UNITED REPUBLIC OF TANZANIA

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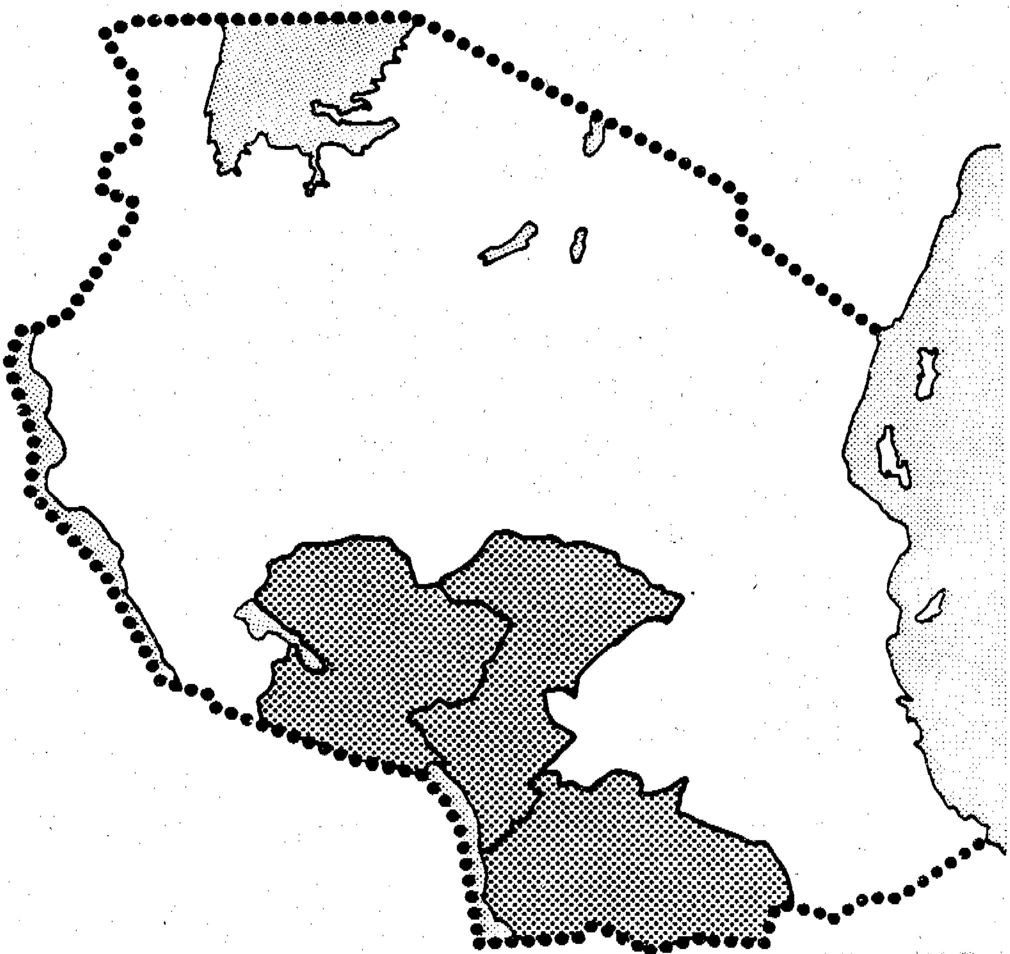
IMPLEMENTATION OF WATER MASTER PLANS FOR IRINGA, RUVUMA AND MBEYA REGIONS

HYDROLOGY - LOW FLOW GAUGINGS 1984



CARL BRO • COWICONSULT • KAMPSAX - KRÜGER • CCKK

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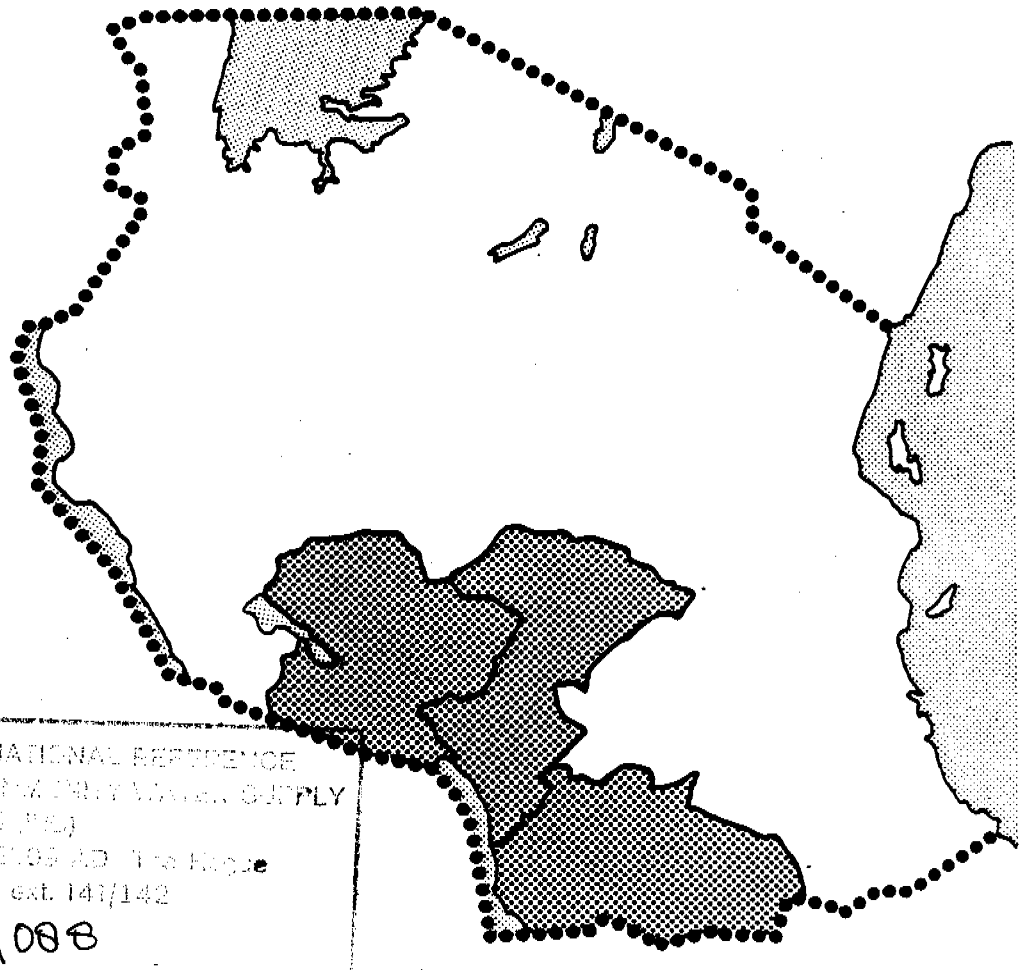

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LOW FLOW STUDIES IN IRINGA, MBEYA AND RUVUMA REGIONS, TANZANIA

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1. INTRODUCTION

The aim of the low flow study is to provide the best possible estimates of the 10-year minimum flows at the selected sources of the village water supply schemes. Such estimates will form the basis for the final design of the individual water supplies and for additional source investigations where selected sources do not have sufficient yields.

The low flow measurement programme was conducted during the months of September, October and November 1984. Two measurements were made at most of the selected sites with approximately one month lag-time between them. At some sites it was not possible to make the second measurement owing to unsually early and heavy rainfall.

The sources, at which the flows were measured, were selected according to the procedure outlined in the Working Paper "Minimum Flow Assessment at Village Level", September 1984, Appendix 1 of this report.

Questionnaires were filled in for each of the measured sites, and the analyses and conclusions from these are detailed in this report.

In addition, a correlation analysis of annual minimum discharges at the permanent hydrological stations in the same areas has been performed.

The field work in the three regions of Tanzania was carried out in close cooperation with the respective MAJI officers who provided helpful and capable field teams.

2. DESCRIPTION OF FIELD WORK

The data needed for the low flow study necessitated two different field activities, a) low flow measurements at 132 sources for future water supplies, and b) evaluation of the permanent hydrological network relevant for the study within the project area.

2.1 Low Flow Measurements

Two field teams in each region were in charge of conducting discharge measurements at pre-selected sites, see Appendix 1 "Working Paper, September 1984 for list of villages. Each team was equipped with a Landrover and put in charge of half the number of districts in their region.

The field teams visited between one and three sites a day and made discharge measurements by pygmy current meter on large and fairly large streams, by V-notch on smaller streams and by bucket on very small streams. The results were entered in a questionnaire where also answers to questions about the stream and the village were noted. These questionnaires have formed the basis for the following analyses.

The field teams and their work was checked at random times by the hydrologists and they have proven to be of very high quality.

The measurements were conducted at the end of the dry season in order to measure the baseflow (groundwater flow) unaffected by rainfall. The measurements were made with a timelag of approximately one month to enable calculation of the rate of depletion by means of which the absolute low flow of 1984 is estimated.

At some sites it was only possible to make one measurement and at other sites the second measurement had been affected by rain.

Two sites were not visited at all, and no estimates of low flow will be made at these sites.

2.2 Network Station Visits

The estimated low flow will be related to the lowest flow obtained in 1984 from the permanent hydrological network stations. To this end, visits to a number of gauging stations were necessary to have a picture of the reliability of the data collected from these.

10-year minimum flows have been calculated for 12 stations during the Water Mater Plan of Iringa, Mbeya and Ruvuma, see Table 1, and these flows will be used in the following analyses. Nine of the above mentioned twelve stations were visited by the hydrologist and one of the remaining three stations was closed because of road construction.

Altogether 19 of the most reliable stations in the network were visited in order to assess the reliability of the data - and out of these 18 stations were found to be in a satisfactory condition.

The water levels from a number of stations have been collected and converted to discharges of which the lowest for each station is found. The ratio of the minimum flow of 1984 and the 10-year minimum will then be used to scale the minimum flow of the measured streams in order to find its 10-year minimum.

Table 1 - 10-year minimum flows at selected hydrological stations

Station	River	Area	10-year minimum	
		km^2	$l/s/km^2$	l/s
1KA 22	Mtitu	445	2.5	1,130
1KA 37A	Lukosi	2890	2.8	8,092
1KA 32A	Lt Ruaha	759	0.3	228
1RC 8A	Kiwira	655	8.3	5,436
3A 8	Myovisi	152	1.6	243
1RC 5A	Kiwira	217	9.5	2,062
1KA 7A	Chimala	167	1.0	167
1RC 3A	Mbaka	645	3.9	2,540
3B 15	Mtembwa	8000	0.01	80
1RB 2	Ruhuhu	2220	6.67	14,830
1KB 19	Hagafiro	153	3.5	536
1KB 18B	Ruhudji	410	3.5	1,435
1RC 2A	Kiwira	1660	5.4	8,964

3. DATA ANALYSES

The questionnaires from each of the selected water supply sources have been analysed and a recession constant calculated, where possible. The recession constants are calculated using the equation

$$Q_2 = Q_1 \times e^{-k(t_2 - t_1)}$$

where

Q_1 is the discharge at the time t_1

Q_2 is the discharge at the time t_2

k is the recession constant varying for each catchment

The recession constants for the selected water supply sources are shown in Table 2.

The lowest discharge for 1984 for 11 out of the 12 selected hydrological stations plus that of station 1KB 18B was found. The number of days ($t_2 - t_1$) from the latest low flow measurement (Q_1) to the lowest discharge at the nearest hydrological station was then found and used in the above equation to find Q_2 (the absolute lowest flow for 1984 at the sources).

The station 1KB 18B was selected as the closest station to station 1KB 19, which has a calculated 10-year minimum, but has been closed because of the Makambako to Songea road construction. The 10-year minimum of 1KB 18B has been estimated by multiplying the 10-year minimum specific yield of 1KB 19 by the catchment area of 1KB 18B. The 10-year minima are shown in Table 1.

At each hydrological station the ratio of the 10-year minimum ($Q_{10\text{-year min}}$) and the lowest 1984 discharge ($Q_{min\ 1984}$) is found and used to scale the calculated 1984 minima of the sources ($q_{min\ 1984}$) near to it, in order to estimate their 10-year minima ($q_{10\text{-year min}}$).

Table 2 - Recession constants

Village name		Date	1st measurem. L/S	Date	2nd measurem. L/S	Recession Constant days^{-1}	Remarks
Iringa							
Ismani Group	1	84.10.03.	88.0	84.10.29.	81.2	0.0031	
	2	84.09.24.	7.7	84.10.26.	8.5		never dries
Tungamalenga		84.10.02.	204.0	84.10.31.	110.6	0.0202	
Nyamahana		84.10.02.	159.0	84.11.05.	155.0	0.0007	
Ilula		84.09.26.	19.2	84.10.27.	13.7	0.0105	
Tanangozi	1	84.09.28.	19.1	84.11.02.	18.8	0.0004	
	2	84.09.28.	8.2	84.11.02.	8.1	0.0002	
Magubike		84.10.01.	34.7	84.11.05.	32.3	0.0019	
Ikungwe		84.10.04.	0.62	84.11.06.	0.26	0.0252	
Mfukulembe		84.10.05.	1.98	84.11.01.	1.95	0.0005	
Idonda		84.10.09.	6.05	84.10.30.	10.85		never dries
Ilula Itunda		84.09.26.	10.2	84.10.27.	4.36	0.0262	
Image		84.09.29.	28.0	84.11.03.	40.6		never dries
Mtitu		84.11.07.	190.1				never dries
Mafuruto		84.10.06.					discharge too large to measure
Ibumu		84.10.29.	5.5				never dries
Mufindi							
Maduma *							
Mbalamaziwa		84.10.03.	8.4	84.10.29.	7.9	0.0021	
Nyakipambo		84.09.27.	0.35	84.10.29.	0.33	0.0018	
Igomaa		84.09.26.					dry
Kiliminzowo		84.10.09.	168.2	84.10.29.	106.4	0.0216	
Wambi		84.09.25.	53.4	84.10.27.	41.4	0.0077	
Njombe							
Ujindile		84.09.29.	5.2	84.10.30.	2.65	0.0206	
Boimanda		84.09.28.	8.2	84.10.31.	7.2	0.0042	
Usalule		84.09.29.	156.0	84.10.30.	154.0	0.0004	
Moronga		84.10.01.	9.9	84.11.02.	16.2		never dries
Makete							
Bulongwa		84.10.17.	16.9	84.11.05.	38.7		never dries
Lupalilo		84.10.16.	1.8	85.11.05	1.5	0.0092	
Ikonda		84.10.01.	0.31	84.11.04.	0.25	0.0061	
Matamba		84.10.18.	4.5	84.11.07.	3.3	0.0165	
Iwawa	1	84.10.16.	0.7	84.11.06.	1.95		never dries
	2	84.10.02.	5.4	84.11.06.	4.64	0.0044	
Kisinga		84.10.01.	10.7	84.11.05.	10.7		never dries
Ihanga		84.10.15.	2.9	84.11.04.	2.2	0.0131	
Ukwama		84.10.02.	1.5	84.11.04.	1.7		never dries
Masisewe		84.10.02.	0.35	84.11.03.	0.16	0.0234	
Mbalatse		84.10.13.	0.65	84.11.02.	0.7		never dries
Igolwa		84.10.15.	0.14	84.11.03.	0.22		never dries
Ukange		84.10.13.	1.37	84.11.03.	1.16	0.0075	

* Source has not been measured

Table 2 - Continued

Village name		Date	1st measurem. L/S	Date	2nd measurem. L/S	Recession Constant days^{-1}	Remarks
Ludewa							
Mawengi		84.10.19.	1.8	84.11.15.	1.6	0.0037	
Itundu	1	84.10.17.	0.7	84.11.13.	0.7		never dries
	2	84.10.17.	0.22	84.11.13.	0.16	0.0113	
Madunda	1	84.10.19.	0.50	84.11.15.	0.55		never dries
	2	84.10.17.	0.46	84.11.15.	0.38	0.0063	
Madilu	1	84.10.15.	0.37	84.11.12.	0.41		never dries
	2	84.11.12.	0.17				never dries
Lugarawa		84.10.15.	0.43	84.11.12.	0.41	0	never dries
Luilo	1	84.10.22.	0.60	84.11.14.	0.15	0.0561	
	2	84.10.22.	1.6	84.11.14.	1.48	0.0034	
Mbozi							
Mbozi West		84.10.05.	834.0	84.11.02.	503.0	0.0173	
Myovisi		84.10.10.	24.5	84.11.01.	22.95	0.0029	
Vwawa		84.10.07.	10.8	84.11.01.	9.5	0.0050	
Katete		84.10.04.	5.6	84.11.05.	7.6		never dries
Ihanda		84.10.09.	0.4				other source should be found
Isandula	1	84.10.06.	1.72	84.11.03.	1.66	0.0013	
	2	84.10.06.	12.2	84.11.03.	26.8		never dries
Senjele		84.10.01.	80.2	84.10.30.	77.7	0.0011	
Hezya		84.10.11.	168.0		180.0		never dries
Vwawa Township		84.10.11.	13.5				never dries
Ileje							
Isoko		84.10.14.	13.6	84.11.08.	29.5		never dries
Sheyo		84.10.13.	6.0				never dries
Itale	1	84.10.12.	13.5			Village position wrong, all villages on watershed	never dries
	2	84.10.12.	12.2				never dries
	3	84.10.12.	168.0				never dries
Mbeya							
Ilongo		84.10.20.	100.0	84.11.13.	177.0		never dries
Mbuyuni		84.10.20.	592.0	84.11.16.	905.0		never dries
Utengule		84.10.21.	184.0	84.11.13.	118.0	0.0183	
Ikhoho		84.10.22.	22.8	84.11.10.	12.1	0.0312	
Ihombe		84.09.28.	13.5	84.10.30.	11.9	0.0039	
Uyole		84.10.22.	6.3	84.11.11.	5.7	0.0053	
Iwindi	1	84.09.28.	24.9	84.10.30.	27.8		never dries
	2	84.09.28.	45.1	84.10.30.	52.0		never dries
Isuto		84.10.18.	9.6				never dries
Itimba		84.10.19.	83.0	84.11.10.	68.8	0.0081	
Rujewa		84.10.21.	2810.0	84.11.15.	2514.0	0.0043	
Ijumbi		84.10.26.	27.0	84.11.12.	30.3		never dries
Isangala		84.10.18.					new source should be found source runs dry

Table 2 - Continued

Village name		Date	1st measurem. L/S	Date	2nd measurem. L/S	Recession Constant $days^{-1}$	Remarks
Chunya							
Mtanila		84.10.17.					dry
Ngwala		84.10.19.	16.3	84.11.13.	9.2	0.0218	
Mkwajuni/Mwambani		84.10.22.	2.77	84.11.19.	2.4	0.0053	
Maleza		84.10.20.	0.96	84.11.17.	0.86	0.0038	
Namkukwe		84.10.26.					dry
Ifyenkenya		84.10.24.	638.6	84.11.15.	1557.0		never dries
Rungwe							
Nsigara		84.10.09.	9.24	84.11.05.	9.4		never dries
Kasiabone		84.10.10.	769.0	84.11.05.	320.0	0.0332	
Ndaga		84.09.29.	3.3	84.10.31.	2.05	0.0140	
Kanyelele		84.10.09.	5.0	84.11.07.	3.2	0.0154	
Ngopyolo		84.10.11.	13.7	84.11.08.	22.8		never dries
Lyenje		84.10.11.	0.065	84.11.07.	0.05	0.0093	
Nditu		84.10.08.	3.35	84.11.07.	2.34	0.0115	
Kyela							
Ngana		84.10.04.	32.1	84.11.03.	30.9	0.0012	
Ngamanga		84.10.06.	164.0	84.11.05.	80.0	0.0229	
Sinyanga		84.10.08.	16.5	84.11.03.	9.8	0.0193	
Songea							
Libango		84.10.19.	24.9	84.11.27.	31.6		never dries
Namabengo		84.11.29.	4.25				never dries
Mpitimbi		84.10.14.	0.46				never dries
Muhukuru		84.10.14.	0.76				never dries
Magagura	1	84.10.11.	0.10	84.11.06.	0.30		never dries
	2	84.10.11.	0.04	84.11.06.	0.05		never dries
Ngahokora		84.10.10.	0.13	84.11.07.	0.08	0.0158	
Matimira		84.10.04.	1.7				never dries
Nakahuga		84.10.05.	0.21	84.11.05.	0.19	0.0032	
Peramiho *							
Lipokela		84.10.09.	0.31	84.11.27.	0.25	0.0043	runs dry
Mbingamhalule		84.10.12.	0.12	84.11.07.	0.07	0.0182	
Limamu		84.10.17.	7.9	84.11.28.	3.2	0.0212	
Hanga		84.11.01.	5.4				never dries
Mlilayoyo		84.10.05.	0.6	84.11.30.	0.33	0.0106	
Mbimbi		84,10.16.	0.45	84.11.29.	0.58		never dries
Kilangalanga		84.10.17.	0.43	84.11.28.	1.0		never dries
Ngwinde		84.10.16.	0.2	84.11.29.	0.2		never dries
Mdwema		84.10.06.	0.13				never dries
Namatuhi		84.10.13.	1.5				
Njalamatata		84.10.17.	2.6	84.11.29.	4.1		never dries
Namangole		84.10.18.	1.21	84.11.28.	1.11	0.0021	
Lilondo	1	84.10.11.	0.48				never dries
	2	84.10.11.	0.69				never dries

* Source has not been measured

Table 2 - Continued.

Village name	Date	1st measurem. L/S	Date	2nd measurem. L/S	Recession Constant $days^{-1}$	Remarks
Mbinga						
Lundo	84.11.14.	7.2				never dries
Mango	84.11.14.	3.3				never dries
Ngindo	84.11.15.	444.0				never dries
Litembo	84.10.17.	6.9	84.11.20.	6.5	0.0015	
Ndumbi	84.11.12.	0.07				never dries
Kindimba chini	84.10.13.	2.7	84.11.08.	2.2	0.0081	
Kindimba juu	84.10.13.	0.5	84.11.08.	0.26	0.0216	
Linda	84.10.22.	1.3	84.11.26.	2.2		never dries
Kihangi	84.10.22.	0.09	84.11.26.	0.06	0.0112	
Silo	84.10.24.	0.32	84.11.26.	0.30	0.0020	
Wukiro	34.10.17.	1.7	84.11.20.	1.48	0.0044	
Mahenge	84.10.17.	0.43	84.11.20.	0.10	0.0420	
Myangayanga	84.10.20.	1.1				never dries
Miyao	84.10.25.	13.3	84.11.21.	20.4		never dries
Sepukila	84.10.18.	0.07				never dries
Malindindo	84.10.16.	4.4	84.11.21.	3.9	0.0031	
Mikalanga	84.10.16.	6.7	84.11.21.	8.0		never dries
Mpepai	84.10.21.					spring source supply out of order
Mbamba bay	84.10.26.	537.0	84.11.16.	3210.0		
Mapilipili Liwihi	84.10.24.	0.006	84.11.26.	0.002	0.0318	never dries
Nangombo	84.10.26.	565.0	84.11.16.	693.0		
Tunduru						
Matemanga	84.10.30.	6.6	84.11.26.	6.3	0.0015	
Nandembo	84.10.28.	2.1	84.11.13.	0.21	0.1272	
Machemba	84.10.27.	2.1	84.11.12.	1.7	0.0122	
Naluwale	84.10.27.	3.7	84.11.13.	2.3	0.0275	
Amani	34.10.23.	17.9	84.11.08.	14.6	0.0121	
Kindamba	84.10.30.	4.5	84.11.27.	2.2	0.0243	
Misyaje	84.10.24.	1.1	84.11.10.	1.3		never dries
Njenga	84.10.25.	32.3	84.11.10.	34.5		never dries
Marumba	84.10.25.	0.35	84.11.10.	0.33	0.0035	

The equation is shown below, and the calculated 10-year minima for the sources are shown in Table 3.

$$q_{10\text{-year min}} = q_{\text{min } 1984} \left(\frac{Q_{10\text{-min}}}{Q_{\text{min } 1984}}\right)$$

For the sources at which only one measurement is valid a recession constant of 0.0300 has been selected with which to calculate the minimum flow of 1984. This recession constant has been selected on the safe side in order not to calculate too large a low flow. The calculated low flow has then been scaled with the ratio of the nearest hydro-station, see equation above..

Table 3 10-year minimum flows

Village Name		Q1 L/S	Recession Constant k	Time lag t	Q min 1984 L/S	10-year minimum L/S
Iringa						
Ismani	1	81.2	0.0031	30	74	34.7
	2	7.7	0.0300	30	3.1	
Tungamalenga		110.6	0.0202	3	104.1	46.9
Nyamahana		155.0	0.0007	10	154	69.3
Ilula		13.7	0.0105	19	11.2	5.0
Tanangozi	1	18.8	0.0004	13	18.7	12.0
	2	8.1	0.0002	13	8.0	
Magubike		32.3	0.0019	10	31.7	14.3
Ikungwe		0.26	0.0252	9	0.21	0.1
Mfukulembe		1.95	0.0005	14	1.94	0.9
Idonda		6.05	0.0300	35	2.12	1.0
Ilula Itunda		4.36	0.0262	19	2.65	1.2
Image		28.0	0.0300	47	6.8	3.1
Mtitu		190.1	0.0300	47	46.4	20.9
Ibumu		5.5	0.0300	16	3.4	1.5
Mufindi						
Maduma						
Mbalamaziwa		7.9	0.0021	17	7.6	3.4
Nyakipambo		0.33	0.0018	17	0.32	0.14
Igomaa					0.0	0
Kiliminzowo		106.4	0.0216	17	73.7	33.2
Wambi		41.4	0.0077	19	35.8	16.1
Njombe						
Ujindile		2.65	0.0206	16	1.91	0.9
Boimanda		7.2	0.0042	15	6.76	3.0
Usalule		154.0	0.0004	16	153.0	68.9
Moronga		9.9	0.0300	46	2.5	1.1

Table 3 Continued

Village Name		Q_1 L/S	Recession Constant k	Time lag t	Q min 1984 L/S	10-year minimum L/S
Makete						
Bulongwa		16.9	0.0300	30	6.9	3.1
Lupalilo		1.5	0.0092	10	1.4	0.6
Ikonda		0.25	0.0061	11	0.23	0.1
Matamba		3.3	0.0165	8	2.9	1.3
Iwawa	1	0.7	0.0300	30	0.3	2.1
	2	4.64	0.0044	9	4.46	
Kisinga		10.7	0.0300	10	7.93	3.6
Ihanga		2.2	0.0131	11	1.9	0.9
Ukwama		1.7	0.0300	11	1.22	0.6
Masisiwe		0.16	0.0234	12	0.12	0.1
Mbalatse		0.65	0.0300	13	0.44	0.2
Igolwa		0.14	0.0300	12	0.1	0.1
Ukange		1.16	0.0075	12	1.06	0.5
Ludewa						
Mawengi		1.6	0.0037	0	1.6	0.7
Itundu	1	0.7	0.0300	2	0.66	0.4
	2	0.22	0.0300	2	0.21	
Madunda	1	0.50	0.0300	0	0.88	0.4
	2	0.38	0.0063	0		
Madilu	1	0.37	0.0300	3	0.49	0.2
	2	0.17	0.0300	3		
Lugarawa		0.41	0.0300	3	0.37	0.2
Luilo	1	0.15	0.0561	1	0.14	0.7
	2	1.48	0.0034	1	1.47	
Mbozi						
Mbozi West		503.0	0.0173	6	453	453
Myovisi		24.5	0.0300	7	19.9	19.9
Vwawa		9.5	0.0300	10	7.0	7.0
Vwawa Township		13.5	0.0300	6	11.3	11.3
Katete		5.6	0.0300	13	3.8	3.8
Ihanda		0.4	0.0300	8	0.3	0.3
Isandula	1	1.66	0.0300	11	1.2	1.2
	2	12.2	0.0300	11	8.8	8.8

Table 3 Continued

Village Name		Q1 L/S	Recession Constant k	Time lag t	Q min 1984 L/S	10-year minimum L/S
Mbozi						
Senjele		77.7	0.0300	16	48.1	48.1
Hezya		168.0	0.0300	6	140.3	140.3
Ileje						
Isoko		13.6	0.0300	52	2.86	2.6
Sheyo		6.0	0.0300	53	1.22	1.1
Itale	1	13.5	0.0300	54	2.67	2.5
	2	12.2	0.0300	54	2.41	2.2
	3	168.0	0.0300	54	33.25	30.6
Mbeya						
Ilongo		100.0	0.0300	33	37.16	18.6
Mbuyuni		592.0	0.0300	33	220	110
Utengule		118.0	0.0184	8	102	51
Ikhoho		12.1	0.0312	13	8.3	4.1
Ihombe		11.9	0.0039		11.9	11.9
Uyole		5.7	0.0053		5.7	5.7
Iwindi	1	24.9	0.0300	19	14.1	39.6
	2	45.1	0.0300	19	25.5	
Isuto		9.6	0.0300	0	9.6	9.6
Itimba		68.8	0.0081		68.8	68.8
Rujewa		2514.0	0.0043	18	2327	1573
Ijumbi		27.0	0.0300	26	12.4	6.2
Isangala					0	0
Chunya						
Mtanila					0.0	0
Ngwala		9.2	0.0218	18	6.2	4.7
Mkwajuni/Mwam.		2.4	0.0053	12	2.3	1.7
Maleza		0.86	0.0038	14	0.82	0.6
Namkukwe					0.0	0
Ifyenkenya		638.6	0.0300	15	407	100

Table 3 Continued

Village Name		Q1 L/S	Recession Constant k	Time lag t	Q min 1984 L/S	10-year minimum L/S
Rungwe						
Nsigara		9.24			9.2	8.3
Kasiabone		320.0	0.0332	30	118.2	108.4
Ndaga		2.05	0.0140	0	2.05	1.85
Kanyelele		3.2	0.0154	29	2.1	1.9
Ngopyolo		13.7			13.7	12.3
Lyenje		0.05	0.0093	33	0.037	0.034
Nditu		2.34	0.0115	29	1.7	1.6
Kyela						
Ngana		30.9	0.0012	0	30.9	13
Ngamanga		80.0	0.0229	0	80.0	35
Sinyanga		9.8	0.0193	0	9.8	4.0
Songea						
Libango		24.9	0.0063	27	21.0	18.9
Namabengo		4.25	0.0300	9	3.24	2.9
Mpitimbi		0.46	0.0300	31	0.2	0.2
Muhukuru		0.76	0.0300	31	0.3	0.3
Magagura	1	0.10	0.0300	35	0.1	0.1
	2	0.04	0.0300	35	0.01	
Ngahokora		0.08	0.0158	36		0.1
Matimira		1.7	0.0300	41	0.5	0.5
Nakahuga		0.19	0.0032	40	0.1	0.1
Peramiho						
Lipokela		0.25	0.0043	11	0.24	0.2
Mbingamhalule		0.07	0.0182	8	0.05	0.1
Limamu		3.2	0.0212	0	3.2	2.9
Lilondo	1	0.48	0.0300	35	0.16	0.4
	2	0.69	0.0300	35	0.23	
Hanga		5.4	0.0300	15	3.44	3.1
Mlilayoyo		0.33	0.0106	0	0.33	0.3
Mbimbi		0.45	0.0300	30	0.25	0.2
Kilangalanga		0.43	0.0300	28	0.25	0.2
Ngwinde		0.20	0.0300	0	0.20	0.2

Table 3 Continued

Village Name	Q1 L/S	Recession Constant k	Time lag t	Q min 1984 L/S	10-year minimum L/S
Songea					
Mdwema	0.13	0.0300	40	0.1	0.1
Namatuhi	1.5	0.0300	32	0.57	0.5
Njalamatata	2.6	0.0300	28	1.12	1.0
Namanguli	1.11	0.0021	0	1.11	1.1
Mbinga					
Lundo	7.2	0.0300	0	7.2	6.5
Mango	3.3	0.0300	0	3.3	3.0
Ngindo	444.0	0.0300	0	444.0	400
Litembo	6.5	0.0015	0	6.5	5.9
Ndumbi	0.07	0.0300	0	0.07	0.1
Kindimba chini	2.2	0.0081	7	2.1	2.1
Kindimba juu	0.26	0.0216	7	0.22	
Linda	1.3	0.0300	23	0.65	0.6
Kihangi	0.06	0.0112	0	0.06	0.1
Silo	0.30	0.0020	0	0.30	0.30
Wukiro	1.48	0.0044	0	1.48	1.3
Mahenge	0.10	0.0420	0	0.10	0.1
Myangayanga	1.1	0.0300	25	0.5	0.4
Miyao	13.3	0.0300	20	7.3	6.6
Sepukila	0.07	0.0300	28	0.03	0.1
Malindindo	3.9	0.0031	0	3.9	3.5
Mikalanga	6.7	0.0300	30	2.7	2.5
Mpepai					
Mbamba Bay	537.0	0.0300	20	295	265
Mapipili Liwihi	0.002	0.0318	0	0.002	0.1
Nangombo	565.0	0.0300	20	310	280
Tunduru					
Matemanga	6.3	0.0015	0	6.3	5.7
Nandembo	0.21	0.1272	2	0.2	0.2
Machemba	1.7	0.0122	3	1.64	1.5
Naluwale	2.3	0.0275	2	2.2	2.0

Table 3 Continued

Village Name	Q_1 L/S	Recession Constant k	Time lag t	Q min 1984 L/S	10-year minimum L/S
Tunduru					
Amani	14.6	0.0121	7	13.4	12.1
Kindamba	2.2	0.0243	0	2.2	2.0
Misyaje	1.1	0.0300	20	0.6	0.5
Njenga	32.3	0.0300	20	17.7	16.0
Marumba	0.33	0.0035	5	0.32	0.3

4. VILLAGE WATER DEMAND VERSUS AVAILABILITY

The village water demand has been calculated during the Water Master Plan of Iringa, Mbeya and Ruvuma for each water supply scheme and has been based on the expected population in the year 2006, multiplied by the amount of water needed per capita per day. Some of the future populations seem to have been estimted rather too high, especially for the arid ares, and it may be advisable to look into this matter. The populations in question are marked by an asterix in Table 4.

Below is a list of water demands versus availability - from which it can be seen that 49% of the village water supply schemes measured will have sufficient water in the year 2006.

In 51% of the schemes the water available is less than what will be needed, and in these schemes it is very important to locate other sources with large enough minimum flows, either to supply all the water needed, or at least enough to supplement the proposed source. Should this not be possible, then an alternative solution, i.e. shallow wells, must be considered.

At some sites it has been difficult to measure the water available, either because of seepage over a large area, or because of water collects underground, resulting in little or no surface flow. Therefore, some of the measurements do not reflect the actual amount of water available. A brief description of each site at which there was a deficit is therefore needed.

Iringa Region, Iringa District

Ilula, Group:

Additional sources may be needed to supply the proposed amount of water. Reconnaissance will be needed.

Ikungwe, Single:

Several streams run through the village, and intakes could be constructed on one or more of these streams. Measurements on these streams will determine how many intakes are necessary.

Ilula Itunda, Single

The measurements were made 100 m upstream of the intake structure, but even so, it is necessary to provide additional water, which may be found in nearby streams.

Image, Group

Since only one measurement was valid here it is difficult to say if the the amount of water available is too small. Additional measurements are necessary here.

Mtitu, Group

There may be enough water available here, but since only one measurement is valid it is difficult to say. Additional measurements are needed to ascertain the quantities of water.

Iringa Region, Mufindi District

Mbalamaziwa, Group

Additional sources are necessary in order to supply the needed amount of water.

Nyakipambo, Group

This group scheme consists of Nyakipambo, Mtambula and Ihegele villages, which in the Water Master Plan were single schemes. It would be an idea either to go back to the original proposal, or to make an additional intake on Msolwa river if enough water is available here.

Igomaa, Single

A new source has to be found here as the proposed source runs dry. Several rivers run parallel to the proposed source, and intakes could be constructed on these when measurements have shown if there is enough water.

Iringa Region, Njombe District

Moronga, Group

It is possible that enough water is available here, but as there is only one valid measurement it is difficult to estimate an exact 10-year minimum.

Iringa Region, Makete District

Bulongwa, Group; Iwawa, Group; Ukwama, Single; Mbalatse, Single; Ukange, Single

At all these villages there may be enough water available, but because only one valid measurement is available it is difficult to be certain, and additional measurements are recommended.

Lupalilo, Group

Several sources run parallel to the proposed source so that intakes could be established on one or more of these, if additional measurements prove the necessity.

Ikonda, Single

Additional intakes should be possible on sources either parallel to the proposed village or southeast of the village.

Matamba, Group

Additional sources are available in the vicinity to augment the supply of the existing, but measurements should be made before selecting the source or sources.

Masisiwe, Single

Several additional sources are available in or near the village, but it may be a problem to get enough head as the village is situated on the watersheds.

Igolwa, Single

This village is also located on the watershed so, even though there are plenty of sources in the vicinity, there is a problem of enough head.

Iringa Region, Ludewa District

Mawengi, Single

Additional sources are needed to supply the necessary amount of water. A reconnaissance must be made to find a suitable supply.

Itundu, Group

Only the proposed sources were measured, therefore it is very likely that the three existing intakes can supply the remaining water, only measurements here can ascertain this.

Madunda, Single

An additional source should be found in order to supply adequate amounts of water.

Madilu, Single

This village is situated on the watershed, so even though plenty of sources are available, not enough head can be found.

Lugarawa, Single

Several additional sources are available here so that intakes on one or more of them could solve the problems of too little water.

Luilo, Group

The potential intake sites should be measured and if enough water is available they should be developed to supplement the proposed sites.

Mbeya Region, Mbeya District

Isangala, Group

The proposed source runs dry here, therefore another source should be found if possible, otherwise alternative supply must be sought.

Mbeya Region, Mbozi District

Ihanda, Single

If enough head is available the proposed intake may be moved downstream to the confluence of the tributary from the south, but measurements should be made beforehand to make sure this is a viable solution.

Mbeya Region, Chunya District

Mtanila, Group

The proposed year 2006 population seems unrealistic, it is doubtful that the soil can support such a population expansion. The source runs dry so that additional sources must be found or shallow wells proposed.

Mwambani/Mkwajuni, Single

Additional sources are needed if the future population has to be supplied. The population increase does seem unrealistic.

Maleza, Single

The population increase seems somewhat unrealistic in such a dry area, but possibly additional sources could be found.

Namkukwe, Single

Additional sources are necessary here as the proposed source runs dry, shallow wells may be a possibility.

Mbeya Region, Rungwe District

Lyenje, Single

This is a spring source and very difficult to measure accurately. Seepage around the source was noticed, therefore it is possible that enough water is available. Additional measurements downstream may give better results.

Ndaga, Group

Additional intakes will be necessary if the proposed supply shall be met, and several sources flowing parallel to the proposed source could supply the required water. Measurements of the amounts will determine the number of necessary additional intakes.

Ruvuma Region, Songea District

Namabengo, Group

The water available is sufficient at present, but cannot supply a future larger population. However, there are several streams to the west and south of the village which could supply the required water, and additional intakes could be constructed there.

Mpitimbi, Group

Mpitimbi already has a source that supplies part of the group. Only one intake was measured although there are two; therefore the yield should be higher. The measurements are very difficult to perform as the water is collected by infiltration wells. The supply here is considered sufficient.

Muhukuru, Group

It is necessary to locate an additional source here as the supply is inadequate.

Magagura, Single

The measurements seem to have been made on another source than the one proposed. The proposed source could later be developed to supplement the one MAJI has selected.

Ngahokora, Single

This source was measured close to its spring source. The intake could be moved downstream and then possibly supply the whole village.

Matimira, Single

The intake site here is very wet but difficult to measure. If the amount of water proves to be too small there will be several possibilities of additional sources nearby; however, they will probably be too low for gravity schemes.

Nakahuga, Single

Several additional sources exist to supplment the proposed source but measurements must take place in order to select the best suited.

Peramiho, Group

It was not possible to perform any measurements here as the water is collected by infiltration galleries, but there seems to be a sufficient supply.

Lipokela, Group

There is an existing bamboo scheme here, which could be supplemented by other sources.

Mbingamhalule, Single

The intake could be moved some distance downhill, but will probably have to be supplemented by other sources.

Lilondo, Single

There are probably no additional sources, therefore other alternatives must be considered if the proposed amount of water shall be supplied.

Mlilayoyo, Single

The measurements made here are not exact as the area is very swampy, and therefore the discharge is very difficult to measure. The amount of water available is considered sufficient.

Mbimbi, Single; Ngwinde, Single; Mdwema, Single; Namatuhi, Single

Additional sources have to be found and measured as the proposed source cannot meet the demand.

Njalamatata, Group

This is a Danida scheme built on MAJI recommendation. In order to supply the future demand an additional source will have to be found.

Namangole, Group

The area is very swampy and therefore very difficult to measure, but the available supply seems to be sufficient.

Kilangalanga, Single

The measurement here seems unrealistic, and the source ought to yield more. Additional measurements are recommended.

Mbinga District

In the mountainous regions of Mbinga District the population tends to be very scattered within the villages and to a large extent to inhabit the watershed areas. As such, it is very difficult to find sources that originate from higher elevations than the habitation. The area is supplied by water through thousands of small streams, all perennial and all with small yields near their spring source. In fact, most houses have their own little furrow that leads water past their house. It is therefore a diffcult task to better their supply through one intake, as parts of the village will always be situated too high for such a supply. A solution, however, would be to construct several small intakes and thereby supply the whole village. Villages with such problems are Linda, Kihangi Mahuka, Silo, Wukiro, Mahenge, Myangayanga, Sepukila and Mapipili Liwihi.

Ndumbi, Single

Plenty of additional sources exist so that adequate water supply should not be a problem. Measurements should be made before selecting an additional source.

Mpepai, Single

Measurements are very difficult here as water is collected in an infiltration well, but the amount is considered sufficient.

Tunduru District

Nandembo, Single; Machemba, Group

Measurements are difficult here as the intake is situated in a pond. The supply should be adequate.

Misyaje, Single; Marumba, Group

An additional source should be found, or an alternative supply considered for both these supplies.

Table 4 - Water demand and availability

Village/Group	Present/future population	Water demand m^3/day	Water availability m^3/day 2-year min.	Water availability m^3/day 10-year min.
Iringa District				
Ismani Group	28,014/42,432	1,051		2.998
Tungamalenga Group *	4,529/13,587	388		4.052
Nyamahana Group *	4,132/13,830	336		5,988
Ilula Group	16,211/40,245	1,002	665	432
Tanangozi Group	20,615/28,830	865		1.037
Magubike Group	5,325/10,465	259		1,236
Ikungwe, Single	1,443/ 1,905	47	14	9
Mfukulembe, Single	1,352/ 1,785	44		78
Idonda, Single	1,334/ 2,588	64		86
Ilula Itunda, Single	4,244/ 9,209	230	160	104
Image Group	8,708/21,989	547	413	268
Mafuluto, Single *	826/ 2,478	61		1.000
Mtitu Group	64,782/99,860	2,480	2,781	1.806
Ibumu	1,725/ 3,470	86		130
Mufindi District				
Maduma, Single	2,912/ 5,824	145		
Mbalamaziwa Group	7,419/14,910	368	451	293
Ihegele	1,295/ 2,590			
Nyakipambo Group	1,082/ 2,835	259	18	12
Mtambula	2,506/ 5,012			
Igomaa, Single	1,291/ 3,382	84		0
Kiliminzowo, Single	1,144/ 3,016	75		2,868
Wambi Group	13,626/28,245	949		1,391
Njombe District				
Ujindile, Single	1,834/ 2,764	69		78
Boimanda, Single	541/ 1,278	31		259
Usalule Group	89,501/195,602	5,209		5,953
Moronga Group	14,962/24,113	598	146	95
Makete District				
Bulongwa Group	17,498/25,481	629	413	268

Table 4 (cont'd)

Village/Group	Present/future population	Water demand m3/day	Water availability m3/day 2-year min.	Water availability m3/day 10-year min.
Makete District				
Lupalilo Group	3.306/ 5.290	131	80	52
Ikonda, Single	888/ 1.420	35	14	9
Matamba Group	7.001/10.100	250	172	112
Iwawa Group	5.779/ 9.245	273	278	181
Kisinga, Single	855/ 1.368	34		311
Ihanga, Single	1.290/ 1.457	36		78
Ukwama, Single	1.327/ 2.672	66	80	52
Masisiwe, Single	900/ 1.359	33	14	9
Mbalatse, Single	1.744/ 1.970	49	26	17
Igolwa, Single	1,570/ 1.805	45	14	9
Ukange, Single	1,316/ 1.842	46	66	43
Ludewa District				
Mawengi, Single	2.371/ 5.572	139	92	60
Itundu Group	3.958/ 9.301	232	54	35
Madunda, Single	1.485/ 3.490	87	54	35
Madilu, Single	2.504/ 5.884	147	26	17
Lugarawa, Single	5.705/13.407	355	26	17
Luilo Group	11.198/27.654	689	97	63
Mbozi District				
Mbosi West Group *	28.056/97.669	2.432		6.912
Myovisi Group	10.682/23.362	580		1.719
Vwawa Group *	18.037/31.601	1.042		1.581
Katete, Single *	2.110/ 8.060	201		328
Ihanda, Single	2.959/ 6.421	160	40	26
Isandula, Single	2.441/ 5.757	143		864
Senjele, Single	2.867/ 6.221	155		4.156
Hezya, Single	2.436/ 5.286	132		12.122
Ileje District				
Isoko Group	5.140/ 9.012	224	347	225
Itale, Single	3.187/ 6.690	167		3.050

Table 4 (cont'd)

Village/Group	Present/future population	Water demand m³/day	Water availability m³/day 2-year min.	Water availability m³/day 10-year min.
Ileje District				
Sheyo, Single	1.632/ 3.084	77		95
Mbeya District				
Ilongo Group *	14.027/46.244	1.152		1.607
Mbuyuni Group *	11.009/36.485	907		9.504
Utengule Group *	7.703/30.658	766		4.406
Ikhoho, Single	1.262/ 1.767	44		354
Ihombe Group	4.555/ 6.211	144		1.028
Uyole Group	9.618/13.271	332		492
Iwindi Group	13.191/18.256	422		3.421
Isuto Group	8.342/11.250	279		829
Itimba, Single	1.605/ 2.188	54		5.944
Rujewa Group *	20.981/86.470	2.779		201.053
Ijumbi Group *	4.843/19.730	522		536
Isangala Group	3.485/ 5.151	128		0
Chunya District				
Mtanila Group *	7.007/34.964	874		0
Ngwala, Single	1.039/ 2.881	72		406
Mkwajuni, Single *				
Mwambani, Single *	5.032/ 15.126	377	226	147
Maleza, Single *	2.199/ 6.597	164	80	52
Namkukwe, Single	3.680/11.040	275		0
Ifyenkenya Group	4.342/10.464	260		8.640
Rungwe District				
Nsigara Group	2.900/ 3.354	83		717
Kasiabone, Single	1.232/ 1.626	24		9.366
Ndaga Group	6.273/10.532	269	245	159
Kanyelele Group	4.730/ 5.020	125		164
Ngopyolo Group	6.797/ 8.973	224		1.063
Lyenje, Single	1.058/ 1.442	36	5	3
Nditu, Single	2.400/ 3.168	79		138

Table 4 (cont´d)

Village/Group	Present/future population	Water demand m^3/day	Water availability m^3/day 2-year min.	Water availability m^3/day 10-year min.
Kyela District				
Ngana Group	25.127/34.740	861		1.123
Ngamanga Group	12.747/19.336	479		3.024
Sinyanga Group	7.325/10.314	255		346
Songea District				
Libango Group	12.863/22.730	566		1.633
Namabengo Group	5.368/13.130	327	386	251
Mpitimbi Group	4.167/10.430	260	26	17
Muhukuru Group	6.192/14.860	370	40	26
Magagura, Single	2.531/ 6.190	154	14	9
Ngahokora, Single	1.629/ 3.990	99	14	9
Matimira, Single	2.591/ 6.560	163	66	43
Peramiho Group	4.555/ 6.882	149		
Lipokela Group *	2.402/ 7.162	117	26	17
Mbingamhalule, Single	2.180/ 5.700	142	14	9
Limamu, Single	2.035/ 5.330	133		268
Lilondo, Single	1.747/ 4.280	106	54	35
Hanga, Single	2.426/ 6.140	153		268
Mlilayoyo, Single	1.032/ 2.520	62	40	26
Mbimbi, Single	1.379/ 3.200	79	26	17
Ngwinde, Single	1.039/ 2.750	68	26	17
Mdwemba, Single	719/ 1.880	46	14	9
Namatuhi, Single	1.331/ 3.260	81	66	43
Njalamatata Group	7.679/18.780	467	132	86
Namangole Group	3.649/ 9.120	227	146	95
Kilangalanga, Single	1.370/ 3.350	83	26	17
Nakahuga, Single	1.527/ 3.740	93	14	9
Mbinga District				
Lundo Group	2.721/ 3.775	93		562
Mango Group	5.474/ 8.300	206		259
Ngindo, Single *	573/ 1.925	48		34.560
Litembo, Single	2.784/ 6.640	165		510

Table 4 (cont'd)

Village/Group	Present/future population	Water demand m^3/day	Water availability m^3/day 2-year min.	Water availability m^3/day 10-year min.
<u>Mbinga District</u>				
Ndumbi, Single	2.518/ 3.700	92	14	9
Kindimba chini/juu, Single	1.721/ 3.320	82		181
Linda, Single	2.044/ 5.212	130	80	52
Kihangi Mahuka, Single	1.607/ 4.100	102	14	9
Silo, Single	2.256/ 4.855	121	42	27
Wukiro, Single	2.720/ 6.490	162	172	112
Mahenge, Single	1.579/ 3.770	94	14	9
Myangayanga Group	6.595/15.960	397	54	35
Miyao Group	4.364/11.570	288		570
Sepukila, Single	1.569/ 3.190	79	14	9
Malindindo, Single	2.053/ 5.235	130		302
Mikalanga, Single	2.294/ 5.850	146		216
Mpepai, Single	3.000/ 7.150	178		
Mbamba Bay Group	5.742/ 8.620	214		22.896
Mapipili Liwihi, Single	2.455/ 6.260	156	11	9
Nangombo, Single	1.770/ 2,650	66		24.192
<u>Tunduru District</u>				
Matemanga Group	4.625/ 8.100	200		492
Nandembo, Single	2.873/ 6.790	169	26	17
Machemba Group	3.938/ 6.970	172	200	130
Naluwale Group	1.415/ 2.560	63		173
Amani Group	3.781/ 9.380	232		1.045
Kindamba, Single	560/ 1.000	24		173
Misyaje, Single	1.183/ 2.700	67	67	43
Njenga, Single	1.625/ 3.900	97		1.382
Marumba Group	4.020/ 8.139	202	40	26

5. CORRELATION ANALYSES

In areas with similar hydrological and geological charactistics the

annual minimum flows from the hydromet stations have been correlated. Within a selected area a period was chosen in which all stations had flow data, the annual minima were then found, and correlation between pairs of stations conducted as shown below.

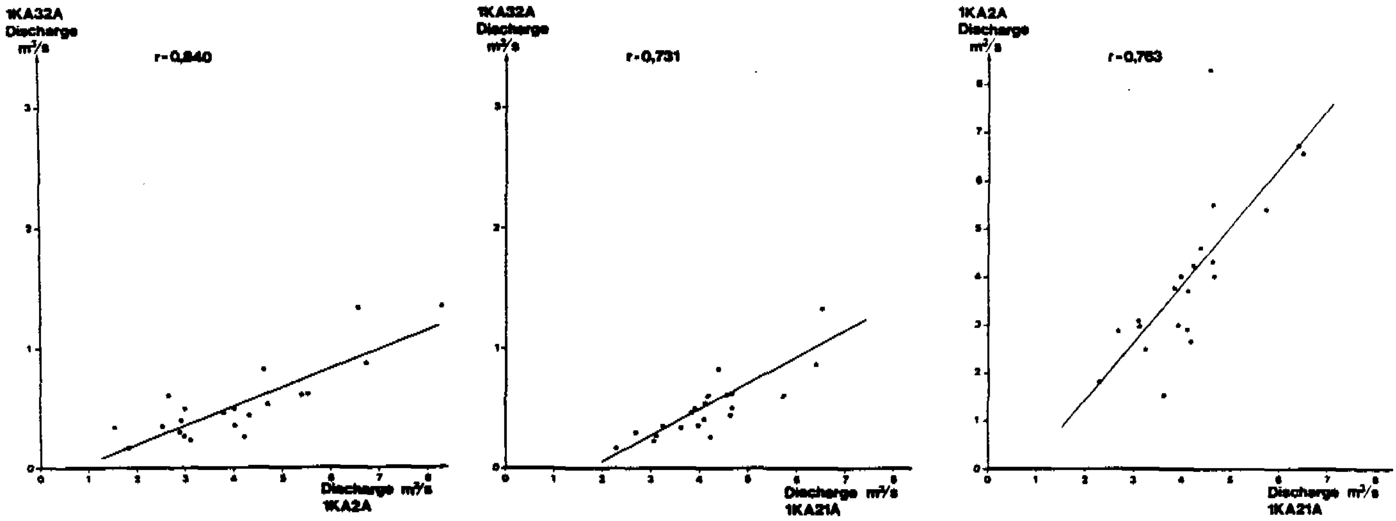


Figure 1 - Correlation of annual minimum flows for hydromet. stations on Lt Ruaha upstream of Iringa

Correlation between the following stations during the period 1958-79 were performed.

Table 5 - Correlation coefficients of annual minimum flows at hydromet. stations on Lt Ruaha river upstream of Iringa

	1KA 22	1KA 39A	1KA 2A	1KA 32A
1KA 21A	0,564	0,781	0,763	0,731
1KA 22	-	0,734	0,840	0,610
1KA 39A	-	-	0,888	0,921
1KA 2A	-	-	-	0,840

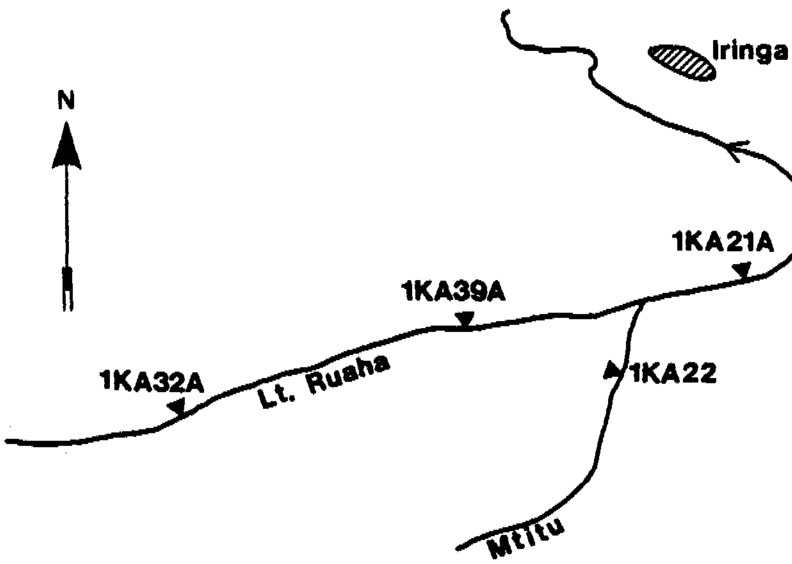


Figure 2 - Hydromet. station on Lt Ruaha river system upstream of Iringa

Table 6 - Correlation coefficients of annual minimum flows at hydromet. stations in the Rungwe, Kyela area

	1RC 5A	1RC 3A	1RC 2A
1RC 8A	0,692	0,090	0,456
1RC 5A	-	0,239	0,209
1RC 3A	-	-	0,517

Table 7 - Correlation coefficients of annual minimum flows at hydromet. stations in the Mbeya, Myovisi area

	3A 14A	3A 6	3A 7A
3A 8	0.01	0.65	0.41
3A 14A	-	0.07	0.10
3A 6	-	-	0.43

The recession constants of a river have in earlier studies, i.e. the Water Master Plan of Iringa, Mbeya and Ruvuma shown to vary little from year to year.

The analogue assumption would then be that the average recession constant at a homogenous area varies little from year to year. If this could be verified by spotchecks during a couple of dry seasons it would be possible to make only one gauging at the ungauged village sources, and with the date of the gauging and the date of the absolute minimum flow at a nearby hydrostation the minimum flow that year could be calculated, and hence the 10-year minimum of that particular village source. A greater number of village sources within such areas could be analysed every season by this method.

Correlation analyses have been conducted in the Rungwe, Kyela area, the Myovisi, Mbeya area and Little Ruaha upstream of Iringa. It has not been possible to identify any other areas in which such correlation would be possible, since in all other areas the topographical and hydrological characteristics vary greatly.

The Rungwe, Kyela area does not seem to have a very good correlation - as shown in Table 6 - nor does the Myovisi, Mbeya area as seen from Table 7; however, the Little Ruaha area upstream of Iringa shows very good correlation.

In the Lt. Ruaha area only a few of the sources need to be measured; it can therefore not be recommended that average recession constants be used in any of the areas of the three regions.

6. CONCLUSIONS AND RECOMMENDATIONS

A number of sources, as seen from Table 4, cannot provide the water which will be needed in the year 2006, and at many locations new or additional sources have to be found. In Mbeya 8 sources do not provide enough water, in Iringa 26 and in Ruvuma 33 sources have too small yields.

This is based on the comparison of the projected water demand in the year 2006 and the minimum flow statistically expected to occur once in 10 years. It is however important to consider that both a projected demand and the 10-year minimum flow are parameters which may have a considerable inherent uncertainty.

The projections of population figures are based on generalized assumptions about growth rates which may or may not apply to the particular village. The 10-year minimum flow is based on various assumptions about similarity between the behaviour of the stream under investigation and a larger stream in the vicinity. Thus, we recommend that the following considerations are applied before rejecting a source not meeting the demand criteria of year 2006.

- Has the past trends in the village development confirmed the earlier population projections?
- What is the consequence of rejecting a source, that is, can additional or alternative sources be developed and at which cost?
- If the 10-year criterion is not met, does the source meet a 5-year criterion or a 2-year criterion, see Table 8), and what are the consequences in terms of reduced availability of water for the villager. Can such a reduction be considered acceptable when compared to the cost of developing either an alternative source or an additional source. This question also relates to the problem of whether a traditional source may be acceptable during a period of deficiency.

Table 8 - Villages with too little water in the year 2006

	2-year minimum	10-year minimum
Iringa	21	26
Mbeya	8	8
Ruvuma	29	33

Of the 132 measured sources 67 have shown not to have sufficient water for the future populations in the year 2006. It is therefore highly recommended that another low flow programme be conducted during the dry season of 1985. This low flow programme should cover 26 sources in Iringa Region, 8 sources in Mbeya Region and 33 sources in Ruvuma Region as recommended in Chapter 4, and should start early September in order to be completed before the rains start. A proposed time-schedule is shown below in Fig. 3.

The sources where not enough water was available can be grouped into two categories:

Category 1: Sources with insufficient water based on two measurements in 1984.

Category 2: Sources with insufficient water based on one measurement in 1984 and an assumed recession constant (safe side).

The recommended low flow programme for 1985 would then comprise two programmes:

Programme for category 1: Measurements at additional/alternative sources

Programme for category 2: Measurements at proposed sources to verify the minimum flow and if necessary measurements at additional/alternative sources.

The village water supply sources under programme 2 are not considered to be many.

WORKING PAPER

MINIMUM FLOW ASSESSMENT
AT VILLAGE LEVEL

SEPTEMBER 1984

DANIDA - CCKK

WORKING PAPER

MINIMUM FLOW ASSESSMENT AT VILLAGE LEVEL

1. INTRODUCTION

During the Water Master Plan, hydrological investigations were aimed at two different main goals. These were :

- to establish the regional hydrological regime comprising precipitation, evaporation, runoff and the distribution of these parameters in time and space.

- to establish estimates for minimum flow at sources near the villages to suit the planning of the water supply schemes.

The estimates of minimum flows had to be based on single measurements carried out during village visits. These were then compared on a regional basis and included in the planning procedure.

It was, however, clear that before actual construction should take place there would be a number of cases where the accuracy of the planning estimates would not be sufficient and where additional source investigations would have to be made.

The aim of the present working paper is thus to outline the principles for selection of village sources for additional measurements, to present the selcted villages and to describe the method of measurement and analysis.

2. SELECTION OF SOURCES FOR ADDITIONAL MEASUREMENTS

2.1 Hydrological zoning

The water master plan results comprised i.a. a map of hydrological zones from which a first estimate of 10 - year minimum flows can be calculated for small catchments. (Drg. No. 6 Box II 10-year minimum runoff in $l/s/km^2$). In general these zones and derived estimates would be more reliable as regards zone 3 and 4 than as regards zone 1 and 2.

Screening from a purely hydrological point of view has thus been performed in the following way:

- if village source yields inzone 1 or 2 are below 4 times the estimated demand these sources are included in the preliminary list of village sources for additional measurements.

- if village source yields in zone 3 or 4 are below 2 times the estimated demand these sources are included in the preliminary list of village sources for additional measurements.

2.2 Construction Programme

The three year rolling construction programme has been studied and all included schemes with surface water sources has been selected for additional measurements unless a relatively large stream with well established dry-season flow is the source.

2.3 Priority Programme

The priority programme of 633 villages has been considered. No single village is included for additional source assessment unless it is included in the priority programme. In the same way, no group scheme has been included for additional measurement unless it comprises a reasonable number of priority schemes.

2.4 Scheme Type

Villages for which conventional pumping has been the only feasible solution indicated in the Master Plan have not been included, as the implementation of such schemes will be defered to some future date.

2.5 Results of screening procedure

The results in terms of village sources to be assessed in more detail are given as a list (Appendix 2.1, 2.2 and 2.3). The number of villages /group schemes are as follows :

	No. of schemes for additional measurements
IRINGA	41
RUVUMA	52
MBEYA	39
TOTAL	132

.../3

3. MEASUREMENTS OF DISCHARGE

3.1 Equipment

The measurements of discharge will all be carried out at relatively small streams. Three types of equipment are envisaged to be sufficient for these measurements which are expected mainly to be in the range of 1 - 50 l/s. The field teams will be equipped with:

- V-notch (90^o)
- calibrated bucket and stopwatch
- micro-propeller (OTT-meter)

The V-notch is manufactured for the purpose, buckets calibrated and the micropropellers are available at the regional hydrological offices to where they were handed over by the end of the Master Plan Phase.

3.2 Staffing

The central Maji authorities (Mr. W. Balaile) have been informed about the programming of the activities and have in turn requested the regional hydrologists to make available two field teams in each region. The activities of these field teams will be supervised by the CCKK-hydrologist. Instructions and a form to be filled in for each source have been prepared (see Appendix 3.1).

4. PRINCIPLES OF ANALYSIS

4.1 General

The basic idea is to carry out two spot measurements at each source with a time lag of approximately one month. During the dry season, when no rain occurs, the flows will represent a baseflow originating from the groundwater.

The two measurements will give information on the rate of depletion of the ground -water reservoir. Based on information from permanent Ma stations, the depletion curve can be extended and a 10-year minimum flow estimate arrived at.

4.2 Recession curve

When a groundwater reservoir is the only source of a stream, which will be the case at the end of the dry season, the discharge will decrease exponentially. Thus, the process can be described by the equation

$Q_2 = Q_1 \times e^{-k(t_2 - t_1)}$ where

Q_1 is discharge at the time t_1

Q_2 is discharge at the time t_2

k is a constant varying from catchment to catchment

The constant k can thus be calculated from two measurements of discharge spaced in time such as to give a reasonable accuracy.

If the time of the annual minimum flow can be estimated, then the same equation can be applied to yield the annual minimum. This minimum flow can then be scaled to give the 10-year minimum flow when compared to the hydrological regime of an adjacent Maji-station with a long record.

5. DATA COLLECTION AND ANALYSIS

5.1 Spot Measurements

The spot measurements are carried out at all selected village scheme sources. These sources appear as a result of the screening procedure and are given in Appendix 2.1, 2.2 and 2.3. The time lag between the two measurements will be approximately one month and the measurement form (Appendix 3.1) will be filled in.
In addition to the measurements, questions will be asked at the local level regarding the reliability of the particular stream (is it ever running dry, how often etc).

5.2 Maji-station minimum flow

By the end of the dry season data on the lowest recorded level (time and gauge height) at the permanent hydro-stations in the area shall be collected. These levels shall be conv-erted to discharges using the available rating curves and the 1984 minimum flow is arrived at for the hydrostations. This flow is then compared with the 10-year minimum at the same station and the ratio is calculated.

DISTRICT	VILLAGE/GROUP	REG.NO.	HYDRO ZONE	R E M A R K S
MAKETE	Kisinga,single,	303	3	
"	Ihanga, single	324	4	
"	Ukwama, single	195	4	
"	Masisiwe, single	325	3-4	
"	Mbalatse single	319	3	
"	Igolwa, single	196	4	
"	Ukange, single	320	4	
LUDEWA	Mawengi, single	95	4	3 year plan
"	Itundu Group	I - 56	4	"
"	Madunda, single	94	4	
"	Madilu, single	96	4	2 intakes
"	Lugarawa, single	108	4	
"	Luilo Group	I - 58	1	

Total No. of Schemes : 41

RUVUMA REGION APPENDIX NO. 2.2 HYDRO MEASUREMENTS

DISTRICT	VILLAGE/GROUP	REG.NO.	HDROL ZONE	R E M A R K S
SONGEA	Libango Group	R - 3	2	3 year plan
"	Namabengo Group	R - 6	2	"
"	Mpitimbi Group	R - 14	2 - 3	"
"	Muhukuru Group	R - 16	2	"
"	Magagura, single	133	2	"
"	Ngahokora, single	134	2	"
"	Matimira, single	66	2	
"	Nakahuga, single	120	3	
"	Peramiho Group	R - 8	3	
"	Lipokela Group	R - 12	3	
"	Mbingamhalule, single	131	3	
"	Limamu, single	96	2	
"	Lilondo, single	93	4	2 intakes
"	Hanga, single	77	3	
"	Mlilayoyo, single	79	3	
"	Mbimbi, single	101	2	
"	Namangole Group	R - 10	2	
"	Kilangalanga, single	271	2	
"	Ngwinde, single	100	2	
"	Mdwema, single	78	2	
"	Namatuhi, single	141	2	
"		154	3	
"	Njalamatata Group	R - 11	2	
MBINGA	Lundo Group	R - 25	3	3 year plan
"	Mango Group	R - 21	2	"
"	Ngindo, single	167	2	"
"	Litembo, single	193	2	"
"	Ndumbi, single	186	2	
"	Kindimba Chini/Juu	188	2	2 intakes
"	Linda, single	202	2	
"	Kihangi Mahuka	227	2	
"	Silo, single	203	2	
"	Wukiro, single	197	2	
"	Mahenge, single	303	2	

.../2

DISTRICT	VILLAGE/GROUP	REG. NO.	HYDRO ZONE	REMARKS
MBINGA	Myangayanga Group	R - 19	2	
"	Miyao Group	R - 23	2	
"	Sepukila, single	243	2	
"	Malindindo, single	215	2	
"	Mikalanga, single	214	2	
"	Mpepai, single	244	2	
"	Mbamba Bay, Group	R - 28	2	
"	Mapipili Liwihi, single	225	2	
"	Nangombo Single	162	2	
TUNDURU	Matemanga Group	R - 31	1	3 year plan
"	Nandembo single	40	1	"
"	Machemba Group	R - 34	1	"
"	Naluwale Group	R - 35	1	" 2 intakes
"	Amani Group	R - 38	1	3 year plan
"	Kindamba single	802	1	"
"	Misyaje single	254	1	
"	Njenga single	8	1	
"	Marumba Group	R - 40	1	

Total No. of Schemes : 52

DISTRICT	VILLAGE	REG.NO.	HYDRO ZONE	REMARKS
MBOZI	Mbozi West, Group	M - 34	1	
	Myovisi Group	M - 39	1	
	Vwawa group	M - 42	1	
	Katete, single	503	1	
	Ihanda, single	435	1	
	Isandula, single	481	1	2 intakes
	Senjele, single	380	1	3 year plan
	Hezya, single	373	3	
ILEJE	Isoko, group	M - 72	4	
	Itale, single	27	4	4 intakes
	Sheyo single	37	4	
MBEYA Rural	Ilongo group	M - 7	2	
	Mbuyuni group	M - 4	2	
	Utengule group	M - 6	1	
	Ikhoho, single	146	1	Hydram
	Ihombe, group	M - 10	1	
	Uyole group	M - 13	2	3 year plan
	Iwindi group	M - 22	2	3 year plan
	Isuto group	M - 26	3	
	Itimba single	106	1	3 year plan
	Rujewa group	M - 3	1	
	Ijumbi group	M - 8	2	
	Isangala group	M - 23	2-3	
CHUNYA	Mtanila group	M - 30	1	3 year plan.
	Ngwala single	514	1	
	Mkwajuni single	9	1	
	Mwambani single	11	1	
	Maleza single	855	1	
	Namkukwe single	14	1	3 year plan Hydram
RUNGWE	Nsigara group	M - 58	4	
	Kasiabone, single	367	4	
	Ndaga group	M - 45	3	
	Kanyelele group	M - 56	4	

Cont'd...

DISTRICT	VILLAGE	REG.NO.	HYDRO ZONE	REMARKS
RUNGWE	Ngopyolo group	M - 65	4	
	Lyenje single	308	4	
	Nditu single	321	4	
KYELA	Ngana group	M - 70	4	
	Ngamanga group	M - 67	4	
	Sinyanga group	M - 68	4	

TOTAL No. of Schemes: 39

C C K K

LOW FLOW MEASUREMENT PROGRAMME

1. VILLAGE

Name .... District ....

Region ....

Single Scheme Planned ☐

Group Scheme Planned ☐ Reference ....

2. SOURCE

Name ....

Spring Source ☐

Stream ☐

Measurement at ☐ Intake site as shown on Village Sketch

☐ Other site, describe location

....

....

3. MEASUREMENT

Date of Visit .... 19 ...

Method : ☐ V-notch ☐ Bucket ☐ ott-meter

V-notch: Head measured in notch (h_1) .... cm
Length top of weir to water level (left) (l_1) .... cm
Length top of weir to water level (right) (l_2) .... cm

Bucket : Volume of bucket(V) .... litres
Time to fill bucket (t_1) .... seconds
Time to fill bucket (t_2) .... seconds
Average time (t_a) .... seconds

Ott-meter: Use Maji standard form to fill in and calculate discharge

4. RELIABILITY OF MEASUREMENT

V-notch : Is all water passing the V-notch or is it bypassed; describe ....

....

Has V-notch been placed horizontally describe any deviation ....

Bucket : Is bucket well calibrated ....

Is all flowing water collected describe ....

....

OTT-Meter ; How many verticals in cross-section has been measured

....

Which heights over river bed has been used for measuring

☐ 0.6 ☐ 0.2/0.8

Describe Site:

Bed :
- ☐ Rocky
- ☐ Stones, boulders
- ☐ gravel
- ☐ sand
- ☐ silt/clay

Bank :
- ☐ no vegetation
- ☐ some vegetation
- ☐ vegetation inteferes with measurement

.../3

5. SOURCE RELIABILITY (INTERVIEW)

Is there a flow at the source all year round
☐ yes
☐ no

Has anybody experienced the source being dry
☐ yes
☐ no

How often does the source dry up
☐ twice a year
☐ once a year
☐ once in two years
☐ less than once in 2 years

How many people collects water from the stream
☐ the whole village
☐ many people
☐ only few

If the source runs dry where is water then collected

....

6. DISCHARGE CALCULATION

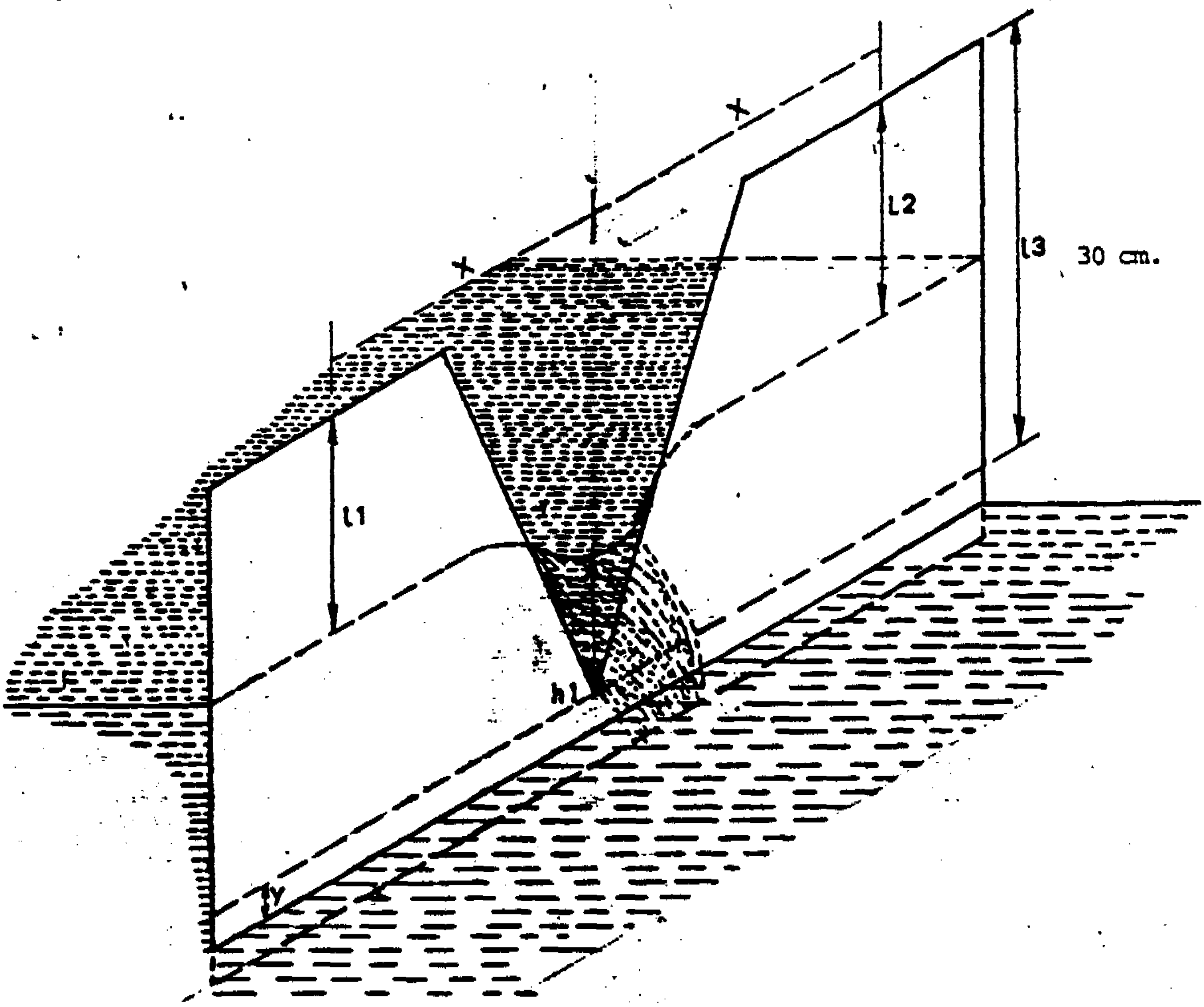
V-notch : Calculate $H = l_3 - (l_1 + l_2)/2$ = ... cm
From Table 1 find Q = ... l/s

Bucket : Calculate Q = V/t = ... l/s

Ott-meter : Calculate Q from standard
Maji calculation form

Field Team Leader	Signature	Date
______________	______________	______________

DEFINITION SKETCH



NOTE: y MUST BE > 5 CM

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Consulting Engineers and Planners Ltd.

TABLE 1

Discharge in l/s for 90° V-notch
(Head H in cm) $Q = 0.0148 \times H^{2.48}$

Head cm	Discharge l/s	Head cm	Discharge l/s
1.0	0.015	19.0	21.9
2.0	0.082	.5	23.4
3.0	0.22	20.0	24.9
4.0	0.46	.5	26.5
5.0	0.80	21.0	28.1
.5	1.01	.5	29.8
6.0	1.26	22.0	31.6
.5	1.54	.5	33.4
7.0	1.85	23.0	35.3
.5	2.19	.5	37.2
8.0	2.56	24.0	39.2
.5	2.99	.5	41.2
9.0	3.44	25.0	43.4
.5	3.93	.5	45.5
10.0	4.47	26.0	47.8
.5	5.04	.5	50.1
11.0	5.66	27.0	52.5
.5	6.32	.5	54.9
12.0	7.02	28.0	57.4
.5	7.77	.5	60.0
13.0	8.56	29.0	62.7
.5	9.40	.5	65.3
14.0	10.3	30.0	68.2
.5	11.2	.5	71.0
15.0	12.2	31.0	73.9
.5	13.3	.5	76.9
16.0	14.3	32.0	80.0
.5	15.5	.5	83.1
17.0	16.7	33.0	86.3
.5	17.9	.5	89.6
18.0	19.2	34.0	92.9
.5	20.6	.5	96.4