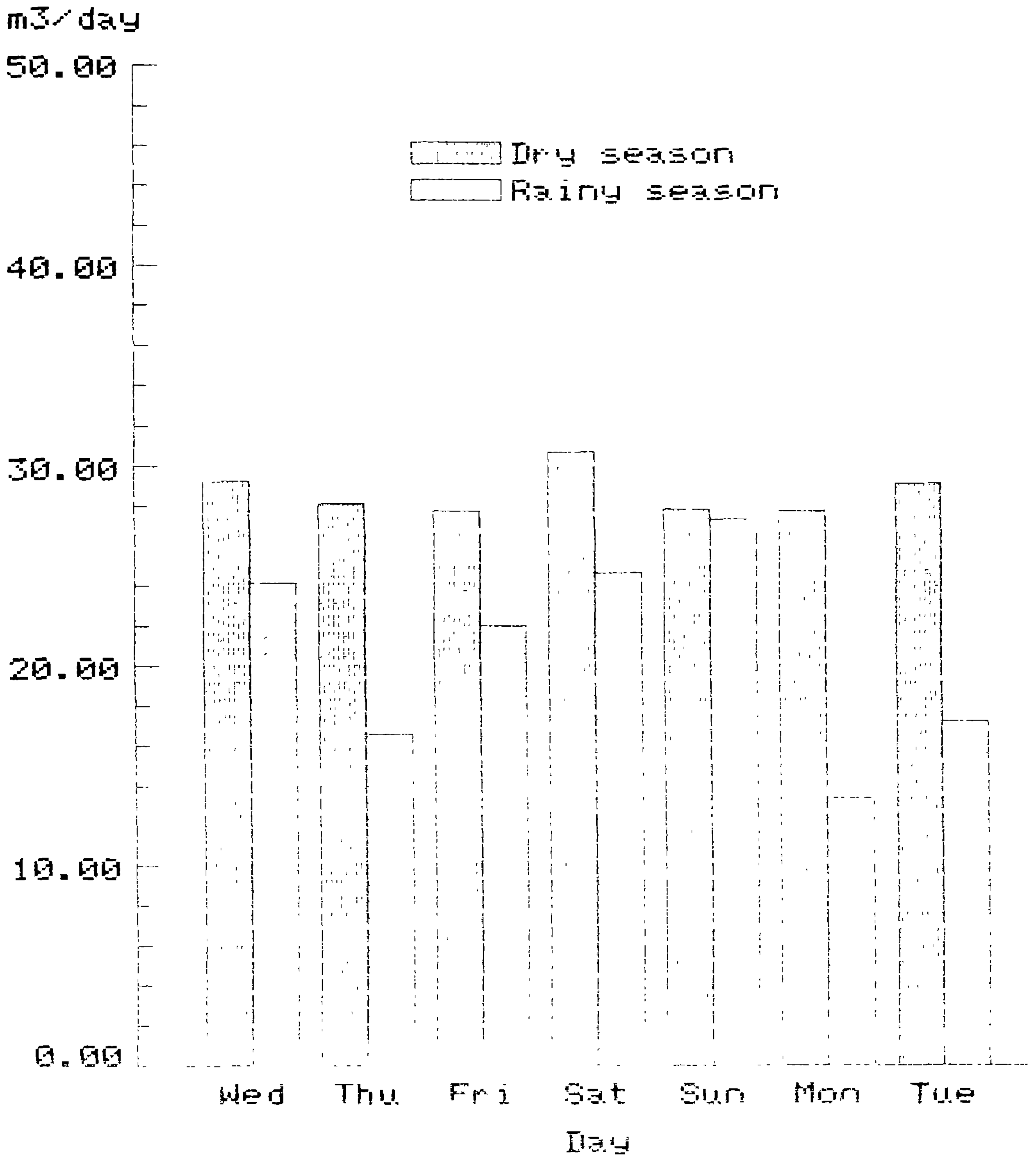

Figure 5.29 - Mbalamaziwa Village: Actual daily consumption excl. losses

DP No.	Average per capita consumption excl.losses and waste	Nos. of people per DP	People supplementing with water from trad. sources	Estimated net water consumption if from W/S only	Comments
1	20.3	160	0	20.3	
2	43.8	184	8	43.9	Market, shops, hotels and bars nearby.
3	13.7	201	0	13.7	Walking distances slightly longer than average.
4	28.0	106	0	28.0	
5	20.1	285	0	20.1	
6	13.4	66	0	13.4	Longer than average walking distances.
7	18.9	51	3	19.0	
8	30.8	93	0	30.8	
10	33.0	11	0	33.0	DPs opened 2 months before metering.
11	24.0	23	0	24.0	
Total	24.1	1180	11	24.2	

Note:

DP no. 9 is excluded as it only supplies the construction camp.

Table 5.28 - Mbalamaziwa Village: Estimated per capita consumption at individual DPs

Type of Consumption		Wed.23/9	Thu.24/9	Fri.25/9	Sat.26/9	Sun.27/9	Mon.28/9	Tue.29/9	Overall average per day
Actual consumption excl. losses	Total	29,253	28,113	27,753	30,638	27,817	27,690	29,112	28,625
	Per Capita	24.8	23.8	23.5	26.0	23.6	23.5	24.7	24.3
Estimated Waste		0	1,000	0	0	0	0	600	229
Actual consumption excl. losses and estimated waste	Total	29,253	27,113	27,753	30,638	27,817	27,690	28,512	28,396
	Per Capita	24.8	23.0	23.5	26.0	23.6	23.5	24.2	24.1
Compensation for use of traditional sources (11 people)									132
Estimated net water consumption if supply from W/S only	Total								28,528
	Per Capita								24.2

Table 5.27 - Mbalamaziwa Village: Water consumption September 1987 (rainy season) in litres per day

Note: Maximum and average figures are underlined.

The average rainy season consumption was 75% of the dry season average, so seasonal variation in consumption is similar to the one recorded in Mlangali village. However, it should be noted that the variation is between actual measurements at specific times, which might not illustrate minimum or maximum consumption of the village.

The estimated waste and use of traditional sources are insignificant for the average per capita consumption.

An analysis of per capita consumption at individual DPs is shown in Table 5.28, which also gives comments and possible explanations to the variations in per capita use. The information on use of traditional sources is from the household interviews.

No exceptional water using activities were taking place during the metering. The high per capita consumption at DP no. 2 is caused by the commercial activities nearby. Assuming that the domestic use at the DP is equal to average the additional water used by hotels, bars, etc. amounts to some 3,600 litres per day or about 12% of the total consumption of the village, or on average about 3 litres per capita per day.

Like in the other villages there is a clear tendency towards lower per capita consumption at DPs with relatively long walking distances (DP nos. 3 and 6), whereas the number of users per DP does not significantly change the per capita consumption.

DP nos. 10 and 11 were not constructed during the rainy season metering and had only been in use for about 2 months, when the dry season metering was performed. At both these new DPs, the per capita consumption was above average (when deducting for hotels, etc), so people are making full use of the supply as soon as it is available.

Type of Consumption		Wed.4/3	Thu.5/3	Fri.6/3	Sat.7/3	Sun.8/3	Mon.9/3	Tue.10/3	Overall average per day
Actual consumption excl. losses	Total	24,143	16,608	21,987	24,691	27,316	13,361	17,210	20,759
	Per Capita	21.1	14.5	19.2	21.5	23.8	11.7	15.0	18.1
Estimated Waste		Negligible							
Actual consumption excl. losses and estimated waste	Total	Figures as above							
	Per Capita								

Note:

8 DPs only. Total population 1146

Estimated water waste negligible

Table 5.26 - Mbalamaziwa Village: Water consumption March 1987 (rainy season) in litres per day

5.5.2 Description of water supply system

Mbalamaziwa village water supply is part of a group scheme serving 8 villages. The supply to Mbalamaziwa was completed early 1986, and has since then provided a very reliable supply to the village. The supply is by gravity from some springs south-east of the village and the water quality is good.

The group scheme transmission system supplies water to Mbalamaziwa storage tank, which supplies 7 DPs through the distribution system. The master meter was installed on the outlet pipe from the tank. One DP north and two DPs east of the main settlement are supplied directly from the transmission system and are therefore not metered by the master meter, but only by the small meters.

There were no interruptions to the water supply during the two metering campaigns.

There are perennial traditional sources (minor streams) between the main settlement and the two sub-settlements north and east of the village and also between the main settlement and the primary school.

Walking distances to DPs are relatively short and very few people rely on supply from traditional sources.

5.5.3 Metering of water consumption

The water consumption was metered both towards the end of the rainy season and towards the end of the dry season during the 1st week of March and the last week of September respectively. There was regular rainfall during the rainy season metering, but no rain during the dry season metering.

The water consumption at individual DPs are shown in Appendix VI pages 7 and 8 both for rainy and dry seasons. Summaries are given in Tables 5.26 and 5.27.

Use of water	Population	%	Households
For domestic purposes only and entirely from the water supply	1,169	99%	260
As above but also for garden watering	0	0%	0
From water supply but supplemented with traditional sources	11	1%	3
Total using water supply	1,180	100%	263

Table 5.25 - Mbalamaziwa Village: Summary of household interviews

Note: People not using water supply were not interviewed. They are estimated at some 20 people only.

It was stated by MAJI staff living at a construction camp in the outskirts of the village that they had observed more people than usual using traditional sources during the metering campaign. The observation cannot be quantified and is thus not taken into account in the evaluation of water use. The construction camp itself is not included in the metered supply.

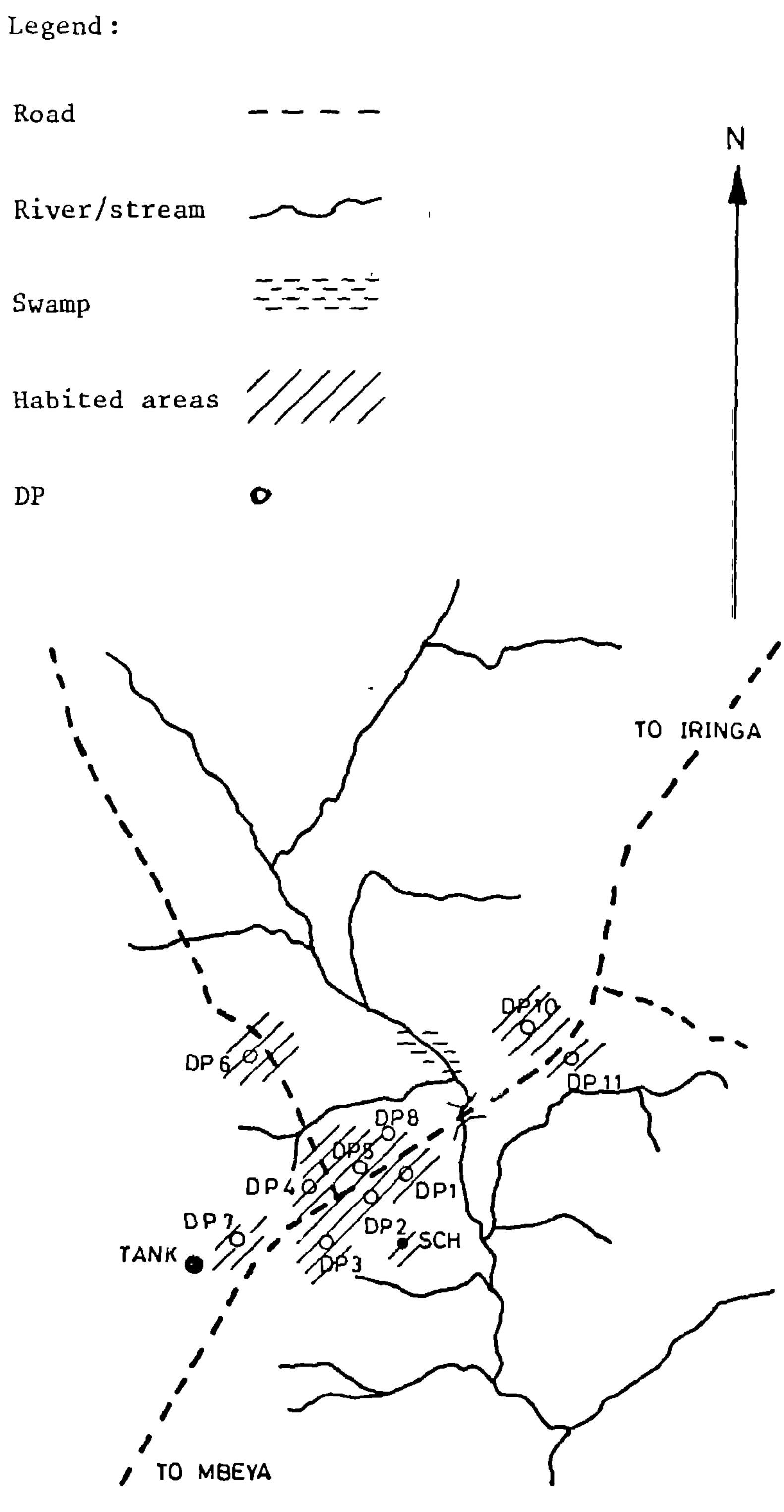

Figure 5.24 - Mbalamaziwa village layout

Scale 1 : 50,000

5.5 Mbalamaziwa Village

5.5.1 Background information

Mbalamaziwa village is situated in Mufindi district along the main Iringa - Mbeya road some 120 km from Iringa town. The altitude is ranging from 1640 m to 1680 m and the mean annual rainfall is 900 mm. The agro-ecological zone (upper plateau) is described in WMP, Vol. 12 Ch. 2.2.4.

The climate is relatively cool, and temperature measurements during the dry season metering of water use ranged between 13^o and 31^o Centigrade during daylight hours. The minimum temperature was 12^{o}C.

The settlement is quite dense on both sides of the main road and only a few families are living away from the main settlement area. The primary school is constructed some 800 m away from the main road and is not supplied by the water supply. The main road has given rise to some commercial activities such as shops, guest houses and bars all situated on the southern side of the road. (See village layout Figure 5.24).

In the period between the rainy season and the dry season metering, two more DPs were constructed to supply some households living east of the main settlement. The two metering campaigns are therefore not related to the same number of people, however, the difference is only some 3%.

A summary of the results of the household interviews is given in Table 5.25. Details are given in Appendix V.

	Doctors' Houses	Nurses' Quarters
Average daily consumption	1,903 l	6,990 l
Overall average	8,893 l	
Nos. of inhabitants	8 nos	26 nos
Average per capita	238 l/day	269 l/day
Overall average per capita	262 l/day	

Table 5.23 - Staff houses: Water consumption

The per capita consumption of the staff houses appears quite high, however, garden watering took place and one stop cock was leaking at the nurses' quarters.

The above figures should not be taken as typical for house connections in rural areas.

5.4.4 Supply to health centre and staff houses

There is a large fairly new health centre in Kiponzelo village. The centre has 14 beds for in-patients, but it is claimed that the number of in-patients often reaches 20. The number of out-patients are estimated at about 160 on average, but the figure may fluctuate considerably.

The health centre is equipped with internal water supply, showers and flush toilets, and during the week of metering (dry season) the water consumption varied from a minimum of 6.6 m^3 to a maximum of 9.0 m^3 per day as shown in Table 5.22.

	Minimum	Average	Maximum
Daily consumption	6,655 l	7,747 l	8,990 l
Assumed distribution on patients:			
. In-patients	-	200 l/day	-
. Out-patients	-	25 l/day	-

Table 5.22 - Kiponzelo health centre: Water consumption

The water consumption appears reasonable when considering a possible distribution on categories of patients as shown in the table.

In connection with the health centre there are doctors' houses and 6 quarters for nurses. The average water consumptions for these houses, which are also equipped with showers and flush toilets, are shown in Table 5.23 for the week of metering (dry season).

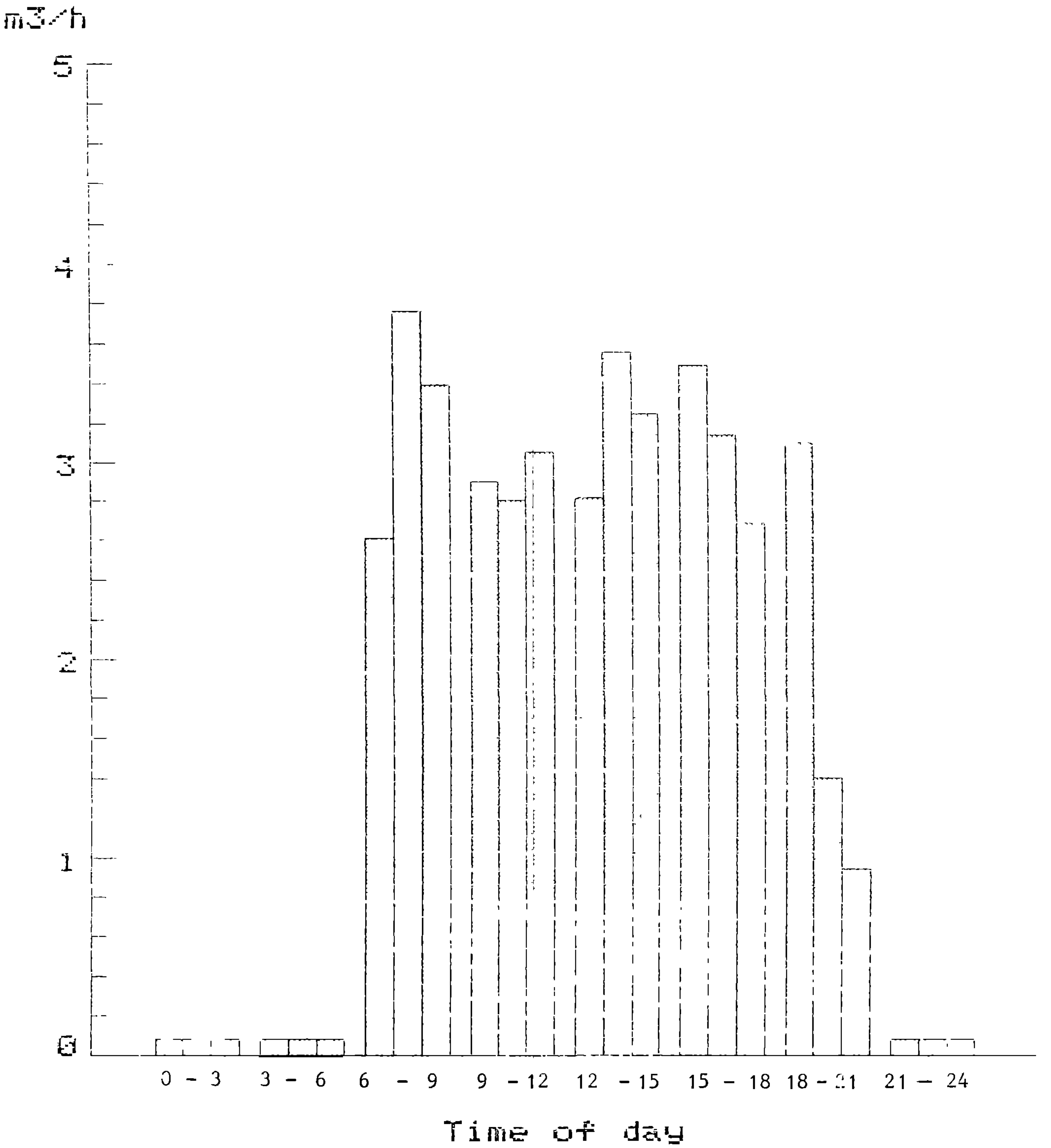

Figure 5.21 - Kiponzelo Village: Hourly consumption, average over 7 days

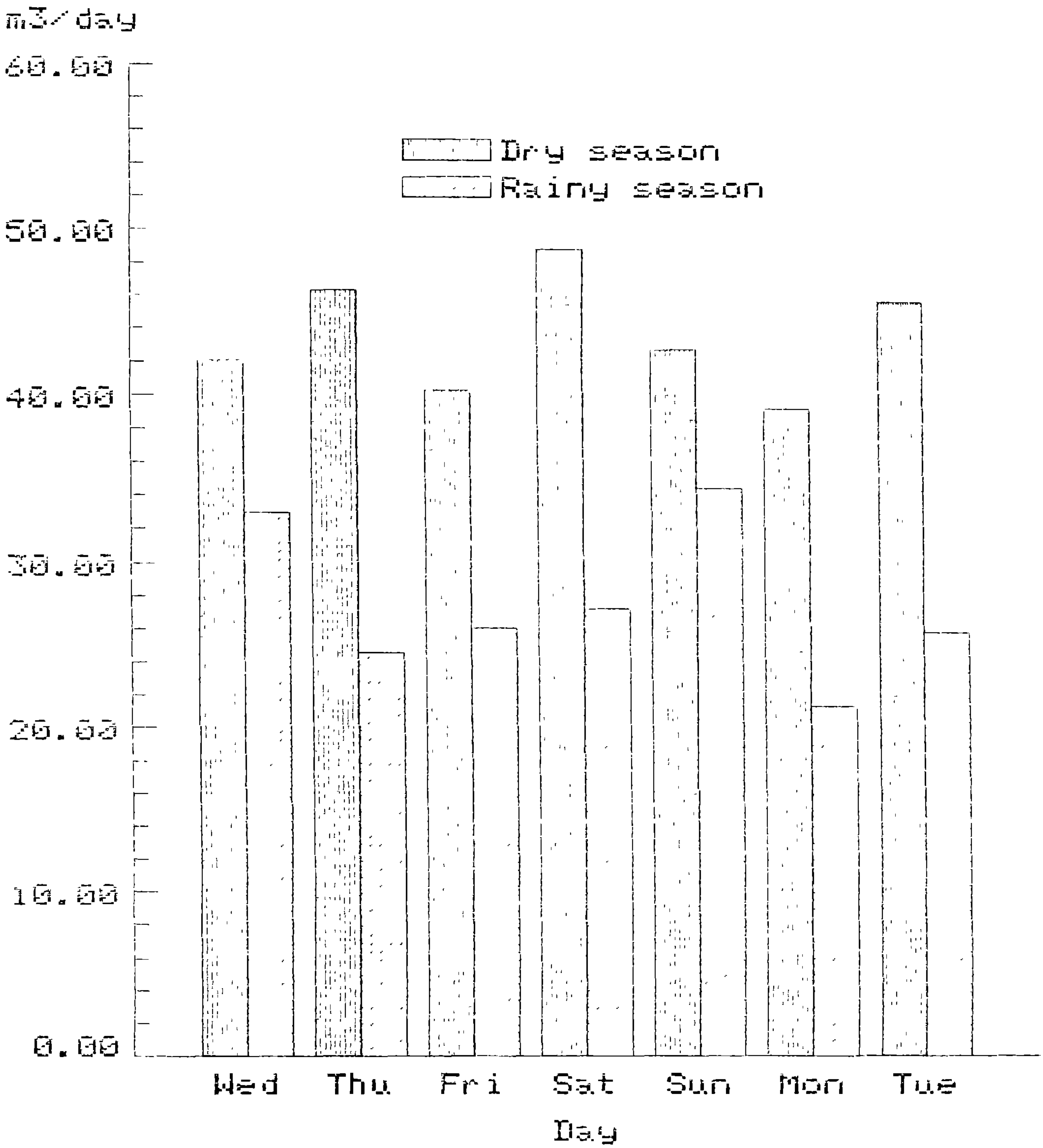

Figure 5.20 - Kiponzelo Village: Actual daily consumption excl. losses

There also appears to be lower per capita consumption at DPs with a high number of users (DP nos. 5, 11 and 13), however, the same DPs are affected by long walking distances, so the effect of many users cannot be quantified.

There was no brickmaking or other unusual water consuming activity taking place during the metering campaign.

Figure 5.20 shows the daily variations in consumption for the whole village. For individual DPs the variations are much higher (see Appendix VI). Also in this village peak days at individual DPs are scattered over the whole period of metering and only 4 DPs out of a total of 14 DPs had peak consumption on any one day (dry season).

Maximum days were occuring on Saturday or Sunday and Monday has the lowest consumption in both cases.

The hourly variations in consumption over the day show for all days except Sunday that peak flows occur in the afternoon between 14.00 hours and 17.00 hours, however, when evaluation average flow over 7 days the peak is occuring between 07.00 and 08.00 hours (see Figure 5.21). The consumption is fairly evenly distributed between 06.00 hours in the morning and 19.00 hours in the evening. The hourly distribution for each day of metering can be seen in Appendix VII.

DP No.	Average per capita consumption excl.losses and waste	Nos. of people per DP	People supplementing with water from trad. sources	Estimated net water consumption if from W/S only	Comments
1	20.2	151	17	21.5	
2	16.4	93	0	16.4	At P.School
3	28.4	149	0	28.4	In centre of village
4	19.6	208	56	22.9	
5	14.6	250	45	16.8	Relatively long walking distances
6	25.1	117	0	25.1	Near centre
7	47.2	86	0	47.2	Village office, Some beer brewing
8	24.1	98	12	25.5	At health centre
9	17.3	163	18	18.6	Relatively long walking distances
10	22.2	64	27	27.3	
11	12.7	386	8	13.0	Many users, long distances
12	16.9	140	3	17.1	Scattered settlement, long distances
13	14.9	261	2	15.0	Scattered settlements, long distances
14	28.8	71	5	29.7	
Total	19.3	2237	193	20.3	

Table 5.19 - Kiponzelo Village: Estimated per capita consumption at individual DPs (dry season)

Type of Consumption		Wed.23/9	Thu.24/9	Fri.25/9	Sat.26/9	Sun.27/9	Mon.28/9	Tue.29/9	Overall average per day
Actual consumption excl. losses	Total Per Capita	42,040 18.8	46,306 20.7	40,222 18.0	48,653 21.7	42,516 19.0	38,987 17.4	45,374 20.3	43,443 19.4
Estimated Waste		0	1,000	0	0	500	0	300	257
Actual consumption excl. losses and estimated waste	Total Per Capita	42,040 18.8	45,306 20.3	40,222 18.0	48,653 21.7	42,016 18.8	38,987 17.4	45,074 20.2	43,186 19.3
Compensation for use of traditional sources (193 people)									2,316
Estimated net water consumption if supply from W/S only	Total Per Capita								45,502 20.3

Table 5.18 - Kiponzelo Village: Water consumption September 1987 (dry season) in litres per day

Note: Maximum and average figures are underlined.

Type of Consumption		Wed.4/3	Thu.5/3	Fri.6/3	Sat.7/3	Sun.8/3	Mon.9/3	Tue.10/3	Overall average per day
Actual consumption excl. losses	Total	32,949	24,513	25,982	27,044	34,274	21,130	25,595	27,355
	Per Capita	14.7	11.0	11.6	12.1	15.3	9.4	11.4	12.2
Estimated Waste		250	1,000	400	0	0	100	200	278
Actual consumption excl. losses and estimated waste	Total	32,699	23,513	25,582	27,044	34,274	21,030	25,395	27,077
	Per Capita	14.6	10.5	11.4	12.1	15.3	9.4	11.4	12.1

Table 5.17 - Kiponzelo Village: Water consumption March 1987 (rainy season) in litres per day

Note: Maximum and average figures are underlined.

There were a few short duration interruptions to the supply during the rainy season metering but no interruption during the dry season.

5.4.3 Metering of water consumption

The water consumption was metered both towards the end of the rainy season and towards the end of the dry season during the second week of March and the last week of September respectively.

There were showers during the rainy season metering and a single heavy downpour the night before the dry season metering commenced.

The water consumptions at individual DPs are shown in Appendix VI both for rainy and dry seasons. Summaries are given in Tables 5.17 and 5.18.

Also for this village there is a significant difference between rainy season consumption and dry season consumption, the former on average being only 63% of the dry season consumption. A contributing factor could be that many villagers were working in their fields during the rainy season metering. There was no special water using activities taking place during the dry season metering, so there might be times of the year with higher consumption.

The estimated waste is insignificant, and the use of traditional sources only amounts to an estimated 5% of the metered consumption.

An analysis of per capita water consumption at individual DPs is shown in Table 5.19, which also gives comments and possible explanations to the variations in per capita use. The information on use of traditional sources is from the household interviews.

No reason for the high per capita consumption at DP 7 has been found, but it could be caused by a different real population distribution on DP nos. 6, 7 and 8 than the result of the interviews shows. Otherwise, variations are small, but with a clear tendency to lower per capita consumption at DPs where relatively long walking distances prevail (DP nos. 5, 9, 11, 12 and 13).

5.6.2. Description of the water supply system

The water supply system covers both Mpitimbi "A" and Mpitimbi "B", and receives water from an old intake and a new intake on two streams in the hills North-East of the villages. The supply is by gravity and in the case of Mpitimbi "B" all DPs are supplied from a ground level tank in the Northern end of the village. The water quality is fair (turbid and coloured in the rainy season) and the system is providing a reliable supply. There were no interruptions to supply during the metering and the master meter was installed between the tank and the first DP, so as to record the total water use of all 15 DPs in the village. No DPs of Mpitimbi "B" are installed on the transmission system.

The new water supply system came into operation early 1985.

5.6.3 Metering of water consumption

The water consumption was only metered towards the end of the dry season during the second week of October. There was no rain during the period and no exceptional water using activities were taking place.

The water consumption at individual DPs are shown in Appendix VI page 9. A summary is given in Table 5.33.

The estimated waste is not significant and the daily variations in consumption over the week are smaller than for other villages in the programme. The estimated compensation for use of traditional sources amounts to some 8% only.

The per capita water consumption at individual DPs is shown in Table 5.34. The interviews were repeated during March 1988 to get better data on users per DP than what was obtained from the first interviews in 1987, which were based on Balozis.

Type of Consumption		Thu.8/10	Fri.9/10	Sat.10/10	Sun.11/10	Mon.12/10	Tue.13/10	Wed.14/10	Overall average per day
Actual consumption excl. losses	Total Per Capita	36,533 23.8	36,801 24.0	40,692 26.6	34,306 22.4	33,096 21.6	32,887 21.5	34,720 22.7	35,576 23.2
Estimated Waste		400	600	500	700	300	0	300	400
Actual consumption excl. losses and estimated waste	Total Per Capita	36,133 23.6	36,201 23.6	40,192 26.2	33,606 21.9	32,796 21.4	32,887 21.5	34,420 22.5	35,176 23.0
Compensation for use of traditional sources (228 people)									2,736
Estimated net water consumption if supply from W/S only	Total Per Capita								37,912 24.7

Table 5.33 - Mpitimbi "B" Village: Water consumption October 1987 (dry season) in litres per day

Note: Maximum and average figures are underlined

DP No.	Average per capita consumption excl.losses and waste	Nos. of people per DP	People supplementing with water from trad. sources	Estimated net water consumption if from W/S only	Comments
1	35.3	45	0	35.3	
2	25.9	78	0	25.9	
3	24.8	98	0	24.8	
4	20.3	139	0	20.3	
5	17.2	138	0	17.2	Long walking distances
6	26.4	60	0	26.4	
7	43.7	41	0	43.7	
8	34.4	88	0	34.4	
10	34.6	88	0	34.6	
11	18.8	81	0	18.8	At School
12	21.1	145	26	23.3	
13	18.4	156	83	24.8	
14	13.3	222	65	16.8	Long walking distances
15	18.8	104	54	25.0	
16	43.0	49	0	43.0	At mosque
Total	23.0	1532	228	24.7	

Table 5.34 - Mpiti[illegible] village: Estimated per capita consumption at individual DPs

Note: DP No. 9 does not exist.

Figure 5.35 shows the daily variations in consumption for the whole village. For individual DPs the variations are much higher (see Appendix VI page 9), and it should be noted that not more that 4 DPs out of the total of 15 have maximum consumption on any one day. Water use in the village is thus not following a common pattern. The maximum day for the whole village occured on Saturday, but daily variations were comparatively small.

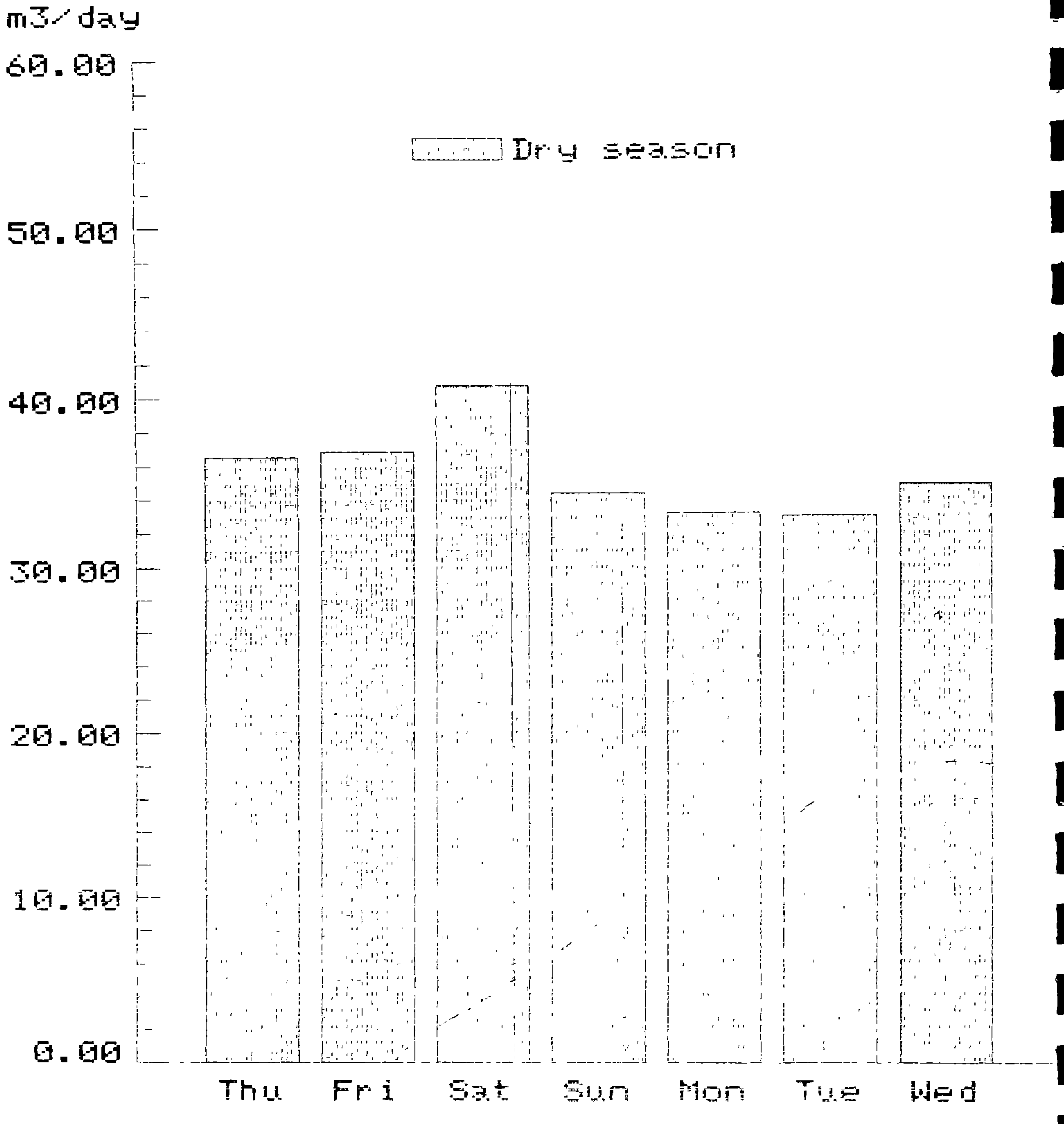

Figure 5.35 - Mpitimbi "B" Village: Actual daily consumption excl. losses

The hourly variations in consumption over the day differs considerably. These variations are shown in Appendix VII, pages 17 to 20, and average over 7 days is shown in Figure 5.36. During the week of metering, three days had peak flow between 07.00 hours and 08.00 hours, one day between 12.00 hours and 13.00 hours and three days between 18.00 hours and 19.00 hours. Water is collected throughout the day and 95% of the water is collected between 06.00 hours and 20.00 hours.

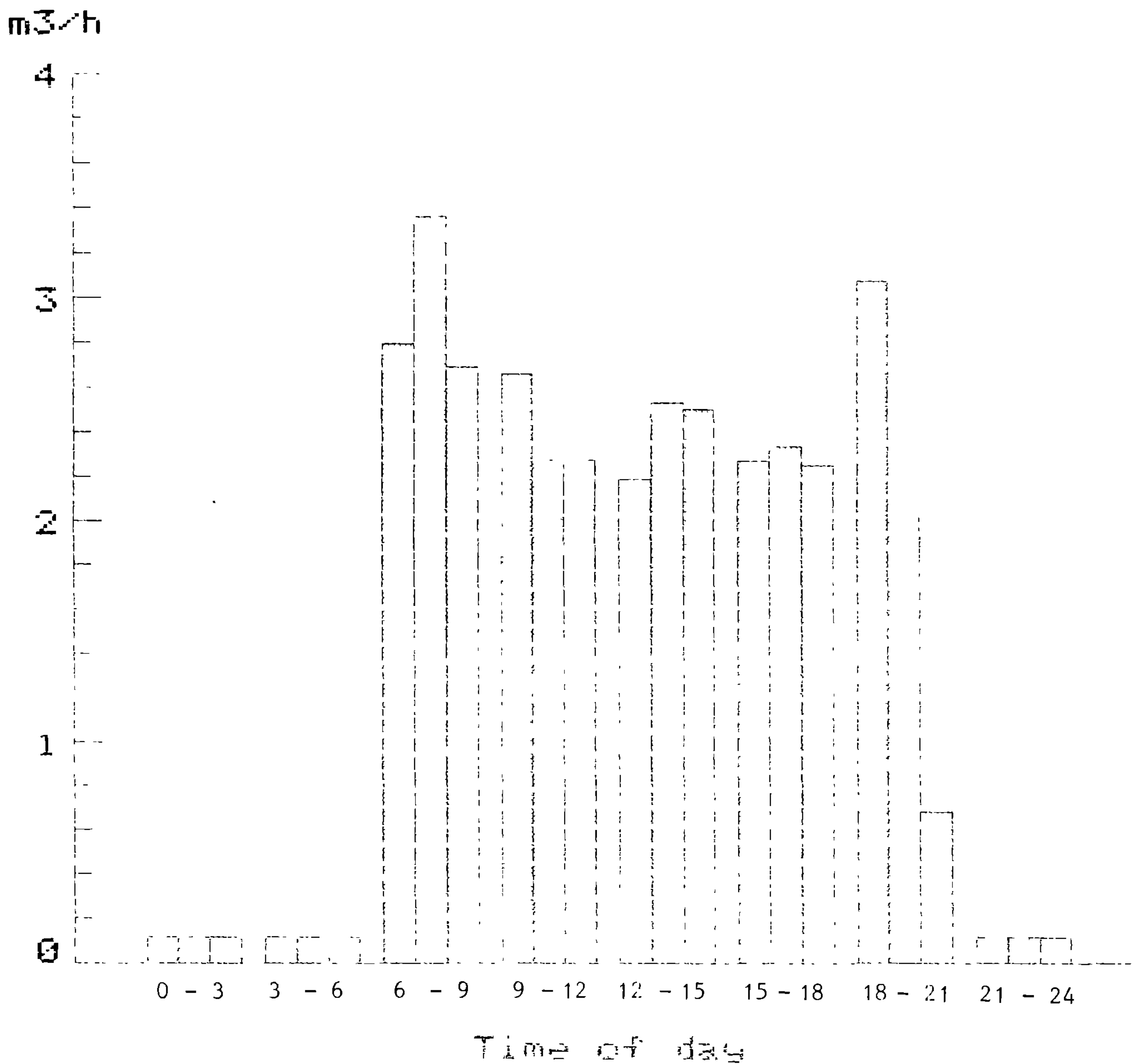

Figure 5.36 - Mpitimbi "B" Village: Hourly consumption, average over 7 days

5.7 Amani Village

5.7.1 Background information

Amani village is situated in Tunduru district some 30 km south of Tunduru town. The altitude is around 500 m and the mean annual rainfall is approximately 1000 mm. The agro-ecological zone (dry eastern zone) is described in WMP Vol. 12 Ch. 2.4.5.

The climate is hot throughout the year and average temperatures recorded during the dry season metering of water use ranged between 23^{o} and 39^{o} Centigrade during daylight hours. The average minimum temperature was 21^{o}C.

There is a primary school in the village, but no health facilities and no commercial activities other than normal smallholder agriculture. The settlement has a very high concentration south of the river (see village layout Figure 5.37) and also a relatively high density north of the river. The fields are situated outside the habitated areas.

A perennial river is flowing through the village and is extensively used for both laundrying and personal hygiene. Due to the dense settlement pattern, walking distances to DPs are short compared with other villages in the study, but even then it is very common that people prefer to do their laundrying and personal hygiene at the river rather than carrying water from DPs to home for such purposes. (This particular result of the household interviews was confirmed by observations).

A summary of the results of the household interviews is given in Table 5.38. Details are given in Appendix V page 6.

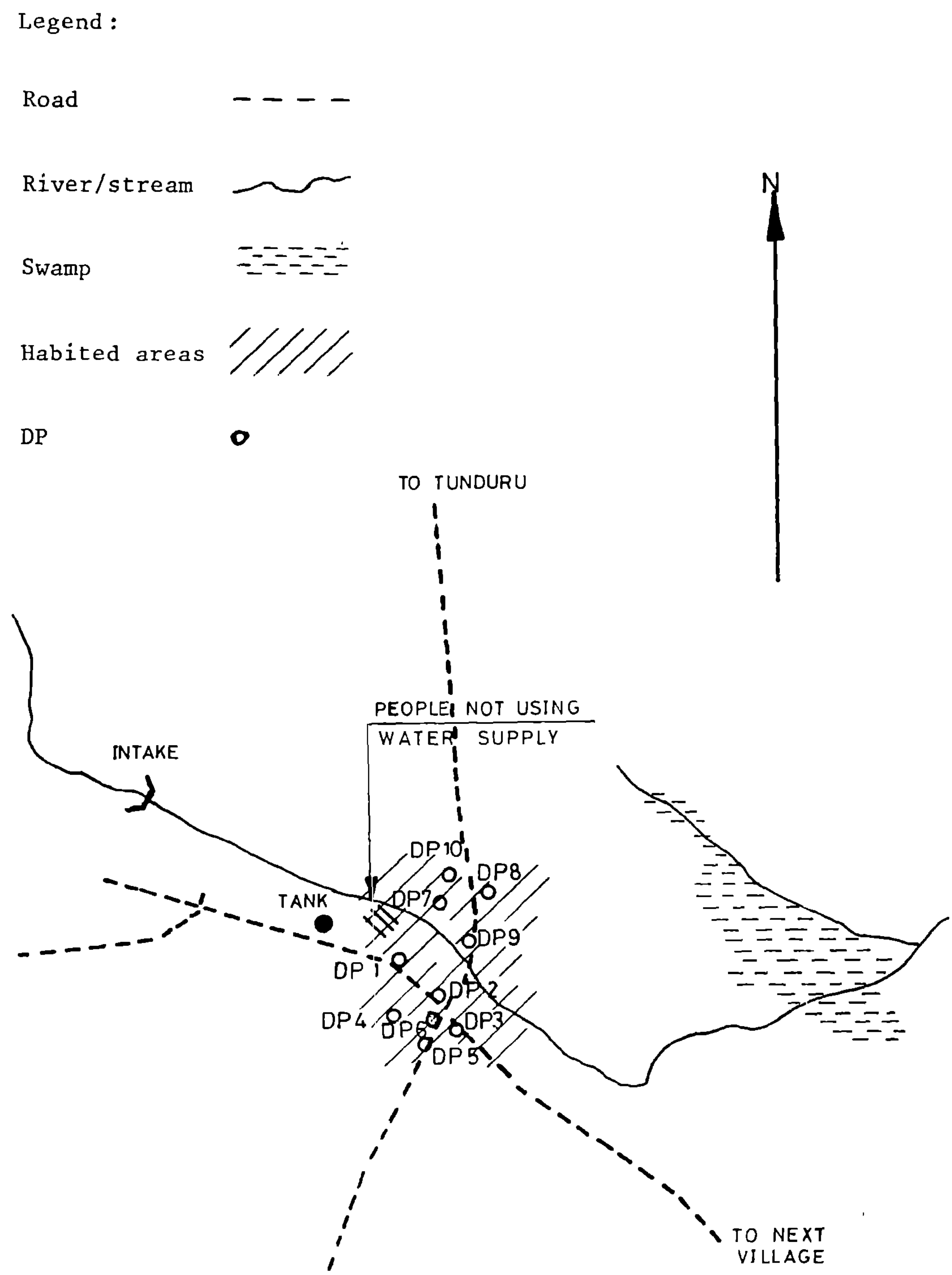

Figure 5.37 - Amani Village layout

Scale 1 : 50,000

Use of water	Population	%	Households
For domestic purposes only and entirely from the water supply	1,017	39%	234
As above but also for garden watering	(9)	0%	(3)
From water supply but supplemented with traditional sources	1,333	52%	319
Total using water supply	2,350	91%	553
From traditional sources only	242	9%	56
Grand total	2,592	100%	609

Table 5.38 - Amani Village: Summary of household interviews

5.7.2 Description of water supply system

Amani village water supply is part of a group scheme covering 3 villages. The supply to Amani was completed in 1985 and Amani village is the one situated closest to the common river intake west of the village. The supply is by gravity and from the Amani storage tank water flows to the 10 DPs and onwards towards the next two villages. It was therefore necessary to install master meters both at the outlet from the tank and south east of the village on the pipe leading to the remaining villages. Water consumption in Amani is thus taken as the difference between the two master meters.

5.7.3 Metering of water consumption

The water consumption was only metered towards the end of the dry season during the last week of October.

The water consumption at individual DPs are shown in Appendix V1 page 10. A summary is given in Table 5.39.

There was no rain during the metering, but the supply to DP no. 10 was interrupted on 22nd October from morning until 19.00 hours. It is remarkable that despite some 3.5 m^3 of water not being collected from DP no. 10 due to technical problems, the consumptions at the two nearby DPs (nos. 7 and 8) appear not to be affected. Users of DP no. 10 might have used the river as source, but could not do that without passing DP no. 7, so it is more likely that the users have refrained from using water that day and waited for the supply to be resumed.

The estimated waste is considerable and was mainly taking place during nights between Friday and Monday at DP nos. 7, 8 and 9.

The maximum consumptions took place on Saturday and Sunday just like in most other villages. That the population is predominantly Muslim appears therefore not to have an effect on the day of maximum use.

An analysis of per capita water consumption at individual DPs is shown in Table 5.40, which also gives comments and possible explanations to the variations in per capita consumption. The information of use of traditional sources is from the household interviews.

There was no exceptional water using activities taking place during the metering and only the high consumption at DP no. 9 give rise to some doubt. However, it might be caused by incorrect population distribution between DP no. 8 and no. 9 or by DP no. 9 being used by other people (passers-by) due to its position very close to the access road to the village.

Type of Consumption		Wed.21/10	Thu.22/10	Fri.23/10	Sat.24/10	Sun.25/10	Mon.26/10	Tue.27/10	Overall average per day
Actual consumption excl. losses	Total	45,217	42,954	51,586	67,559	64,729	47,936	47,716	52,528
	Per Capita	19.2	18.3	22.0	28.7	27.5	20.4	20.3	22.4
Estimated Waste		0	3,000	3,000	15,500	15,700	6,000	1,400	6,371
Actual consumption excl. losses and estimated waste	Total	45,217	39,954	48,586	52,059	49,029	41,936	46,316	46,157
	Per Capita	19.2	17.0	20.7	22.2	20.9	17.8	19.7	19.6
Compensation for use of traditional sources (1333 people)									15,996
Estimated net water consumption if supply from W/S only	Total								62,153
	Per Capita								26.4

Table 5.39 - Amani Village: Water consumption October 1987 (dry season) in litres per day

Note: Maximum and average figures are underlined.

DP No.	Average per capita consumption excl. losses and est. waste	Nos. of people per DP	People supplementing with water from trad. sources	Estimated net water consumption if supply from W/S only	Comment
1	27.0	240	23	28.2	
2	38.3	90	90	50.3	At school and few people
3	11.3	587	539	22.3	
4.	17.6	313	95	21.2	
5	19.3	336	66	21.7	
6	35.0	70	10	36.7	Near village office and few people
7	16.6	269	269	28.6	
8	17.0	189	81	22.1	Maybe incorrect population distribution between DP 8 and DP 9
9	40.4	99	84	50.6	
10	22.2	157	76	28.0	
Total	19.6	2350	1330	26.4	

Table 5.40 - Amani Village: Estimated per capita consumption at individual DPs

High number of users per DP might increase the proportion of people using traditional sources (DP nos. 3 and 7 in particular), however, when looking at DP nos. 4 and 5, which also have high number of users, but few users of traditional sources, it appears that walking distance to the traditional source is of much higher significance.

Figure 5.41 shows the daily variations in consumption for the whole village. For individual DPs the variations are much higher (see Appendix VI page 10), and also in this village maximum days of individual DPs do not necessarily follow the pattern of the village as a whole. No more than 3 DPs out of the total of 10 have maximum days on any one day.

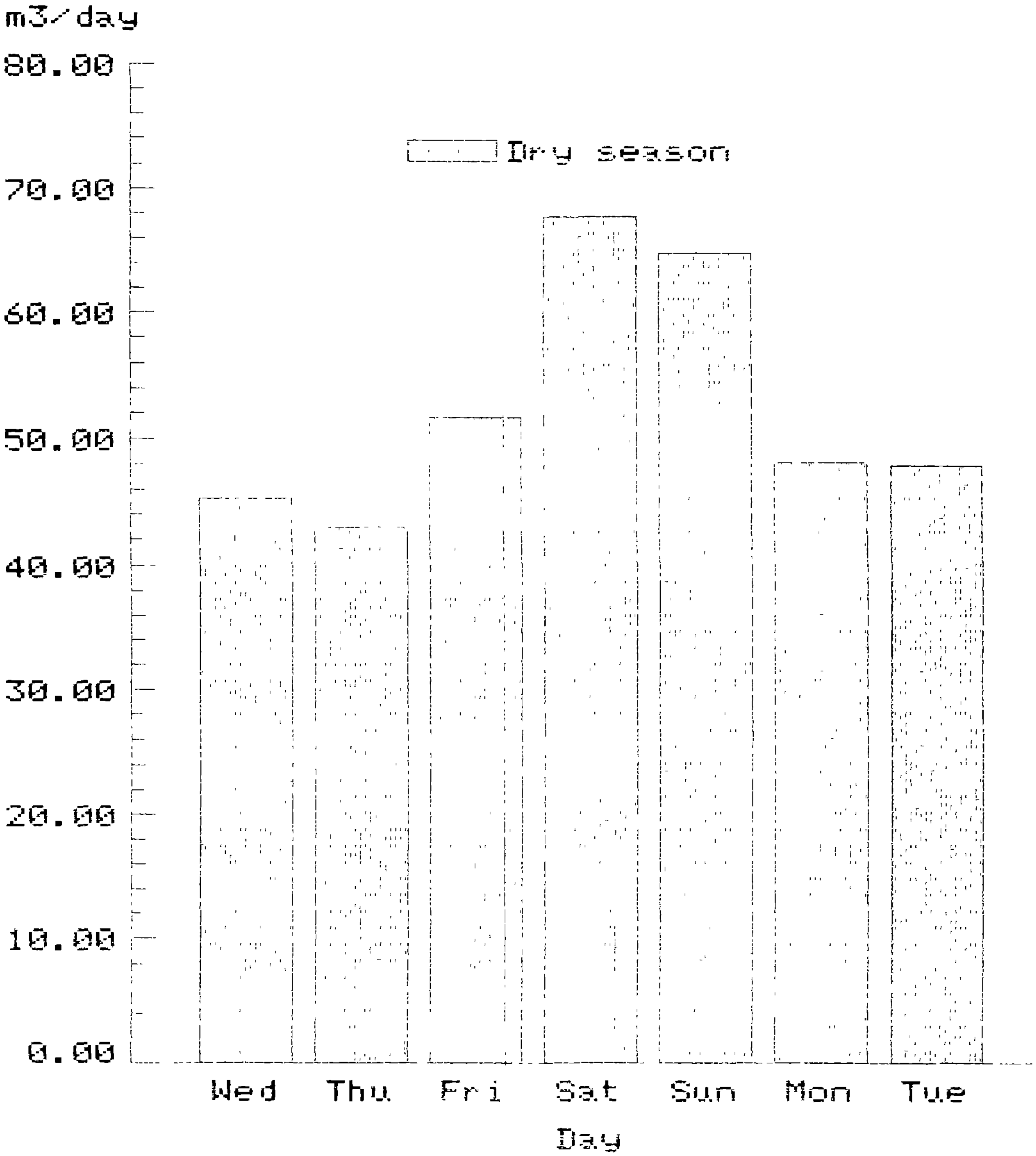

Figure 5.41 - Amani Village: Actual daily consumption excl. losses

The hourly variations in consumption over the day also differ from day to day. These hourly variations as recorded by the master meters are shown in Appendix VII pages 21 to 24.

It was noticed during the metering that many people in Amani village were drawing water after 21.00 hours. Whether that is a common practice valid for the whole year, or only at that particular time of the year where fields were being worked on in the day-time, is not known. As a follow up on the observation, additional readings were made at 22.00 hours on one night, which showed that consumption between 21.00 hours and 22.00 hours was almost as big as between 20.00 hours and 21.00 hours.

Figure 5.42 shows average hourly consumption over 7 days of metering, and it can be seen that peak hours occur earlier and later in the day than in the other villages analysed. This might be caused by high temperatures in the middle of the day or by work in the fields outside the village during the time of metering.

Peak flows on individual days occured from 06.00 hours to 08.00 hours and 16.00 hours to 20.00 hours.

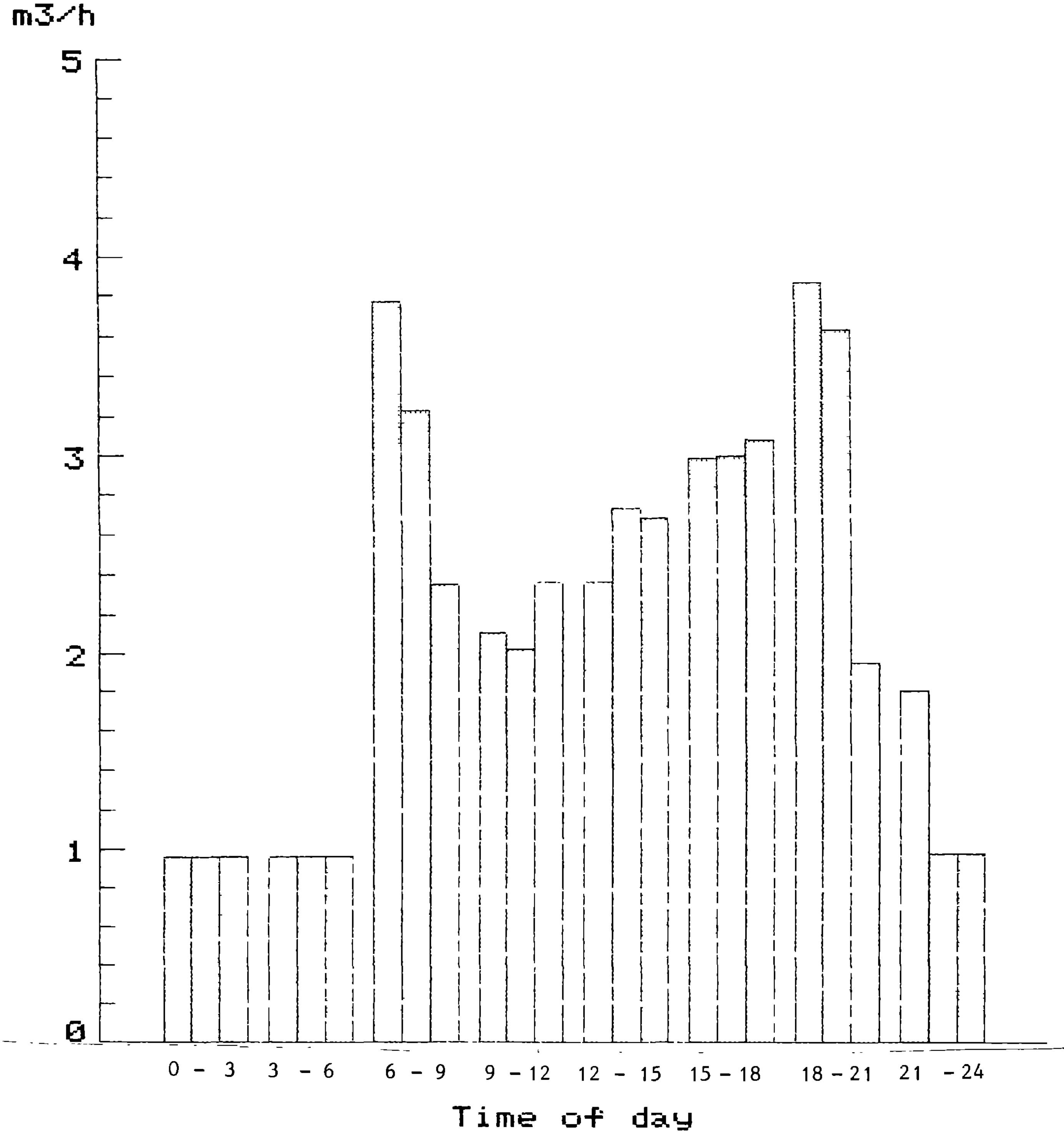

Figure 5.42 -- Amani Village: Hourly consumption, average over 7 days (incl. waste and loss)

6. SEASONAL VARIATION IN CONSUMPTION

6.1 Introduction

It is common that water consumption from public water supplies varies with the seasons of the year. In the study area there are two distinct seasons. The rainy season normally occurs from November to April, and the dry season from May to October. The cloud cover and the rainfall have a reducing effect on the air temperatures, so temperatures during the rainy season are moderate. Low temperatures are prevailing from June to August and the highest temperatures normally occur in October - November just before the start of the rains.

Highest water consumption from a water supply should therefore be expected towards the end of the dry season, where temperatures are high, minor traditional sources might have dried up and no possibilities for supplementing with water from roof catchments etc. exists. The above reasoning for expected high water consumption is in agreement with statements by many villagers, who expressed surprise when the first metering campaign was carried out during the month of March. The timing of the first campaign was fixed to March due to the evaluation of the project and it was decided already at that time, that metering of water consumption should take place in September - October as well.

6.2 Water consumption during March and September/ October 1987

For the purpose of providing a basis for determination of design water demand the dry season metering would suffice, and with reference to the above reasoning, it is considered reasonable to conclude that the results of the dry season metering are illustrating the order of magnitude of the maximum weekly consumption in the six villages.

A master meter has been installed in a selected village for recording of seasonal variations in order to verify the above assumptions.

The metering during March (rainy season) took place in 4 villages only, and it cannot be stated whether or not that period illustrates minimum weekly consumption.

Despite the uncertainties involved, the rainy season and dry season results of the metering are compared in Table 6.1.

It can be seen from the table that the average per capita consumption during the two weeks of metering varied some 20% from average of the two seasons, and that for individual villages the variation ranged from 14% to 24%.

Variations of this order of magnitude are not unusual in urban water supplies, and the results show that seasonal variations are normal also in rural areas. Thorough consideration should therefore be given to the timing of studies of water use, particularly, if the purpose of the study is to provide data for design purposes.

Village	Rainy Season		Dry Season	
	Remarks	Actual Average Consumption Per Capita Excl. Losses & Est. Waste (Litres per day)	Actual Average Consumption Per Capita Excl. Losses & Est. Waste (Litres per day)	Remarks
Kasumulu	No Rain	15.4	25.1	Brick making
Mlangali	Regular Rainfall	22.0	29.2	No unusual activity
Kiponzelo	Regular Rainfall	12.1	19.3	No unusual activity
Mbalamaziwa	Regular Rainfall	18.1	24.1	No unusual activity
Weighted Average	Consumption 81% of Average*	16.0	23.6	Consumption 119% of Average*

Table 6.1 - Comparison of rainy and dry season per capita consumption

* This is not the annual average consumption, but average of the two weeks of metering.

7. PER CAPITA CONSUMPTION IN DRY SEASON

7.1 Introduction

A public water supply shall be able to fulfill demands throughout the year and designs of such systems must therefore secure that sufficient capacity is available to cope with the demand on days with maximum usage.

Since the purpose of this study is to provide a basis for determination of design criteria it is sufficient to evaluate the results of the dry season metering. Consequently most figures in this (and subsequent) chapter(s) are from the dry season metering.

7.2 Comparison of Village Per Capita Consumptions

When designing rural water supplies, efforts should be made to supply as high a percentage of the population as possible within the economical and technological constraints of the project. Furthermore, it should be taken for granted that the water supplied is of better quality than the water from traditional sources, so the use of traditional sources should be discouraged.

Basis for comparison of per capita consumption of the six villages should therefore be the actual water consumption less losses and estimated waste, but compensated for use of traditional sources (see Chapter 4.4).

Due to the inherent inaccuracies of such adjustments (inaccuracies related both to the household interviews and to the quantity of water applied), the adjustments are made to the average consumption only. (Daily variations within the week are dealt with in next chapter).

The sensitivity of the results to the somehow arbitrary figure of 12 litres per capita per day chosen as compensation for use of traditional sources for laundrying and personal hygiene is very low (see chapter 4.4). A 50% increase or decrease of the rate of compensation only effects the average per capita consumption with ± 5%, which is insignificant (see Table 7.1).

Village	Population using water supply	Actual average consumption excl. losses & estimated waste Litres/day	Compensation for use of traditional sources Litres/day	Estimated average water consumption if supply is from water supply only Litres/day	Percent of average consumption of six villages %	Sensitivity to 50% increase in compensation for use of traditional sources %
Kasumulu	1,729	25.1	2.7	27.8	110%	5%
Mlangali	1,186	29.2	1.0	30.2	119%	2%
Kiponzelo	2,237	19.3	1.0	20.3	80%	3%
Mbalamaziwa	1,180	24.1	0.1	24.2	96%	0%
Mpitimbi "B"	1,532	23.0	1.8	24.7	98%	4%
Amani	2,350	19.6	6.8	26.4	104%	13%
Average of all six villages	10,214	22.6	2.6	25.3	100%	5%
Average if villages with highest and lowest per capita consumption are eliminated	6,791	22.5	3.5	26.0	103%	7%
Average if the two villages with highest per capita compensation are eliminated	6,135	23.1	1.0	24.1	95%	2%

Table 7.1 - Average per capita water consumptions

The estimated weighted average per capita water consumption if no traditional sources are used is 25.3 litres per day based on all six villages of the study. If the two villages with the highest and lowest per capita consumption (Mlangali and Kiponzelo respectively) are eliminated from the calculations the average per capita consumption increases by 3%, whereas it decreases by 5% if the two villages with the highest compensation for use of traditional sources are eliminated (Kasumulu and Amani).

The elimination of any one or two of the six villages does not effect the per capita average with more than 7% in upward direction or 6% in downward direction, so the per capita consumptions of the six villages appear fairly consistent, and results of the study would not have differed significantly even if the study had only covered four of the six villages.

As mentioned in Chapter 3.3 the sample of villages is not a random sample, and it is also unknown whether or not the per capita consumptions follows the pattern of a normal distribution function. Despite these uncertainties, some statistics have been worked out for comparison with the sampled data.

The mean per capita consumption is 25.6 l/day and the standard deviation (if normal function) is 3.40 (the standard deviation of the actual sample is 3.10).

Assuming that the sample is random and the distribution follows the normal function it can be stated that 90% of the villages would have an average per capita consumption between approximately 23 and 28 litres per day. If that statement is reasonably correct, then increasing the sample size with more villages would not alter the mean significantly.

If consumption is compared to altitude and daylight temperatures, there appears to be a trend towards higher consumption in villages with hot climate (and low altitude).

The level of correlation is, however, quite low (Spearman's Rho 0.600 for temperatures and -0.614 for altitude). Nothing conclusive can therefore be stated on any relationship of consumption to temperatures and altitudes.

For per capita consumptions at individual DPs there appear to be a clear indication of lower water consumption with increasing walking distances. (see Chapter 5).

However, that tendency is not clear when comparing the overall average consumption rates for all 6 villages in Table 7.1 with general impression of walking distances.

The analysis of per capita consumptions at individual DPs has for the two villages with highest average number of users (Kiponzelo and Amani) shown a tendency towards relatively low actual per capita consumption at DPs with more than approximately 200 users (all DPs were with one tap only.

In Kiponzelo, two DPs with many users have relatively long walking distances too, so the lower per capita consumptions are probably an effect of both. In Amani, walking distances are relatively short both to DPs and to the river, so at DPs with many users more people might be tempted to use the traditional sources. Queueing was observed at Amani only.

An analysis of the effect of nos. of users per DP should be based on the actual amount of water drawn at the DPs, as the compensation for use of traditional sources would blur the effect.

Table 7.2 shows the average nos. of users per DP and the actual average amount of water drawn per capita. It is clearly seen that Kiponzelo and Amani villages with relatively high number of users per DP have the lowest actual per capita consumptions.

Village	Population	Nos. of DPs	Average nos. of users per DP	Actual average amount of water drawn per capita
Kasumulu	1,729	14	124	25.1
Mlangali	1,186	11	108	29.2
Kiponzelo	2,237	14	160	19.3
Mbalamaziwa	1,180	10	118	24.1
Mpitimbi "B"	1,532	15	102	23.0
Amani	2,350	10	235	19.6
Average	1,702	12.3	138	22.6

Table 7.2 - Nos. of users per DP and water drawn per capita

The effect of number of users per DP was tried out in Amani village, by fixing a second tap on those DPs with high number of users.

Metering with a total of 10 taps took place on Tuesday, Wednesday and Thursday, additional taps were fitted on Friday to 5 of the DPs and metering with 15 taps continued until the following Thursday. When comparing the actual consumption of Tuesday, Wednesday and Thursday of the first week with the consumption of Monday, Tuesday and Wednesday the second week, an increase in consumption of 13% was found.

Similar analyses of the other villages show no increases.

When comparing the 5 DPs where extra taps were fitted with the 5 DPs with no change, the difference was very clear. The consumption at the 5 DPs with 2 taps increased by 23%, whereas it decreased by 3% at the DPs with 1 tap (i.e. no change). The increase in consumption is considerable particularly when bearing in mind that people had very few days to get used to the higher service level. Further analysis showed that the increase was bigger than average at the DPs situated relatively far from the river (DP nos. 1, 4 and 5).

The actual weighted average consumption taking week-end use into consideration is shown in Table 7.3 below.

The correlation between actual amount of water drawn and nos. of users per DP is shown in Figure 7.4, there should, however, be paid attention to the fact that the correlation is influenced to some extent by walking distances to DPs (Kiponzelo) and proximity of traditional sources (Amani), so the effect of nos. of users on the consumption is considered less than what is indicated in Figure 7.4. (The Spearman's correlation factor is -0.657 only).

Village	Population	Nos. of taps	Users per tap	Actual Average amount of water drawn per capita
Amani 20/10 to 25/10	2,350	10	235	19.0
Amani 23/10 to 28/10	2,350	15	157	20.3
Average	2,350	12.5	188	19.6

Table 7.3 - Amani Village: Effect of increased nos. of taps

Some socio-economic data of four of the villages were collected during the pre-evaluation study performed in March 1987. Based on these data and general impression of conditions in the six villages, the villages might be termed as below or above average as shown in Table 7.5.

When comparing the socio-economic conditions with the per capita water consumption as done in Table 7.5, it appears that there is a tendency of villages with above average socio-economic conditions to have below average water consumption and vise versa.

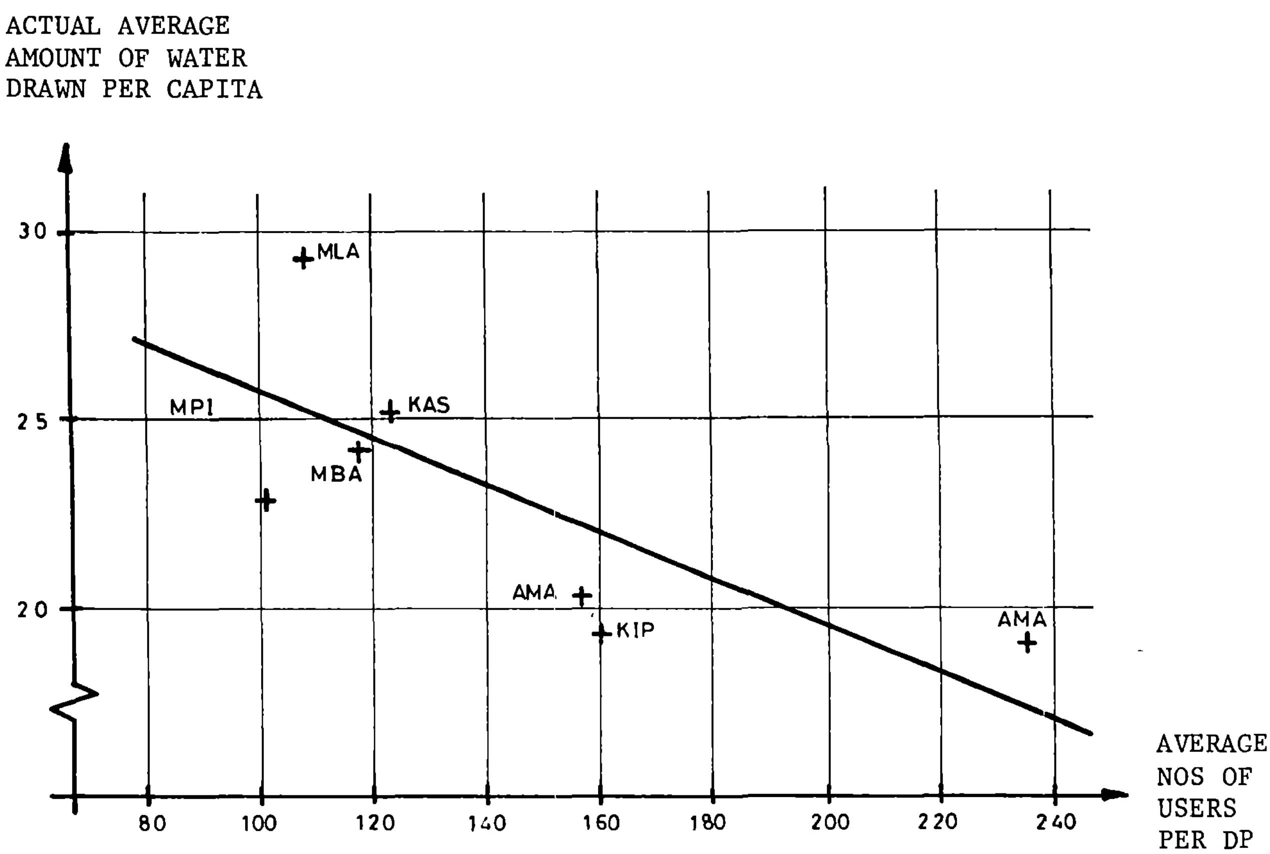

Figure 7.4 - Actual amount of water drawn related to nos. of users per DP

Spearman`s Rho - 0.657

It is, however, believed that the data evaluated is insufficient to make any conclusion on the relationship between water consumption and socio-economic conditions for villages in general, and it appears that differences in consumption in the sample villages cannot be explained by variations in such socio-economic conditions.

Village	Socio-Economic Conditions	Per Capita Water Consumption
Kasumulu	Above average	Near average
Mlangali	Below average	Above average
Kiponzelo	Above average	Below average
Mbalamaziwa	Above average	Near average
Mpitimbi "B"	Below average	Near average
Amani	Below average	Near average

Table 7.5 - Socio-economic conditions of sample villages

7.3 Summary of Findings

In the sub-chapter above the per capita water consumptions of the villages are evaluated and correlated with various findings. The conclusive results are summarised in Table 7.6.

It could be argued that the most appropriate per capita water consumption to be used for design purposes would be the amount derived from those villages, which are least influenced by the findings summarised in Table 7.6.

Village	Average per capita consumption	Effect of use of traditional sources	Effect of relatively long walking distances	Proportion of estimated waste	Average nos. of users per DP	Nos. of "abnormal" findings
Kasumulu	Near average	Moderate	Moderate	Low	Near average	None
Mlangali	High	Low	None	High	Near average	Two
Kiponzelo	Low	Low	Moderate	Low	High	Two
Mbalamaziwa	Near average	Low	None	Low	Near average	None
Mpitimbi "B"	Near average	Moderate	Moderate	Low	Low	One
Amani	Near average	High	None	High	Very high	Three

Table 7.6 - Summary of findings related to per capita consumption

Note: "Abnormal" findings are underlined

The effect of such considerations are shown in Table 7.7.

Nos. of "abnormal" findings	Population (nos. of villages)	Estimated average per capita consumption if supply is from water supply only
1. None	2,909	26.3 litres/day
(Kasumulu, Mbalamaziwa)	(2)	
2. One or less	4,441	25.8 litres/day
(the above + Mpitimbi "B")	(3)	
3. Two or less	7,864	24.9 litres/day
(the above + Mlangali and Kiponzelo	(5)	
4. Three or less	10,214	25.3 litres/day
(all villages)	(6)	

Table 7.7 - Average per capita consumption related to other findings.

The differences in per capita consumption in Table 7.7 above are marginal (only some 3% around average) and for design purposes it appears insignificant, which option is chosen.

The actual per capita consumptions for both the first two options are more than 24 litres/day and the two options have a very low sensitivity to the rate of compensation for use of traditional sources, so the element of assumption is very low. The two last options have higher (but still relatively low) sensitivity to rate of compensation (less than 5%).

Comparing with the other combinations of villages in Table 7.1 shows again only marginal differences, therefore, it is proposed that 26 litres is chosen as basic per capita consumption per day.

8. VARIATION IN DAILY CONSUMPTION

8.1 Introduction

In the previous chapter the average per capita consumptions during a week towards the end of the dry season were evaluated. There are, however, large variations in daily consumptions within the week. Such variations should be taken into account when designing water supplies, otherwise frequent water shortages will be experienced by the consumers.

The variations found during the study are evaluated below and recommendations given for how to include such variations in the design.

8.2 Water Consumption Pattern

As described in Chapter 5, the consumption pattern may be very different from one part of the village to another or from one DP to another. Days with maximum consumption at individual DPs might occur on any day of the week as illustrated in Table 8.1.

However, when considering the cummulative consumption at all DPs (total consumption of the village) a more regular consumption pattern has been found (see Table 8.2). Investigation of a single DP can therefore rarely be taken as representative for a complete village.

It can be seen from Table 8.2 that most commonly, Saturday is the day with the highest consumption and that consumption in general is high on Fridays and Sundays and low the rest of the week. If the evaluation is based on dry season results only, there is a slight difference resulting in high consumption in the middle of the week instead of on Sunday. The variations are shown in Figure 8.3.

Only Kasumulu village differs significantly from the general pattern of high consumption during the weekend, but also in Kasumulu there are three consecutive days with relatively high consumption within a week.

Village	Season	Nos. of DPs	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.
Kasumulu	Rainy	14	1	0	0	2	3	2	2
"	Dry	14	0	2	5	0	0	4	3
Mlangali	Rainy	11	1	1	1	5	1	1	-
"	Dry	11	1	2	2	1	1	3	1
Kiponzelo	Rainy	14	4	2	0	0	7	1	0
"	Dry	14	3	3	2	4	1	0	1
Mbalamaziwa	Rainy	8	2	0	1	1	4	0	0
"	Dry	10	3	0	1	2	2	1	1
Mpitimbi "B"	Dry	16	-	4	3	4	2	1	1
Amani	Dry	10	1	0	1	2	2	2	2

Table 8.1 - Nos. of days with weekly maximum consumption at individual DPs after deduction of waste

Village	Season	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.
Kasumulu	Rainy	Below	Below	Below	Below	Above	Above	Max
"	Dry	Above	Max	Above	Below	Below	Above	Above
Mlangali	Rainy	Below	Above	Above	Max	Above	Below	-
"	Dry	Below	Above	Above	Max	Below	Above	Above
Kiponzelo	Rainy	Above	Below	Below	Below	Max	Below	Below
"	Dry	Below	Above	Below	Max	Below	Below	Above
Mbalamaziwa	Rainy	Above	Below	Above	Above	Max	Below	Below
"	Dry	Above	Below	Below	Max	Below	Below	Above
Mpitimbi "B"	Dry	-	Above	Above	Max	Below	Below	Below
Amani	Dry	Below	Below	Above	Max	Above	Below	Above
Total of all villages both seasons		Below	Below	Above	Max	Above	Below	Below
Total of all villages dry season only		Above	Below	Above	Max	Below	Below	Above

Table 8.2 - Daily variations in consumption related to weekly average

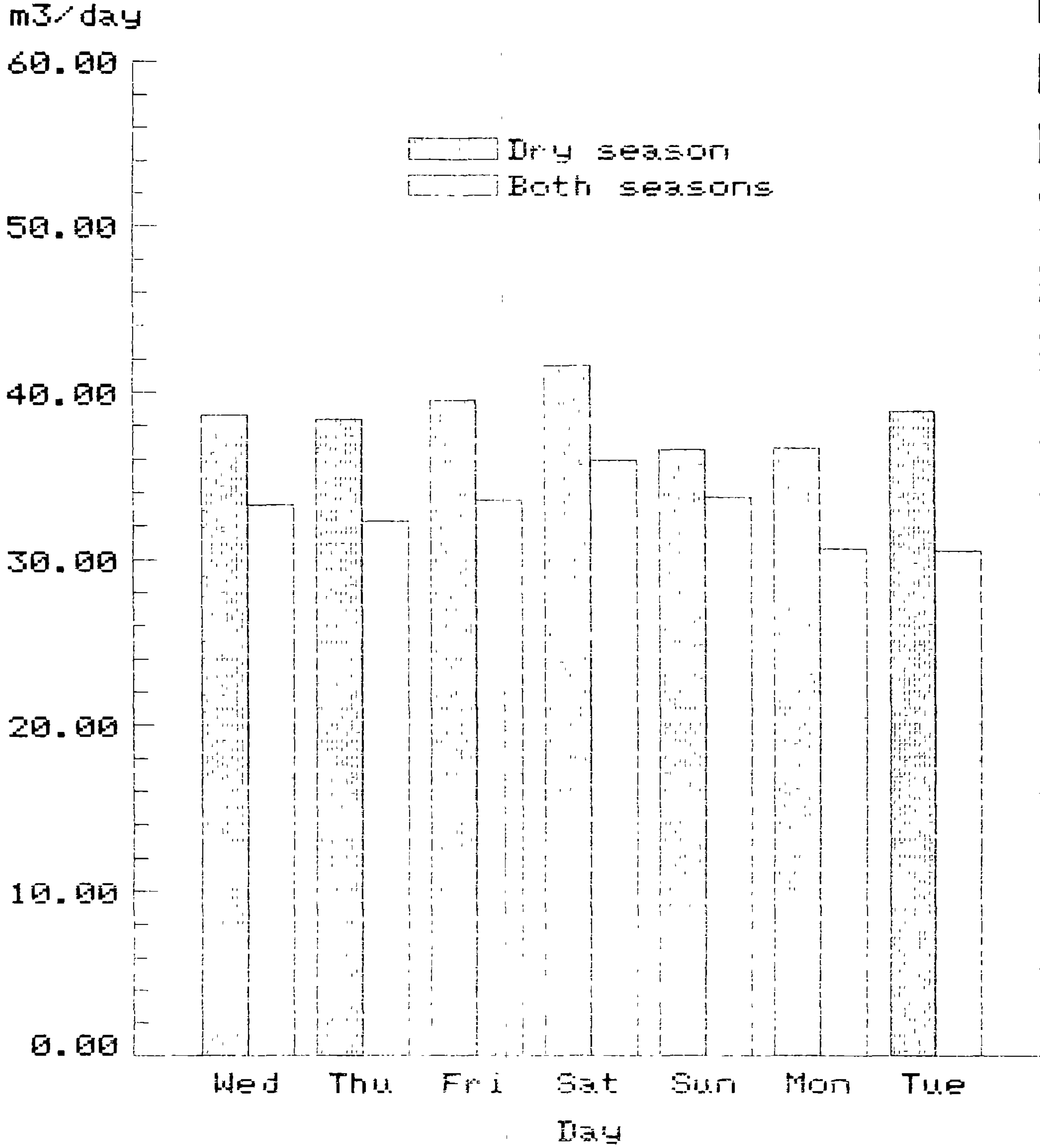

Figure 8.3 - Daily variations in consumption, average of six villages (consumption excl. loss and waste)

It can therefore be concluded that variations in consumption within the week are common in villages, and that it is reasonable to base average weekly consumptions on measurements for 7 days with commencement and termination of measurements during the middle of the week. Measurements for more or fewer than 7 days will biase the results.

The cummulative daily variations for all 6 villages are illustrated in Figure 8.3.

8.3 Allowance for Maximum Days

As mentioned in the introduction to this chapter, it is necessary to incorporate an allowance for maximum days in the design of water supplies.

Since waste of water (see Chapter 9.3) is independant of water consumption, it is most appropriate to determine allowance for maximum days based on actual consumption excluding losses and estimated waste.

The actual figures are shown in Table 8.4 both for the rainy and the dry season, and the relationship between maximum day and average day consumption is worked out (maximum day factor).

The difference between maximum and average days are in general bigger during the rainy season than during the dry season, both in actual figures and percentage wise. This is a clear illustration of rainfalls' influence on water consumption. That the maximum day factors for Kasumulu village are almost equal for rainy and dry season supports the above statement, because the weather was dry during both metering campaigns in that particular village.

Village	Season	Maximum day	Average day	Maximum day per capita	Average day per capita	Maximum Day factor	
Kasumulu	Rainy	29,162	26,612	16.9	15.4	1.10	-
"	Dry	48,472	43,362	28.0	25.1	-	1.12
Mlangali	Rainy	31,780	26,095	26.8	22.0	1.22	-
"	Dry	37,527	34,674	31.6	29.2	-	1.08
Kiponzelo	Rainy	34,274	27,077	15.3	12.1	1.27	-
"	Dry	48,653	43,186	21.7	19.3	-	1.13
Mbalamaziwa	Rainy	27,316	20,759	23.8	18.1	1.32	-
"	Dry	30,638	28,396	26.0	24.1	-	1.08
Mpitimbi "B"	Dry	40,192	35,176	26.2	23.0	-	1.14
Amani	Dry	52,059	46,157	22.2	19.6	-	1.13
Average rainy season		30,633	25,136	19.5	16.0	1.22	-
Average both seasons		38,007	33,149	22.3	19.5	1.15	
Average dry season		42,924	38,492	25.2	22.6	-	1.12

Table 8.4 - Factor for maximum day within a week

It is intended that the maximum day factor be applied to the dry season water consumption as that is most appropriate for design purposes. It can be seen from Table 8.4 that the maximum day factors do not vary much during the dry season. It is, therefore, recommended that the average factor of 1.12 is applied, which means that for design purposes the maximum day has a consumption, which is 12% higher than the average day, or in other words some extra 3 litres per capita per day shall be allowed.

9. WASTE OF WATER

9.1 Introduction

The definition of water waste is the amount of water reaching DPs (and passing through the tap), but not being used for any purpose by the consumers. This means water wasted by leaving taps running at night (or in the day) and water lost through leaking taps. Water used for cleaning buckets etc. at DPs is not waste.

Before both metering campaigns, defective taps (bibcocks) were replaced with new ones, so the estimated waste in this study is for taps left open. No DPs were fitted with special self closing taps.

9.2 Method of Estimation

Since the DPs were not under observation for 24 hours, the amount of water considered wasted can only be estimated based on some assumptions.

For 5 of the six villages very little water use was metered between 21.00 hours and 06.00 hours the next morning. For Amani village, the same applies from 22.00 hours to 06.00 hours (see Chapter 5.7). However, in some villages there happened to be single days with relatively large quantities of water being metered during the night. It appears likely, that such quantities of water have not been utilised and any night flow above some one to two hundred litres per DP has consequently been considered water waste.

The order of magnitude of flow from an open tap is some 600 to 2000 litres per hour. The highest water waste from one tap occured during a night preceeding the days reported on at Mbalamaziwa village, where about 27 m^3 was wasted. Fortunately such events are uncommon.

During the day meters were read every hour, and some instances of exceptional high hourly water consumption have been recorded.

For such hours comparisons have been made with hourly flows for the same hour on the other days of the study, and flows significantly exceeding the highest flow on other days has been considered possible water waste.

The above method is thus based on assumptions, in particular in respect of water wasted in daytime.

Excessive flows might not be waste, but on the other hand limited waste could have taken place without being found with the above methods. Excessive waste could, however, not have taken place in the daytime because DPs were visited at least every hour and many were under almost constant observation.

Under normal circumstances more waste of water, than what has been found during the metering campaigns should therefore be expected.

9.3 Estimated Water Waste

The estimated waste is shown in Table 9.1. It can be seen that only Mlangali and Amani villages have any significant waste. For Mlangali village wastage occurs at all DPs on random days of the week both during the rainy and the dry seasons, whereas 95% of the wastage at Amani village is from 3 DPs only. By making the users at these 3 DPs aware of the problem the wastage could be reduced considerably, so the wastage experienced at Amani during the week of metering is considered exceptional. Consequently, Amani village is suggested eliminated from the dry season calculations of waste, with the result that the average dry season wastage is reduced to 0.6 litres per capita per day, which is almost equal to the average rainy season wastage of 0.7 litres per capita.

Wastage is not a function of consumption, but only depends on the careful usage of DPs by consumers, therefore it is recommended that the allowance for waste is made a fixed amount independant of consumption. However, as stated in section 9.2 above, more wastage should be expected under normal circumstances, so it is recommended that an allowance of 1 litre per capita per day be made for water waste.

Village	Season	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average per village per day	Average per capita per day
Kasumulu	Rainy	0	500	100	0	950	0	600	307	0.2
"	Dry	0	1,400	700	400	0	2,600	500	800	0.5
Mlangali	Rainy	400	2,500	5,100	1,000	1,600	6,100	8,500	3,600	3.0
"	Dry	2,600	2,400	3,700	3,000	7,600	300	1,100	2,957	2.5
Kiponzelo	Rainy	250	1,000	400	0	0	100	200	278	0.1
"	Dry	0	1,000	0	0	500	0	300	257	0.1
Mbalamaziwa	Rainy	-	-	-	-	-	-	-	Negligible	0.0
"	Dry	0	1,000	0	0	0	0	600	229	0.2
Mpitimbi "B"	Dry	400	600	500	700	300	0	300	400	0.3
Amani	Dry	0	3,000	3,000	15,500	15,700	6,000	1,400	6,371	2.7
Average rainy season		163	1,000	1,400	250	638	1,550	2,325	1,046	0.7
Average both seasons		365	1,340	1,350	2,060	2,665	1,510	1,350	1,520	0.9
Average dry season		500	1,567	1,317	3,267	4,017	1,483	700	1,835	1.1

Table 9.1 - Estimated water waste in litres per day

10. LOSSES OF WATER

10.1 Introduction

The definition in this study for water losses is the water lost through leakages in pipes and fittings and should not be confused with the wastage described in Chapter 9.

The study was only concerned with distribution systems, so the losses found do not represent total losses of the water supply systems.

10.2 Method of Measuring Losses

The actual losses found are worked out as the difference between the cummulative quantity of water used at DPs deducted from the quantity recorded by the master meter installed at the outlet from the storage tank.

A check on the losses was made by reading the master meter during one or two nights during each period of metering. If an hour with no flow occured it could be concluded that there was no loss (or very little loss) in the system. When there was a flow at night, the flow was compared with possible night use at DPs and with the difference between total flows through the master meter and the meters at DPs, in order to find the rate of loss.

The losses are characterised by an almost constant hourly rate of loss through leakages irrespective of time. However, a slightly lower rate of loss will occur during daytime due to the reduced pressure in the distribution system during hours with consumption.

10.3 Losses during Metering

Two of the villages studied during the rainy season (Kasumulu and Kiponzelo) had very high losses and the two other ones no losses at all. At Kasumulu a leak was found and repaired before the dry season metering, resulting in small losses only during the dry season metering.

The distribution system in Kiponzelo is some 15 years old and it was found to have many leakages causing 60% of the water to be lost. The system was repaired and subsequent metering, with the master meter only, indicated a loss of some 10 m^3 per day.

From the cummulative quantities of water used at DPs and at the master meters in Mpitimbi "B" and Mlangali it appears that there were some small losses during the dry season.

The losses were not confirmed by the reading of the master meters at night, because the rates of losses were smaller than the flow rate required to start the master meters (0.08 m^3/h).

When comparing the total quantities measured at DPs with the quantities measured at master meters at villages with no loss, it can be seen that the recorded quantities in all cases are bigger at DPs than at the master meters (see Table 10.1). This is most likely caused by inaccuracy of recording by the master meter at small flow rates, which can be measured more accurately by the small meters at DPs. A difference should therefore be expected and for this study it is only 1.9% on average. This means that in theory the losses found should be adjusted with a factor of 1.02, which, however, is totally insignificant for the results.

The small differences in results of metering with the small meters as compared to the master meters show that the results are free from major metering errors and that no meter was defective.

Village	Season	Total quantity at DPs m^3	Total quantity at master meter m^3	Nos. of days	Difference per day m^3	Average hourly rate of loss m^3/h	Hourly rate of loss measured at night m^3/h	Metering error %	Loss in % of design capacity	Remarks
Kasumulu	Rainy	201.73	391.57	7	27.12	1.13	1.16	N/A	37%	incl.contractors camp
"	Dry	352.14	375.98	7	3.41	0.14	0.17	N/A	4%	
Mlangali	Rainy	190.69	186.53	7	-0.59	N/A	0.00	+2.2%	0%	10 DPs only
"	Dry	258.64	259.96	7	0.19	0.01	0.00	N/A	0%	"
Kiponzelo	Rainy	122.42	279.36	3	52.31	2.18	2.54	N/A	60%	incl.health centre & staff houses
"	Dry	.	.	.	10.00	0.42	N/A	N/A	11%	Not during metering
Mbalamaziwa	Rainy	131.97	131.37	7	-0.01	N/A	0.00	+0.5%	0%	7 DPs only
"	Dry	187.18	183.44	7	-0.53	N/A	0.00	+2.0%	0%	"
Mpitimbi "B"	Dry	249.04	258.11	7	1.30	0.05	0.00	N/A	2%	dry season only
Amani	Dry	367.70	359.54	7	-1.17	N/A	0.00	+2.3%	0%	"
Average of all villages before repair		-	-	-	13.46	-	-	-	17%	-
Average of all villages after repair		-	-	-	2.48	-	-	-	3%	-
Average of both cases		-	-	-	9.43	-	-	-	12%	-

Table 10.1 - Water losses in distribution systems

Under normal circumstances village water supplies are not metered, so the leakages found due to the metering campaigns might not have been repaired. It would therefore appear most correct to use the losses found before the repairs as a guide for design purposes. However, the leakages at Kiponzelo were causing losses so big that they would normally be seen and repaired.

It is normal practice to define losses in percent of design capacity, and it can be seen from Table 10.1, that average losses were reduced to 3% after the repairs were carried out. It should, however, be borne in mind that these losses are in the distribution system only and that all systems (apart from Kiponzelo) are less than 3 years old. Higher rates of losses should therefore be expected in future.

10.4 Recommendations

It is quite normal for design purposes to make an allowance for losses of 20% of the design capacity. That is for the complete water supply systems covering transmission system, storage tanks and distribution systems, and the results of this study does not provide basis for altering that figure.

It is, however, suggested that half of the total loss be allocated to the transmission system and the other half to the distribution system, i.e the design capacity of distribution systems will be reduced by 10% compared to present practise.

11. WATER CONSUMPTION IN FUTURE

11.1 WMP and pre-evaluation study

The design criteria used in WMP for per capita water use are based on the results of interviews of sample households in eight villages carried out during 1981, however, no metering was carried out. A similar method with interviews was applied for sample households in 4 villages during the pre-evaluation study in March 1987, resulting in per capita consumptions very similar to the ones found in 1981. There is therefore no indication of increased per capita water use during the 6 years.

The rainy season metering, which took place in the same 4 villages at the same time, showed a higher average per capita consumption, however, that should be taken as an outcome of the different methods applied and not as an indication of increased consumption.

In the WMP criteria, an allowance for future increase in consumption of 2.6 litres per capita has been made. There is probably an element of rounding up in the figure too, and the present study has not given rise to any change of the size of the allowance, provided the present service level is not improved.

11.2 Effects of change to service level

The present study has not looked into the possible effect of improved service levels, consideration should, however, be given to possible improvements before decision is made on changing design criteria.

Some institutions and aid programmes encourage villagers to have their own vegetable gardens in order to improve on the nutritional condition of the population (in particular children). Garden watering is not allowed from the village water supplies provided under the MAJI/DANIDA programme and the supplies do not have the capacity either.

The increasing emphasis on health education might have an effect on the water use, and the provision of washing slabs and public bathing facilities as suggested by the Evaluation Mission could have a considerable effect if the suggestions are implemented.

The single most important aspect to consider in this connection, is whether or not private house connections should be allowed in future. If house connections are allowed the per capita consumption for people with house connections is likely to double from the present rate.

It is not the objective of this study to recommend changes in service levels, so no allowance has been made for such possible changes.

12. DESIGN PER CAPITA WATER DEMAND

12.1 Introduction

This chapter summarises the findings of the previous chapters and propose a revised rate for the per capita water demand, which is sufficient to meet the present demand established by this study.

It is stressed that the figures relate to the present service level and that they are intended for design purposes.

12.2 Proposed Design Demand

Table 12.1 summarises the different components of the water demand, and for easy reference, the related WMP and MAJI design criteria are shown too.

The reason for having different components for distribution and transmission systems are given in Chapters 10 and 15.

The proposed per capita water demand of 36 litres per day is considerably higher than the WMP criteria. This large difference is mainly attributed to the daily and seasonal variations, which were not taken into account at the time of WMP, but also due to the different methods of study applied (interviews and metering). For details see Appendix VIII.

With the present knowledge of actual water consumption in the villages there is thus no justification to supply less water than provided by the MAJI design criteria.

When comparing the proposed maximum day per capita consumption of 30* litres with actual consumptions exclusive losses during the metering (Chapter 5), it can be seen that the figure is only exceeded in Mlangali, but that three other villages are within 95% of the figure.

For 4 out of the six sample villages the only extra allowance provided is therefore the small allowance for future.

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* Average consumption plus allowances for peak day and waste

Component of water use	Chapter ref.	Distribution system	Transmission system	WMP Volume 12	MAJI Design criteria
Average consumption	Ch. 7	26.0	26.0	17.4	
Allowance for peak days	Ch. 8	3.1	0.0	-	25.0
Allowance for future	Ch. 11	2.2	2.0	2.6	
Waste of water	Ch. 9	1.0	1.0	-	
System losses	Ch. 10	3.6	7.2	5.0	8.3
Rounding of figures	-	0.1	- 0.2	-	- 0.3
Total		36.0	36.0	25.0	33.0

Table 12.1 - Proposal for design water demand in litres per capita per day

13. COLLECTORS OF WATER

13.1 Introduction and Methodology

Concurrently with the dry season metering of water consumption, observations (counting) of all people collecting water were carried out at all DPs on an ordinary weekday and on a school holiday.

The primary purpose of the observations was to see how big a proportion of the water carried away from DPs was carried by children. In this context children were defined as being below 15 years of age, and the observations were made by villagers living near the DPs, so most consumers (if not all) would be well known to the observer, who therefore should be able to determine the age of water collectors reasonably well.

Counting was taking place from 06.00 hours in the morning to 21.00 hours at night (22.00 hours in Amani) and nos. of collectors were recorded for each hour at each DP.

There was differentiated between three categories of collectors:

- Adults (assumed to use containers with approx. 20 litres capacity);
- Children using containers with approx. 20 litres capacity;
- Children using smaller containers.

After the observations the enumerators were asked about their general impression about size of containers used by small children. The replies varied from 1 litre "sufuria" (cooking pot) to 1 gallon (about 4.5 litres), and it appears that containers with capacities between 5 and 20 litres are very rarely used.

13.2 Results of Observations

The results of the observations are summarised in Table 13.1 below. Figures are given in Appendix IX.

The calculations are made by assuming an average volume of the small containers used by children (based on statements by observers) and then distribute the rest of the total water quantity on the other categories of collectors.

	Weekday			School Holiday		
	Adults	Children Large Contain.	Children Small Contain	Adults	Children Large Contain.	Children Small Contain.
Total nos. of collections	7,673	3,733	4,954	7,179	4,048	5,533
Estimated average volume used per collection	19	19	4.5	18	18	4.5
Percent of total volume	62%	29%	9%	57%	32%	11%
Percentage of total volume collected by adults and children	62%	38%		57%	43%	
Average Nos. of collections per household per day	3.3	1.6	2.2	3.1	1.8	2.4
Total average nos. of collections per household per day	7.1			7.3		

Table 13.1 - Summary of data on water collections

The resulting average volume of water used per collection with large containers is 19 and 18 litres for ordinary weekdays and school holidays respectively. This amount is slightly lower than expected as it also covers the amount of water used at the DP for washing the bucket, etc.

For individual villages the amount of water per collection varied from 14 l to 25 l with Amani as the lowest and Mpitimbi "B" as the highest. The reason for this big difference is not known, but could be caused by counting errors and misjudgement of volumes of large containers used by children. Bearing in mind the large number of collections observed (more than 33,000), it may be concluded that the average figure is representing the real situation fairly well.

It can be seen from Table 13.1 that on average, some 40% of the total volume of water is collected by children and that the proportion collected by children is a little higher on days, when children are not attending schools.

When looking at numbers of collections it can be seen that on average, some 55% of the collection trips to DPs are made by children, the children are thus having a great share of the work with collecting water. The study has not revealed whether or not the children's workload is higher in villages with water supplies than in villages with traditional sources only, but from the individual village data there appears to be a slight tendency towards relatively fewer collection trips made by children in villages with comparatively long walking distances.

14. VARIATIONS OVER THE DAY (PEAK FLOWS)

14.1 Introduction

In preceeding chapters seasonal variations and daily variations within the week have been evaluated. For the design of distribution systems the variations over the day also need to be considered, so as to provide sufficient capacity of the distribution system to supply water to consumers at the time required by them. For design purposes it is normal to apply a peak factor to the average flow on the maximum day, and the peak factor is defined as the peak flow required divided by the average flow.

14.2 Methodology

As explained in Chapter 10, the rate of loss in a system is almost constant over the day, so comparison of peak flows in different villages should be based on the actual net consumption. This means that when basing the calculations on flows measured with the master meter losses and waste should be deducted, and when calculations are based on meters at DPs, waste only should be deducted.

The resulting peak factors are in this study termed "net peak factors" and should not be confused with the peak factor used for design purposes, which is applied to the total water demand inclusive of loss and waste.

The master meters were read every quarter of an hour and the small meters at DPs every hour from 06.00 hours in the morning to 21.00 hours in the evening. It is thus possible to work out quarter hourly and hourly net peak factors for the whole village and hourly net peak factors for DPs.

14.3 Peak Flows and Peak Factors during Metering

The peak flows adjusted for loss and waste and the related net peak factors are shown in Appendix X.

As peak factors are used on maximum day consumption it is most appropriate to evaluate the results from the dry season, which had the highest peak flows in all cases but one, and which also covers more villages.

If the minimum recorded peak flow is divided by nos. of DPs (taps) we get the average flow rate to DPs during peak flows. This is shown in Table 14.1.

Village	Nos. of DPs (taps)	Average flow to DPs during peak hours	Average flow to DPs during peak quarters	Average nos. of users per DP (taps)
Kasumulu	14	0.440 m^3/h	0.120 m^3/h	124
Mlangali	10*	0.440 m^3/h	0.140 m^3/h	110
Kiponzelo	14	0.410 m^3/h	-	160
Mbalamaziwa	7*	0.660 m^3/h	0.200 m^3/h	154
Mpitimbi "B"	15	0.300 m^3/h	0.110 m^3/h	102
Amani	15	0.310 m^3/h	0.110 m^3/h	157
Weighted average	-	0.403 m^3/h	0.127 m^3/h	134

* only DPs covered by master meter

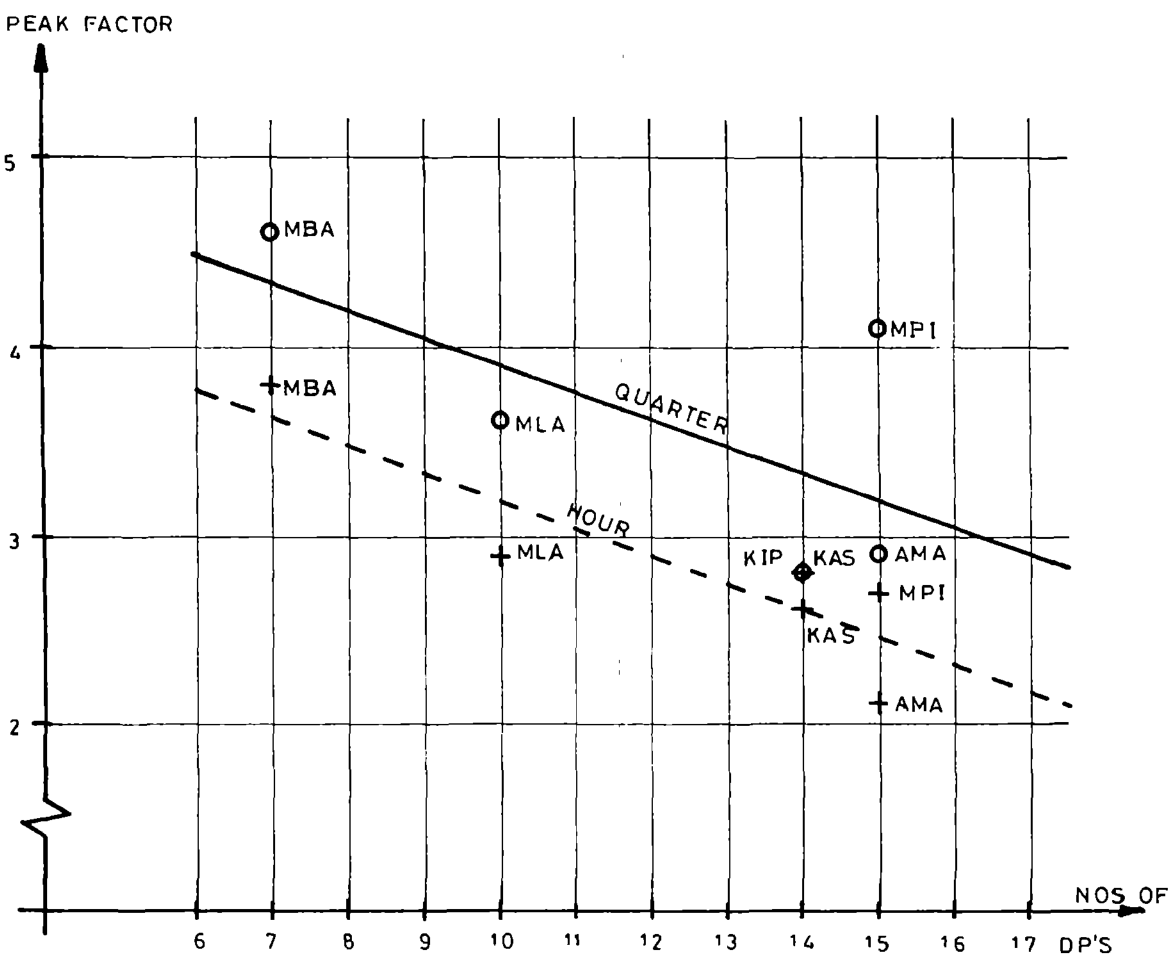
Table 14.1 - Average flow rates to DPs during peak flows

It could be expected that DPs with higher number of users would get comparatively higher flow rates, but that is not the case for the sample analysed. If the results from Mbalamaziwa are left out, the rates are fairly similar for all the villages irrespective of numbers of users per DP. That indicates that consumers at DPs with many users spread the collection of water over larger intervals of time, presumably to avoid queueing (queueing was, however, only observed at a few DPs in Amani). For comparison it should be noted that the theoretical design flow rate per DP (tap) is 0.150 m^3/h for a quarter of an hour, so on average, the theoretic capacity has only been reached at Mbalamaziwa, where it was exceeded by 33%.

The above leads to the assumption that peak factors will get smaller when numbers of DPs are increased i.e. negative correlation. The assumption is shown graphically in Figure 14.2 and using Spearman's Rho as a measure of correlation indicates reasonable level of correlation for peak hour factor (-0.800), whereas the level of correlation is poor for peak quarter factor (-0.375). The ultimate effect of the correlation is when all households have private connections, which based on experience from urban supplies brings the peak factor down to about 2.0.

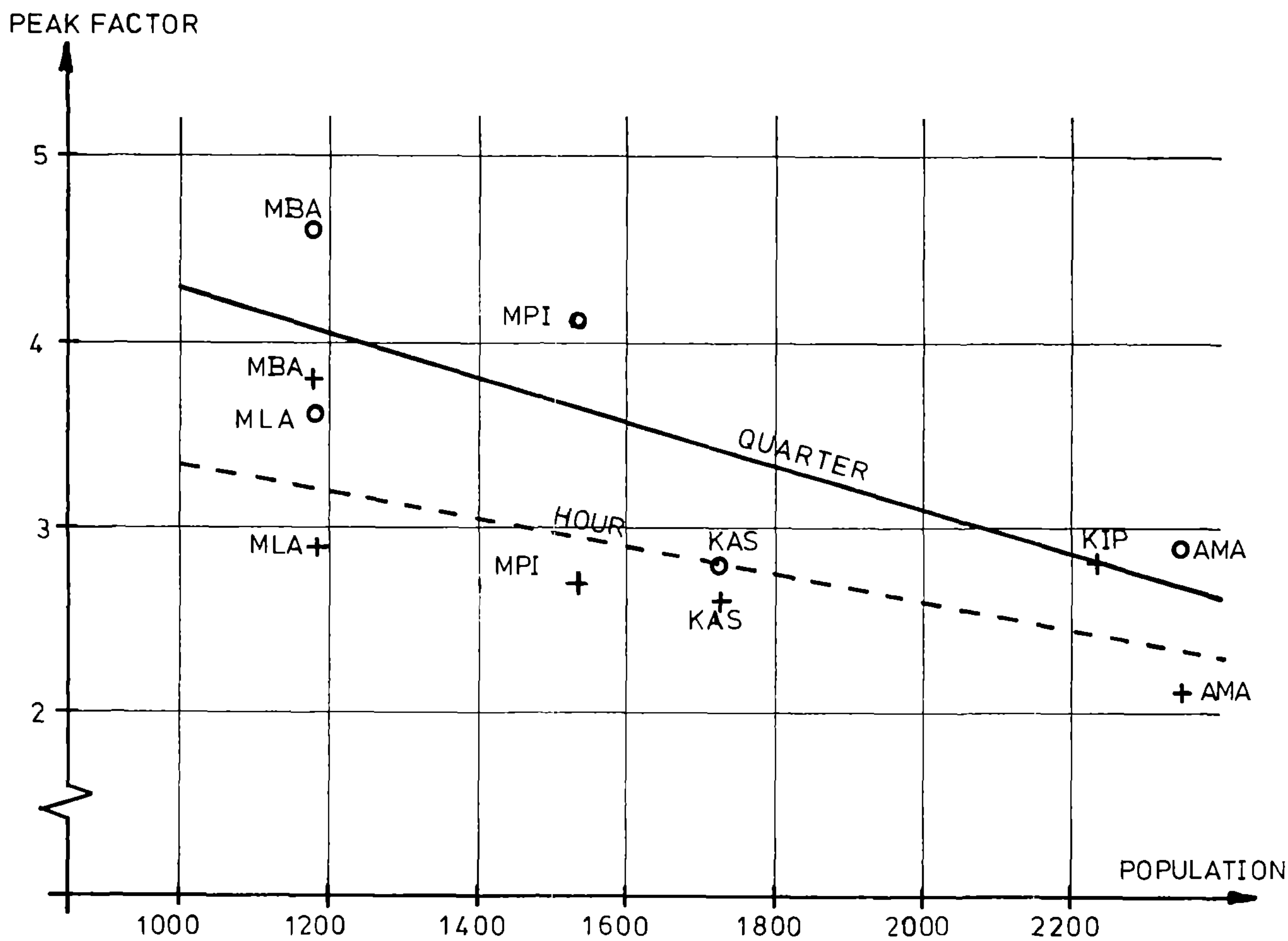
On average villages will in future have some 20 DPs (taps), which might bring the net peak factor for quarter hour flow down to around 2.6 (based on Figure 14.2).

It is seen from the above that there is some degree of correlation between peak factors and number of DPs. Relatively large numbers of DPs normally relate to relatively large populations, so the assumption is made that there is correlation between peak factors and populations (nos. of consumers). The assumption is graphically shown in Figure 14.3 and reasonable level of correlation is found both for peak hour and peak quarter factors (Spearman's Rho -0.829 and -0.800 respectively).



Spearman's Rho: Hour -0.800
Quarter -0.375

Figure 14.2 - Peak factors and nos. of DPs



Spearman's Rho:	Hour	-0.829
	Quarter	-0.800

Figure 14.3 - Peak factors and population

The best fit (straight) lines in Figure 14.3 cannot be used for extrapolation to future population figures because net peak factors below some 2.5 would be unrealistic for a supply based on public taps. The future population of an average village in the 3 regions is projected to some 3,500 people, so based on the findings shown in Figure 14.3 it appears reasonably safe to propose a net peak quarter factor of 3.0 for villages with more than 2,000 inhabitants in future.

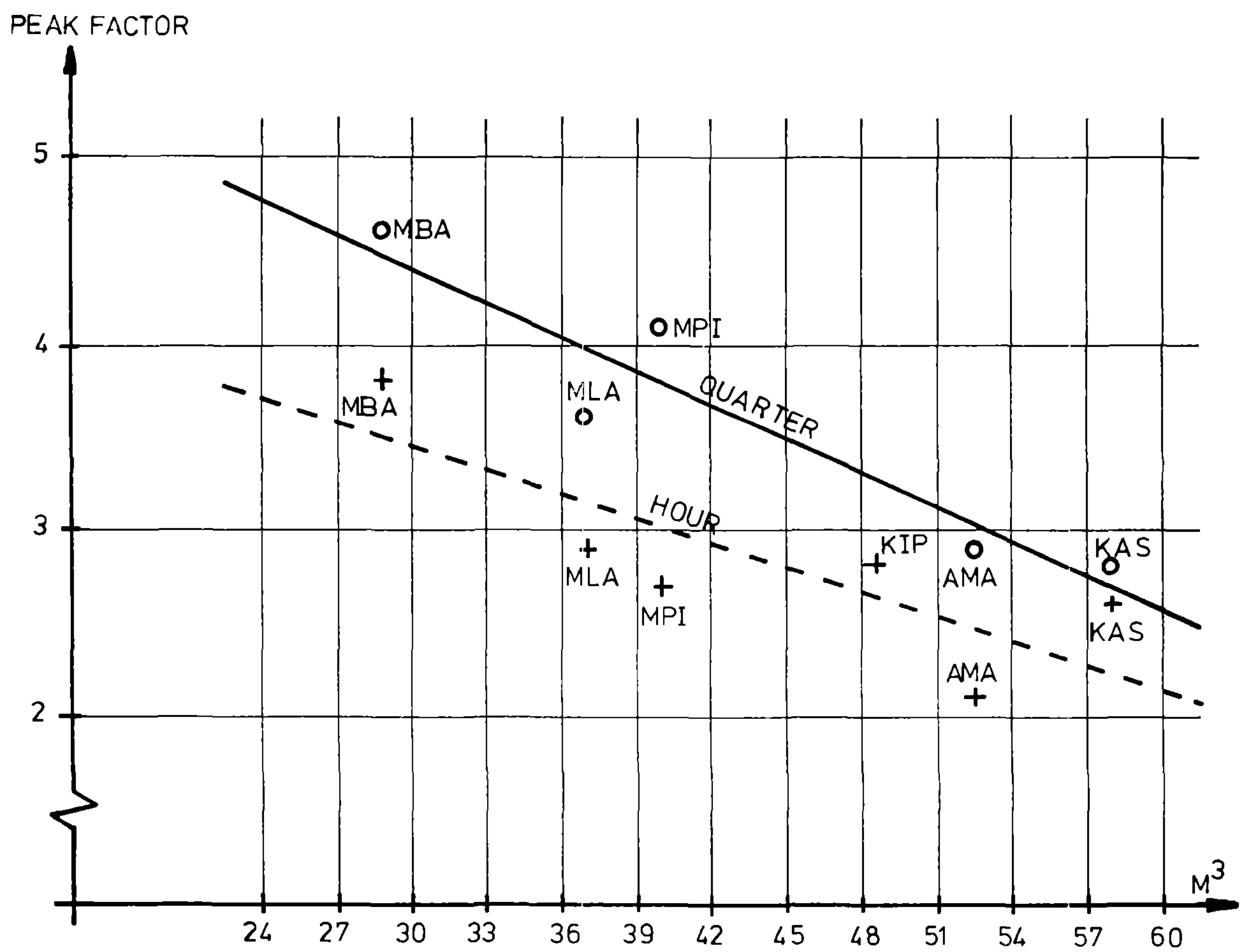
The data shown in Figure 14.3 are based on actual consumption and are therefore biased in villages where there is extensive use of traditional sources as supplement to the water supply. This is particularly the case for Amani village (see Chapter 5.7). If all villagers in Amani used the water supply only, the consumption would increase and the peak factor most likely decrease. The net peak factor of 3.0 is thus likely to be on the safe side.

Due to the use of traditional sources it will be more correct to correlate peak factors with the maximum daily consumption, which is done in Figure 14.4. The level of correlation using the Spearman's Rho is good both for peak hour and peak quarter factors (-0.886 and -0.900 respectively).

For most of the individual villages there is, however, not very good correlation between peak factors and total daily consumption.

From Figure 14.4 it appears reasonable to suggest a net peak factor of 2.6 for villages with maximum day consumption above 60 m^3 (corresponding to a population of approximately 2000 people).

From evaluation of the rainy season metering it was found that Kasumulu village had higher peak factors than the others. A hypothesis was made that relatively high peak factors should be expected in villages with high daylight temperatures because people would avoid collecting water in the middle of the day.



Spearman's Rho:	Hour	-0.886
	Quarter	-0.900

Figure 14.4 - Peak factors and maximum day consumption

The result would be that consumption would be concentrated in the morning and evening hours. It is correct that relatively small amounts of water are collected in the two warmest (low altitude) villages, Kasumulu and Amani, during mid day, however, that is not increasing the peak factors, because there is a tendency to collect water until later in the evening in villages with hot climate than in villages with cool climate (see Figures for hourly consumption in Chapter 5).

There is a good negative correlation found between peak factors and average daylight temperatures (i.e. peak factors decrease with increasing temperatures), but as the two warmest villages also have relatively high populations the hypothesis for dependence on temperature is not proved by the findings.

14.4 Summary of Findings and Recommendations

From evaluation of the data from the dry season metering the findings can be summarised as per the following statements:

- Peak flows appear not to be related to number of users per DP;
- Peak factors are decreasing with increasing number of DPs;
- Peak factors are decreasing with increasing population;
- Peak factors are decreasing with increasing daily consumption.

For design purposes it is most appropriate to use the net peak factors found based on quarter hour flow (or even for shorter periods if data is available). The relationship between net peak factors calculated from different time intervals are shown in Figure 14.5 based on recorded flows at Kasumulu village related to maximum day consumption. It can be seen from the figure that the peak factors increase when time intervals are reduced, and also that the relative increase gets smaller and smaller with sub-division of time intervals. There is a gradual increase in peak factors until the ½ hour interval, but after that point the curve flattens out. Extrapolation of the curve by continuing the trend indicates that the maximum net peak factor would not exceed 2.84 even if the time interval is reduced to less than one minute. Basing recommendations on recorded 1/4 hour peak flows is, therefore, unlikely to result in errors above 1%, whereas basing the recommendations on 1 hour flows would result in erros of some 10%. Consequently the quarter hour net peak factors found are evaluated further.

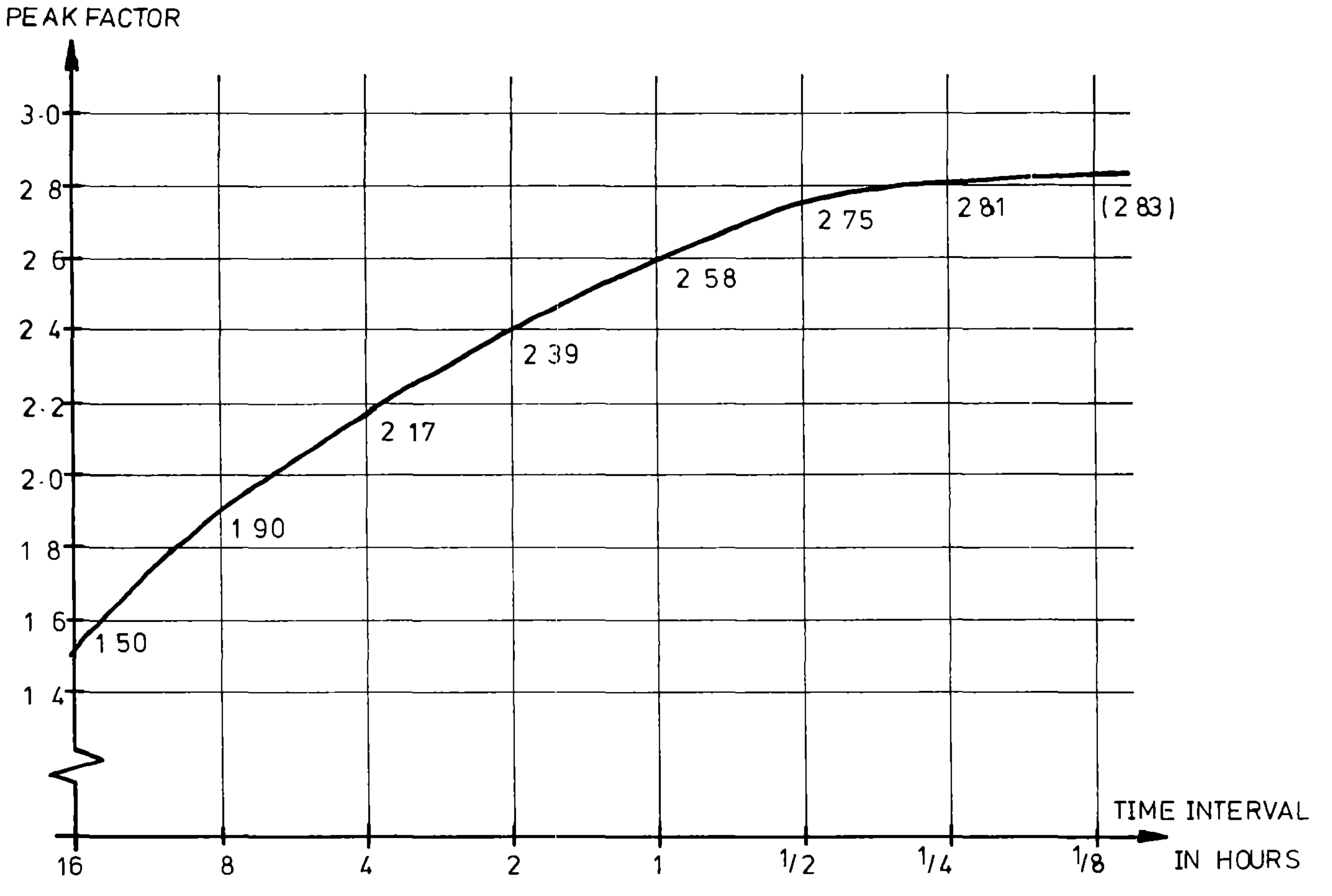


Figure 14.5 - Net peak factors related to time intervals (Kasumulu village)

A water supply is normally designed for the future demand based on the projected future population. The majority of the villages in the 3 regions will have a future population above 2,000 people, so the peak factors found for smaller populations will only apply in rare cases.

The most operative indicators of peak factors are population and water quantities. Incidentally they are also the ones, where the best correlation is found, therefore recommendations will be based on those two indicators only.

The net peak factor found for daily consumption above 60 m^3 (approximately 2000 people) is 2.6, which corresponds reasonably well with the one found related to population of 3.0. Furthermore, it was concluded above. that the one based on population was likely to be on the higher side due to the use of traditional sources. Consequently a net peak factor of 2.7 is considered appropriate. This means that in theory all water can be collected within 9 hours. To change this peak factor to design peak factor, consideration shall be given to the allowances for loss and waste (see Chapters 9 and 10). The net peak factor will therefore only apply to some 87% of total per capita demand, which means that the design peak factor will be approximately 2.5.

It is consequently recommended that the design peak factor be 2.5 for villages with future population above 2000 inhabitants.

For villages with less than 2000 inhabitants, the peak factor of 3.0 presently used should be applied.

14.5 Peak Flows and Peak Factors at DPs

It was shown above that the peak factor is relatively high for villages with few inhabitants. It may therefore be assumed that peak factors for individual DPs will be high.

To look into this assumption the data for Kasumulu village were selected for further analysis. Kasumulu was chosen because the average flows to DPs during peak hours and peak quarters are close to the average for all villages (see Table 14.1). Furthermore, Kasumulu's data are also close to average in respect of inhabitants, nos. of users per DP and per capita consumption, and it is the village with overall peak factors nearest to the ones recommended in section 14.4 above. It is thus reasonable to assume that the data from Kasumulu is the most representative for the whole study.

In Appendix X the peak flows at individual DPs are listed for each day of the study, and the average peak flows per DP are worked out for each day and each DP. One of the DPs had exceptionally high consumption and peak flows due to production of bricks (see Chapter 5.2), so that DP is not used for the evaluation.

The average peak flows per day for the remaining DPs ranged from 0.390 m^3/hour to 0.525 m^3/hour and somehow reflects the variations in total consumption i.e. they are relatively high on days with high consumption.

For individual DPs the variations are bigger and average peak flows range from 0.249 m^3/hour to 0.751 m^3/hour with an average of 0.444 m^3/hour. The flow rates do not correlate with number of users per DP and therefore supports the first statement on peak flows in general in Chapter 14.4.

The maximum peak flows at individual DPs range from 0.332 m^3/hour to 0.921 m^3/hour with an average of 0.620 m^3/hour. The design peak flow to DPs (one tap) used at present is 10 l/min., which equals to 0.600 m^3/hour.

It is found that the design peak flow is slightly lower than the average of maximum peak hour flows recorded. From Appendix X and from Table 14.1 it can be seen that for the villages as a whole, the average peak quarter flow rates are 27% higher than the peak hour flow rates. About the same relationship between the two flow rates should be expected at DPs, which means that the average maximum peak quarter flow rate per DP would be some 0.800 m^3/hour. In Kasumulu the maximum peak hour flow rates exceeded that value for 4 DPs out of a total of 14 DPs, and capacity measurements at DPs showed that capacities of up to 30 l/min. per tap was common. It can therefore be concluded that the flow capacity of DPs is not a limiting factor for the peak flows, but irrespective of the flow capacity of the DP, there is a practical limit for how many consumers can fill their buckets within a certain time.

Assuming that each water collection at a DP equals some 20 litres, the average peak hour numbers of collections per DP were 22, with variations from a minimum of 12 to a maximum of 37.

It, therefore, appears reasonable to continue designing DPs for a flow rate of 0.600 m^3/hour, which equals some 30 collections per hour.

That actual flow rates are exceeding this design value in some instances does not pose a problem, because all the maximum peak flows of individual DPs do not occur on the same days or during the same hours. Taking Kasumulu as an example, not more than 4 DPs out of the 14 Nos. had maximum peak hour flow on the same day, and none of these flows occured during the same hour.

15. DEMAND FOR STORAGE

15.1 Introduction and Methodology

It was shown in Chapter 14 (and in Appendix VII) that the consumption varies over the day from practically no consumption at night to high consumption during peak hours.

It is possible to design complete water supply systems for peak flows, but that would make the systems extremely expensive and also demand that the water sources have capacities sufficient to meet peak flows. It is much more economical to design large parts of the systems (normally the transmission system) for average flows over 24 hours, and then introduce storage tanks to accummulate the flow at night and to deliver the extra quantities needed in the day time, when consumption is high (the statement is only correct for gravity systems).

The storage provided shall be sufficient to supply the quantities consumed in excess of the average flow, but no storage is needed for losses as they occur on a continuous basis. Water wastage is mainly during the night, so no storage is needed for the allowance for waste.

In order to compare storage demands for different villages of this study, it is necessary to base the calculations on actual consumption exclusive of losses and waste, as the proportions of losses and waste differ from one village to another. The storage demands calculated on this basis are termed "net-storage demands".

15.2 Storage Demands to Balance Hourly Variations

Calculation of storage demands has been carried out from the dry season data only, and is based on hourly flows less losses and waste.

Storage demands for each day of metering is shown in Appendix XI and a summary of maximum demands is given in Table 15.1.

Village	Actual maximum net storage demand	Max. storage demand in % of max. day consumption	Day of maximum storage demand
Kasumulu	17.8 m^3	37%	Friday
Mlangali	15.5 m^3	41%	Saturday
Kiponzelo	19.3 m^3	40%	Saturday
Mbalamaziwa	11.7 m^3	41%	Saturday
Mpitimbi "B"	14.7 m^3	37%	Thursday
Amani	16.4 m^3	31%	Friday
Average	15.9 m^3	38%	-

Table 15.1 - Maximum net storage demands

It can be seen from the table that the maximum net storage demands in percent of maximum day consumptions are of the same order of magnitude with the exception of the storage demand of Amani, which is quite low. The reason for the low storage demand is that people in Amani village were collecting large amounts of water up to 10 p.m., whereas other villages used very small quantities after 9 p.m. Further analysis have shown that the single most important factor on storage demand is the number of hours with consumption, and that fluctuations in consumption within those hours (peak flows) have no significant effect.

The timing of peak flows (in morning, midday or evening) and the relative size of peak factors have no significant effect either.

A quick (but still quite accurate) way of calculating storage demands is therefore to multiply average inflow to the tank with number of hours with practically no water use (normally 9½ to 10 hours during the night), which results in a net storage demand of some 40%.

The highest storage demands normally occur on days with maximum (or near maximum) consumption, so there is no tendency to lower storage demand with increasing consumption. Similarly, there is no tendency to lower storage demand with increasing population.

Changes in storage demand in future are therefore unlikely, unless large numbers of house connections are introduced.

The findings on storage demand are summarised in the following statements, and it is also written for how many of the six villages in the study the statements are correct.

- Demand for storage decreases with increasing nos. of consumption hours (correct for 5 villages);

- Timing of peak flows and size of peak factors have no significant effect on storage demand (correct for all villages);

- Storage demands are highest on days with maximum (or near maximum) consumption (correct for all villages);

- Future changes to storage demands are unlikely unless service levels change (e.g. house connections);

- Storage demands (in percent of consumption) are independant of per capita consumption and village populations.

In respect of storage demand Amani village is quite different from the other villages, due to the prolonged hours of consumption. It would therefore be reasonable to base recommendations for design criteria on the other 5 villages only.

With reference to Table 15.1 and the statements above, it is recommended that the net storage demand to balance hourly variations, is set at 40% of the net design consumption.

15.3 Storage Demands to Balance Variations in Daily Consumption

It was argued in Chapter 15.1 above that a more economical design is achieved by introducing storage to balance variations in flow than to design the whole system for maximum flows.

In Chapter 8, the variations in daily consumption were analysed and it was concluded that allowances need to be made in the design for such variations. If it is possible within practical limits to provide storage to balance these daily variations, the allowance needs only to be made in the distribution system, which will result in a more economical overall system (see Chapter 16).

Tabel 15.2 shows the net storage demands for the weeks of metering during the dry season.

It can be seen that the storage demands are high when days with above average consumption are following each other (see also Table 8.2). The maximum day factor (see Table 8.4) has only limited effect on the storage demand.

Village	Max. Net consumption m^3	Net storage demand		Nos. of consecutive days with consumption above average
		Actual m^3	Percent of max. net con.	
Kasumulu	48.5	11.6	24%	3
Mlangali	37.5	4.7	13%	3
Kiponzelo	48.7	5.5	11%	1
Mbalamaziwa	28.2	2.6	9%	1
Mpitimbi "B"	40.2	7.0	17%	3
Amani	52.1	11.2	21%	3
Average	42.5	7.1	17%	2.3

Table 15.2 - Net storage demands to balance daily variations

It can be seen that 4 out of the six villages had 3 consecutive days with consumption above average, so it is considered necessary to provide sufficient storage to cope with such situations. Furthermore, only one week was investigated per village, so the results should be used with caution. It is consequently recommended that the allowance for storage to balance daily variations is set at not less than some 25%.

15.4 Storage for Seasonal Variations

The storage demand found for balancing daily variations is certainly within practical limits, so it could be worth investigating whether it would be advantageous to provide storage for balancing seasonal variations. The data collected during the study is, however, insufficient for a correct analysis (see Chapter 6), but the viability of the suggestion could be tested based on assumptions.

Assuming that the results of the two weeks of metering (rainy season and dry season) are representative of the two seasons, it is found that the dry season consumption is some 19% above annual average consumption (see Table 6.1). Furthermore, it appears reasonable to assume that there would be 3 consecutive months with above average consumption (September to November), resulting in seasonal storage demand equal to 19% of 90 days of average consumption.

This amounts to a seasonal net storage demand of some 1,400 m^3 for an average village (future population 3,500). Such large storage tanks cannot be built with the technology presently in use by the project, and would not be economically feasible either (even when constructed in phases), therefore, storage for seasonal variations should not be provided.

15.5 Recommendations for Storage

The total storage to be provided comprises allowance for hourly variations and daily variations within a week. It was concluded in Chapter 15.2 that Amani village is an exceptional case in respect of storage, and in Chapter 15.3 that storage for daily variations shall be able to balance 3 consecutive days with high consumption. Consequently, Table 15.3 is limited to show the combined storage requirements for the villages with "normal" storage demands (ref. Tables 15.1 and 15.2).

Village	Storage for hourly variations	Storage for daily variations	Total net storage demand
Kasumulu	37%	24%	61%
Mlangali	41%	13%	54%
Mpitimbi "B"	37%	17%	54%
Average	38%	18%	56%
Maximum	41%	24%	65%

Table 15.3 - Total net storage demand

The amount of data for calculation of storage for daily variations is quite small, so it is recommended that the maximum net storage demand of some 65% should be used.

The percentage used for design purposes is applied to total water demand inclusive of losses and waste. This means that the percentage used for design will be less than the percentage found for net storage demand. The corresponding design percentage will be approximately 57%, so it is recommended to design for a storage capacity of say 60% of the design (future) water consumption. This means that an average village (future population 3,500) will require a tank with a capacity of 75 m^3.

For comparison the present design criteria specifies 50% storage.

The incremental cost of the extra storage recommended is marginal (see Chapter 16), and storage has the further advantage of improving the water quality.

16. COST IMPLICATIONS

16.1 General

In the Water Master Plan Volume 5.A Chapter 6, the cost basis (1980/81 price level) is given and sensitivity of cost analysis based on changes of various parameters.

Rather than using this 6-7 years old sensitivity analysis, it was decided to make up-to-date analyses of the cost implications resulting from the revisions of design criteria proposed from findings of this study.

The analyses are based on current price level (late 1987) and actual cost of some village water supplies considered typical (piped schemes only).

Details of the present cost basis is given in Appendix XII.

16.2 Phasing of Construction

Earlier analyses have shown that phasing of construction was uneconomical apart from parts of the distribution system, where DPs are constructed for the 10-year population only. However, taking into consideration the considerable increase in per capita demand proposed in this report, it should be investigated whether or not phasing of construction will be feasible.

By using the "present worth method" (future cost discounted to present cost level), it is found that phasing of construction of storage tanks will only be feasible if the real interest rate (interest less inflation) exceeds 8% per year, which is unlikely, so phasing of storage tanks is not recommended.

When pipe sizes increase, the costs related to flow capacities decrease. Phasing of pipes (adding another pipe after say 10 years) is therefore more feasible for large schemes than for small schemes, and similarly phasing is more feasible in the upper (large capacity) parts of a scheme than in the lower parts (only gravity supplies are analysed).

The first phase needs to have a capacity of some 70 to 75% of the total design capacity to be able to meet demands in 10 years from construction. Furthermore, the cost of laying for instance a 75 mm pipe is practically the same as for a 110 mm pipe, so the initial capital cost is not reduced much by introducing phasing.

By use of "the present worth method" the break even real interest rates have been found for different scheme sizes (design populations) for phasing of upper part of transmission system. These interest rates are shown in Figure 16.1 as a function of the design population. It can be seen that even for schemes with design population of 60,000 (some 15 to 20 villages) the real interest rate needs to be above 8% to make phasing economical. Such a high rate is unlikely, so phasing of pipes is not feasible either.

16.3 Increase of Construction Cost

Detailed cost basis for the findings in this chapter is given in Appendix XII.

It is found that the cost of transmission systems will increase with some 23% due to the proposed increase of per capita demand from 25 l/d to 36 l/d. The increase of cost for distribution systems are not so big, due to the proposed reduction of the peak factor from 3.0 to 2.5 and also due to the design flow to single DPs remaining the same as before. The resulting cost increase is found to be some 9% for the distribution system and the overall increase of pipe cost (both transmission and distribution) amounts to some 15%.

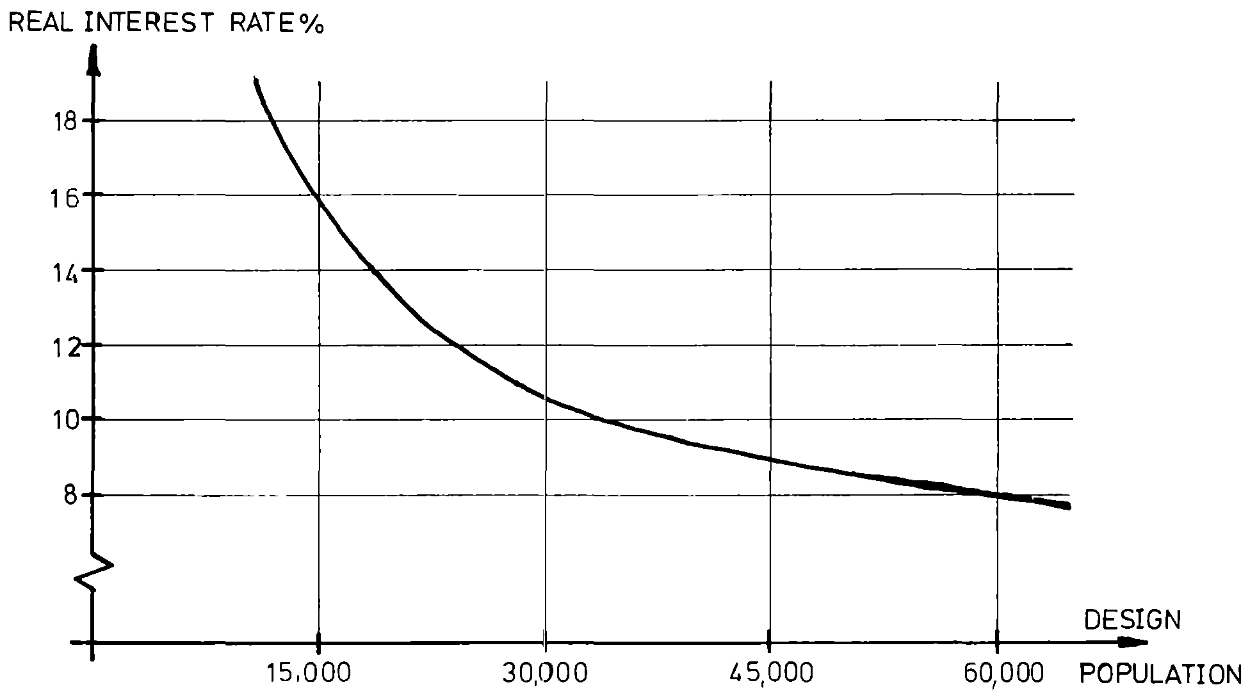


Figure 16.1 - Break even real interest rates for phasing of construction

From analyses of constructed schemes it is found that cost of pipes (materials and freight) amounts to about 60% of total scheme cost.

The proposed increase of storage capacity, both due to increased per capita demand and storage to balance daily variations in consumption, results in a cost increase of 42%, however, cost of storage is only some 3% of total cost, so overall cost increase from storage is marginal.

No increase is anticipated in cost of mobilisation, labour, transport on site and other local cost, but interregional transport will increase with approximately the same rate as cost of pipes.

The estimated cost increases are summarised in Table 16.2.

Cost component	Percent of overall cost	Cost increase	Overall cost increase
Pipes	60%	15%	9.0%
Storage	3%	42%	1.3%
Interregional transport	4%	15%	0.6%
Total	-	-	10.9%

Table 16.2 - Cost increases

The total effect of the recommendations of this study on construction cost is an increase of some 11%. This complies very well with findings of WMP, which indicates some 12 to 13% increase (WMP Vol.5A, Figure 6.15), without considering the reduced peak factor. Taking the peak factor into account (WMP Vol.5A, Figure 6.16), brings the cost increases down to 11 to 12%, which is the same as found in this study.

The cost analyses in Appendix XII show that average per capita cost is some DKK 315/- for gravity schemes (price level late 1987). As a consequence of the recommendations of this report the average per capita cost will increase to some DKK 350/- (US $ 54) for gravity schemes.

APPENDIX I

PARTICIPANTS
IN STUDY

APPENDIX 1

PARTICIPANTS IN STUDY

The following staff from Regional Water Engineers' Offices and DANIDA Implementation Offices participated in the field work and computation of data.

Activity/Name	Rainy season		Dry season		
	Iringa	Mbeya	Mbeya	Iringa	Ruvuma
Supervision of meter readers, reading of master meter and data computation					
George B Kazimoto	x	x	x	x	x
Kitolo Kisuda	x	x	x	x	x
Kalokola Johansen	x	x	x	x	x
Elias T Kajurunga	x	x			
Kissa Buja			x	x	
Michael D Nkuki				x	
Ernest Mboua			x		
Daniel Mwaipopo			x		
Contancia Timothy					x
John D Malunda					x
Meetings with villagers and household interviews					
Vicky Myavilwa	x				
Anita Charles	x				
Alfeya Mwaveya			x		
Benedict Mwakalebela			x		
Zubby Mkwandah					x
Maurus Haule					x

APPENDIX II

DEFINITIONS & ABBREVIATIONS

DEFINITIONS

Water supply system :

- Single scheme: Water supply covering one village only.
- Group scheme: Water supply covering two villages or more.
- Gravity supply: Water is flowing by gravitation only, i.e. no pumps involved.
- Transmission system: The water intake and pipelines leading to village storage tanks.
- Distribution system: The village storage tank, pipelines leading to DP's, DP's and other installation in the village.

Traditional sources :

- In this report any point of water collection not supplied from the water supply system.

Water demand :

- The amount of water demanded to fulfil the requirements of the consumers including losses and waste.
- Future water demand is the estimated amount of water required to fulfil the demand in year 2006 (also called "Design capacity")

Water consumption :

- In this report the amount of water, which has been tapped from the village storage tank.
- Average consumption: Average of consumption during the respective metering period (7 days), i.e. it is <u>not</u> annual average.

		. Maximum day consumption: The day with the highest consumption figure during the respective metering period (7 days), i.e. it is not annual maximum.
		. Net water consumption if from water supply only: The estimated amount of water which would be used if no alternative (traditional) sources were available.
Losses	:	. The water lost through leakages in pipes and fittings.
Waste	:	. The water passing through leaking or left open taps and which is not being used for any purpose.
Seasonal variations	:	. The variations in water consumption occuring over the year.
Daily variations	:	. In this report the variations in daily consumption within the respective metering period.
Maximum day factor	:	. Maximum day consumption divided by average day consumption.
Hourly variations	:	. The variations in flow per hour within a day.
Peak flow	:	. The maximum flow of water within a certain period.
Peak factor	:	. The peak flow divided by the corresponding average flow.
		. Net peak factor is the factor based on consumption without losses and waste.

. Design peak factor is the factor based on the water demand.

Storage demand : . The requirement to storage for balancing daily and hourly variations, normally expressed as a percentage of water demand.

. Net storage demand: The storage required based on consumption without losses and waste.

. Design storage demand is a percentage of the water demand.

Spearman's Rho : . A figure expressing how strong a tendency of correlation is.

If the figure is "0" there is no correlation. If it is near to "+1" or "-1" there is a strong correlation.

The fewer numbers "n" in a sample the nearer, the Rho should be to "± 1" to support strong correlation. It can be tentatively concluded that for the sample sizes of this report Rho should be numerically bigger than indicated below to support strong correlation:

n = 5, Rho > 0.700
n = 6, Rho > 0.600

ABBREVIATIONS

Balozi	:	Swahili term for "ten cell leader" in the villages (actually no abbreviation)
DANIDA	:	Danish International Development Agency
DKK	:	Danish kroner
DP	:	Domestic (water) Point: (Public stand post)
l/c/d	:	Litres per capita per day
l/min.	:	Litres per minute
m^3/h	:	Cubic metre per hour
MAJI	:	Ministry of Water
RWE	:	Regional Water Engineer
TZS	:	Tanzania Shillings
WMP	:	Water Master Plans for Iringa, Ruvuma and Mbeya Regions
W/S	:	Water Supply

APPENDIX III

DATA ON METERS USED

ZENNER ZÄHLER

Turbine water meter

Multi-jet wet dial

Type **MNK**

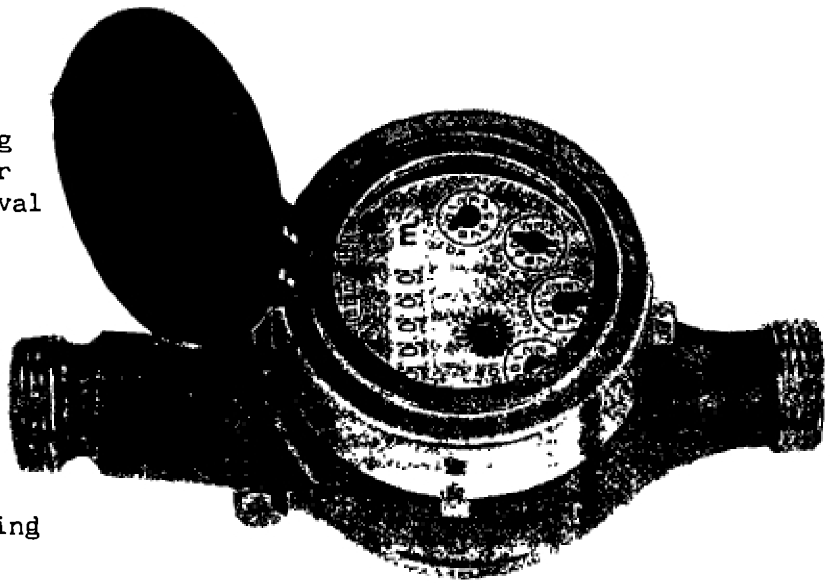
For cold water up to 30°C PN 16

Usage

- Individual registration of water consumption
- For horizontal mounting

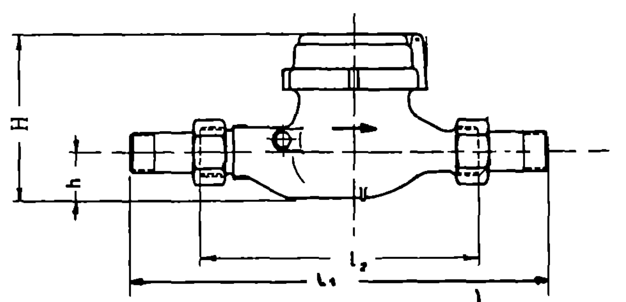
Characteristics

- Low friction as all moving parts are working in water
- Approved by PTB (EC approval metrologic classes A + B Qn1,5 and Qn2,5 also in class C)

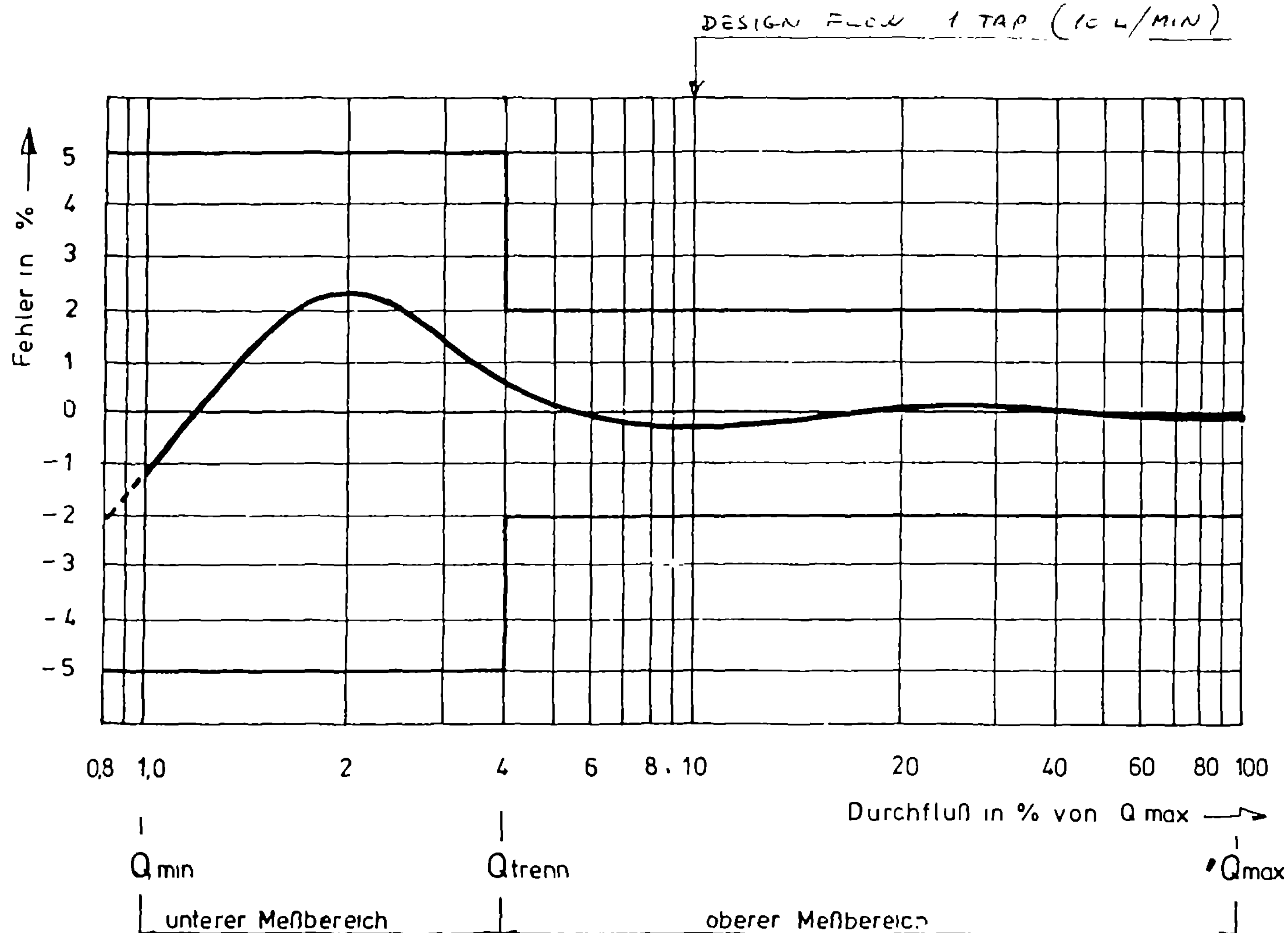


- Large measuring range
- Body measurements according DIN and ISO
- High quality, wear and tear resistant materials

Technical data



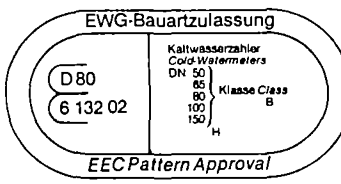
Diameter nominal DN	mm	15	20	25	30	40	flangesDN50
Max.flowrate (1bar loss of pressure) Qmax	m^3/h	4,3	6	10	12	20	30
Nominal flowrate Qn	m^3/h	1,5	2,5	5	6	10	15
Dial up to		100.000					
Length without connection screws	mm	170/165	190	260	260	300	300
Lenght with connection screws	mm	250/245	288	380	380	440	flanges
Height total with closed lid (L)	mm	120	120	130	130	145	200
Height to the pipe	mm	33	33	39	39	50	83
Net weight without connection screws	kg	1,35	1,5	2,4	2,4	3,7	flanges
Net weight with connection screws	kg	1,5	2,0	3,1	3,1	5	9



Typische Fehlerkurve (Klasse B)

SCAN – VALVE A/S
Telf. (06) 34 24 44

MEINECKE



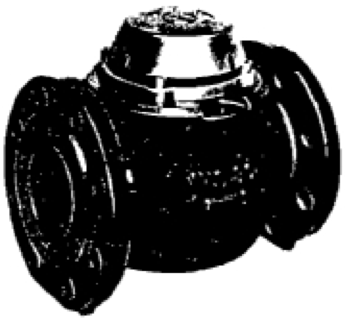
QN	DN
15	50
25	65
40	80
60	100
150	150

Meinecke-Cosmos Woltmann vandmålere
Type WS Super Tør

En ægte tørløber, dvs overførings- og rulletælleværk er anbragt i det beskyttede tælleværksrum. Kun vingehjulet bevæger sig i vand. Vingehjulets drejebevægelser overføres umiddelbart til tælleværksrummet via en magnetkobling

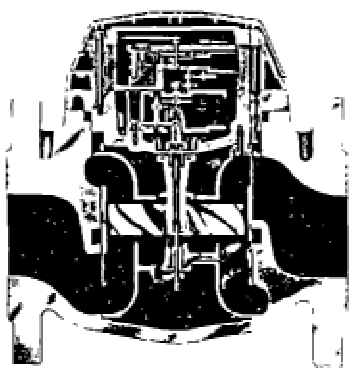
Udtagelig målerindsats, udvendig regulering fra oven, forberedt for optisk scanning af vingehjulets omdrejninger.

Stikprop til elektronisk fjernoverføring af måleresultaterne kan indføres i måleren uden beskadigelse af den centrale plombe og plomberes separat. Stikproppen afgiver - alt efter indbygningsstilling - 1 eller 10 impulser (ved varmtvandsmålere 4 eller 10) pr. midtviseromdrejning.



Tabel over ydelser

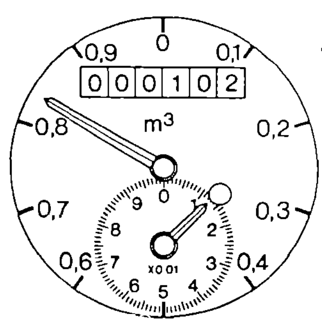
DN : nominel målerstørrelse
Qmax : maximal gennemstrømning (få minutter)
Qn : nominel gennemstrømning (vedvarende)
Qt : gennemstrømningstærskel ±2%
Qmin : minimal gennemstrømning ±5% (nedre måleområdegrænse)



Type WS

For temperaturer indtil 40°C

DN mm	Qmax m³/h	Qn m³/h	Qt m³/h	Qmin m³/h	Start m³/h	SCS nr.
50	35	20	1,5	0,18	0,08	R487130.172
~~65~~	~~70~~	~~40~~	~~3~~	~~0,25~~	~~0,15~~	~~R487130.173~~
~~80~~	~~110~~	~~55~~	~~3~~	~~0,25~~	~~0,15~~	~~R487130.174~~
~~100~~	~~180~~	~~90~~	~~4~~	~~0,35~~	~~0,18~~	~~R487130.176~~
~~150~~	~~350~~	~~300~~	~~5~~	~~0,80~~	~~0,50~~	~~R487130.178~~



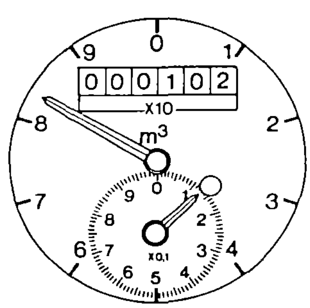
DN 50 100

Type WS

For temperaturer indtil 130°C [1])

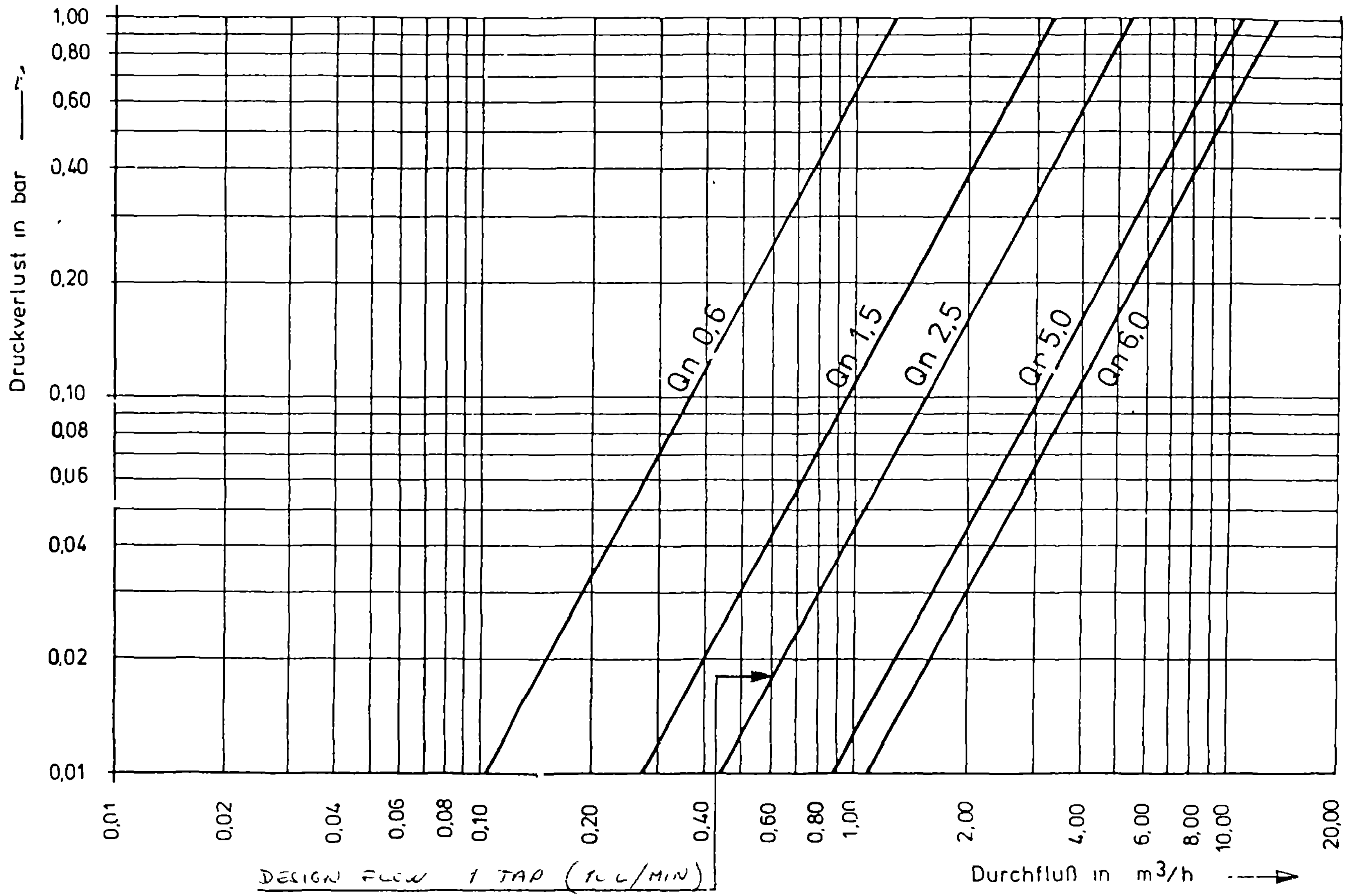
DN mm	Qmax m³/h	Qn m³/h	Qt m³/h	Qmin m³/h	Start m³/h	SCS nr.
50	30	15	1,5	0,3	0,15	R487174.172
65	60	25	3	0,5	0,25	R487174.173
80	85	40	3	0,5	0,25	R487174.174
100	125	60	4	0,6	0,40	R487174.176
150	300	150	12	1,0	0,50	R487174.178

[1]) For målere for temperaturer indtil 90°C gælder der samme værdier



DN 150

Målerne opfylder de i tabellen angivne værdier Det er fabriksangivelser, som er baseret på fabrikkens egne undersøgelser og erfaringer Ved koldtvandsmålere garanteres overholdelse af de lovmæssige forskrifter ved EWG-tilladelsen og justeringen.



Druckverlustkurve

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Telf. (06) 34 24 44

MEINECKE

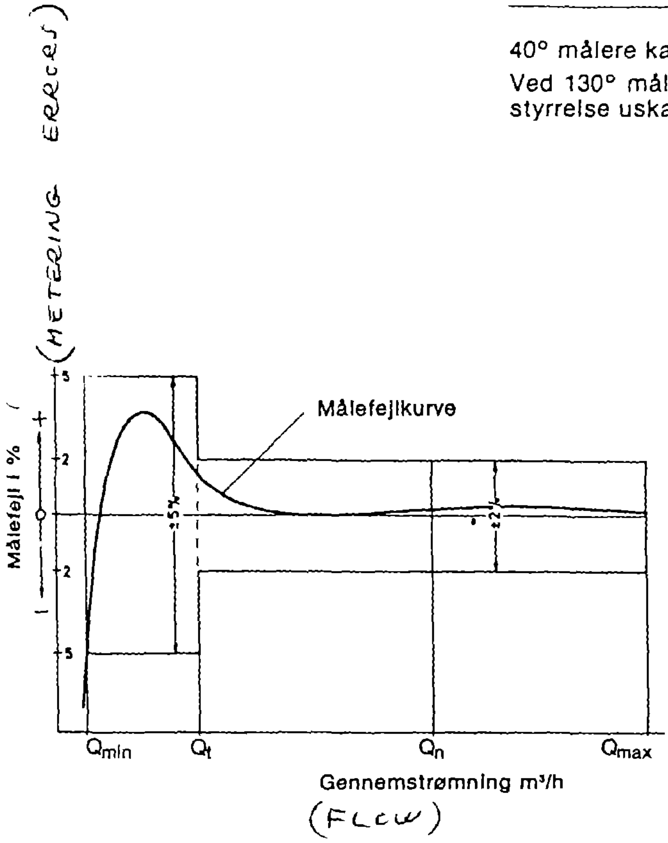
Type WS

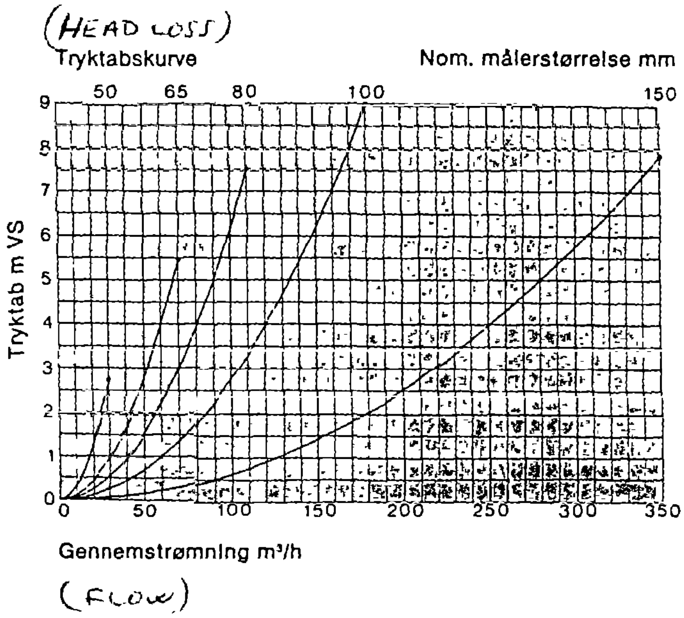
Udførelser

DN	50	65	80	100	150
Temperatur til .... °C			40 90 130		
Nominelt tryk .... bar	16 40	16	16 40	16 40	16

40° målere kan overbelastes indtil 50°C.

Ved 130° målerne er en kortvarig overtemperatur til 150°C ved driftsforstyrrelse uskadelig.





APPENDIX IV

FORMS USED
DURING STUDY

KIJIJI . . . . TAREHE . . . .

KITUO . . . . MSOMAJI . . . .

METER NO. . . . . UKARASA 1.

SAA YA KISWAHILI	SAA YA KIZUNGU	METER	READING	CONSUMPTION
12.00 (ASUBUHI)	6.00			
1.00	7.00			
2.00	8.00			
3.00	9.00			
4.00	10.00			
5.00	11.00			
6.00	12.00			
7.00	13.00			

VILLAGE . . . . DATE OF READINGS . . . .

DP . . . . METER NO. . . . .

I. CONSUMPTION IN M^3 (INCL. WASTAGE)

READING AT 21:00	☐	☐		(1)
READING AT 06:00	☐		☐	(2)
READING AT 21:00 THE DAY BEFORE		☐	☐	(3)
DAY USAGE (1) − (2)	☐			(4)
NIGHT USAGE (2) − (3)			☐	(5)
TOTAL DAILY CONSUMPTION (1) − (3)		☐		(6)
NOS. OF HOUSEHOLDS USING DP (ESTIMATE)			☐	(7)
CONSUMPTION PER HOUSEHOLD	$\frac{☐}{☐}$	$\frac{(6)}{(7)}$ =	☐	(8)
NOS. OF CAPITA USING DP (ESTIMATE)			☐	(9)
CONSUMPTION PER CAPITA	$\frac{☐}{☐}$	$\frac{(6)}{(9)}$ =	☐	(10)

II. FLOWS IN M^3/HOUR

DAY FLOW PER HOUR (4)	☐	$\times \frac{1}{15}$ =	☐	(11)
NIGHT FLOW PER HOUR (5)	☐	$\times \frac{1}{9}$ =	☐	(12)
AVERAGE FLOW PER HOUR (6)	☐	$\times \frac{1}{24}$ =	☐	(13)
PEAK HOUR FLOW BETWEEN AND			☐	(14)
PEAK HOUR FACTOR	$\frac{(14)\ ☐}{(13)\ ☐}$	=	☐	(15)
MAX. PEAK FLOW MEASURED AT DP OVER 5 MIN.			☐	(16)
MAX. PEAK FACTOR	$\frac{(16)\ ☐}{(13)\ ☐}$	$\times 12$ =	☐	(17)

COMPUTATIONS BY . . . . DATE . . . .

VILLAGE .... DATE OF READINGS ......

PLACE .... MASTER METER NO. ......

I. TOTAL DAILY CONSUMPTION IN M^3 (INCL. LOSSES)

READING AT 21:00				1
READING AT 06:00				2
READING AT 21.00 THE DAY BEFORE				3
DAY USAGE	1 − 2			4
NIGHT USAGE	2 − 3			5
TOTAL DAILY CONSUMPTION	1 − 3			6
NOS. OF HOUSEHOLDS USING WATER SUPPLY				7
AVERAGE CONSUMPTION PER HOUSEHOLD	$\frac{6}{7}$		=	8
TOTAL POPULATION USING WATER SUPPLY				9
AVERAGE CONSUMPTION PER CAPITA	$\frac{6}{9}$		=	10

II. PEAK FACTOR

PEAK QUARTER FLOW BETWEEN AND				11
AVERAGE FLOW PER QUARTER	6	$\times \frac{1}{96}$	=	12
PEAK FACTOR	$\frac{11}{12}$		=	13

III. WATER LOSSES (LEAKAGE)

READING AT 03:00				14
READING AT 24:00				15
LOSS (LEAKAGE) DURING 3 HOURS AT NIGHT	14 − 15			16
TOTAL LOSS IN PERCENT OF TOTAL DAILY CONSUMPTION	$\frac{16}{6}$	× 800	=	%

COMPUTATIONS BY .... DATE ......

VILLAGE .... DATE ....

PLACE .... READER ....

MASTER METER NO. .... PAGE 1

TIME	READING / CONSUMPTION	TIME	READING / CONSUMPTION
06.00		09.45	
06.15		10.00	
06.30		10,15	
06.45		10.30	
07.00		10.45	
07.15		11.00	
07.30		11.15	
07.45		11.30	
08.00		11.45	
08.15		12.00	
08.30		12.15	
08.45		12.30	
09.00		12.45	
09.15		13 00	
09.30		13.15	

INSTRUCTION TO USERS OF HOUSEHOLD QUESTIONAIRE

1. Prepare check list with names of VWC members and Scheme Attendants

2. Prepare questionaire for each DP by filling in name of village and name of DP.

3. First question to the one interviewed is:

   "Which DP do you use normally?"

   (ya kawaida, unatumia kituo gani cha maji?)

   Select the questionaire for that DP.

4. Fill in name of head of household or other identification of the household.

5. Question (A). The information required is the number of people who resides in the household at present (i.e the ones sleeping there) and shall not include anybody who belongs to the household, but is out of the village these days.

6. Question (B), (See remarks under 5.)

7. Question (C). The answer to record is only "Yes or No" irrespective of number of livestock or size of garden.

8. Question (D), The water used from elsewhere can be water from the roof of the house or water carried home for domestic use (but not for livestock or gardening) or water used at the source, for instance if people are bathing or washing clothes at the river. The answer to record is only "Yes or No".

9. Question (E). If people reply "Yes" then ask for either the name of the scheme attendant or where he/she lives to confirm that the one interviewed has replied correctly. If no name or place of living can be given the answer is "No".

10. Question (F). Same procedure as under 9 above.

11. Question (G). Typical answers could be:

Answer	Record in questionaire
- Village chairman (Mwenyekiti)	VC
- Village Secretary (Katibu)	K
- Ten Cell Leader (Balozi)	B
- Scheme attendant (mhudumu wa mradi)	M
- Tap attendant (Mwangalizi wa kituo)	MK
- VWC Member (Kamati ya Maji)	VWC

12. Question (H). Record "Yes or No"

HE/1987.03.04

HOUSEHOLD QUESTIONAIRE: TRANSLATION TO ENGLISH

Village: ....

Name of DP ....

Page No.

Household	Name of head of household or other identification

Question A :	How many adults (over 15 years of age) stay here at present?
Question B :	How many children (below 15 years of age)stay here at present?
Question C :	Do you use water from the DP for watering garden and/or livestock?
Question D :	Do you normally use water from elsewhere for laundry or bathing?
Question E :	Do you know the Scheme Attendant?
Question F :	Do you know a member of the Village Water Committee?
Question G :	Who do you go to if there is something wrong with the DP?
Question H :	Have you ever reported about the DP not functioning?

HE/1987.03.04

Kijiji ....

Jina la Kituo ....

Ukurasa ....

Kaya Na.	Jina la Mkuu wa Kaya au utambulisho mwingine	A Kuna watu wangapi (zaidi ya miaka 15) wanaoishi hapa kwa sasa hivi?	B Kuna watoto wangapi chini ya miaka 15 wanaoishi hapa kwa sasa hivi?	C Je mnatumia maji kutoka kwenye kituo kwa kumwagilia bustani au kunywesha mifugo?	D Je mnatumia maji kutoka sehemu nyingine yoyote kwa kuoga au kufua?	E Je unamfahamu Mhudumu wa Mradi?	F Je unamfahamu Mjumbe wa kamati ya Maji?	G Je unakwenda kwa nani kama kuna ubovu kwenye kituo?	H Je umewahi kutoa taarifa kuhusu kituo kama hakifanyi kazi?
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO
				YES/NO	YES/NO	YES/NO	YES/NO		YES/NO

APPENDIX V

HOUSEHOLD
INTERVIEWS

DP No.	For domestic purposes only	Domestic plus garden and livestock	Supplementing from traditional sources	Total
1	66	0	52	118
2	76	16	6	98
3	101	0	0	101
4	61	0	22	83
5	103	0	0	103
6	128	0	0	128
7	113	0	114	227
8	72	14	0	86
9	100	21	0	121
10	34	72	0	106
11	102	0	61	163
12	70	21	131	222
13	107	27	0	134
14	27	12	0	39
Total	1,160	183	386	1,729

Kasumulu village - Household interviews
Nos. of consumers per DP

DP No.	For domestic purposes only	Domestic plus garden and livestock	Supplementing from traditional sources	Total
11	157	0	10	167
12	132	0	49	181
13	164	0	0	164
14	62	11	46	119
15	41	0	28	
16	Not functioning at time of census			153
17	76	0	8	
18	87	0	26	113
19	87	5	2	94
20	108	0	5	113
21	71	0	11	82
Total	985	16	185	1,186

Mlangali village - Household interviews
Nos. of consumers per DP

DP No.	For domestic purposes only	Domestic plus garden and livestock	Supplementing from traditional sources	Total
1	134	(17) both	17	151
2	72	21	0	93
3	137	12	0	149
4	152	0	56	208
5	199	6	45	250
6	117	0	0	117
7	86	0	0	86
8	86	(12) both	12	98
9	145	(5) both	18	163
10	31	6 +(5) both	27	64
11	363	15 +(8) both	8	386
12	137	0	3	140
13	254	5	2	261
14	66	(5) both	5	71
Total	1,979	65 +(52)	193	2,237

Kiponzelo village - Household interviews
Nos. of consumers per DP

DP No.	For domestic purposes only	Domestic plus garden and livestock	Supplementing from traditional sources	Total
1	160	0	0	160
2	176	0	8	184
3	201	0	0	201
4	106	0	0	106
5	285	0	0	285
6	66	0	0	66
7	48	0	3	51
8	93	0	0	93
10	11	0	0	11
11	23	0	0	23
Total	1,169	0	11	1,180

Note: No DP no. 9

Mbalamaziwa village - Household interviews
Nos. of consumers per DP

DP No.	For domestic purposes only	Domestic plus garden and livestock	Supplementing from traditional sources	Total
1	45	0	0	45
2	78	0	0	78
3	98	0	0	98
4	139	0	0	139
5	138	0	0	138
6	60	0	0	60
7	41	0	0	41
8	88	0	0	88
10	88	0	0	88
11	81	0	0	81
12	119	0	26	145
13	73	0	83	156
14	157	0	65	222
15	50	0	54	104
16	49	0	0	49
Total	1,304	0	228	1,532

Please note that there is no DP No. 9

Mpitimbi village - Household interviews

Nos. of consumers per DP

DP No.	For domestic purposes only	Domestic plus garden and livestock	Supplementing from traditional sources	Total
1	217	0	23	240
2	0	0	90	90
3	48	0	539	587
4	218	0	95	313
5	270	9 both	66	336
6	60	0	10	70
7	0	0	269	269
8	108	0	81	189
9	15	0	84	99
10	81	0	76	157
Total	1,017	(9)	1,333	2,350

Amani village - Household interviews
Nos. of consumers per DP

APPENDIX VI

WATER CONSUMPTIONS AT DP'S

DP No.	Wed.25/3	Thu.26/3	Fri.27/3	Sat.28/3	Sun.29/3	Mon.30/3	Tue.31/3	Total
1	859	593	610	610	598	864	<u>991</u>	5,125
2	1,527	1,433	1,875	1,677	1,847	<u>1,913</u>	1,691	11,963
3	686	1,148	975	<u>1,217</u>	895	624	802	6,347
4	1,441	1,327	1,131	<u>1,496</u>	1,258	1,152	1,252	9,057
5	<u>1,265</u>	958	934	955	<u>1,208</u>	1,181	1,045	7,546
6	1,353	1,342	1,196	2,237	<u>3,037</u>	1,844	2,896	13,905
7	2,537	3,006	2,818	3,029	2,900	3,057	<u>3,538</u>	20,885
8	2,497	1,817	1,327	1,908	<u>3,135</u>	2,200	2,758	15,642
9	2,805	2,781	3,292	2,325	<u>3,405</u>	2,941	2,999	20,548
10	<u>2,687</u>	1,576	1,692	2,098	2,239	2,627	2,459	15,378
11	1,832	1,995	1,936	2,023	2,072	<u>2,535</u>	2,191	14,584
12	1,773	<u>2,990</u>	1,449	2,271	2,343	2,764	2,422	16,012
13	1,936	2,468	2,097	1,822	<u>2,636</u>	2,581	2,244	15,784
14	2,242	2,240	2,136	2,277	2,290	2,001	2,474	15,660
Total	25,440	25,674	23,468	25,945	<u>29,863</u>	28,284	29,762	188,436

Note: Maximum days are underlined

Kasumulu village - Water consumption, rainy season (in litres per day)

DP No.	Wed.9/9	Thu.10/9	Fri.11/9	Sat.12/9	Sun.13/9	Mon.14/9	Tue.15/9	Total
1	1,244	1,316	1,569	1,330	1,126	1,837	1,761	10,183
2	1,385	2,271	1,717	2,195	2,322	1,623	2,481	13,994
3	1,085	1,351	2,829	1,200	1,429	2,375	1,900	12,169
4	1,688	2,300	1,613	1,183	1,584	1,247	1,323	10,938
5	1,517	2,554	2,554	2,005	1,568	2,789	1,647	14,634
6	3,058	3,282	2,867	3,285	2,179	3,027	3,826	21,524
7	4,030	5,051	4,814	2,574	2,772	3,333	2,334	24,908
8	2,088	2,395	2,125	2,054	1,809	2,538	1,919	14,928
9	6,481	5,315	6,574	6,173	3,355	3,519	3,657	35,074
10	5,016	5,588	5,700*	5,678	4,034	6,995	5,992	39,003
11	3,248	3,667	3,225	2,305	2,508	2,664	3,385	21,002
12	1,947	2,339	2,654	2,656	2,741	3,260	2,327	17,924
13	2,857	3,664	4,448	3,316	3,250	3,520	3,769	24,824
14	8,057	8,779	5,727	5,155	3,744	7,816	8,751*	48,029
Total	43,701	49,872	48,416	41,109	34,421	46,543	45,072	309,134

Note: Maximum days are underlined

* After deduction of waste from others

Kasumulu village - Water consumption, dry season (in litres per day)

DP No.	Tue.24/3	Wed.25/3	Thu.26/3	Fri.27/3	Sat.28/3	Sun.29/3	Mon.30/3	Total
11	1,495	1,522	1,537	2,560	3,694	2,936	2,355	16,099
12	1,473	2,648	2,498	1,924	2,250	2,318	1,755	14,866
13	2,063	2,201	2,999	2,571	4,532	2,795	3,815	20,976
14	2,369	4,320	3,859*	2,639	2,947	6,425	2,446	25,005
15	1,769	1,638	1,818	3,632	3,653	1,460	1,421	15,391
16	1,435	1,156	1,338	1,158	2,245	1,463	905	9,700
17	2,163	2,828	5,059	4,480*	3,184	2,083	2,102	21,899
18	5,007	4,364	3,600	3,458	3,283	4,954	3,616	28,282
19	1,429	2,798	2,216	2,901	2,754*	4,265	2,056	18,419
20	2,225	1,635	5,968	2,024	2,870	3,058*	2,269	20,049
21	1,129	1,278	1,359	661	1,968	1,205	9,582	17,182
Total	22,557	26,388	32,251	28,008	33,380	32,962	32,322	207,868

Note: Maximum days are underlined

* After deduction of waste from others

Mlangali village - Water consumption, rainy season (in litres per day)

DP No.	Wed.9/9	Thu.10/9	Fri.11/9	Sat.12/9	Sun.13/9	Mon.14/9	Tue.15/9	Total
11	5,257	6,707	7,587	6,562	5,338	5,738	5,835	43,024
12	3,261	2,877	3,402	3,288	3,442	2,383	2,852	21,505
13	3,943	4,238	2,898	3,464	3,423	2,945	4,015	24,926
14	5,591	3,936	4,475	4,586	3,558	5,645	3,684	31,475
15	2,679	2,957	2,824	2,410	8,211	1,889	2,417	23,387
16	1,615	1,486	1,586	2,399	2,428	3,161	2,077	14,752
17	1,525	1,783	3,899	3,525	3,630	2,034	3,312	19,708
18	1,771	1,252	2,666	2,998	2,963	2,705	4,175	18,530
19	4,985	5,068	6,583	6,447*	3,857	3,398	4,228	34,566
20	4,197*	4,663	3,753	4,281	2,596	3,688	3,592	26,770
21	665	617	620	567	633	1,087	582	4,771
Total	35,489	35,584	40,293	40,527	40,079	34,673	36,769	263,414

* After deduction of waste from others

Mlangali village - Water consumption dry season (in litres per day)

Note: Maximum days are underlined

DP No.	Wed.4/3	Thu.5/3	Fri.6/3	Sat.7/3	Sun.8/3	Mon.9/3	Tue.10/3	Total
1	2,294	2,533	1,729	2,224	2,105	1,394	2,199	14,478
2	2,057	1,766	1,593	1,977	2,075	1,659	2,069	13,196
3	2,838	2,023	2,749	3,210	4,136	2,283	3,141	20,380
4	2,815	2,326	1,435	3,615	4,475	1,796	2,197	18,659
5	2,995	2,740	2,401	2,331	3,375	2,084	2,098	18,024
6	3,618	1,252	3,431	2,811	4,206	1,015	1,310	17,643
7	2,097	2,325	2,490	1,484	2,055	1,284	2,082	13,817
8	1,468	938	1,109	1,750	3,271	722	1,669	10,927
9	2,639	1,731	2,173	1,067*	783*	2,635	1,362	12,390
10	1,044	730	704	1,225	2,008	352	339	6,402
11	3,366	1,898	2,240	1,369*	1,573*	1,870	2,716	15,032
12	2,066	1,316	1,294	1,677	1,677	968	1,603	10,601
13	2,423	1,960	1,818	1,405*	1,458*	1,789	1,908	12,761
14	1,229	975	816	899*	1,077*	1,279	902*	7,177
Total	32,949	24,513	25,982	27,044	34,274	21,130	25,595	191,487

Note: Maximum days are underlined

* Interruptions to supply

Kiponzelo village - Water consumption, rainy season (in litres per day)

DP No.	Wed.23/9	Thu.24/9	Fri.25/9	Sat.26/9	Sun.27/9	Mon.28/9	Tue.29/9	Total
1	2,742	3,803	3,245	3,145	2,658	3,171	2,548	21,312
2	1,571	1,580	1,183	1,660	1,658	1,580	1,457	10,689
3	4,316	4,378	4,410	4,332	3,877	3,999	4,319	29,631
4	4,306	4,997	3,244	4,212	3,992	4,093	4,022	28,866
5	3,478	4,045	3,717	3,713	4,920	2,528	3,172	25,573
6	2,692	4,024	2,699	2,965	3,744	2,620	1,778	20,522
7	3,541	3,121	3,977	5,693	3,998	3,538	4,826	28,694
8	1,495	1,292	1,607	3,644	3,321	2,166	3,493	17,018
9	3,820	3,202	2,536	3,333	2,039	2,021	3,464	20,415
10	1,859	1,486	1,348	1,295	1,706	1,215	1,038	9,947
11	4,419	5,068	4,756	4,779	4,489	4,629	6,258	34,398
12	2,012	2,315	3,062	2,846	2,027	2,227	2,055	16,544
13	4,342	4,218	3,220	3,777	3,203	4,101	4,307	27,168
14	1,447	2,777	1,218	3,259	884	1,099	2,637	14,321
Total	42,040	46,306	40,222	48,653	42,516	38,987	45,374	304,098

Note: Maximum days are underlined

Kiponzelo village - Water consumption, dry season (in litres per day)

DP No.	Wed.4/3	Thu.5/3	Fri.6/3	Sat.7/3	Sun.8/3	Mon.9/3	Tue.10/3	Total
1	2,832	1,964	2,604	2,644	3,075	1,279	2,080	16,478
2	5,064	4,168	6,754	7,022	7,357	3,495	4,183	38,043
3	3,751	1,886	1,879	1,865	3,387	794	2,005	15,567
4	2,483	1,988	2,335	3,126	3,347	1,105	1,694	16,078
5	3,303	3,099	4,765	4,288	3,498	2,036	3,042	24,031
6	1,504	1,225	1,536	2,254	3,253	1,978	1,598	13,348
7	3,586	708	644	1,046	1,044	1,490	1,004	9,522
8	1,620	1,570	1,470	2,446	2,355	1,184	1,604	12,249
Total	24,143	16,608	21,987	24,691	27,316	13,361	17,210	145,316

Note: Maximum days are underlined

Mbalamaziwa village - Water consumption, rainy season (in litres per day)

DP No.	Wed.23/9	Thu.24/9	Fri.25/9	Sat.26/9	Sun.27/9	Mon.28/9	Tue.29/9	Total
1	3,166	3,281	3,239	3,976	3,303	2,921	2,868	22,754
2	8,759	6,896	7,570	9,389	7,591	7,362	8,835	56,402
3	3,719	2,543	2,763	2,370	2,747	2,588	2,518	19,248
4	3,639	2,895	2,974	3,394	2,285	3,361	2,228	20,776
5	4,256	7,241	5,613	5,306	6,007	6,496	6,234	41,153
6	795	1,045	1,162	904	817	779	691	6,193
7	1,210	656	693	1,152	736	553	1,762	6,762
8	2,528	2,469	2,873	3,113	3,294	2,852	2,954	20,083
10	271	356	331	320	484	442	338	2,542
11	910	731	535	714	553	336	684	4,463
Total	29,253	28,113	27,753	30,638	27,817	27,690	29,112	200,376

Note: Maximum days are underlined
No DP no. 9

Mbalamaziwa village - Water consumption, dry season (in litres per day)

DP No.	Thu.8/10	Fri.9/10	Sat.10/10	Sun.11/10	Mon.12/10	Tue.13/10	Wed.14/10	Total
1	1,828	1,078	2,410	1,502	1,755	1,407	1,145	11,125
2	1,691	1,990	2,721	2,329	1,644	1,923	1,823	14,121
3	2,696	1,753	2,614	3,412	2,180	2,074	2,297	17,026
4	3,564	2,936	2,384	2,624	3,163	2,585	3,198	20,454
5	2,055	2,994	2,484	2,114	2,124	2,266	2,614	16,651
6	2,140	1,765	1,463	1,561	1,013	1,232	1,896	11,070
7	1,743	1,860	2,093	2,836	1,567	1,287	1,870	13,256
8	2,788	3,559	3,437	2,424	2,460	3,736	2,767	21,171
10	2,737	2,337	4,512	2,661	2,765	3,571	2,942	21,525
11	1,706	1,334	1,783	773	1,969	1,534	1,884	10,983
12	2,764	3,178	4,742	2,804	3,244	2,558	3,057	22,347
13	2,778	3,659	2,874	2,251	3,079	2,449	3,057	20,147
14	2,799	3,851	2,934	2,731	2,921	2,695	2,793	20,724
15	2,757	2,258	1,999	1,880	1,816	1,772	1,196	13,678
16	2,487	2,249	2,242	2,404	1,396	1,798	2,181	14,757
Total	36,533	36,801	40,692	34,306	33,096	32,887	34,720	249,035

Note: Maximum days are underlined
No DP no. 9

Mpitimbi "B" village - Water consumption, dry season (in litres per day)

APPENDIX VI

DP No.	Wed.21/10	Thu.22/10	Fri.23/10	Sat.24/10	Sun.25/10	Mon.26/10	Tue.27/10	Total
1	4,345	6,516	8,240	8,022	5,838	5,809	6,522	45,292
2	4,433	3,938	3,978	3,335	2,642	2,627	3,196	24,149
3	6,004	6,804	6,830	7,462	7,165	5,647	7,059	46,971
4	4,004	4,746	5,679	6,283	6,390	6,114*	5,984	39,200
5	5,947	6,555	6,746	7,022	7,638	5,015	6,413	45,336
6	2,422	2,565	2,233	2,292	1,906	3,126	2,587	17,131
7	4,626	3,527	8,231	6,473	7,707	4,312	3,852	38,728
8	3,724	2,148	3,151	14,368	3,161	6,911	4,027	37,490
9	6,142	5,747	2,470	8,671	17,978	4,408	2,574	47,990
10	3,570	408*	4,028	3,631	4,304	3,967	5,502	25,410
Total	45,217	42,954	51,586	67,559	64,729	47,936	47,716	367,697

Note: Maximum days are underlined (after deduction of waste)

* Interruption to supply

Amani village - Water consumption, dry season (in litres per day)

APPENDIX VII

HOURLY VARIATIONS OF CONSUMPTION

Kasumulu : Hourly Flow

Legend : Time of day : 1 = 00.00 to 03.00

2 = 03.00 to 06.00

3 = 06.00 to 09.00

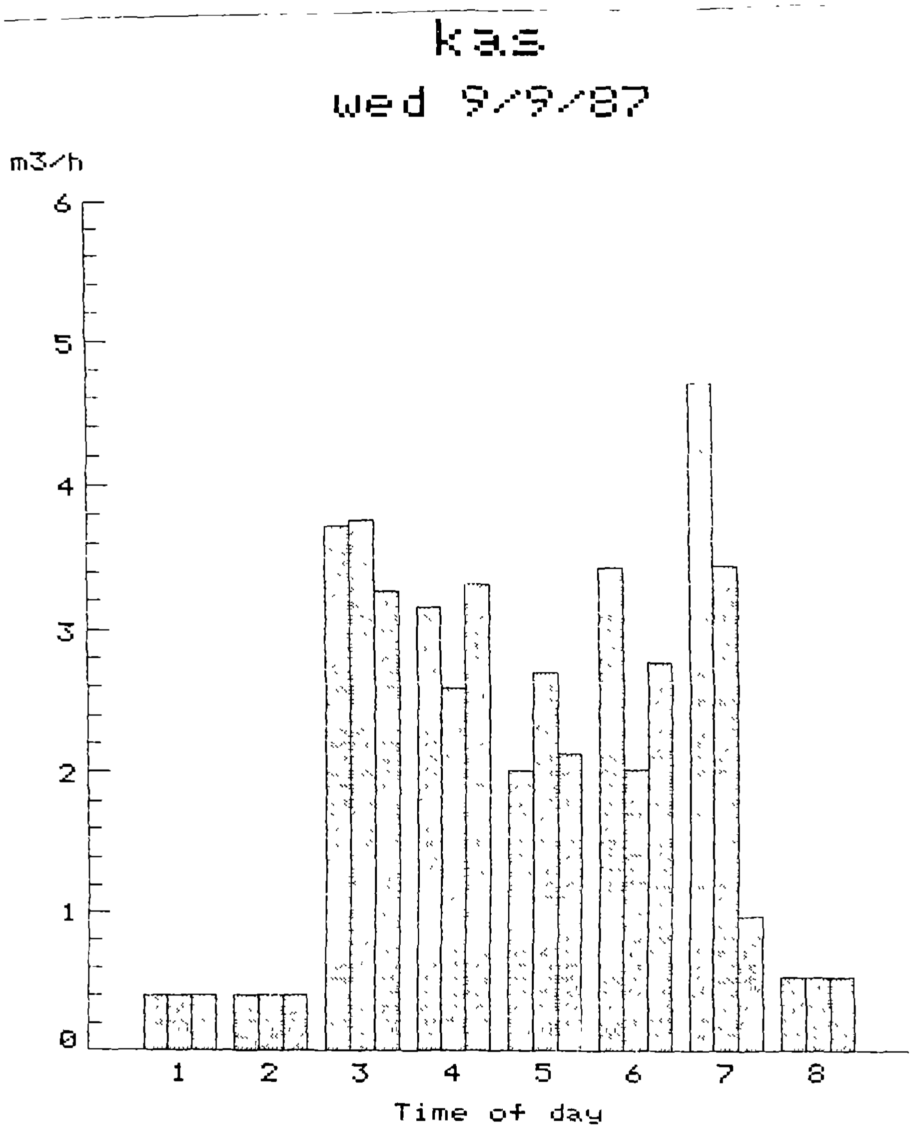
4 = 09.00 to 12.00

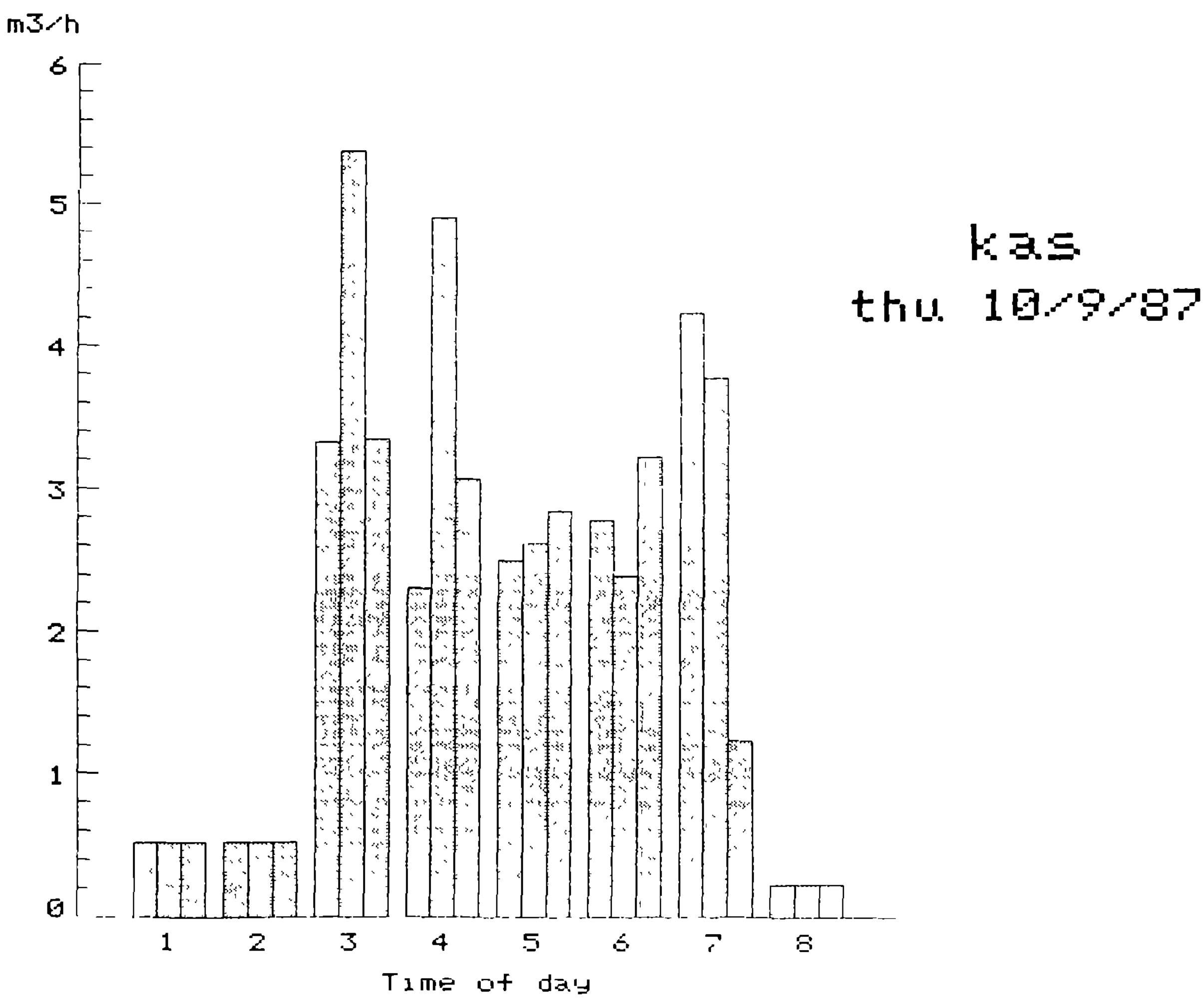
5 = 12.00 to 15.00

6 = 15.00 to 18.00

7 = 18.00 to 21.00

8 = 21.00 to 24.00

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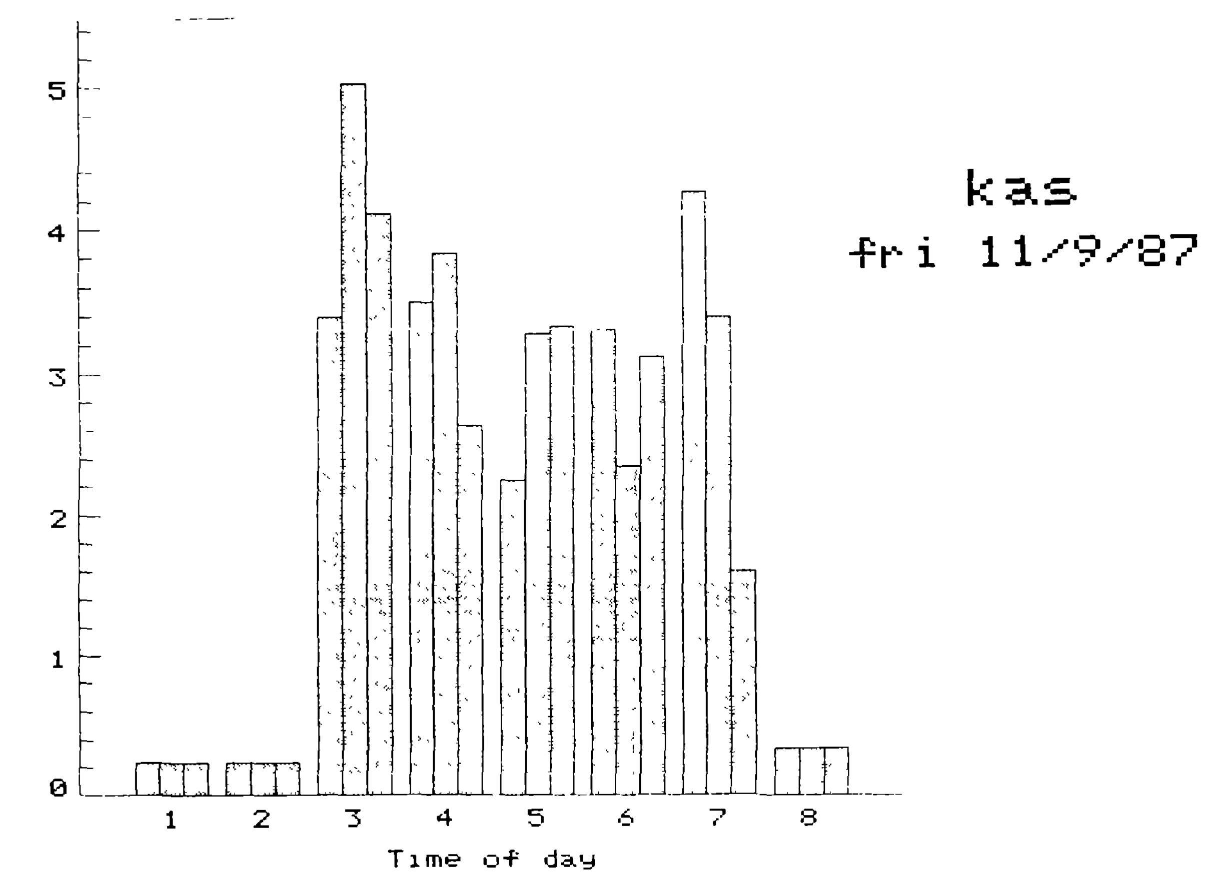
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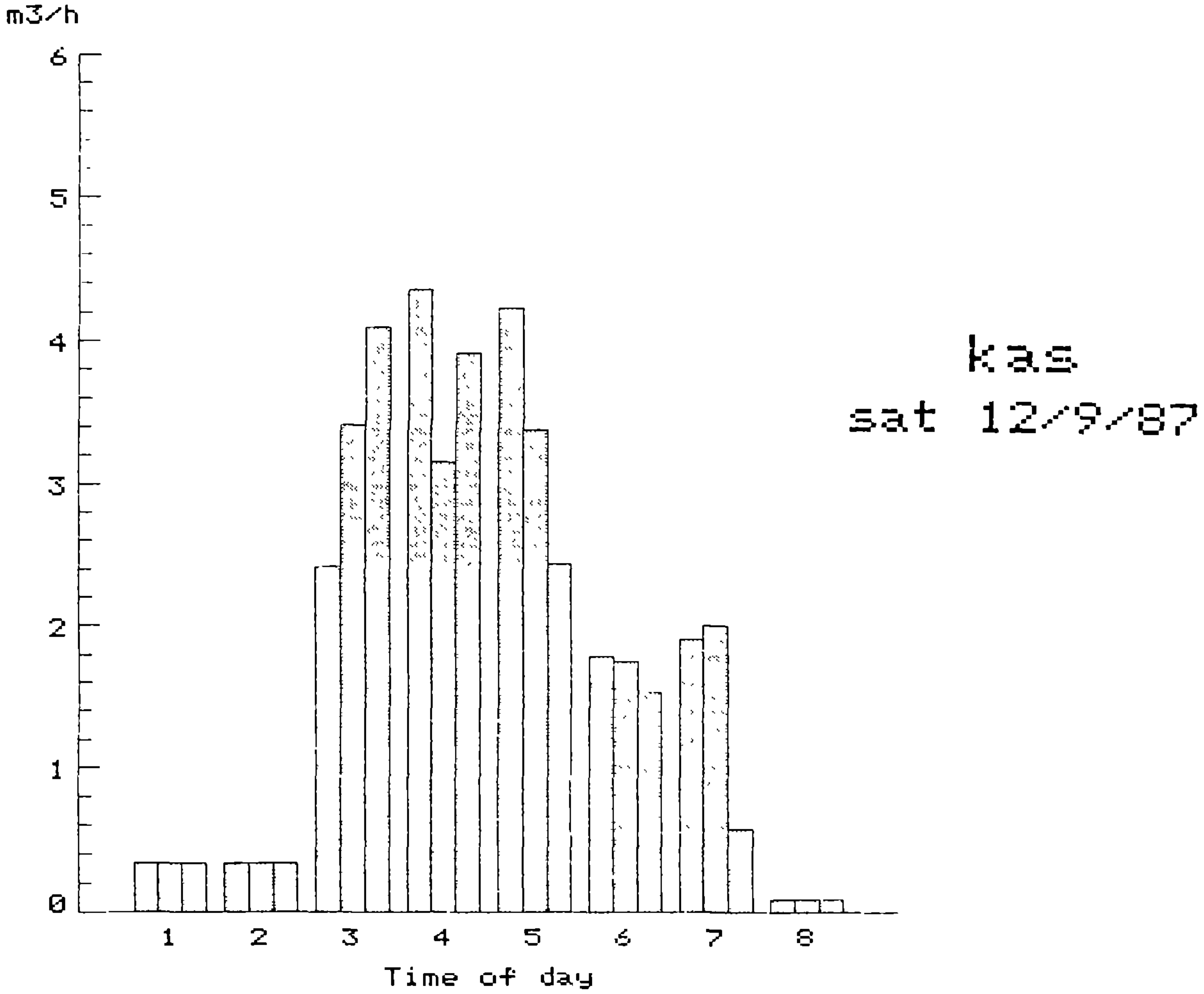
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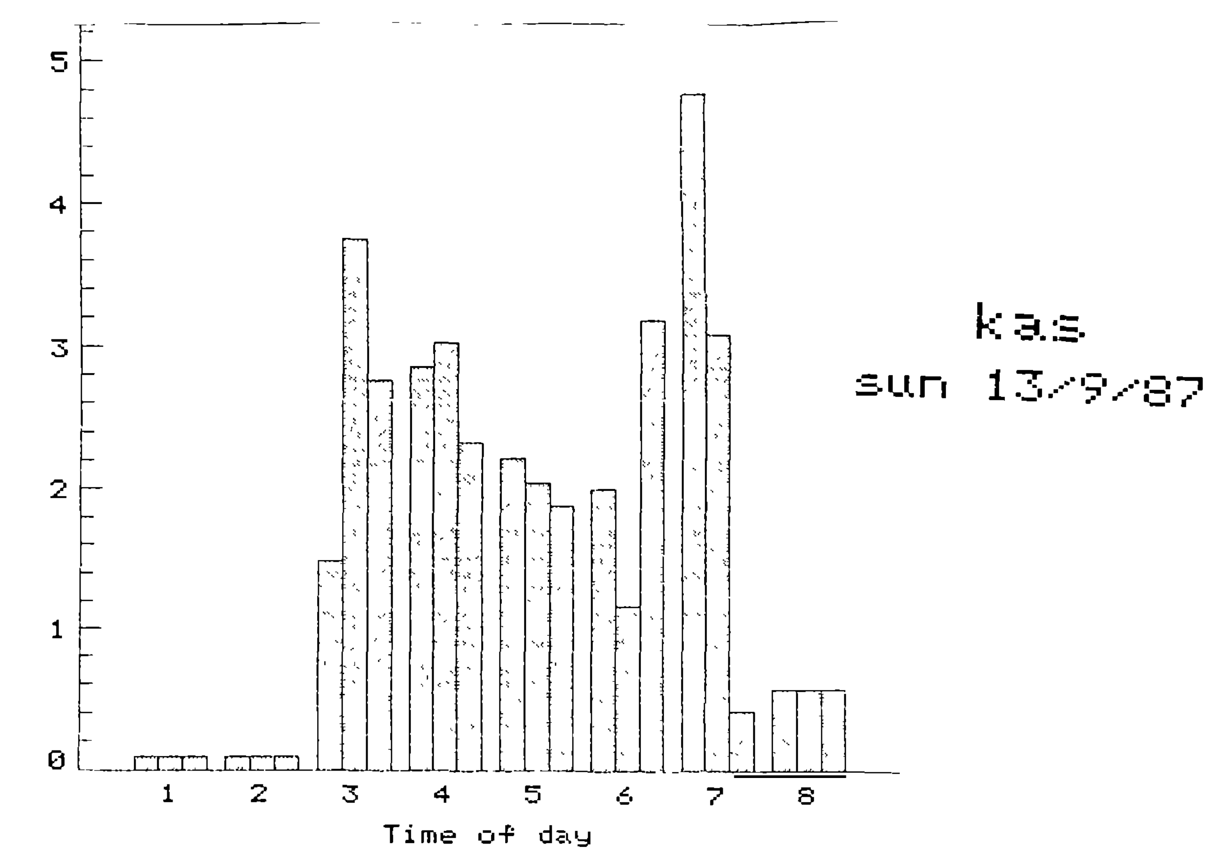
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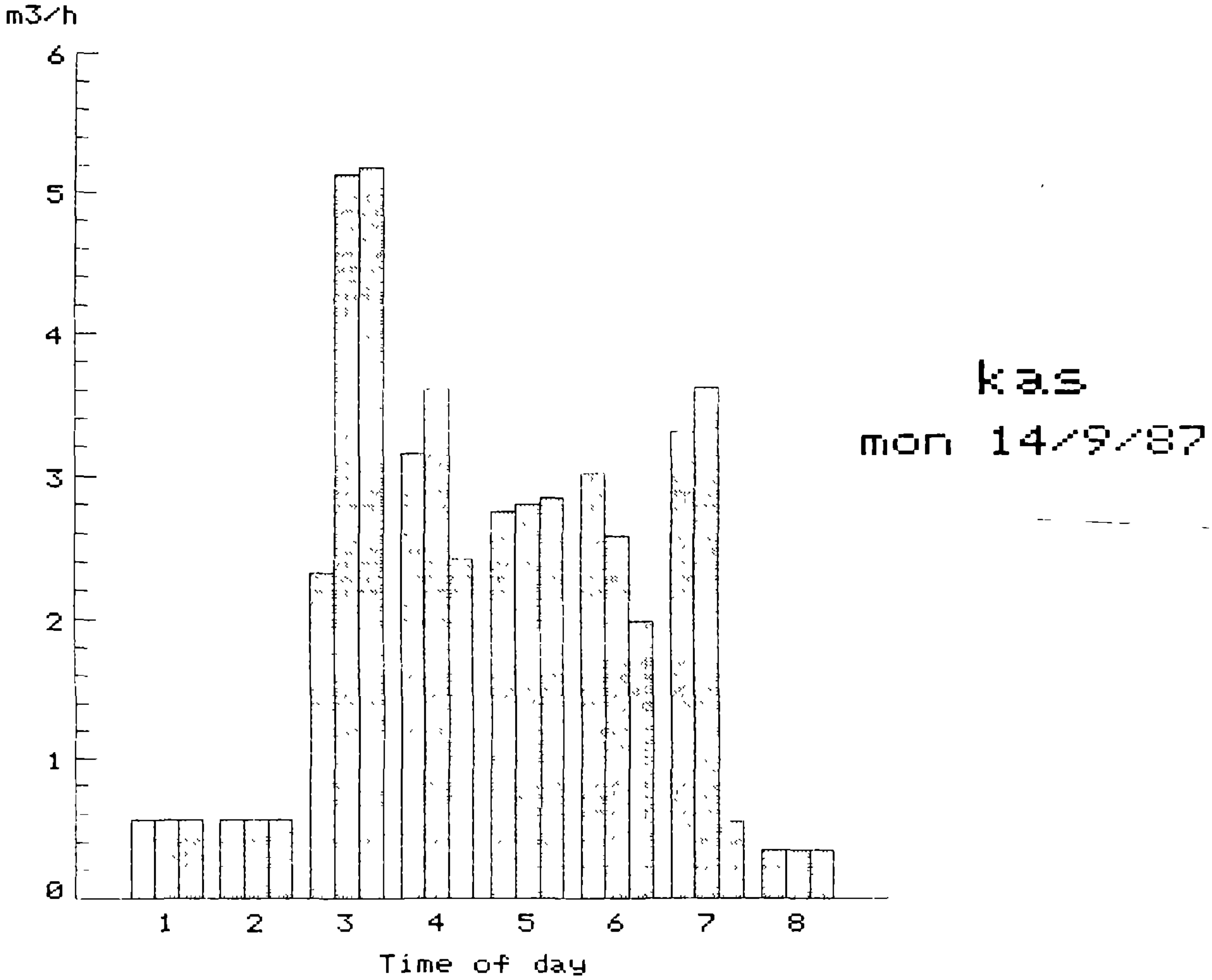
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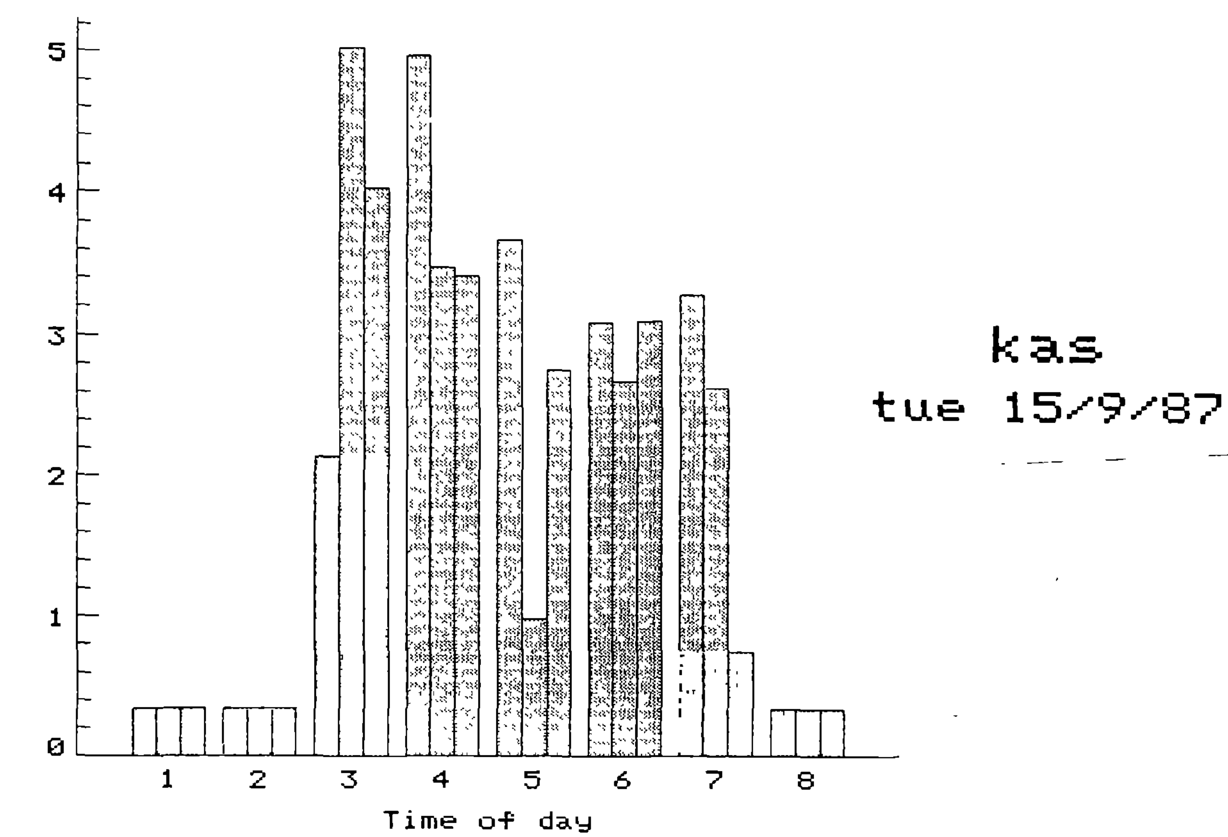
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Mlangali : Hourly Flow

Legend : Time of day : 1 = 00.00 to 03.00

2 = 03.00 to 06.00

3 = 06.00 to 09.00

4 = 09.00 to 12.00

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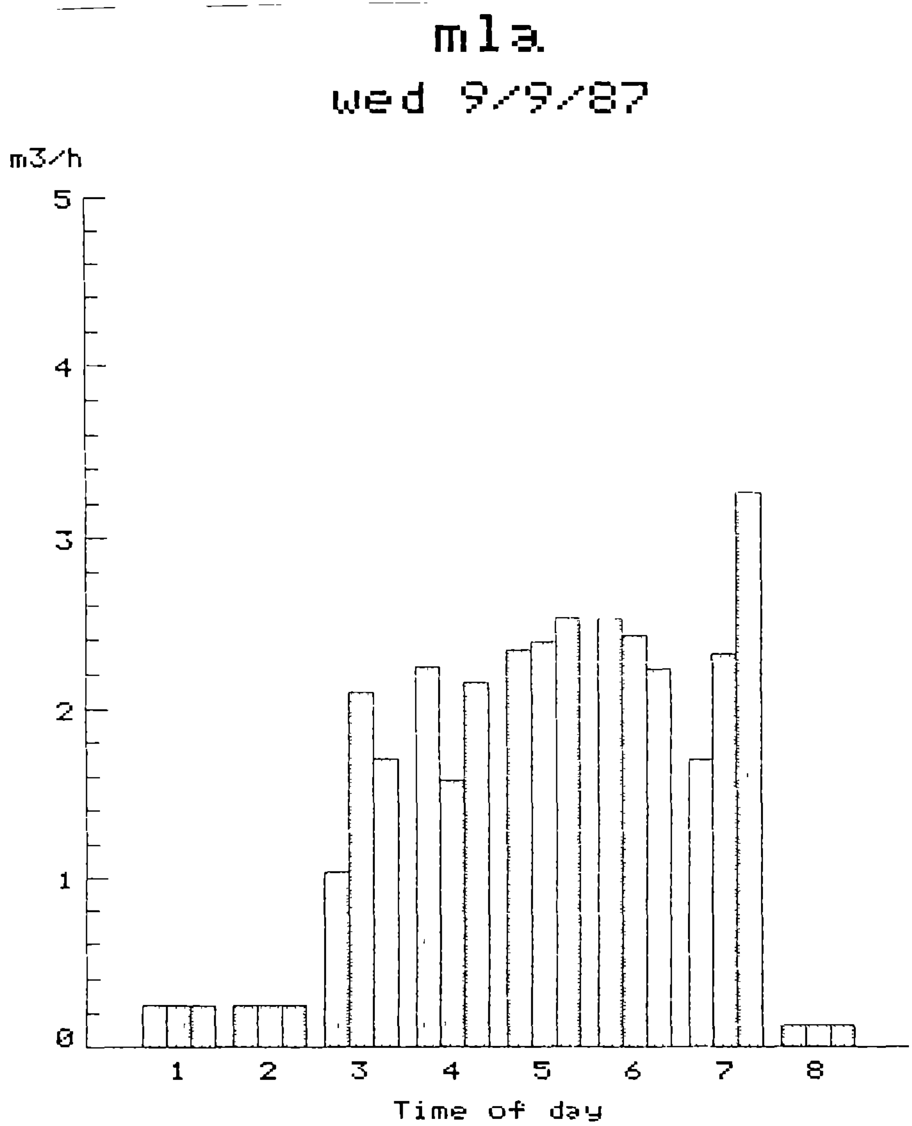
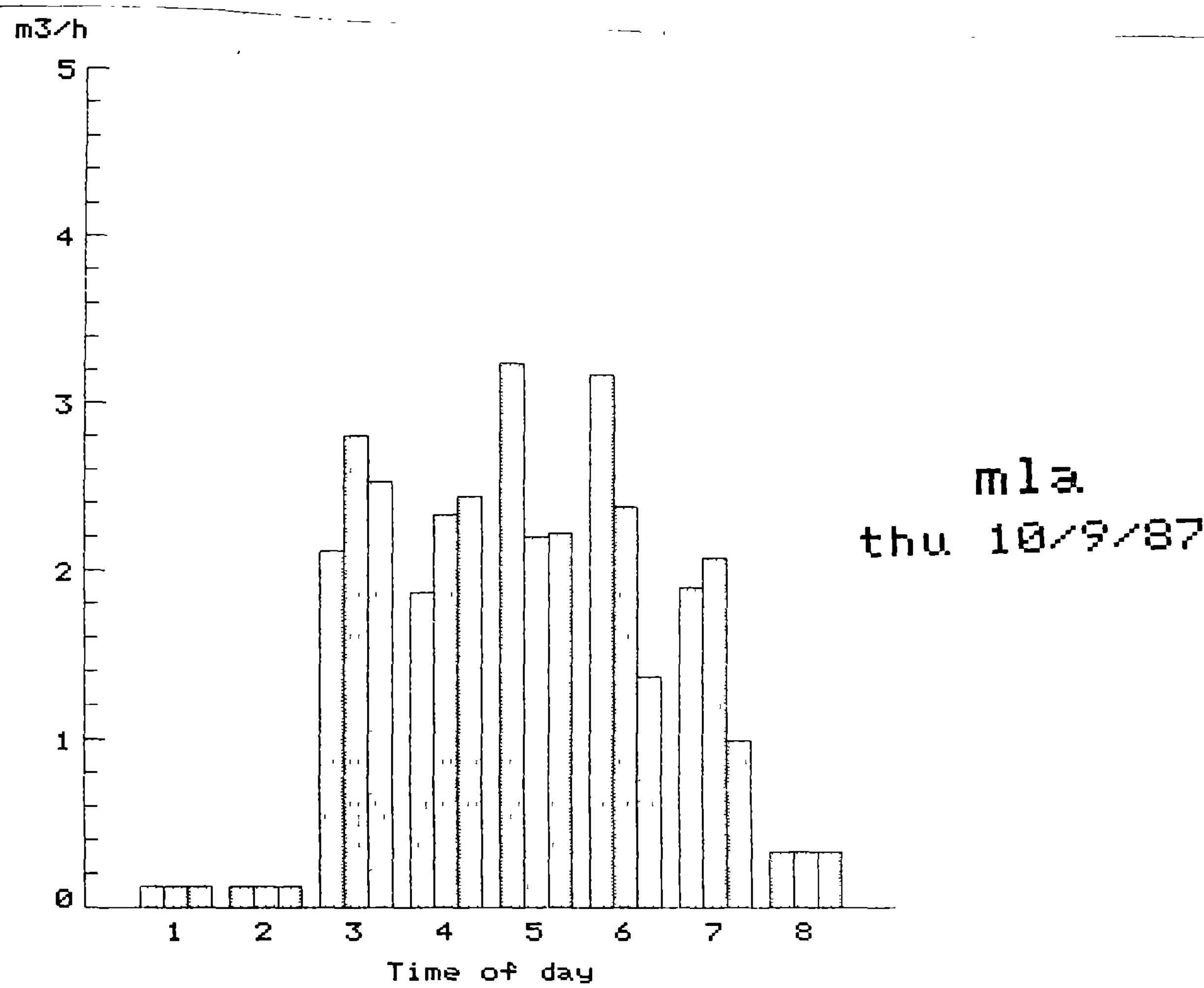
6 = 15.00 to 18.00

7 = 18.00 to 21.00

8 = 21.00 to 24.00

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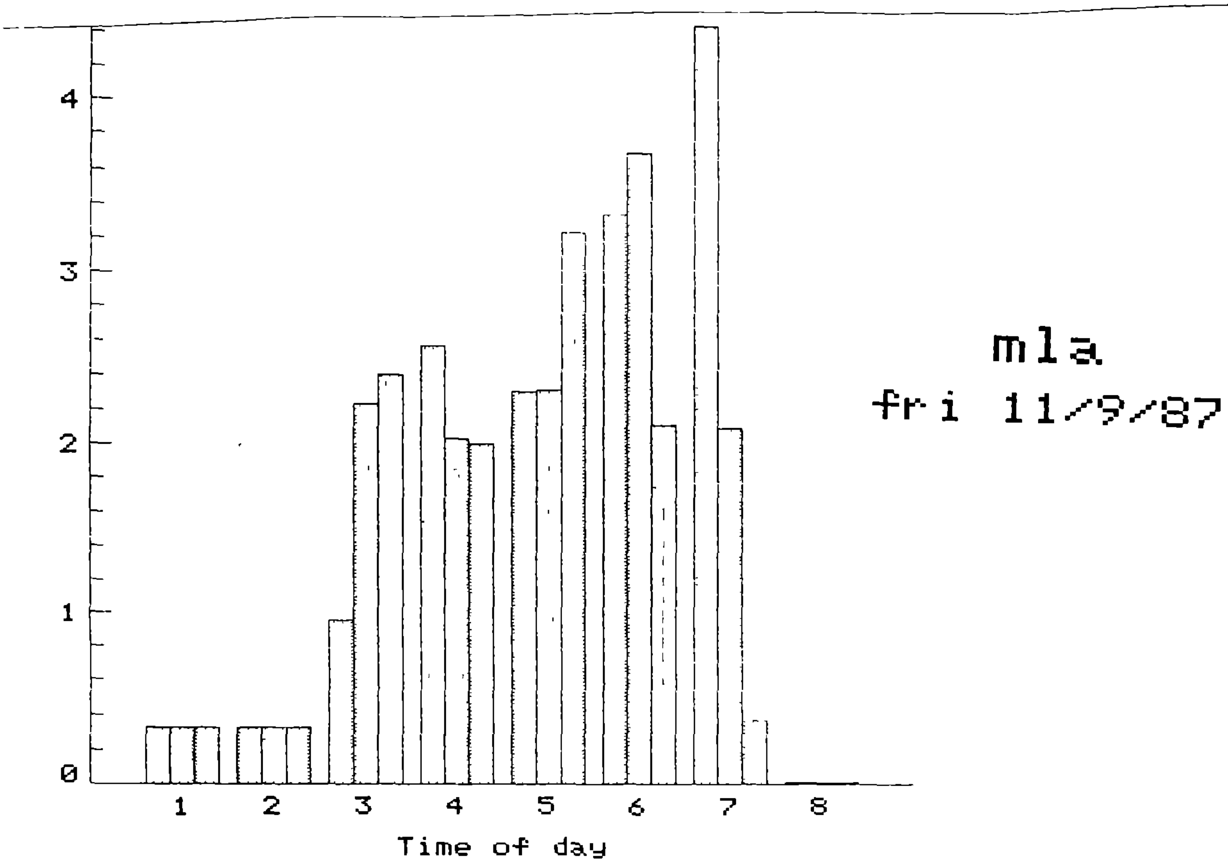
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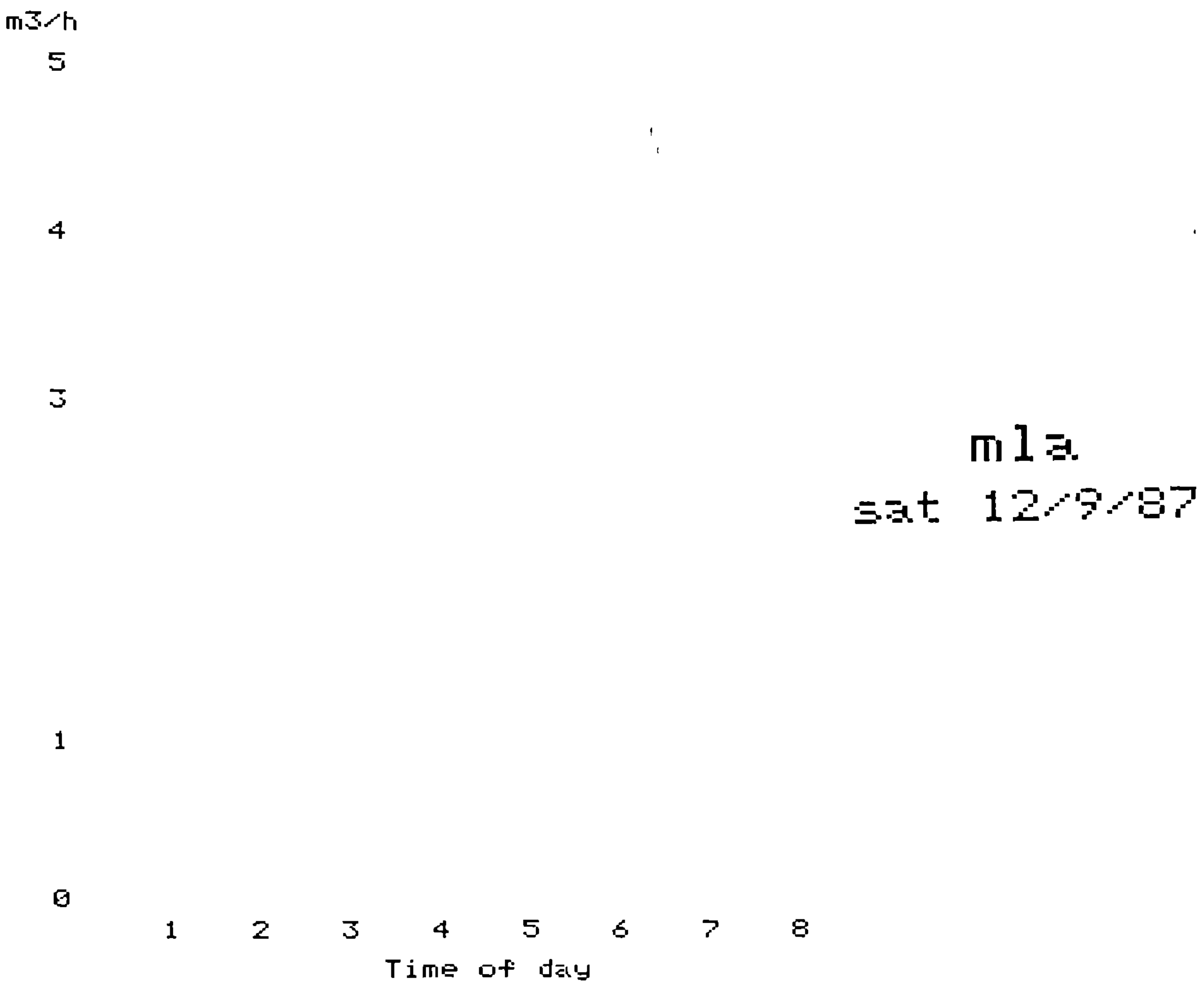
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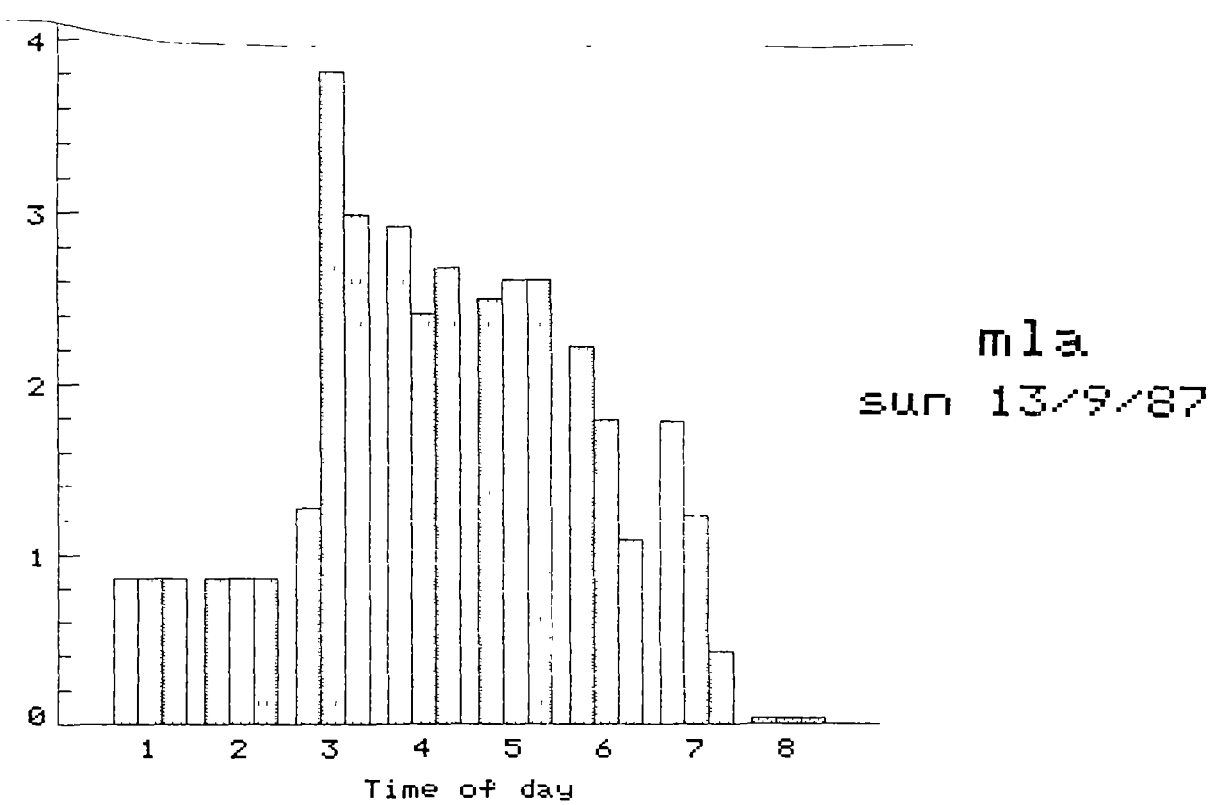
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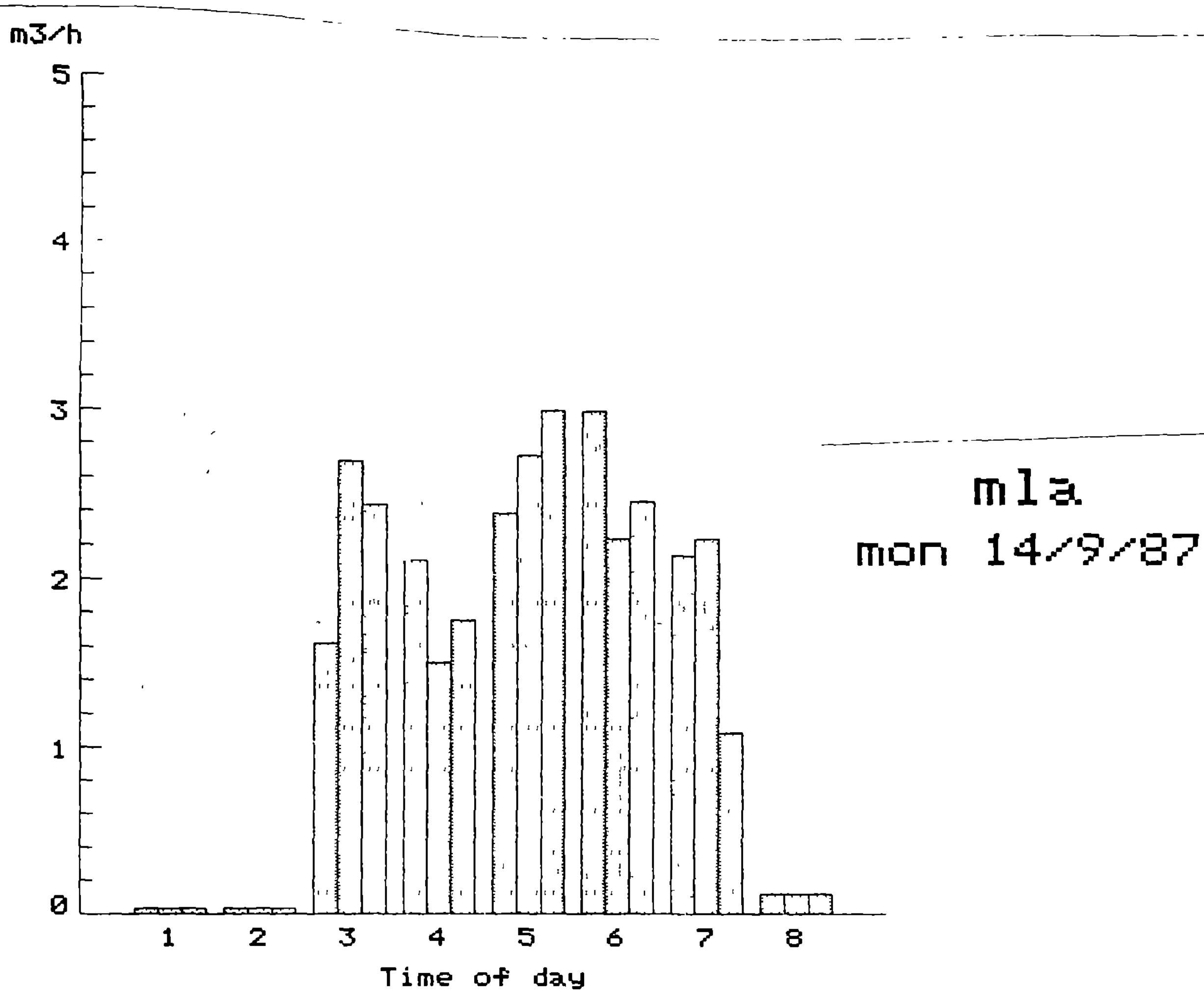
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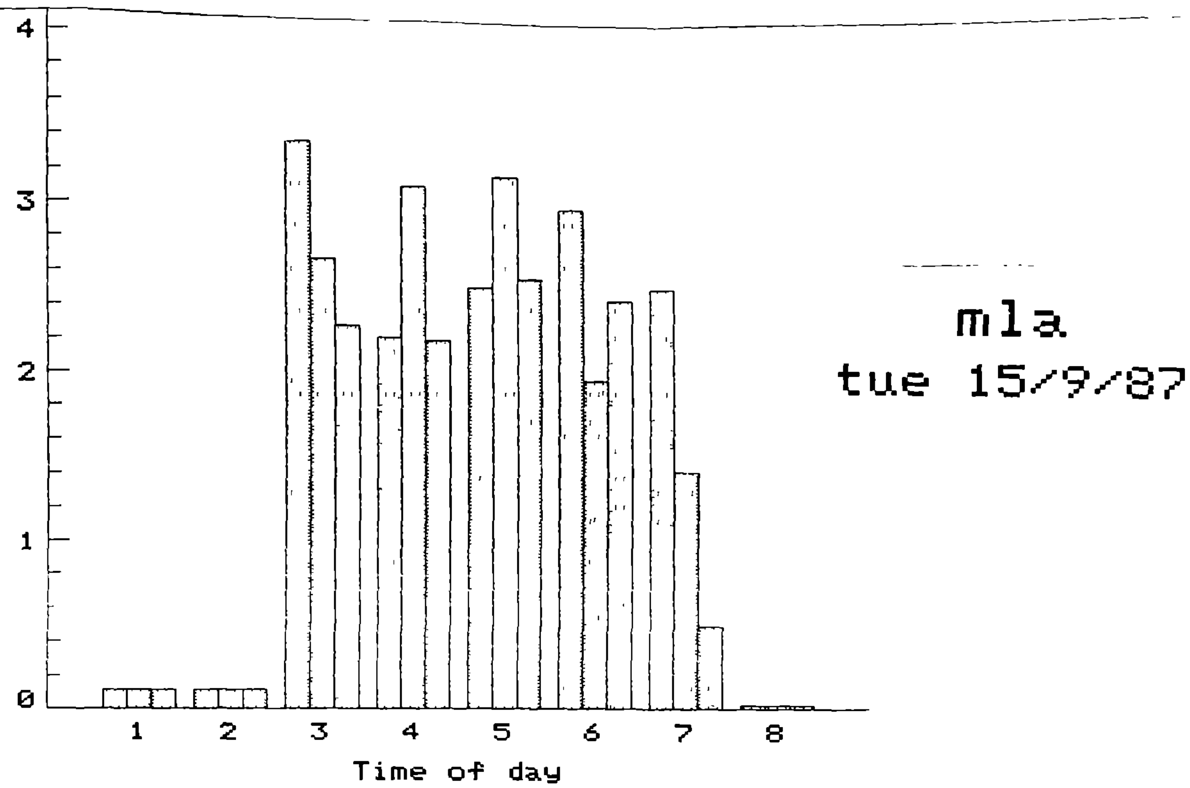
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Kiponzelo : Hourly Flow

Legend : Time of day :

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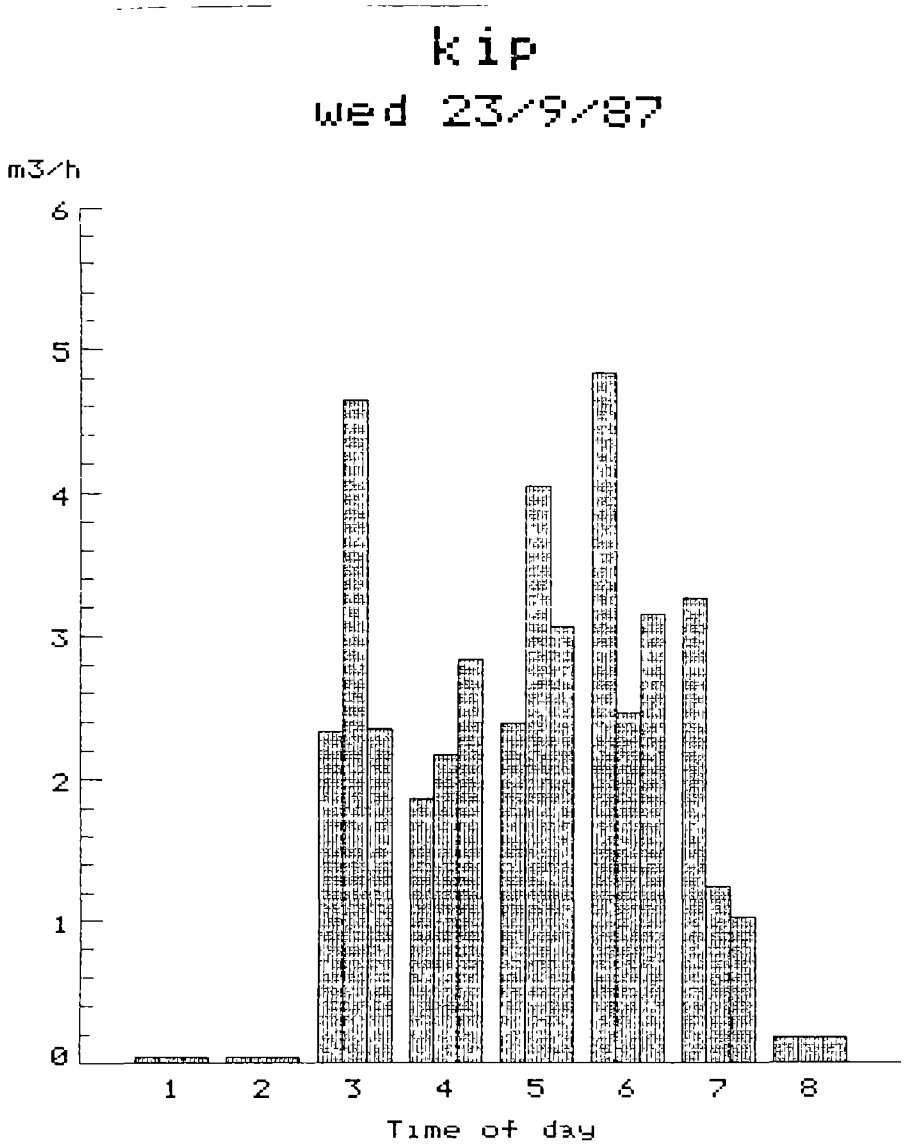
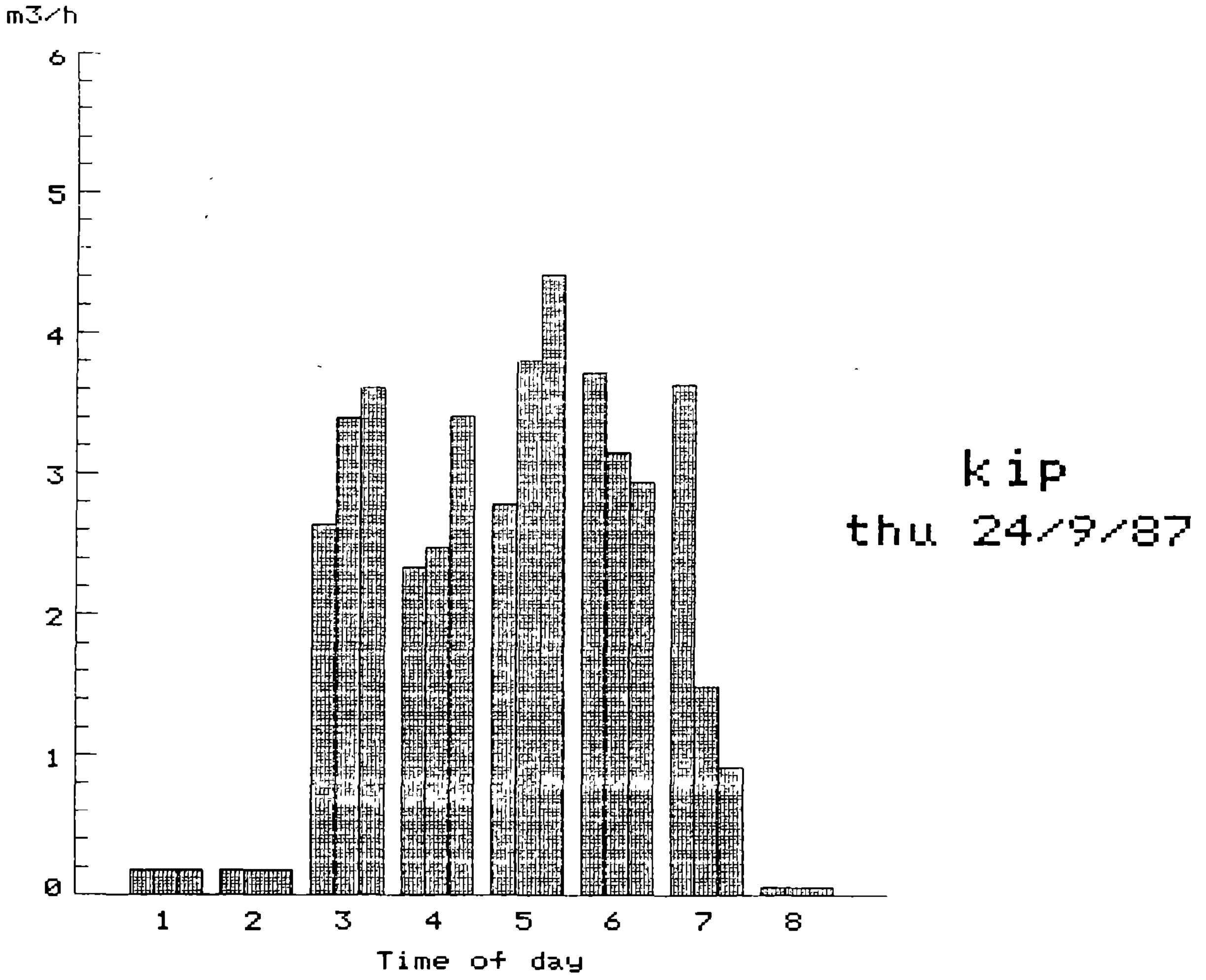
3	=	06.00 to 09.00
4	=	09.00 to 12.00
5	=	12.00 to 15.00
6	=	15.00 to 18.00
7	=	18.00 to 21.00
8	=	21.00 to 24.00

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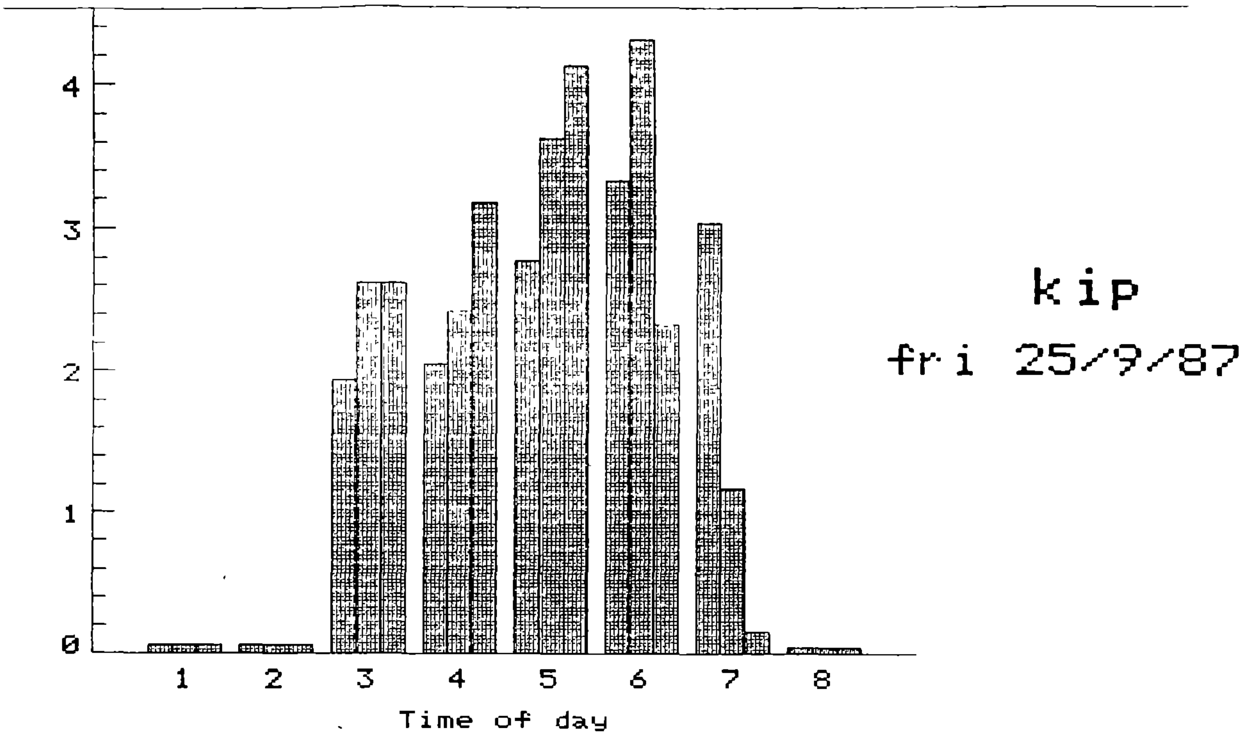
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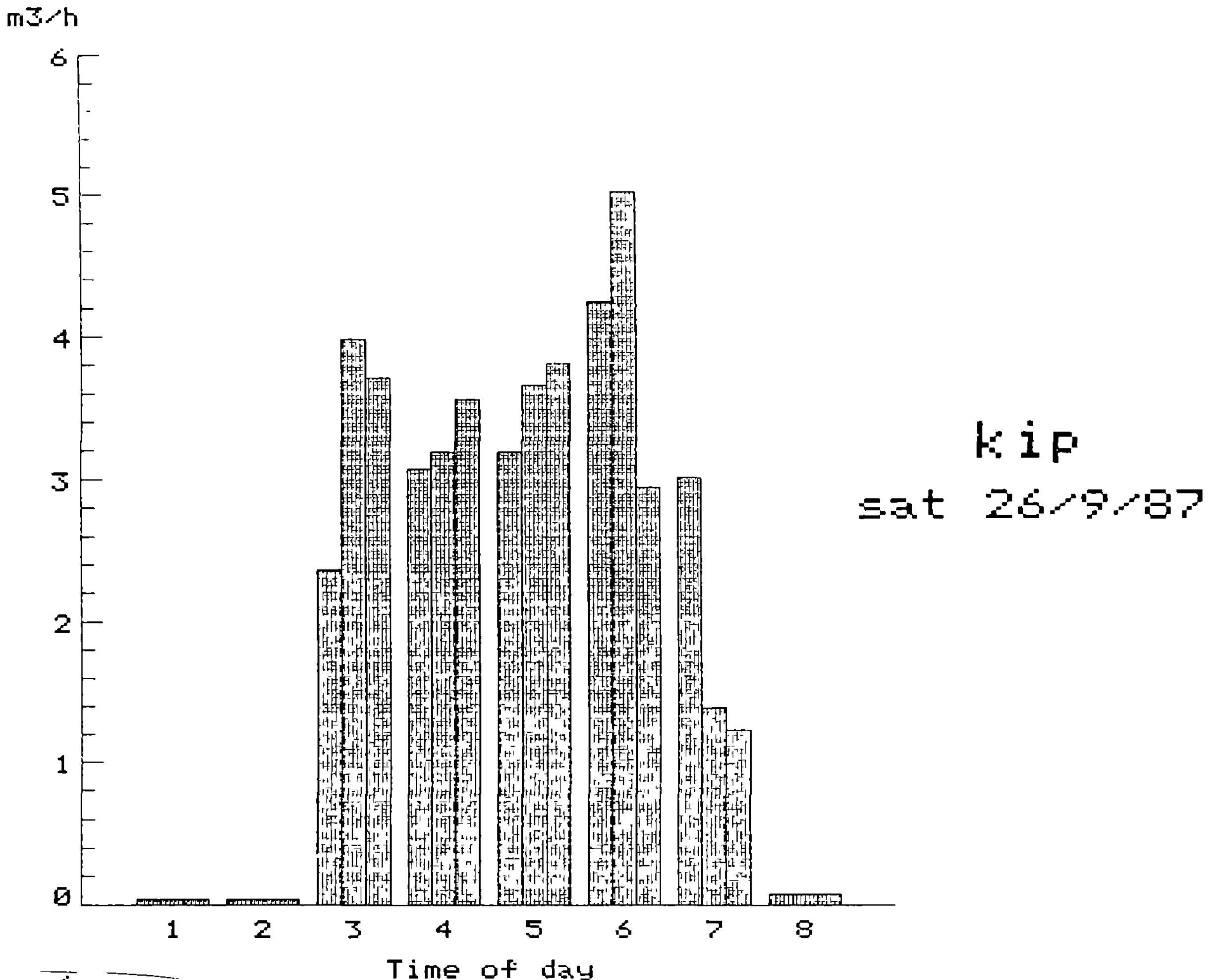
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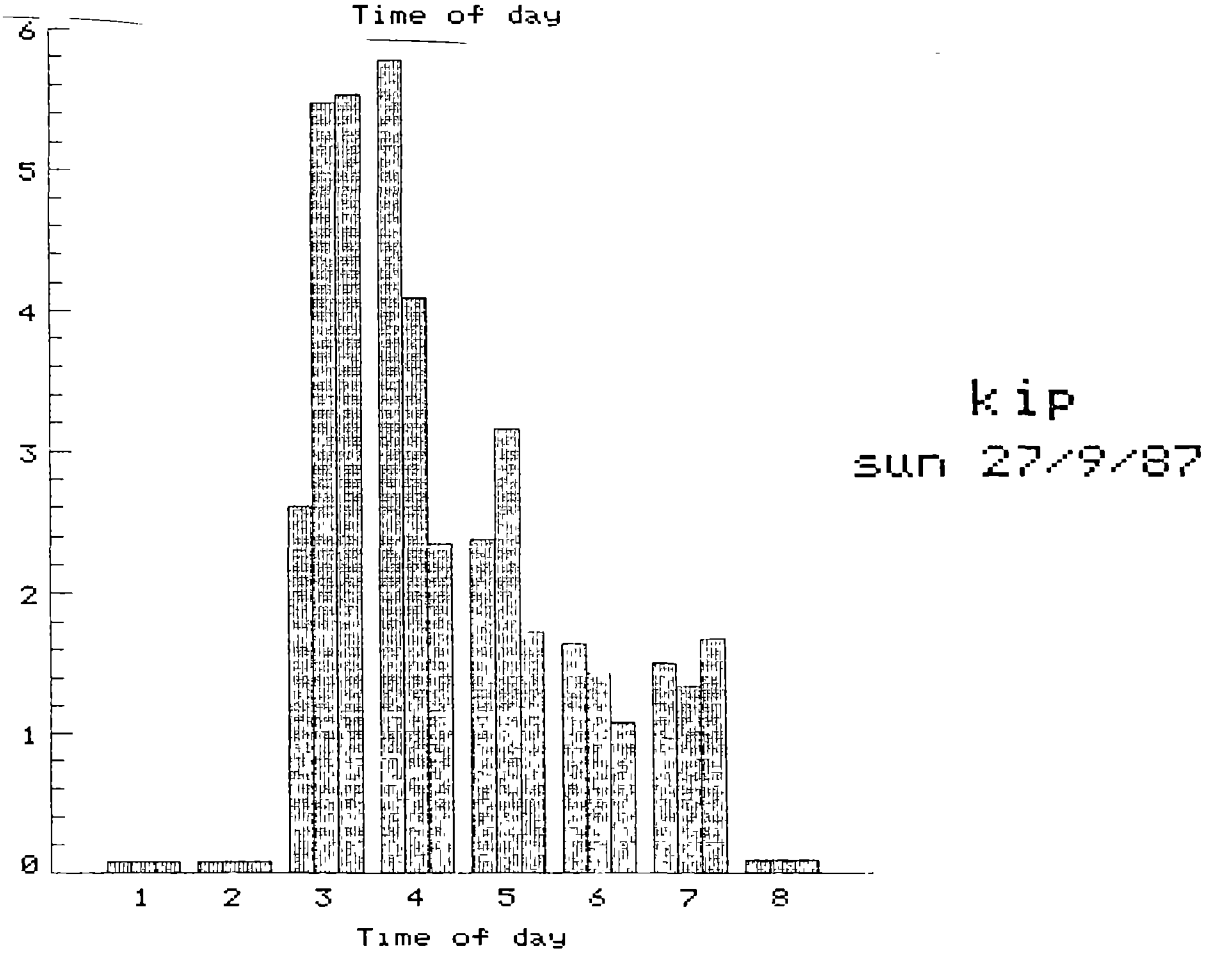
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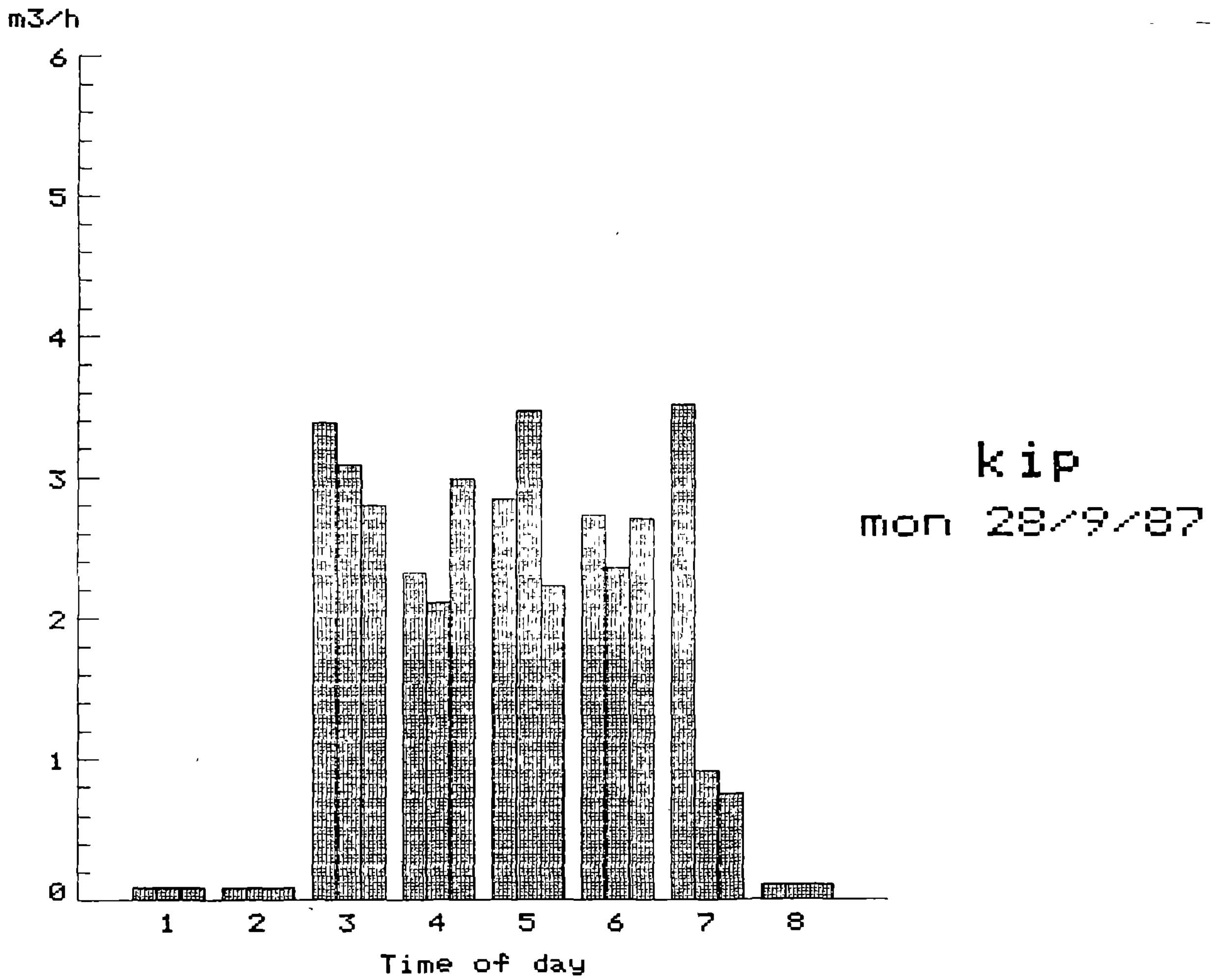
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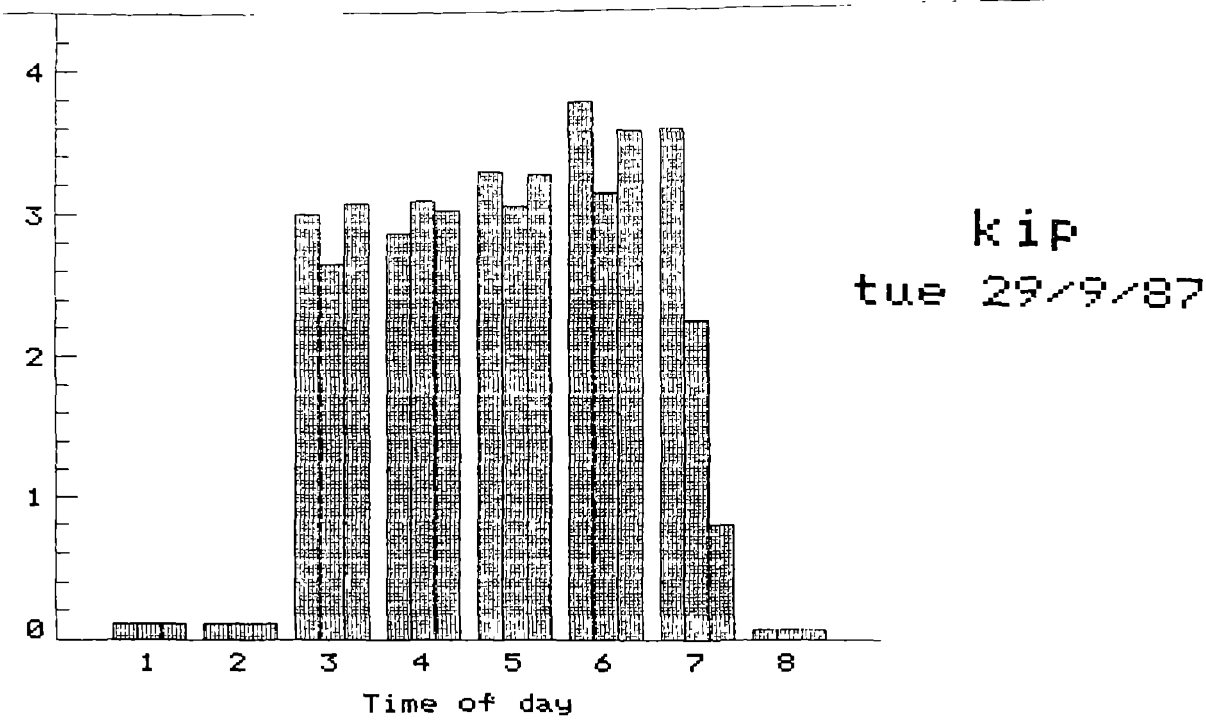
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Mbalamaziwa : Hourly Flow

Legend : Time of day : 1 = 00.00 to 03.00

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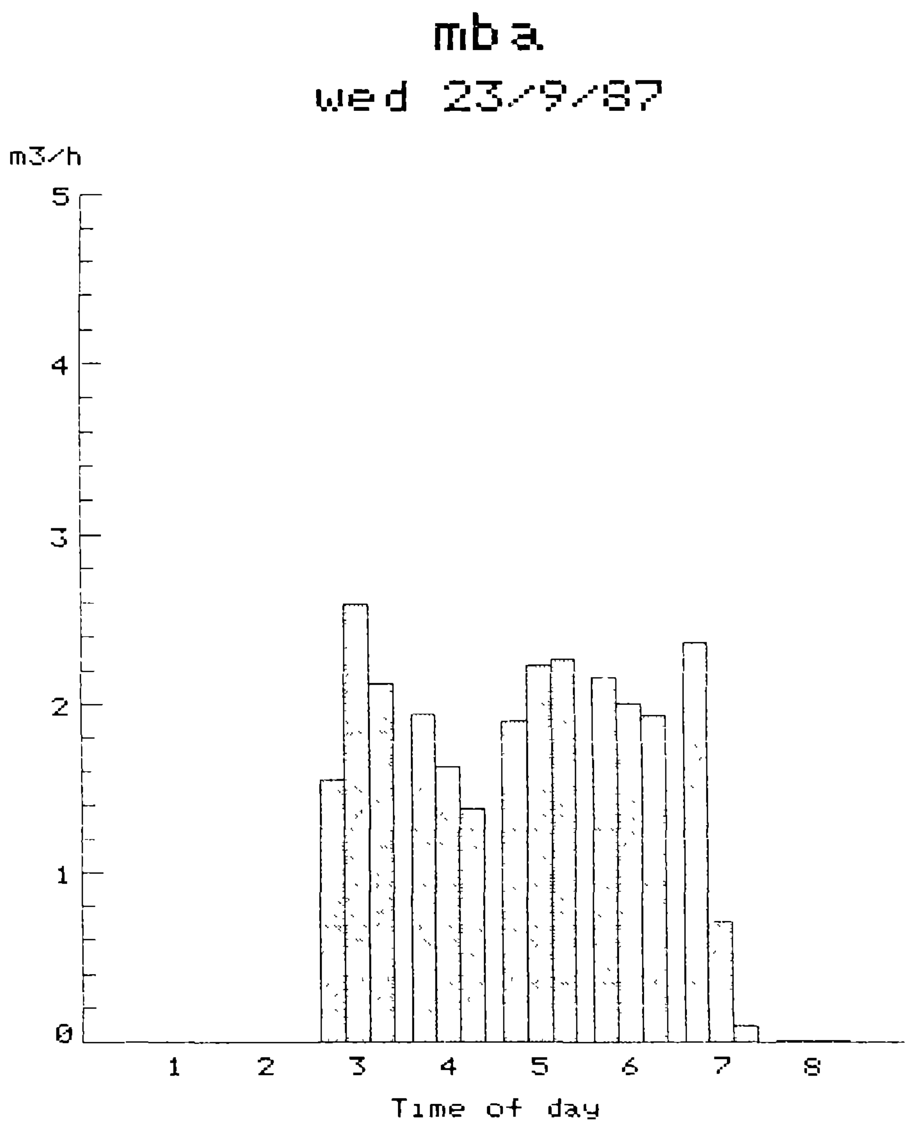

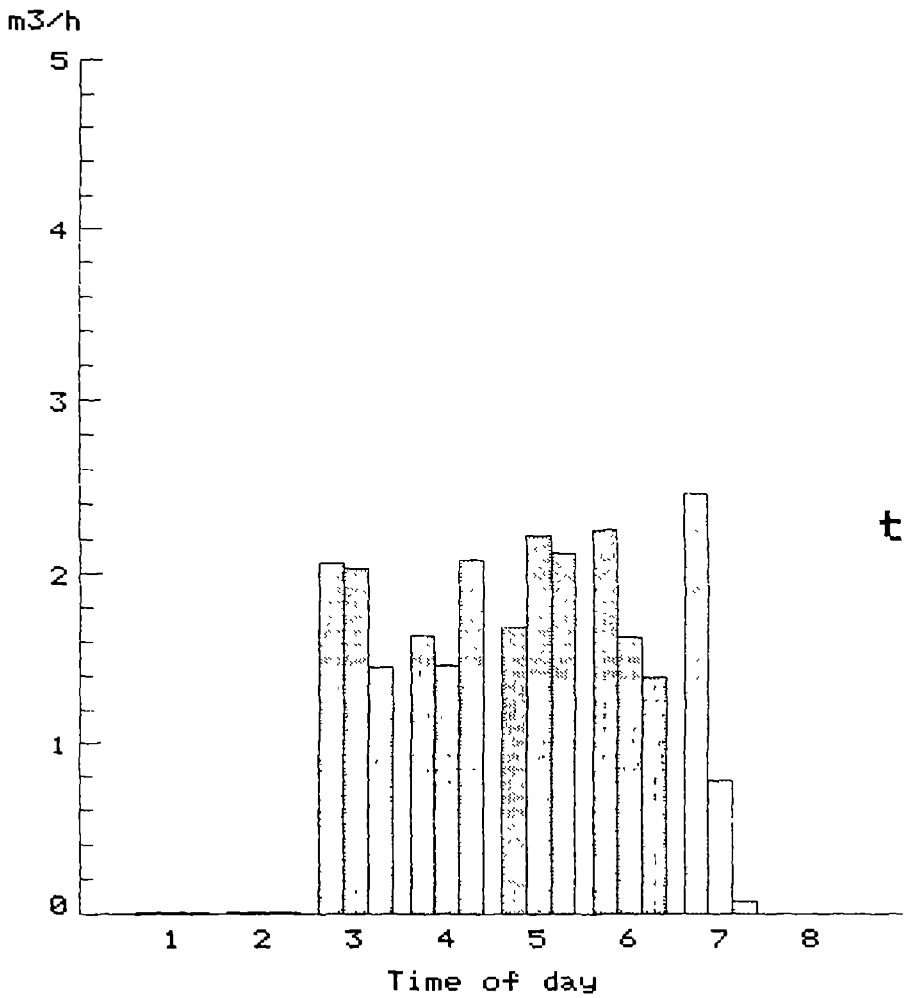

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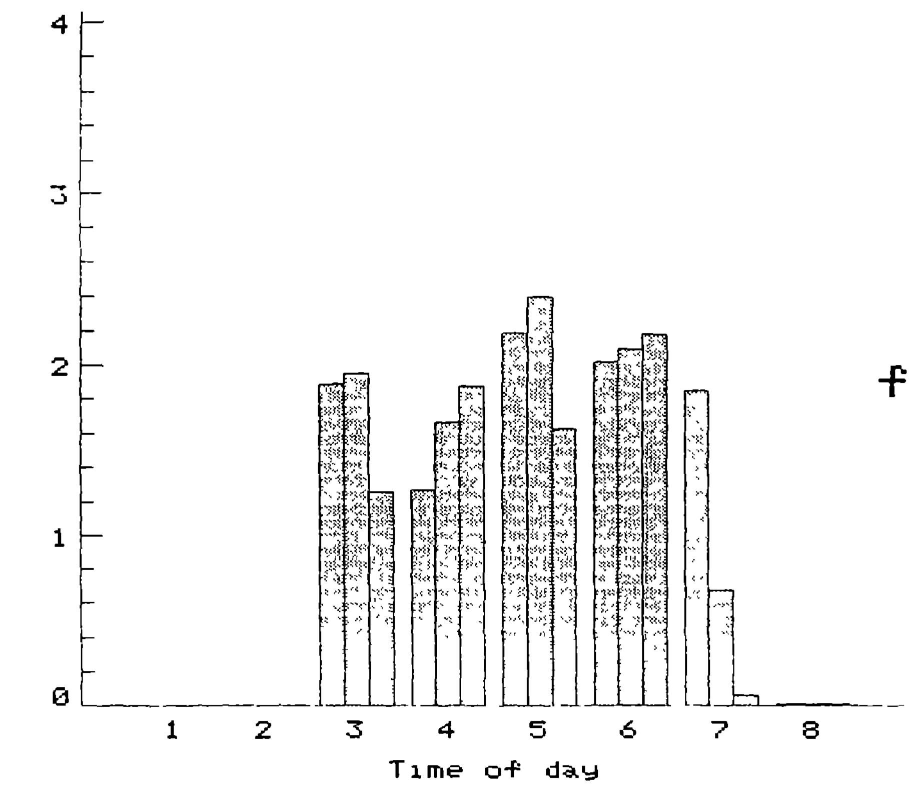

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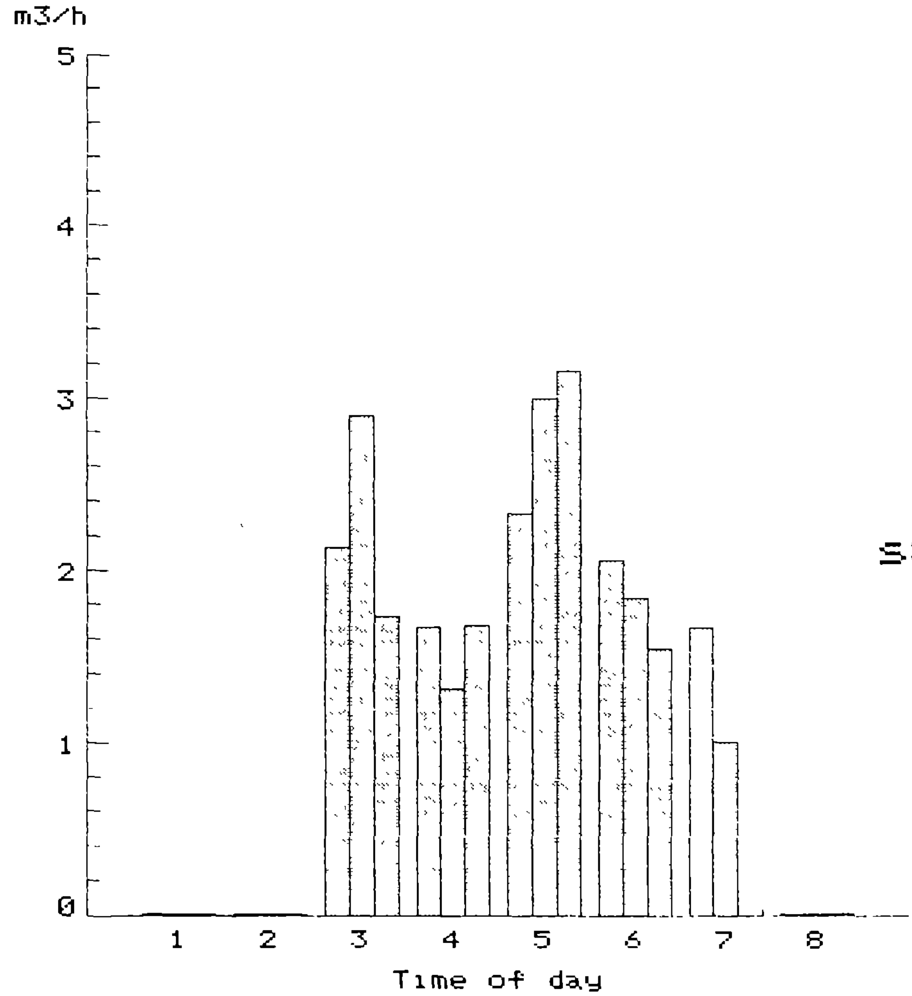

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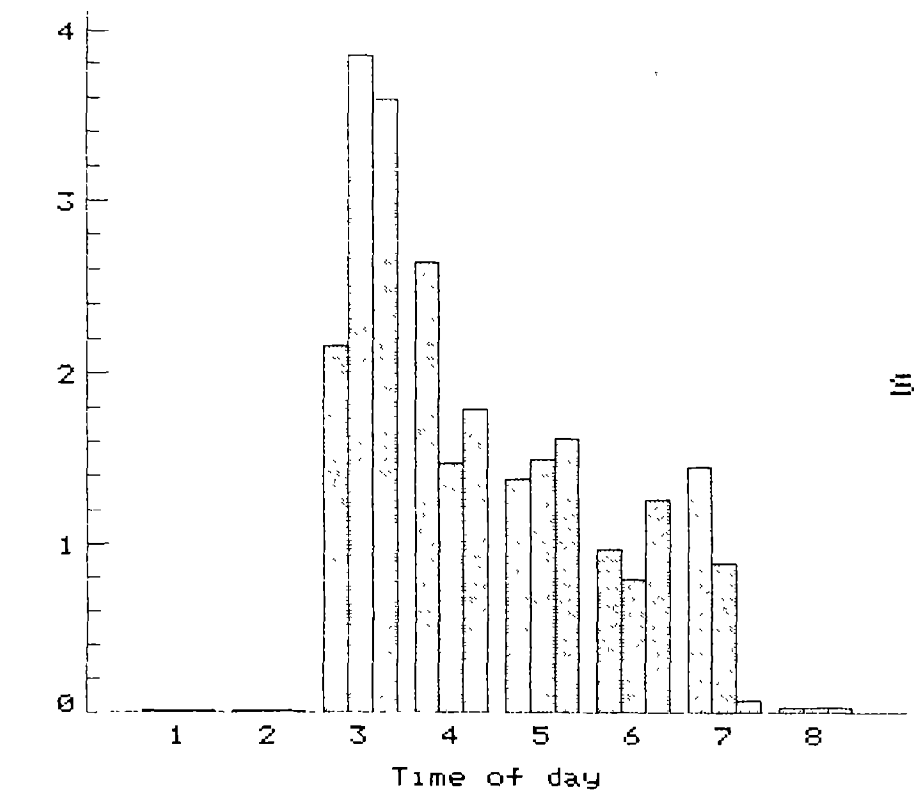

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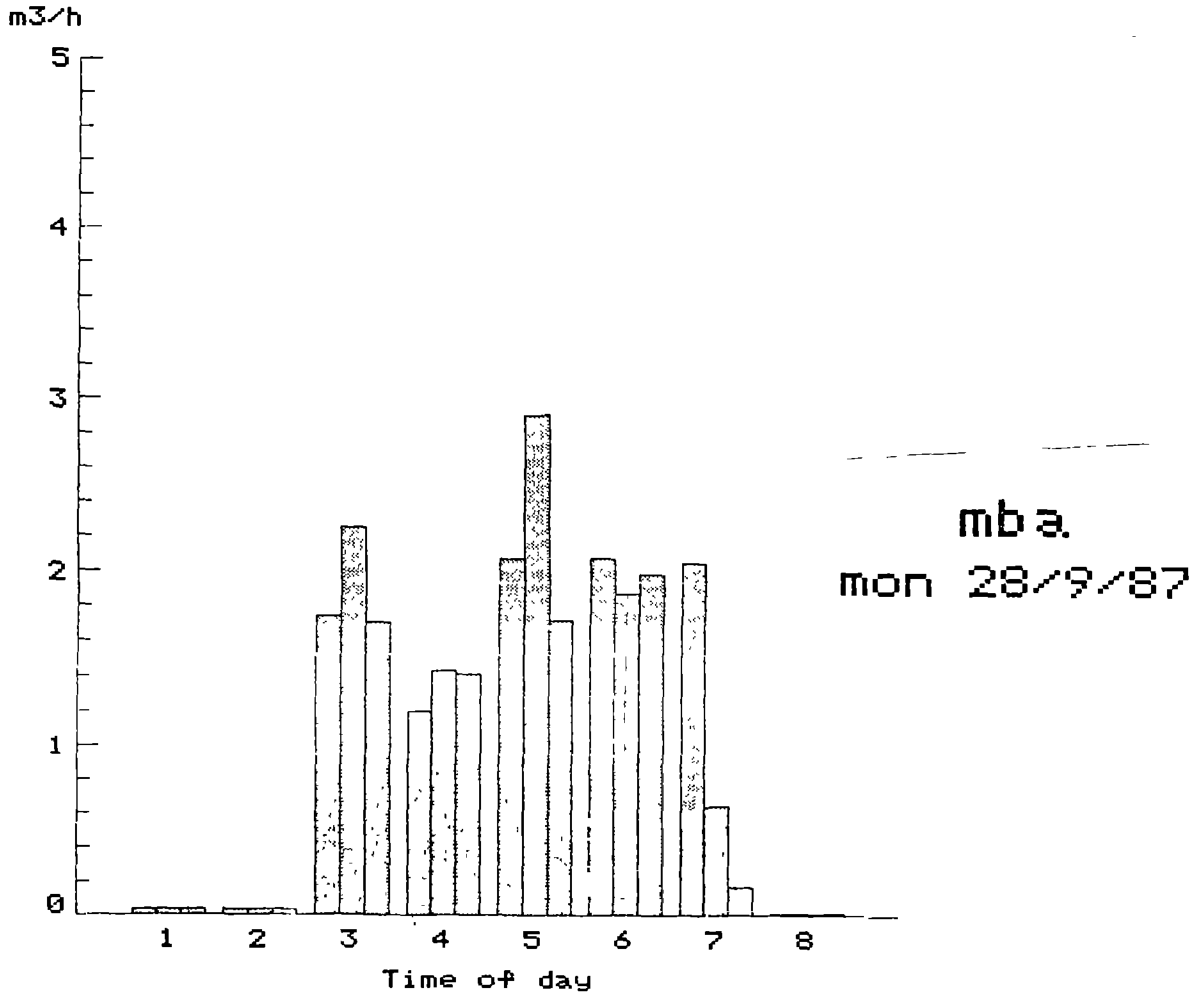
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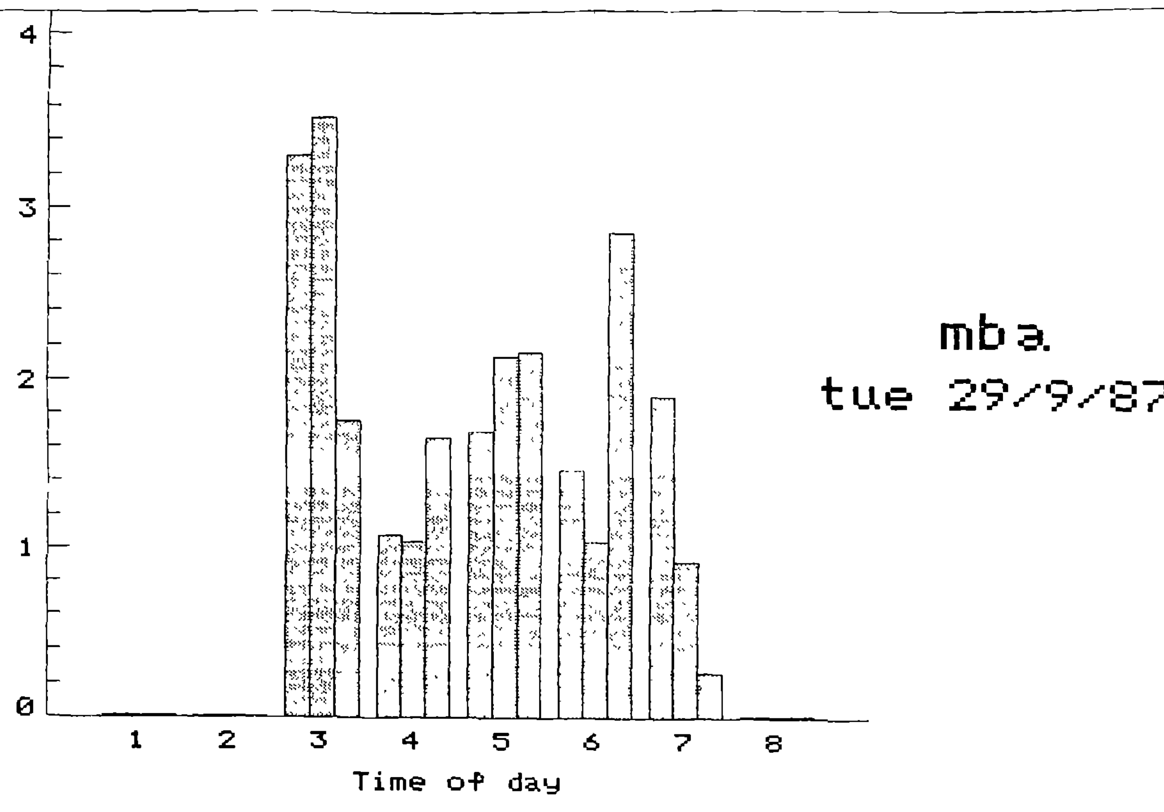
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Mpitimbi "B" : Hourly Flow

Legend : Time of day : 1 = 00.00 to 03.00
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5 = 12.00 to 15.00
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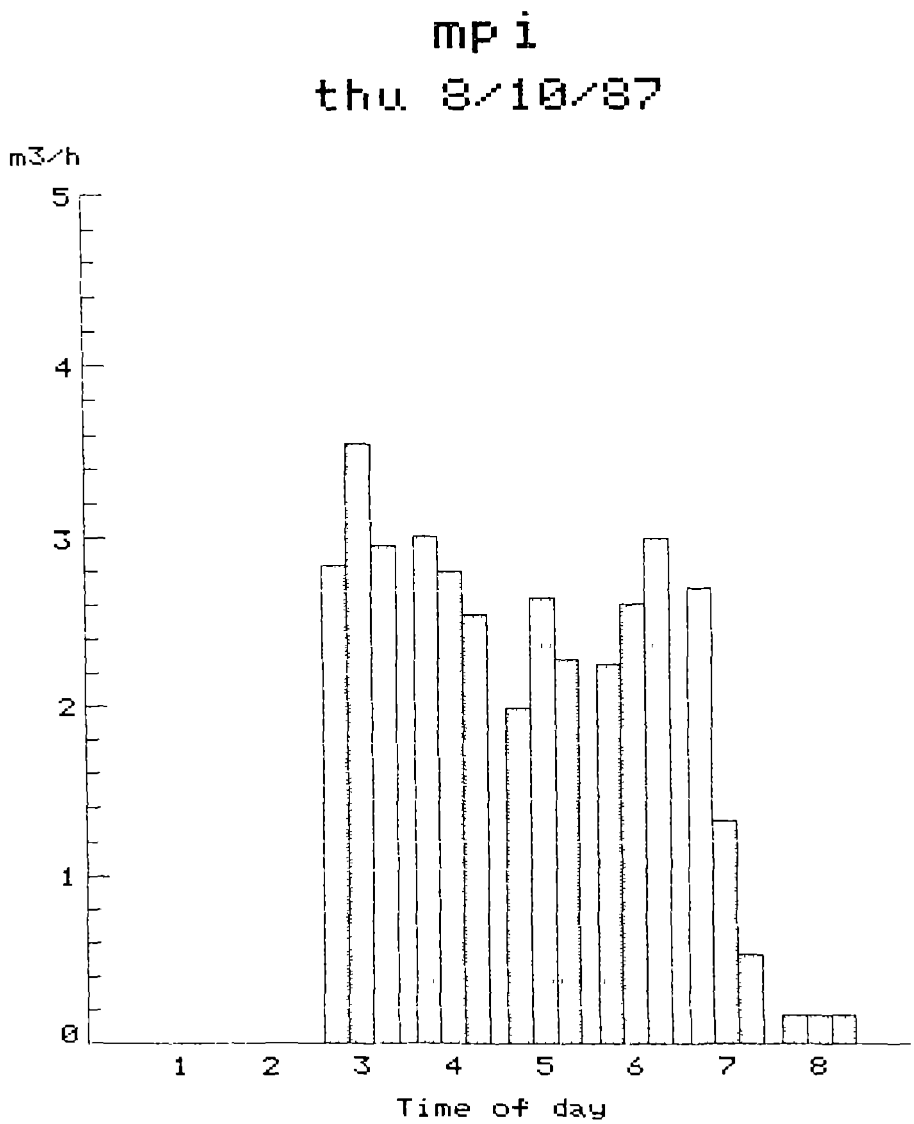

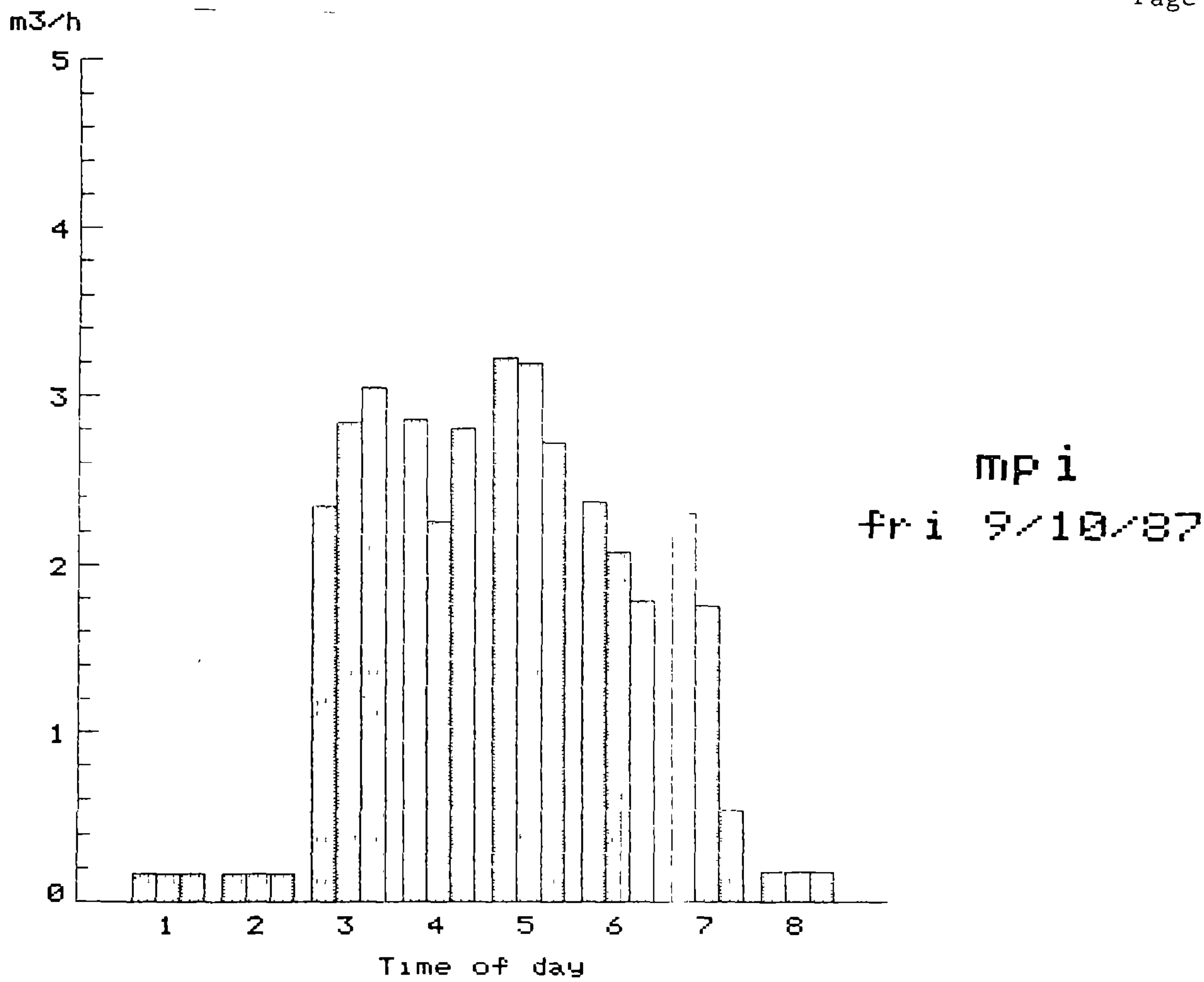
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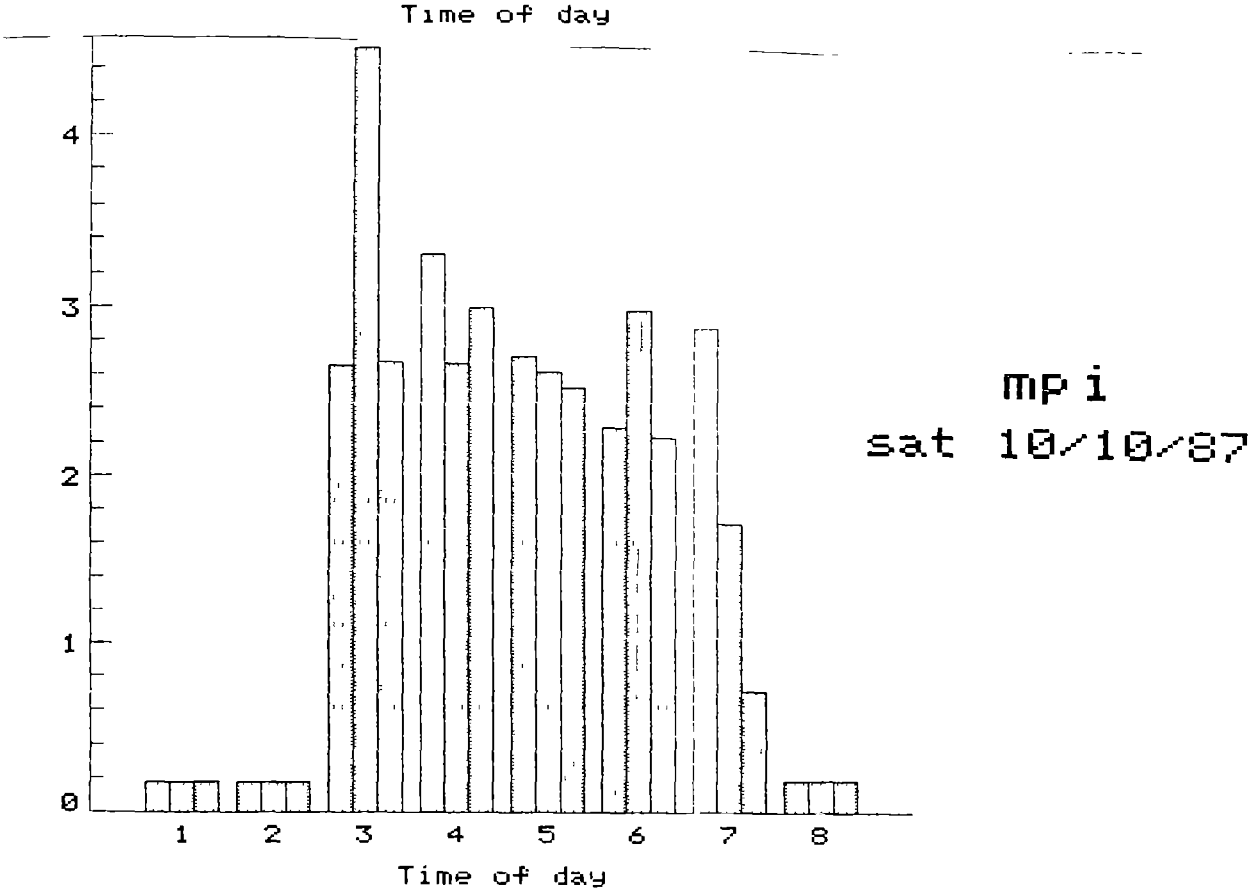
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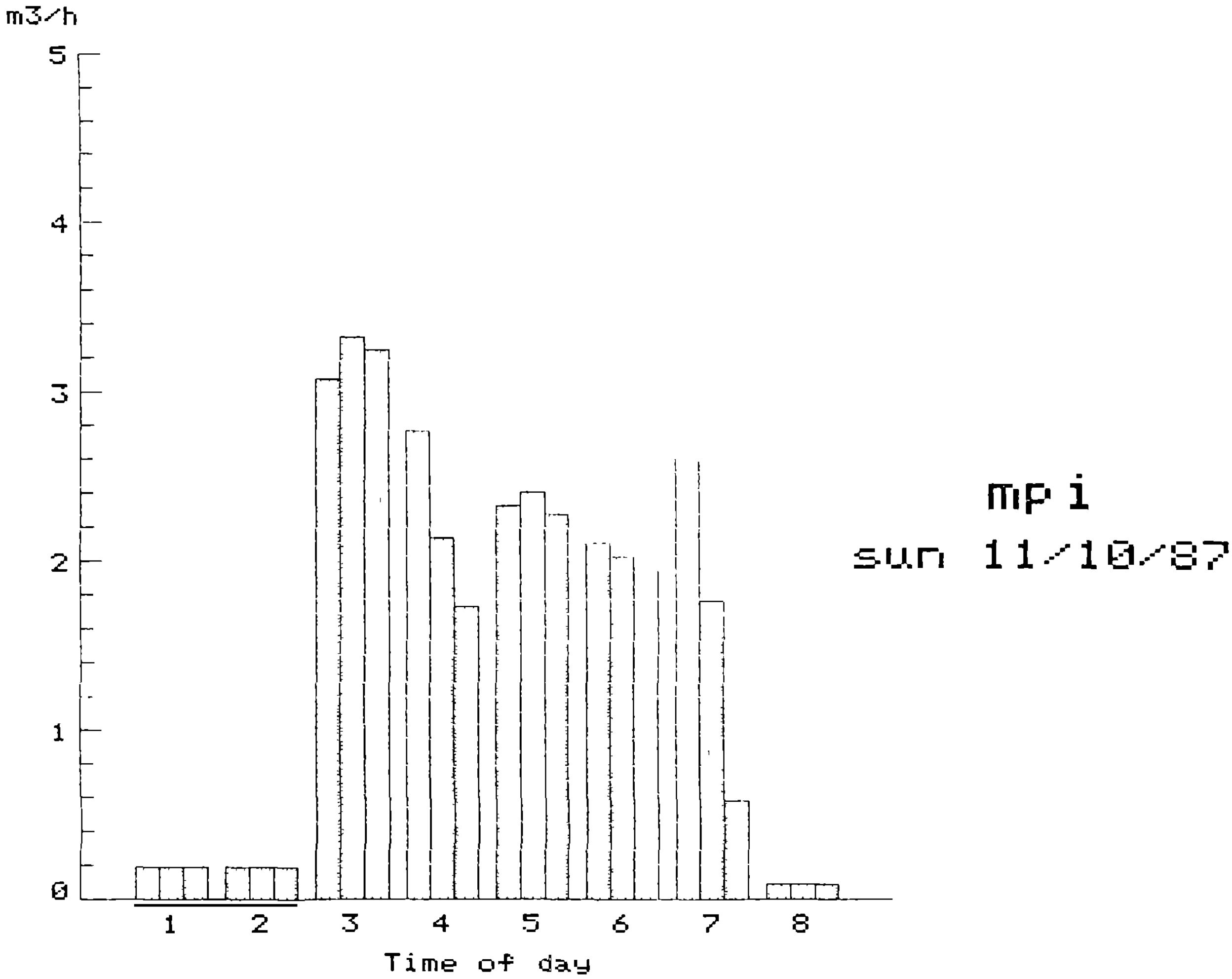
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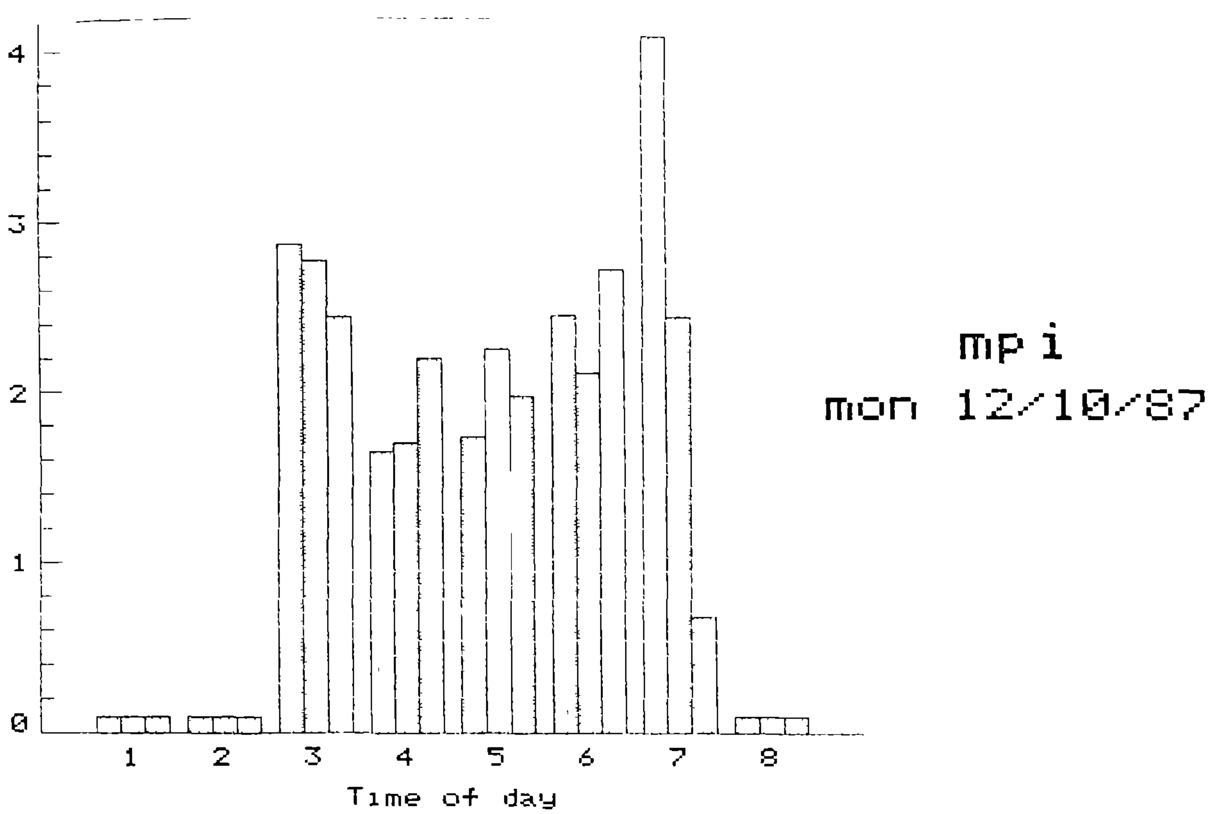
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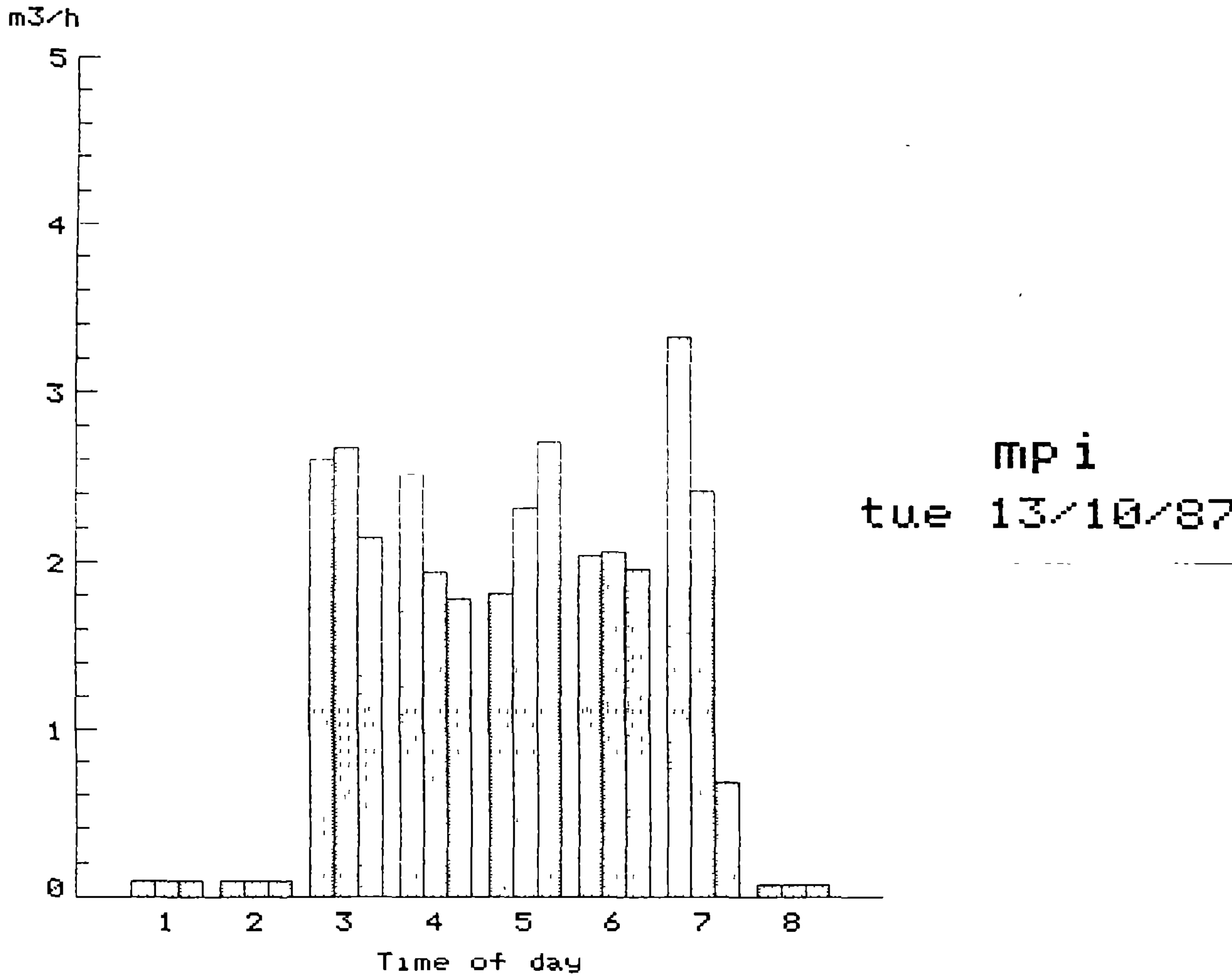
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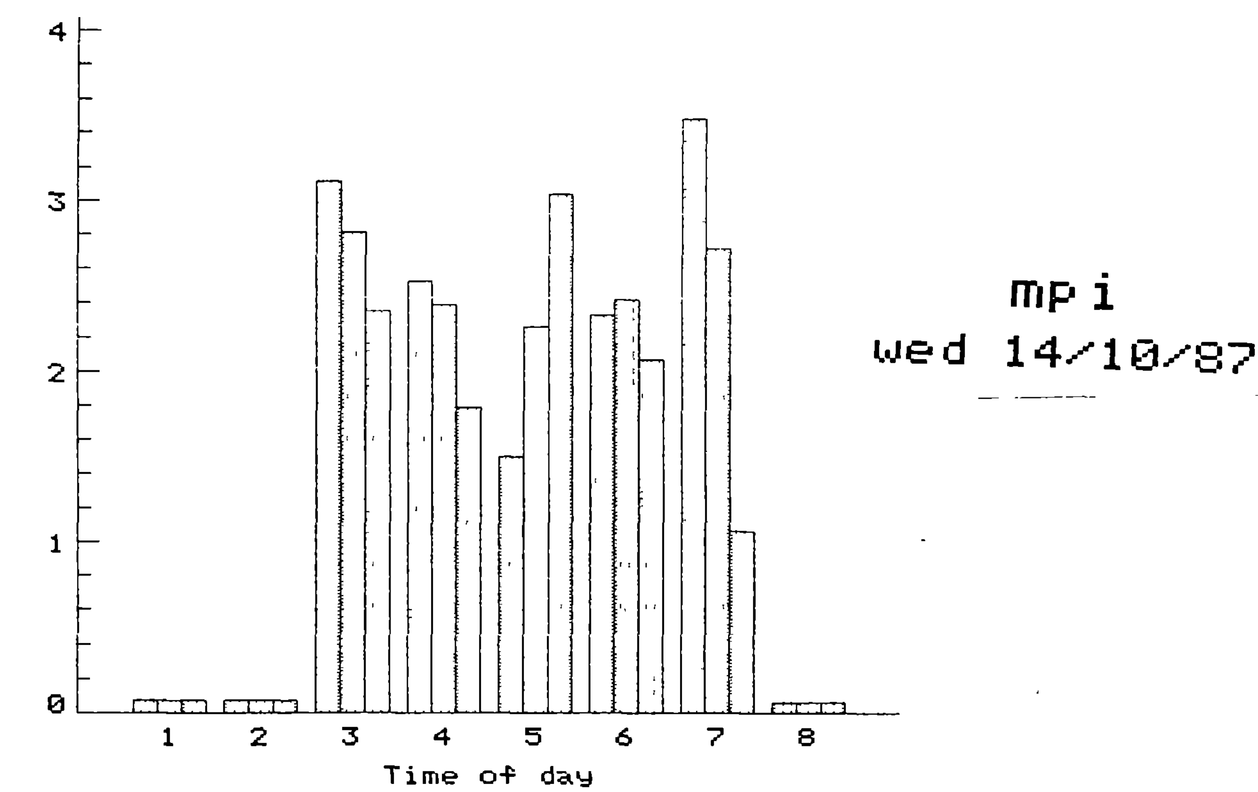
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Amani : Hourly Flow

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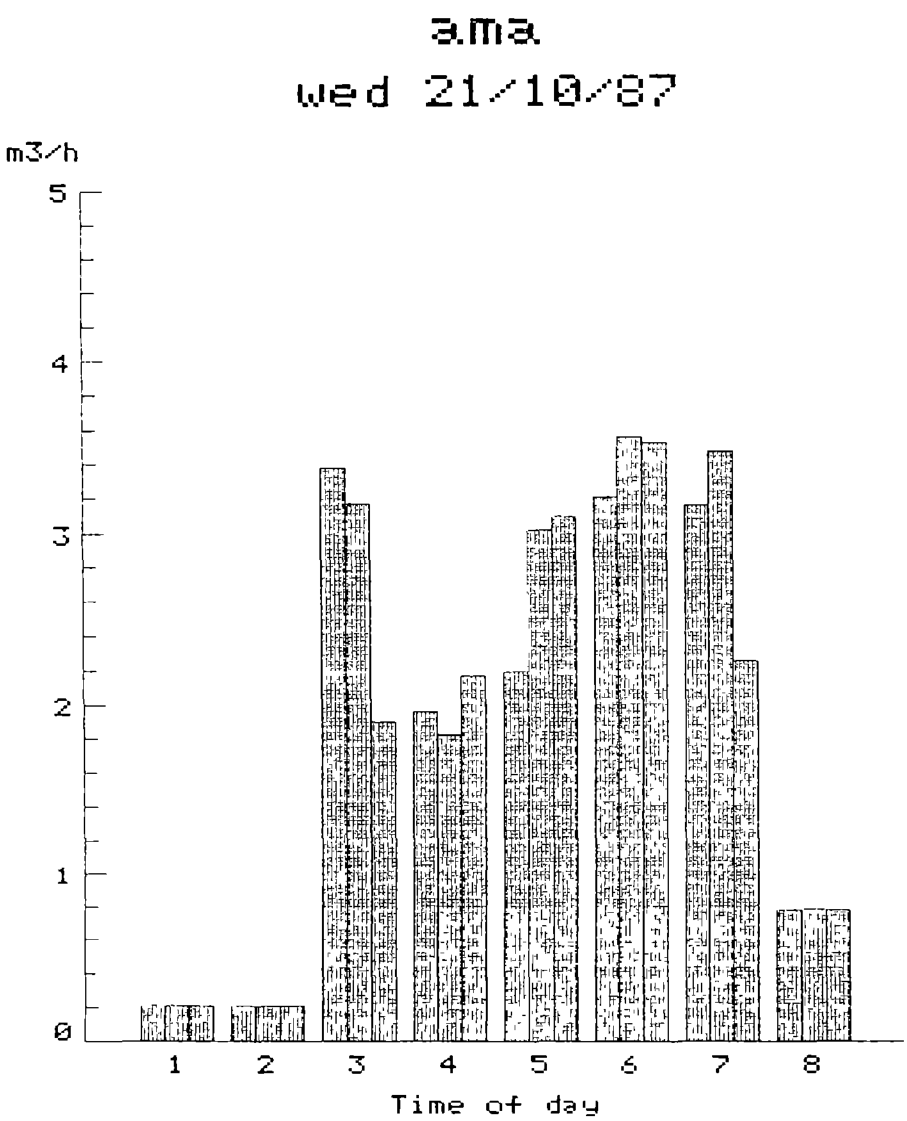

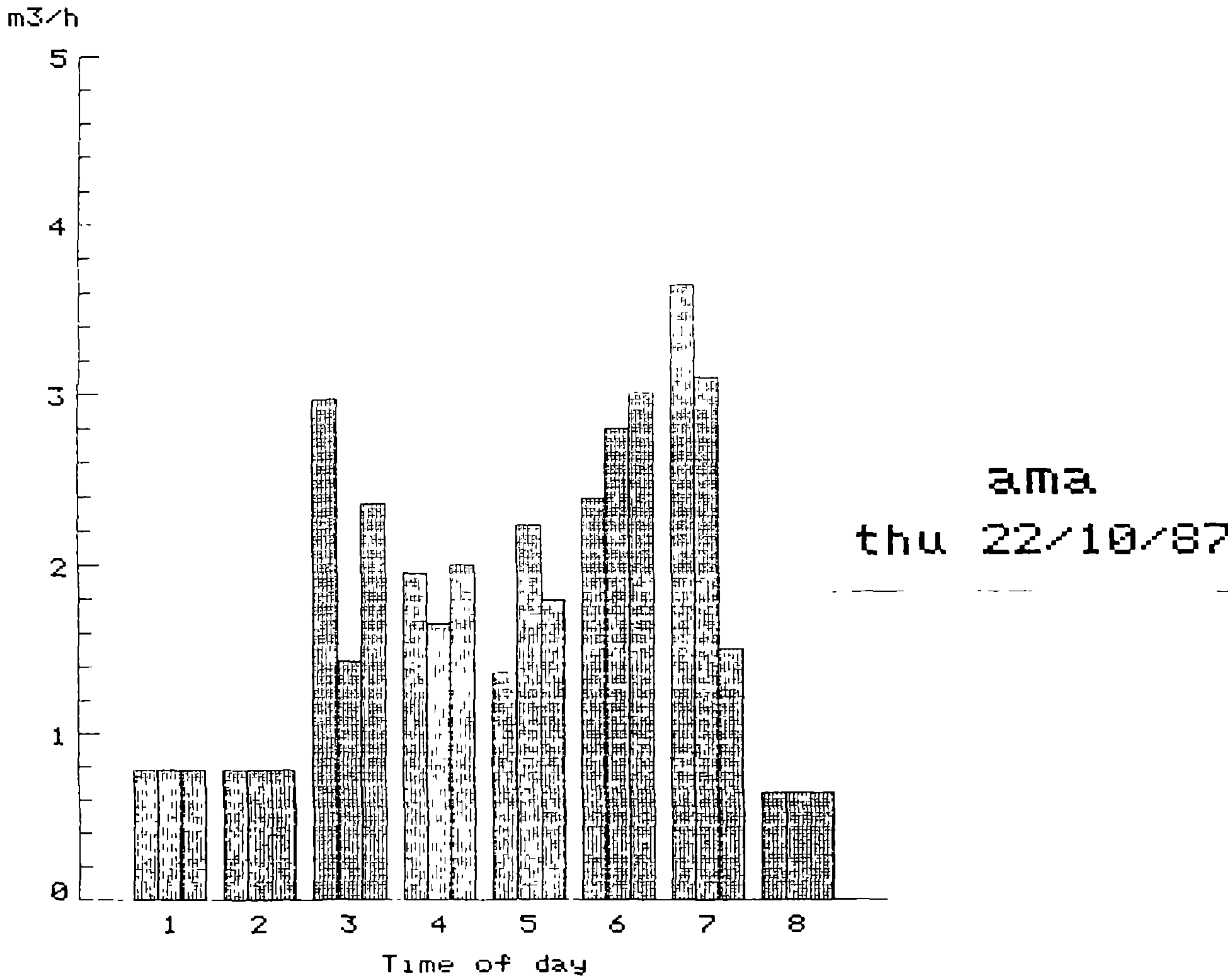
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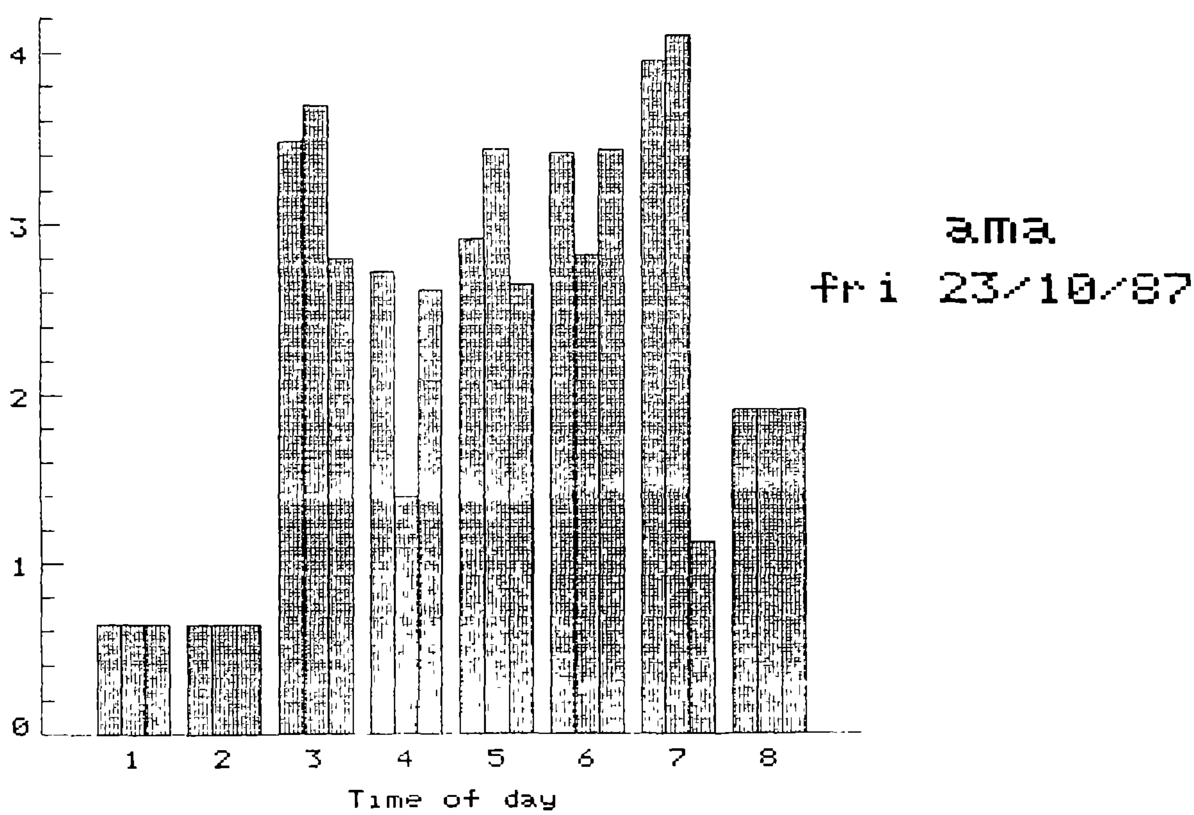
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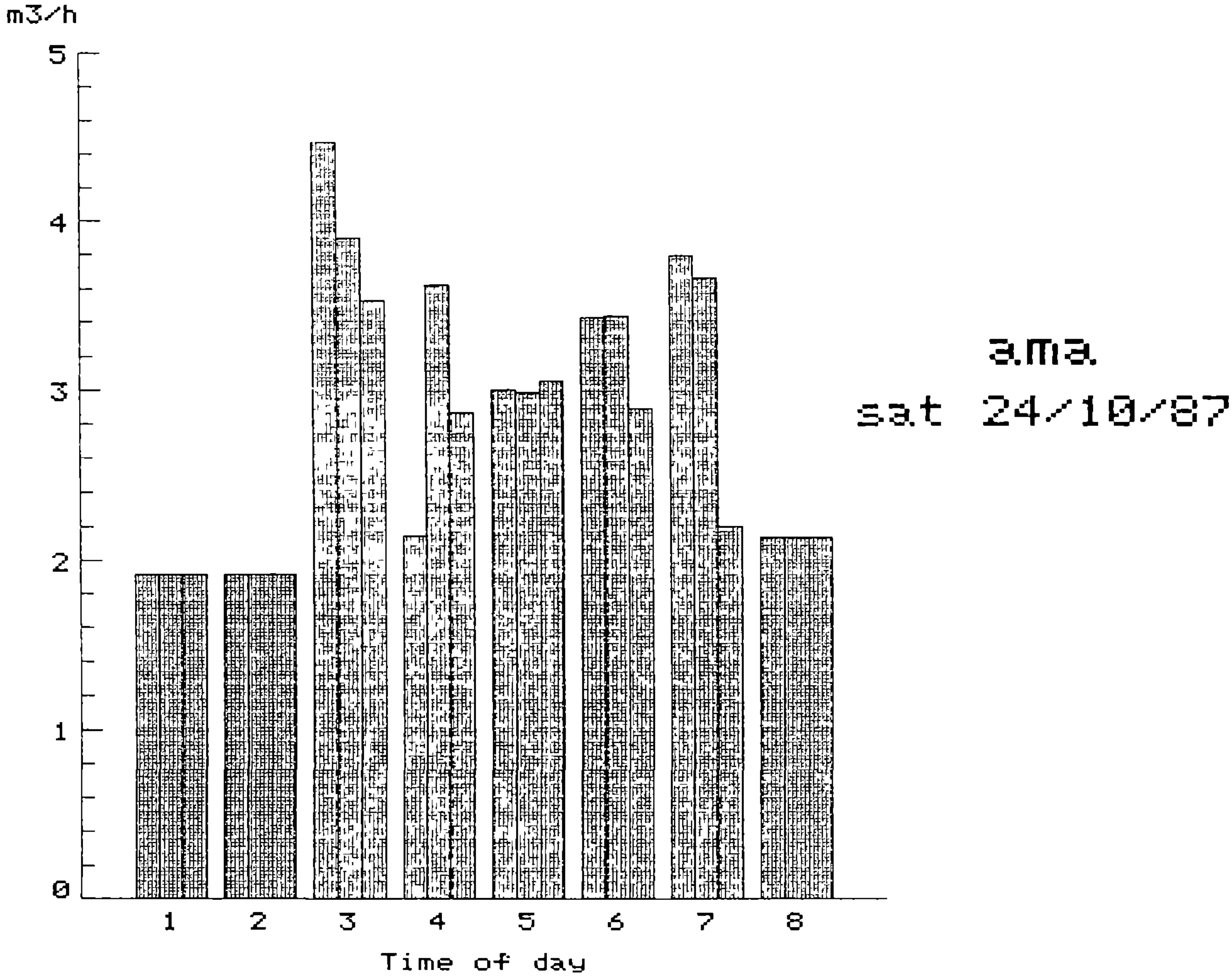
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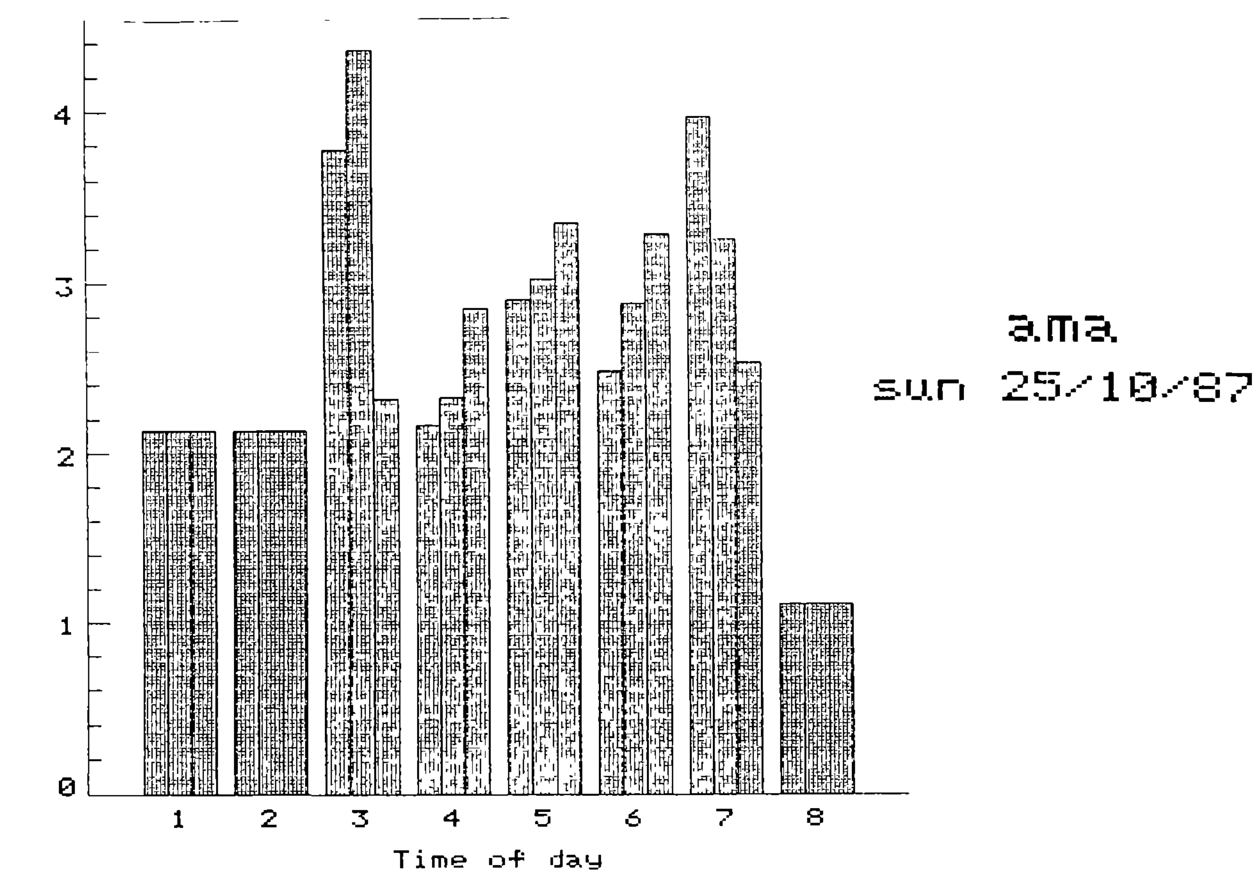
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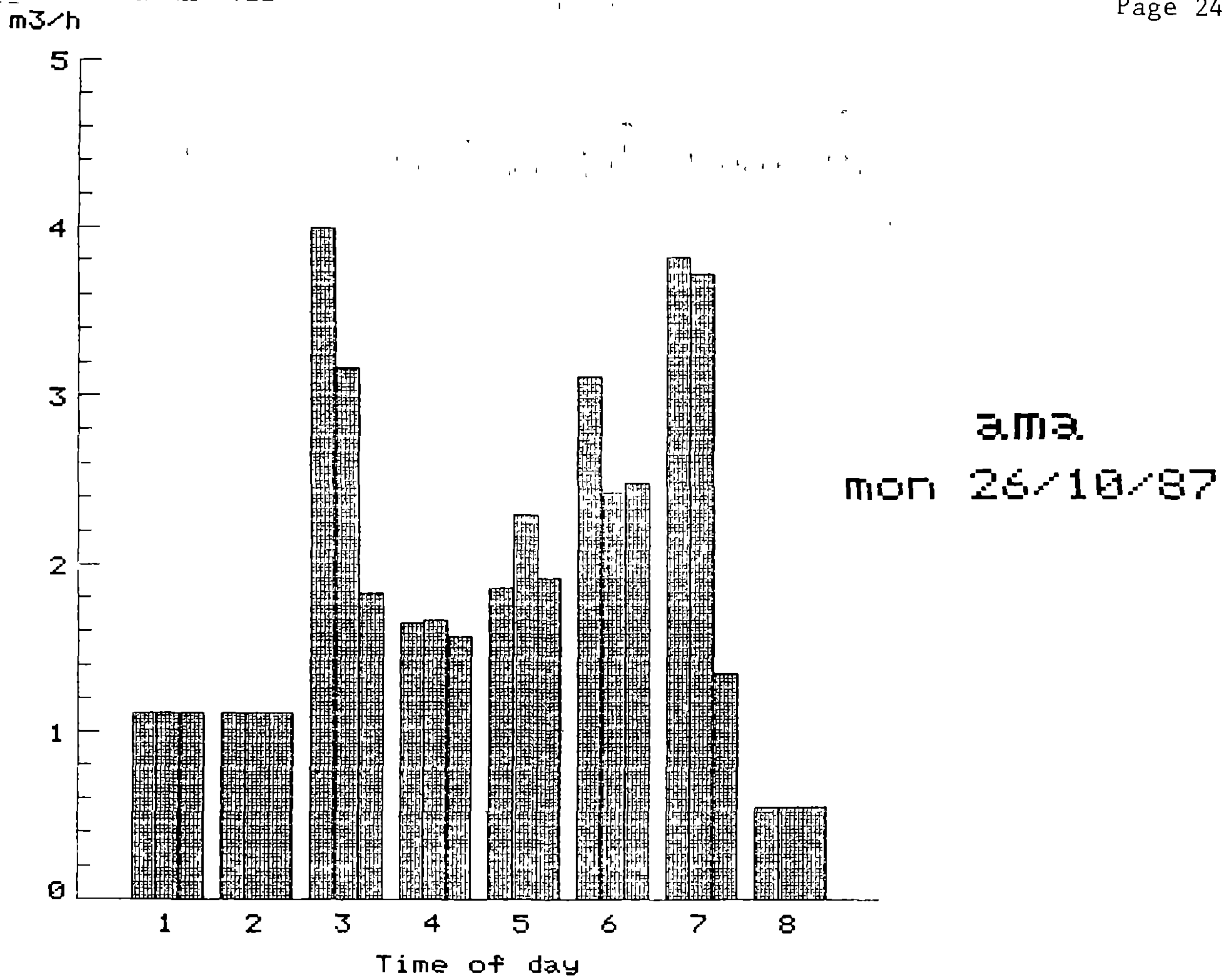
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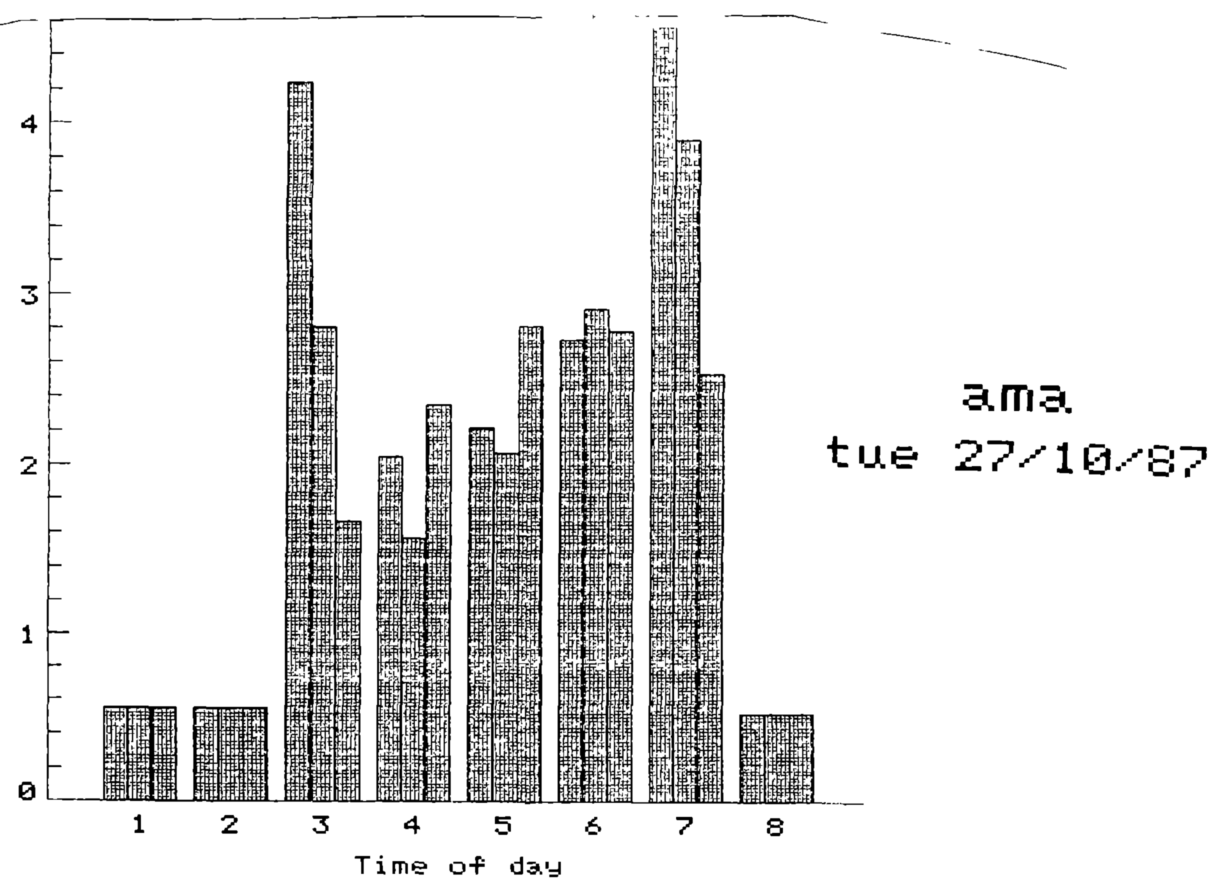
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APPENDIX VIII

COMPARISON OF
WMP STUDY AND
PRESENT STUDY
ON WATER USE

Comparison between Per Capita Water Consumption in WMP Study and this Study

The basis for the WMP figures for per capita water consumption was the results of interviews carried out on sample households in 8 villages in Iringa and Mbeya regions during 1980/81 (ref. WMP Volume 12, page 8.9). The data on water consumption were collected concurrently with collection of other data in a total of 55 villages from September 1980 to February 1981 in Iringa and Mbeya regions and from May to October 1981 in Ruvuma region.

About two thirds of the period (Iringa and Mbeya regions) were in months, which are normally in the rainy season, so based on the findings of this study, the figures collected during WMP are likely to be below the annual average. Furthermore, due to travelling time from regional town to villages and back, it is assumed that most of the interviews took place on Mondays to Fridays, which means that water consumption data collected relates to Sundays to Thursdays, which according to findings of this study in most cases are days with below average consumption. Design need to be for the maximum day, so adjustments shall also be made for the weekly maximum day.

Water use at the tap was included in the WMP figures, but no allowance was made for waste as defined in this study. Furthermore, there appears to be no allowance for water use at public facilities such as schools, dispensaries, bars, hotels, markets, etc.

By using factors of adjustment derived from this study (percentages in brackets) to WMP figures the WMP per capita consumption changes as shown in the following table.

Component	Amount	Sum
Basic per capita consumption	14.5 l	14.5 l
Water use at tap	2.9 l	17.4 l
Adjustment due to seasonal variations (15 to 20%)	3.0 l	20.4 l
Adjustment due to time of week for interviews (5%)	1.0 l	21.4 l
Water use at public facilitates	2.0 l	23.4 l
Allowance for peak days (12%)	2.8 l	26.2 l
Allowance for waste	1.0 l	27.2 l
Total	27.2 l	-

The figure 27.2 l per day shall be compared to the present figure of 30.1 l per day (design water demand less system losses and allowance for future, see Chapter 12). The remaining difference of some 3 l per day (some 10% only) can easily be due to the different methods applied in the two studies, but can also be caused by mis-information (probably unintentionally) by the ones interviewed.

From WMP Volume 12, Table 8.18 it can be derived that some 22% of the water is collected by children. This is significantly different from the observations of this study (see Chapter 13), which shows that some 40% of the water is collected by children. There is apparently a tendency by adults to underestimate the workload of the children, which in turn results in too low estimates of water consumption when the estimates are based on interviews. The tendency is supported by findings of the "Pre-evaluation Study" Chapter 7.

APPENDIX IX

COLLECTORS OF WATER

Item	Date 10/9/87 (Thu)			Date 13/9/87 (Sun)		
	Adults	Children Large Contain.	Children Small Contain.	Adults	Children Large Contain.	Children Small Contain.
Total Nos. of Collections	1,552	497	916	1,205	665	822
Actual consumption excl. loss and waste	48,472 1			34,421 1		
Estimated average volume used per collection	21.4	21.4	5.0	16.2	16.2	5.0
Percent of total volume	69%	22%	9%	57%	31%	12%
Average Nos. of collections per household	4.3	1.4	2.5	3.3	1.8	2.3

VILLAGE: Kasumulu

Item	Date 15/9/87 (Tue)			Date 13/9/87 (Sun)		
	Adults	Children Large Contain.	Children Small Contain.	Adults	Children Large Contain.	Children Small Contain.
Total Nos. of Collections	976	509	661	845	527	777
Actual consumption excl. loss and waste	35,669 1			32,479 1		
Estimated average volume used per collection	21.8	21.8	5.0	20.8	20.8	5.0
Percent of total volume	60%	31%	9%	54%	34%	12%
Average Nos. of collections per household	3.5	1.8	2.4	3.0	1.9	2.8

VILLAGE: Mlangali

Item	Date 29/9/87 (Tue)			Date 26/9/87 (Sat*)		
	Adults	Children Large Contain.	Children Small Contain.	Adults	Children Large Contain.	Children Small Contain.
Total Nos. of Collections	1,278	693	972	1,503	880	1,447
Actual consumption excl. loss and waste	45,074 1			48,653 1		
Estimated average volume used per collection	20.4	20.4	5.0	18.0	18.0	5.0
Percent of total volume	58%	31%	11%	.56%	32%	12%
Average Nos. of collections per household	2.8	1.5	2.1	3.3	1.9	2.5

VILLAGE: Kiponzelo   * Sat. was school holiday

Item	Date 28/9/87 (Mon)			Date 24/9/87 (Thu*)		
	Adults	Children Large Contain.	Children Small Contain.	Adults	Children Large Contain.	Children Small Contain.
Total Nos. of Collections	874	474	638	883	419	836
Actual consumption excl. loss and waste	27,690 1			27,113 1		
Estimated average volume used per collection	18.2	18.2	5.0	17.6	17.6	5.0
Percent of total volume	57%	31%	12%	58%	27%	15%
Average Nos. of collections per household	3.3	1.8	2.4	3.4	1.6	3.2

VILLAGE: Mbalamaziwa   * Thu. was school holiday

Item	Date 14/10/87 (Wed)			Date 11/10/87 (Sun)		
		Children			Children	
	Adults	Large Contain.	Small Contain.	Adults	Large Contain.	Small Contain.
Total Nos. of Collections	865	336	709	826	356	831
Actual consumption excl. loss and waste	34,420 l			33,606 l		
Estimated average volume used per collection	25.7	25.7	5.0	24.9	24.9	5.0
Percent of total volume	65%	25%	10%	61%	27%	10%
Average Nos. of collections per household	2.7	1.0	2.2	2.5	1.1	2.6

VILLAGE: Mpitimbi "B"

Item	Date 27/10/87 (Tue)			Date 25/10/87 (Sun)		
		Children			Children	
	Adults	Large Contain.	Small Contain.	Adults	Large Contain.	Small Contain.
Total Nos. of Collections	2,128	1,224	1,058	1,917	1,201	1,120
Actual consumption excl. loss and waste	46,316 l			49,029 l		
Estimated average volume used per collection	13.2	13.2	2.0	15.0	15.0	2.0
Percent of total volume	60%	35%	5%	59%	36%	5%
Average Nos. of collections per household	3.5	2.0	1.7	3.1	2.0	1.8

VILLAGE: Amani

APPENDIX X

PEAK FLOWS AND
PEAK FACTORS

Week Day	Rainy Season					Dry Season				
	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor
Tue	-	-	-	-	-	-	-	-	-	-
Wed	27.184	3.20	2.8	1.41	5.0	50.258	4.85	2.3	1.29	2.5
Thu	28.045	3.57	3.1	1.32	4.5	57,797	5.53	2.3	1.60	2.7
Fri	25.111	3.20	3.1	0.97	3.7	54.326	5.81	2.6	1.69	3.0
Sat	26.254	4.47	4.1	1.86	6.8	43.911	5.00	2.7	1.52	3.3
Sun	31.726	4.62	3.5	1.35	4.1	38.354	4.82	3.0	1.63	4.1
Mon	30.062	3.81	3.0	1.57	5.0	52.312	6.22	2.9	1.64	3.0
Tue	31.193	3.51	2.7	1.07	3.3	49.586	5.76	2.8	1.50	2.9
Wed	-	-	-	-	-	-	-	-	-	-
Max. flows to max. day	31.726	4.62	3.5	1.86	5.6	57.797	6.22	2.6	1.69	2.8
Max. flow per DP	-	0.33	-	0.13	-	-	0.44	-	0.12	-

Net Peak Flow and Factors Village: Kasumulu

Note: Figures are inclusive of contractor's camp

Week Day	Rainy Season					Dry Season				
	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor
Tue	21.028	2.52	2.9	0.83	3.8	-	-	-	-	-
Wed	22.540	2.84	3.0	0.86	3.7	32.224	3.25	2.4	0.95	2.8
Thu	25.762	2.87	2.7	0.92	3.4	32.567	3.23	2.4	1.13	3.3
Fri	26.357	3.41	3.1	1.00	3.6	35.973	4.43	3.0	1.38	3.7
Sat	29.762	3.54	2.9	1.12	3.6	36.960	3.33	2.2	1.11	2.9
Sun	25.657	3.60	3.4	1.00	3.7	31.846	3.80	2.9	1.26	3.8
Mon	21.500	3.06	3.4	0.94	4.2	33.386	3.15	2.3	1.06	3.0
Tue	-	-	-	-	-	35.187	3.59	2.4	0.99	2.7
Wed	-	-	-	-	-	-	-	-	-	-
Max. flows to max. day	29.762	3.60	2.9	1.12	3.6	36.960	4.43	2.9	1.38	3.6
Max. flow per DP	-	0.36	-	0.11	-	-	0.44	-	0.14	-

Net Peak Flow and Factors Village: Mlangali

Note: 10 DPs only

Week Day	Rainy Season					Dry Season				
	Net daily consump-tion	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor	Net daily consump-tion	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor
Tue	-	-	-	-	-	-	-	-	No master meter installed	-
Wed	-	-	-	-	-	42.040	4.85	2.8		-
Thu	-	-	-	-	-	45.306	4.42	2.3		-
Fri	-	-	-	-	-	40.222	4.32	2.6		-
Sat	-	-	-	-	-	48.653	5.02	2.5		-
Sun	-	-	-	-	-	42.016	5.77	3.3		-
Mon	-	-	-	-	-	38.987	3.53	2.2		-
Tue	-	-	-	-	-	45.074	3.80	2.0		-
Wed	-	-	-	-	-	-	-	-		-
Max. flows to max. day	-	-	-	-	-	48.653	5.77	2.8		-
Max. flow per DP	-	-	-	-	-	-	0.41	-		-

Net Peak Flow and Factors Village: Kiponzelo

Note: No master meter installed. Computations for dry season only.

Week Day	Rainy Season					Dry Season				
	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor
Tue	-	-	-	-	-	-	-	-	-	-
Wed	22.639	2.91	3.1	1.19	5.0	27.277	2.75	2.4	0.84	3.0
Thu	15.383	2.01	3.1	0.59	3.7	24.981	2.85	2.7	0.85	3.3
Fri	20.451	2.28	2.7	0.62	2.9	25.725	2.43	2.3	0.79	2.9
Sat	22.437	2.58	2.8	0.83	3.6	28.700	3.31	2.8	0.93	3.1
Sun	24.063	No Reading		-		25.963	4.07	3.8	1.12	4.1
Mon	11.383	1.48	3.1	0.49	4.1	26.133	3.04	2.8	1.04	3.8
Tue	15.612	1.87	2.9	0.63	3.9	27.399	4.60	4.0	1.37	4.8
Wed	-	-	-	-	-	-	-	-	-	-
Max. flows to max. day	24.063	2.91	2.9	1.19	4.7	28.700	4.60	3.8	1.37	4.6
Max. flow per DP	-	0.42	-	0.17	-	-	0.66	-	0.20	-

Net Peak Flow and Factors Village: Mbalamaziwa

Note: 7 DPs only

Week Day	Rainy Season					Dry Season				
	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor
Tue						-	-	-	-	-
Wed						-	-	-	-	-
Thu						36.133	3.72	2.5	1.48	3.9
Fri						36.201	3.51	2.3	1.15	3.0
Sat						40.192	4.53	2.7	1.71	4.1
Sun						33.606	4.19	3.0	1.29	3.7
Mon						32.796	4.19	3.1	1.16	3.4
Tue						32.887	3.48	2.5	1.03	3.0
Wed						34.420	3.93	2.7	1.20	3.3
Max. flows to max. day						40.192	4.53	2.7	1.71	4.1
Max. flow per DP						-	0.30	-	0.11	-

Net Peak Flow and Factors Village: Mpitimbi "B"

Week Day	Rainy Season					Dry Season				
	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor	Net daily consumption	Hourly peak flow	Hourly peak factor	Quarterly peak flow	Quarterly peak factor
Tue						(37.781)	(3.67)	(2.3)	(1.05)	(2.7)*
Wed						45.217	3.98	2.1	1.08	2.3 *
Thu						39.954	3.92	2.4	1.04	2.5 *
Fri						48.586	4.06	2.0	1.59	3.1
Sat						52.059	4.47	2.1	1.33	2.5
Sun						49.029	4.52	2.2	1.25	2.4
Mon						41.936	4.65	2.7	1.30	3.0
Tue						46.316	4.58	2.4	1.25	2.6
Wed						(50.360)	(3.79)	(1.8)	(1.20)	(2.3)
Max. flows to max. day						52.059	4.65	2.1	1.59	2.9
Max. flow per DP						-	0.31	-	0.11	-

Net Peak Flow and Factors Village: Amani

Note: Computations for dry season only.

* 10 taps only. The remaining days 15 taps.

DP No. / Nos.of users	Wed.9/9	Thu.10/9	Fri.11/9	Sat.12/9	Sun.13/9	Mon.14/9	Tue.15/9	Average	Maximum
1/118	0.195	0.148	0.277	0.286	0.208	0.408	0.224	0.249	0.408
2/ 98	0.256	0.237	0.297	0.324	0.318	0.323	0.332	0.298	0.332
3/101	0.320	0.339	0.509	0.157	0.251	0.420	0.224	0.317	0.509
4/ 83	0.224	0.436	0.274	0.211	0.278	0.278	0.196	0.271	0.436
5/103	0.261	0.492	0.690	0.270	0.571	0.380	0.200	0.409	0.690
6/128	0.525	0.493	0.579	0.433	0.249	0.676	0.502	0.494	0.676
7/227	0.530	0.576	0.487	0.359	0.393	0.554	0.311	0.459	0.576
8/ 86	0.312	0.222	0.532	0.451	0.192	0.480	0.257	0.349	0.532
9/121	0.881	0.685	0.921	0.661	0.875	0.671	0.564	0.751	0.921 Garden watering
10/106	0.741	0.848	0.734	0.695	0.481	0.605	0.778	0.697	0.848 Garden watering
11/163	0.633	0.516	0.435	0.456	0.537	0.406	0.719	0.529	0.719
12/222	0.335	0.340	0.343	0.360	0.551	0.542	0.344	0.402	0.551
13/134	0.358	0.546	0.755	0.413	0.376	0.518	0.869	0.548	0.869
14/ 39	1.144	0.991	0.956	0.963	0.348	1.118	1.632	1.022	1.632 Market brick making
Average of all	0.480	0.491	0.556	0.431	0.402	0.527	0.511	0.485	0.693
Average if DP 14 is left out	0.429	0.453	0.525	0.390	0.406	0.481	0.425	0.444	0.620

Note: Maximum flow rates are underlined

Kasumulu village - Peak flows per hour, dry season

APPENDIX XI

STORAGE DEMAND

Day and Date	Net daily consumption m3	Net storage demand: Actual m3	Net storage demand: Percent of net consump.
Wed. 9/9	43.7	15.3	35%
Thu. 10/9	48.5	17.2	35%
Fri. 11/9	47.7	17.8	37%
Sat. 12/9	40.7	15.2	37%
Sun. 13/9	34.4	14.1	41%
Mon. 14/9	43.9	16.9	38%
Tue. 15/9	44.6	16.8	38%
Average	43.4	16.2	37%
Maximum storage demand in relation to max.day		17.8	37%

Village: Kasumulu

(Maximum is underlined)

Day and Date	Net daily consumption m3	Net storage demand: Actual m3	Net storage demand: Percent of net consump.
Wed. 9/9	32.9	12.4	38%
Thu. 10/9	33.2	12.8	39%
Fri. 11/9	36.6	15.4	42%
Sat. 12/9	37.5	15.5	41%
Sun. 13/9	32.5	13.2	41%
Mon. 14/9	34.4	13.2	38%
Tue. 15/9	35.7	14.3	40%
Average	34.7	13.8	40%
Maximum storage demand in relation to max.day		15.5	41%

Village: Mlangali

(Maximum is underlined)

Day and Date	Net daily consumption m^3	Net storage demand	
		Actual m^3	Percent of net consump.
Wed. 23/9	42.0	16.7	40%
Thu. 24/9	45.3	17.8	39%
Fri. 25/9	40.2	16.6	41%
Sat. 26/9	48.7	19.3	40%
Sun. 27/9	42.0	17.4	41%
Mon. 28/9	39.0	15.4	39%
Tue. 29/9	45.1	17.3	38%
Average	43.2	17.2	40%
Maximum storage demand in relation to max.day		19.3	40%

Village: Kiponzelo

(Maximum is underlined)

Day and Date	Net daily consumption m^3	Net storage demand	
		Actual m^3	Percent of net consump.
Wed. 23/9	27.0	11.4	42%
Thu. 24/9	24.4	10.2	42%
Fri. 25/9	25.1	10.7	43%
Sat. 26/9	28.2	11.7	41%
Sun. 27/9	25.5	10.6	42%
Mon. 28/9	25.5	10.6	42%
Tue. 29/9	26.8	11.0	41%
Average	26.1	10.9	42%
Maximum storage demand in relation to max.day		11.7	41%

Village: Mbalamaziwa (7 DPs only)

(Maximum is underlined)

Day and Date	Net daily consumption m^3	Net storage demand	
		Actual m^3	Percent of net consump.
Thu. 8/10	36.1	14.7	41%
Fri. 9/10	36.2	13.0	36%
Sat. 10/10	40.2	14.4	36%
Sun. 11/10	33.6	11.7	35%
Mon. 12/10	32.8	12.2	37%
Tue. 13/10	32.9	12.3	37%
Wed. 14/10	34.4	12.6	37%
Average	35.2	13.0	37%
Maximum storage demand in relation to max.day		14.7	37%

Village: Mpitimbi "B"

(Maximum is underlined)

Day and Date	Net daily consumption m^3	Net storage demand	
		Actual m^3	Percent of net consump.
Wed. 21/10	45.2	15.1	33%
Thu. 22/10	40.0	11.1	28%
Fri. 23/10	48.6	16.4	34%
Sat. 24/10	52.1	15.8	30%
Sun. 25/10	49.0	13.9	28%
Mon. 26/10	41.9	12.1	29%
Tue. 27/10	46.3	13.8	30%
Average	46.2	14.0	30%
Maximum storage demand in relation to max.day		16.4	31%

Village: Amani

(Maximum is underlined)

APPENDIX XII

BASIS FOR COST ESTIMATES

BASIS FOR COST ESTIMATES (LATE 1987 PRICE LEVEL)

a) Group Scheme of 9 Villages in Iringa Region (Mbalamaziwa)

- Design population 22,600 (2,500 per village);
- Construction 1985 to 1988;
- Applied rate of inflation 5% per year on cost defined in DKK;
- Average exchange rates: 1985 - 1.60
  1986 - 3.63
  1987 - 9.00
- Total construction cost DKK 8,590,000/- or DKK 950,000/- per village and DKK 380/- per capita;
- Cost components:

Pipes and fittings	61%
Local materials & labour	15%
Transport	24%

b) Storage Tanks

- Construction cost 45 m^3 : TZS 295,000/-
- Construction cost 75 m^3 : TZS 420,000/-
- Increase in volume 67%, in cost 42%

c) "Average WMP Village"

Present population (1987/88)	2,000
10 Year population	2,650
Design population (2006)	3,500

- Construction cost per village based on extrapolation from (a) above: DKK 1,100,000/-

- Construction cost per capita: DKK 315/- (US $ 48.-)

- Cost components:

Cost components:	Pipes & fittings	60%
	Local materials & labour	15%
	(out of which 1/5 is cost of storage)	
	Transport	25%
	(out of which 1/6 is interregional)	

d) Cost of Pipes

- Current (late 1987) rates including freight;

- Average friction loss 0.5%;

- Transmission system: Flow increase of 44% (from 25 l/c/d to 36 l/c/d) increases pipe cost by 23.3%;

- Distribution system: Flow increase of 20% (from 25 l/c/d x 3 to 36 l/c/d x 2.5) increases pipe cost by 9.1%;

- Distribution of pipe cost: Transmission system 40%
  Distribution system 60%

- Total pipe cost increase: 14.8% say 15%

e) Phasing of Construction of Transmission System

- Cost of pipes in % of total construction cost:
  - Flow below 3 l/sec : 50%
  - Flow 3 - 6 l/sec : 60%
  - Flow 6 - 15 l/sec : 65%
  - Flow above 15 l/sec : 70%

- Phase 2 construction after 10 years;

- Capacity of phase 1 : 73% of design capacity