

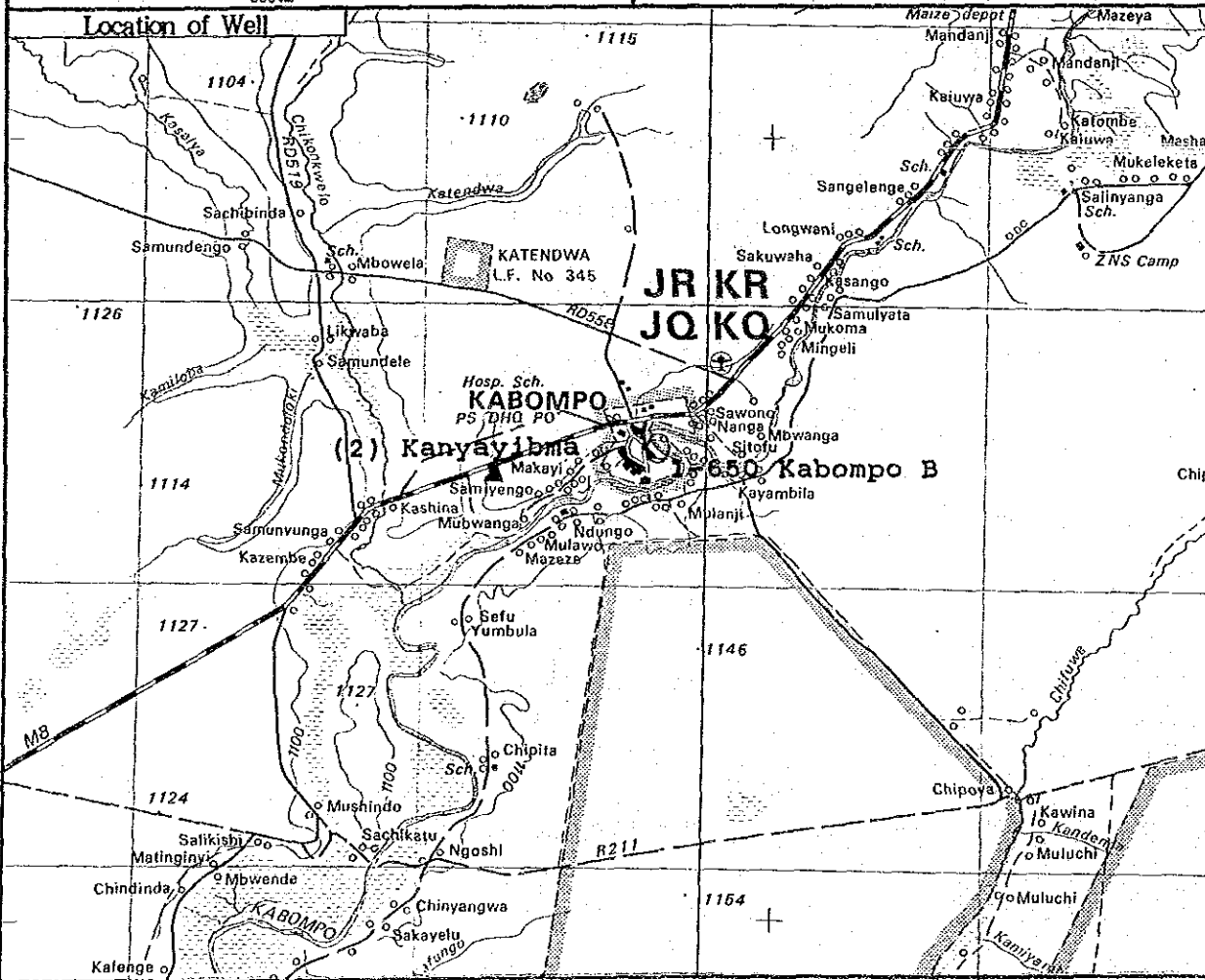
SUPPLEMENT - 2.1

INVENTORY OF WELL OBSERVATION

No.1 Kanyilaba	(2.1- 1)
No.2 Kanyayimbu	(2.1- 2)
No.3 Watopa	(2.1- 3)
No.4-1 Luanchama	(2.1- 4)
No.4-2 Lishawa	(2.1- 5)
No.5 Machatanga	(2.1- 6)
No.6-1 Milne Farm	(2.1- 7)
No.6-2 Litoya	(2.1- 8)
No.7 Kansofu	(2.1- 9)
No.8 Mwambashi	(2.1-10)
No.9 Kabulanda	(2.1-11)
No.10 Mpatamato	(2.1-12)
No.11 Machiya	(2.1-13)
No.12 Chilenga	(2.1-14)
No.14 Lupemba	(2.1-15)
No.15 Kafue H/B	(2.1-16)
No.16 Upper Kaleya Dam	(2.1-17)
No.17 Uruaff Farm	(2.1-18)
No.18 Mutamina	(2.1-19)

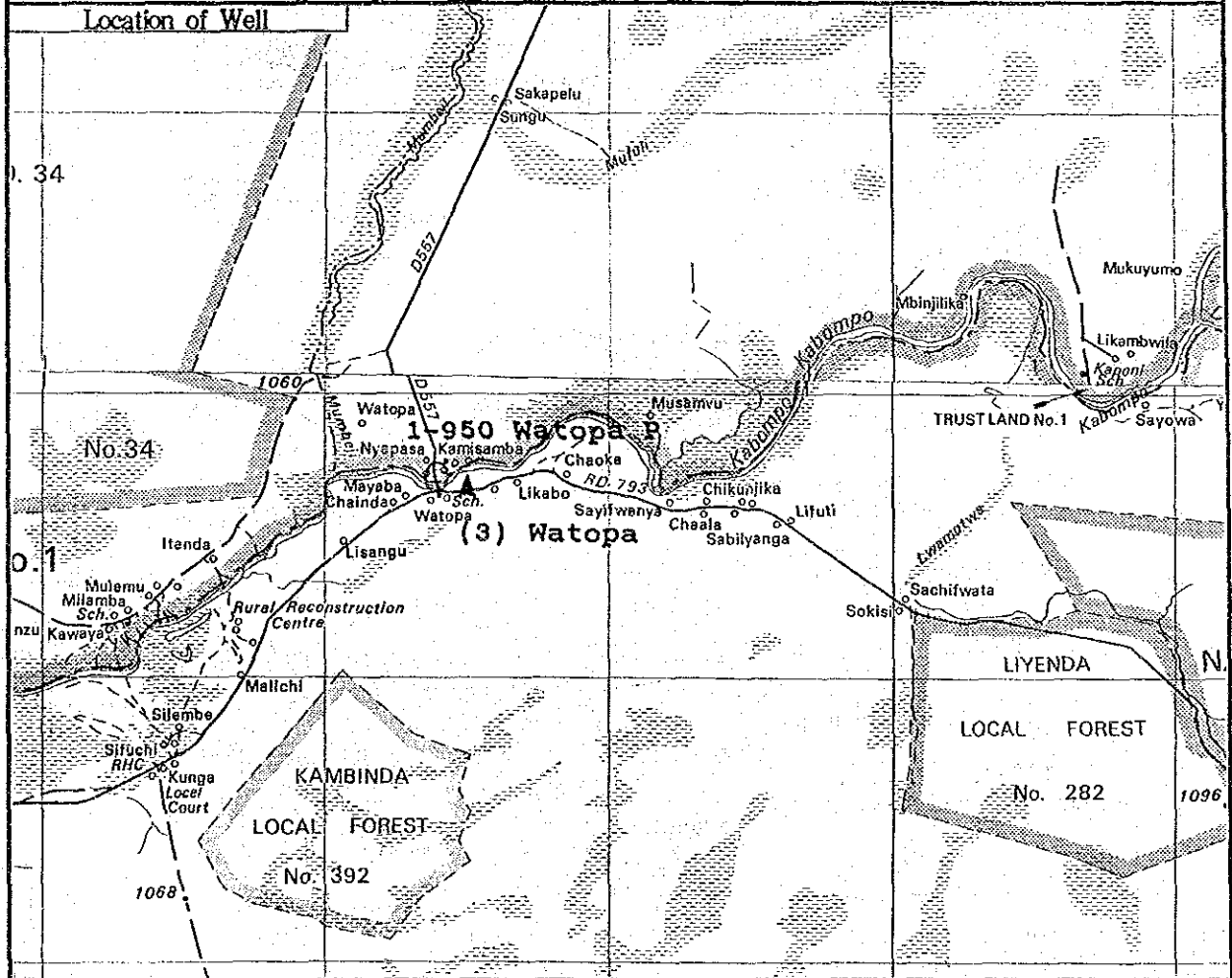
Observation Well

Well No. & Name	2 Kanyayimbu	<h3>Cross Section of Well</h3>
Related Hydro.St.	St.1 - 650	
Well Type	Shallow Digging	
Used for	Domestic Use	
Depth	14.00m	
Diameter	130cm	
<h3>Sketch of Well</h3>		
<h3>Water Quality</h3> <p> T = 25.0°C EC = 110 μmho/cm pH = 6.0 RpH = 6.0 (23.7.90) </p>		

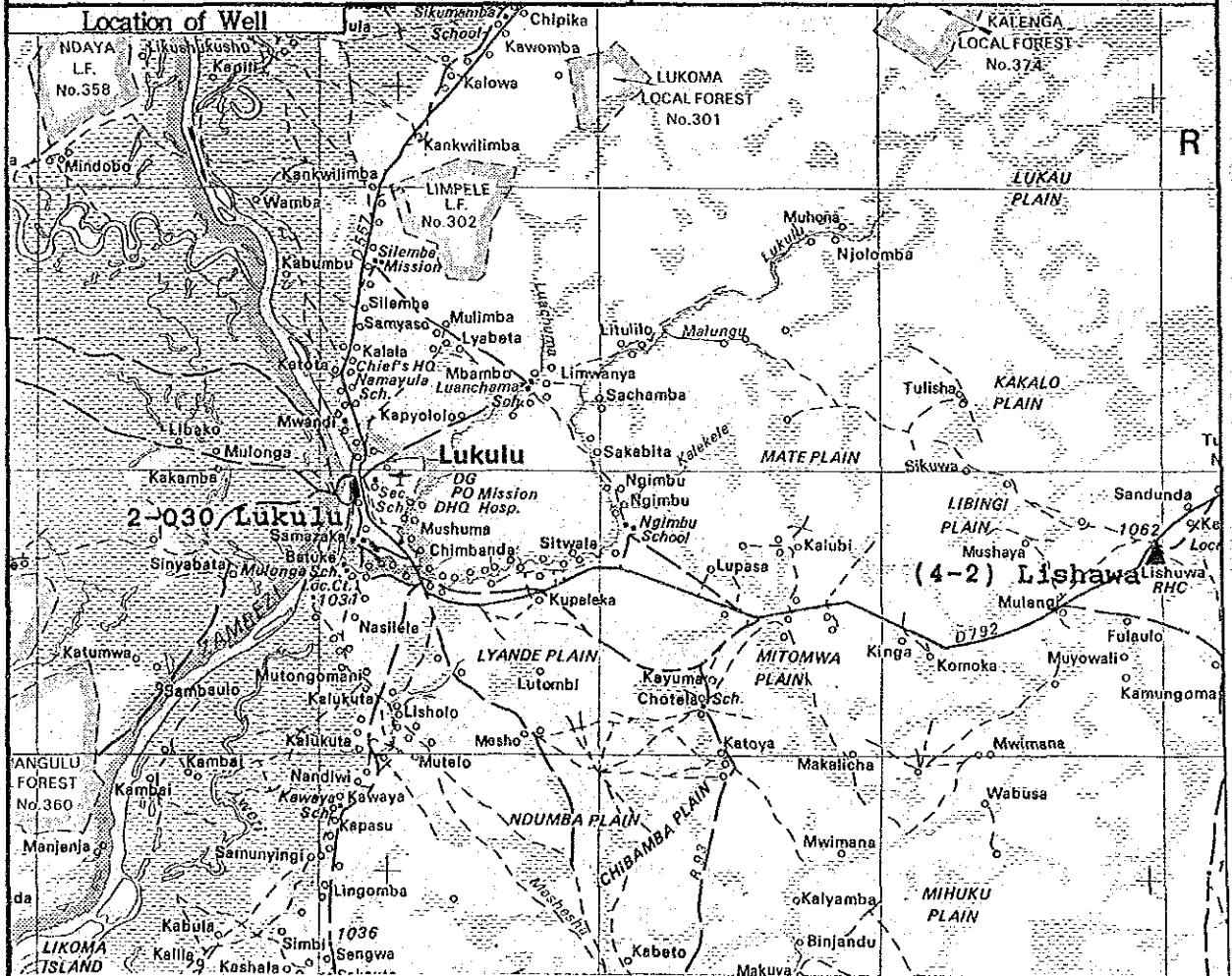
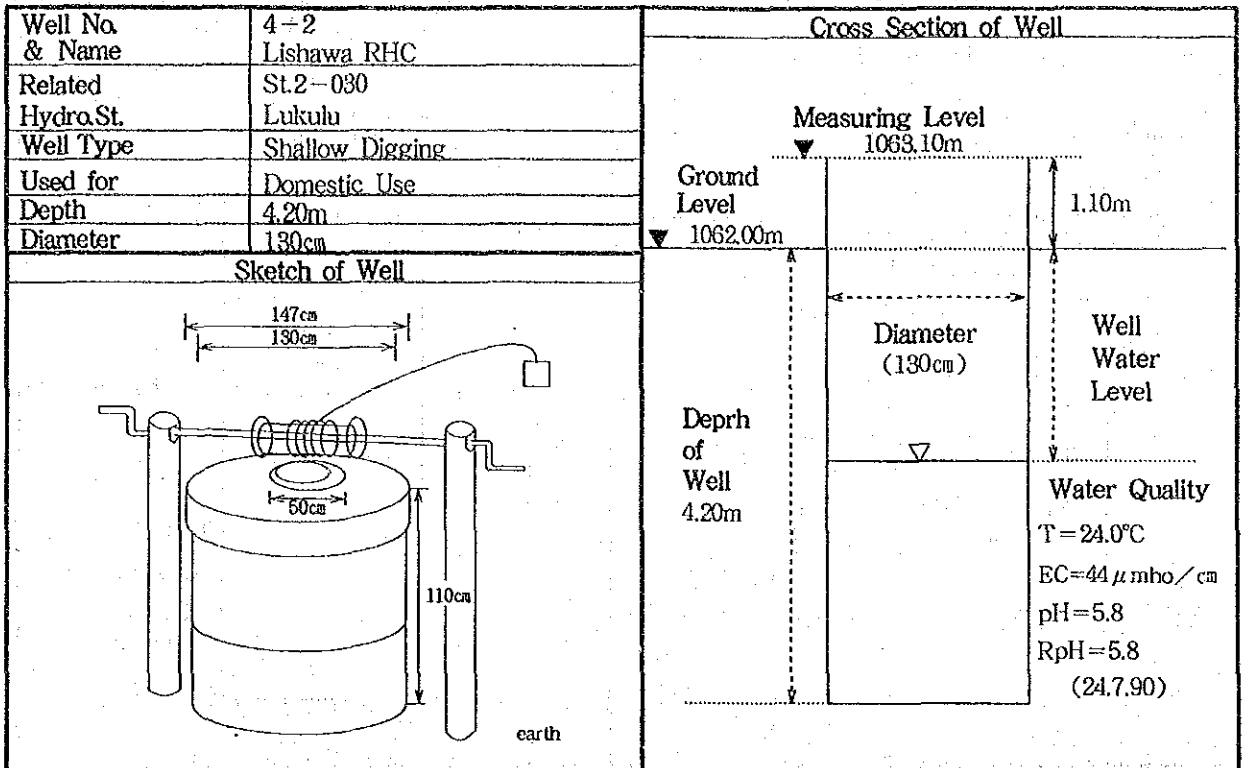


Observation Well

Well No. & Name	3 Watopa	Cross Section of Well	
Related	St.1-950	Measuring Level 1038.49m	
Hydro.St.	Watopa pontoon	Ground Level 1038.06m	0.43m
Well Type	Shallow Digging	Diameter (130cm)	
Used for	No use	Well Water Level	
Depth	11.79m	Water Quality	
Diameter	130cm	T=24.8°C	
Sketch of Well		EC=350 μmho/cm	
		pH=7.1	
		RpH=7.7 (23.7.90)	

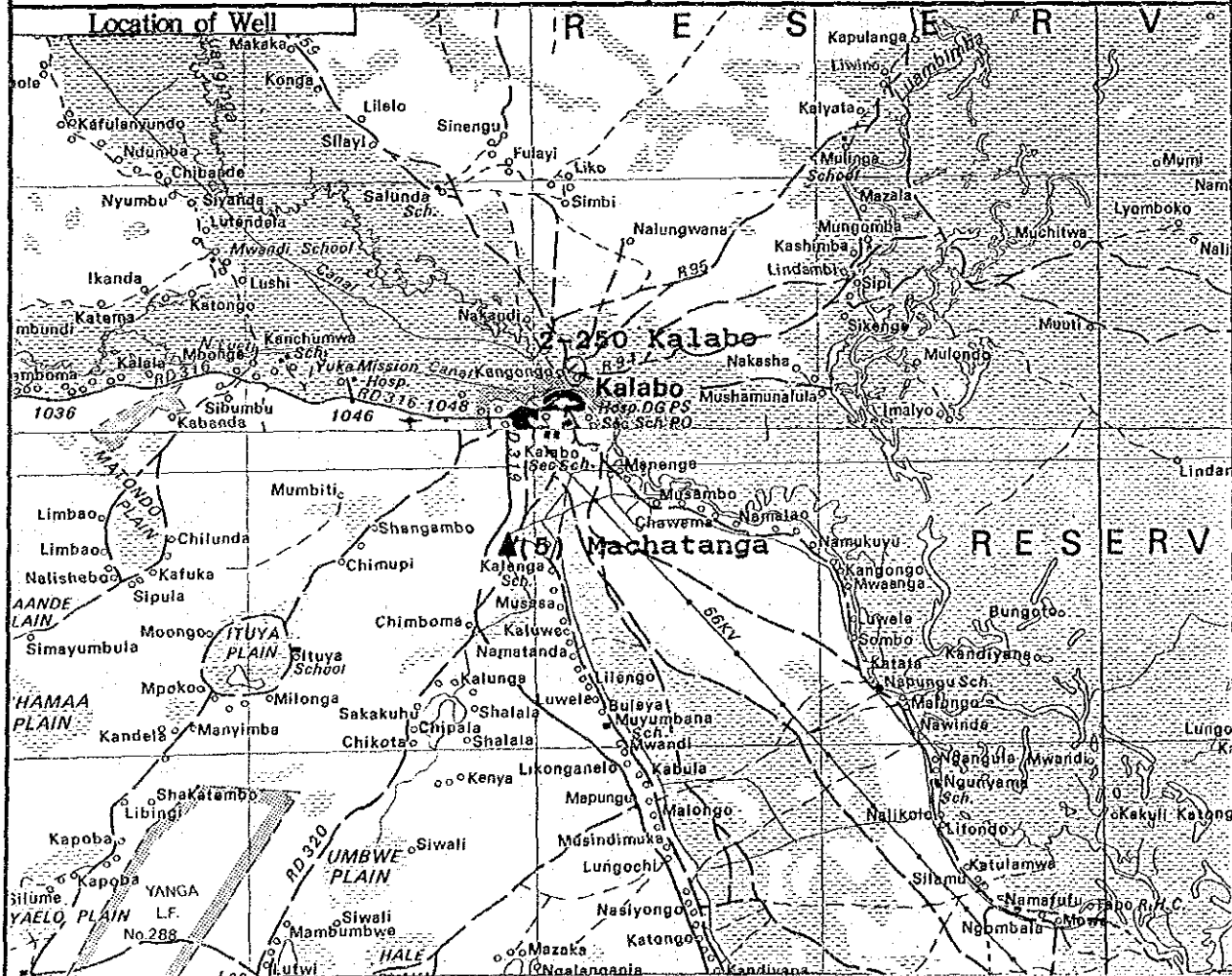


Observation Well



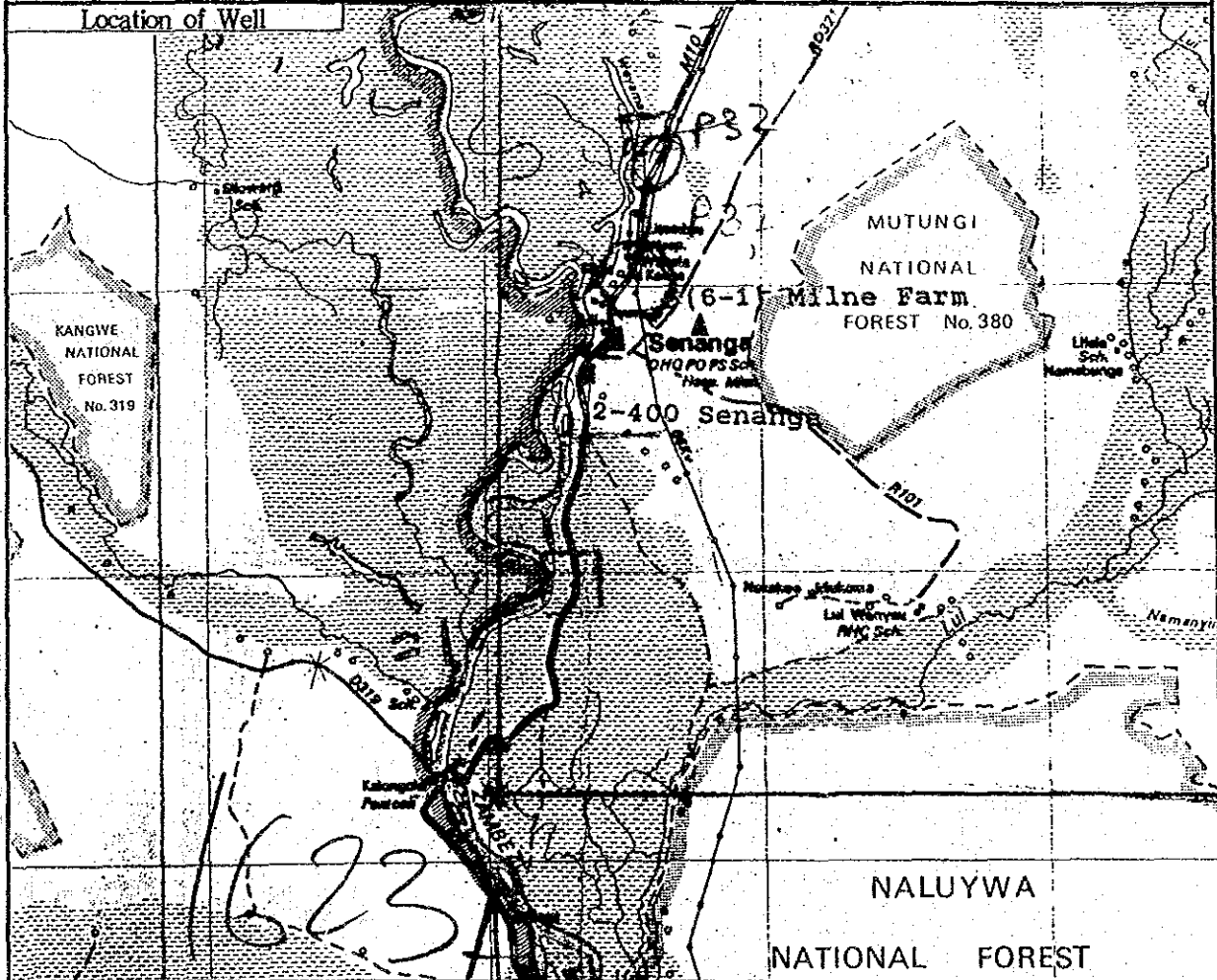
Observation Well

Well No. & Name	5 Machatanga	Cross Section of Well	
Related Hydro.St.	St.2-250 Kalabo	Measuring Level 1032.82m	
Well Type	Shallow Digging	Ground Level 1031.92m	Well Water Level
Used for	Domestic Use	Depth of Well 3.29m	
Depth	3.29m		Diameter (130cm)
Diameter	140cm		
Sketch of Well			

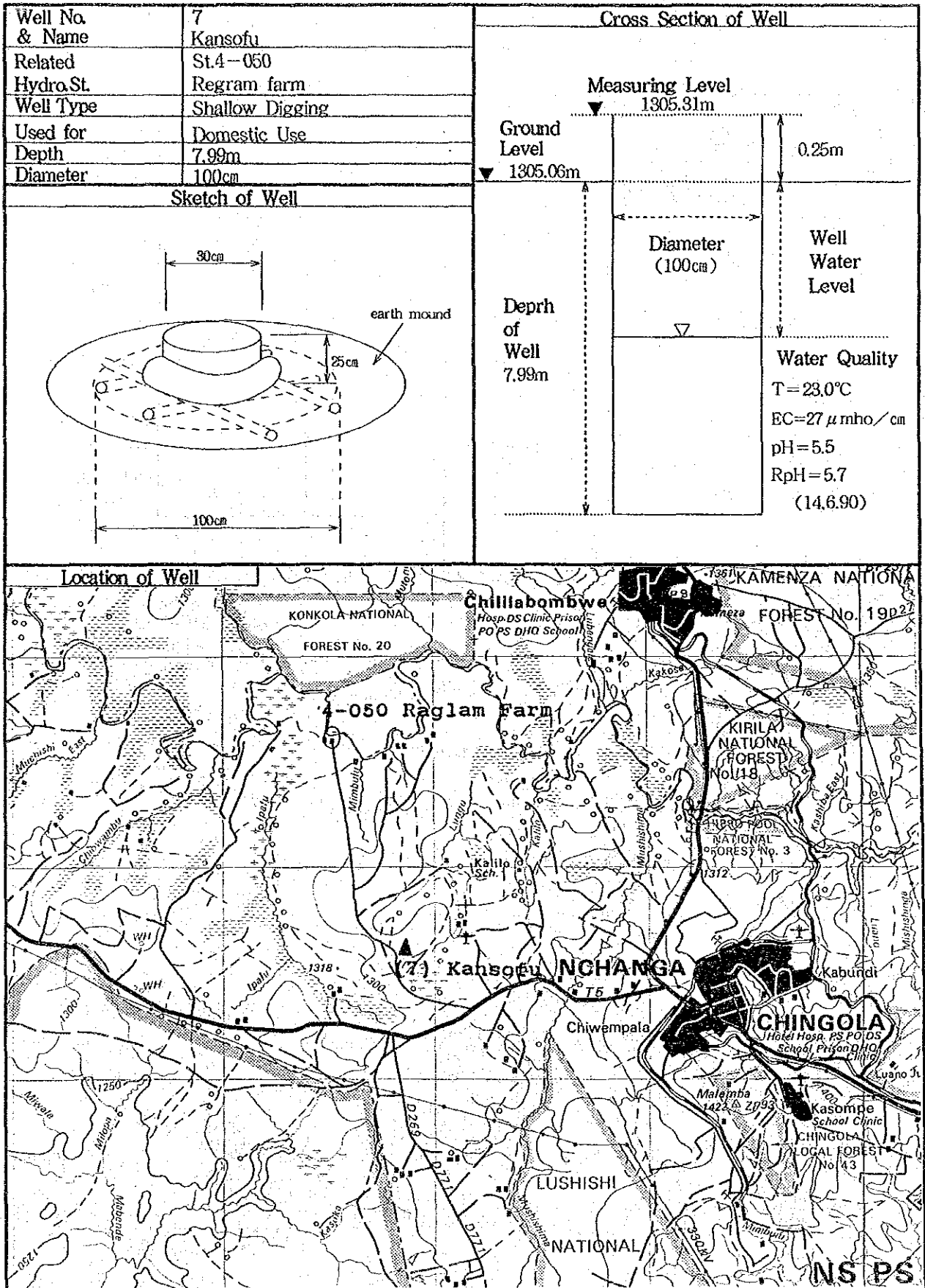


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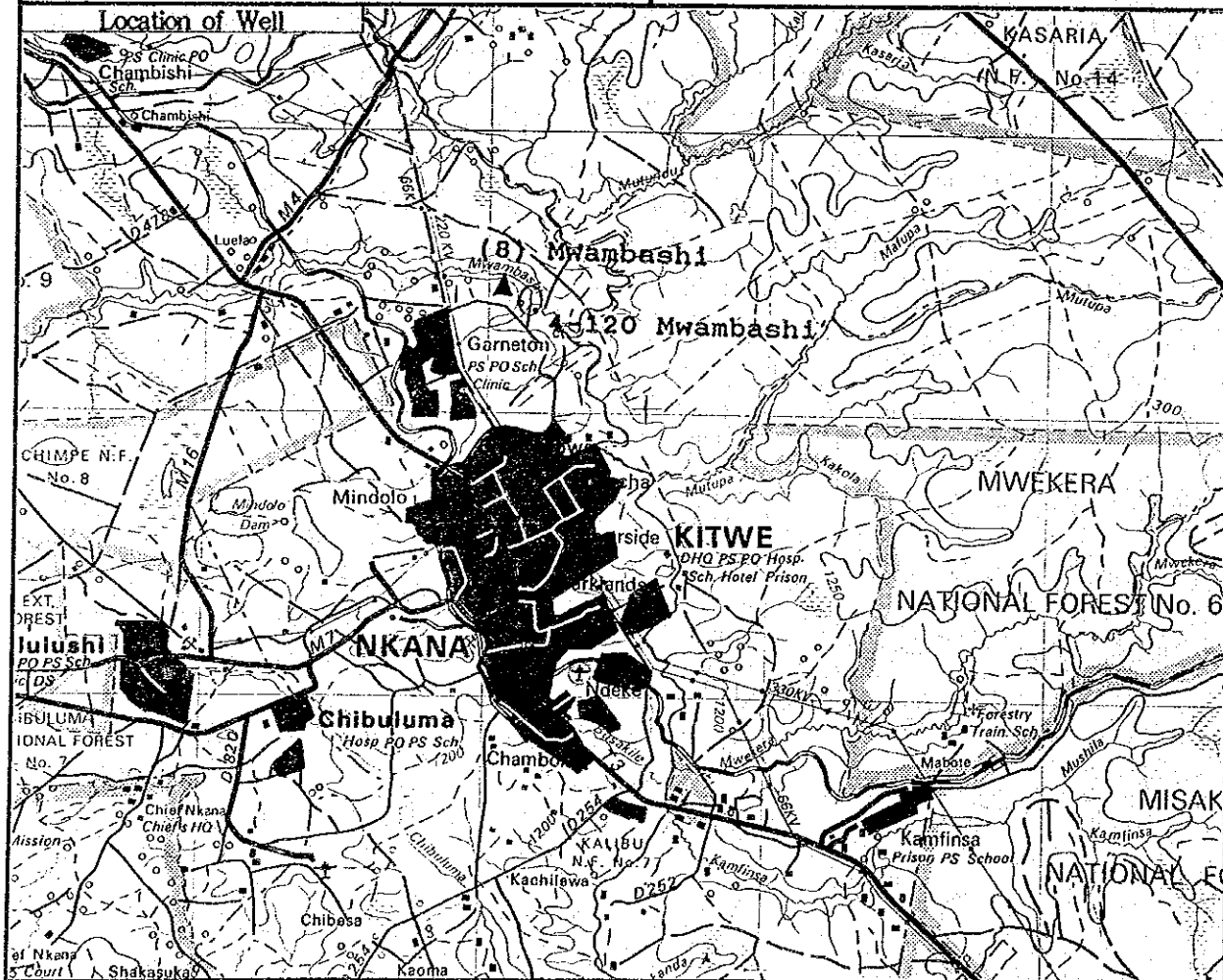
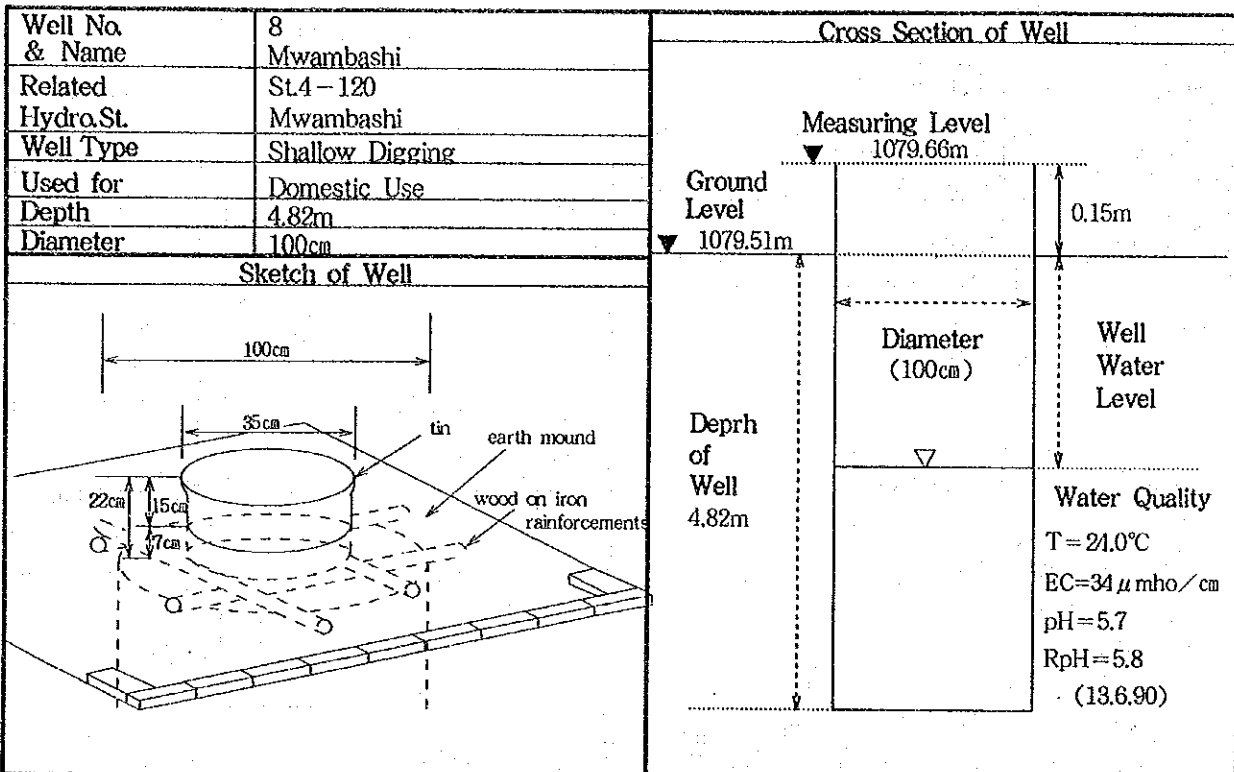
Well No. & Name	6-1 Milne farm	Cross Section of Well	
Related	St.2-400		
Hydro.St.	Senanga		
Well Type	Shallow Digging		
Used for	Domestic Use		
Depth	2.21m		
Diameter	130cm		
Sketch of Well			



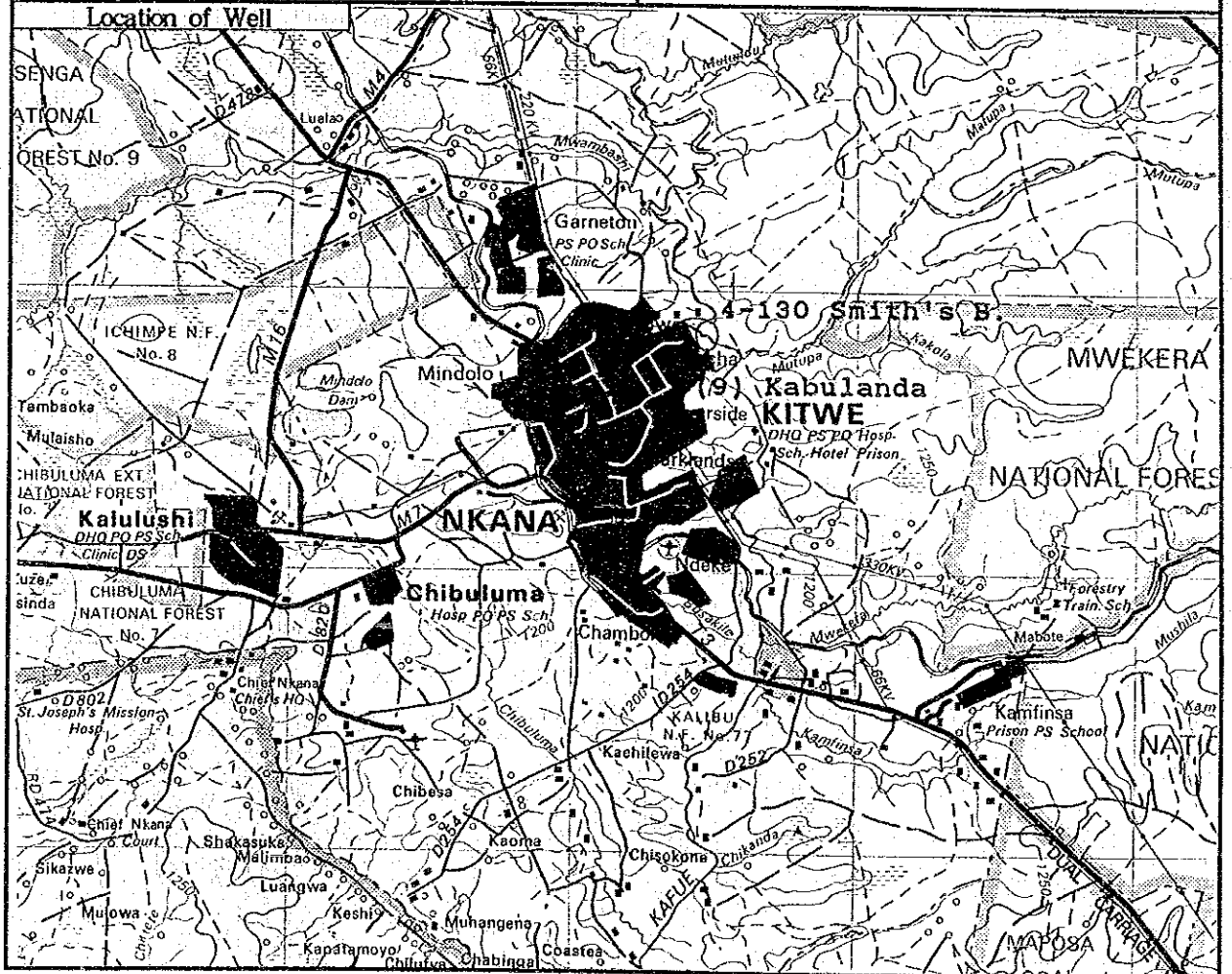
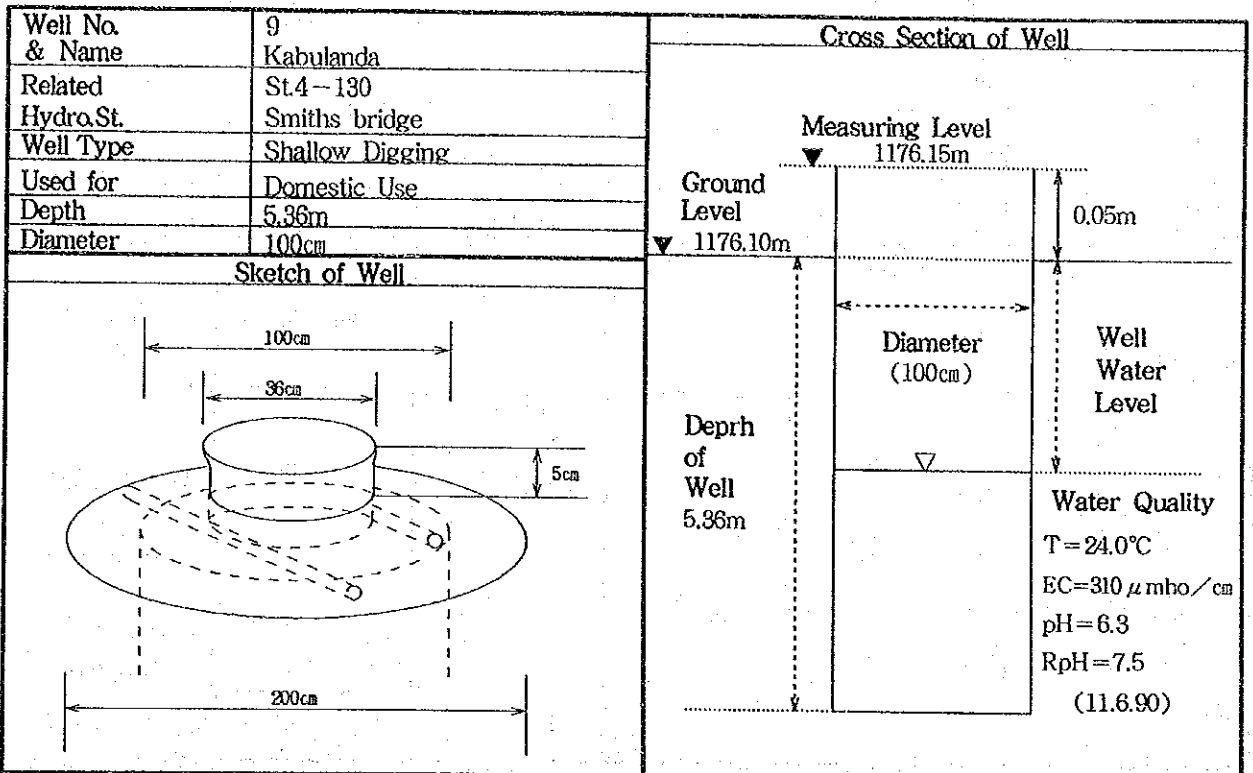
Observation Well



Observation Well

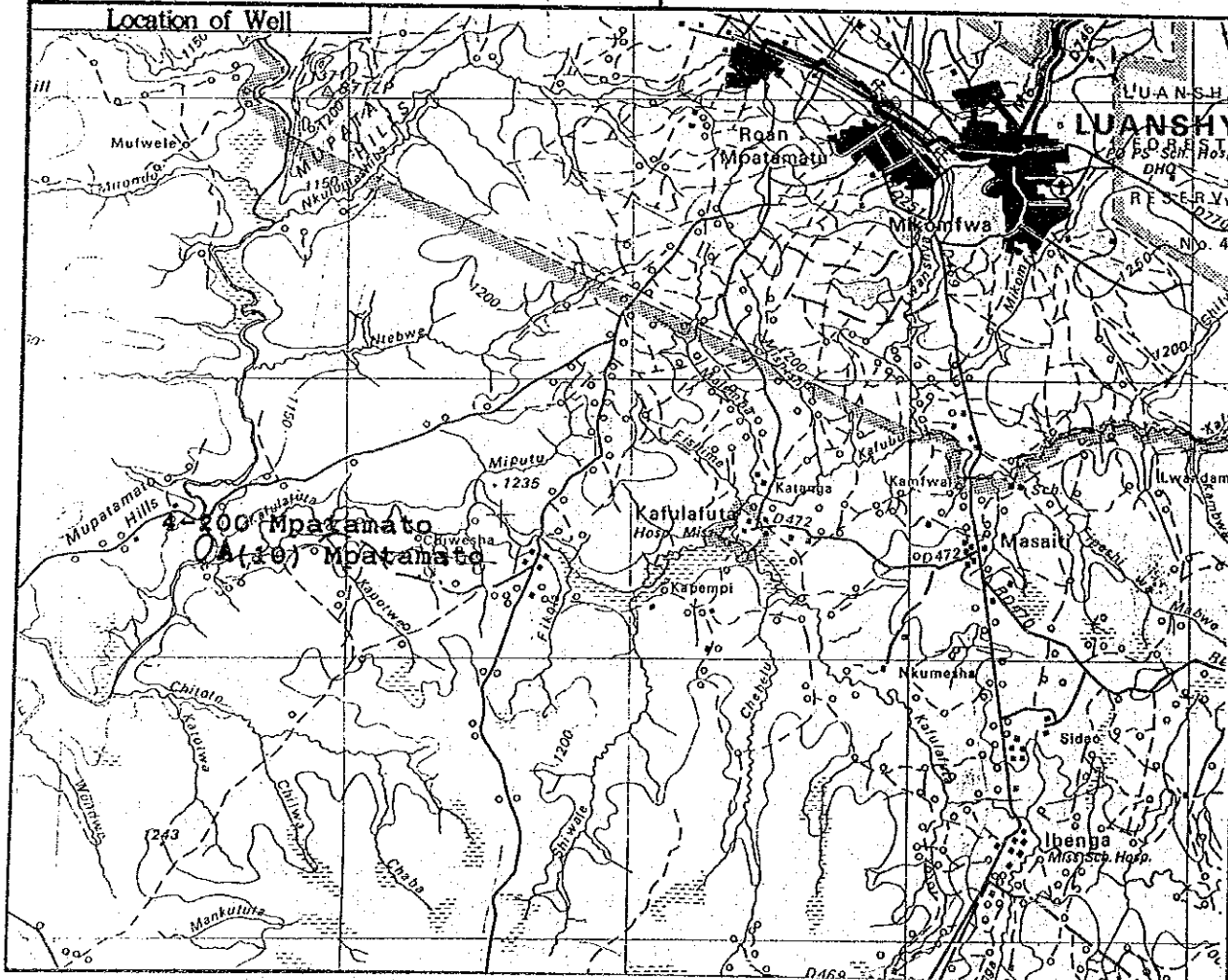


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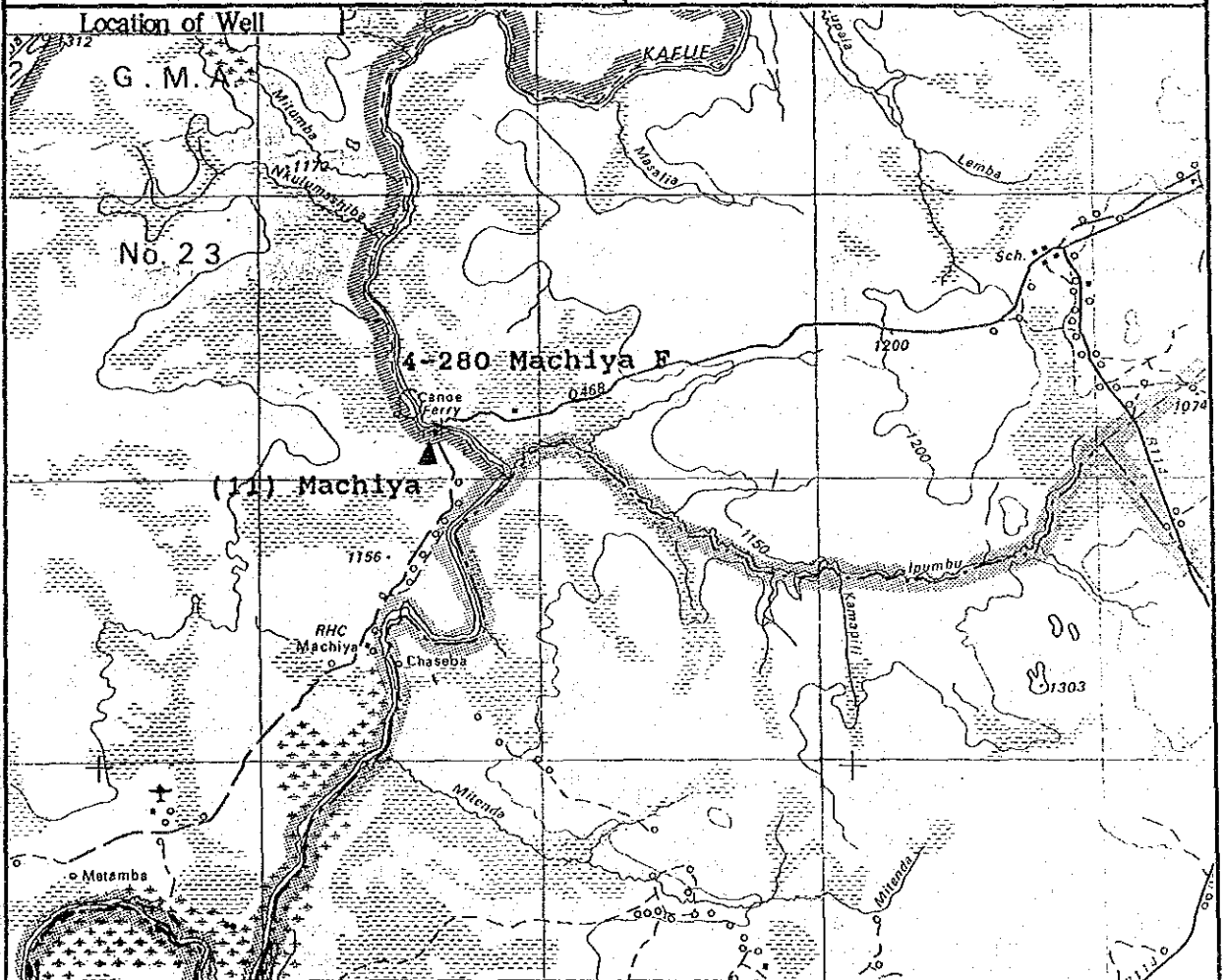
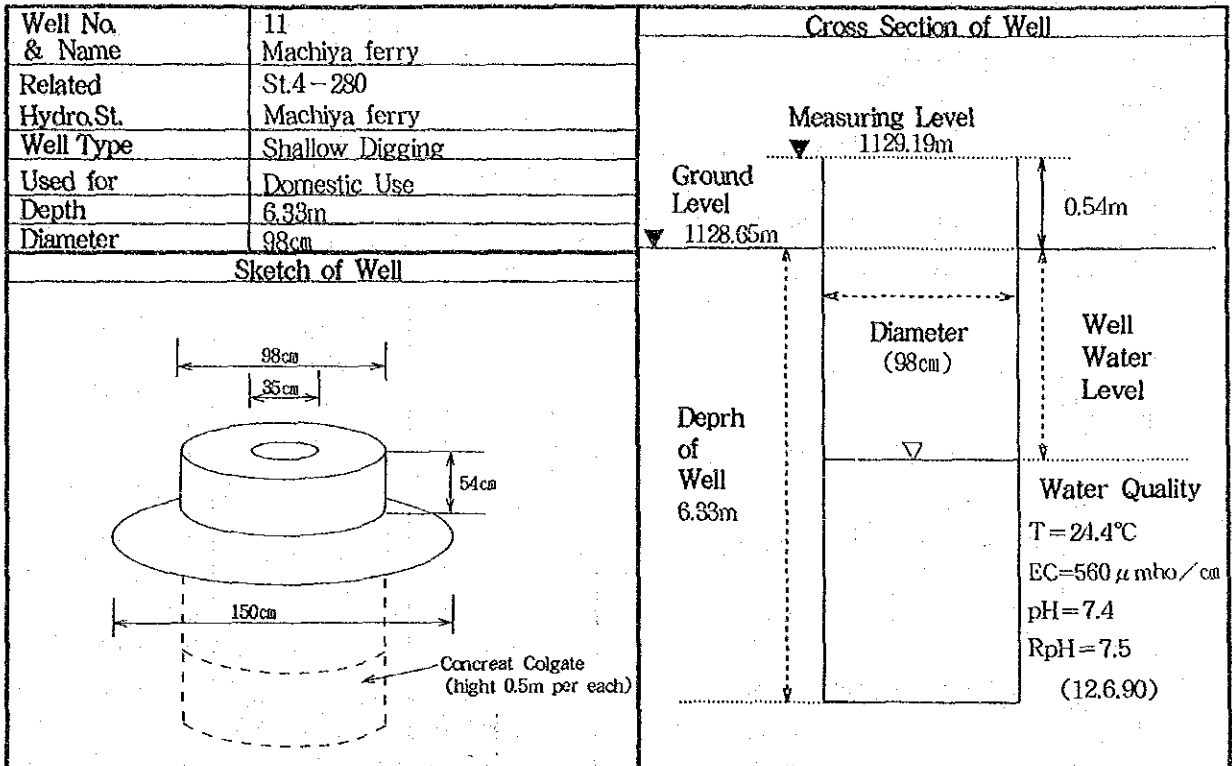


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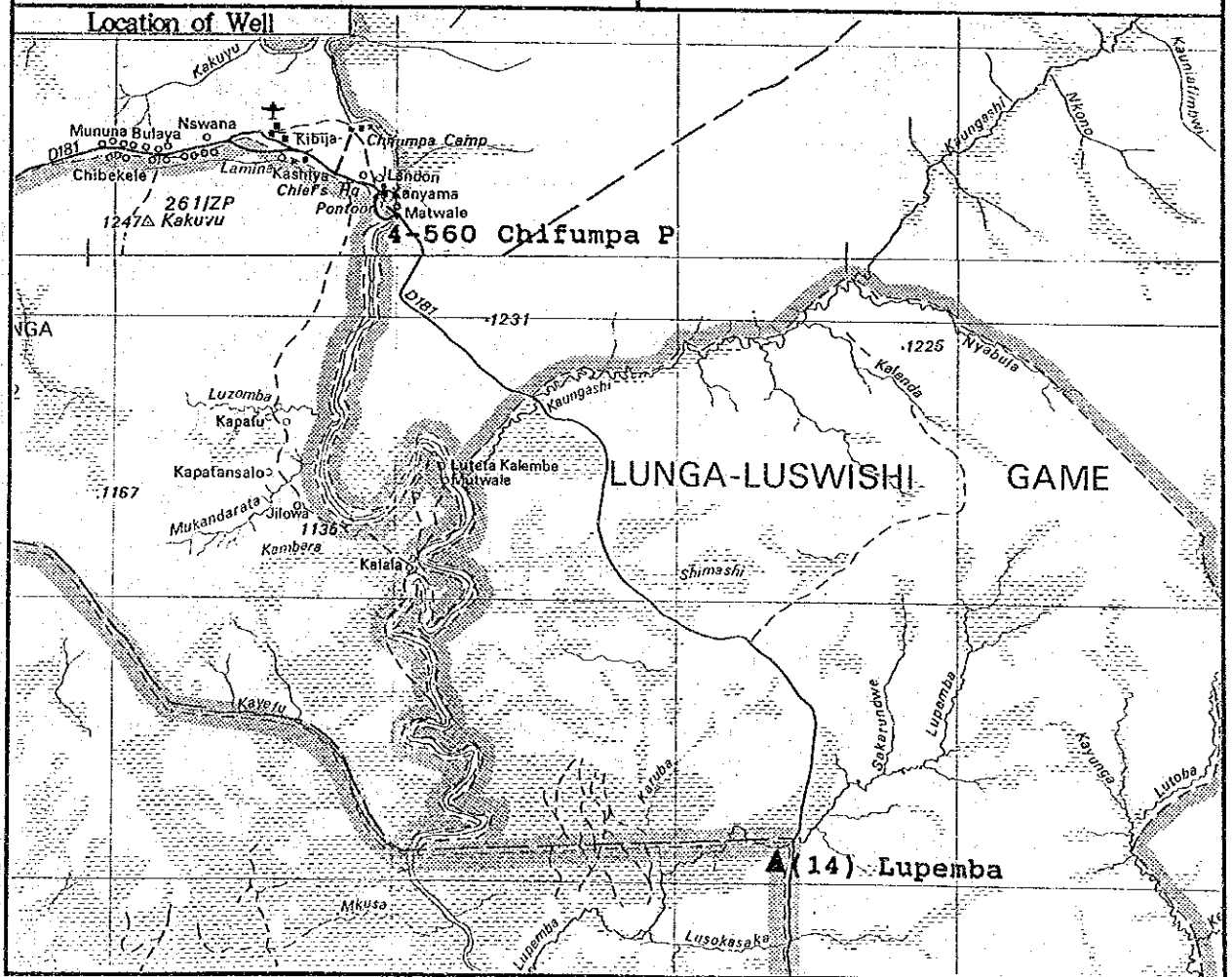
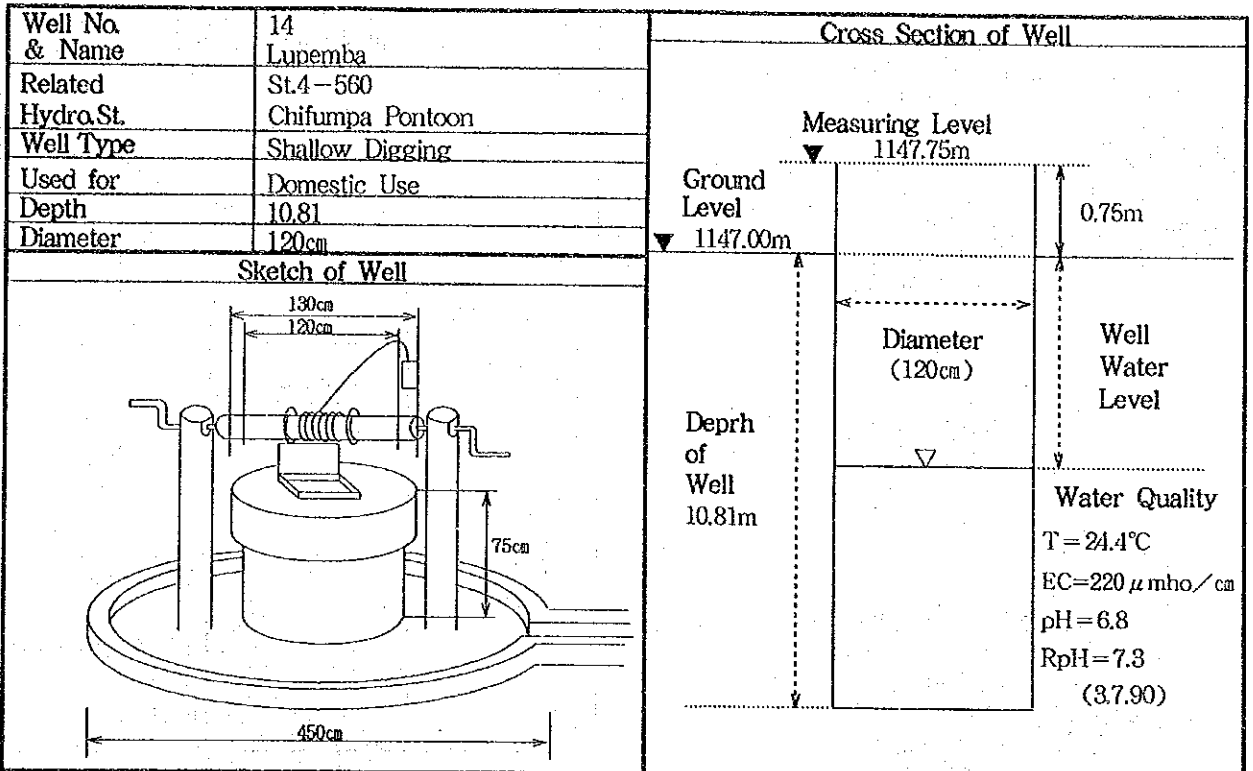
Well No. & Name	10 Mpatamato	Cross Section of Well	
Related Hydro.St.	St.4-200 Mpatamato	Measuring Level 1170.80m	
Well Type	Shallow Digging	Ground Level 1170.80m	0.00m
Used for	Domestic Use	Diameter (50cm)	
Depth	1.60m		
Diameter	50cm	Well Water Level	
Sketch of Well		Water Quality	
		T = 19.2°C EC = 38 μmho/cm pH = 6.2 RpH = 6.6 (13.6.90)	



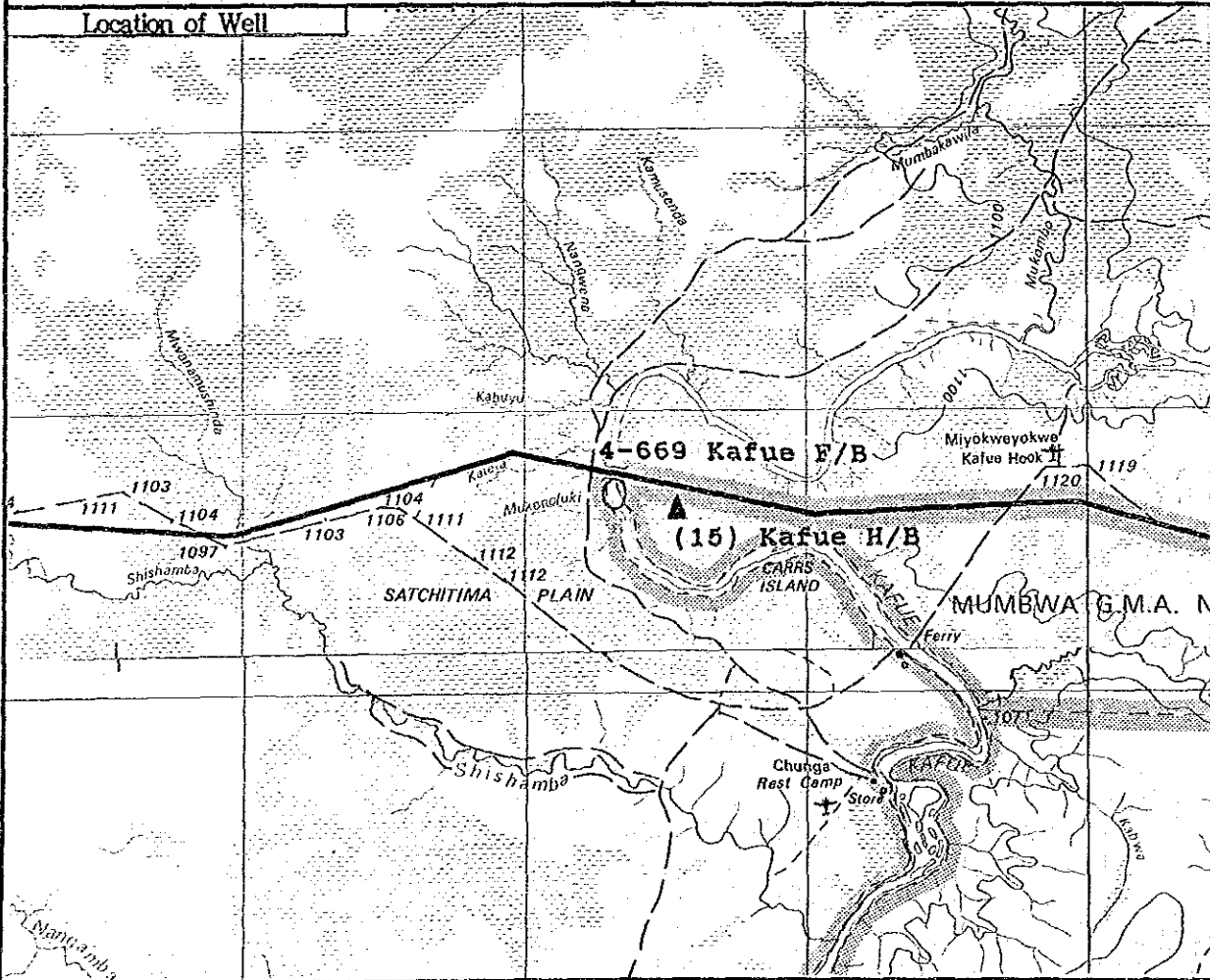
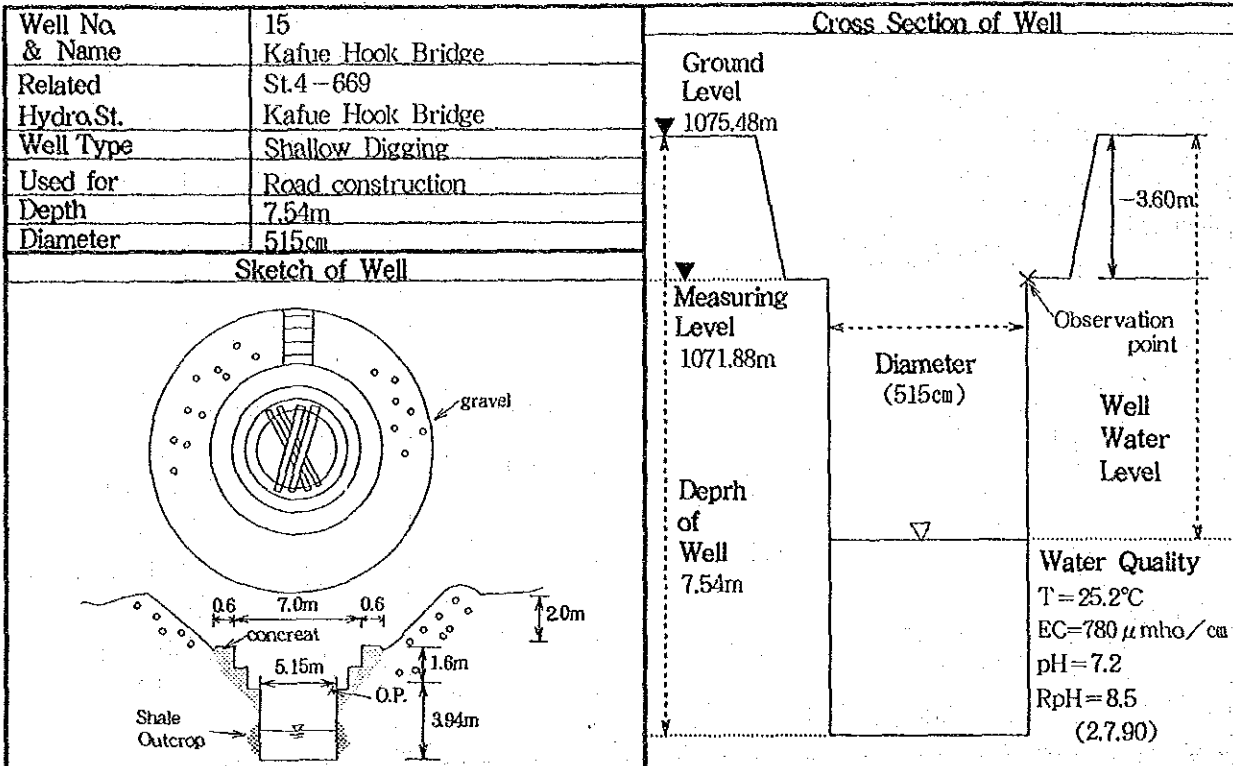
Observation Well



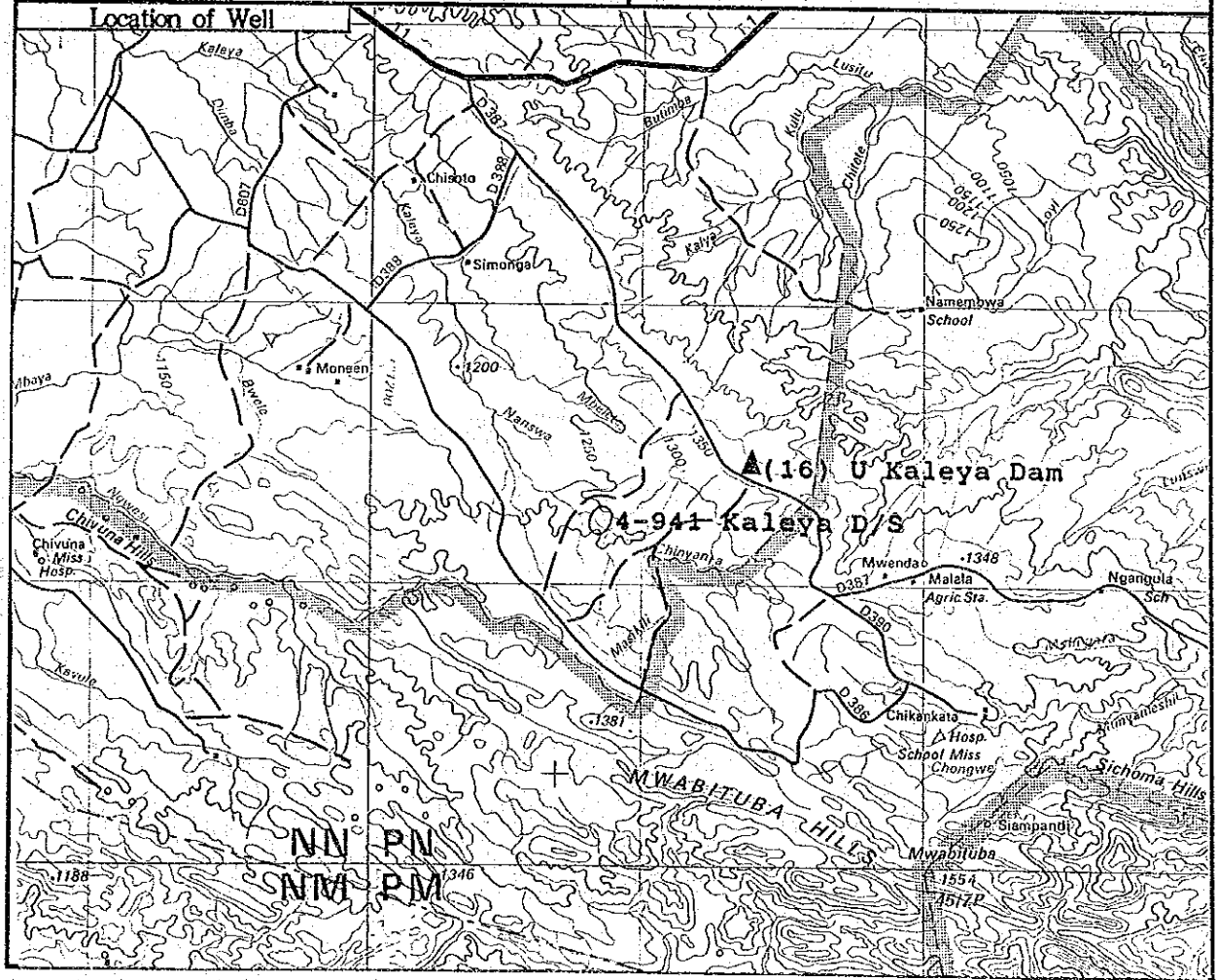
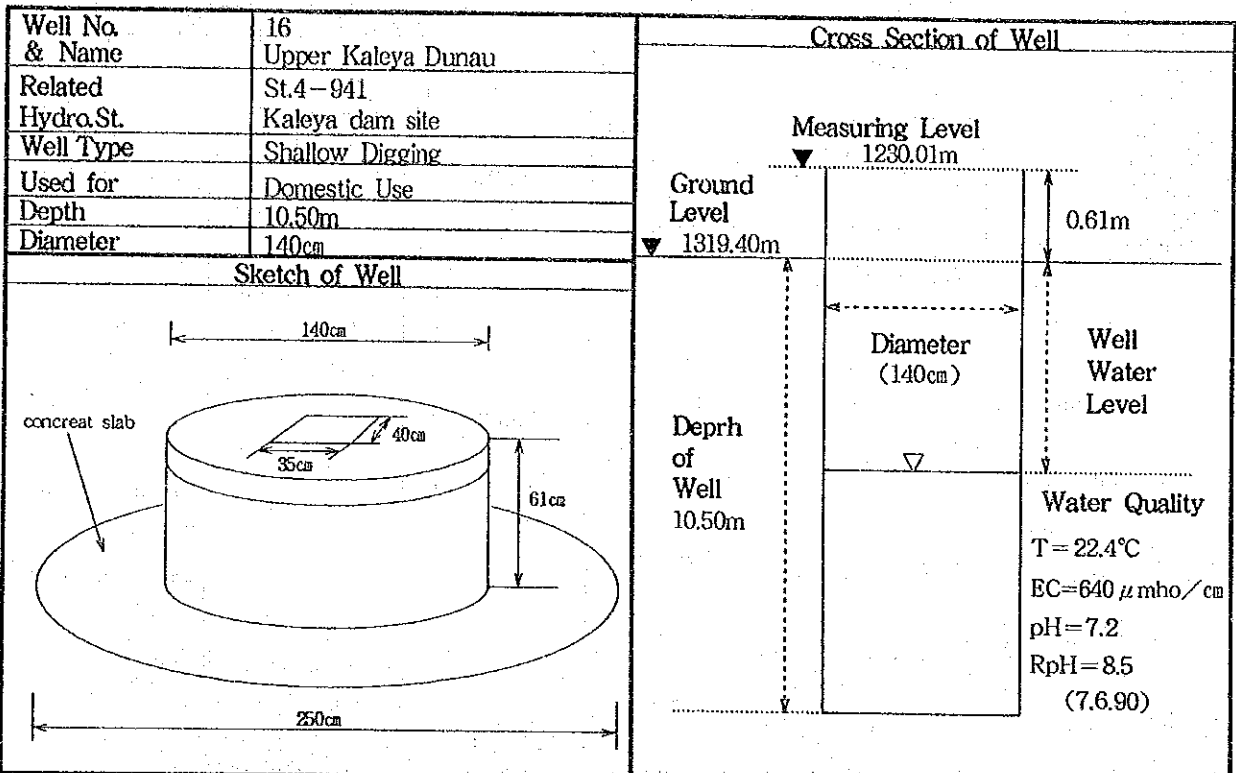
Observation Well



Observation Well

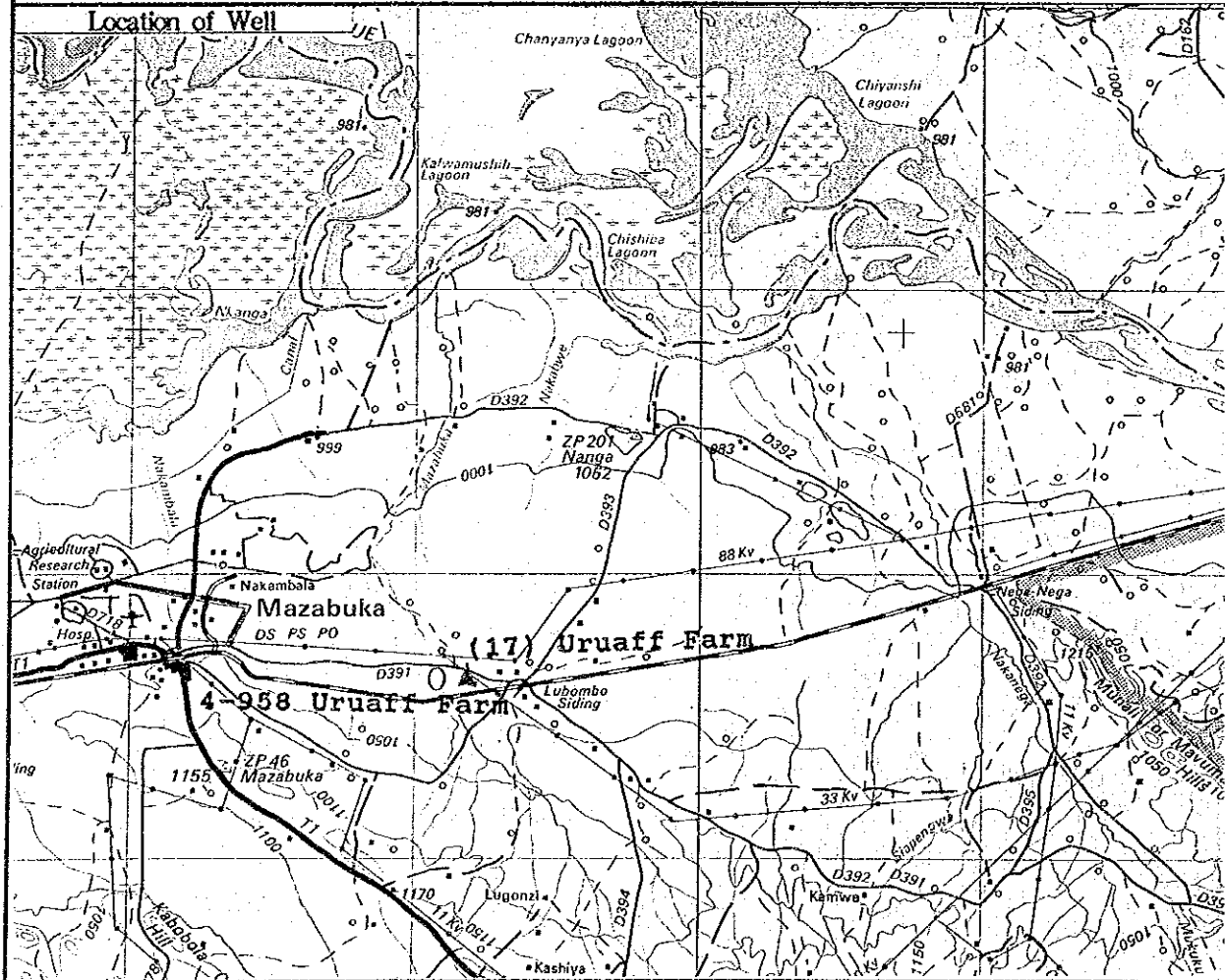


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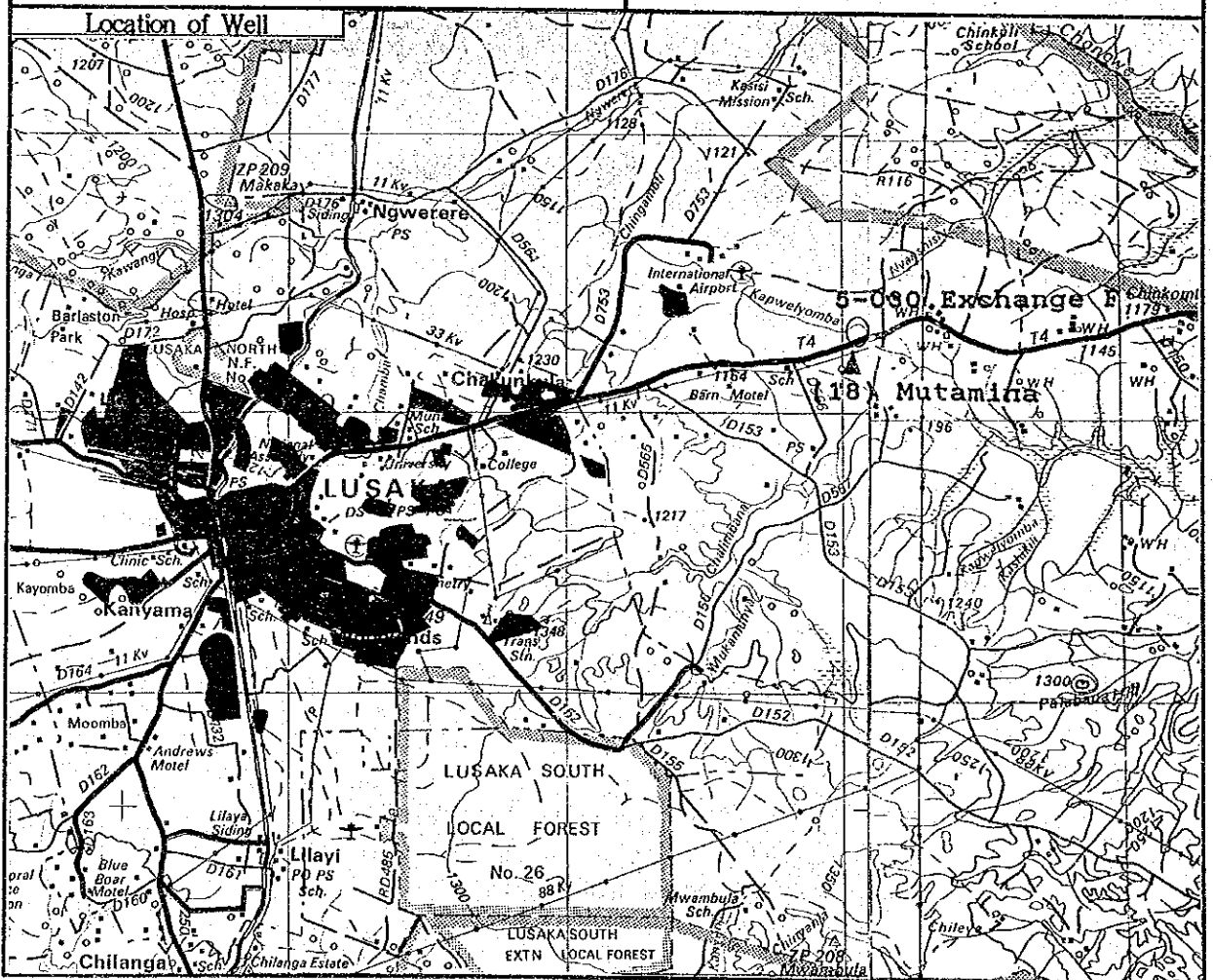
Observation Well

Well No. & Name	17 Uraff farm	Cross Section of Well	
Related Hydro.St.	St.4-958 Uruaff farm		
Well Type	Shallow Digging		
Used for	Domestic Us		
Depth	4.50m		
Diameter	120cm		
Sketch of Well		<p>Ground Level 1319.40m</p> <p>Measuring Level 1319.90m</p> <p>0.50m</p> <p>Diameter (120cm)</p> <p>Well Water Level</p> <p>Deprh of Well 4.50m</p> <p>Water Quality T = 24.0°C EC = 1400 μmho/cm pH = 7.3 RpH = 8.5 (7.7.90)</p>	



Observation Well

Well No. & Name	18 Mutamina	Cross Section of Well	
Related Hydro.St.	St.5-030	Measuring Level ▼ 1120.36m	
Well Type	Exchange farm	Ground Level ▼ 1120.27m	0.09m
Used for	Shallow Digging	Well Water Level	
Depth	Domestic Use	Water Quality	
Diameter	.90m	T = 23.3°C	
Sketch of Well		EC = 780 μmho/cm	
		pH = 7.2 (6.6.90)	
		Depth of Well 3.90m	



CHAPTER - 3

WATER QUALITY INVESTIGATION

3 WATER QUALITY INVESTIGATION

3.1 Water Sampling

(1) Time Schedule of Sampling

To generally comprehend the water quality of main streams, the programs for water sampling and test were executed through the following three (3) seasons. See Fig.-3.1.

- 1) 1st Program: (1990, Jun. and Jul.)
in Dry Season
- 2) 2nd Program: (1990, Dec., 1991, Jan. and Feb.)
in Rainy Season
- 3) 3rd Program: (1991, Aug. and Sep.)
in Dry Season

The 1st Program was the original program proposed at the beginning of this Study. However, in response to the request from the Counterpart the 2nd and 3rd Program were additionally formulated, in order to study the pollutant loads from mining operations in rainy season that the 1st program could not detect during the dry season.

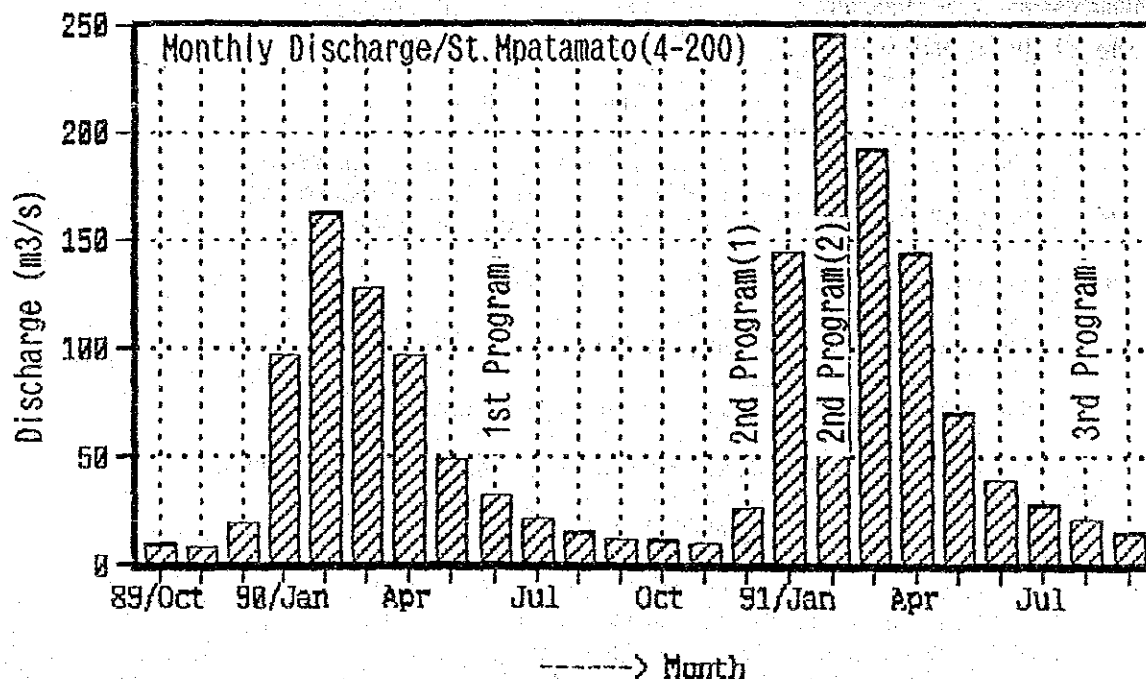


Fig.-3.1 Time Schedule of Sampling

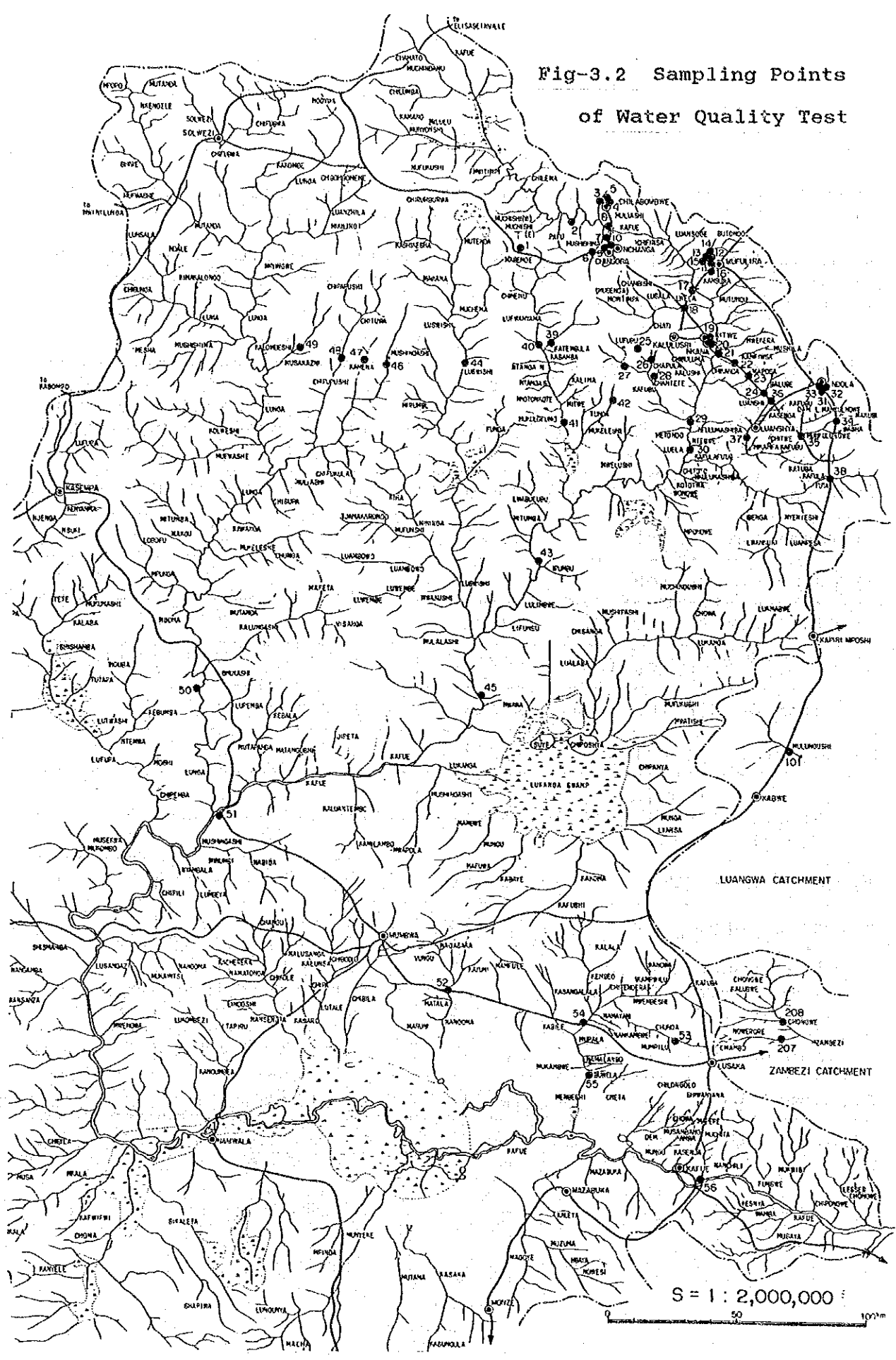
(2) Sampling Points

The water sampling and test were carried out at the following points.

- 1) 56 points on the Kafue River
 - < Hydrometric Stations >
 - + Point No.2 : Raglam Farm (4-050)
 - + Point No.30 : Mpatamato (4-200)
 - + Point No.43 : Machiya Ferry (4-280)
 - + Point No.45 : Chilenga (4-350)
 - + Point No.50 : Chifumpa Pontoon (4-560)
 - + Point No.51 : Lubungu (4-450)
 - < Other Main Points >
 - = Around Chililabombwe =
 - + Point No.3 : Man Made Channel
 - + Point No.4 : Konkola Slime Dam
 - = Around Chingola =
 - + Point No.7 : Waste Water Stream
 - + Point No.8 : Chililabombwe Road Bridge
 - = Around Mufulira =
 - + Point No.14 : Mufulira River
 - + Point No.16 : Kansunswa River
 - = Around Kitwe =
 - + Point No.19 : Kitwe River
 - + Point No.21 : Community Center Bridge
 - = Around Ndola =
 - + Point No.32 : Ndola Waste Water
 - + Point No.33 : Ndola Dam
 - = Around Lusaka =
 - + Point No.53 : Chunga River (Kasupe Mission)
 - + Point No.54 : Mwembeshi River (Road Bridge)
 - + Point No.56 : Water Intake for Lusaka
- 2) 2 points on the Luangwa River
 - < Hydrometric Station >
 - + Point No.102: Luangwa Bridge (5-940)
 - < Other Point >
 - + Point No.101: Mulungshi River (Mulungshi)
- 3) 8 points at the main stream of the Zambezi River
 - < Hydrometric Stations >
 - + Point No.201: Zambezi Pump House (1-150)
 - + Point No.202: Kabompo Boma (1-650)
 - + Point No.203: Watopa Pontoon (1-950)
 - + Point No.204: Lukulu (2-030)
 - + Point No.205: Kalabo (2-250)
 - + Point No.206: Senanga (2-400)
 - < Other Main Points >
 - + Point No.207: Ngwerere River (Bomanza Panch)
 - + Point No.208: Chongwe River (Route D176 Bridge)

The locations of points are shown in Fig.-3.2. The locations of hydrometric stations are referred to Chapter-1.

Fig-3.2 Sampling Points
of Water Quality Test



3.2 Water Quality Tests

3.2.1 Test Items

Through the programs for water quality test, general items and special items as shown in Table-3.1 were tested.

Water quality tests for general items were carried out at all the points mentioned above. However, test for special items were made at the selected points.

Table-3.1 Test Items for Water Quality

Test Items	Unit	1st Program	2nd Program	3rd Program
=====				
<< General Items >>				
1) Temperature (Temp)	Deg.C	0	0	0
2) Turbidity (Turb)	mg/lit.	0	0	0
3) Hydrogen Ion (pH)	-	0	0	0
4) Ele. Conductivity (EC)	mv/cm	0	0	0
5) Dissolved Oxygen (DO)	mg/lit.	0	0	0
6) Chloride Ion (Cl ⁻)	mg/lit.	0	0	0
7) Copper Ion (Cu ²⁺)	mg/lit.	0	0	0
8) Manganese Ion (Mn ²⁺)		-	0	0
+++++				
<< Special Items >>				
1) Total Iron (Fe)	mg/lit.	0	-	-
2) Total Copper (Cu)	mg/lit.	0	-	-
3) Total Manganese (Mn)	mg/lit.	0	-	-
4) Arsenic (As)	mg/lit.	0	-	-
5) Cadmium (Cd)	mg/lit.	0	-	-
6) Lead (Pb)	mg/lit.	0	-	-
=====				

[Note] 0: done, -: not done

3.2.2 Test Methods

(1) General Items

Regarding five (5) items (Temperature, Turbidity, Hydrogen Ion, Electric Conductivity and Dissolved Oxygen), just after sampling, the water samples were measured in the field by the Water Checker (Horiba Co., Ltd., Japan). Furthermore, the water samples were measured again in the laboratory to determine changes in the water quality.

In the 1st Program, chloride ions and copper ions of the same water sample were analyzed by the Ion Meter (Horiba Co., Ltd., Japan). The quantitative limit of the Ion Meter for analyzing both ions is 0.15 mg/lit. In the 2nd and 3rd Program, copper and manganese ions were analyzed by the German-make Photometer (quantitative limit: 0.1 mg/lit.). Also in 2nd and 3rd Program, chloride ions were analyzed by the Volumetric Titration Method (quantitative limit: 0.3 mg/lit.).

(2) Special Items

The water samples were analyzed by a simplified detecting tube ("Yoshitest", Yoshitomi Seiyaku Co., Ltd., Japan). The quantitative limits for total iron, total copper, total manganese and arsenic were 0.5 mg/lit., and for cadmium, 0.1 mg/lit. Because chemical constituents change to insoluble salts, such as hydroxides, after sampling and are suspended in insoluble matter, the water samples were acidified with sulfuric acid before being analyzed.

3.2.3 Test Results

All the test results of water quality are shown in Table-3.2 and 3.3 for general items and 3.4 for special items. The summaries of test results are as follows.

- 1) A total number of 279 water samples was tested, including 66 tests in laboratory.
- 2) The main pollutant sources (organic and non-organic) to rivers in the Copperbelt areas are the waste water produced by the mining work and related activities. The contamination caused by these pollutant sources were found at some points.
- 3) Judging from the test results, the pollution caused at the upper Kafue River does not affect the middle and lower stream due to self purification system of Kafue River.
- 4) In some tributaries around Lusaka affected by the municipal waste water, there is active overgrowth of plants and algae. The water is contaminated with organic pollution causing the eutrophication at some dead water areas.
- 5) The water quality of the main streams of Zambezi and Luangwa River is good.
- 6) The water quality in rainy season shows higher turbidity

than that in dry season. On the contrary, chloride ion in rainy season is lower than that in wet season, generally.

7) Ions of copper and manganese etc. are found in the waste water from mining and river water affected by this in the Copperbelt areas. But these ions are not found in the middle and lower reaches of the Kafue River.

Table-3.2 Test Results of General Items

Test Items	Data Items	Test Results			
		1-Pgm	2-Pgm	3-Pgm	Total
1) Temperature [Temp] (Deg.C)	Nu.of Sample	121	98	60	279
	Max.	25.4	33.9	31.7	33.9
	Min.	14.7	17.0	17.2	14.7
	Average	19.9	23.8	20.0	21.3
2) Turbidity [Turb] (mg/lit)	Nu.of Sample	109	98	60	267
	Max.	257	399	330	399
	Min.	2	2	1	1
	Average	12	44	24	26
3) pH value [pH]	Nu.of Sample	120	97	59	276
	Max.	8.6	9.5	8.6	9.5
	Min.	5.9	5.4	6.2	5.4
	Average	7.5	7.9	8.0	7.7
4) Ele.Conductivity [EC] (mv/cm)	Nu.of Sample	110	97	60	267
	Max.	1.9	2.9	2.0	2.9
	Min.	0.1	0.2	0.2	0.1
	Average	0.9	1.0	0.8	0.9
5) Dissolved Oxygen [DO] (mg/lit)	Nu.of Sample	111	96	42	249
	Max.	12.3	18.0	10.7	18.0
	Min.	0.7	0.1	0.5	0.1
	Average	7.4	5.2	6.6	6.4
6) Chloride Ion [Cl-] (mg/lit)	Nu.of Sample	41	93	6	140
	Max.	53.6	18.0	3.0	53.6
	Min.	0.6	0.0	0.6	0.0
	Average	6.4	1.0	2.4	2.7
7) Copper Ion [Cu2+] (mg/lit)	Nu.of Sample	42	93	60	195
	Max.	6.3	51.0	38.0	28.0
	Min.	0.0	0.0	0.0	0.0
	Average	0.3	0.8	2.4	0.4
8) Manganese Ion [Mn2+] (mg/lit)	Nu.of Sample	-	93	59	152
	Max.	-	28.0	27.0	28.0
	Min.	-	0.0	0.0	0.0
	Average	-	0.3	0.5	0.4
Sampling Year/Month		'90/Jun	'91/Feb	'91/Aug	Average
Average	4-050 Raglam Farm	12.9	57.5	3.9	30.4
Monthly	4-200 Mpatamato	31.9	245.6	21.2	92.1
Discharge (m3/s)	4-280 Machiya Ferry	47.0	341.5	32.4	105.8
	4-350 Chilenga	60.6	336.3	36.8	167.1
	4-450 Lubungu	67.9	290.3	38.5	168.4
	4-560 Chifumpa Pon.	41.6	220.7	30.4	110.0

Table-3.3 Water Quality Test Results (General Items) - 1/7

River Basin	NO.	Sampling Points	Sample No.	Sampling		Test Date	Temp. deg. C	Turb. mg/l	pH	E. C. mv/cm	DO mg/l	Cl mg/l	Cu2+ mg/l	Mn2+ mg/l
				Date	Time									
				D:M:Y	h:m	D:M:Y								
Kafue	1	Muchishi R.	1-a-1	20:06:90	10:10	on spot	18.1	7	7.8	0.5	6.7	-	-	-
			1-a-2	20:06:90	10:10	04:07:90	21.2	11	8.2	0.8	8.2	1.0	0.0	-
			1-b-1	05:12:90	12:45	on spot	23.0	9	8.6	0.8	3.2	0.0	0.0	0.0
			1-c-1	06:08:91	12:45	on spot	22.0	42	7.1	0.6	-	-	0.0	0.0
	2	Raglam Farm (St. 4-050)	2-a-1	06:06:90	16:30	on spot	23.0	2	7.7	1.0	7.7	-	-	-
			2-a-2	06:06:90	16:30	14:06:90	17.7	4	8.0	0.8	7.6	3.3	0.0	-
			2-b-1	05:12:90	12:04	on spot	24.0	4	8.3	0.9	6.2	2.5	0.0	0.0
			2-b-2	14:02:91	12:47	on spot	26.5	50	7.6	0.9	2.9	0.0	0.0	0.0
			2-c-1	06:08:91	13:15	on spot	24.0	25	8.6	0.7	-	-	0.0	0.0
	3	Man Made Channel	3-a-1	20:06:90	11:50	on spot	19.1	3	8.3	1.1	9.0	-	-	-
			3-b-1	05:12:90	12:15	on spot	20.0	4	8.4	1.4	7.1	0.0	0.0	0.0
			3-b-2	14:02:91	11:06	on spot	24.5	28	8.3	0.8	6.0	0.0	0.0	0.0
			3-c-1	06:08:91	15:39	on spot	22.0	30	8.5	0.8	-	-	19.0	0.0
	4	Konkola Slime Dam	4-a-1	20:06:90	11:40	on spot	20.5	7	7.8	1.0	7.8	-	-	-
			4-b-1	05:12:90	12:20	on spot	22.0	9	9.1	2.2	6.5	0.0	0.0	0.0
			4-b-2	14:02:91	11:13	on spot	24.9	40	8.5	0.9	4.7	0.0	0.0	0.0
			4-c-1	06:08:91	15:50	on spot	20.0	21	7.4	1.1	-	-	12.0	0.0
	5	Stream (from Slime Dam)	5-a-1	20:06:90	11:40	on spot	19.0	6	7.6	1.1	7.6	-	-	-
			5-b-1	05:12:90	12:30	on spot	23.0	68	8.2	2.9	6.3	0.0	0.0	0.0
			5-b-2	14:02:91	11:00	on spot	23.5	70	7.6	0.8	4.4	0.0	0.0	0.0
			5-c-1	06:08:91	16:50	on spot	18.0	55	8.0	0.7	-	-	15.0	0.0
	6	Mushishima R	6-a-1	20:06:90	09:30	on spot	14.9	3	8.0	1.0	7.4	-	-	-
			6-a-2	20:06:90	09:30	04:07:90	21.1	7	7.4	0.9	7.8	0.9	0.0	-
			6-b-1	05:12:90	10:16	on spot	17.0	41	7.8	1.1	7.1	0.0	0.0	0.0
			6-b-2	14:02:91	12:00	on spot	23.0	34	7.0	0.7	4.9	18.0	0.0	0.1
			6-c-1	06:08:91	16:45	on spot	19.0	31	7.8	0.8	-	-	0.0	0.0
	7	Stream (Waste Water)	7-a-1	20:06:90	10:45	on spot	25.1	257	7.8	1.9	7.0	-	-	-
			7-a-2	20:06:90	09:30	28:06:90	23.8	-	6.7	1.8	5.8	14.0	6.3	-
			7-b-1	05:12:90	09:45	on spot	29.4	270	7.1	2.0	8.2	1.2	51.0	28.0
			7-b-2	14:02:91	14:48	on spot	28.7	9	5.4	2.6	5.2	0.0	0.0	0.0
			7-c-1	06:08:91	12:30	on spot	21.0	22	6.2	1.8	-	-	38.0	27.0
	8	Kafue R (Chililabombwe Rd. Bridge)	8-a-1	06:06:90	15:30	on spot	23.3	19	8.0	1.1	8.0	-	-	-
8-a-2			06:06:90	15:30	14:06:90	17.7	15	7.5	1.0	7.6	-	-	-	
8-a-3			06:06:90	15:30	04:07:90	21.0	19	8.0	0.8	9.3	-	1.2	-	
8-a-4			20:06:90	11:00	on spot	21.4	67	8.3	1.2	7.0	2.5	-	-	
8-a-5			20:06:90	11:00	28:06:90	23.8	55	7.3	0.9	6.2	-	2.1	-	
8-b-1			05:12:90	11:54	on spot	25.2	22	8.5	1.1	0.5	0.0	1.0	0.2	
8-b-2			14:02:91	11:34	on spot	25.2	130	8.1	0.9	4.4	0.0	0.0	0.5	
8-c-1			06:08:91	11:30	on spot	20.7	29	8.4	1.1	-	-	0.2	0.3	
9	Stream (to Chingola R)	9-a-1	20:06:90	08:30	on spot	24.2	21	7.5	0.3	2.5	5.7	-	-	
		9-a-2	20:06:90	08:30	04:07:90	20.8	8	6.7	0.2	5.9	-	0.0	-	
		9-b-1	05:12:90	12:35	on spot	32.5	24	7.8	0.4	1.8	5.9	0.0	0.0	
		9-b-2	14:02:91	11:45	on spot	25.6	40	7.8	0.7	4.9	0.0	0.0	0.0	
		9-c-1	06:08:91	10:20	on spot	19.0	16	8.1	1.2	-	-	0.0	0.0	

Table-3.3 Water Quality Test Results (General Items) - 2/7

River Basin	NO.	Sampling Points	Sample No.	Sampling		Test Date	Temp. deg. C	Turb. mg/l	pH	E.C. mv/cm	DO mg/l	Cl mg/l	Cu2+ mg/l	Mn2+ mg/l
				Date	Time									
				D:M:Y	h:m	D:M:Y								
Kafue	10	Stream (near Nchanga Open Pit)	10-a-1	20:06:90	09:10	on spot	18.5	32	8.0	1.1	8.4	-	-	-
			10-a-2	20:06:90	09:10	01:07:90	24.1	22	7.3	1.0	5.7	9.1	0.4	-
			10-b-1	05:12:90	12:12	on spot	27.6	180	9.5	2.5	0.6	0.0	25.0	0.0
			10-b-2	14:02:91	15:25	on spot	25.8	46	7.5	0.8	5.6	0.0	0.0	0.0
			10-c-1	06:08:91	10:48	on spot	20.0	22	8.1	1.4	-	-	0.3	0.0
	11	Man Made Channel	11-a-1	20:06:90	13:50	on spot	25.4	34	8.7	1.2	6.2	-	-	-
			11-b-1	07:12:90	13:59	on spot	20.3	121	8.4	-	-	0.0	0.0	0.0
			11-b-2	14:02:91	15:25	on spot	28.1	47	8.2	0.9	5.3	0.0	0.0	0.0
			11-c-1	06:08:91	10:35	on spot	23.0	330	8.2	1.2	-	-	0.0	0.0
	12	Stream (to Mufulira R)	12-a-1	20:06:90	14:00	on spot	22.7	6	8.6	0.2	7.6	-	-	-
12-a-2			20:06:90	14:00	25:06:90	22.0	3	7.4	0.1	4.8	-	-	-	
12-b-1			07:12:90	13:59	on spot	28.3	25	8.4	0.2	-	0.0	0.0	0.0	
12-b-2			13:02:91	12:12	on spot	30.5	25	8.5	0.2	4.3	15.0	0.2	0.0	
12-c-1			05:08:91	11:50	on spot	19.9	14	8.3	1.0	-	-	35.0	N.D.	
13	Stream (from Slime Dam)	13-a-1	20:06:90	14:00	on spot	21.0	9	8.4	1.2	8.7	-	-	-	
		13-b-1	07:12:90	14:10	on spot	30.3	10	8.8	1.6	6.1	0.0	0.0	0.0	
		13-b-2	13:02:91	12:20	on spot	25.7	15	7.9	0.4	5.2	0.0	0.3	0.0	
		13-c-1	05:08:91	10:45	on spot	19.0	17	8.2	1.0	-	-	26.0	0.0	
14	Mufulira R	14-a-1	20:06:90	14:10	on spot	19.9	9	8.0	1.1	7.2	-	-	-	
		14-b-1	07:12:90	09:40	on spot	30.3	8	8.1	1.2	7.2	0.0	0.0	0.0	
		14-b-2	13:02:91	12:10	on spot	24.1	20	7.9	0.9	4.9	12.0	0.2	0.2	
		14-c-1	05:08:91	11:32	on spot	19.8	15	8.0	1.0	-	-	0.0	0.0	
15	Mufulira R (after Confluence)	15-a-1	20:06:90	14:10	01:07:90	24.0	7	7.7	1.0	7.8	1.8	-	-	
		15-b-1	07:12:90	09:27	on spot	31.2	4	7.3	0.7	2.4	0.0	0.0	0.0	
		15-b-2	13:02:91	12:40	on spot	25.1	21	7.8	0.8	3.9	0.0	0.0	0.0	
		15-c-1	05:08:91	12:15	on spot	22.0	12	8.5	2.0	-	-	0.0	0.0	
16	Kansunswa R	16-a-1	20:06:90	13:20	on spot	19.5	6	7.1	0.8	2.1	-	-	-	
		16-a-2	20:06:90	13:20	04:07:90	21.2	7	5.9	0.8	6.6	3.2	-	-	
		16-b-1	07:12:90	09:50	on spot	29.1	4	7.3	0.7	2.4	0.0	0.0	0.0	
		16-b-2	13:02:91	11:34	on spot	25.2	19	6.8	0.9	3.6	0.0	0.0	0.2	
		16-c-1	05:08:91	09:45	on spot	19.0	19	8.3	1.0	-	-	0.0	0.0	
17	Kafue R (near Kafironda)	17-a-1	07:06:90	08:30	on spot	21.1	7	8.1	1.1	8.6	-	-	-	
		17-a-2	07:06:90	08:30	14:06:90	17.0	7	8.2	1.1	7.5	2.4	0.0	-	
		17-a-3	20:06:90	13:10	on spot	20.7	4	8.2	1.1	6.5	-	-	-	
		17-a-4	20:06:90	13:10	01:07:90	24.4	4	7.5	1.0	6.5	3.5	0.2	-	
		17-b-1	07:12:90	08:35	on spot	29.2	42	7.5	0.7	4.7	0.0	0.0	0.0	
		17-b-2	13:02:91	11:19	on spot	25.2	109	8.3	1.2	4.9	14	0.3	0.2	
		17-c-1	05:08:91	10:39	on spot	18.3	20	-	1.0	-	-	0.0	0.0	
18	Mwambashi R	18-a-1	06:06:90	15:10	on spot	21.7	5	7.4	-	5.6	-	-	-	
		18-a-2	06:06:90	15:10	14:06:90	17.4	3	7.9	0.6	7.8	4.1	0.0	-	
		18-b-1	07:12:90	08:20	on spot	25.7	6	7.2	1.2	4.9	0.0	0.0	0.0	
		18-b-2	13:02:91	11:00	on spot	23.1	5	7.7	0.7	4.4	0.0	0.0	0.0	
		18-c-1	04:08:91	14:16	on spot	26.0	7	8.2	1.1	4.3	-	0.0	0.0	

Table-3.3 Water Quality Test Results (General Items) - 3/7

River Basin	NO.	Sampling Points	Sample No.	Sampling		Test Date	Temp. deg. C	Turb. mg/l	pH	E.C. mv/cm	DO mg/l	Cl mg/l	Cu ²⁺ mg/l	Mn ²⁺ mg/l
				Date	Time									
				D:M:Y	h:m	D:H:Y								
Kafue	19	Kitwe R	19-a-1	20:06:90	08:10	on spot	18.7	40	7.4	0.9	3.5	-	-	-
			19-a-2	20:06:90	08:10	04:07:90	21.0	18	6.6	0.9	4.1	17.0	-	-
			19-b-1	06:12:90	11:10	on spot	20.8	46	8.1	1.1	4.6	0.0	0.0	0.0
			19-b-2	16:02:91	07:30	on spot	22.7	252	8.4	1.9	4.7	0.0	0.0	0.0
			19-c-1	04:08:91	13:55	on spot	21.0	30	8.4	1.0	2.5	-	0.0	0.0
	20	Stream (near Tailing Dam)	20-a-1	21:06:90	09:30	on spot	18.2	8	7.7	1.2	7.0	-	-	-
			20-a-2	21:06:90	09:30	04:07:90	21.6	6	7.0	1.0	8.5	7.8	0.0	-
			20-b-1	06:12:90	11:20	on spot	20.2	16	7.7	1.6	6.4	0.0	0.0	0.0
			20-b-2	16:02:91	07:45	on spot	22.4	18	8.3	1.2	5.3	0.0	0.0	0.0
			20-c-1	04:08:91	13:30	on spot	19.0	15	6.7	1.3	6.7	-	0.0	0.0
	21	Kafue R (Community Centre Br)	21-a-1	06:06:90	13:30	on spot	21.5	5	7.6	1.1	8.1	-	-	-
			21-a-2	06:06:90	13:30	14:06:90	17.8	5	7.5	1.0	7.3	-	0.0	-
			21-a-3	18:06:90	17:10	on spot	20.7	4	8.1	1.0	7.7	-	-	-
			21-a-4	18:06:90	17:10	25:06:90	22.6	2	6.8	1.0	8.2	7.0	0.3	-
			21-b-1	06:12:90	11:45	on spot	22.2	4	7.2	0.9	7.2	0.0	0.0	0.0
			21-b-2	16:02:91	08:20	on spot	24.4	35	8.2	0.7	4.9	13.0	0.0	0.1
			21-c-1	04:08:91	13:15	on spot	21.2	8	8.0	0.4	7.6	-	0.0	0.0
	22	Kamfinsa R	22-a-1	06:06:90	13:20	on spot	20.9	2	7.7	0.7	7.3	-	-	-
			22-a-2	06:06:90	13:20	14:06:90	18.0	3	6.9	0.4	7.7	-	0.0	-
			22-b-1	06:12:90	12:05	on spot	21.9	38	7.5	0.7	7.5	0.0	0.0	0.0
22-b-2			16:02:91	08:33	on spot	22.3	22	8.4	0.2	4.5	0.0	0.0	0.0	
22-c-1			04:08:91	13:05	on spot	19.5	7	8.2	0.5	6.3	-	0.0	0.0	
23	Maposa R	23-a-1	08:06:90	11:00	on spot	17.2	9	7.8	0.7	8.6	-	-	-	
		23-a-2	08:06:90	11:00	14:06:90	17.9	17	7.4	0.5	7.2	-	0.0	-	
		23-b-1	06:12:90	12:20	on spot	20.9	61	7.8	0.6	7.7	0.0	0.0	0.0	
		23-b-2	16:02:91	08:55	on spot	22.8	19	7.2	0.4	2.7	0.0	0.0	0.0	
		23-c-1	04:08:91	12:30	on spot	18.9	6	8.5	0.4	5.2	-	0.0	0.0	
24	Baluba R	24-a-1	08:06:90	11:20	on spot	18.4	3	6.4	0.6	6.9	-	-	-	
		24-a-2	08:06:90	11:20	14:06:90	17.6	4	6.7	0.4	7.1	-	0.0	-	
		24-b-1	06:12:90	09:36	on spot	21.2	2	7.5	0.8	6.4	0.0	0.0	0.0	
		24-b-2	16:02:91	09:02	on spot	22.6	15	7.3	0.2	4.1	0.0	0.0	0.0	
		24-c-1	04:08:91	12:35	on spot	19.2	7	7.9	0.5	4.3	-	0.0	0.0	
25	Stream (upper Chapula)	25-a-1	19:06:90	08:30	on spot	16.4	6	7.4	0.4	8.6	-	-	-	
		25-a-2	19:06:90	08:30	25:06:90	21.7	2	6.8	0.6	9.7	6.1	0.4	-	
		25-b-1	08:12:90	09:30	on spot	21.5	4	7.6	0.8	7.2	0.0	0.0	0.0	
		25-c-1	04:08:91	12:47	on spot	18.0	8	7.8	0.6	4.8	-	0.0	0.0	
26	Chapula (near St. Joseph)	26-a-1	19:06:90	15:50	on spot	21.2	9	7.8	1.0	7.8	-	-	-	
		26-a-2	19:06:90	15:50	25:06:90	22.2	4	7.7	1.0	8.1	0.9	0.0	-	
		26-b-1	08:12:90	10:45	on spot	20.9	6	7.9	0.8	6.9	0.0	0.0	0.0	
		26-c-1	04:08:91	15:20	on spot	18.0	9	8.0	0.5	5.3	-	0.0	0.0	
27	Kafubu R	27-a-1	19:06:90	10:15	on spot	20.1	6	8.0	1.0	10.5	-	-	-	
		27-b-1	05:12:90	08:20	on spot	19.8	63	7.3	0.6	5.1	0.0	0.0	0.0	
		27-b-2	12:02:91	16:09	on spot	20.7	81	7.7	0.7	6.2	0.0	0.0	0.0	
		27-c-1	04:08:91	11:30	on spot	17.9	8	8.4	1.0	8.2	-	0.0	0.0	

Table-3.3 Water Quality Test Results (General Items) - 4/7

River Basin	NO.	Sampling Points	Sample No.	Sampling		T e s t Date	Temp. deg. C	Turb. mg/l	pH	E.C. mv/cm	DO mg/l	cl mg/l	Cu2+ mg/l	Mn2+ mg/l
				Date	Time									
				D : M : Y	h : m	D : M : Y								
Kafue	28	Chantete R	28-a-1	19:06:90	15:40	on spot	16.5	6	7.2	0.5	4.9	-	-	-
			28-a-2	19:06:90	15:40	04:07:90	21.1	3	7.5	0.9	8.2	2.9	0.0	-
			28-b-1	05:12:90	08:45	on spot	20.5	35	7.7	0.8	7.2	0.0	0.0	0.0
			28-c-1	04:08:91	14:25	on spot	19.0	5	7.8	0.8	7.6	-	0.0	0.0
	29	Kafue R (Emerald Mine)	29-a-1	19:06:90	17:00	on spot	20.7	5	8.8	1.1	8.7	-	-	-
			29-c-1	04:08:91	16:20	on spot	18.0	9	6.9	1.1	7.5	-	0.0	0.0
	30	Mpatamato (St. 4-200)	30-a-1	21:06:90	11:10	on spot	20.9	-	-	1.1	8.7	-	-	-
			30-a-2	21:06:90	11:10	01:07:90	24.1	7	7.3	1.0	7.8	2.7	0.0	-
			30-b-1	15:02:91	10:20	on spot	24.8	36	8.4	0.9	5.2	12.0	0.0	0.1
			30-c-1	07:08:91	10:05	on spot	19.2	9	8.3	0.9	7.6	-	0.0	0.0
	31	Stream (Ndola Mushishi Rd.)	31-a-1	18:06:90	15:50	on spot	20.6	5	8.4	1.0	5.0	-	-	-
			31-b-1	07:12:90	14:50	on spot	26.5	5	7.9	0.9	3.9	0.0	0.0	0.0
			31-b-2	16:02:91	10:50	on spot	26.2	10	8.2	2.1	6.0	0.0	0.0	0.0
			31-c-1	07:08:91	16:15	on spot	20.0	8	8.0	0.3	6.8	-	0.0	0.0
	32	Stream (Ndola Waste Water)	32-a-1	18:06:90	16:20	on spot	21.9	51	6.1	1.0	0.7	-	-	-
			32-b-1	07:12:90	16:20	on spot	25.9	57	6.7	0.8	0.6	0.0	0.0	0.0
			32-b-2	16:02:91	10:10	on spot	25.3	80	6.9	2.5	0.9	0.0	0.0	0.0
			32-c-1	07:08:91	16:30	on spot	22.0	48	6.2	1.2	0.5	-	0.0	0.0
	33	Ndola Dam (Kafubu)	33-a-1	18:06:90	16:10	on spot	21.0	6	8.7	1.0	12.3	-	-	-
			33-b-1	07:12:90	16:50	on spot	25.8	5	7.4	1.1	0.1	0.0	0.0	0.0
			33-b-2	16:02:91	10:33	on spot	24.6	7	8.3	2.0	18.0	0.0	0.0	0.0
			33-c-1	07:08:91	16:50	on spot	21.8	10	7.6	1.1	10.7	-	0.0	0.0
	34	Munkulungwe R	34-a-1	18:06:90	15:10	on spot	17.9	9	7.6	1.0	7.6	-	-	-
			34-b-1	07:12:90	17:50	on spot	23.7	6	7.6	0.9	0.3	0.0	0.0	0.0
			34-b-2	16:02:91	12:30	on spot	24.7	8	8.4	1.1	6.9	0.0	0.0	0.0
			34-c-1	07:08:91	15:02	on spot	20.0	8	8.1	0.8	6.7	-	0.0	0.0
	35	Kafubu R	35-a-1	06:06:90	12:50	on spot	19.4	3	7.7	1.1	8.1	-	-	-
			35-a-2	06:06:90	12:50	14:06:90	17.9	8	8.0	1.0	7.3	-	0.0	-
			35-b-1	07:12:90	18:30	on spot	22.0	40	8.2	1.2	0.7	0.0	0.0	0.0
			35-b-2	13:02:91	15:03	on spot	25.7	5	7.9	2.2	8.3	0.0	0.0	0.0
			35-c-1	07:08:91	13:25	on spot	20.0	8	8.5	0.7	7.6	-	0.0	0.0
	36	Luanshya R (Upper)	36-a-1	08:06:90	11:30	on spot	19.3	6	6.4	0.6	1.5	-	-	-
			36-a-2	08:06:90	11:30	14:06:90	18.3	10	7.7	0.4	7.1	-	0.0	-
			36-b-1	06:12:90	14:20	on spot	20.5	5	7.2	0.4	1.3	0.0	0.0	0.0
			36-b-2	16:02:91	09:10	on spot	22.7	15	7.5	0.2	4.7	0.0	0.0	0.0
			36-c-1	07:08:91	13:40	on spot	19.2	9	7.7	1.0	6.5	-	0.0	0.0
	37	Luanshya (near Makoma)	37-a-1	21:06:90	10:05	on spot	21.2	23	7.7	1.1	6.2	-	-	-
			37-a-2	21:06:90	10:05	01:07:90	24.4	12	7.2	1.0	6.7	4.6	0.0	-
37-b-1			06:12:90	15:30	on spot	19.6	15	7.5	1.3	7.2	0.0	0.0	0.0	
37-b-2			16:02:91	09:45	on spot	23.2	18	7.6	0.3	4.6	0.0	0.0	0.0	
37-c-1			07:08:91	14:02	on spot	19.5	12	8.1	1.1	6.1	-	0.0	0.0	
38	Kafulafuta R	38-a-1	06:06:90	12:30	on spot	17.8	2	7.5	1.0	8.1	-	-	-	
		38-a-2	06:06:90	12:30	14:06:90	17.5	6	7.8	0.8	7.5	-	0.0	-	
		38-b-1	07:12:90	18:10	on spot	20.2	23	7.3	0.9	7.5	0.0	0.0	0.0	
		38-b-2	16:02:91	13:30	on spot	26.2	7	8.4	0.7	6.8	0.0	0.0	0.0	
		38-c-1	07:08:91	15:30	on spot	20.0	7	8.0	0.6	6.2	-	0.0	0.0	

Table-3.3 Water Quality Test Results (General Items) -- 5/7

River Basin	NO.	Sampling Points	Sample No.	Sampling		Test Date	Temp. deg. C	Turb. mg/l	pH	E.C. mv/cm	DO mg/l	Cl mg/l	Cu ²⁺ mg/l	Mn ²⁺ mg/l
				Date	Time									
				D:M:Y	h:m	D:M:Y								
Kafue	39	Katembula R	39-a-1	07:06:90	08:50	on spot	17.6	11	8.1	1.1	8.8	-	-	-
			39-a-2	07:06:90	08:50	14:06:90	17.2	8	8.1	1.0	7.7	2.3	0.0	-
			39-b-1	08:12:90	11:30	on spot	19.5	10	7.9	1.2	7.6	0.0	0.0	0.0
			39-c-1	08:08:91	09:30	on spot	18.0	9	7.9	0.4	5.7	-	0.0	0.0
	40	Lufwanyama (Upper)	40-a-1	07:06:90	09:00	on spot	16.8	4	8.2	1.1	8.9	-	-	-
			40-a-2	07:06:90	09:00	14:06:90	17.4	9	8.4	1.1	7.7	2.0	0.0	-
			40-b-1	08:12:90	11:50	on spot	19.2	10	7.5	1.1	8.1	0.0	0.0	0.0
			40-c-1	08:08:91	09:48	on spot	18.9	6	7.8	0.4	5.5	-	0.0	0.0
	41	Lufwanyama (Middle)	41-a-1	19:06:90	13:00	on spot	19.3	4	7.1	1.0	7.5	-	-	-
			41-b-1	08:12:90	12:20	on spot	19.5	6	7.6	1.2	7.5	0.0	0.0	0.0
			41-c-1	08:08:91	10:15	on spot	19.0	5	8.2	0.4	6.2	-	0.0	0.0
	42	Mukeleshi R	42-a-1	19:06:90	10:15	on spot	20.1	6	8.0	1.0	10.5	-	-	-
			42-b-1	08:12:90	12:52	on spot	20.1	4	7.5	1.1	8.5	0.0	0.0	0.0
			42-c-1	08:08:91	10:48	on spot	19.5	5	8.0	0.5	9.1	-	0.0	0.0
	43	Machiya Ferry (St. 4-280)	43-a-1	12:06:90	10:00	on spot	21.1	-	8.1	-	-	-	-	-
			43-a-2	12:06:90	10:00	25:06:90	22.0	4	7.8	1.0	8.6	2.2	0.0	-
43-b-1			08:12:90	13:25	on spot	22.2	3	7.9	1.1	7.9	0.0	0.0	0.0	
43-c-1			08:08:91	16:50	on spot	18.3	8	7.0	0.9	7.3	-	0.0	0.0	
44	Luswishi R	44-a-1	07:06:90	10:30	on spot	19.0	3	6.0	1.1	8.8	-	-	-	
		44-a-2	07:06:90	10:30	14:06:90	17.4	3	8.4	1.0	7.4	4.5	0.0	-	
		44-b-1	08:12:90	13:52	on spot	20.0	22	7.6	1.6	7.8	0.0	0.0	0.0	
		44-c-1	08:08:91	11:02	on spot	19.2	6	8.3	0.8	7.3	-	0.0	0.0	
45	Chilenga (St. 4-350)	45-a-1	12:06:90	10:00	on spot	21.1	-	7.8	-	-	-	-	-	
		45-a-2	12:06:90	10:00	25:06:90	22.2	4	7.6	1.0	8.6	2.2	0.0	-	
		45-b-1	08:12:90	14:30	on spot	21.0	29	8.1	1.5	8.0	0.0	0.0	0.0	
		45-c-1	08:08:91	17:55	on spot	20.0	6	8.5	0.2	6.9	-	0.0	0.0	
46	Mushingashi R	46-a-1	07:06:90	11:10	on spot	18.4	7	7.6	1.1	7.8	-	-	-	
		46-a-2	07:06:90	11:10	14:06:90	17.6	4	8.3	0.9	7.4	5.7	0.0	-	
		46-b-1	08:12:90	14:48	on spot	19.1	6	7.3	1.2	7.0	0.0	0.0	0.0	
		46-c-1	08:08:91	12:05	on spot	19.0	7	8.2	0.6	7.2	-	0.0	0.0	
47	Kamena R	47-a-1	07:06:90	11:20	on spot	15.9	4	7.3	1.0	7.7	-	-	-	
		47-a-2	07:06:90	11:20	14:06:90	17.7	2	6.3	1.0	7.7	0.7	0.0	-	
		47-b-1	08:12:90	15:23	on spot	19.2	3	7.5	1.0	6.9	0.0	0.0	0.0	
		47-c-1	08:08:91	12:43	on spot	19.7	8	8.4	0.4	7.2	-	0.0	0.0	
48	Chipupushi R	48-a-1	07:06:90	11:40	on spot	17.5	4	7.6	1.1	8.1	-	-	-	
		48-a-2	07:06:90	11:40	14:06:90	17.6	2	8.0	1.0	7.3	4.5	0.0	-	
		48-b-1	08:12:90	15:49	on spot	18.2	2	8.1	1.1	7.7	0.0	0.0	0.0	
		48-c-1	08:08:91	13:14	on spot	19.3	7	7.5	0.5	7.1	-	0.0	0.0	
49	Muzakazhi R	49-a-1	07:06:90	12:00	on spot	16.4	3	7.6	1.0	7.9	-	-	-	
		49-a-2	07:06:90	12:00	14:06:90	17.5	2	8.2	0.9	7.6	0.7	0.0	-	
		49-b-1	08:12:90	15:49	on spot	18.4	11	7.2	1.1	7.2	0.0	0.0	0.0	
		49-c-1	05:08:91	08:20	on spot	17.2	6	8.3	0.3	6.3	-	0.0	0.0	
50	Chifumpa P. (St. 4-560)	50-a-1	03:07:90	13:00	on spot	23.4	-	7.1	-	-	-	-	-	
		50-a-2	03:07:90	13:00	05:07:90	23.3	3	7.8	1.0	8.5	2.6	-	-	
		50-b-1	08:12:90	16:25	on spot	19.8	21	7.3	2.0	8.3	0.0	0.0	0.0	
		50-c-1	08:08:91	15:49	on spot	19.3	77	8.0	0.6	7.8	-	0.0	0.0	

Table-3.3 Water Quality Test Results (General Items) - 6/7

River Basin	NO.	Sampling Points	Sample No.	Sampling		Test Date	Temp. deg. C	Turb. mg/l	pH	E.C. mv/cm	DO mg/l	Cl mg/l	Cu ²⁺ mg/l	Mn ²⁺ mg/l
				Date	Time									
				D:M:Y	h:m	D:M:Y	C							
Kafue	51	Lubungu (St. 4-450)	51-a-1	03:07:90	16:00	on spot	21.3	-	8.0	-	-	-	-	-
			51-a-2	03:07:90	16:00	05:07:90	22.1	3.0	7.6	1.1	8.4	1.5	-	-
			51-c-1	08:08:91	13:38	on spot	18.9	8	7.9	0.6	7.1	-	0.0	0.0
	52	Nangoma R	52-a-1	06:07:90	11:50	on spot	16.5	4	7.2	0.7	9.5	-	-	-
			52-b-1	08:12:90	17:20	on spot	21.5	32	7.9	1.2	7.2	0.0	0.0	0.0
			52-b-2	16:02:91	07:54	on spot	23.2	10	-	0.7	4.1	-	-	-
	53	Chunga R (Kasup Mission)	53-a-1	06:07:90	09:40	on spot	16.3	12	6.6	0.5	5.7	-	-	-
			53-a-2	06:07:90	09:40	09:07:90	20.8	15	6.0	0.8	5.5	53.6	-	-
			53-b-1	03:01:91	15:50	on spot	23.7	25	7.7	0.9	2.9	0.0	0.0	0.0
			53-b-2	06:02:91	11:56	on spot	23.5	124	8.2	0.8	5	-	-	-
			53-c-1	08:08:91	14:10	on spot	20.0	7	7.5	0.3	6.8	-	0.0	0.0
			53-c-2	28:08:91	07:10	on spot	18.5	66	8.0	0.9	4.2	3.0	0.0	0.1
	54	Mwembeshi R (Road Bridge)	54-a-1	06:07:90	10:50	on spot	14.7	26	7.2	0.7	8.3	-	-	-
			54-a-2	06:07:90	10:50	09:07:90	21.3	20	6.5	0.9	7.7	32.3	-	-
			54-b-1	03:01:91	14:45	on spot	24.8	85	8.2	0.8	1.6	0.0	0.0	0.0
			54-b-2	06:02:91	10:04	on spot	23.8	117	8.0	0.9	3.7	-	-	-
			54-c-1	27:08:91	17:36	on spot	21.8	92	8.5	0.6	8.8	3.0	0.1	0.1
	55	Mwembeshi R (Shibuyunji)	55-a-1	06:07:90	13:00	on spot	19.1	18	7.2	0.8	7.9	-	-	-
			55-b-1	03:01:91	13:10	on spot	25.7	140	8.2	0.8	1.3	0.0	0.0	0.0
			55-b-2	05:02:91	14:00	on spot	26.2	42	8.1	0.9	3.0	-	-	-
55-c-1			27:08:91	16:45	on spot	25.6	97	8.3	0.6	-	3.0	0.1	0.1	
56	Kafue R (Water Intake)	56-a-1	05:06:90	11:50	on spot	21.3	2	7.6	1.1	7.6	-	-	-	
		56-b-1	02:01:91	12:45	on spot	27.0	12	8.9	0.5	2.8	0.0	0.0	0.0	
		56-b-2	05:02:91	14:00	on spot	25.7	10	8.8	0.9	4.6	-	-	-	
		56-c-1	27:08:91	11:20	on spot	22.0	1	7.9	0.2	7.0	0.6	0.1	0.2	
Luangwa	101	Mulungushi R	101-a-1	06:06:90	11:20	on spot	18.7	4	7.5	1.0	8.8	-	0.0	-
			101-a-2	06:06:90	11:20	14:06:90	17.5	4	7.8	0.7	7.1	-	0.0	-
			101-b-1	09:12:90	15:50	on spot	20.7	3	7.9	1.2	8.2	0.0	0.0	0.0
			101-b-2	12:02:91	12:45	on spot	23.8	37	8.0	0.9	8.5	0.0	0.0	0.0
			101-c-1	04:08:91	10:30	on spot	19	3	7.9	0.9	7.6	-	0.0	0.0
	102	Luangwa Br. (St. 5-940)	102-a-1	08:06:90	12:00	11:06:90	21.9	35	8.2	0.6	8.6	-	-	-
			102-a-2	08:06:90	12:00	14:06:90	19.9	32	8.0	0.6	6.6	-	-	-
			102-b-1	01:02:91	12:00	on spot	33.9	288	8.2	0.9	5.3	0.0	0.0	0.0
			102-c-1	05:09:91	11:30	on spot	31.7	28	8.2	0.5	7.5	-	0.0	0.0
Zambezi	201	Zambezi P/H (St. 1-150)	201-a-1	23:06:90	09:00	on spot	20.0	-	6.3	-	-	-	-	
			201-a-2	23:06:90	09:00	04:07:90	16.8	3	6.8	0.4	8.2	2.0	0.0	-
	202	Kabompo Boma (St. 1-650)	202-a-1	23:06:90	11:50	on spot	20.8	-	8.1	-	-	-	-	
			202-a-2	23:06:90	11:00	04:07:90	16.8	2	7.2	0.9	9.3	2.5	0.0	-
	203	Watopa P. (St. 1-950)	203-a-1	23:06:90	16:00	on spot	21.0	-	8.0	-	-	-	-	
			203-a-2	23:06:90	16:00	04:07:90	16.8	3	7.3	1.0	8.4	6.9	0.0	-
	204	Lukulu (St. 2-030)	204-a-1	22:06:90	11:30	on spot	22.0	-	7.9	-	-	-	-	
			204-a-2	22:06:90	11:30	04:07:90	16.9	2	7.0	0.9	8.2	2.0	0.0	-
	205	Kalabo (St. 2-250)	205-a-1	20:06:90	17:30	on spot	20.8	-	6.0	-	-	-	-	
			205-a-2	20:06:90	17:30	04:07:90	17.0	2	7.0	0.5	7.9	0.6	0.0	-
	206	Senanga (St. 2-400)	206-a-1	25:06:90	09:30	on spot	20.0	-	6.8	-	-	-	-	
			206-a-2	25:06:90	09:30	04:07:90	17.1	5	7.0	0.7	9.0	0.9	0.0	-

Table-3.3 Water Quality Test Results (General Items) - 7/7

River Basin	NO.	Sampling Points	Sample No.	Sampling		Test Date	Temp. deg. C	Turb. mg/l	pH	E.C. mv/cm	DO mg/l	Cl mg/l	Cu ²⁺ mg/l	Mn ²⁺ mg/l
				Date	Time									
				D : M : Y	h : m									
Zambezi	207	Ngwerere R (Bomanza Panch)	207-a-1	06:07:90	14:30	on spot	18.9	18	6.9	0.7	6.9	-	-	-
			207-a-2	06:07:90	14:30	09:07:90	20.9	16	6.8	0.9	8.4	32.5	-	-
			207-b-1	03:01:91	15:42	on spot	24.0	399	7.9	0.9	0.8	0.0	0.0	0.0
			207-b-2	06:02:91	14:00	on spot	22.6	137	9.1	0.8	3.2	0.0	0.0	0.0
			207-c-1	29:08:91	11:35	on spot	19.4	28	8.0	0.6	6.1	3.0	0.0	0.0
	208	Chongwe R (Route D176 Br)	208-a-1	06:07:90	14:50	on spot	19.8	4	7.3	0.6	6.0	-	-	-
			208-a-2	06:07:90	14:50	09:07:90	20.8	4	6.2	0.8	8.7	1.6	-	-
			208-b-1	03:01:91	08:30	on spot	22.7	26	8.3	0.8	1.1	0.0	0.0	0.0
			208-b-2	07:02:91	11:00	on spot	23.6	56	8.3	0.9	5.0	0.0	0.0	0.0
			208-c-1	29:08:91	12:22	on spot	20.3	20	8.3	0.5	9.2	2.0	0.1	0.0
M a x.							33.9	399	9.5	2.9	18.0	53.6	51.0	28.0
M i n.							14.7	1	5.4	0.1	0.1	0.0	0.0	0.0
Average							21.3	26	7.7	0.9	6.4	2.7	1.2	0.4
Nu. of Data							279	267	276	267	249	140	195	152

Table-3.4 Water Quality Test Results (Special Items)

River Basin	NO.	Sampling Points	Sample No.	Sampling		Fe mg/l	Cu mg/l	Mn mg/l	As mg/l	Cd mg/l	Pb mg/l	pH	Remarks
				Date	Time								
				D : M : Y	h : m								
Kafue	2	Raglam Farm (St. 4-050)	2-a-2	06:06:90	16:30	-	N.D.	N.D.	-	-	N.D.	-	
	7	Stream (Waste Water)	7-a-2	20:06:90	09:30	6	23	27	tr	N.D.	1	-	
			7-a-2	20:06:90	09:30	4	43	31	tr	N.D.	2	5.6	
			7-a-2	20:06:90	09:30	5	45	31	5	N.D.	2	4.7	
			7-a-2	20:06:90	09:30	10	53	32	7	N.D.	2	4.0	
			7-a-2	20:06:90	09:30	8	47	32	10	N.D.	4	4.6	
	8	Kafue R (Chililabombwe Rd. Bridge)	8-a-5	20:06:90	11:00	tr	0.3	0.2	N.D.	N.D.	tr	-	
			8-a-5	20:06:90	11:00	0.3	1.0	0.4	N.D.	N.D.	tr	5.3	
			8-a-5	20:06:90	11:00	0.4	1.0	0.6	tr	N.D.	tr	3.5	
	17	Kafue R (near Kafironda)	17-a-4	20:06:90	13:10	tr	tr	N.D.	N.D.	N.D.	N.D.	-	
	21	Kafue R (Comm.Center Br)	21-a-2	06:06:90	13:30	tr	N.D.	N.D.	N.D.	N.D.	N.D.	-	
			21-a-4	18:06:90	17:10	tr	tr	N.D.	N.D.	N.D.	N.D.	-	

[Note] tr:Trace (very small amount), N.D.:Not detected

3.3 Consideration on Test Results

(1) Water Quality of Kafue River

< Main Pollutant Source >

There are large-scale stops and deposit yards of copper ore. Plants, business offices and allied offices of the refinery, are widely distributed throughout the Copperbelt Province and the upper reaches of Kafue River, and they make up towns such as Ndola, Kitwe, Chingola, Chililambwe, Mufulira and Luanshya. These business establishments and towns feed industrial waste water and municipal sewage water into the Kafue River through waterways and small rivers.

The waste water produced by the mining work, the main pollutant source, contains many inorganic matter. The tributary river, feeding the waste water near the Chililambwe Bridge of Kafue River, is considerably polluted by waste water from Chingola. This is shown in the test results of the water in dry and rainy season sampled at Point-7. Besides a large quantity of copper and manganese, iron and toxic substances such as arsenic and lead can also be detected in the water sample at Point-7. In the water sampled at Point-8, the Chililambwe Bridge, same substances as detected at Point-7 are also detected. This Point-8 is located at the downstream of Point-7.

The test results shows that river water in rainy season becomes high turbidity and slightly alkaline. That is why the rain water flush the suspended solids and mining lime deposits into the rivers.

< Pollution and Self-purification >

Judging from the test results of samples collected at the middle and lower reaches of Kafue River, the pollution caused at the upper Kafue River never affects the middle and lower stream of Kafue River.

In general, mining waste water contains a large quantity of suspended matter and metallic components, because an acidification of waste water will increase the quantity of the dissolved metallic components. The test results show that the water-soluble metallic components are hydrated to hydroxides which become insoluble metal salts and precipitate onto the river bed along with other suspended matter. This occurs because the acidic waste water is artificially neutralized with limestone, and the water of Kafue River shows neutral or slightly alkaline. Besides, according to the data of electric conductivity and chloride concentration, good water from tributary rivers feeds into the Kafue River resulting in a dilution of the river water which allows the water quality of the Kafue River to improve.

< Organic Pollution >

To examine organic pollution, the dissolved oxygen and its change were measured instead of measuring such organic water pollution indexes as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). It can be inferred from test results that the extent of the organic pollution in the upper reaches of Kafue River is not a great problem, although the dissolved oxygen measured at some tributaries (Point-19 and 32) in Kitwe and Ndola municipalities shows low values, and the water of these points is emitting an offensive odor.

The year-round water temperature of the tributary rivers feeding Kafue River is comparatively high resulting in the increased density of water plants. There are some cases in which the carbon dioxide assimilation of water plants allows the dissolved oxygen concentration and the pH value to increase, especially at Ndola. Active overgrowth of plants and algae cause the eutrophication of the river water stagnation to become more and more marked.

< Countermeasure and Monitoring >

At present, the main stream of Kafue River can purify itself. However, the metallic components in the waste water will deposit for many years at the bottom of river. Ultimately these deposits might become a source of pollution. If the river water is used for drinking water, it is necessary to take measures to enforce waste water treatment such as neutralization, precipitation and separation.

It will also be necessary to monitor the quality of the river water to reduce the pollutant loads before they are fed into the river since the mining waste water contains many kinds of materials restricted by the water quality standard as shown in Table-3.5.

Table-3.5 Water Quality Standard (Unit: mg/lit)

Standard	Fe	Cu	Mn	As	Cd	Pb
Environmental Quality Standard (Japan; 1970)	-	-	-	0.05	0.01	0.1
Effluent Standard (Japan; 1970)	10	3	10	0.5	0.1	1.0
Water Quality Standard for Drinking Water (Japan; 1970)	0.3	1.0	0.3	0.05	0.01	0.1
Water Quality Guideline for Drinking Water (Zambia; 1986)						
- Permissible Limit -	1.0	1.5	-	0.05	0.1	0.05
- Desirable Limit -	0.3	1.0	-	0.01	0.005	0.01

(2) Water Quality in Other Rivers

Some tributaries around Lusaka (point 53 and 54) are affected by the municipal waste water of Lusaka, which contributes to the increase of organic pollution and causes the eutrophication in the dead-water area to become increasingly conspicuous.

The water in the main stream of Luangwa River and Zambezi River, some tributaries of which are only slightly affected by the municipal waste water from Lusaka, seems to be of good quality judging from the results of this investigation.

(3) Seasonal Variation of Water Quality

As general tendency that the tests results revealed, the water quality in rainy season shows higher turbidity and slightly lower electric conductivity than those in dry season. The rain water bring a lot of suspended solid to rivers. The decrease of electric conductivity is caused by dilution due to rain water. Judging from higher water temperature and lower dissolved oxygen, it is presumed that the organic materials are increased in rainy season. Fig.-3.3 shows the seasonal variation of water quality at the main points along the main stream of Kafue River. At all points the values of turbidity in rainy season are higher than those in dry season. This tendency is appeared at almost all test points.

The direct pollutant loads from the process waste water of the mining activities are generally constant through the year unless the activities change. However, in rainy season the indirect pollutant roads from mining stopes, deposits, yards etc. are brought to rivers with rain water. The higher turbidity in rainy season is testified by this fact.

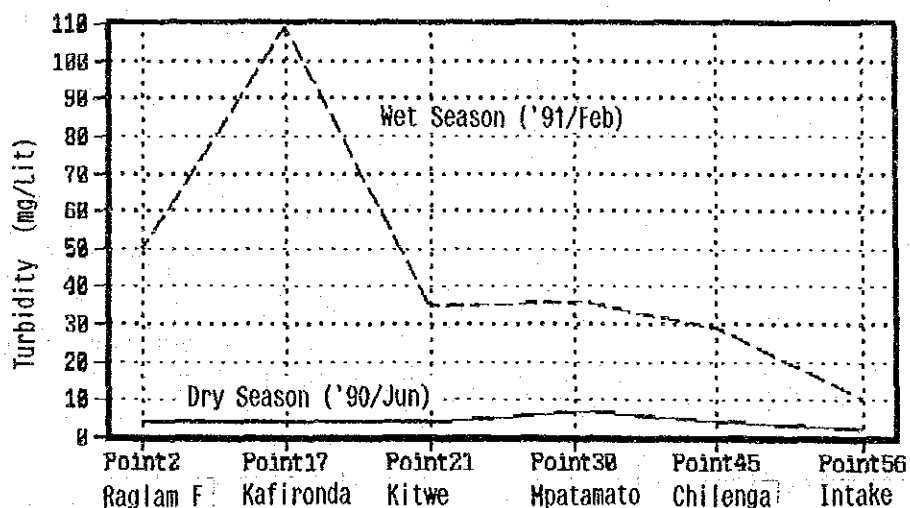


Fig.-3.3 Variation of Turbidity along Kafue River

