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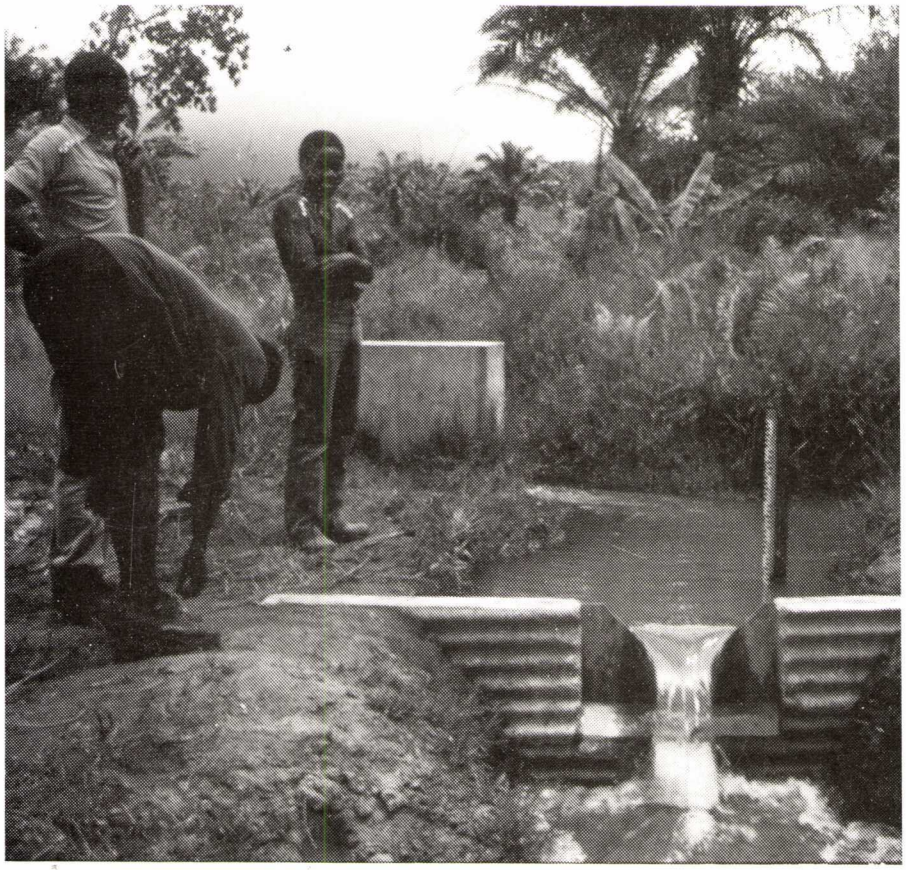
NORWEGIAN
WATER RESOURCES AND
ENERGY ADMINISTRATION

TAN 055 - PHASE III

WATER SUPPLY AND SANITATION DEVELOPMENT KIGOMA AND RUKWA REGIONS , TANZANIA



HYDROLOGICAL
INVESTIGATIONS
1986 - 1987

By Kjell Repp

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Sammendrag/Abstract

Water resources investigations carried out during 1986-1987 are briefly summarised, and recommendations on selection of water sources for the rural water supply development are given. A comprehensive list of low flow measurements is included in Appendices 1 and 2.

Emneord/Subject Terms

Tanzania. Hydrology.
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1.0 GENERAL

A preliminary travel report was submitted to the Ministry of Water, and NORAD in mid-November 1987. The report included a brief description of the activities carried out by the advisory hydrologist (AH) during his short visit to the Kigoma and Rukwa regions, as well as some recommendations for the work program in the near future. The compilation of the detailed work program for the national network was left to the regional hydrologists. It should be noted that the preliminary travel report contained an error on the first page. 14. October - 27. November should be corrected to 14. September - 27. October.

This report briefly describes the results of the hydrological work connected to the water supply development which has been carried out in the region during the last year, as well as giving some recommendations on the selection of water sources for some villages.

For further references, see "Work Program" of June 1987, and "Travel Report" of November 1987, as well as previous reports submitted by the AH.

1.2 Summary and Recommendations

1.2.1 General

Very brief summaries of the findings and recommendations are given for each scheme, followed by a few general comments. It should be noted that the results of the water quality analyses may necessitate an alteration of the proposed solutions.

1.2.2 Kigoma Region

Kasangezi

The existing intake should be abandoned in favour of the proposed one in Muzye River, which will provide a sufficient quantity of water to cover the demand. The new water intake will also make possible an extension to the Rusesa g/s, which will face a shortage of water in the future.

Kasulu Urban

The daily waterlevel observations in Nyanka River and Miseno River should continue for another year, followed by a thorough hydrological analyses. The discharge of the Mgandazi River should be measured every two weeks during the coming dry season.

Kabingo/Kiyobela

Groundwater investigations and levelling to take place before any decision regarding future water sources are taken.

Bukirilo

Groundwater investigations to be carried out.

Kakonko

The recommendations included in the 1987-report from the AH are still valid (confirmed by the 1987-observations).

Kibondo Area

A thorough water resources investigation should be carried out. Immediate measure: Spring protection.

Kumhasha

Infiltration scheme (see 2.2.8).

Mukabuye

New water intake to be constructed in the Kumnyva Mpanga River. No more investigations necessary.

Kasanda

Alternative water sources to be identified (see 2.2.10).

1.2.3 Rukwa Region

Matanga g/s

It is recommended to rehabilitate and improve the Katuka River intake. The yield of the two other intakes is very small, and in any case other water sources have to be identified.

Chala g/s

Sport discharge measurements during the coming dry season.

Pito g/s

In the future the Kalenge River should be connected to the present water supply scheme. A few spot discharge measurements should be carried out at the existing intake in the Mwimbi River as well as the Kalenge River the next dry season.

Namanyere

The Kitete River may probably cover the water demand in Namanyere. This assumption, however, is only based on a few observations during 1987, and should be confirmed by more

measurements during 1988.

Mpanda Urban

Additional flow measurements at Ikolongo Spring during the rainy as well as the dry season 1988.

Sumbawanga Urban

A comprehensive hydrological analysis should be carried out, covering the whole Sumbawanga Area (see 3.2.7).

2. KIGOMA REGION

2.1 Rainfall 1986-87

The spatial distribution of rainfall during the last hydrological year was rather uneven (Figure 2.1). The middle part of the region received high amounts of rainfall compared to the long term mean, while the northern areas, represented by Kibondo and Kakonko were extremely dry.

Very high rainfall variations are exemplified by the two missions Mulera and Heri, which are located very close to each other. Mulera Mission received an abundance of rainfall, while the rainfall at Heri Mission was very low compared to the long term mean. In this context it should be noted that the periods of records varies. Even when considering similar periods, however, the pattern is the same, and should be remembered when extrapolating data from one catchment to another.

2.2 Runoff Analyses and Results

2.2.1 General

Very few spot discharge measurements were carried out in the region during the last dry season. High priority was supposed to be given to the establishment of flow recession curves for specified rivers in selected areas. Virtually nothing of this program was carried out, and the recommendations therefore still have to be based on correlation between sporadic flow measurements and rainfall statistics.

At present, however, when the hydrological services to TAN -055 are connected to the Norwegian Water Resources and Energy Administration, a high variety of hydrological computer programs and expertice is available, and other methods to estimate the low flow and the design flow should be looked into. One possibility could be a special computer program based on catchment charac-

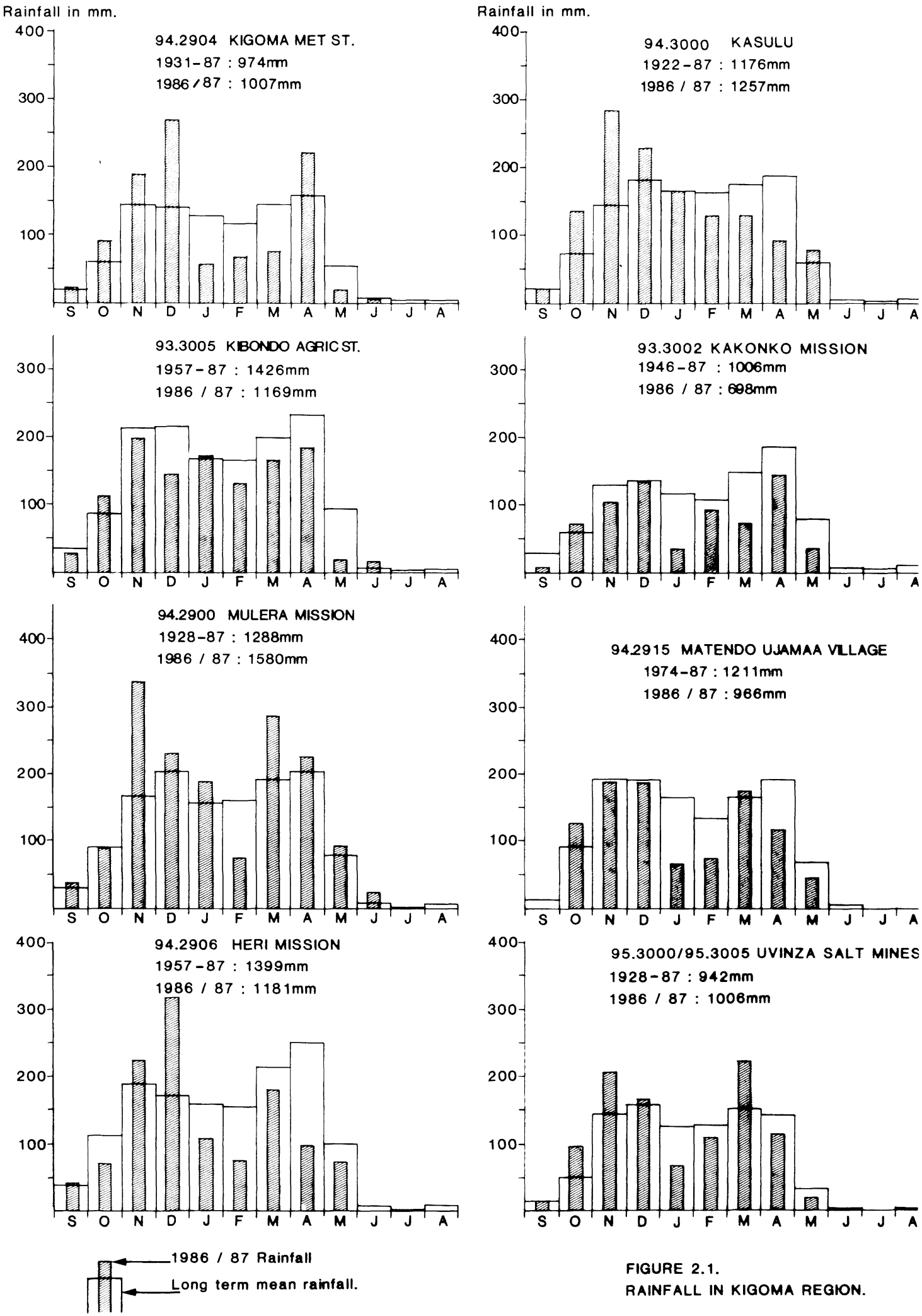

FIGURE 2.1.
RAINFALL IN KIGOMA REGION.

teristics. Lack of homogeneous runoff observations for the calibration of the model is a severe obstacle, however. This work should be included in the updating of the hydrological investigations in the region. Despite of these possibilities, however, as many recession curves as possible should be established during the next dry season, i.e. during 1988.

Below follows a brief description of the various water supply schemes visited by the AH in September/October 1987.

Figure 2.2. shows the various schemes where spot discharge measurments have been carried out, while all measurements are included in Appendix 1.

2.2.2 Kasangezi (Figure 2.3)

It has earlier been recommended to abandon the present intake in Karenge River in favour of the more remote Muzye River, due to the very low yield of the first one. The P.P & P section has questioned this recommendation, however, showing to the fact that the measured flow during 1981 was sufficient to cover the water demand in the village (Appendix 1). In order to evaluate the flow results, however, it is necessary to compare with the annual rainfall distribution during the years when flow measurements have been carried out, and also compare with the flow recession (in this case 1981). Examination of the daily and monthly rainfall during 1981 reveals that the rainfall during May 1981 was extremely high, which influenced the flow recession during the following dry season, which was extremely short. The onset of the rain as early as August stopped the flow recession temporarily, and the flow never dropped below 3 l/sec, which is slightly less than the projected water demand in the year 2007.

Ignoring the early rain and extrapolating the flow recession up to the end of October, however, results in a flow less than 1.5 l/sec. This value is in accordance with the results from other

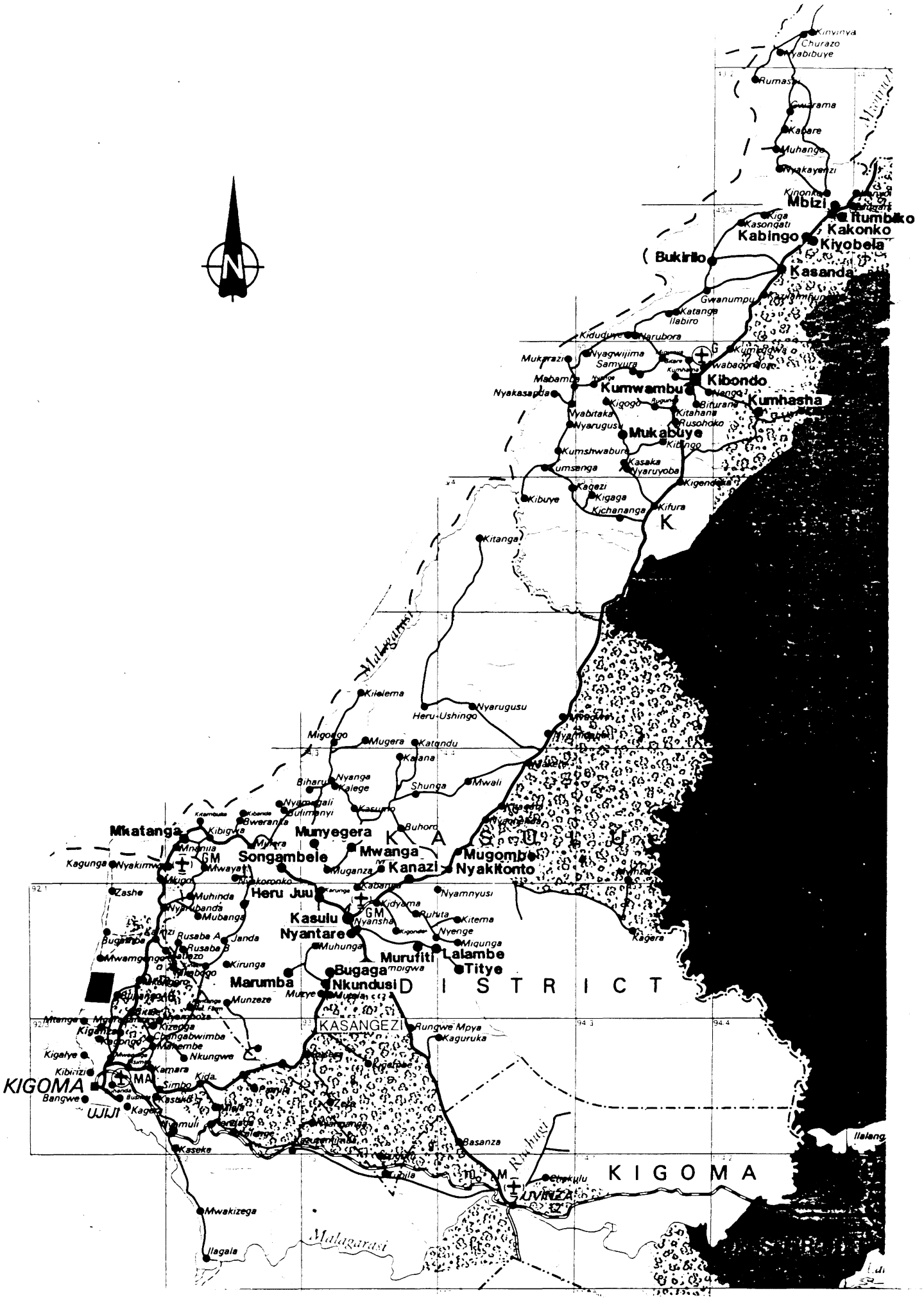

Figure 2.2 Location Map.

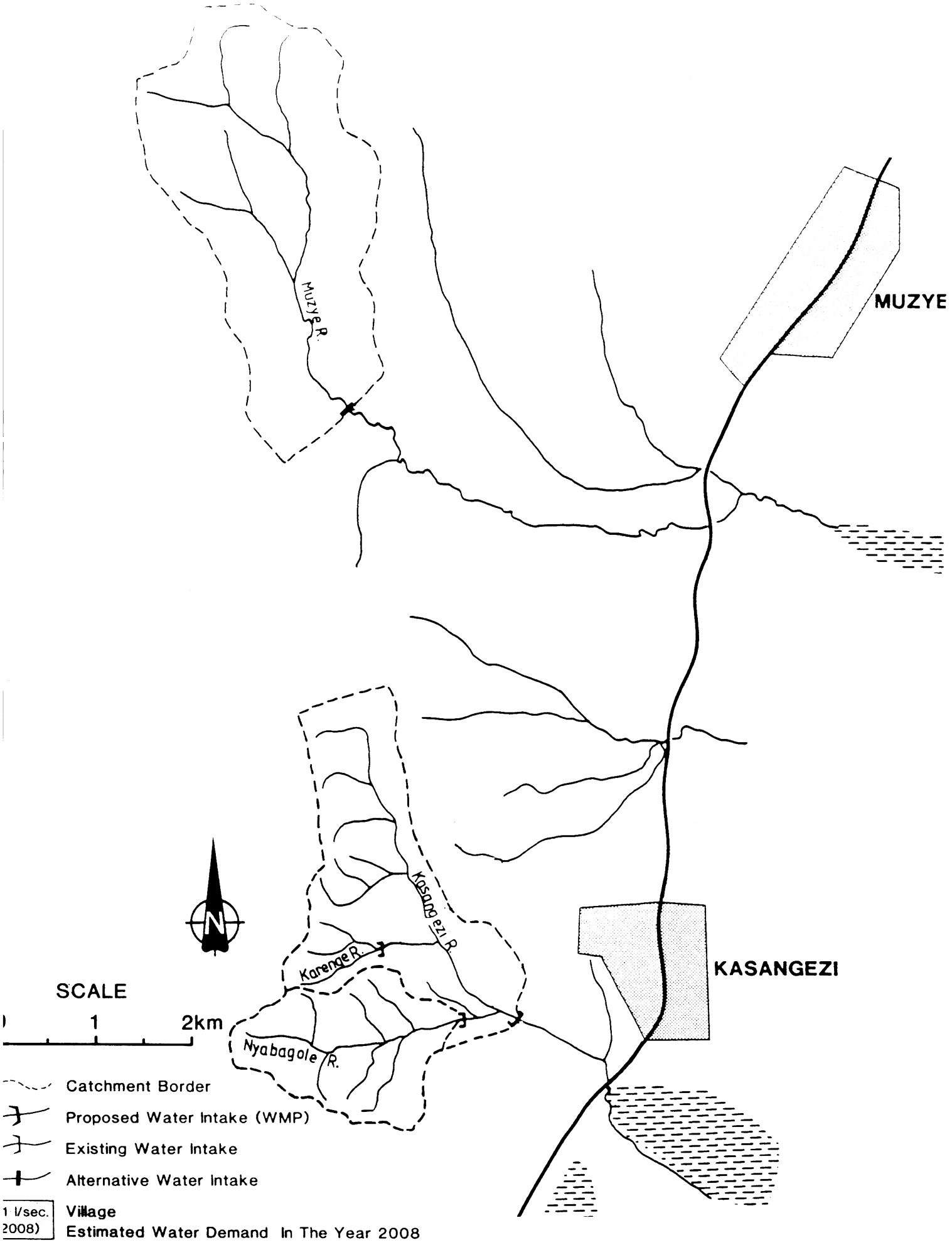

Figure 2.3 Alternative Water Sources to Kasangezi WSS.

years, especially when considering the extremely high rainfall in May 1981.

Application of rainfall statistics and all available flow measurements to estimate the low flows with 5,10 and 20 years return period gives respectively 1.1, 1.0 and 0.9 l/sec. Considering the reservations above, 19812 should probably be excluded, and the values are too high. The estimations shown in figure 2.18 in the AH's report of March 1986 (based on the 1985-measurement) are probably more representative.

On this background it is strongly recommended to abandon the Karenge River Intake and develop the Muzye River.

Also the fact that the Rusesa group scheme will face a shortage of water in the near future (see earlier reports by the AH, and by Samset/Stokkeland) favours the selection of the Muzye River as the water source to Kasangezi Village. The Rusesa g/s can then easily be connected to the Muzye River Intake, where the yield is sufficient to cover both schemes. This connection should be considered when designing the gravity main from the intake.

2.2.3 Kasulu Urban and Nyantara g/s (Figure 2.4)

The runofff observations at the existing intake in Nyanka River and the proposed intake in Miseno River are continuing for at least another year. Unfortunately none of the two weirs are functioning quite satisfactorily. The one at Nyanka intake is strongly influenced by bedload transport and needs frequently cleaning, while the one in Miseno River is too small, and should be raised by 25 cm in order to monitor the high flows during the rainy season. During the AH's visit to the region, there was also a small leakage which was supposed to be repaired. If not already done, the rehabilitation and improvement of the weir should be carried out immediately.

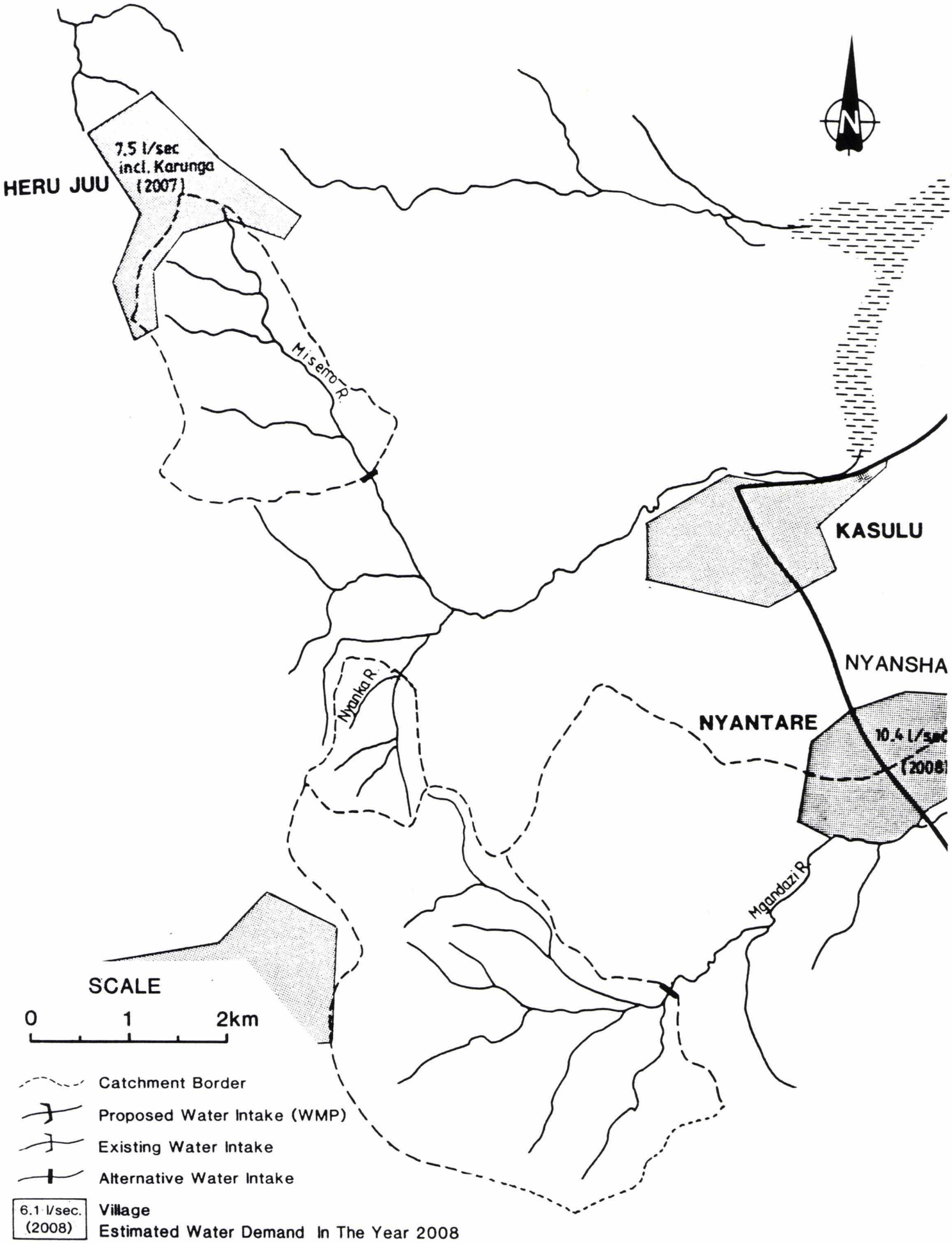

Figure 2.4 Alternative Water Sources to Kasulu Urban and Nyantara g/s.

Of the proposed montly discharge measurements in Mgandazi River, only one measurements was carried out, on 17. July, 1987. Hopefully the measuring program can be carried out the next dry season, whereafter the flow recession curve can be established and the analyses completed.

2.2.4 Kabingo/Kiyobela (Figure 2.5)

Low flow measurements were carried out as shown in Table 2.1 below.

Table 2.1 Low Flow Measurements in the Kabingo Area during the Dry Season 1987

Date	River/Location	Flow, l/sec
12.08.87	Kiziguzigu R., d/s of confluence	7.3
30.09.87	"	5.4
13.08.87	Lusange R. (Kange R. or Kasange R.) at alternative intake (incl. tank flow)	7.2
30.09.87	"	7.0
13.08.87	Ngoma R. (Rusengi R.) d/s of alternative intake	9.5
30.09.87	"	6.6

The flow values are very confusing, especially when comparing with the results from earlier years, which are much lower. The Kibond-Kakonko area received very small amounts of rainfall during the last rainy season. A probable explanation is that the flow measurements on 30 September have been influenced by rain, which is confirmed by the rainfall observations at Kakonko Mission. The explanation is further confirmed by the flow recession from 13 August up to 30 September, which is very small. Unfortunately the lack of any recession curves from the Kibondo District makes extrapolations of the single August measurements impossible, and reliable estimates of the 1987 low flow cannot be computed. If using recession constants derived for the Kasulu area, very rough estimates indicate low flows of 3-4,5 l/sec, which are comparable to earlier estimates.

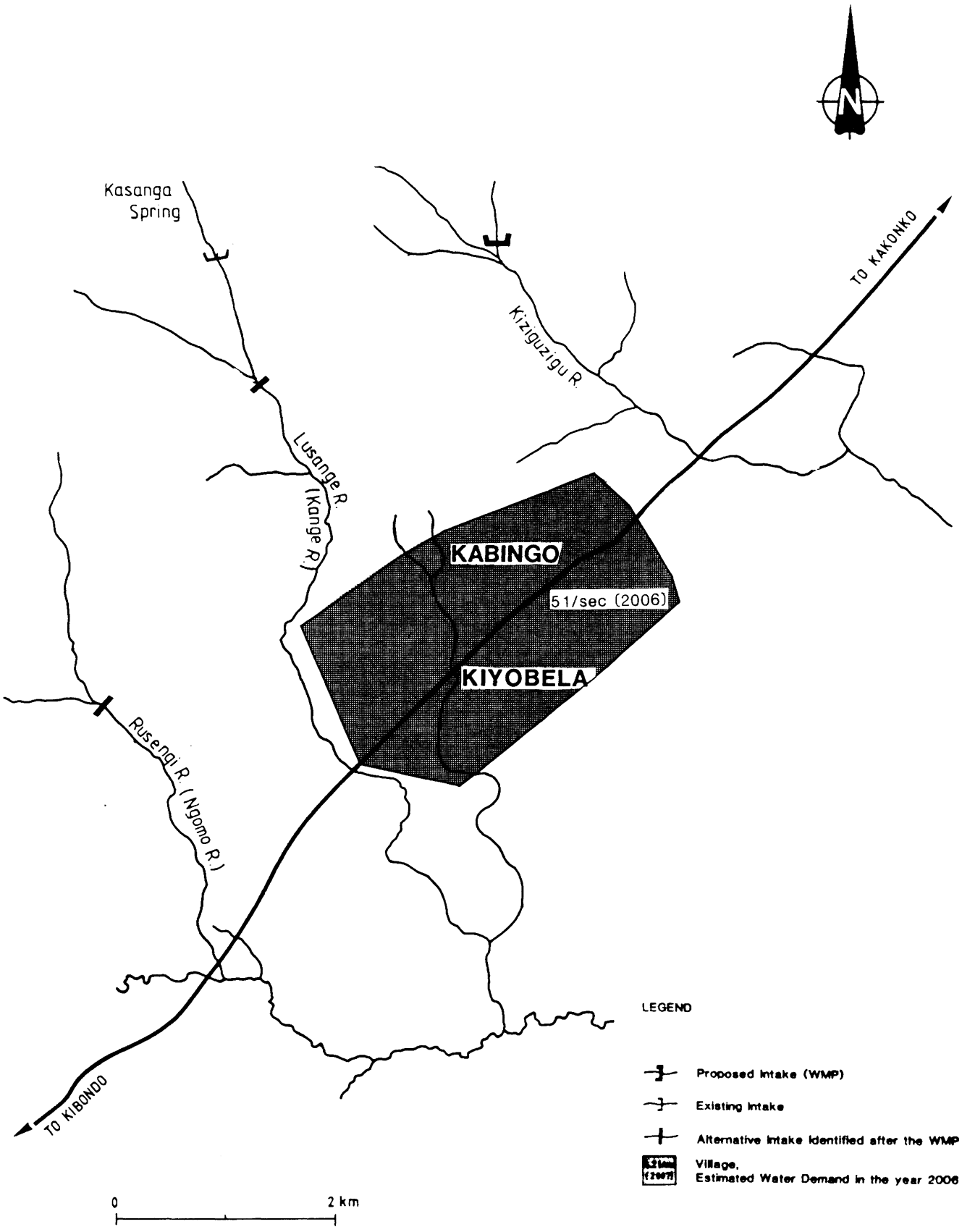

Figure 2.5 Alternative Water Sources to Kabingo/Kiyobela WSS.

The sporadic discharge measurements during the last three years show, however, that the two villages Kabingo and Kiyobela can not be served by one water source, if not the yield of the present intake can be increased by infiltration. The intake was visited on 30 September, and there are probably a lot of groundwater in the area. The existence and possibilities of extracting sufficient amounts of groundwater has to be confirmed by ground investigations, however. Before any decisions regarding the future water supply to Kabingo/Kiyobela are made, it is necessary to make proper levellings from the existing storage tank at Irela Hill to the various proposed intake sites, since any increases in altitudes of the proposed intakes will probably reduce the yield of the sources. The selection of sources will depend on the levels of the proposed intakes. Regarding water quantities, the two rivers Lusange and Ngomo seems to be the most reliable sources.

2.2.5 Bukirilo g/s (Figure 2.6)

The various water sources for the Bukirilo g/s are too small compared to the water demand in the two villages. There seems to be a lot of water in the ground and in the lower areas, but hardly enough in the higher areas from where gravity water supply could be possible. At the proposed intake site (WMP) in Kavumu River the low flow has been measured during the last three years to respectively 1.1 l/sec in 1985, 2.6 l/sec in 1986, and 2.8 l/sec in 1987. The value from 1987 is influenced by rain, and should be excluded. The nearby Kumgogo River was measured on 1 October 1987 to 1.7 l/sec, which is even less compared to the flow at the proposed intake. At both places there could be possibilities for increasing the yield by infiltration. In that case the Kumogogo River is probably the most promising one. Ground investigations should therefore be carried out before any decision regarding the water supply is taken. It is also assumed that the water discharge increases rather fast downstream from the two possible intakes, and relocation of the storage tanks should be considered.

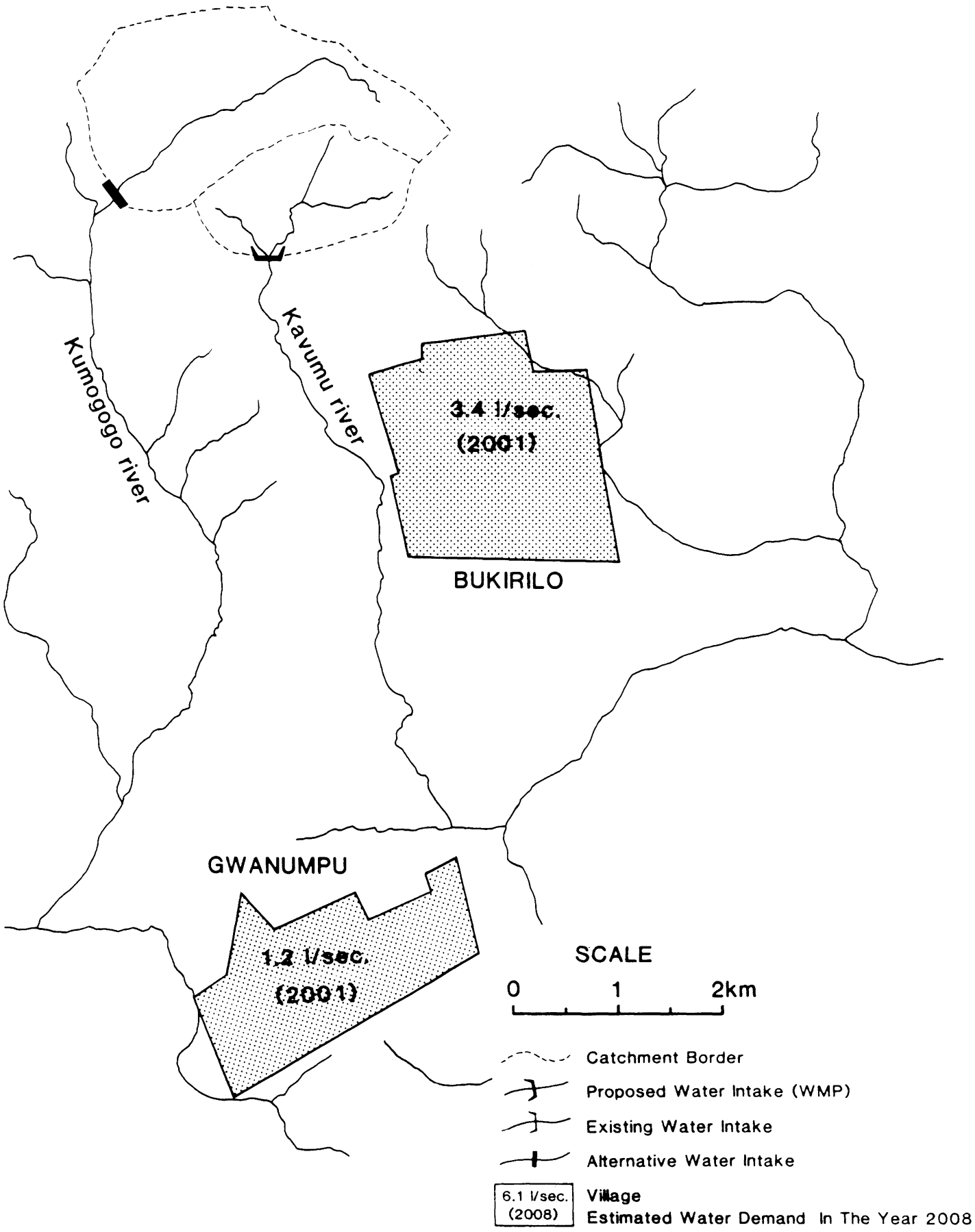

Figure 2.6 Alternative Water Sources to Bukirilo g/s.

2.2.6 Kakonko g/s (Figure 2.7)

After a brief reconnaissance in the small valley NNW of the Kakonko Mission (Figure 2.7), the conclusions reached in the "Hydrological Investigations 1985-86" report still seem to be valid. The valley was almost completely dry. Two shallow wells were observed, out of which one was dry and the other one had some water. The water potential seems to be very limited.

At Kakonko Mission, however, a shallow well had recently been excavated, and some testing of the yield was carried out in October 1987. The results from those observations might be quite useful for the District Water Engineer in his water supply planning. The flow of the spring at lower Mbizi was measured on 10 October 1987 to 1.53 l/sec (influenced by rain).

2.2.7 Kibondo Area (Figure 2.8)

The Kibondo Town and its densely populated sub-villages are located at a very high altitude compared to the surrounding areas. A map study has been carried out in order to identify possible sources for gravity water supply. The only area of necessary altitude was found NW of Bukirilo 20-30 kilmetres away from Kibondo. Those hills are very dry, however, and will not provide sufficient quantities of water. The only possible source in the future is probably pumping from the Nyawela River (existing intake). Prior to the implementation of the Kibondo area water supply a comprehensive water resources study should be carried out, however.

In the meantime traditional sources are being improved by means of spring protection. Fifteen of those springs were visited by the AH, and discharge measurements were carried out in order to identify the water potential of the area. All the springs are listed in Table 2.2, with numbers referring to Figure 2.8.

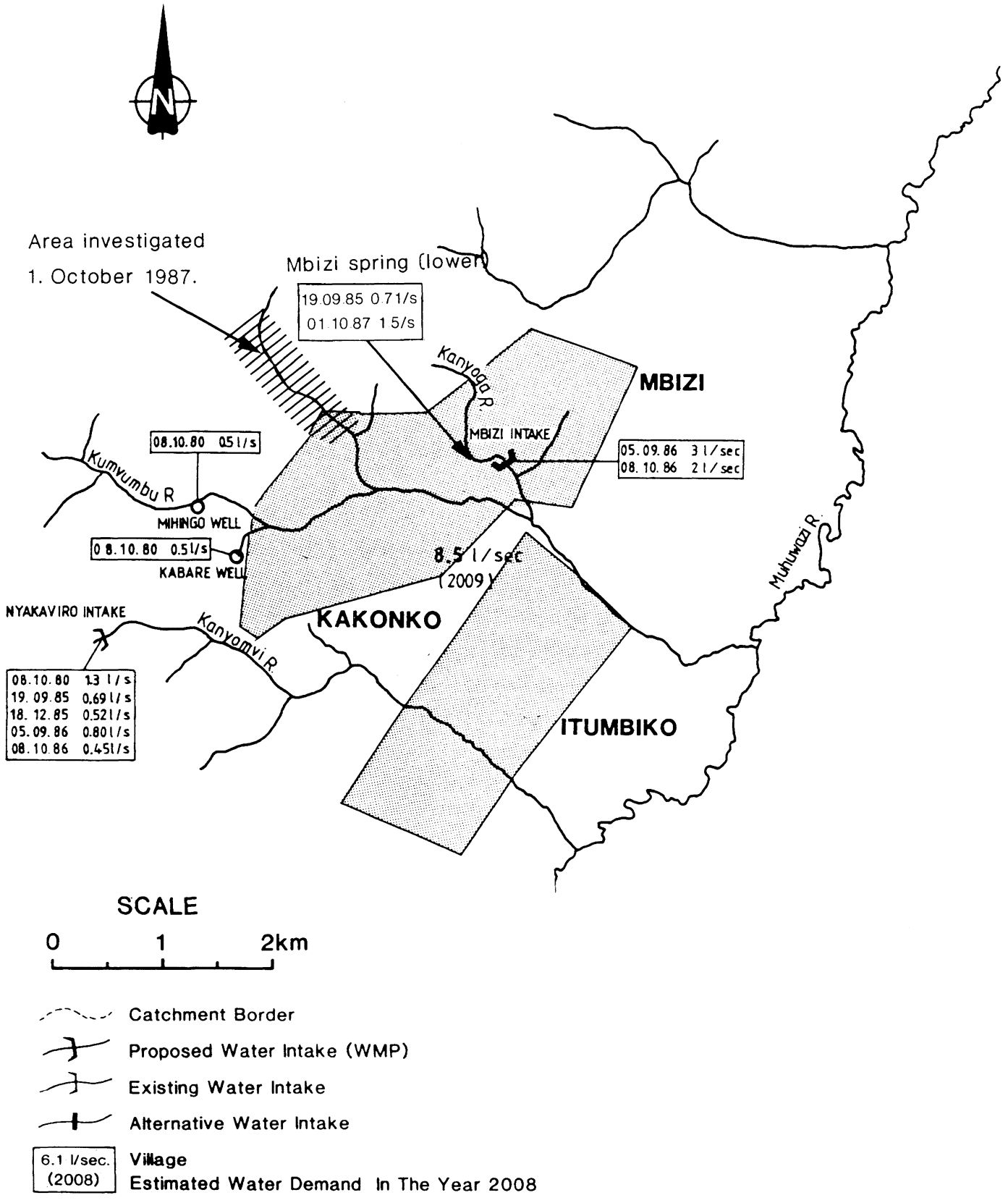

Figure 2.7 Alternative Water Sources to Kakonko g/s.

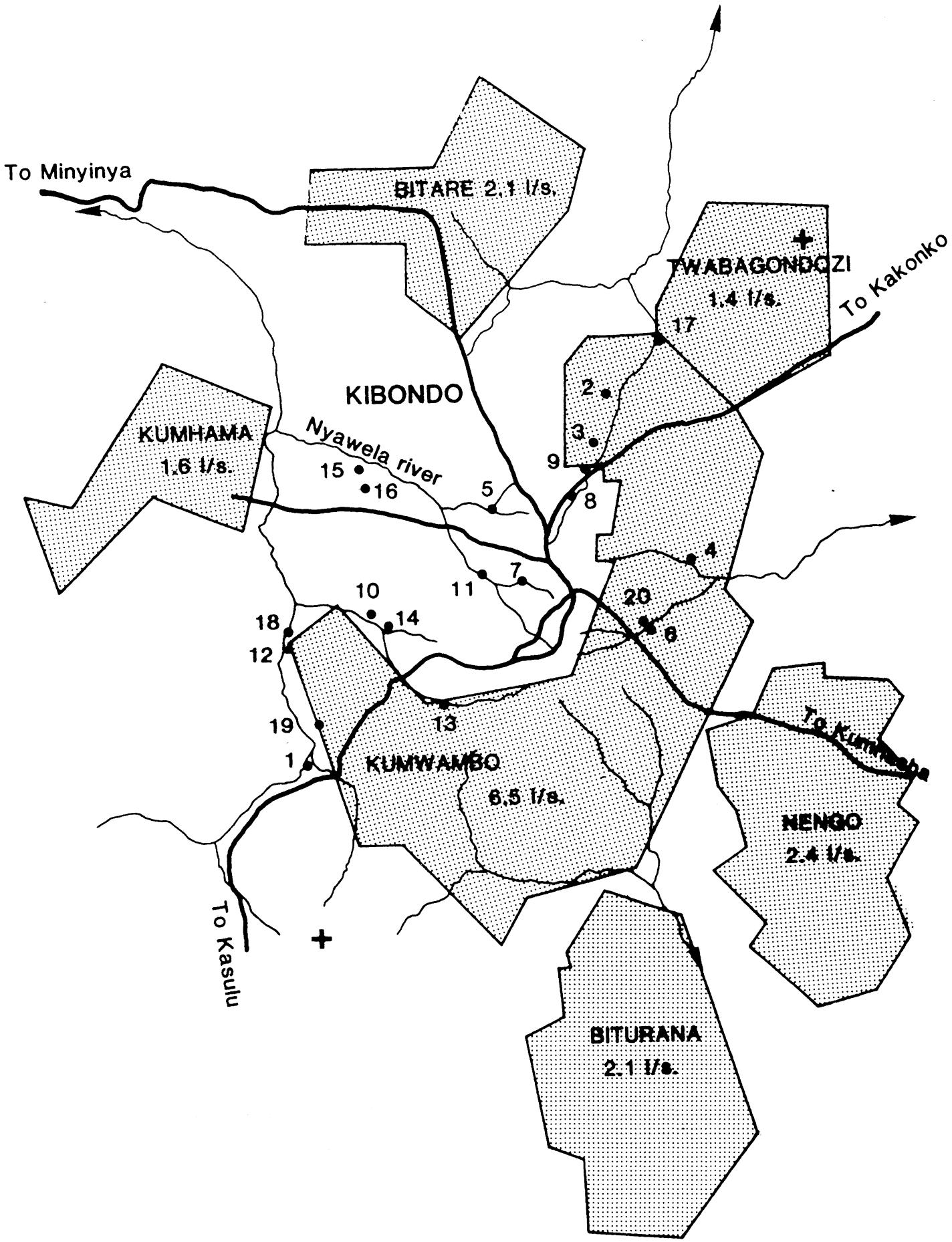

Figure 2.8 Selected Springs in the Kibondo Area.

Table 2.2: KIBONDO - TRADITIONAL SOURCES

Discharge measurements 2 - 4 October 1987

Ref. no.	Name/Place	Q l/sec	Remarks
1	Chemli Spring	6	Estimate
2	Kumwayi/Kitudamvula	1.0	Bucket/Stopwatch
3	Kumwayi/Kumwayi	0.20	Bucket/Stopwatch
4	Kamilamihange/Kumweluro		Not measured
5	Nyakigati/Nyawela	0.4	Estimate
6	Kamilanzovu/Kanyamahela	0.53	Bucket/Stopwatch
7	Nankuye/Nyawela		Not measured
8	Kumwayi/Kumwayi	0.26	Bucket/Stopwatch
9	Kumwayi/kumwayi		Not measured
10	Nyesage/Kabwigwa	0.24	Bucket/Stopwatch
11	Kumujigojigo/Nyawela		Not measured
12	Kwilibha/Kumwambo	0.09	Bucket/Stopwatch
13	Kabwigwa/Kabwigwa		Not measured
14	Kabwigwa	0.25	Bucket/Stopwatch
15	Nyabwolo/Nyamwela A	0.51	Bucket/Stopwatch
16	Nkundabhalima	0.30	Bucket/Stopwatch
17	Nyamata	1.84	V-notch
18	?	0.26	Bucket/Stopwatch
19	Kumwambo/Kumwambo ?	0.14	Bucket/Stopwatch
20	(Kamilanzovu/Kanyamahela)	0.60	Bucket/Stopwatch

2.2.8 Kumhasha (Figure 2.9)

At Kuamhasha the WMP has proposed to augment the existing pumping scheme from the Nyaryumbu River. In order to avoid the polluted water from the village, it was proposed to move the pumping station approximately 700 metres upstream from the previous one, which is in a very poor condition. Another possible intake site has later been identified in the Chigazulu River to the NW of the village, however, from where gravity water supply might be possible. The low flow was measured in 1980 (exact location unknown), 1985, 1986 and 1987, to respectively 1.2, 0.62, 1.0 and 2 l/sec. All values except the latter one (influenced by rain) are below the projected water demand of 1.5 l/sec in the year 2007. During the reconnaissance in early October 1987 the flow was measured just at the concluence between the two small rivers (both rivers measured). By moving a few hundred metres upstream along the eastern tributary, the flow was estimated to approximately 3 l/s. Heavy vegetation made any measurements impossible. It is assumed that the yield of the source may be increased by an infiltration trench across the small valley. Before any decision regarding the selection of water source is made, however, the water quality as well as the level of the existing storage tank should be checked.

2.2.9 Mukabuye (Figure 2.10)

The water yield from the existing gravity scheme from Kumuyumpu River is not even sufficient to meet the present water demand. In order to cover the demand the WMP has proposed deep boreholes with handpumps. Another possible source has been identified in the Kumnyva Mpanga River. Discharge measurements during 1986 and 1987 showed a low flow of more than 10 l/sec. Application of rainfall statistics indicate low flow with return intervals of 5, 10 and 20 years to respectively 12.3, 12.8 and 13.3 l/sec. The proposed deep groundwater utilization should therefore be abandoned in favour of the alternative intake in Kumnywa Mpanga River, which can easily be connected to the gravity main from the

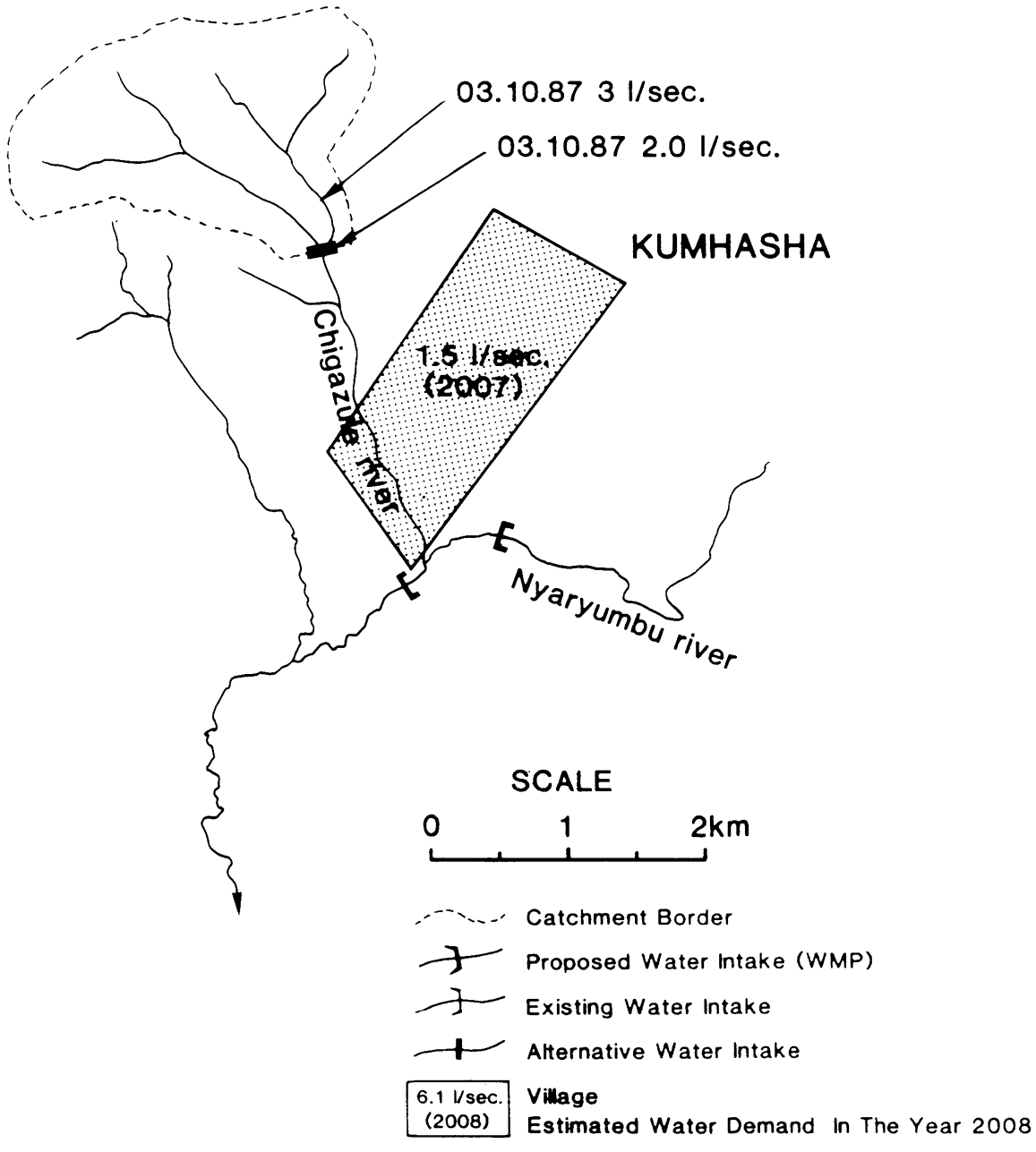

Figure 2.9 Alternative Water Sources to Kumhasha WSS.

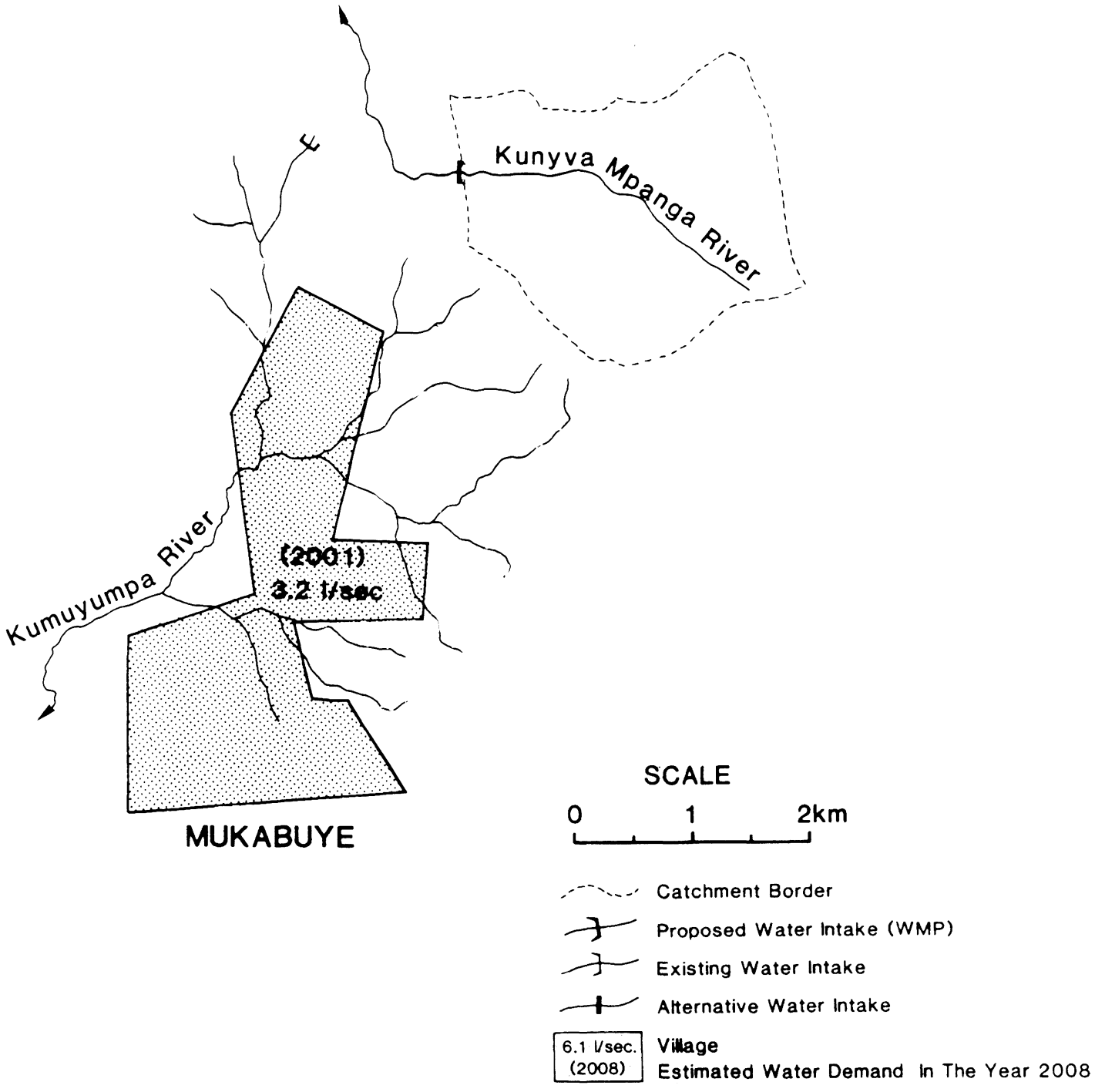

Figure 2.10 Alternative Water Sources to Mukabuye WSS.

existing intake. The alternative intake may have to be moved a bit further upstream from the flow measuring point, in order to get sufficient height. This will have negligible effects on the discharge, however.

2.2.10 Kasanda (Figure 2.11)

Gravity water supply from Lusenge River has been considered as an alternative to the proposed pumping station at Muhwazi River (WMP). The minimum flow during 1987 was measured as shown in Figure 2.11 to 2.6 l/sec, which is slightly less than the projected water demand. Estimated 10-years low flow is 2.7 l/sec.

The location of the alternative water intake should be considered by a water engineer, however.

If it is possible to place the intake downstream of the small tributary from the west, supplementary low flow measurements should be carried out during the next dry season. After the assessment of the necessary altitude of the intake, additional flow measurements should also be carried out in the larger southern tributary entering the Lusenge River from NW.

2.2.11 Songambele g/s

The Songambele g/s was described by the AH in his report one year ago, and the construction of the new water intake in the Nyanfizi River has already started. The yield of the water source is quite sufficient, but the P.P & P section at RWE's office in Kigoma requested some information on expected floods of the river.

Application of the TRRL East African Flood Model gives a design flood of 5.2 m^3/sec (10 years return interval).

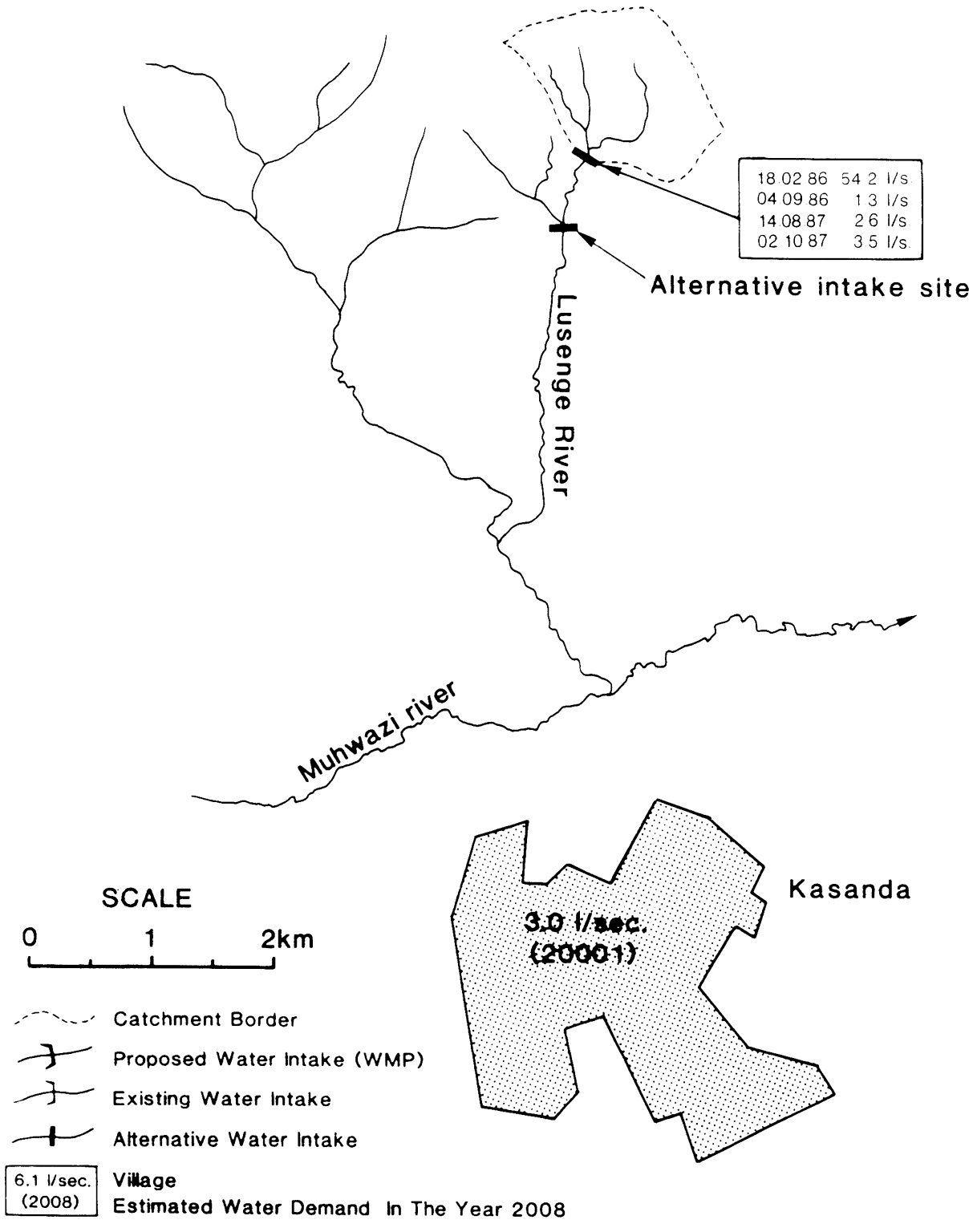

Figure 2.11 Alternative Water Sources to Kasanda WSS.

3. RUKWA REGION

3.1 Rainfall 1986-87

Montly rainfall at some selected stations is shown in Figure 3.1. The rainfall in most of the region was rather high compared to the long term mean. Only at Mpanda was the rainfall during the hydrological year 1987/87 below the average. In some areas the rainfall was extremely high (e.g. Karema).

It should be noted that Figure 3.1 illustrates the need for an updating of the WMP Volume 7, Hydrology. The results of the rainfall analyses deviate fairly much from the results in the WMP, where very short records were included.

3.2 Runoff Analyses and Results

3.2.1 General

The Hydro-Section at RWE's Office in Sumbawanga has carried out an impressing amount of work during the dry season 1987. The work program compiled by the AH in June 1987 has been completed by almost 100%, as well as additional surveys and investigations.

During the AH's visit in last October numerous discharge measurements were carried out in the Rukwa valley, in order to get some information on the runoff conditions along the escarpment. The results might be of minor importance for water supply purposes, but will be valuable in the rural development planning. The investigations will also simplify any flood estimations to be done in connection with the Rukwa Road.

All spot discharge measurements carried out during the last dry season are included in Appendix 2 while the villages are shown in Figure 3.2.

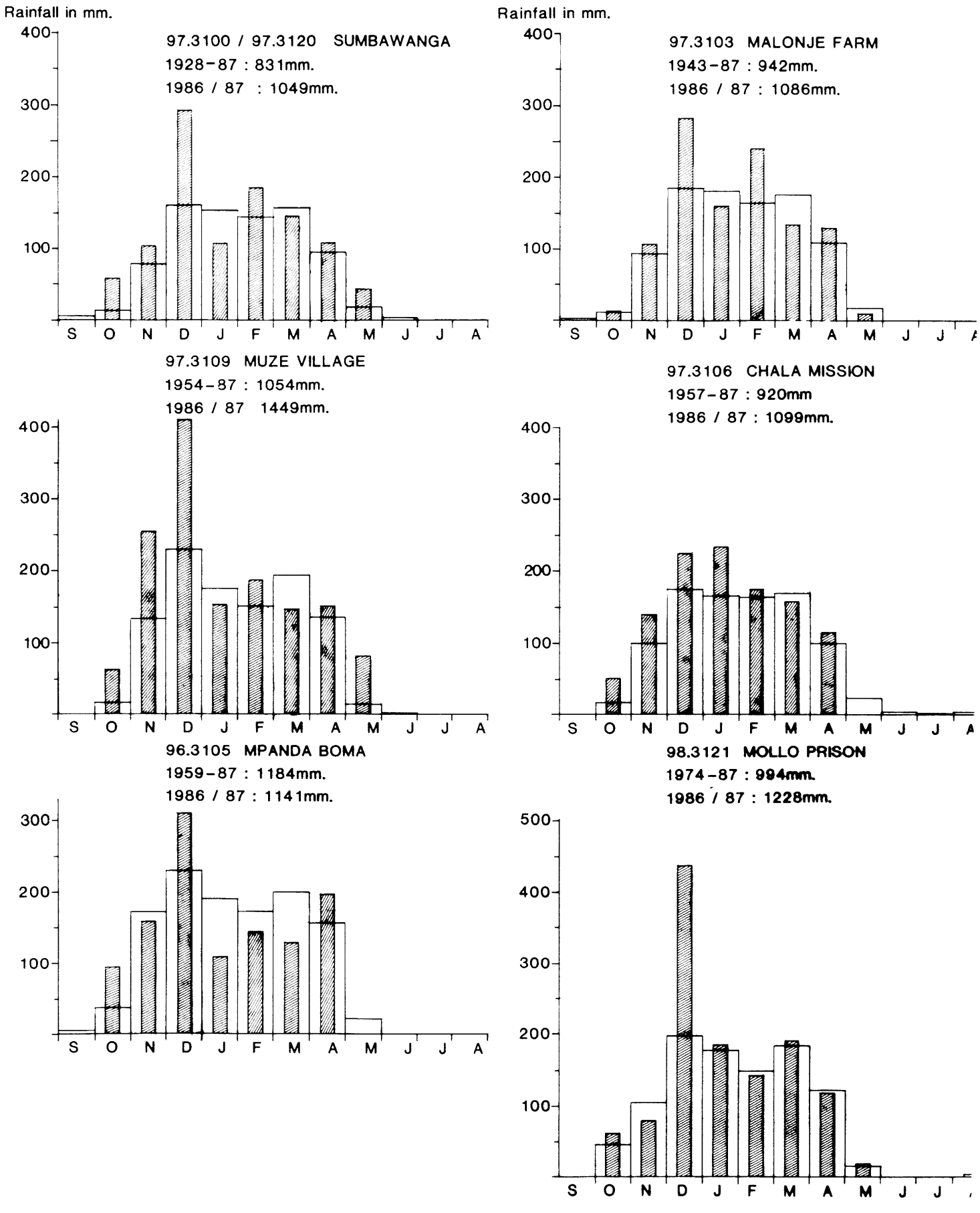

FIGURE 3.1
RAINFALL IN RUKWA REGION

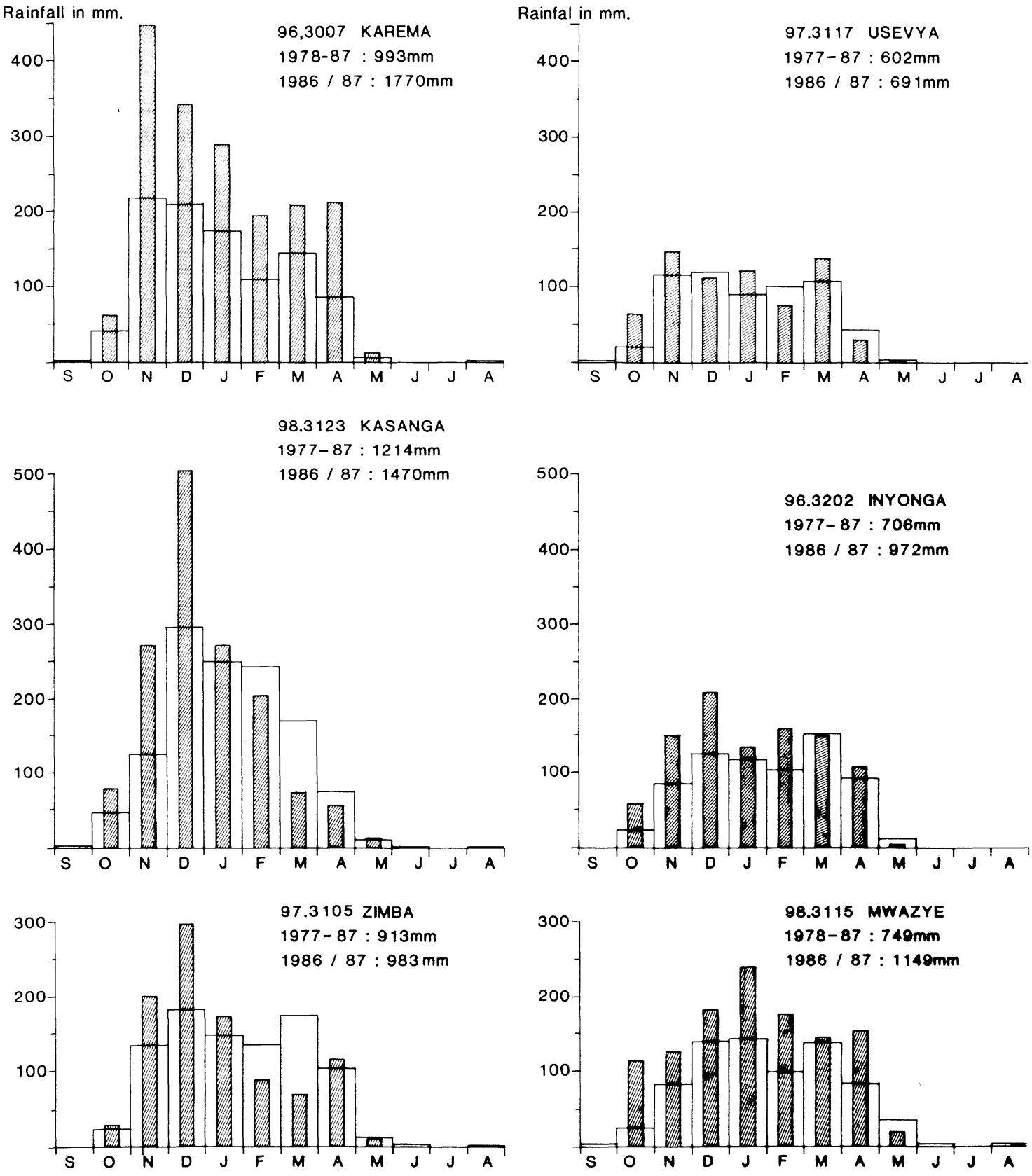

FIGURE 3.1 Cont'd.

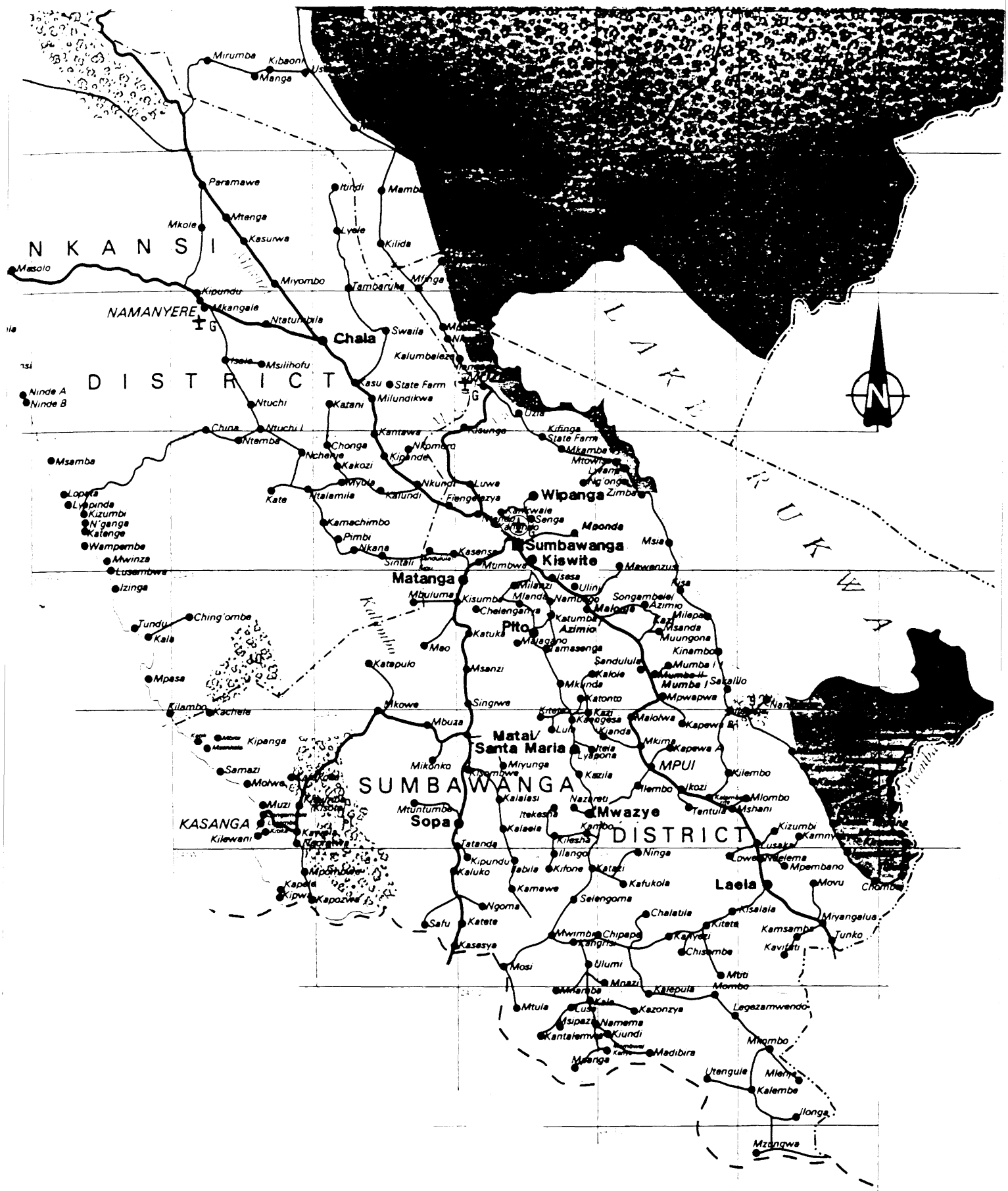

Figure 3.2 Location Map.

3.3.2 Matanga g/s (Figure 3.3)

The investigations during 1987 have only confirmed the previous estimates of the water yield from the three existing intakes. Estimated 5 year low flow is slightly less than 10 l/sec, while the 20 year low flow is calculated to 8.3 l/sec, using rainfall statistics. 75% of the water is coming from the Katuka River intake. Obviously several water sources have to be exploited in order to cover the future water demand to Matanga g/s. Map studies have revealed, however, the presence of several rivers at sufficient altitude within easy reach of the Matanga g/s. At present no information on the yield of those rivers exists. Next dry season spot discharge measurements should be carried out, in order to establish the runoff relationship to the Katuka River and its tributaries. Details and locations will follow in the work program for the dry season 1988.

3.2.3 Chala g/s (Figure 3.4)

So far the runoff observations in Chalantai River are rather confusing. The low flow has been measured to 2.0, 6.2, and 24.0 l/sec, respectively in 1984, -86 and -87. The great variations are difficult to explain, and should be followed by additional measurements during 1988.

Discharge measurements during 1987 were also carried out in the nearby Kauzike River, where the low flow was measured to 6 l/sec on 25 September. Application of rainfall statistics gives a 5 year low flow of approximately 3 l/sec. Utilization of both rivers may cover the water demand, but this assumption should be confirmed by a few spot measurements the coming dry season.

3.2.4 Pito g/s (Figure 3.5)

As pointed out in earlier reports, the water yield at the existing intake is not sufficient to cover the demand to the group scheme. After identifying the nearby Kalenge River as a

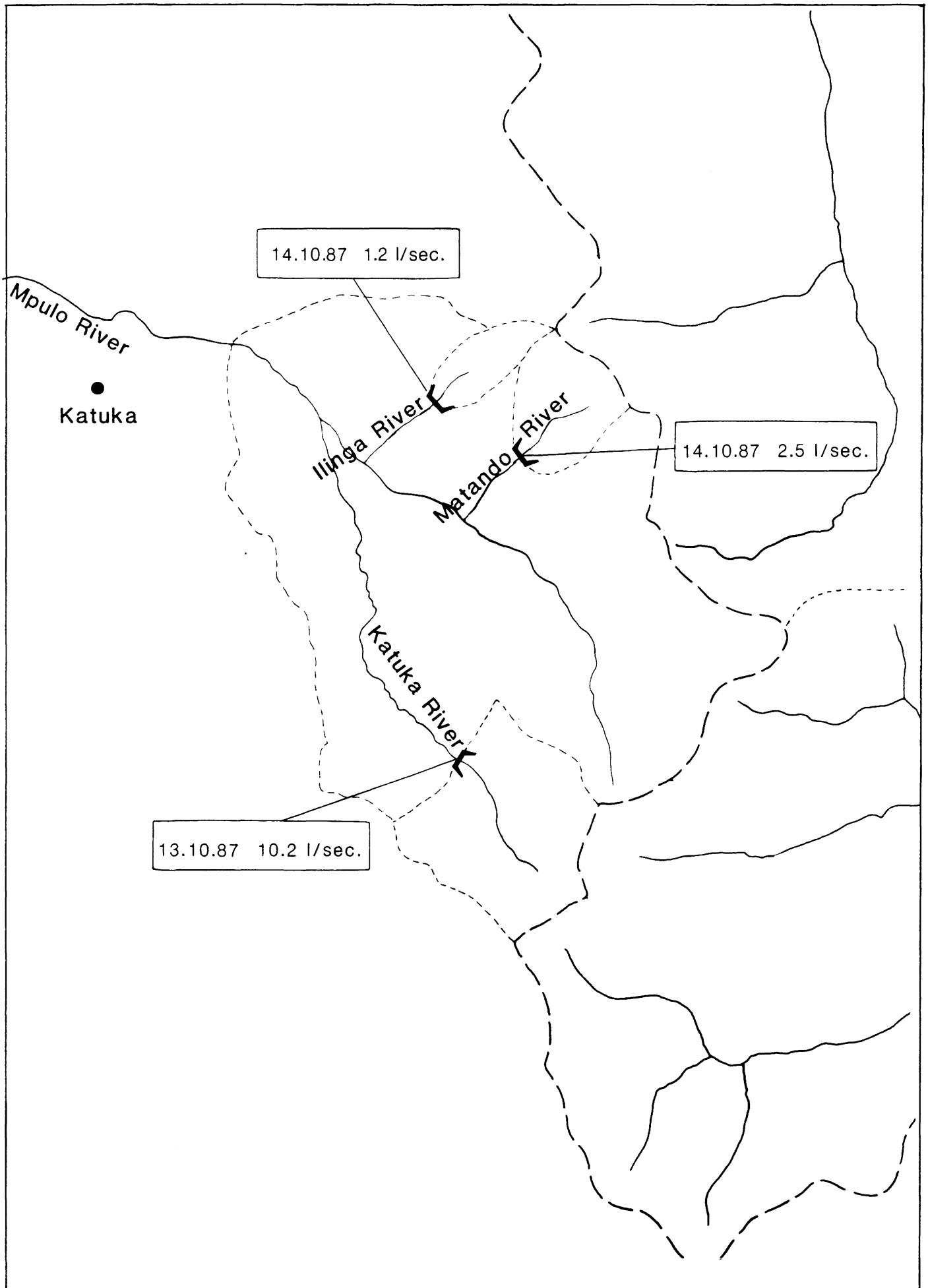

Figure 3.3 Alternative Water Sources to Matanga g/s.

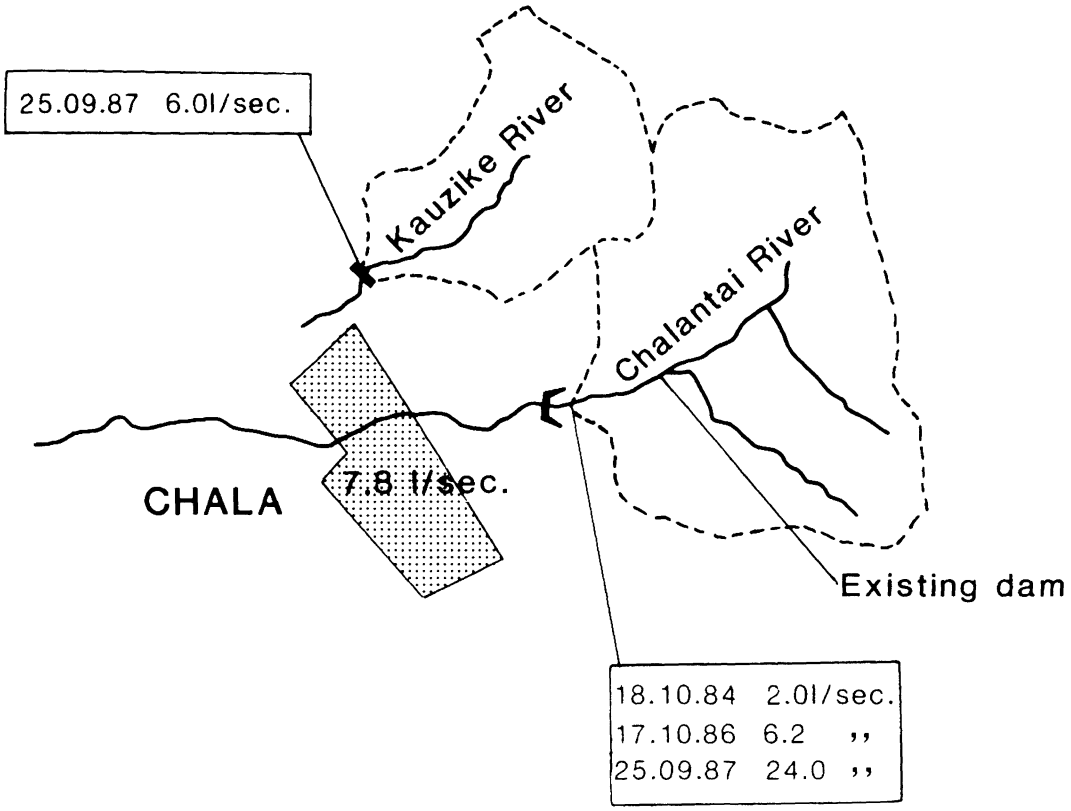

Figure 3.4 Alternative Water Sources to Chala g/s.

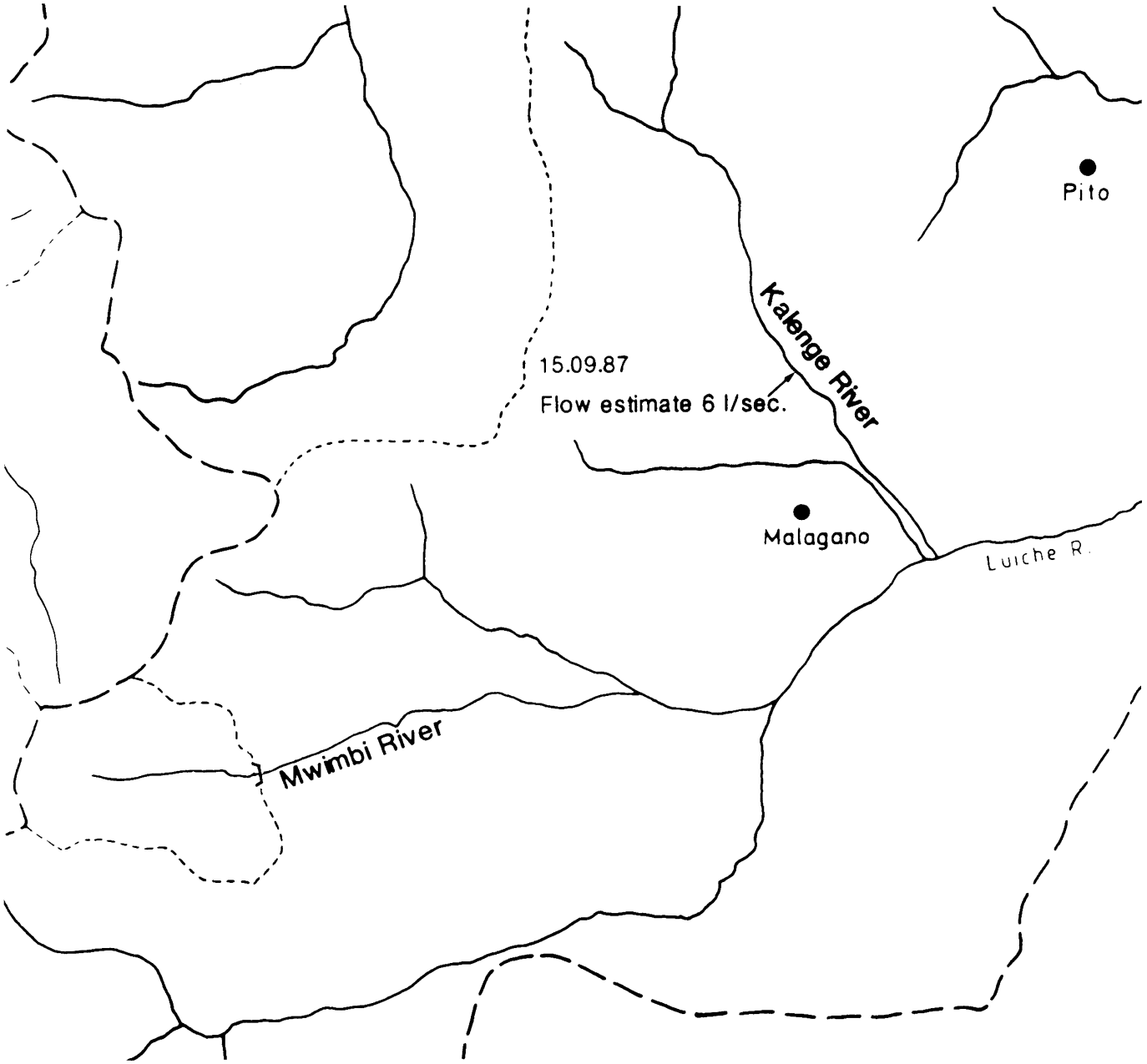

Figure 3.5 Alternative Water Sources to Pito g/s.

future potential water source, the river was visited in October 1987. The flow was estimated to 5-6 l/sec just upstream of the school in Malangano, which reduced to the 5 year low flow gives approximately 3 l/sec. It is therefore recommended, as the need arises in the future, to connect the Kalenge River to the existing gravity main for the Pito group scheme.

3.2.5 **Namanyere** (Figure 3.6)

The only reliable sources for gravity water supply to Namanyere are located to the mountainous area in the southwest, where three different rivers have been investigated. Spot discharge measurements were carried out in the two rivers Namteketa and Nankala in July 1982, a rather dry year. The yield is small, however, and even below the confluence the observed flow was less than the projected water demand to Namanyere.

During 1987 another tributary to the Nkulugusu River, namely the Kitete River, was identified, and minor investigtions were carried out. The flow recession observed during the period August-October reveals that the river can probably provide the sufficient amount of water for Namanyere. This assumption, however, is only based on one year of observations, and another year of observations is necessary before any decisions are made.

3.2.6 **Mpanda Urban** (enclosed map)

The water demand to Mpanda Urban WS is estimated to 60 l/sec (according to information from RWE's Office). At present there is no reliable water supply, and the possibilities for gravity water supply have therefore been investigated. The DWE's staff has identified a few selected springs and rivers where spot discharge measurments have been carried out by the Hydro-Section in Sumbawanga. The locations and the results are shown on the map enclosed. As can be seen there are substantial amounts of water flowing from the higher area in the NE, out of which the

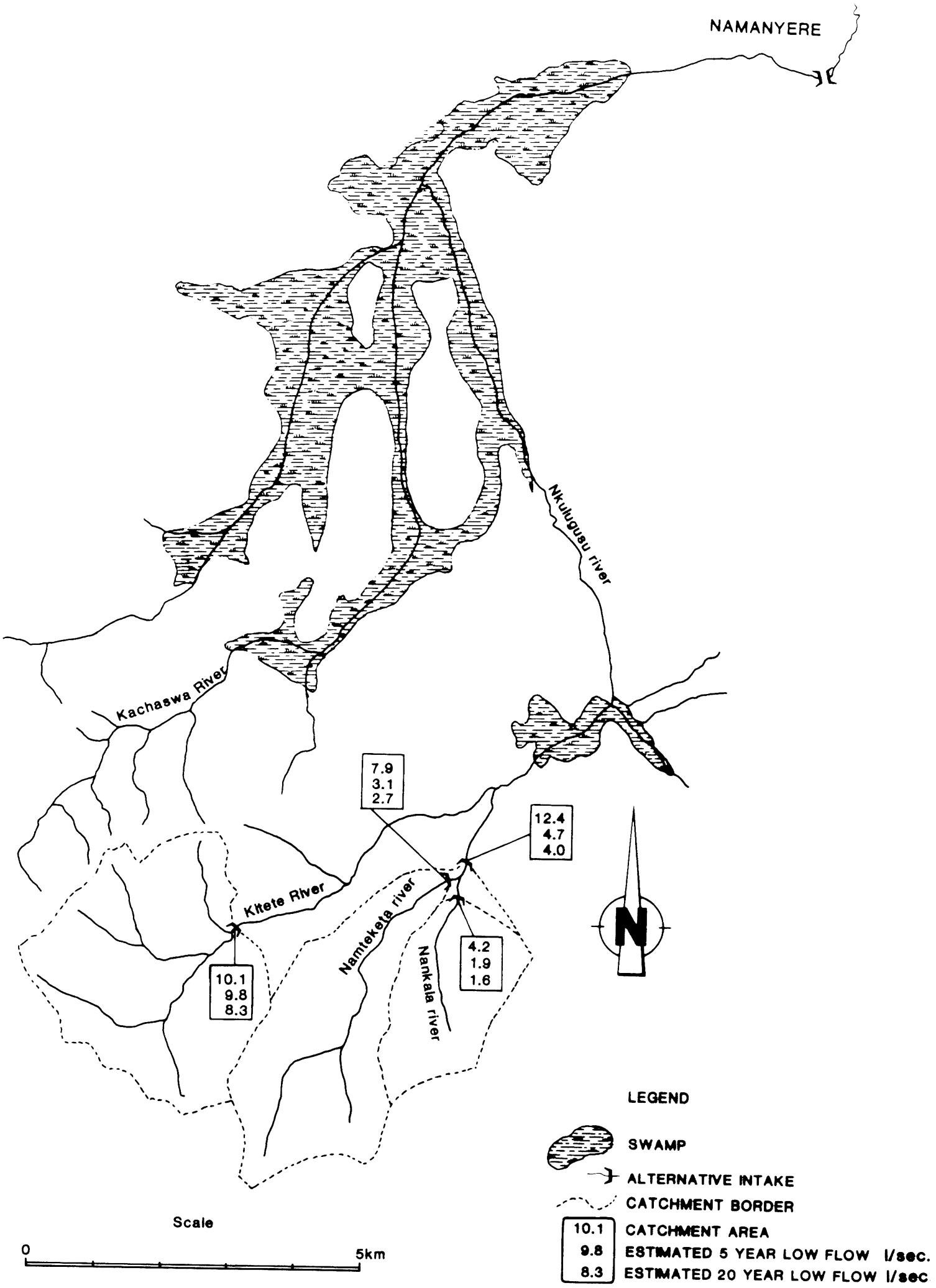

Figure 3.6 Alternative Water Sources to Namanyere WSS.

Ikilongo spring seems to be the most reliable one. The low flow was measured on 1 October 1987 to 114 l/sec. Application of rainfall statistics indicates a 20 year low flow of 88 l/sec, which will cover the water demand to some villages as well. This assumption is based on only one observation year, and considering the importance of the scheme as well as the costs involved in the development, the runoff observations should be confirmed by additional measurements during the dry season in 1988.

The flow measurements in the area also reveal very small correlation between low flow and catchment area. This divergence is probably explained by varying phreatic water divides compared to the surface water divides.

3.2.7 Sumbawanga Urban WSS

The various water sources for Sumbawanga Urban have been investigated for several years. As the data base increases, some of the data from the early eighties appear to be rather unreliable. Permanent weirs were constructed upstream of the existing intakes in the Kanantumbi and Muva rivers in late 1986, while another weir was established in the Momoka River earlier the same year. The Momoka River was identified as a possible water source a few years ago.

Runoff observations during 1986/87 indicate that the earlier 20 year low flow has been underestimated, especially at the Muva intake, but also at the Wipanga intake.

The present data base is faily large, and it is therefore proposed that a comprehensive hydrological analysis is being carried out, using daily observed runoff at Luiche/Uzia for calibration of a runoff model already developed. Daily runoff at Muze/Muze should be used for correlation and quality control of the Luiche River data, and further for the assessment of daily, montly and annual runoff. Then flow duration curves can be assessed for the various intakes, which is very important

since water reservoirs will be necessary in the future. Additional benefits for the Rukwa road planning will be gained through flood assessments for the two rivers Luiche and Muze.

For confirmation of the low flow, a model based on catchment characteristics should be used. Such a model has already been developed at NVE, and may be calibrated for the purpose. The whole study, including data quality control and model calibration, is expected to take approximately one month, and may be started as soon as a request is received.

During the AH's visit to the region in October 1987 montly runoff with 10 years return interval as well as a flood analysis for the Kanantumbi intake was requested.

Some rough estimates have been done, based on earlier reports, and adjustments based on recent observations. Floods with 10 and 20 years return interval have been assessed by application of the TRRL-model for East Africa. Montly runoff values are shown in Table 3.1.

Table 3.1 Montly runoff at Kanantumbi water intake (10 years return interval), l/sec.

J	F	M	A	M	J	J	A	S	O	N	D
42	55	54	55	34	27	23	20	18	16	17	46

The 10 years instantaneous maximum flood has been roughly estimated to 2.7 m^3/sec.

APPENDIX 1

LOW FLOW MEASUREMENTS - KIGOMA REGION

(list not complete)

LOW FLOW MEASUREMENTS/KIGOMA REGION

Village	Demand, l/sec Q_{24}	Q_{pd}	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
KASANGEZI	3.6	5.4	2007	Karenge R.	Sept.80	0.5	0.8	0.63	V-notch. Exist int.
					11.06.81	9.0			Bucket
					17.06.81	7.0			"
					30.06.81	5.5			"
					17.07.81	10.0			
					31.07.81	9.0			
					13.08.81	7.0			
					27.08.81	5.0			
					09.09.81	5.0			
					24.09.81	3.0			
					09.10.81	3.0		3.75	
					30.10.81	4.0			
					05.06.85	0.7		0.88	
					11.10.85	0.75			
					17.07.87	3.5			
					22.09.87	1.8			
				Muzye R.	27.06.85	44.0	7.8		V-notch. Prop. int. (RWE)
					03.09.85	34.5			Pygmee-Ott
					12.09.85	32.2			V-notch
					03.10.85	23.8		3.05	"
					11.11.85	28.4			Pygmee-Ott.
					04.06.86	90.4			
					22.07.86	64.9			
RUSESA g/s	12.7	15.9	2006	Kasengezi R.	04.09.80	9.0	7.1	1.27	Pygmee-Ott. Old int.
					11.06.81	65.0			
					17.06.81	59.0			
					30.06.81	56.0			
					17.07.81	55.0			
					12.08.81	51.0			
					27.08.81	47.0			
					09.09.81	41.0			
					29.10.81	37.0	5.21		

Village	Demand, l/sec Q_{24}	Q_{pd}	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
RUSESA (cont'd)					29.09.84	3.6		0.51	V-notch (fixed)
					03.10.85	5.3		0.75	" "
					03.10.85	2.2	4.03	0.55	Bucket, before confluence
				Nyabagole R.	17.06.81	31.0	2.59		At new intake
					17.07.81	25.0			
					13.08.81	19.0			
					27.08.81	18.0			
					24.09.81	10.0			
					30.10.81	14.0			
					20.10.84	1.9			V-notch (fixed, new int.)
					03.10.85	4.3			" " "
BUGAGA g/s	10.0	15.0	2007	Mushori R.	04.09.80	14.0	1.66		At intake.
					12.09.85	12.9			V-notch. At intake.
					03.10.85	10.4		6.27	" " "
					11.10.85	11.4			" " "
					03.04.86	20.2			
					01.10.86	15.7			
				Nyabushish R.	03.10.85	9.4	1.22	7.71	Bucket. Opposite to intake.
					11.10.85	12.6		10.33	" " "
					03.04.86	21.0			
NKUNDUZI	2.1	3.1	2006	Mubanga R.	17.06.80	3.5			Exact position unknown.
				Rundugu R.	17.06.80	2.5			" "
				Mubanga R.	13.09.85	8.1	1.5	5.40	Bucket. After confluence.
					05.10.85	8.0			" "
					05.10.85	3.3	0.54	6.11	Bucket. Before confluence.
					04.06.86	9.7			
					02.10.86	4.5			V-notch (portable).
				Rundugu R.	04.06.86	21.9			
					02.10.86	5.7			V-notch (portable).

Village	Demand, l/sec Q_{24}	Q_{pd}	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
MARUMBA	4.2	6.2	2001	Kaligamba R.	04.10.85	2.33	< 1	> 2.33	Bucket.
					03.10.86	4.49			V-notch (portable)
				Nyakivuba R.	27.06.80	5.0			Proposed int. WMP, d/s of pond.
					13.09.85	4.5			
					05.06.86	13.5			
					03.10.86	4.7			
				Kisito R.	04.10.85	4.26	< 1	> 4.26	Bucket.
					05.06.86	27.10			After confluence w/Kaligamba R.
					03.10.86	5.7			V-notch, portable
MURUFITI g/s	6.4	9.6	2007	Mgandazi R.	17.06.80	1500	61.9		Old Intake.
					04.10.85	11.5	61.0	0.19	Pygmee-Ott. Inflow to pond.
					04.10.85	4.0	61.5	0.07	V-notch. After pond.
					04.10.85	26.7	61.9	0.43	Pygmee-Ott. Old intake.
					06.11.85	44.4			
					22.07.86	87.0			Midway between pond & old int.
					01.10.86	54.6			
KASULU	47.0	56.0	2005	Miseno R.	05.10.85	28.1	5.13	5.48	Pygmee-Ott.
					24.12.85	33.5			
					06.06.86	77.6			
					02.10.86	28.7			
					24.09.87	33.0			V-notch and Pygmee-Ott.
				Nyanka R.	07.10.85	16.9	1.52	11.12	V-noth (fixed). Exist intake.
					24.12.85	25.4			
					06.06.86	25.4			
					02.10.86	20.9			
					23.09.87	19.6			
HERU JUU g/s	7.5	9.8	2007	Ghogo R.	23.09.85	11.2			V-noth and bucket.
					06.10.85	14.7			Pygmee-Ott & bucket.
					03.10.86	13.9			V-notch (fixed).
SONGAMBELE g/s	8.9	11.6	2007	Nyanfizi R.	04.10.86	36.6			Pygmee-Ott.

Village	Demand, l/sec Q_{24}	Q_{pd}	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
NYANTARA g/s	10.4	13.5	2008	Mgandazi R.	31.08.85	34.1	11.45	2.98	V-notch (fixed)
					07.10.85	28.7			
					06.11.85	44.5			
					24.12.85	69.8			
					06.06.86	101.0			
					02.10.86	35.7			
					17.07.87	70.4			Pygmee Ott.
					24.09.87	42.9			" "
MUNYEGERA	3.4	5.1	2001	Lugambwa R.	07.10.85	10.4	4.12	2.52	V-notch, at alt. intake
					05.06.86	64.7			
					03.10.86	9.0			
MWANGA	4.7	7.0	2007	Nyanzanze R.	11.06.80	5.0			?
					07.10.85	1.52	0.74	2.05	Bucket, just u/s waterfall
					05.06.86	3.5			
				Kigombe R.	07.10.85	6.00	1.92	3.13	Bucket, at alt. intake.
					05.06.86	29.50			
					03.10.86	7.08			V-notch (portable)
BUKUBA	4.4	6.6	2001	Nyanzogoro	12.10.80	6.00			?
					07.10.85	5.3	4.18	1.27	Bucket, at prop. intake.
MSAMBARA	4.3	5.4	2006	Muganga R.	31.10.84	2.6	3.6	0.72	V-notch (fixed). Exist int.
					05.11.84	12.0			
					14.05.86	59.4			
KALELA	2.9	4.3	2004	Kunde R.	09.10.85	5.1			
MKONOGORO g/s	42.3	48.7	2006	Nyete R.	05.06.80	30.0			
					05.09.80	29.0	15.8	1.8	Pygmee-Ott 200m u/s of intake
					19.09.80	48.0			?
					09.10.80	43.0			?

Village	Demand, l/sec Q_{24}	Q_{pd}	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
MKONGORO g/s (cont'd)				Kaseke R.	18.08.81	232.0	40.0		U/s of road bridge to Mkongoro
					01.09.81	83.0			
					15.09.81	145.0			
					22.09.81	98.0			
					16.10.81	105.0			
					07.11.81	83.0			
					09.10.85	67.4	22.6		Pygmee-Ott. Alt.int. (RWE)
MGARANGANZA g/s	7.5	11.2	2004	Muanda R.	26.09.79	9.0			At intake.
					30.08.80	6.0			V-notch, intake.
					19.09.80	(3.9)			
					14.10.80	4.5			
					Apr. 81	6.0			
					18.06.84	3.6			
					12.07.84	3.4			
					30.07.84	3.2			
					10.09.84	2.6			
					24.09.84	(2.3)			
					05.11.84	(1.9)			
NYAKITONTO	(3.6)		2001	Chai R.	19.02.86	7.3			Bucket
					14.05.86	19.6			
MUGOMBE	(2.6)		2001	Janda R.	19.02.86	7.7			
KUMWAMBO	(6.5)		2001	Kibingo R.	06.09.86	2.0			V-notch

Village	Demand, l/sec Q_{24}	Q_{pd}	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
KABINGO g/s	5.0	6.5	2006	Kiziguzigu R.	18.09.80	4.3			Prop.int.
					07.11.80	5-10			Estimated
					01.02.85	3.0			
					20.09.85	2.1			Bucket, d/s of confluence.
					18.12.85	2.5			
					18.02.86	4.42			
					08.10.86	2.99			V-notch, portable
					12.08.87	7.3			Pygmee Ott d/s of confluence
					30.09.87	5.4			" " "
				Lusange R.	01.02.85	0.44			Bucket, inflow to storage tank
				(Kange R.)	18.09.85	1.61			Exist. intake
					18.09.85	(0.22)			
					18.12.85	1.72			
					18.02.86	3.72			Alt. intake + inflow to storage
					08.10.86	3.88			tank (Bucket).
					13.08.87	7.2			V-notch (portable)
					30.09.87	7.0			
				Rusengi R.	09.10.86	3.95			
				(Ngomo R.)	13.08.87	9.50			
					30.09.87	6.60			
KAKONKO g/s	8.5	11.0	2009	Nyakaviro R.	08.10.80	1.3			
				(exist. int)	01.02.85	1.0			?
					19.09.85	0.69			Bucket, u/s intake.
					18.12.85	0.52			
					05.09.86	0.8			V-notch (portable).
					08.10.86	0.45			V-notch (portable).
				Kanyaga R.	19.09.85	1.1			Bucket, upper Mbizi.
					19.09.85	1.53			Bucket, lower Mbizi.
					01.10.87	0.70			Bucket, lower Mbizi.
					05.09.86	3.0			At small bridge.
					08.10.86	2.0			Estimate.

Village	Demand, l/sec Q_{24}	Q_{pd}	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
CHURAZO g/s	2.6	3.9	2006	Kifunza R.	15.10.80	3.0	16.9	0.18	
					17.12.85	2.6			Fixed V-notch.
BUKIRILO	3.4	5.0	2001	Kavumu R.	20.09.85	1.1	1.9	0.6	Bucket, prop. int.
					04.09.86	2.6			
					15.08.87	4.0			V-notch, portable.
					01.10.87	2.77			
				Kumjigojigo R.20	20.09.85	0.54			Bucket
				Kumgogo R.	01.10.87	1.68			V-notch, portable, alt.int.
BUKIRILO g/s	4.6	7.0	2001						
KUMHASHA	1.5	2.2	2007	Chigazule R.	20.11.80	1.0			
					20.09.85	0.62			Bucket, d/s of prop. intake.Farming, irr. est. 2-3 l/sec.
					04.09.86	1.0			V-notch, at prop. int.
					15.08.87	3.0			V-notch, portable
					03.10.87	2.0			
KASEKE	4.3	6.4	2007	Nyamponda R.	16.08.84	10.8			
					29.08.84	5.7			
					28.08.85	31.5	73.4		V-notch (fixed).
					23.09.85	21.5			" "
					08.10.85	14.5			" "
					08.10.85	12.5	50.4	0.25	Bucket, 150 m d/s of int.
NYAMOLI	2.0	3.0	2007				2.0		
KASANDA	(3.0)		2001	Lusenge R.	18.02.86	54.2			
					04.09.86	1.3			
					14.08.87	2.6			V-notch, portable
					02.10.87	3.5			

Village	Demand, l/sec Q_{24}	Q_{pd}	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
MLELA	3.2	4.8	2006	Spring	01.09.84	5.8			Pygmee-Ott.
					31.05.85	12.4			Near village.
					31.05.85	7.1			Upper reaches of the stream/spring.
					31.05.85	2.6			
					18.11.85	3.4			
MUKABUYE	(3.2)		2001	Kumnywa	06.09.86	12.4			
				Mpanga R.	16.08.87	14.5			V-notch, portable.
					03.10.87	28.2			
MKATANGA g/s	(14.0)			Kivuruga R.	17.06.86	17.7	1.41		
(MANYOVU)					04.10.86	6.1		4.3	
KIBONDO TOWN				Kumwambo R.	19.02.86	17.1			
					05.09.86	3.0			V-notch (portable).
					02.10.87	12.6			
KANAZI	4.2	5.9	2007	Maurwbezi R.	02.08.80	3-4	1.11	3.15	At prop. int.
				Spring I	04.05.85	2.3			Bucket
					30.08.85	2.1			
					09.09.85	2.0			
					16.09.85	2.0			
					16.11.85	1.7			
					08.03.86	2.9			
					14.03.86	2.9			
					24.03.86	2.9			
					03.04.86	2.9			
					11.04.86	2.9			
					18.04.86	3.3			
					25.04.86	3.3			
					12.05.86	3.3			
					14.06.86	2.9			
					26.06.86	2.9			

Village	Demand, l/sec Q_{24}	Q_{pd}	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
KANAZI (cont'd)				Spring II	30.08.85	2.3			
					09.09.85	2.1			
					16.09.85	2.0			
					06.11.85	1.5			
					08.03.86	6.7			
					14.03.86	8.0			
					24.03.86	10.0			
					03.04.86	10.0			
					11.04.86	10.0			
					18.04.86	10.0			
					25.04.86	10.0			
					13.05.86	8.0			
					14.06.86	6.7			
					26.06.86	5.0			
				Spring III	30.08.85	2.6			
					09.09.85	2.5			
					16.09.85	2.4			
					06.11.85	1.5			
					08.03.86	8.0			
					14.03.86	8.0			
					24.03.86	8.0			
					03.04.86	8.0			
					11.04.86	6.7			
					18.04.86	8.0			
					25.04.86	8.0			
					13.05.86	8.0			
					14.06.86	5.7			
					26.06.86	5.0			
					01.10.86	2.3			
				Spring I+II	01.10.86	3.2			
				Mgurubezi R.	30.08.85	13.2			V-notch, d/s of 3 springs.

APPENDIX 2

LOW FLOW MEASUREMENTS - RUKWA REGION

(list not complete)

LOW FLOW MEASUREMENTS/RUKWA REGION

Village	Demand, l/sec	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
NAMANYERE	4.1	2001	Namteketa R u/s	19.07.82	2.9	7.85		u/s of alternative intake
			Namteketa R. d/s	19.07.82	4.4	12.40		d/s of river confluence
			Nankala R.	19.07.82	1.8	4.23		
			Kitete R.	12.08.87	27.0	10.05		
				11.09.87	18.0			
				09.10.87	14.0			
MATANGA g/s	16.6		Katuka R.	02.11.85	13.0	2.83		u/s of exist. int.
				09.05.86	22.0			
				21.05.86	17.0			
				05.06.86	16.0			
				02.07.86	16.0			
				30.07.86	11.0			
				04.09.86	9.1			
				20.10.86	6.6			
				27.05.87	49.0			
				21.07.87	23.0			
				30.07.87	20.0			
				20.08.87	17.0			
				13.10.87	10.2			
			Katuka R. (Mpulo R.)	05.11.85	45.0	21.68		u/s of Katuka Village
			Matonta R.	05.11.85	1.5	1.13		u/s of exist. int.
				09.05.86	5.5			d/s of exist. int.
				21.05.86	9.0			u/s of exist. int.
				05.06.86	9.0			
				02.07.86	6.0			
				30.07.86	3.0			
				04.09.86	2.6			
				07.10.86	2.4			
				20.10.86	2.4			

Village	Demand, l/sec	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks	
MATANGA g/s cont'd		2001	Matonta R.	27.05.87	16.0				
				30.07.87	8.0				
				20.08.87	5.0				
				14.10.87	2.5				
			Ilanga	05.11.85	0.6	0.57		u/s of exist. int.	
				09.05.86	4.0			d/s of exist int.	
				21.05.86	2.0			u/s of exist. int.	
				02.07.86	4.0				
				30.07.86	4.0				
				04.09.86	2.8				
				07.10.86	2.1				
				20.10.86	1.7				
				30.07.87	4.0				
				20.08.87	3.0				
				14.10.87	1.2				
MWAZYE g/s	(4.0)	2001	Mwazye R.	18.09.80	7.75	4.29		Northern tributary	Ref. WMP Vol. 5
					0.60	1.28		Southern tributary	
					8.50	7.73		Exist. int.	
				27.10.86	19.40				
PITO g/s	(7.8)	2001	Mwimbi R. (Luiche)	27.10.86	8.3	2.24			
				18.08.87	19.0				
				24.09.87	17.0				
MATAI	(6.5)	2001	Matwazi R.	28.10.86	22.6	16.15		At exist. intake	
SOPA	(2.1)	2001	Kate R.	30.06.81	~ 4.0	1.88		Estimated. At intake.	
				28.10.86	6.5			At intake.	
LAELA g/s	(10.5)	2001	Mpona R.	29.10.86	6.9	11.12		Total at int.	
			Kanondo R.	29.10.86	3.7				

Village	Demand,l/sec	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
ITEKESHA		2001	Nkukumo River	13.06.83	17.0	1.63		Surface velocity (Nasari)
				06.07.87	12.0			
				24.09.87	11.0			
MAWENZUSI	1.5	2001	Nzovwe River	05.11.84	28	84.98		At pumphouse
				30.01.85	1001			
				22.04.86	1566			
				30.05.86	933			
				11.04.87	1804			
				13.04.87	1208			
				14.04.87	1236			
				15.04.87	1707			
				02.08.82	204	74.3		At intake
				01.10.82	75			"
				04.11.83	52			"
				10.10.84	29			Intake channel and main channel
				30.10.84	5.4			" " "
				11.02.85	23			Intake channel?
				01.11.84	68	117.8		At Rd.brd. downstream of escarpment
KASOTE	2.2	2001	Kapondwe	05.09.80	50			
				02.11.83	19			
				19.09.84	12			
				29.10.84	5			Estimated (KR)
				25.10.85	22			
KAFUKOKA		2001	Lyamvya Spring	05.09.80	10			
				27.03.84	5-10			Estimated (KR)
				01.08.84	12			
				29.10.84	4.8			V-notch
				25.10.85	15			Baby-Ott.
				29.10.84	1.2			Small spring further north

Village	Demand, l/sec	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
CHINA		2001	China River	17.08.83	46.0			V/A method (Mhina)
KAPOZWA		2001	Mvundwi River (Mkamba R.)	23.08.83	5.0			V-notch (Mhina)
KAOZE		2001	Kaoze River	16.06.83	41.0			Velocity/Area (Mwangosi)
MIYUNGA		2001	Lolesha River	24.08.83	3.0	1.93		V-notch (Mhina)
KAPENTA		2001	Lundwe River	11.08.83	137.0			V/A method (Mwampulo)
NKUNDI	2.2	2001	Itende River	11.12.85	1.0			
				18.12.85	1.5			
				30.10.86	1.4			
			Kawa River	11.12.85	3.0			
				18.12.85	1.5			
				30.10.86	47.9			
				21.09.87	14.0			
SUMGAMILA		2001	Chankala River	24.09.86	2.7			
KANOGE		2001	Manga Juu River	22.09.86	22.0			
				09.04.87	44.0			
				23.06.87	50.4			
				24.08.87	24.0			
KABURONGE		2001	Kaburonge River	22.09.86	19.0			
MWEZE		2001	Msimbazi River	21.09.86	9.7			Pumphouse
					0.8			Proposed intake
			Lugonesi River	21.09.86	2.6			

Village	Demand, l/sec	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. $l/sec.km^2$	Remarks
ILEMBA		2001	Mkange R.	10.10.80	50-60	126.1		Estimated.
				04.10.84	~ 300			Estimated.
MPONDA		2001	Mwambazi R.	11.08.80	100.0	22.05		At road brg. to Mponda Vill.
				13.08.80	117.0			
				15.08.80	105.0			
			Mponda River	03.07.81	8.0			Existing intake.
				14.09.81	14.0			
				05.05.82	25.0			
				19.05.82	152.0			
				26.07.82	4.0			
MFINGA		2001	Chikwale R.	16.10.87	33.6			
MPETE		2001	Mpete R.	16.10.87	132.4			At Rukwa road brg.
KALUMBALESA		2001	Kilambwa R.	16.10.87	38.0			At Rukwa road brg.
MPWAPWA		2001	Nakilulu R.	06.08.86	10.0			
				26.08.86	6.5			
				08.10.86	2.1			
				25.11.86	1.6			
				29.11.86	12.1			
				23.12.86	34.0			
				20.06.86	12.0			
				27.07.87	7.0			
				17.08.87	5.0			
				28.09.87	2.8			
KALUNDI		2001	Iyali R.	03.08.87	33.0			
			Nzwelamkwale R.		15.0			

Village	Demand, l/sec	Year	River/Spring	Date/ Year	Qobs, l/sec	Catchment area, km^2	Qspes. l/sec.km^2	Remarks
CHALA g/s	7.8	2001	Chalantai R.	15.04.82	52.0	4.99		
				18.10.84	2.0			
				17.10.86	6.2			
				05.03.87	40.5			
				19.03.87	72.0			
				02.04.87	52.0			
				16.04.87	60.0			
				08.05.87	59.0			
				21.05.87	47.0			
				02.06.87	46.0			
				22.07.87	36.0			
				07.08.87	31.0			
				25.09.87	24.0			
			Kauzike R.	08.05.87	32.0			
				21.05.87	24.3			
				22.07.87	12.0			
				07.08.87	9.0			
				25.09.87	6.0			

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