REPUBLIC OF ZAMBIA

MINISTRY OF ENERGY AND WATER DEVELOPMENT

FINAL REPORT

SUPPORTING

TO

THE MASTER PLAN STUDY

ON

HYDROLOGIC OBSERVATION SYSTEMS

OF

THE MAJOR RIVER BASINS

IN

ZAMBIA

MARCH, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF ZAMBIA
MINISTRY OF ENERGY AND WATER DEVELOPMENT

FINAL REPORT
SUPPORTING

THE MASTER PLAN STUDY
ON
HYDROLOGIC OBSERVATION SYSTEMS
OF
THE MAJOR RIVER BASINS
IN
ZAMBIA

MARCH, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

THE MASTER PLAN STUDY ON HYDROLOGIC OBSERVATION SYSTEMS
OF THE MAJOR RIVER BASINS IN ZAMBIA

FINAL REPORT
SUPPORTING

C O N T E N T S

ABBREVIATION

< GENERAL >

Study	: The master plan study on hydrologic observation systems of the major river basins in Zambia
Study Team	: The team dispatched by JICA to carry out Study
Study Area	: The area covered by Study
GDP	: Gross Domestic Product
FNDP	: Forth National Development Plan
BOD	: Biochemical Oxygen Demand
COD	: Chemical Oxygen Demand

< ORGANIZATION AND FIRM >

J I C A	: Japan International Cooperation Agency
D W A	: Department of Water Affairs, Ministry of Energy and Water Development, Republic of Zambia
Z R A	: Zambezi River Authority
Z E S C O	: Zambia Electric Supply Company
ZR	: Zambia Railways
TAZARA	: Tanzania - Zambia Railway Authority
IDWSSD	: International Drinking Water Supply and Sanitation Decade
UN	: United Nation
UNDP	: United Nation Development Program
WMO	: World Meteorological Organization
MEWD	: Ministry of Energy and Water Development
SADCC	: South African Development Coordination Conference

< UNIT >

km	: Kilometer, 1km = 1000m
m	: Meter, 1m = 100cm
cm	: Centimeter, 1cm = 10mm
mm	: Millimeter
f	: Feet, 1f = 12 inches = 1/3 yard = 0.3048m
km2	: Square kilometer, 1km2 = 1000m2
m2	: Square meter
m3	: Cubic meter
bcm	: Billion cubic meter, 1bcm = 1000mcm
mcm	: Million cubic meter, 1mcm = 1000000m3
m/s	: Meter per second
m3/s	: Cubic meter per second
mcm/yr	: Million cubic meter per year
mg/lit	: Miligram per litter

CHAPTER - 1

HYDROLOGIC OBSERVATION

<<<<< CHAPTER-1 HYDROLOGIC OBSERVATION >>>>>

C O N T E N T S

LIST OF FIGURES AND TABLES

1 HYDROLOGIC OBSERVATION

1.1 Selection of Hydrometric Observation Points

1.1.1 River Systems and Existing Stations

(1) River Systems

From the view point of hydrologic observation the Zambia is divided into the following 6 basins: (See Fig-1.1)

1) Zambezi River Main Stream Upper Basin
2) Zambezi River Main Stream Middle Basin
3) Zambezi River Main Stream Lower Basin
4) Kafue River Basin
5) Luangwa River Basin and
   Zambezi River Main Stream Lowest Basin
6) Chambeshi River and Luapula River Basin
7) Lake Tanganyika Basin

According to the No. of basin above, the hydrometric station No. is given. For example, the hydrometric station Raglam Farm is numbered as 4-050, because this station is located in the upstream of Kafue River Basin. The basin 1), 2),3),4) and 5) above belong to the Zambezi River System and the basin 6) and 7) belong to the Zaire River System. The catchment area of Zambezi River occupies 3/4 of the whole area of Zambia.

The Study Area is covered by the two basin above: a)Zambezi River Main Stream Basin(upper, middle, lower and lowest: Total area is some 240 thousand km2) and b) Kafue River Basin (Total area is some 150 thousand km2). In Study Area, there exist three big dams: 1) Kariba Dam along the Zambezi River Main Stream, 2) Itezhitezhi Dam along Kafue River and 3) Kafue Gorge Dam along Kafue River.

(2) Existing Hydrometric Stations

In Zambia, more than 240 hydrometric stations where the river water level is observed daily and flow measurement are carried out periodically, are registered at the Department of Water Affairs (DWA). These stations are almost working. Refer to Fig.1-1 and Supplement-A.

At each station, a observer is employed by DWA to make daily observation (twice a day) of river water level using the staff gauge installed at the station. At some stations, automatic recorders were installed, but at almost all stations, no recorder is working now.

In Study Area, about 150 hydrometric stations are distributed. At these stations, daily observation of river water level is continued, but the frequency of periodic flow measurement has been decreased in recent years.

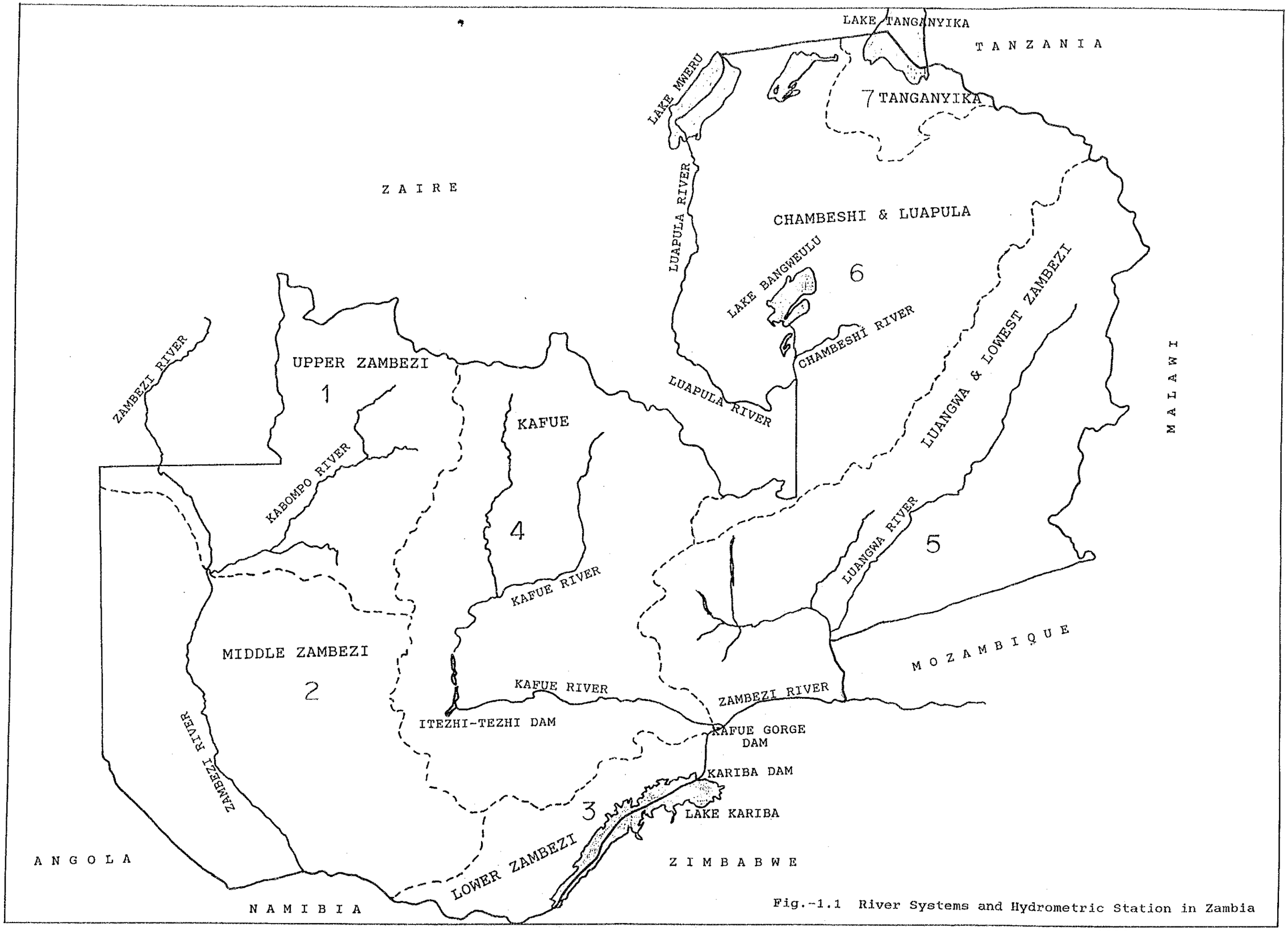


Fig.-1.1 River Systems and Hydrometric Station in Zambia

1.1.2 Hydrometric Observation Points

On the basis of the results of field reconnaissance, existing data analysis and preliminary study for calculation of river flow pattern, the mutual discussions between Study Team and Counterpart Agency DWA have been taken regarding the hydrometric stations to be dealt and observed in this Study. The discussions concluded and selected the following 19 hydrometric stations. Refer to Table-1.1 and Fig.-1.2.

<<< Station >>>		<<<Catchment Area>>>
<Zambezi Main River Basin>	.....	7 stations
o 1-150	Zambezi Pump House	: 82,275km2
o 1-650	Kabompo Boma	: 42,740km2
o 1-950	Watopa Pontoon	: 66,449km2
o 2-030	Lukulu	: 206,531km2
o 2-250	Kalabo	: 34,620km2
o 2-400	Senanga	: 278,298km2
* 5-030	Exchange Farm	: 67km2
<Kafue River Basin>	.....	11 stations
o 4-050	Raglam Farm	: 4,999km2
* 4-120	Mwambashi	: 869km2
* 4-130	Smith's Bridge	: 8,599km2
* 4-200	Mpatamato	: 11,655km2
o 4-280	Machiya Ferry	: 22,920km2
o 4-350	Chilenga	: 29,008km2
o 4-450	Lubungu	: 54,442km2
o 4-560	Chifumpa Pontoon	: 21,445km2
o 4-669	Kafue Hook Bridge	: 95,053km2
* 4-941	Kaleya Dam Site	: 45km2
* 4-958	Uruaff Farm	: 140km2
<Luangwa River Basin>	.....	1 station
o 5-940	Luangwa Bridge	: 143,781km2

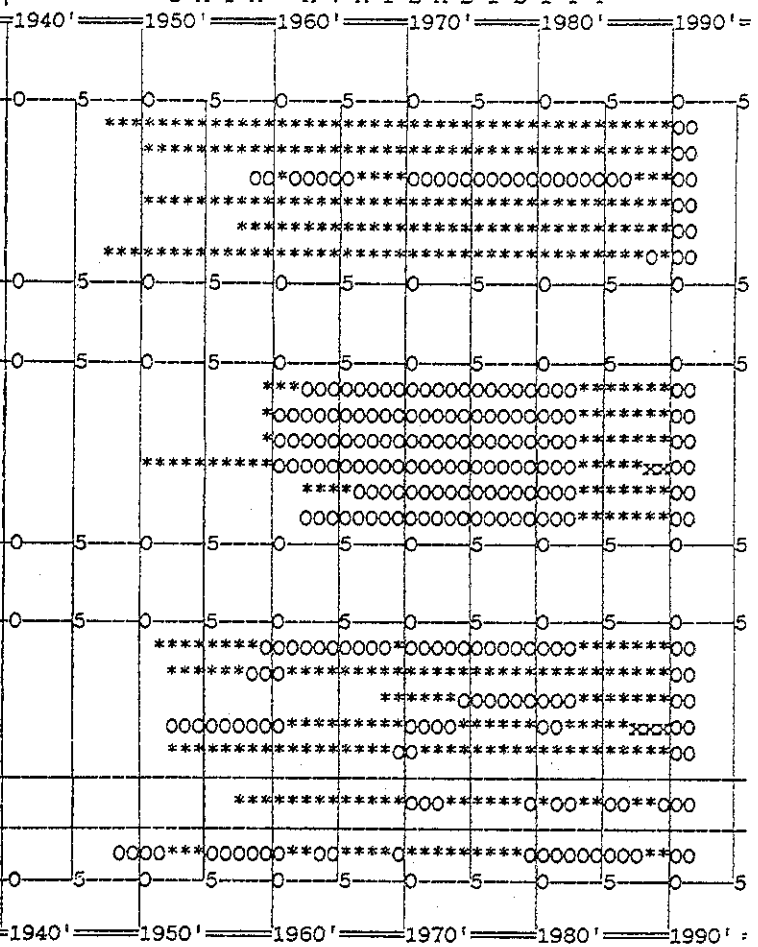
[Note] 1) o:Staff-gauge station *:Automatic Recording station
2) Value of catchment area includes that of foreign countries' areas.

These stations were selected for the following reasons:

1) The stations are well located so as to comprehend the river flow pattern uniformly throughout Study Area.
2) The stations have long term observation data so that the long term flow pattern is estimated.
3) Those points: Kariba Dam, Itezhi-tezhi Dam, Kafue Gorge Dam, Sesheke (middle part of Zambezi River), Victoria Falls and Luangwa (the most downstream part of Zambezi River), should be reference points. However, no observation will be done at those stations in this Study. Because at each dam periodic data such as reservoir water level and gate operation etc. are recorded, and at the other three points flow measurement is difficult due to the reason that the international boundary is laid on the river.
4) At promising exploitation points having small catchment area, water level recorder should be set.

Table- 1.1 Hydrometric Stations Selected in Study

NO	ST.NO.	AREA(km2)	RIVER	LOCATION	OPENED	CLOSED	S.G	AUT	DIS
<STATIONS COVERED BY MONGU TEAM>									
<<< ZAMBEZI RIVER BASIN >>>									
1	1-150	82,275	Zambezi	Zambezi Pump House	02/1947		Y	N	Y
2	1-650	42,740	kabompo	Kabompo Boma	10/1950		Y	N	Y
3	1-950	66,449	Kabompo	Watopa Pontoon	05/1958		Y	N	Y
4	2-030	206,531	Zambezi	Lukulu	10/1950		Y	N	Y
5	2-250	34,620	Luanginga	Kalabo	11/1957		Y	N	Y
6	2-400	278,298	Zambezi	Senanga	11/1947		Y	N	Y
<STATIONS COVERED BY KITWE TEAM>									
<<< KAFUE RIVER BASIN >>>									
7	4-050	4,999	Kafue	/ Raglam Farm	09/1959		Y	N	Y
8	4-120	869	Mwambashi	/ Mwambashi	10/1959		Y	Y	Y
9	4-130	8,599	Kafue	/ Smith's Bridge	08/1958		Y	Y	Y
10	4-200	11,655	Kafue	/ Mpatamato	12/1950	10/1987	Y	Y	Y
11	4-280	22,920	Kafue	/ Machiya Ferry	06/1962		Y	N	Y
12	4-350	34,162	Kafue	/ Chilenga	06/1962		Y	N	Y
<STATIONS COVERED BY LUSAKA TEAM>									
<<< KAFUE RIVER BASIN >>>									
13	4-450	54,442	Kafue	/ Lubungu	06/1951		Y	N	Y
14	4-560	21,445	Lunga	/ Chifumpa Pontoon	02/1953		Y	N	Y
15	4-669	95,053	Kafue	/ Kafue Hook Bridge	01/1968		Y	N	Y
16	4-941	45	Kaleya	/ Kaleya Dam Site	12/1952	10/1986	Y	Y	Y
17	4-958	140	Mazabuka	/ Uruaff Farm	10/1952		Y	Y	Y
<<< ZAMBEZI RIVER BASIN >>>									
18	5-030	107	Kapiriombwa	Exchange Farm	04/1957		Y	Y	Y
<<< LUANGWA RIVER BASIN >>>									
19	5-940	143,781	Luangwa	/ Luangwa RD BG	10/1948		Y	N	Y



<NOTE> S.G : Staff Gauge, AUT : Automatic Recorder, Dis : Discharge Rating Curve, Y : Available, (Y) : Previously worked,
N : Not Available, O : Water level and discharge data are available,
X : Data is not available

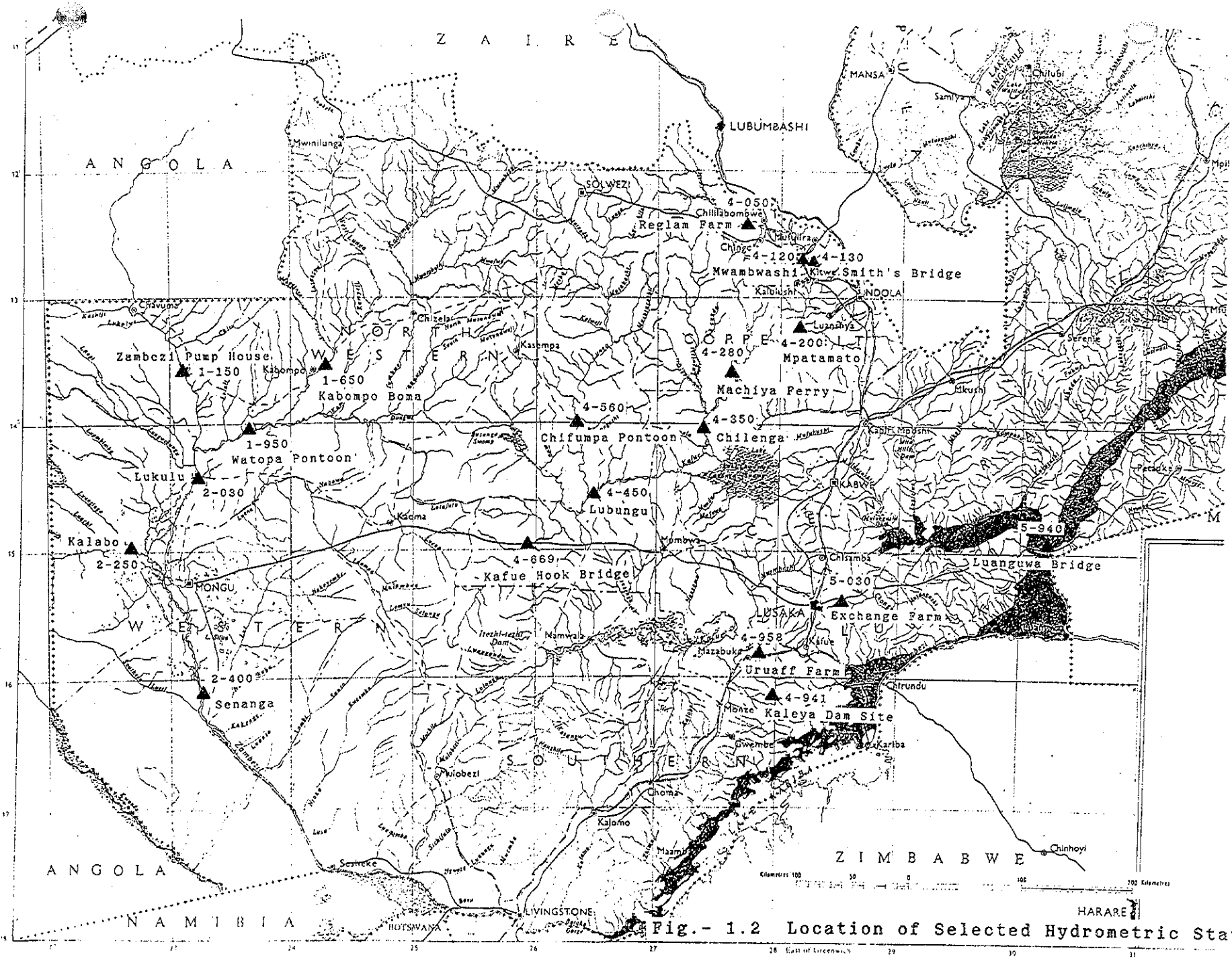


Fig.- 1.2 Location of Selected Hydrometric Stations

1.2 Topographic Survey

Topographic survey for the 19 stations selected in Study was carried out by employing the local survey company under the Study Team's supervision. The survey includes the followings:

1) Leveling Survey for Establishment of Bench Mark
2) Cross Sectional Survey of River
3) Relative Position Survey between Bench Mark & Base Point
4) Leveling Survey for Water Level Gauge

1.2.1 Methodology of Survey

(1) Leveling Survey

To establish Bench Mark at observation stations, leveling survey was carried out. The most appropriate equipment was applied according to the distance between the existing Bench Mark or equivalent point and observation station, out of the following three methods: 1) Automatic Level 2) Distance Meter 3) Barometer.

< Specification of Leveling Survey by Automatic Level >

1) Forth Grade Leveling Survey Standards for Public Works in Japan shall be applied to this survey.
2) The automatic level and other equipment shall be checked and adjusted before commencement of the survey and once every two weeks during the survey.
3) Measurement shall be made in both directions, forward and backward. The forward and backward measurement shall be done within one day.
4) Temporary bench marks shall be marked at about one (1) or one and half (1.5) kilometers interval on unmovable and firm points along leveling route.
5) Number of measuring points along leveling route shall be even.
6) Backsights and foresights shall be approximately equal in distance and the maximum sight distance shall not exceed seventy (70) meters.
7) Allowable height difference between forward measurement and backward measurement shall be within 20mm x $\sqrt{S}$, where S is the distance between existing bench mark and newly established bench mark in kilometer.
8) The height difference of the loop shall distributed to each measuring point in proportion to length of each section.

< Specification of Leveling Survey by Distance Meter >

1) The height difference between two points shall be calculated by measuring distance and vertical angle between two points by using an electro-optical distance meter.
2) The maximum distance between two measuring points shall be less than two (2) kilometers.
3) The distance between two points shall be measured by electro-optical distance meter at least three times with meas-

urement error less than five (5) centimeters.

4) The allowable height difference between foresight and backsight measurement shall not exceed thirty (30) centimeters.
5) The vertical angle shall be measured two times at the normal telescope position and at reverse so that the total angle shall be about three hundreds sixty (360) degrees. The difference of total vertical angle between foresight and backsight shall be less than thirty (30) seconds.
6) All survey work shall be carried out in accordance with the detailed instructions given by the Engineer.

< Specification of Leveling Survey by Super Barometer >

1) The height difference between two points shall be calculated by measuring barometric pressure by using super-barometers.
2) The maximum distance between two points shall be less than two(2) kilometers. However, the Engineer shall be able to direct longer distance taking into consideration weather conditions and topographic conditions etc.
3) The barometric pressure and air temperature at the two points shall be measured at the same time.
4) All survey works shall be carried out in accordance with detailed instructions given by the Engineer.

(2) Cross Sectional Survey of River

To establish rating curve for flow measurement, the cross sectional survey shall be carried out at each observation station in the following manner.

1) The cross section line shall be determined in perpendicular to the center line of the river channel, along which the bench mark and base point shall be installed at both banks.
2) The length of cross sectional survey shall be more than that covering the section of the maximum water level in the past, the final length shall be directed by the Engineer.
3) The interval of measuring point shall be less than twenty (20) meters, including additional topographically transformed points.
4) Measurement on land shall be made in the following ways.
   a) The distance shall be measured by tape.
   b) The height shall be measured by leveling survey by automatic level and/or other indirect leveling survey
5) The distance measurement on river water shall be made in the following ways.
   a) Type A (in case that the width of river channel is not so wide): The distance shall be directly measured by measuring tape or rope.
   b) Type B (in case that the width of river channel is wide) : The distance shall be measured by an electro-optical distance meter.
6) The height measurement on river water shall be made in the following ways.
   a) The water depth shall be measured by measuring staff or rod, or measuring rope with weight.

b) The water level shall be measured before and after survey work, and intermediate of survey if necessary.

(3) Relative Position Survey

A set of bench mark and base point was installed along the cross sectional line at each station. In case of wide river, another base point was installed along either side of river bank so that the triangle is formulated by these three points and it is easy to position a boat by a simple survey method at the time of flow measurement.

(4) Leveling Survey of Water Level Gauge

The height of datum point of water level gauge was determined by leveling survey by automatic level, connecting with the bench mark which elevation was obtained through the work (1-1) above.

1.2.2 Results of Survey

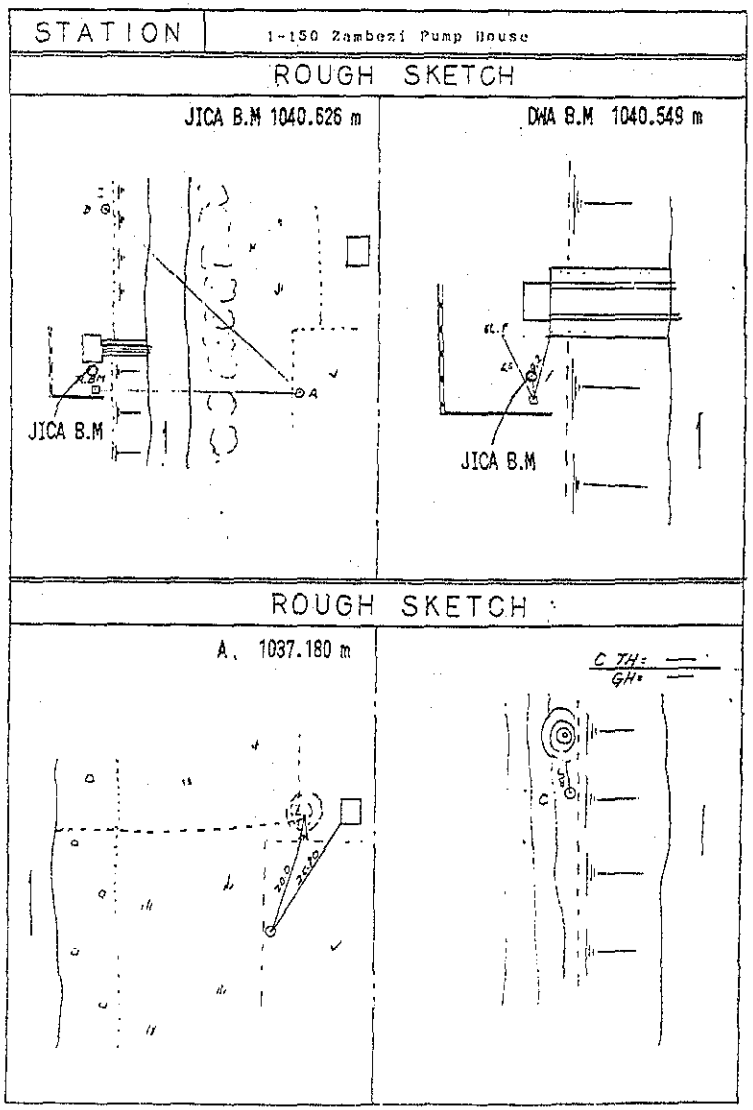
The results of leveling survey are summarized as shown in Table-1.2. The survey results are shown in Fig.-1.3.

Table- 1.2 Result of Survey for Hydrometric Stations

St. No.	<--National B/M--> Name	Elev.(m)	<---------Leveling----------> A1	A2	A3	B1	B2	JDG	River B/M Elev.(m)
1-150	T=P6	1056.230	-	41.0	-	128	80	OK	1040.626
1-650	T=TP28	1128.980	2.0	5.2	-	53	15	OK	1053.327
1-950	T=TP30	1110.380	-	-	62.0	157	76	OK	1037.048
2-030	T=P7	1032.430	-	5.4	-	46	4	OK	1026.740
2-250	B=H89	1046.000	-	7.9	-	56	55	OK	1020.800
2-400	B=17F7	1009.392	0.1	-	-	6	0	OK	1000.718
4-050	B=14M30	1321.953	1.5	16.6	-	85	83	OK	1264.930
4-120	B=KITWE	1205.831	-	-	12.0	69	0	OK	1175.285
4-130	B=RM88CL	1200.269	5.0	-	-	44	28	OK	1167.580
4-200	B=E7M165	1208.594	-	-	28.0	105	46	OK	1169.247
4-280	B=E7M120	1196.963	-	-	28.0	105	38	OK	1125.174
4-350	B=E7M75	1161.896	-	-	21.0	91	11	OK	1120.684
4-450	B=12M120	1120.492	0.4	-	-	12	5	OK	1098.285
4-560	B=43M81A	1079.549	0.8	-	-	17	16	OK	1116.743
4-669	B=19/19	1147.963	-	-	36.0	120	100	OK	1072.868
4-941	B=19F1	1136.021	-	13.8	-	74	42	OK	1247.486
4-958	B=9/19	1125.102	0.3	-	-	10	6	OK	1027.622
5-030	B=12/63	1097.606	0.1	-	-	6	0	OK	1118.198
5-940	B=TS289	944.570	-	-	12.0	69	9	OK	368.842
[Total]			10.2	89.9	199.0				

[Note] A1 : Distance surveyed with autolevel (km)
A2 : Distance surveyed with distance meter (km)
A3 : Distance surveyed with super-barometer
B1 : Allowable error (mm), B2 : Actual error (mm)
JDG: Judgment of survey accuracy

DESCRIPTION



Location

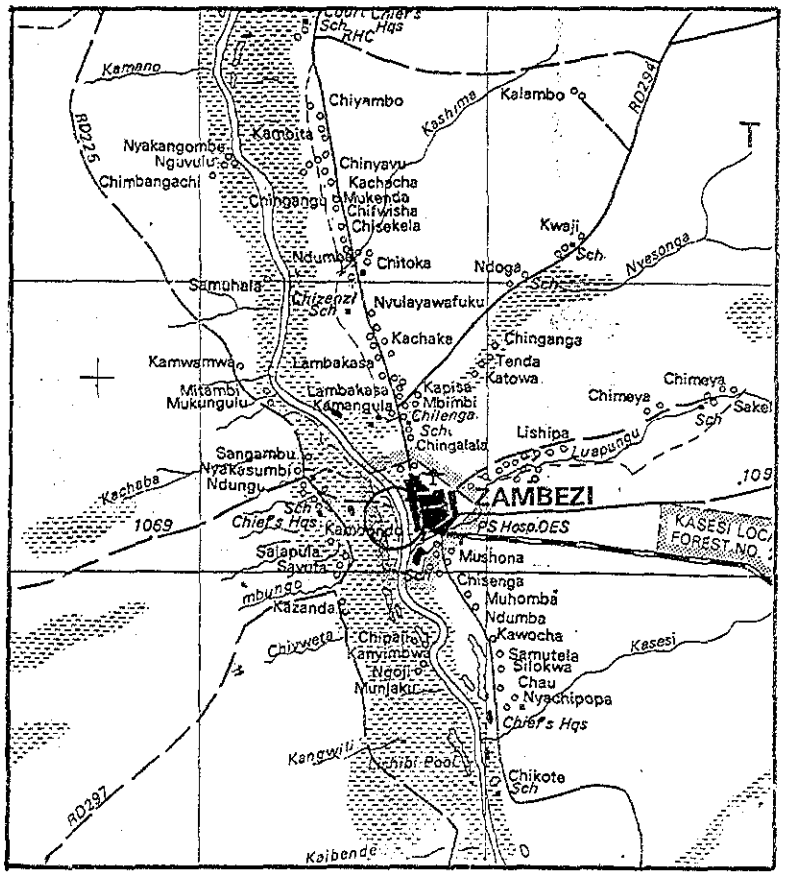


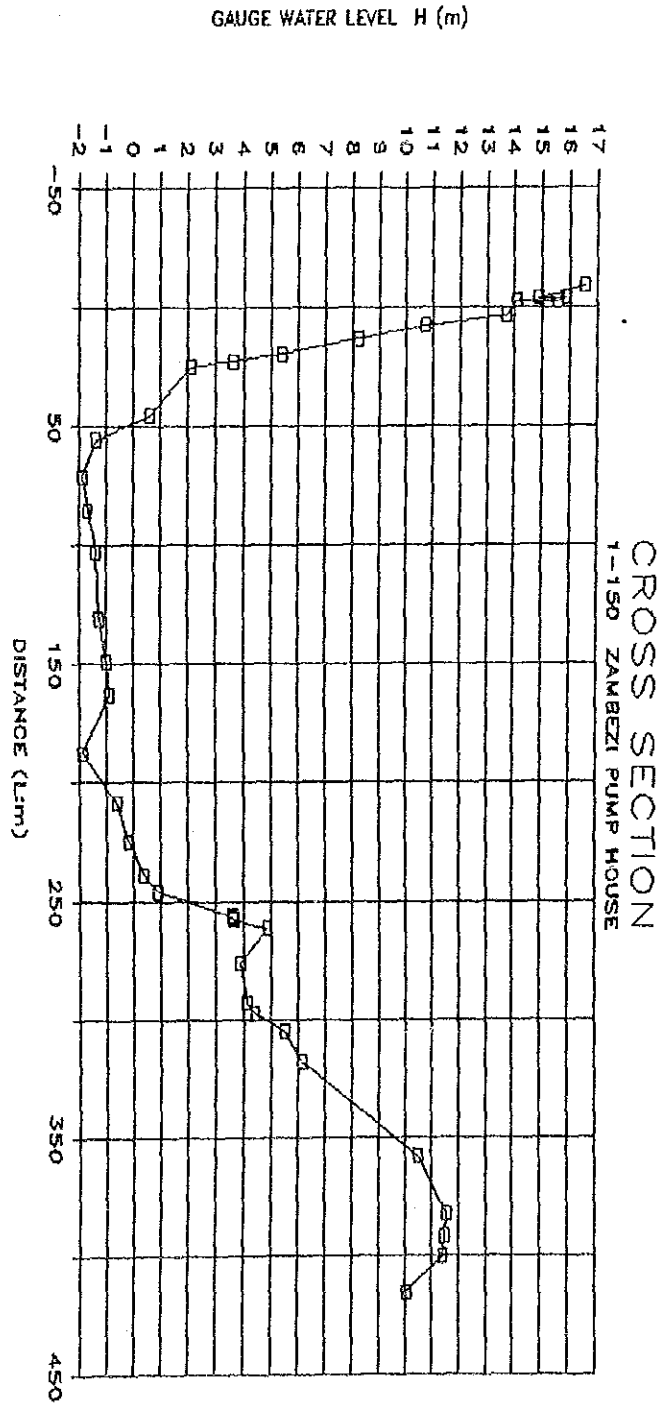
Fig.-1.3(1) Survey Result of St. 1-150 Zambezi Pump House

1-150 ZAMBEZI PUMP HOUSE
CROSS SECTIONAL SURVEY DATA

GAUGE PLATE ZERO (0) ELEVATION 1,026.65

X	Y	H
(8.60)	1043.20	16.55
(3.60)	1041.54	14.89
(3.60)	1042.55	15.90
(2.50)	1042.18	15.53
(2.50)	1040.74	14.09
3.50	1040.37	13.72
7.90	1037.38	10.73
13.20	1034.89	8.24
19.90	1032.04	5.39
22.80	1030.24	3.59
25.10	1028.74	2.09
45.50	1027.24	0.59
55.70	1025.24	(1.41)
71.60	1024.74	(1.91)
85.30	1024.94	(1.71)
102.70	1025.24	(1.41)
130.90	1025.34	(1.31)
149.20	1025.64	(1.01)
162.90	1025.74	(0.91)
187.80	1024.74	(1.91)
208.60	1026.04	(0.61)
225.00	1026.44	(0.21)
239.00	1027.04	0.39
245.90	1027.54	0.89
256.50	1030.24	3.59
257.80	1030.31	3.66
261.70	1031.51	4.86
276.20	1030.54	3.89
292.80	1030.77	4.12
297.20	1031.07	4.42
305.10	1032.15	5.50
317.90	1032.83	6.18
358.20	1037.16	10.51
382.40	1038.24	11.59
392.10	1038.18	11.53
400.30	1038.09	11.44
415.30	1036.74	10.09

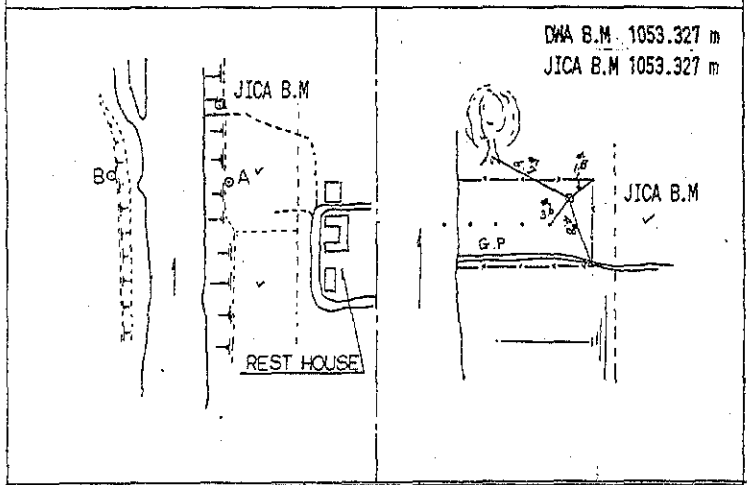
JICA B.M at L/B 1040.626 m



DESCRIPTION

STATION	1-650 Kabompo Boma

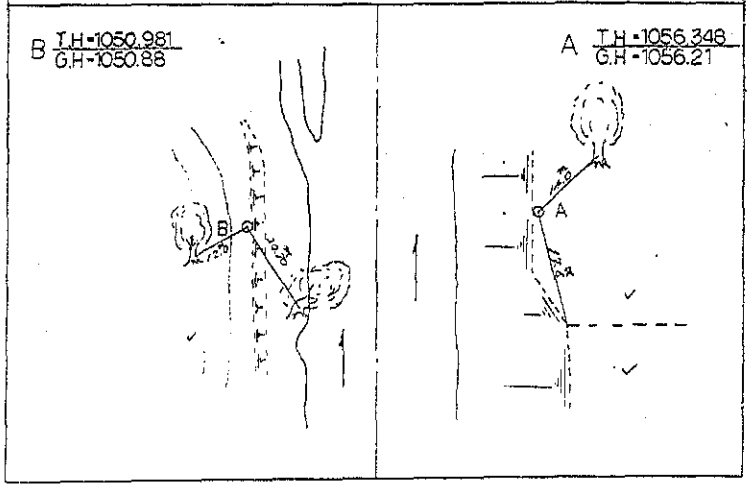
ROUGH SKETCH



ROUGH SKETCH

B I.H-1050.981 / G.H-1050.88

A I.H-1056.348 / G.H-1056.21



Location

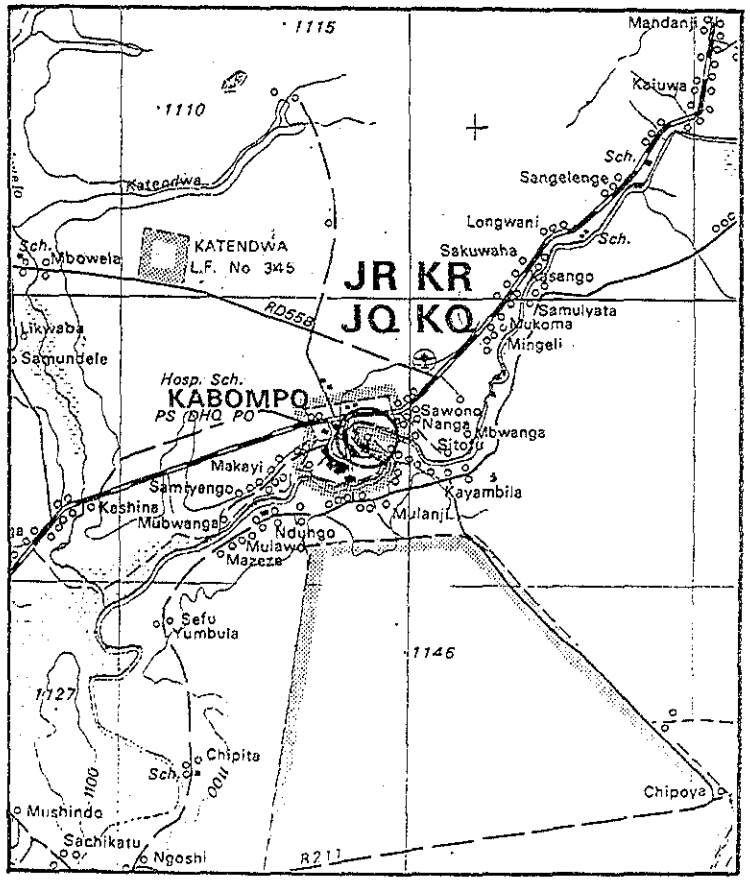
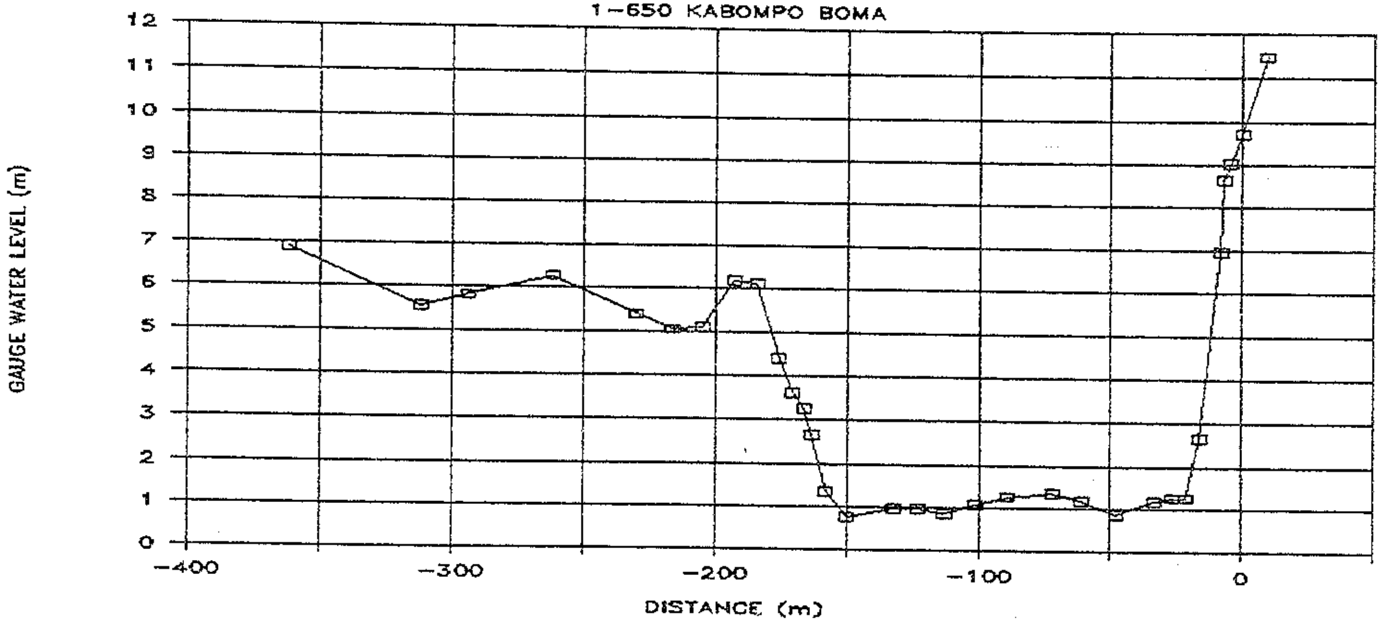


Fig.-1.3(2) Survey Result of St. 1-650 Kabompo Boma

CROSS SECTION at
1-650 KABOMPO BOMA



1-650 KABOMPO BOMA
CROSS SECTIONAL SURVEY DATA

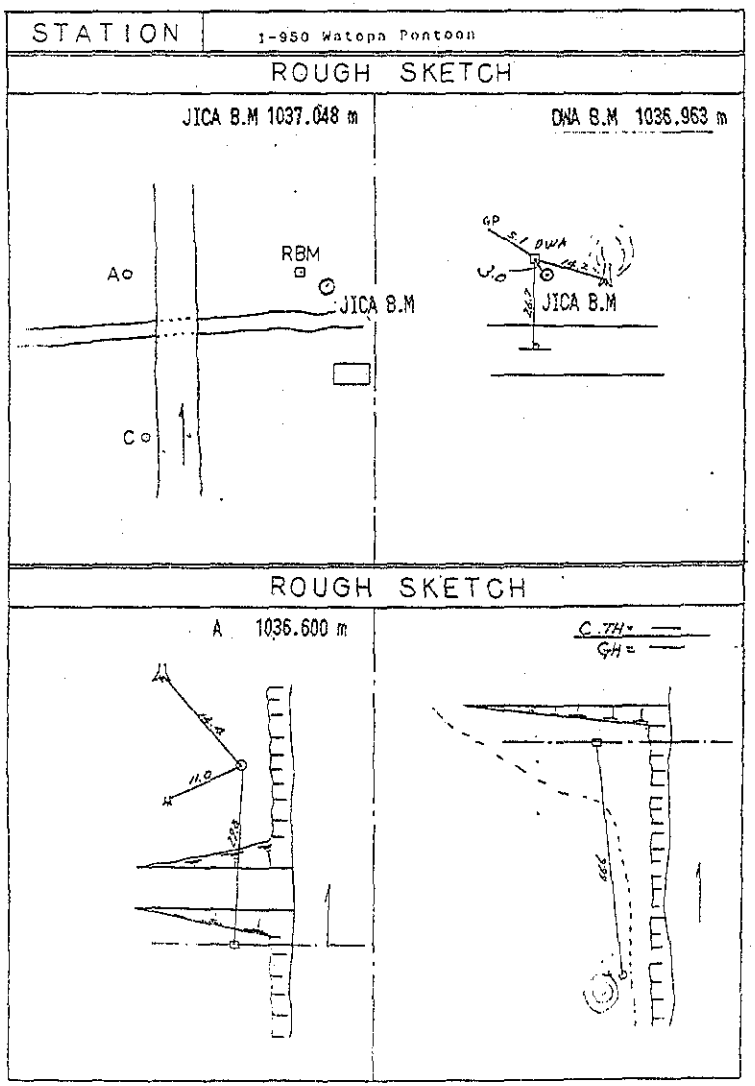
GAUGE PLATE ZERO (0) ELEVATION
1,046.50

Left Bank <-------- --------->Right Bank

X	Y	H
(361.90)	1053.39	6.89
(311.90)	1052.04	5.54
(293.90)	1052.32	5.82
(261.96)	1052.77	6.27
(229.90)	1051.89	5.39
(216.40)	1051.54	5.04
(204.90)	1051.59	5.09
(192.90)	1052.68	6.18
(184.40)	1052.61	6.11
(175.90)	1050.88	4.38
(170.90)	1050.11	3.61
(166.40)	1049.75	3.25
(163.50)	1049.17	2.67
(158.20)	1047.87	1.37
(150.10)	1047.27	0.77
(132.40)	1047.47	0.97
(123.20)	1047.47	0.97
(113.10)	1047.37	0.87
(101.30)	1047.57	1.07
(89.20)	1047.77	1.27
(72.00)	1047.87	1.37
(61.10)	1047.67	1.17
(47.80)	1047.37	0.87
(33.50)	1047.67	1.17
(26.30)	1047.77	1.27
(21.30)	1047.77	1.27
(16.20)	1049.17	2.67
(8.10)	1053.45	6.95
(7.10)	1055.15	8.65
(4.40)	1055.55	9.05
0.00	1056.21	9.71
9.30	1057.99	11.49

JICA B.M at R/B 1053.327 m

DESCRIPTION



Location

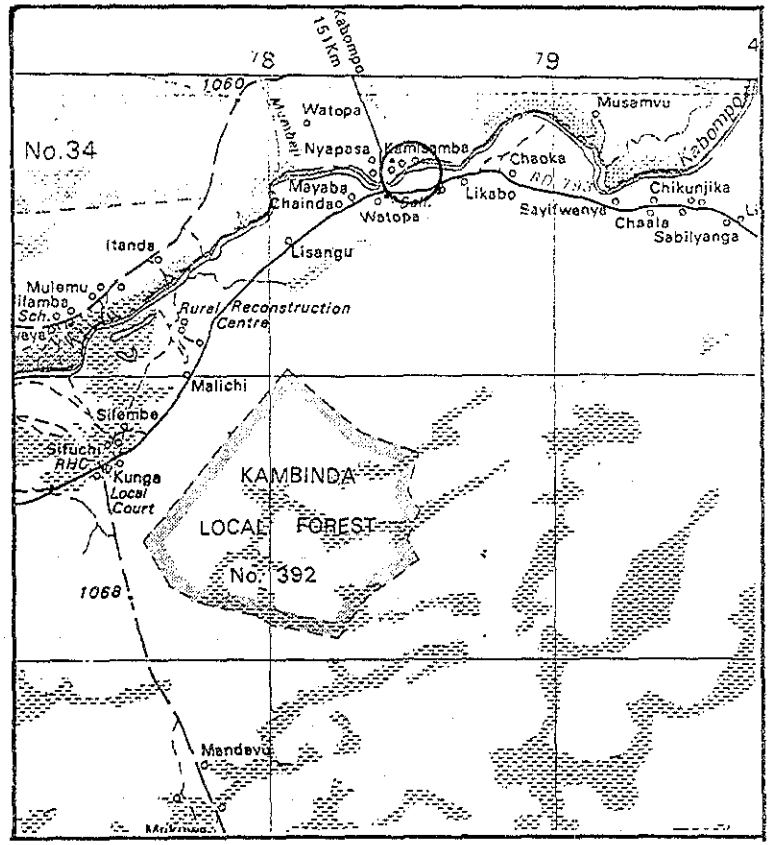


Fig.-1.3(3) Survey Result of St. 1-950 Watopa pontoon

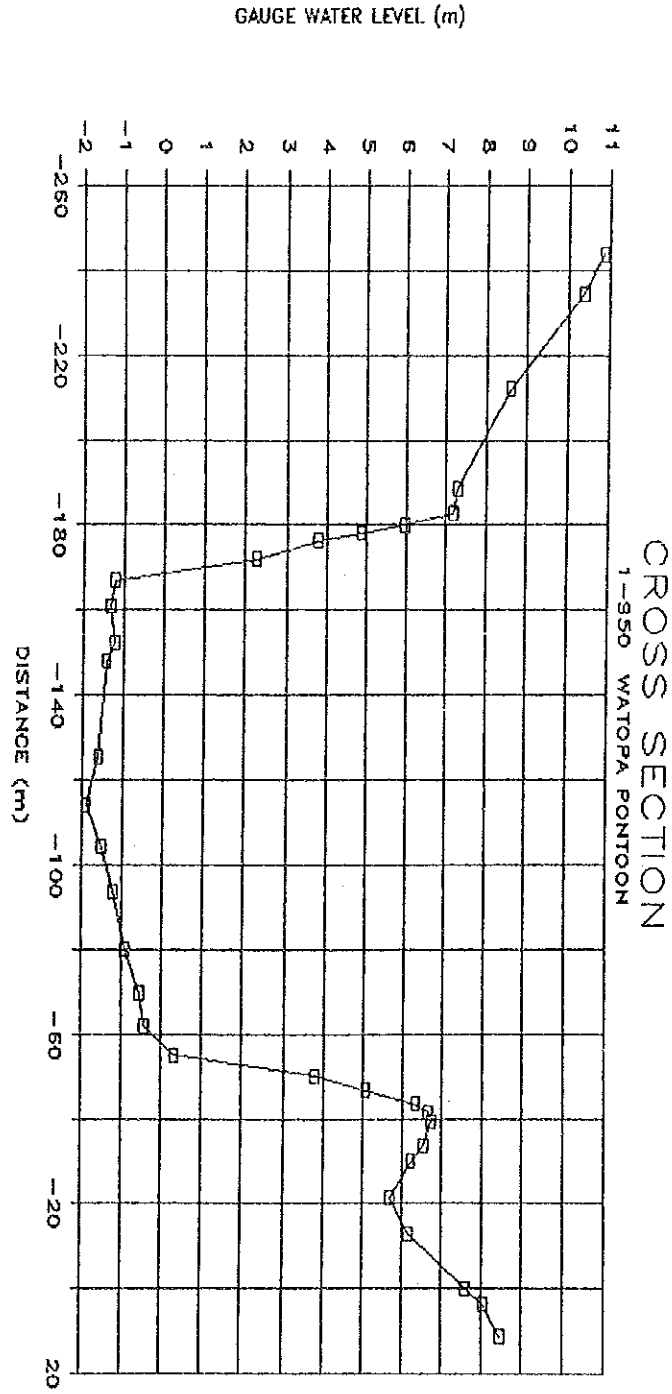
1-950 WATOPA PONTOON
CROSS SECTIONAL SURVEY DATA

GAUGE PLATE ZERO (0) ELEVATION 1,029.18

Left Bank <-------- ; -------->Right Bank

X	Y	H
(243.99)	1040.04	10.86
(234.61)	1039.55	10.37
(212.17)	1037.79	8.61
(188.69)	1036.46	7.28
(182.94)	1036.37	7.19
(180.24)	1035.13	5.95
(178.31)	1034.05	4.87
(176.48)	1032.96	3.78
(172.11)	1031.46	2.28
(167.03)	1027.96	(1.22)
(160.98)	1027.86	(1.32)
(152.52)	1027.96	(1.22)
(148.16)	1027.76	(1.42)
(125.55)	1027.56	(1.62)
(114.24)	1027.26	(1.92)
(104.53)	1027.66	(1.52)
(93.86)	1027.96	(1.22)
(80.36)	1028.26	(0.92)
(69.71)	1028.66	(0.52)
(61.92)	1028.76	(0.42)
(55.20)	1029.51	0.33
(50.20)	1032.96	3.78
(46.90)	1034.24	5.06
(43.60)	1035.50	6.32
(41.62)	1035.83	6.65
(39.60)	1035.90	6.72
(33.70)	1035.70	6.52
(30.00)	1035.39	6.21
(21.40)	1034.88	5.70
(13.00)	1035.34	6.16
0.00	1036.78	7.60
3.70	1037.24	8.06
11.30	1037.66	8.48

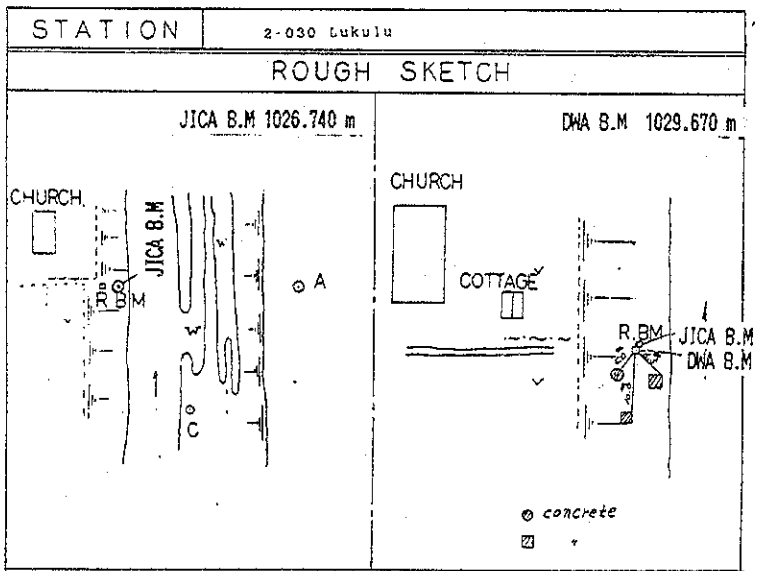
JICA B.M at R/B 1037.048 m



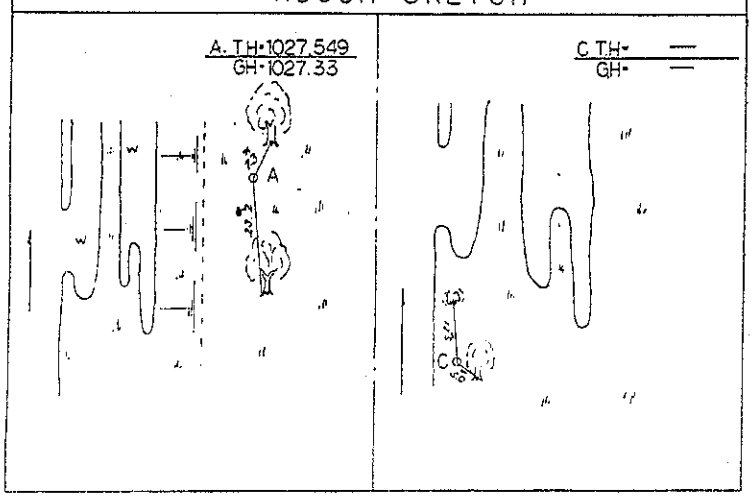
DESCRIPTION

STATION	2-030 Lukulu

ROUGH SKETCH



ROUGH SKETCH



Location

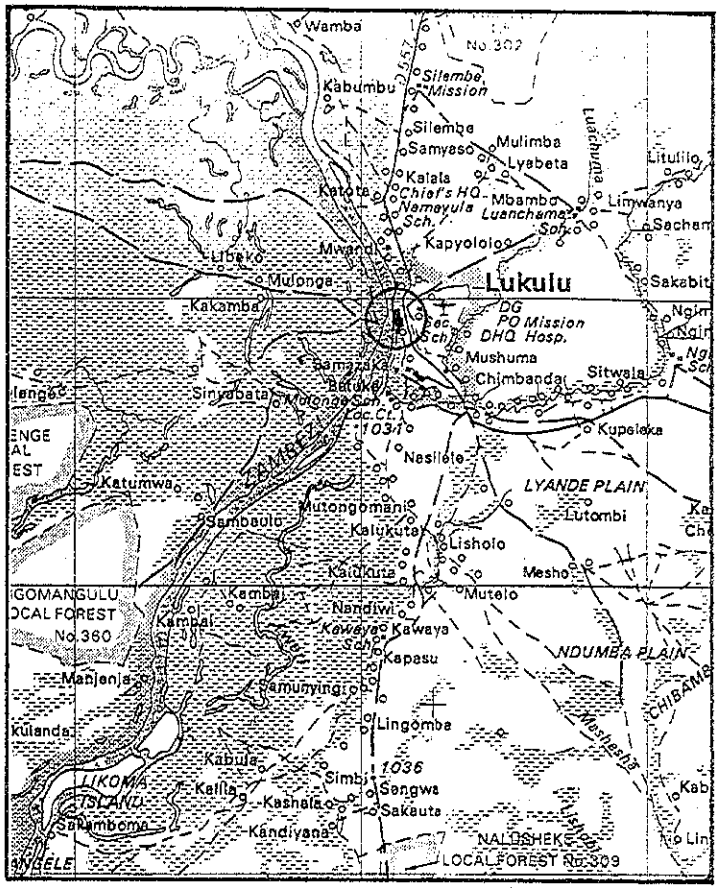


Fig.-1.3(4) Survey Result of St. 2-030 Lukulu

2-030 LUKULU
CROSS SECTIONAL SURVEY DATA

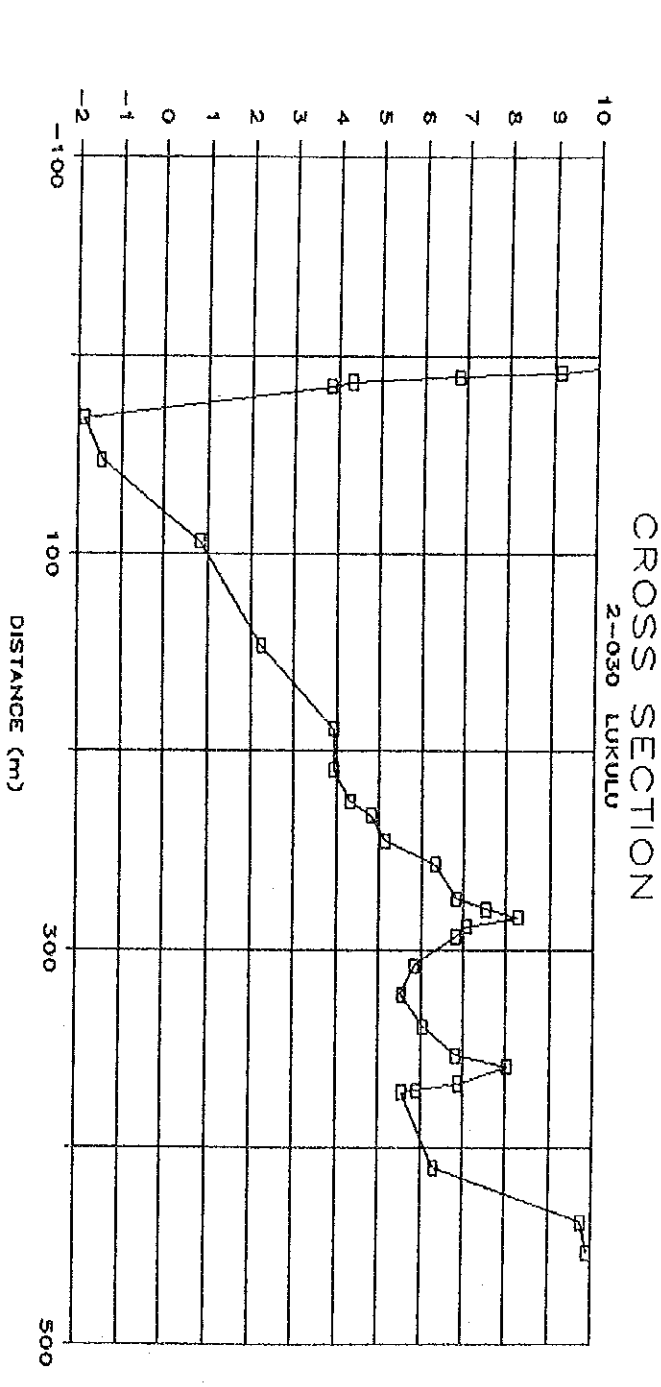
GAUGE PLATE ZERO (0) ELEVATION 1,017.44

X	Y	H
(39.00)	1038.13	20.69
(35.40)	1037.75	20.31
(25.00)	1036.09	18.65
(15.10)	1033.78	16.34
(6.00)	1031.69	14.25
0.00	1029.67	12.23
5.50	1028.09	10.65
8.40	1026.59	9.15
10.40	1024.26	6.82
13.40	1021.76	4.32
15.40	1021.26	3.82
31.62	1015.56	(1.88)
52.62	1015.96	(1.48)
93.87	1018.26	0.82
146.12	1019.66	2.22
188.92	1021.36	3.92
209.62	1021.36	3.92
225.42	1021.76	4.32
232.52	1022.26	4.82
245.22	1022.56	5.12
256.92	1023.76	6.32
274.52	1024.26	6.82
279.76	1024.96	7.52
283.95	1025.71	8.27
288.36	1024.49	7.05
293.56	1024.27	6.83
308.02	1023.27	5.83
322.52	1022.97	5.53
338.82	1023.47	6.03
353.32	1024.27	6.83
359.07	1025.44	8.00
367.68	1024.31	6.87
371.06	1023.34	5.90
372.22	1022.99	5.55
410.27	1023.74	6.30
437.91	1027.17	9.73
453.22	1027.33	9.89

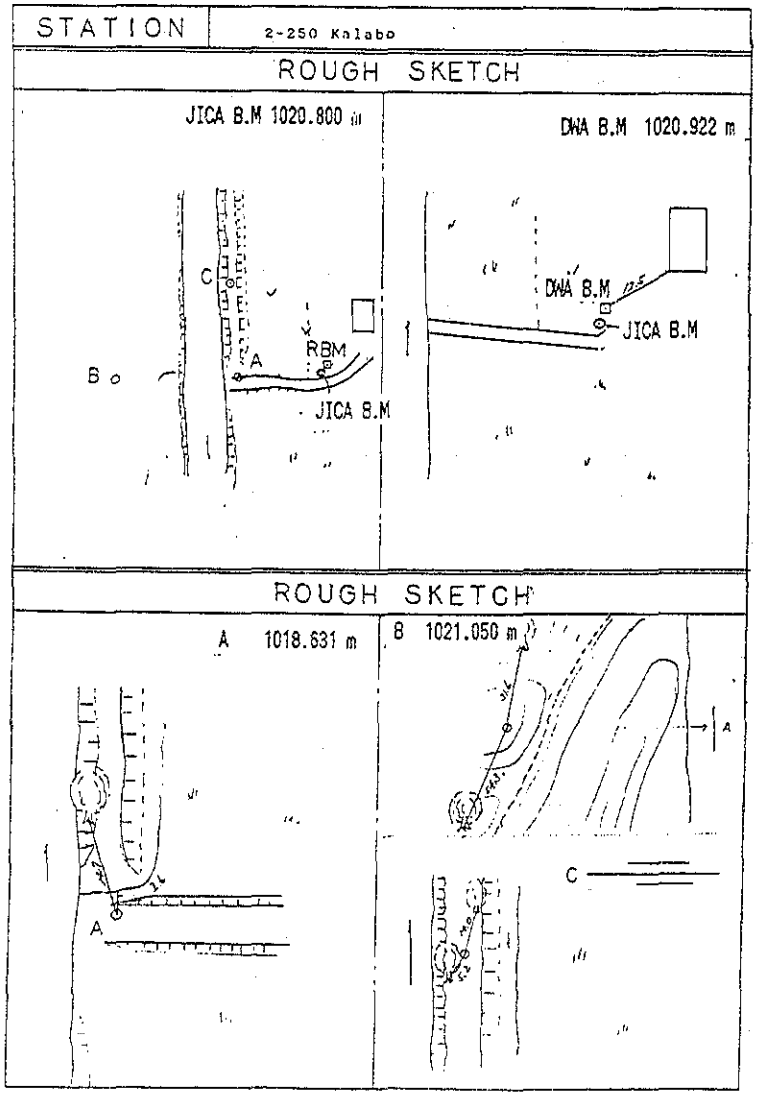
JICA B.M at L/B 1026.740 m

Left Bank <--------

-------->Right Bank



DESCRIPTION



Location

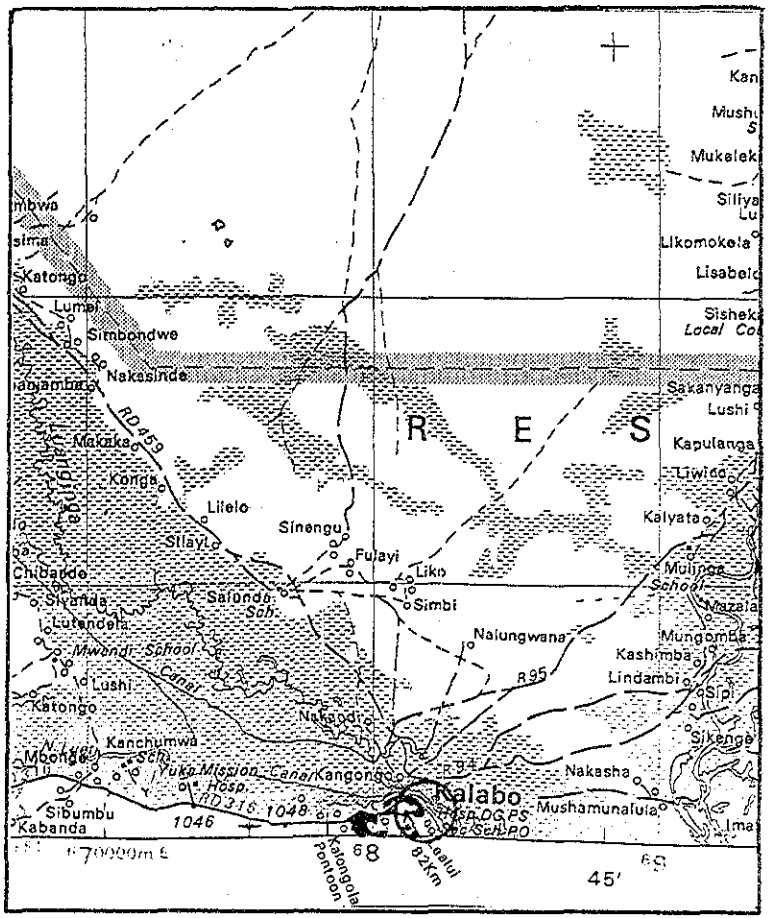


Fig.-1.3(5) Survey Result of St. 2-250 Kalabo

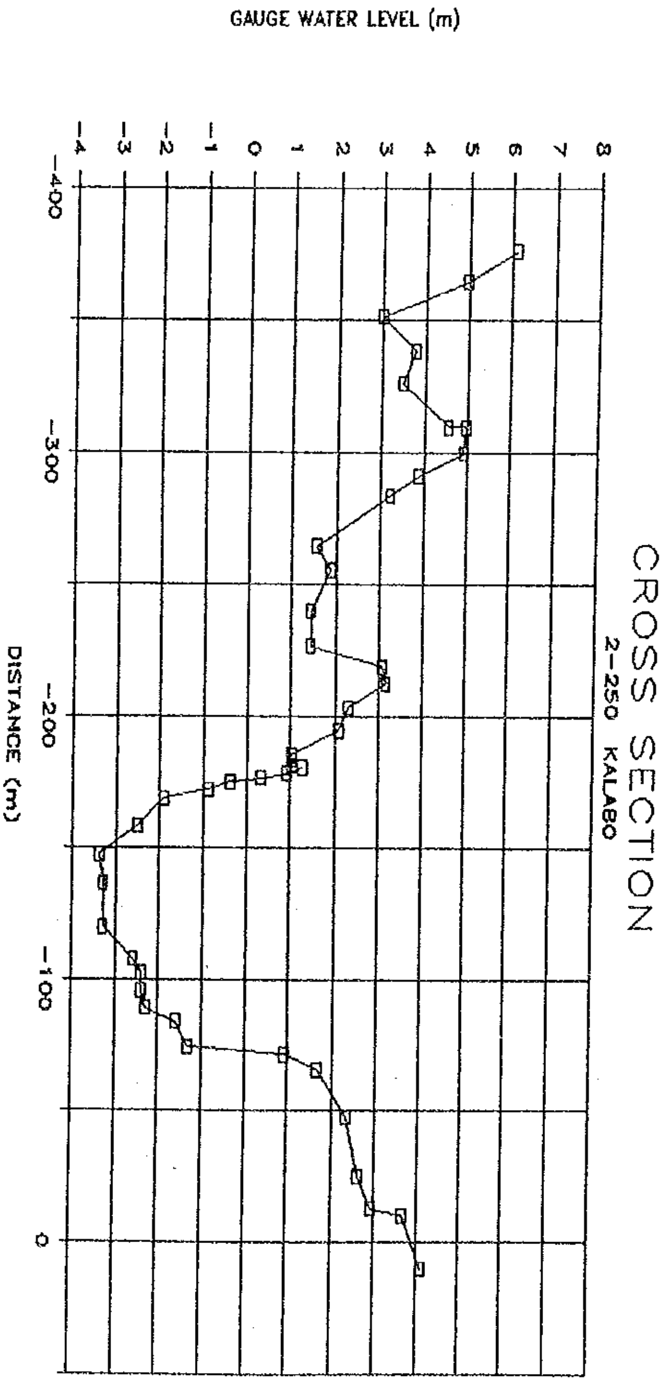
2-250 KALABO
CROSS SECTIONAL SURVEY DATA

GAUGE PLATE ZERO (0) ELEVATION
1,015.90

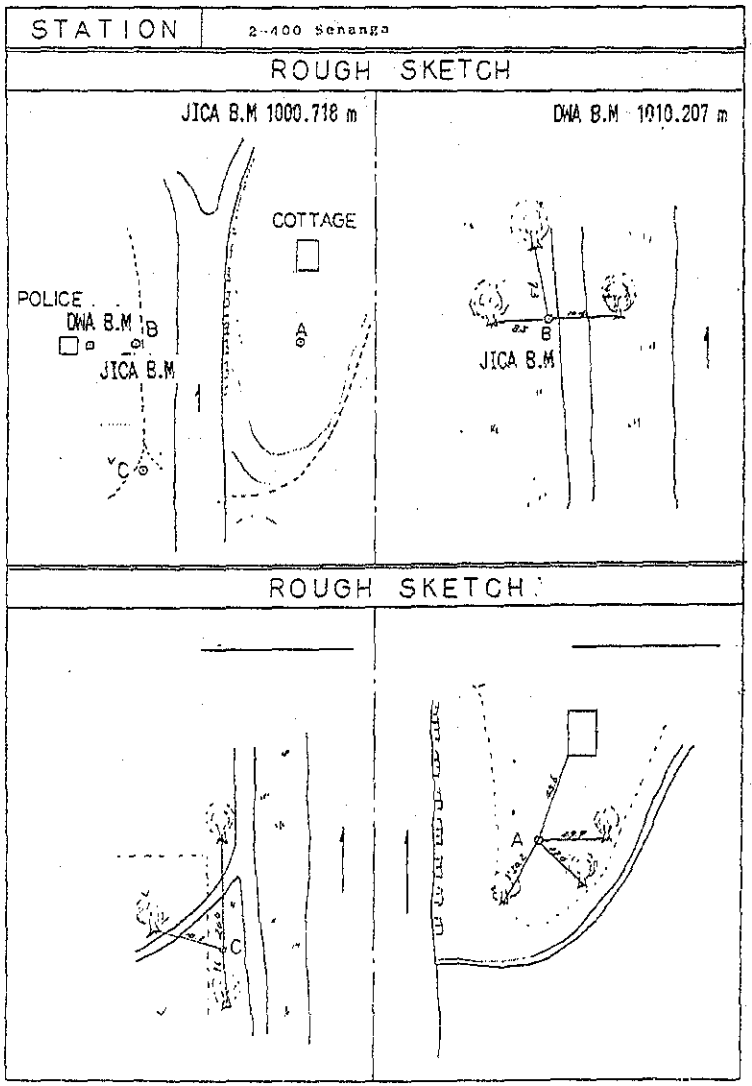
X	Y	H
(376.30)	1022.00	6.10
(376.30)	1020.87	4.97
(364.60)	1018.89	2.99
(351.30)	1019.68	3.78
(338.30)	1019.38	3.48
(326.10)	1020.46	4.56
(309.80)	1020.86	4.96
(309.60)	1020.81	4.91
(299.60)	1019.78	3.88
(290.90)	1019.13	3.23
(283.80)	1017.46	1.56
(264.50)	1017.78	1.88
(255.70)	1017.33	1.43
(239.90)	1017.33	1.43
(226.50)	1018.97	3.07
(218.80)	1019.05	3.15
(212.30)	1018.18	2.28
(203.20)	1017.98	2.08
(194.80)	1016.92	1.02
(185.40)	1016.91	1.01
(181.00)	1017.16	1.26
(180.35)	1016.81	0.91
(178.15)	1016.21	0.31
(176.35)	1015.51	(0.39)
(174.95)	1015.01	(0.89)
(172.25)	1014.01	(1.89)
(168.65)	1013.41	(2.49)
(158.35)	1012.51	(3.39)
(147.25)	1012.61	(3.29)
(136.35)	1012.61	(3.29)
(119.85)	1013.31	(2.59)
(107.75)	1013.51	(2.39)
(102.40)	1013.51	(2.39)
(95.35)	1013.61	(2.29)
(89.15)	1014.31	(1.59)
(83.85)	1014.61	(1.29)
(74.35)	1016.81	0.91
(71.45)	1017.55	1.65
(65.55)	1018.22	2.32
(47.90)	1018.50	2.60
(25.50)	1018.83	2.93
(13.00)	1019.57	3.67
(10.40)	1020.03	4.13
10.00	1021.25	5.35

Left Bank <---------
--------->Right Bank

JICA B.M at L/B 1020.795 m



DESCRIPTION



Location

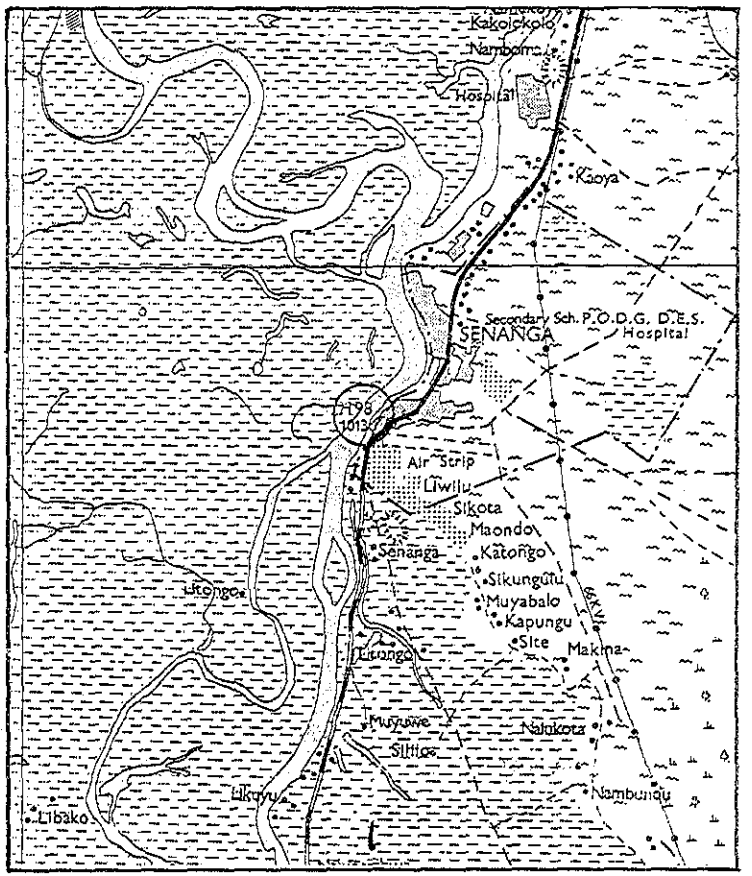


Fig.-1.3(6) Survey Result of St. 2-400 Senanga

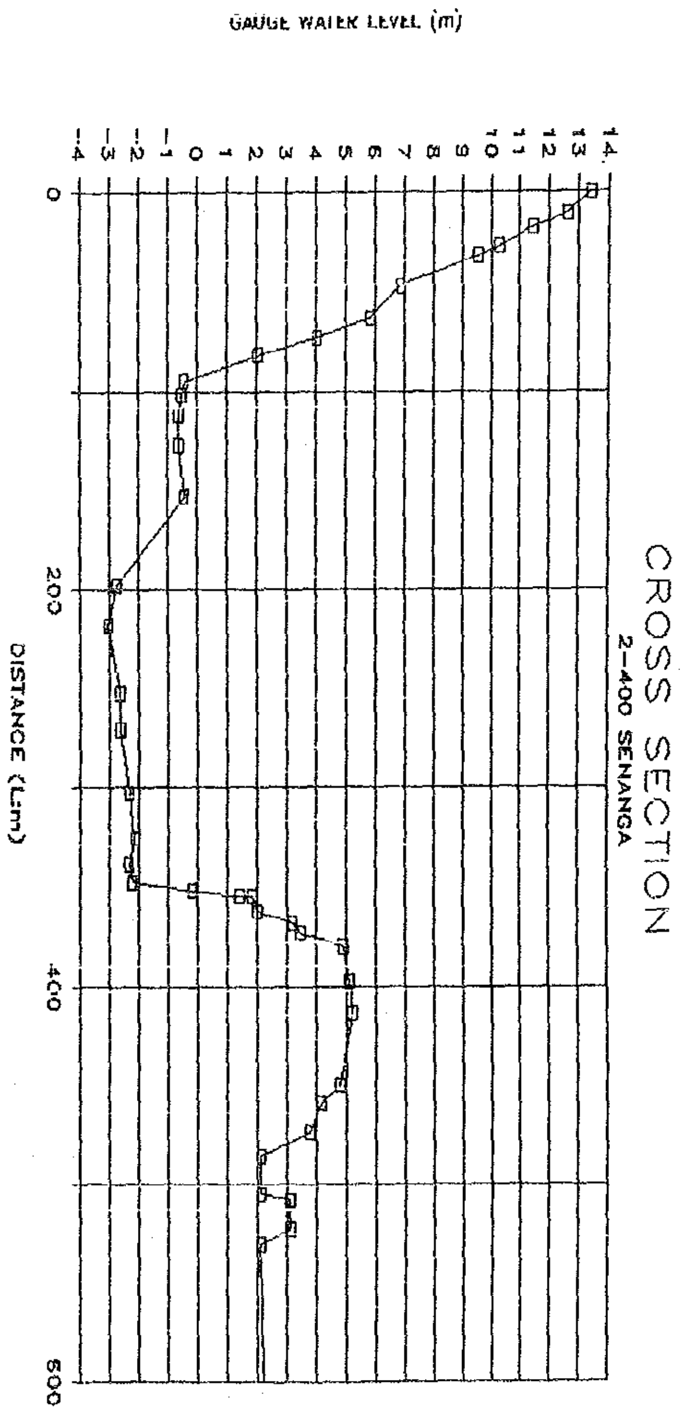
2-400 SENANGA
CROSS SECTIONAL SURVEY DATA

GAUGE PLATE ZERO (0) ELEVATION 996.79

X	Y	H
0.00	1010.21	13.42
10.50	1009.43	12.64
17.60	1008.24	11.45
27.00	1007.10	10.31
31.70	1006.36	9.57
46.50	1003.67	6.88
62.80	1002.63	5.84
72.80	1000.83	4.04
81.70	998.84	2.05
94.90	996.34	(0.45)
101.80	996.24	(0.55)
111.30	996.14	(0.65)
126.70	996.14	(0.65)
152.90	996.34	(0.45)
198.00	994.04	(2.75)
218.40	993.74	(3.05)
252.50	994.14	(2.65)
271.00	994.14	(2.65)
302.40	994.44	(2.35)
325.50	994.64	(2.15)
338.50	994.44	(2.35)
347.60	994.54	(2.25)
351.70	996.59	(0.20)
354.70	998.19	1.40
354.70	998.63	1.84
362.30	998.81	2.02
368.00	999.98	3.19
373.30	1000.28	3.49
379.70	1001.70	4.91
397.50	1001.90	5.11
413.60	1002.00	5.21
450.00	1001.58	4.79
459.20	1000.94	4.15
473.80	1000.59	3.80
485.80	998.92	2.13
505.00	998.92	2.13
508.00	999.92	3.13
523.00	999.92	3.13
530.00	998.92	2.13
662.60	999.04	2.25
688.00	999.14	2.35
1850.00	999.50	2.71
1950.00	1002.03	5.24

Left Bank <-------- --------->Right Bank

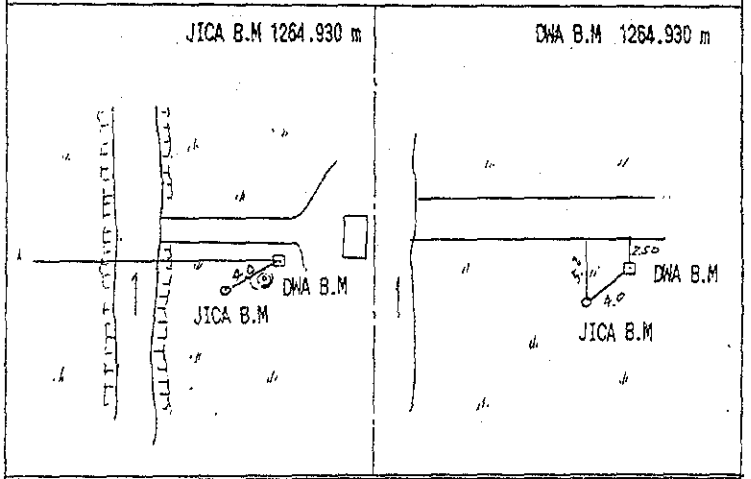
JICA B.M at L/B 1000.718 m



DESCRIPTION

STATION	4-050 Raglam Farm

ROUGH SKETCH



ROUGH SKETCH

Location

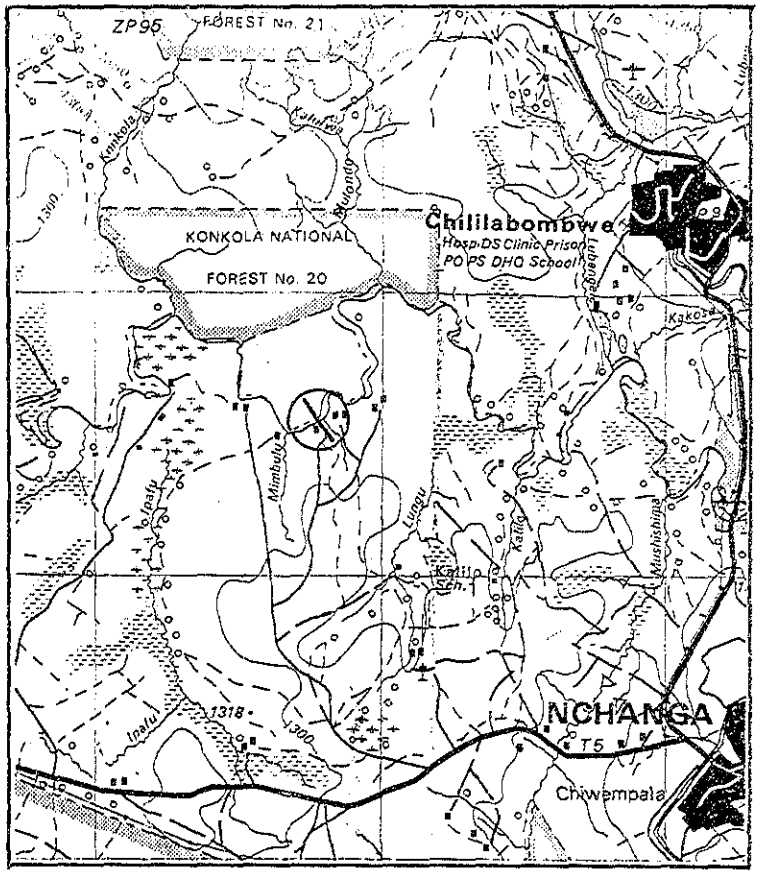


Fig.-1.3(7) Survey Result of St. 4-050 Raglam Farm

4-050 RAGLAM FARM
CROSS SECTIONAL SURVEY DATA

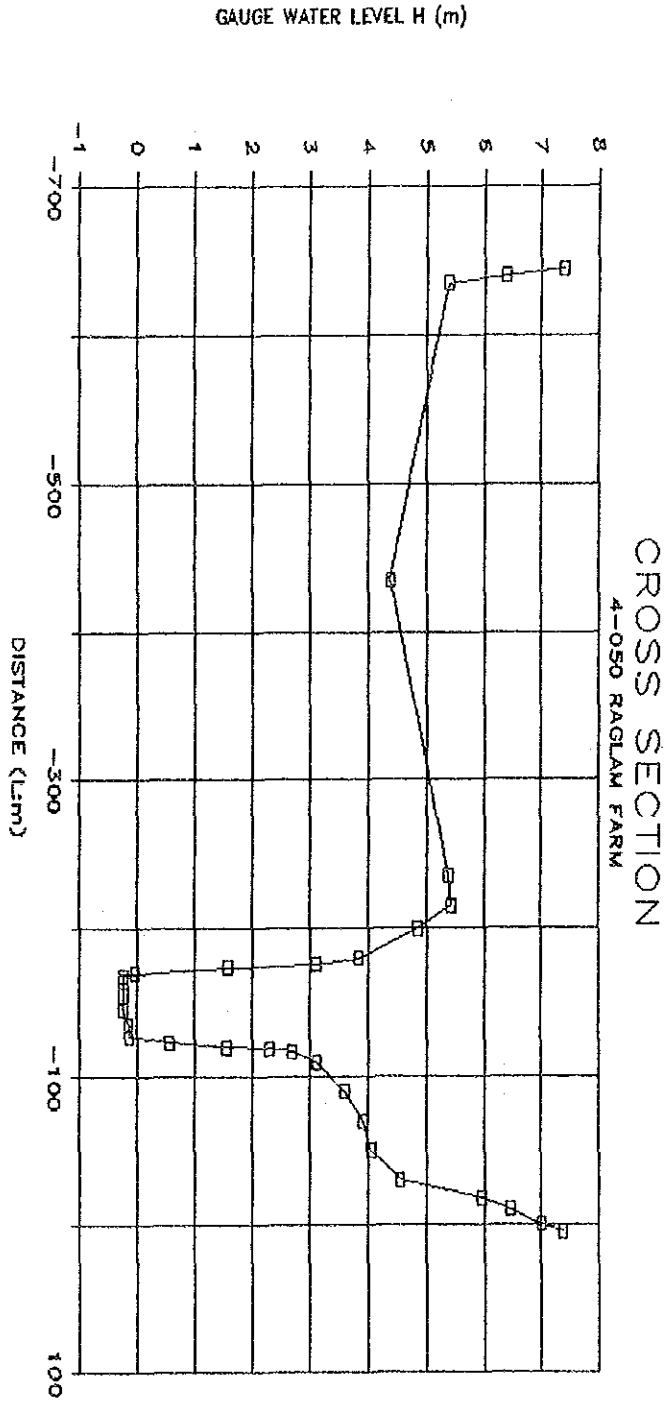
GAUGE PLATE ZERO (0) ELEVATION 1,257.92

X	Y	H
5.00	1265.30	7.38
0.00	1264.93	7.01
(10.00)	1264.38	6.46
(17.50)	1263.88	5.96
(30.00)	1262.47	4.55
(50.00)	1261.98	4.06
(70.00)	1261.85	3.93
(89.70)	1261.54	3.62
(110.00)	1261.04	3.12
(117.00)	1260.61	2.69
(119.00)	1260.21	2.29
(120.00)	1259.47	1.55
(123.00)	1258.47	0.55
(127.50)	1257.77	(0.15)
(135.00)	1257.77	(0.15)
(145.00)	1257.67	(0.25)
(155.00)	1257.67	(0.25)
(165.00)	1257.67	(0.25)
(168.00)	1257.67	(0.25)
(170.00)	1257.87	(0.05)
(173.50)	1259.49	1.57
(176.00)	1261.03	3.11
(180.00)	1261.76	3.84
(200.00)	1262.77	4.85
(215.00)	1263.36	5.44
(235.00)	1263.31	5.39
(435.00)	1262.31	4.39
(635.00)	1263.31	5.39
(640.00)	1264.31	6.39
(645.00)	1265.31	7.39

JICA B.M at R/B 1264.962 m

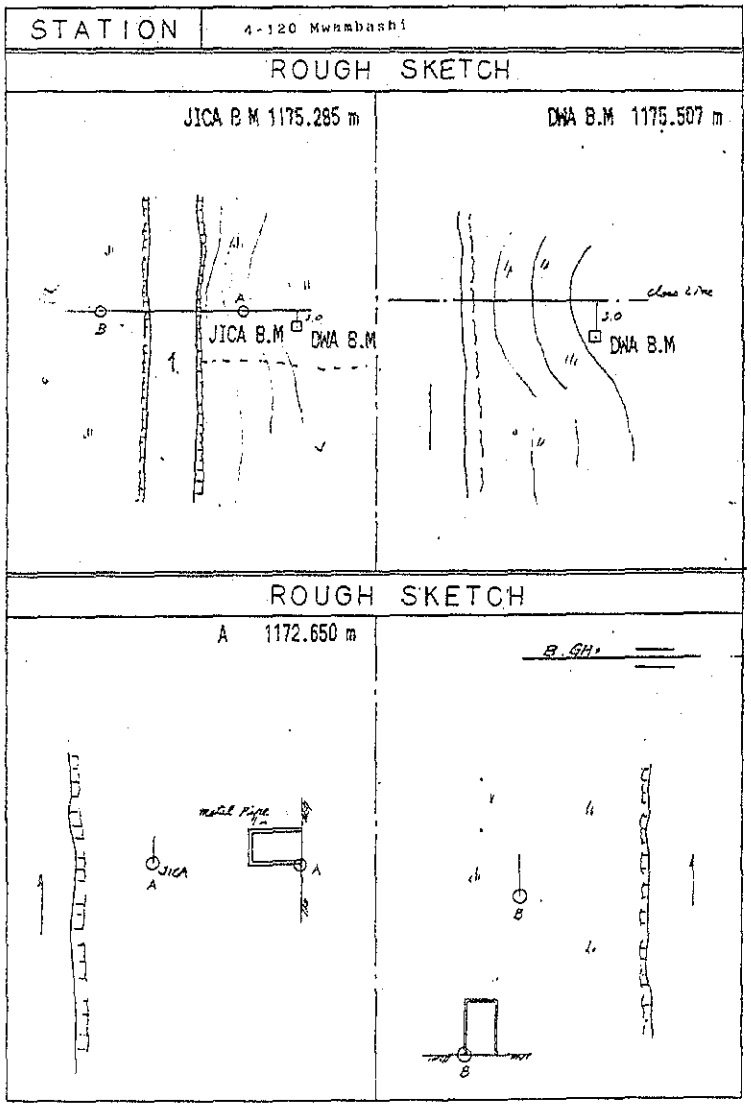
Left Bank <--------

-------->Right Bank



CROSS SECTION
4-050 RAGLAM FARM

DESCRIPTION



Location

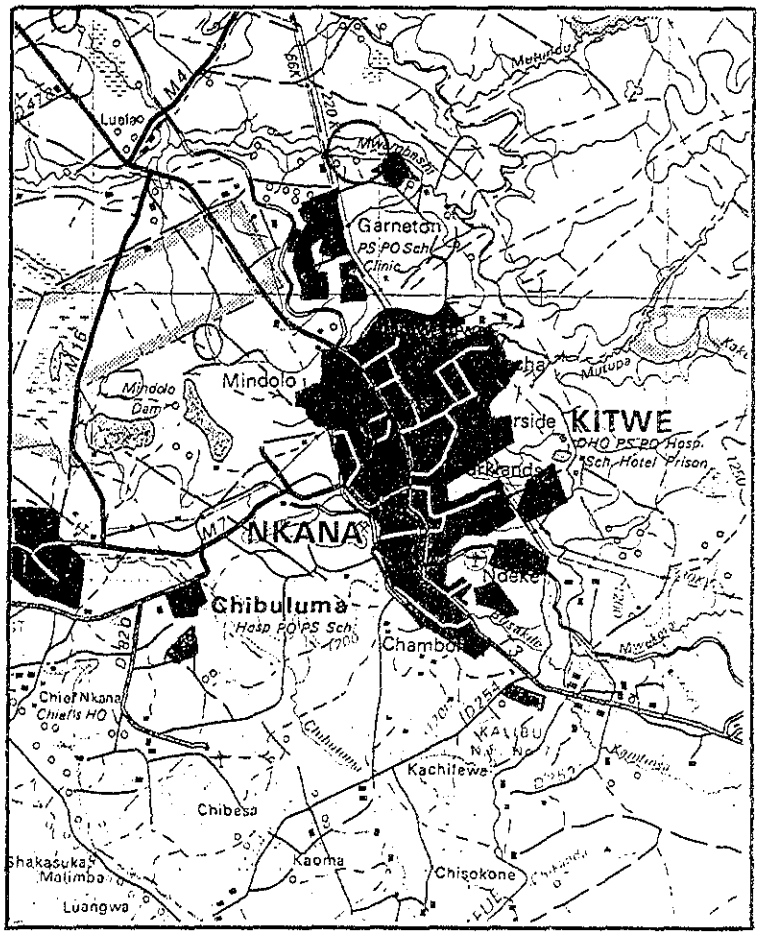
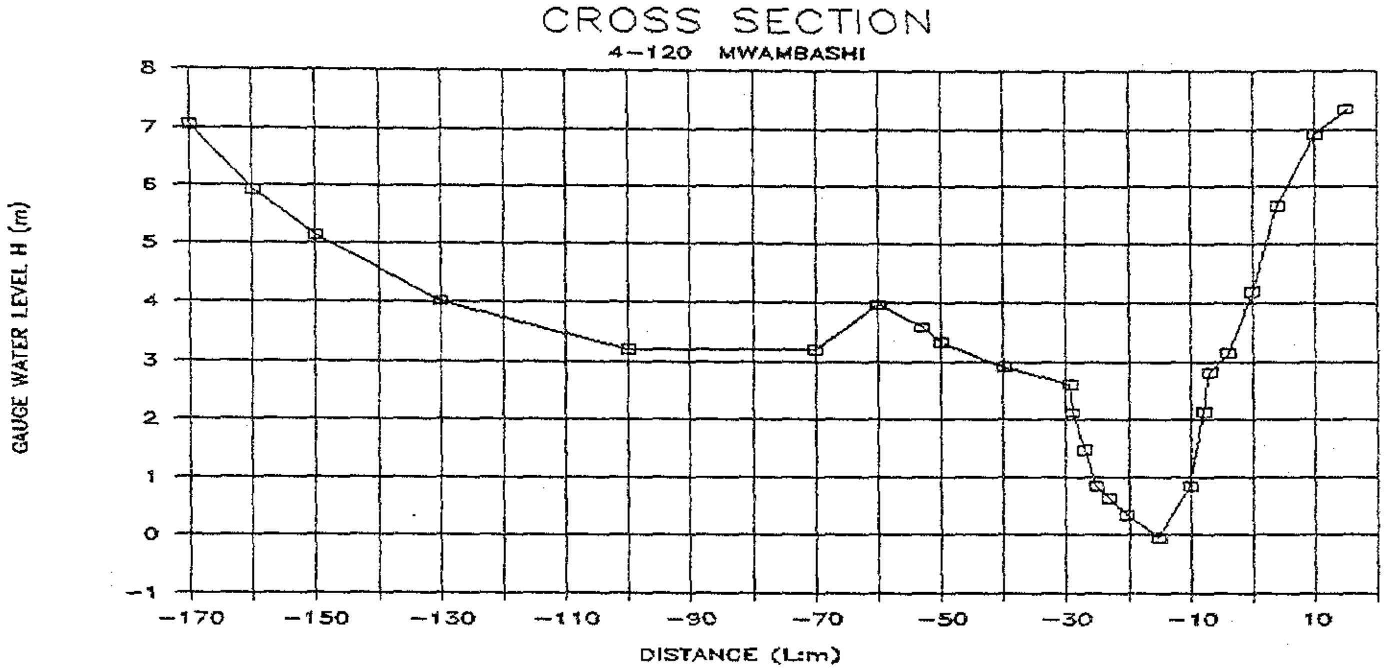


Fig.-1.3(8) Survey Result of St. 4-120 Mwambashi



4-120 MWAMBASHI
CROSS SECTIONAL SURVEY DATA

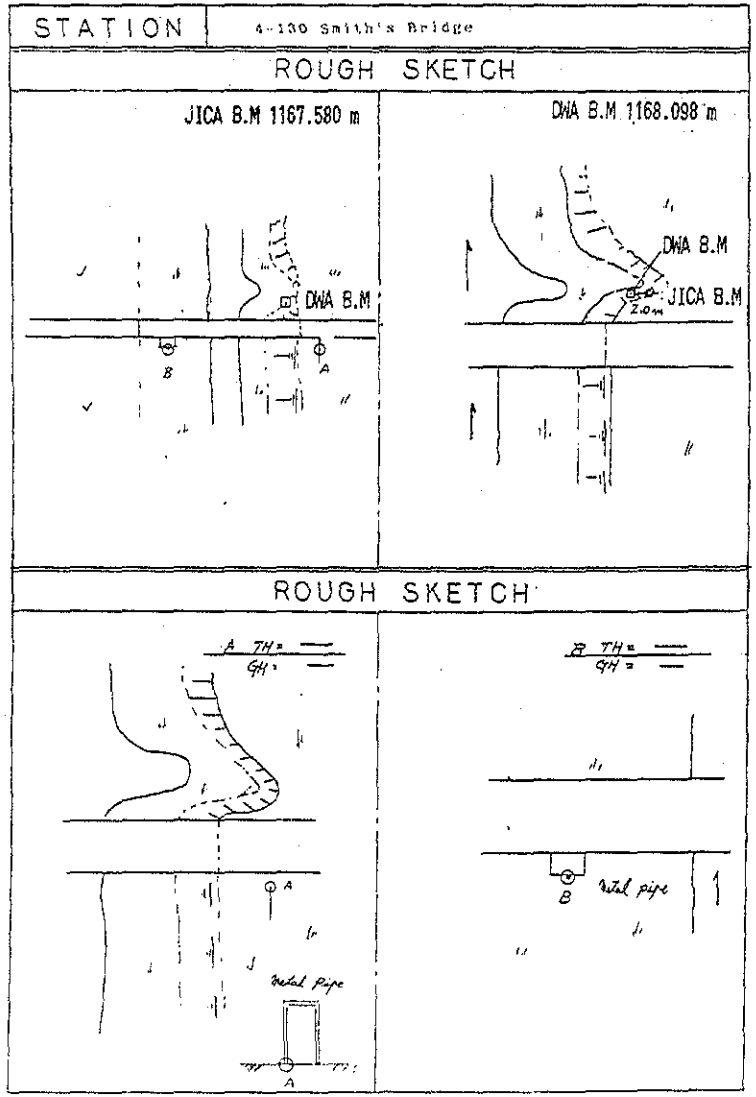
GAUGE PLATE ZERO (0) ELEVATION
1,168.46

Left Bank <-------- -------->Right Bank

X	Y	
(170.00)	1175.50	7.04
(160.00)	1174.40	5.94
(150.00)	1173.60	5.14
(130.00)	1172.48	4.02
(100.00)	1171.68	3.22
(70.00)	1171.68	3.22
(60.00)	1172.43	3.97
(53.00)	1172.06	3.60
(50.00)	1171.81	3.35
(40.00)	1171.38	2.92
(29.40)	1171.06	2.60
(29.00)	1170.58	2.12
(27.00)	1169.94	1.48
(25.20)	1169.29	0.83
(23.20)	1169.09	0.63
(20.20)	1168.79	0.33
(15.20)	1168.39	(0.07)
(10.20)	1169.29	0.83
(8.00)	1170.59	2.13
(7.00)	1171.28	2.82
(4.00)	1171.63	3.17
0.00	1172.65	4.19
4.00	1174.14	5.68
10.00	1175.38	6.92
15.00	1175.81	7.35

JICA B.M at R/B 1175.285 m

DESCRIPTION



Location

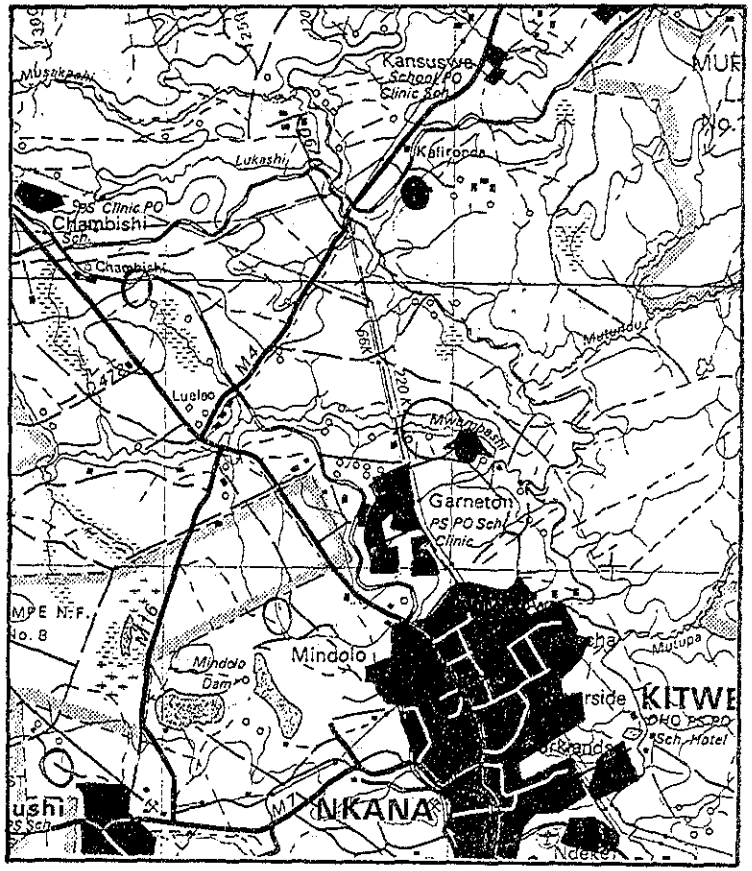


Fig.-1.3(9) Survey Result of St. 4-130 Smith's Bridge

4-130 SMITH'S BRIDGE
CROSS SECTIONAL SURVEY DATA

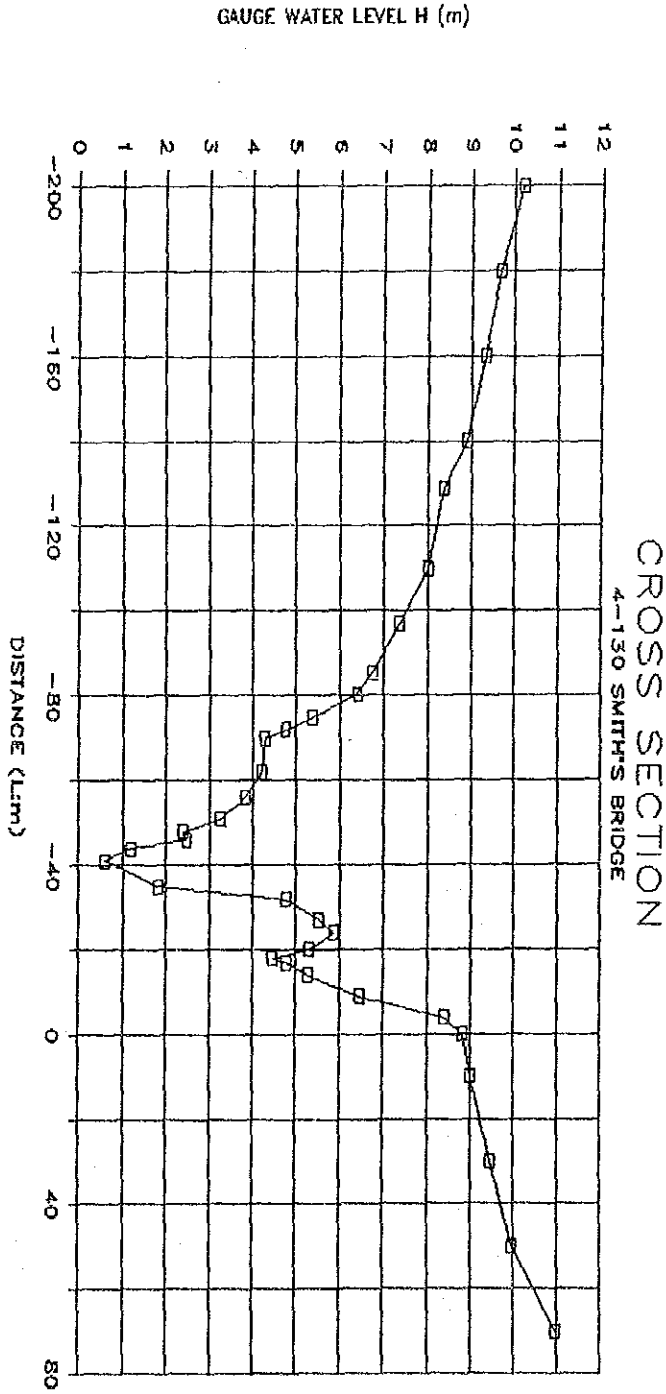
GAUGE PLATE ZERO (0) ELEVATION 1,161.04

X	Y	H
(200.00)	1171.24	10.20
(180.00)	1170.72	9.68
(160.00)	1170.35	9.31
(140.00)	1169.93	8.89
(129.00)	1169.40	8.36
(110.00)	1169.06	8.02
(97.00)	1168.39	7.35
(85.50)	1167.78	6.74
(80.50)	1167.45	6.41
(75.00)	1166.42	5.38
(72.00)	1165.80	4.76
(70.00)	1165.32	4.28
(62.00)	1165.26	4.22
(56.00)	1164.87	3.83
(51.00)	1164.31	3.27
(48.00)	1163.41	2.37
(46.00)	1163.51	2.47
(44.00)	1162.21	1.17
(41.00)	1161.61	0.57
(35.00)	1162.86	1.82
(32.00)	1165.81	4.77
(27.00)	1166.55	5.51
(24.00)	1166.90	5.86
(20.00)	1166.34	5.30
(18.00)	1165.49	4.45
(17.00)	1165.82	4.78
(14.00)	1166.32	5.28
(9.00)	1167.51	6.47
(4.00)	1169.44	8.40
0.00	1169.87	8.83
10.00	1170.03	8.99
30.00	1170.50	9.46
50.00	1171.00	9.96
70.00	1172.00	10.96

JICA B.M at R/B 1167.580 m

Left Bank <--------

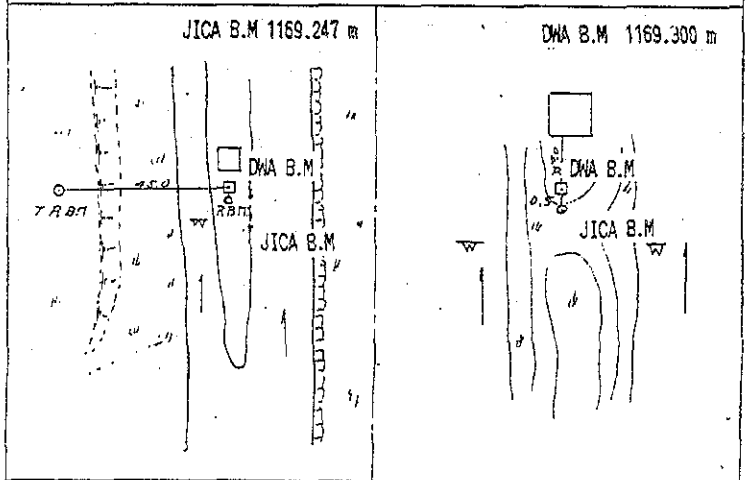
-------->Right Bank



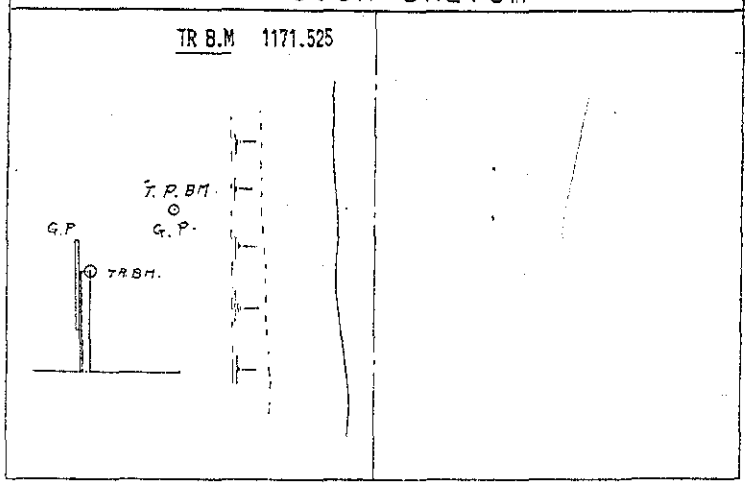
DESCRIPTION

STATION	4-200 Mpatamato

ROUGH SKETCH



ROUGH SKETCH



Location

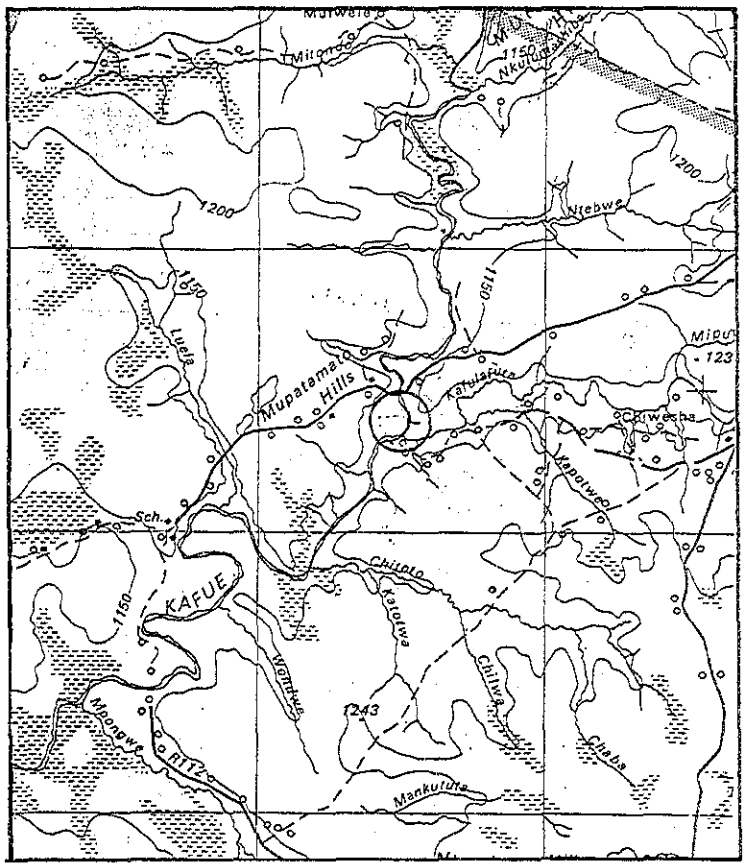


Fig.-1.3(10) Survey Result of St. 4-200 Mpatamato

4-200 MPATAMATO
CROSS SECTIONAL SURVEY DATA

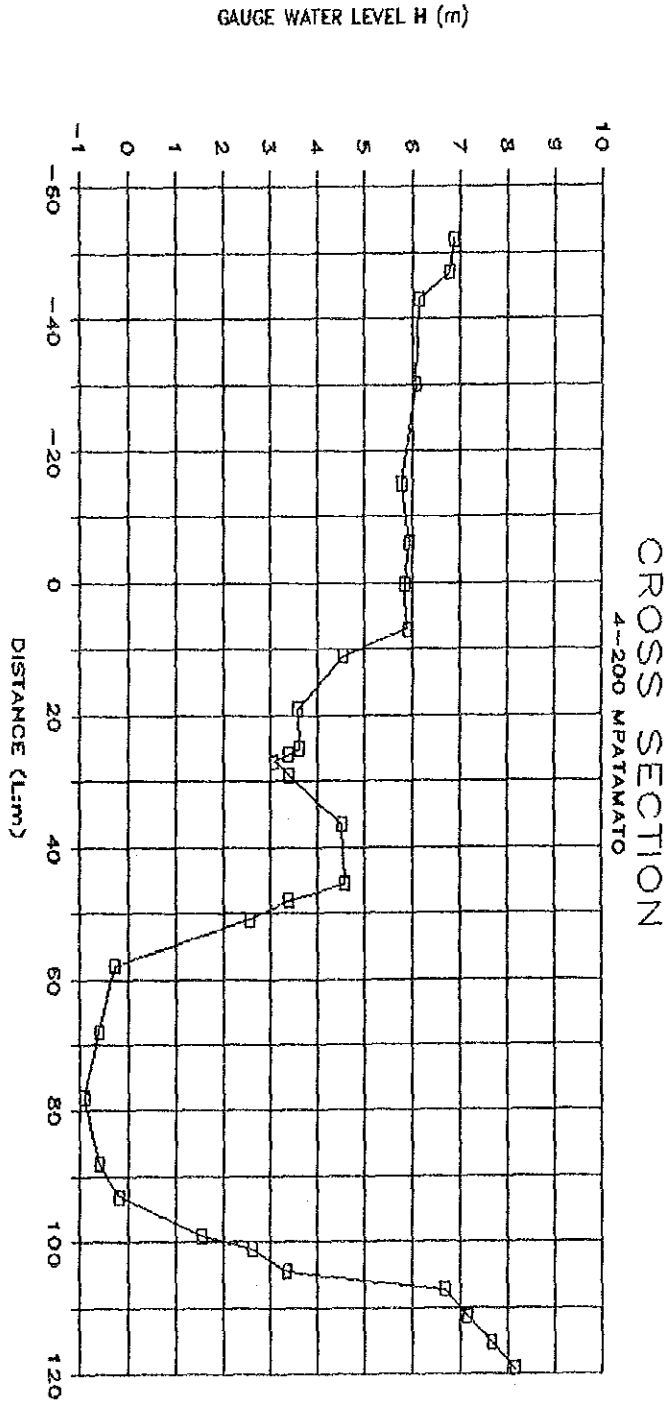
GAUGE PLATE ZERO (0) ELEVATION 1,164.18

X	Y	H
(52.00)	1171.05	6.87
(47.00)	1170.95	6.77
(43.00)	1170.31	6.13
(30.00)	1170.25	6.07
(15.00)	1169.95	5.77
(6.00)	1170.11	5.93
0.00	1170.00	5.82
7.00	1170.06	5.88
11.00	1168.72	4.54
19.00	1167.74	3.56
25.00	1167.79	3.61
26.00	1167.56	3.38
27.00	1167.25	3.07
29.00	1167.56	3.38
36.50	1168.69	4.51
45.50	1168.75	4.57
48.00	1167.57	3.39
51.00	1166.72	2.54
58.00	1163.87	(0.31)
68.00	1163.57	(0.61)
78.00	1163.27	(0.91)
88.00	1163.57	(0.61)
93.00	1163.97	(0.21)
99.00	1165.72	1.54
101.00	1166.77	2.59
104.50	1167.54	3.36
107.20	1170.84	6.66
111.20	1171.34	7.16
115.20	1171.84	7.66
119.20	1172.34	8.16

JICA B.M at L/B 1169.247 m

Left Bank <--------

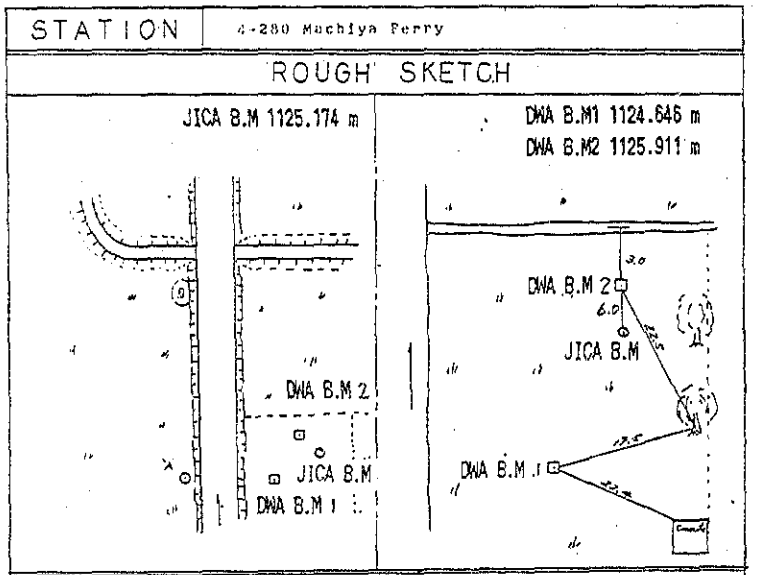
--------->Right Bank



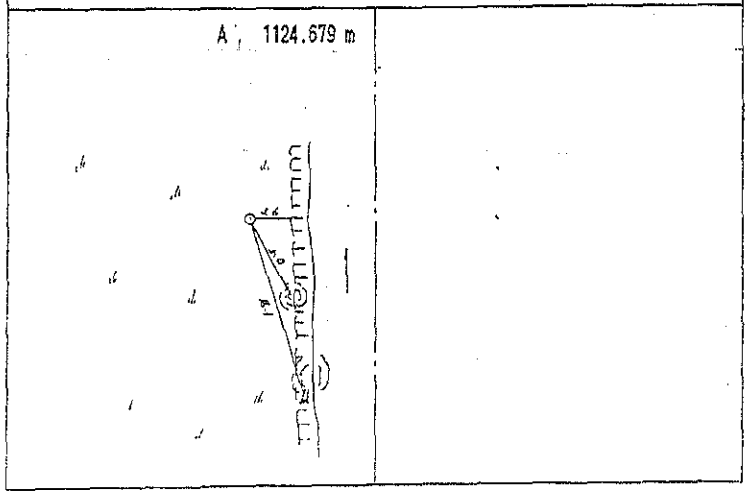
DESCRIPTION

STATION	4-280 Machiya Ferry

ROUGH SKETCH



ROUGH SKETCH



Location

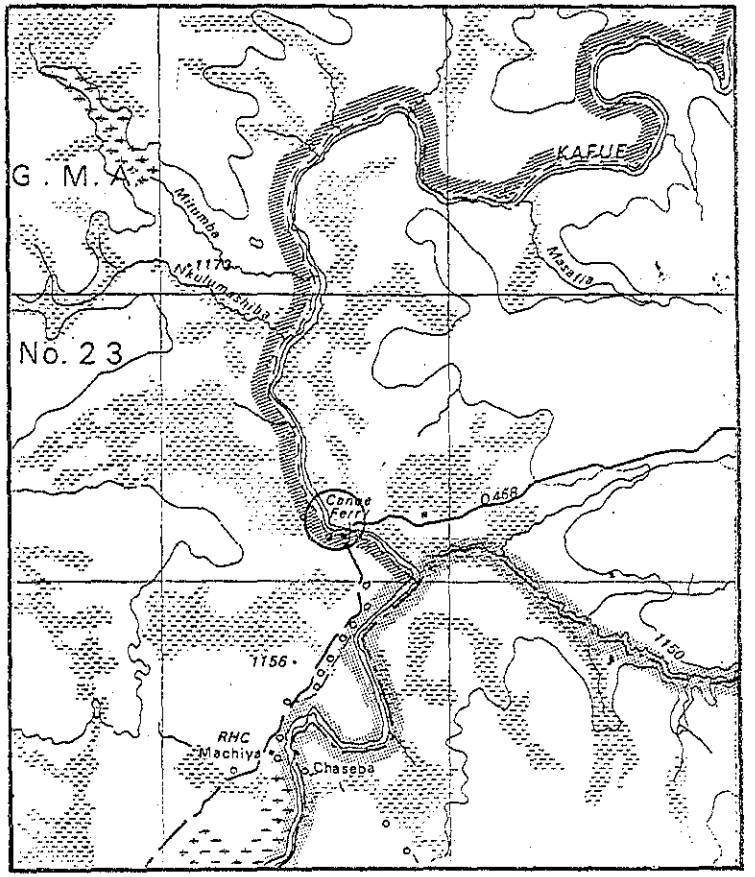


Fig.-1.3(11) Survey Result of st. 4-280 Machiya Ferry

4-280 MACHIYA FERRY
CROSS SECTIONAL SURVEY DATA

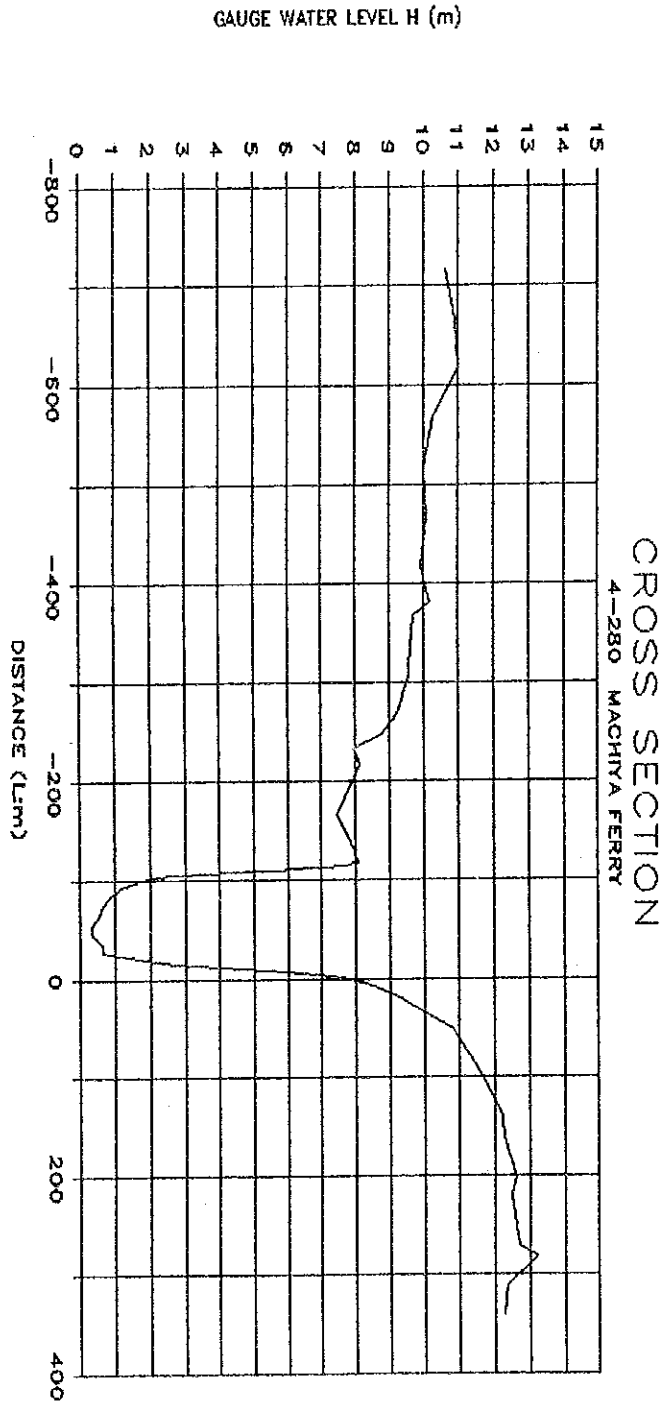
GAUGE PLATE ZERO (0) ELEVATION
1,116.61

X	Y	H
(717.16)	1127.25	10.64
(667.16)	1127.53	10.92
(617.16)	1127.58	10.97
(567.16)	1126.87	10.26
(517.16)	1126.65	10.04
(467.16)	1126.73	10.12
(417.16)	1126.54	9.93
(382.16)	1126.81	10.20
(367.16)	1126.32	9.71
(317.16)	1126.18	9.57
(307.16)	1126.20	9.59
(267.16)	1125.85	9.24
(247.16)	1125.36	8.75
(234.16)	1124.58	7.97
(217.16)	1124.74	8.13
(167.16)	1124.07	7.46
(142.16)	1124.45	7.84
(117.16)	1124.68	8.07
(117.16)	1124.56	7.95
(113.96)	1124.32	7.71
(112.36)	1123.56	6.95
(111.16)	1122.54	5.93
(110.50)	1122.55	5.94
(109.90)	1121.71	5.10
(103.70)	1118.65	2.04
(93.80)	1117.80	1.19
(84.00)	1117.45	0.84
(73.90)	1117.25	0.64
(65.20)	1117.15	0.54
(55.00)	1116.95	0.34
(44.70)	1116.95	0.34
(35.30)	1117.25	0.64
(27.00)	1117.25	0.64
(15.50)	1119.30	2.69
(9.00)	1121.95	5.34
(6.50)	1122.55	5.94
(3.00)	1123.95	7.34
0.00	1124.43	7.82
4.60	1124.91	8.30
17.00	1125.81	9.20
51.40	1127.44	10.83
102.00	1128.30	11.69
140.00	1128.81	12.20
162.00	1128.89	12.28
202.00	1129.21	12.60
220.00	1129.09	12.48
270.00	1129.32	12.71
282.00	1129.82	13.21
310.00	1128.96	12.35
340.00	1128.87	12.26

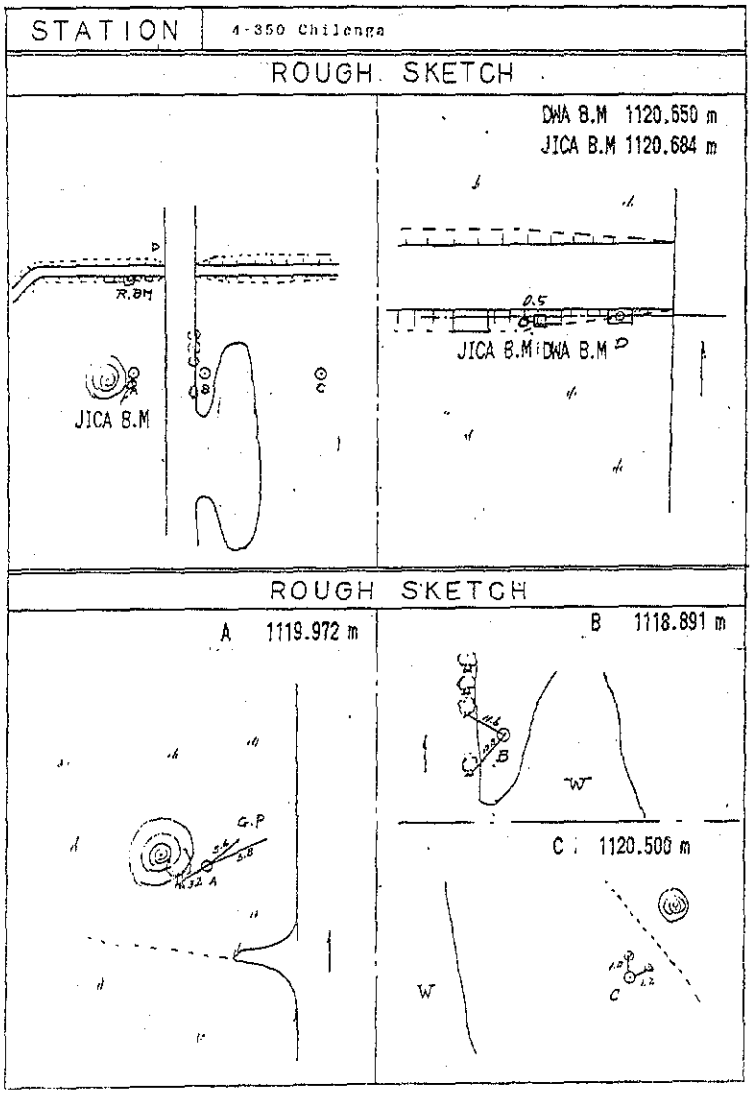
Left Bank <--------

--------->Right Bank

JICA B.M at R/B 1125.174 m



DESCRIPTION



Location

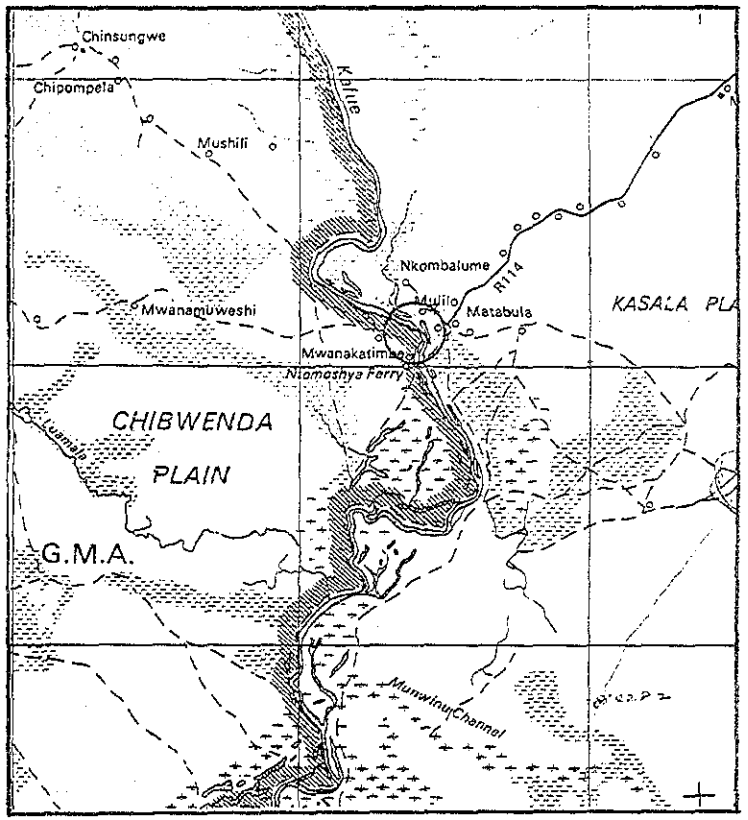


Fig.-1.3(12) Survey Result of St. 4-350 Chilenga

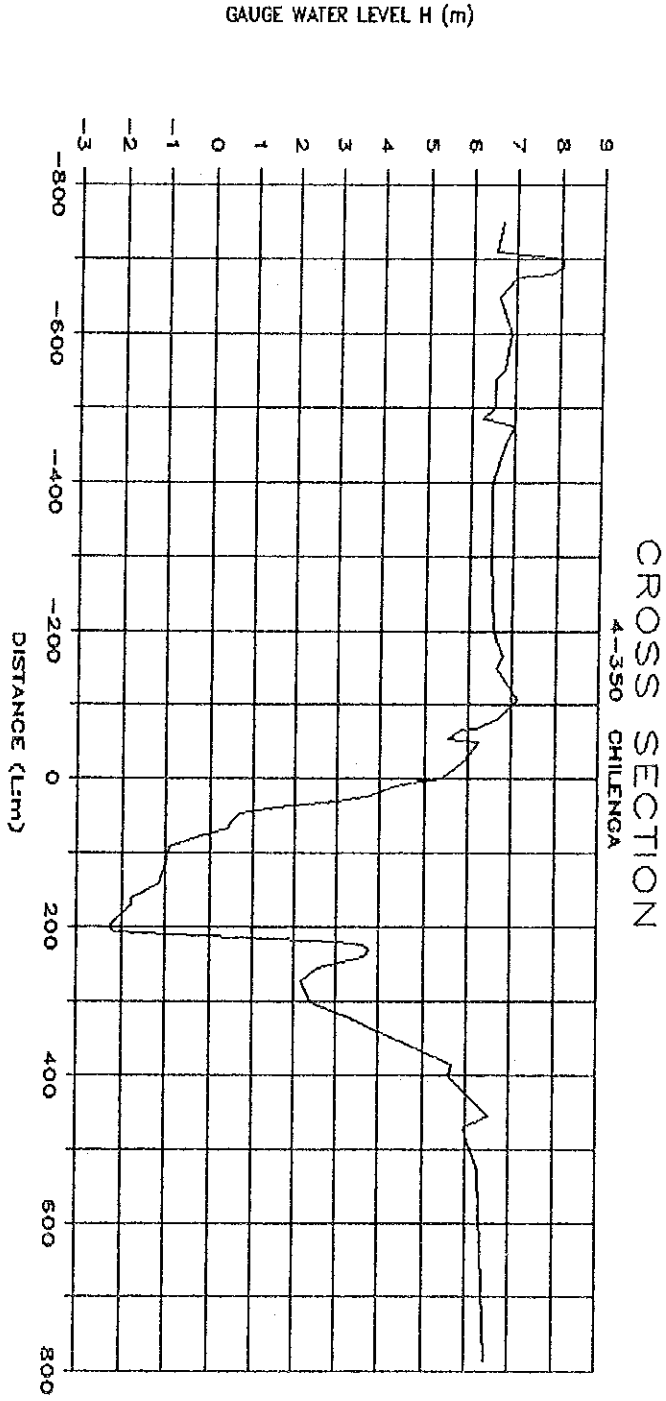
4-350 CHILENGA
CROSS SECTIONAL SURVEY DATA

GAUGE PLATE ZERO (0) ELEVATION 1,114.41

X	Y	H
(750.00)	1121.09	6.68
(710.00)	1120.93	6.52
(700.00)	1122.44	8.03
(690.00)	1122.47	8.06
(680.00)	1122.20	7.79
(675.00)	1121.38	6.97
(650.00)	1121.00	6.59
(600.00)	1121.31	6.90
(550.00)	1121.14	6.73
(540.00)	1120.93	6.52
(500.00)	1120.94	6.53
(485.00)	1120.66	6.25
(475.00)	1121.41	7.00
(450.00)	1121.20	6.79
(400.00)	1120.91	6.50
(350.00)	1120.90	6.49
(300.00)	1120.89	6.48
(250.00)	1120.95	6.54
(200.00)	1120.98	6.57
(165.00)	1121.17	6.76
(150.00)	1121.06	6.65
(108.00)	1121.53	7.12
(80.00)	1121.10	6.69
(69.00)	1120.60	6.19
(67.00)	1120.25	5.84
(55.00)	1119.96	5.55
(50.00)	1120.65	6.24
(23.50)	1120.29	5.88
0.00	1119.80	5.39
7.00	1118.91	4.50
23.50	1118.07	3.66
30.10	1117.42	3.01
38.00	1115.93	1.52
47.00	1115.10	0.69
57.30	1114.92	0.51
66.90	1114.81	0.40
76.00	1114.20	(0.21)
91.30	1113.49	(0.92)
108.20	1113.43	(0.98)
120.60	1113.38	(1.03)
140.40	1113.28	(1.13)
161.30	1112.63	(1.78)
168.70	1112.63	(1.78)
181.40	1112.43	(1.98)
196.20	1112.18	(2.23)
201.30	1112.18	(2.23)
206.10	1112.23	(2.18)
210.70	1113.53	(0.88)
212.50	1114.28	(0.13)
218.20	1116.73	2.32
220.80	1117.47	3.06
223.25	1118.04	3.63
230.85	1118.19	3.78
239.85	1118.06	3.65
255.85	1116.95	2.54
273.85	1116.57	2.16
302.85	1116.82	2.41
319.85	1117.68	3.27
341.14	1118.39	3.98
385.14	1120.09	5.68
402.14	1120.02	5.61
455.14	1120.93	6.52
470.14	1120.39	5.98
481.14	1120.42	6.01
530.14	1120.70	6.29
585.14	1120.73	6.32
635.14	1120.76	6.35
685.14	1120.80	6.39
735.14	1120.84	6.43
785.14	1120.88	6.47

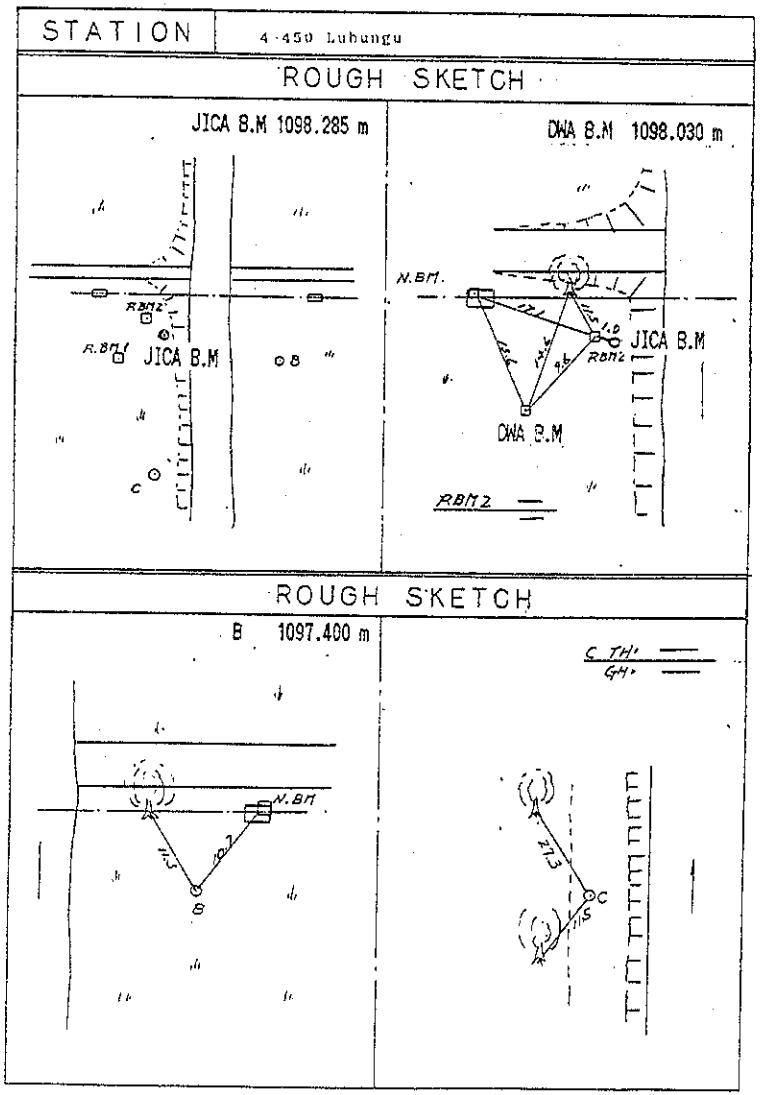
Left Bank <--------

---------->Right Bank



JICA B.M at L/B 1120.684 m

DESCRIPTION



Location

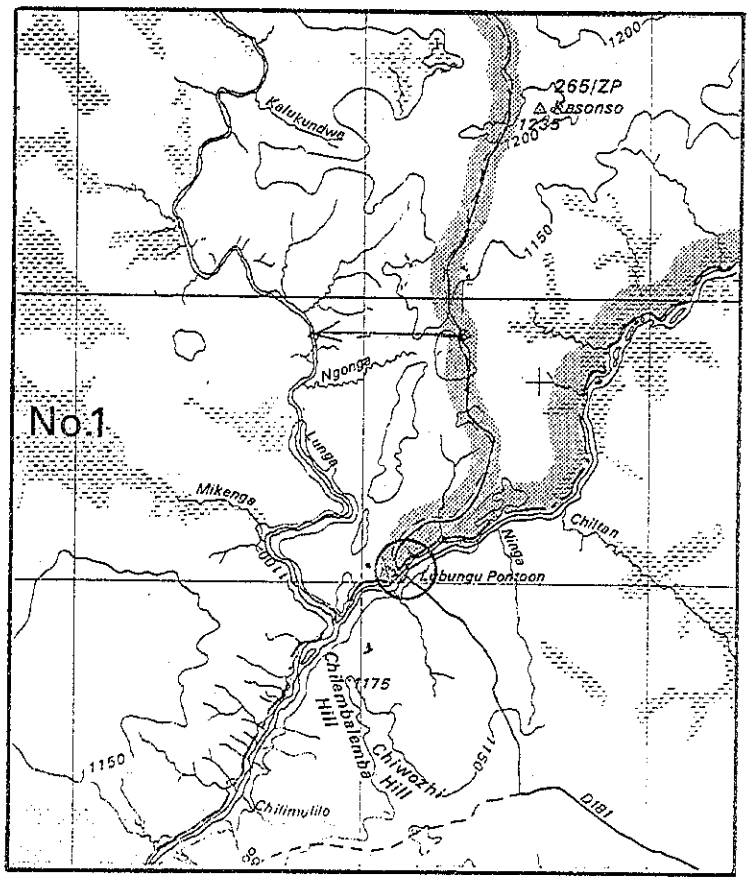


Fig.-1.3(13) Survey Result of St. 4-450 Lubungu

4-450 LUBUNGU
CROSS SECTIONAL SURVEY DATA

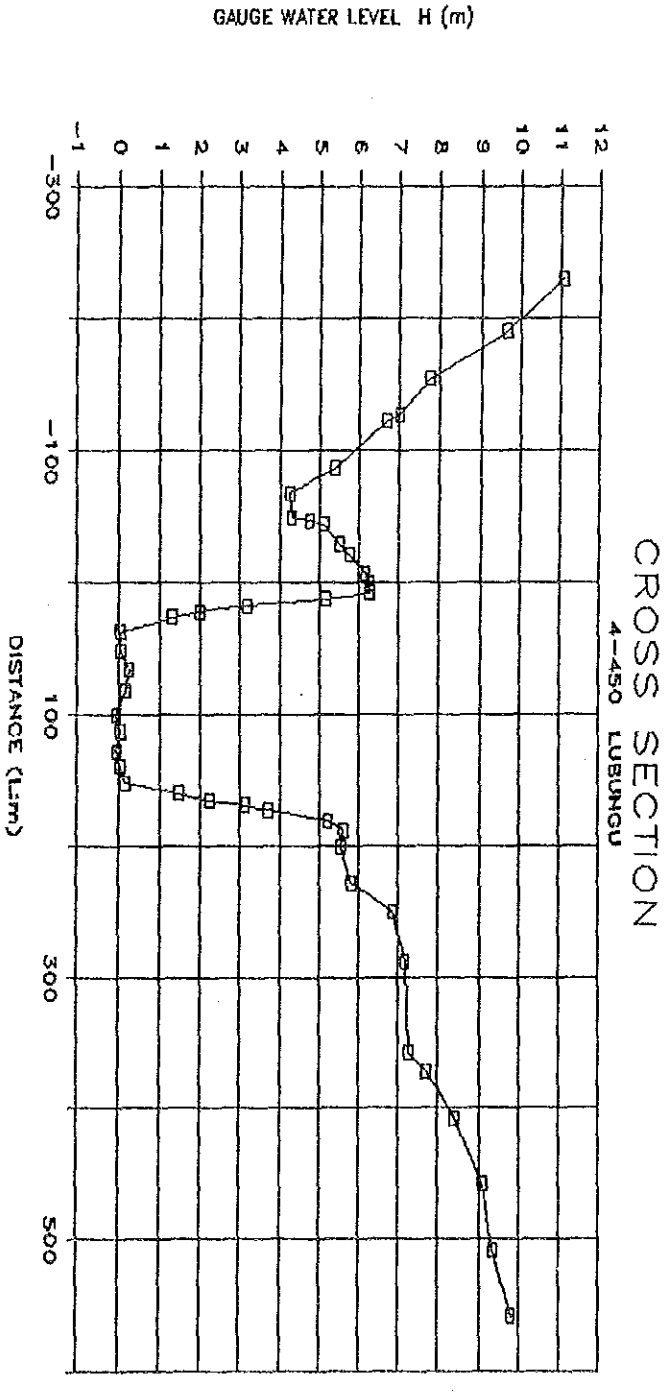
GAUGE PLATE ZERO (0) ELEVATION 1,091.64

X	Y	H
(230.00)	1102.72	11.08
(190.00)	1101.31	9.67
(154.50)	1099.41	7.77
(127.10)	1098.66	7.02
(122.00)	1098.33	6.69
(86.70)	1097.04	5.40
(67.50)	1095.90	4.26
(49.00)	1095.95	4.31
(47.00)	1096.40	4.76
(43.80)	1096.75	5.11
(29.20)	1097.16	5.52
(20.90)	1097.40	5.76
(6.29)	1097.82	6.18
0.00	1097.93	6.29
7.60	1097.91	6.27
12.60	1096.80	5.16
17.80	1094.81	3.17
21.80	1093.65	2.01
26.40	1092.95	1.31
37.60	1091.70	0.06
52.60	1091.70	0.06
65.90	1091.90	0.26
82.50	1091.80	0.16
100.70	1091.60	(0.04)
113.15	1091.70	0.06
127.80	1091.60	(0.04)
139.90	1091.70	0.06
152.10	1091.80	0.16
159.80	1093.10	1.46
165.40	1093.85	2.21
168.70	1094.76	3.12
172.80	1095.34	3.70
181.30	1096.86	5.22
188.20	1097.27	5.63
201.00	1097.18	5.54
228.20	1097.46	5.82
250.10	1098.50	6.86
288.20	1098.81	7.17
357.60	1098.91	7.27
372.20	1099.37	7.73
407.60	1100.04	8.40
457.60	1100.74	9.10
507.60	1100.98	9.34
557.60	1101.44	9.80

JICA B.M at L/B 1098.285 m

Left Bank <--------

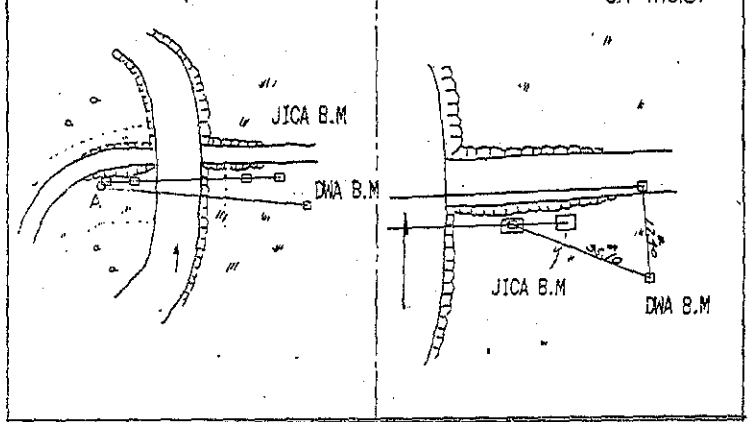
--------> Right Bank



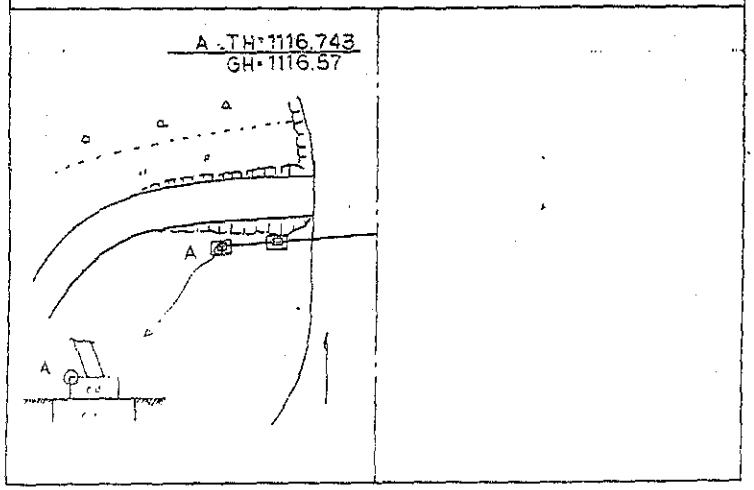
DESCRIPTION

STATION	4-560 Chifumpa Pontoon

ROUGH SKETCH



ROUGH SKETCH



Location

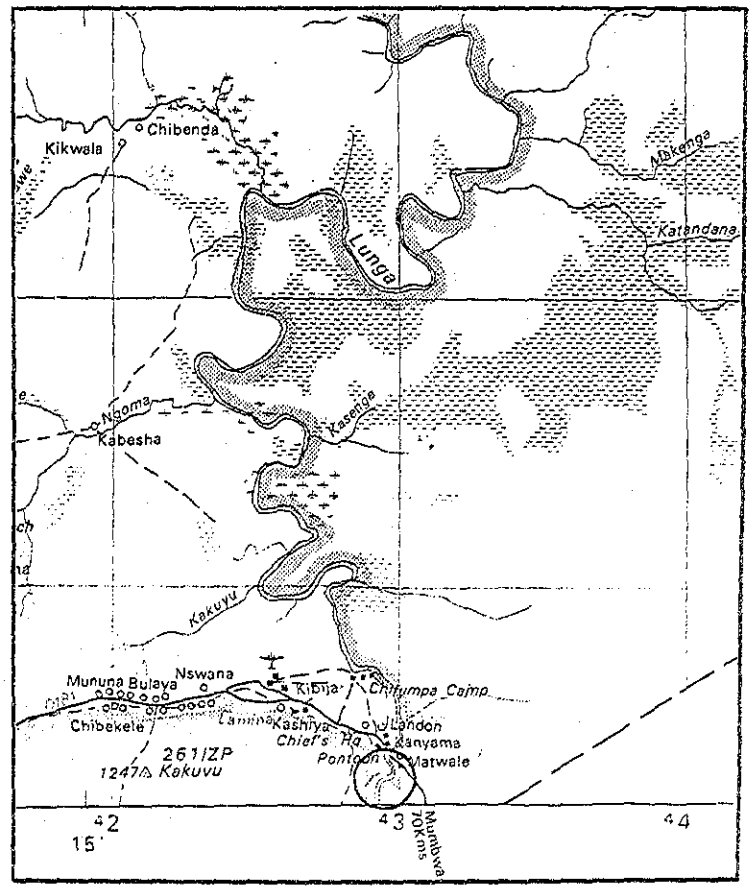


Fig.-1.3(14) Survey Result of St. 4-560 Chifumpa Pontoon

4-560 CHIFUMPA PONTOON
CROSS SECTIONAL SURVEY DATA

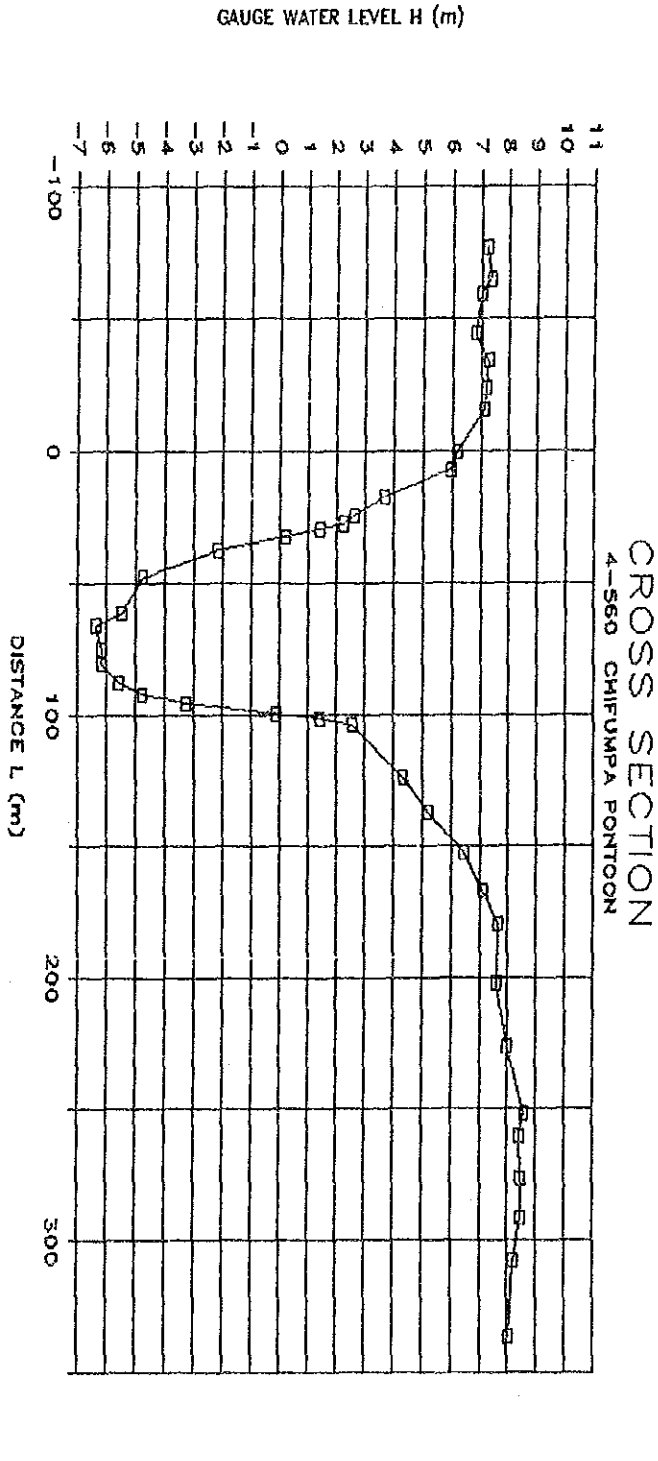
GAUGE PLATE ZERO (0) ELEVATION 1,110.36

X	Y	H
(77.00)	1117.62	7.26
(65.00)	1117.73	7.37
(59.60)	1117.40	7.04
(44.40)	1117.17	6.81
(34.30)	1117.66	7.30
(23.70)	1117.56	7.20
(15.70)	1117.49	7.13
0.00	1116.57	6.21
7.20	1116.33	5.97
17.30	1114.08	3.72
24.20	1113.01	2.65
27.60	1112.62	2.26
29.50	1111.79	1.43
32.40	1110.58	0.22
37.50	1108.18	(2.18)
47.50	1105.58	(4.78)
61.50	1104.88	(5.48)
65.90	1103.98	(6.38)
75.10	1104.18	(6.18)
81.10	1104.18	(6.18)
87.50	1104.78	(5.58)
92.30	1105.58	(4.78)
95.80	1107.08	(3.28)
99.70	1110.28	(0.08)
101.45	1111.77	1.41
104.05	1112.94	2.58
123.75	1114.72	4.36
137.25	1115.61	5.25
152.45	1116.81	6.45
167.25	1117.51	7.15
180.05	1118.01	7.65
202.45	1117.98	7.62
226.35	1118.35	7.99
251.55	1118.94	8.58
260.15	1118.75	8.39
276.35	1118.82	8.46
291.25	1118.83	8.47
307.85	1118.56	8.20
336.35	1118.40	8.04

JICA B.M at L/B 1116.743 m

Left Bank <---------

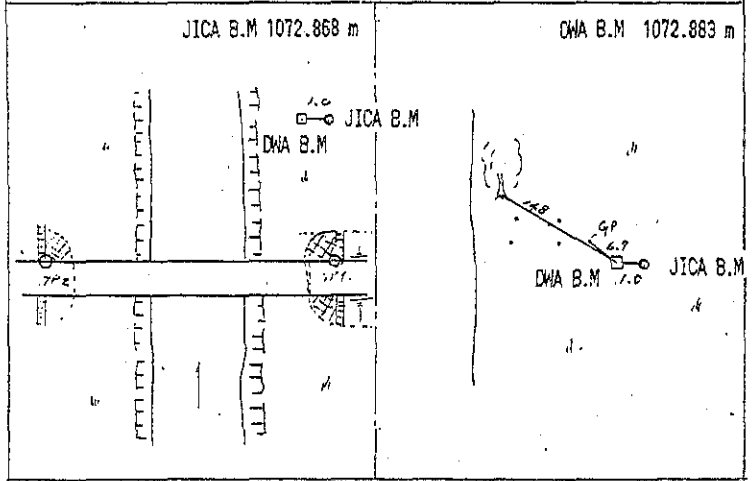
---------->Right Bank



DESCRIPTION

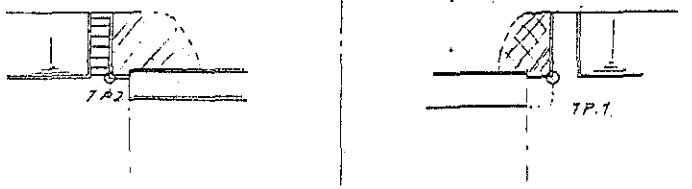
STATION	4-669 Kafue Hook Bridge

ROUGH SKETCH



ROUGH SKETCH

TP2 1078.921 m TP1 1078.911 m



Location

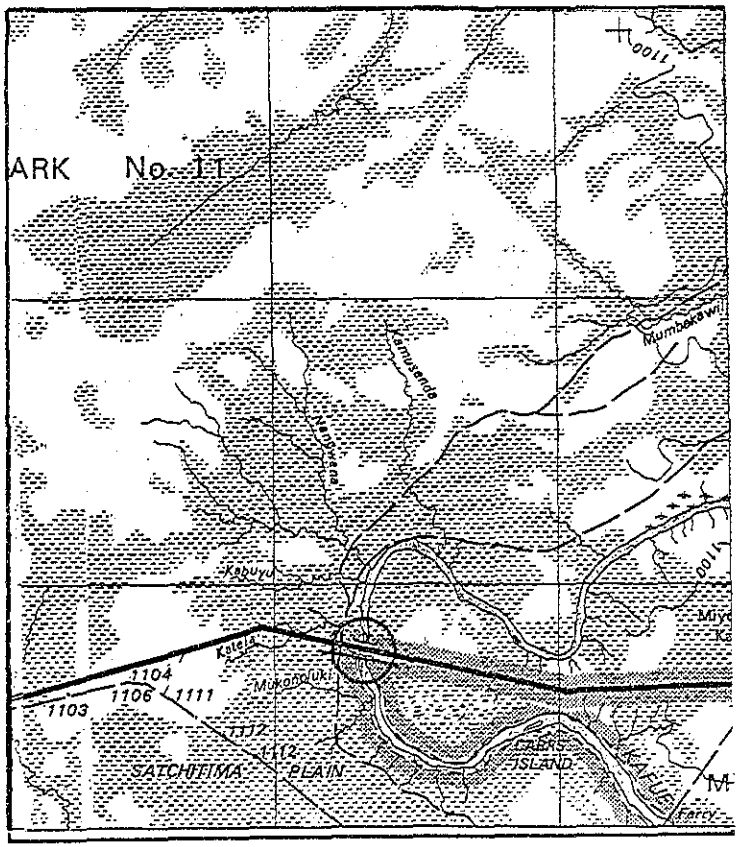


Fig.-1.3(15) Survey Result of St. 4-669 Kafue Hook Bridge

4-669 KAFUE HOOK BRIDGE
CROSS SECTIONAL SURVEY DATA

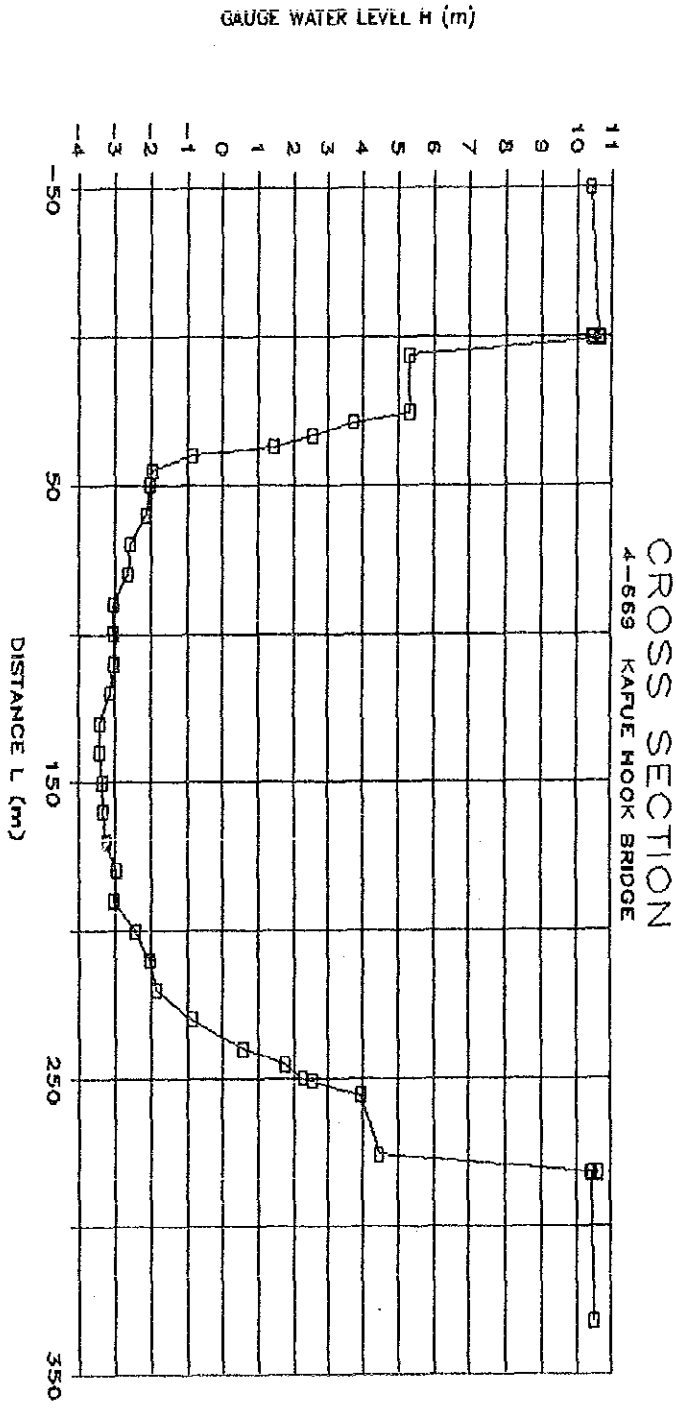
GAUGE WATER LEVEL (0) ELEVATION 1,068.30

X	Y	H
(50.00)	1078.70	10.40
0.00	1078.93	10.63
0.00	1078.73	10.43
0.80	1078.97	10.67
0.80	1078.75	10.45
6.20	1073.61	5.31
25.50	1073.62	5.32
29.00	1072.02	3.72
33.20	1070.85	2.55
37.00	1069.75	1.45
40.00	1067.45	(0.85)
45.00	1066.35	(1.95)
50.00	1066.25	(2.05)
60.00	1066.15	(2.15)
70.00	1065.75	(2.55)
80.00	1065.65	(2.65)
90.00	1065.25	(3.05)
100.00	1065.25	(3.05)
110.00	1065.25	(3.05)
120.00	1065.15	(3.15)
130.00	1064.85	(3.45)
140.00	1064.85	(3.45)
150.00	1064.95	(3.35)
160.00	1064.95	(3.35)
170.00	1065.05	(3.25)
180.00	1065.35	(2.95)
190.00	1065.25	(3.05)
200.00	1065.85	(2.45)
210.00	1066.25	(2.05)
220.00	1066.45	(1.85)
230.00	1067.45	(0.85)
240.00	1068.85	0.55
245.00	1070.05	1.75
250.00	1070.55	2.25
251.00	1070.85	2.55
255.50	1072.26	3.96
275.90	1072.76	4.46
281.90	1078.72	10.42
281.90	1078.95	10.65
282.30	1078.95	10.65
282.30	1078.77	10.47
332.00	1078.81	10.51

JICA B.M at R/B 1072.868 m

Left Bank <--------

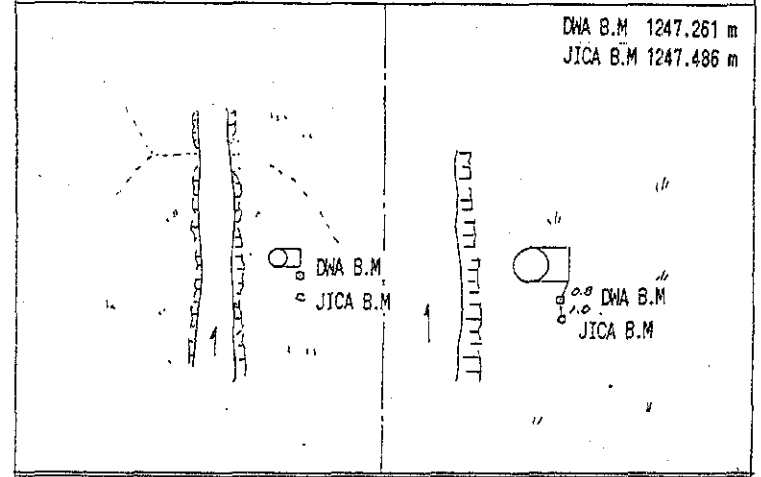
--------->Right Bank



DESCRIPTION

STATION	4-941 Kaleya Dam Site

ROUGH SKETCH



ROUGH SKETCH

Location

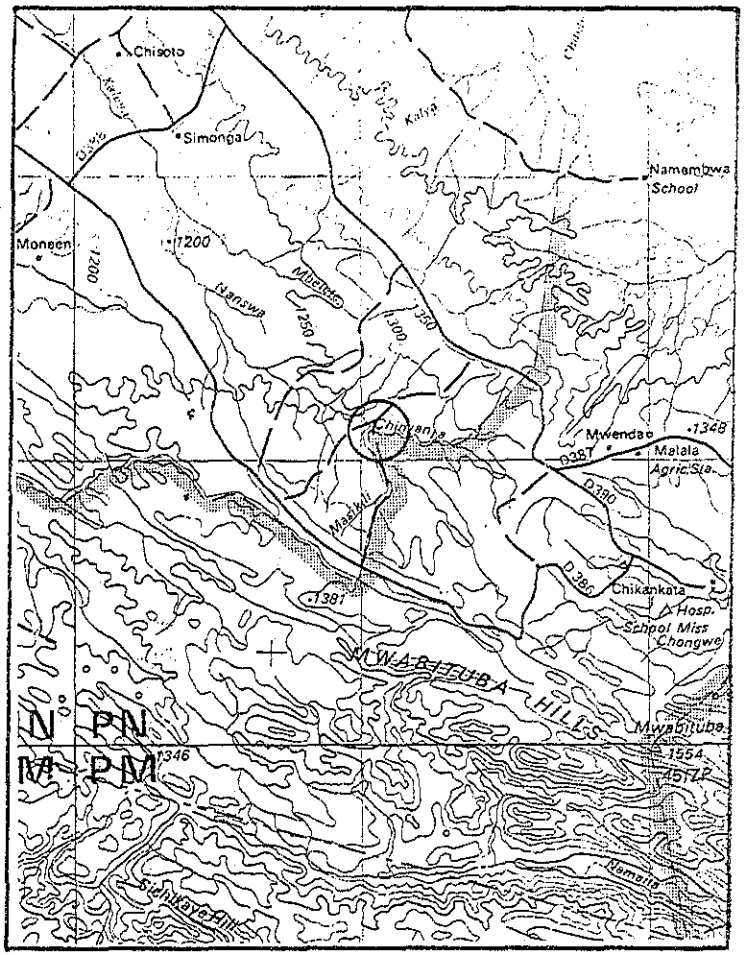


Fig.-1.3(16) Survey Result of St. 4-941 Kaleya Dam Site

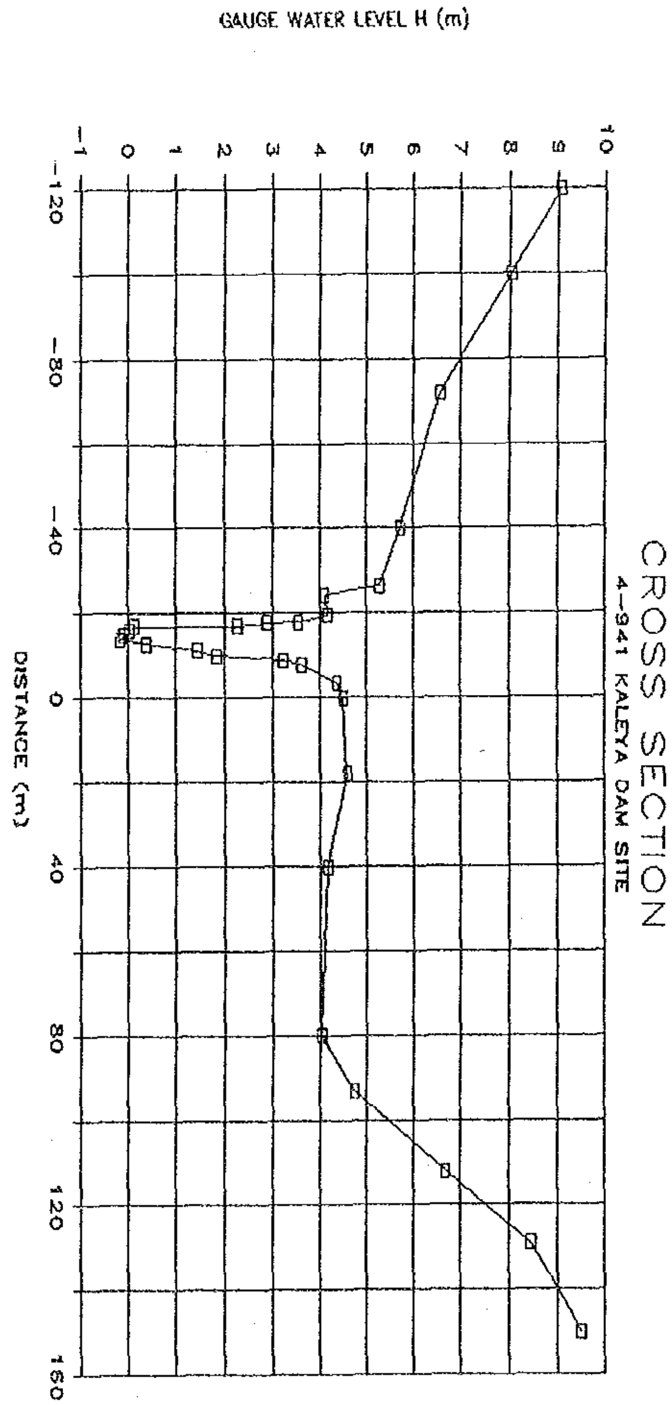
4-941 KALEYA DAM SITE
CROSS SECTIONAL SURVEY DATA

GAUGE PLATE ZERO (0) ELEVATION 1242.73

Left Bank <--------- --------->Right Bank

X	Y	H
(120.00)	1251.79	9.056
(100.00)	1250.75	8.016
(72.00)	1249.30	6.566
(40.00)	1248.45	5.716
(26.50)	1248.02	5.286
(24.50)	1246.84	4.106
(19.50)	1246.89	4.156
(18.00)	1246.26	3.526
(17.80)	1245.60	2.866
(17.00)	1244.97	2.236
(17.00)	1242.85	0.116
(16.00)	1242.76	0.026
(15.00)	1242.62	(0.114)
(14.00)	1242.57	(0.164)
(13.00)	1243.12	0.386
(11.50)	1244.16	1.426
(10.00)	1244.57	1.836
(9.00)	1245.95	3.216
(8.00)	1246.33	3.596
(3.50)	1247.10	4.366
0.00	1247.22	4.486
18.00	1247.32	4.586
40.00	1246.89	4.156
80.00	1246.76	4.026
93.00	1247.48	4.746
112.00	1249.42	6.686
129.00	1251.19	8.456
150.00	1252.25	9.516

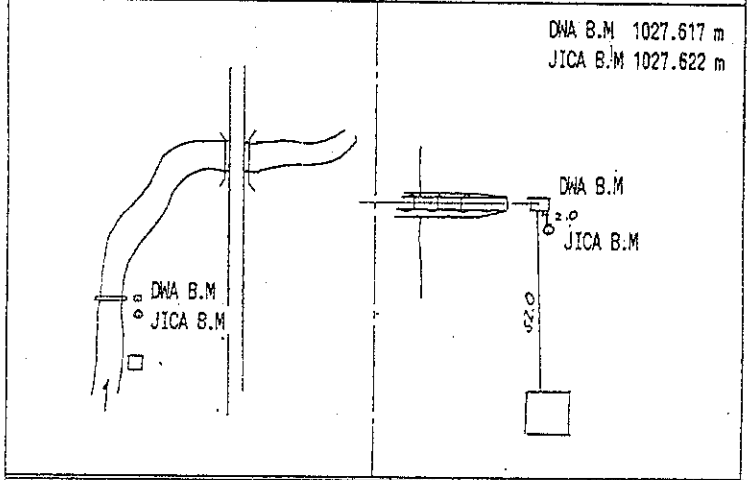
JICA B.M at R/B 1247.486 m



DESCRIPTION

STATION	4-958 Uruaff Farm

ROUGH SKETCH



ROUGH SKETCH

Location

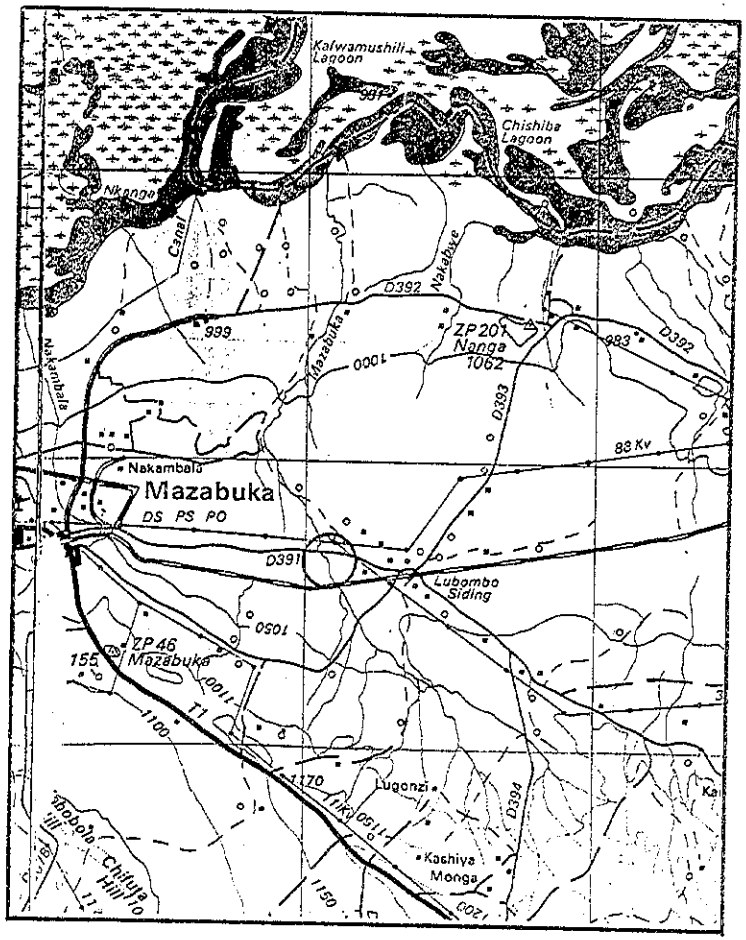


Fig.-1.3(17) Survey Result of St. 4-958 Uruaff Farm

4-958 URUAFF FARM
CROSS SECTIONAL SURVEY DATA

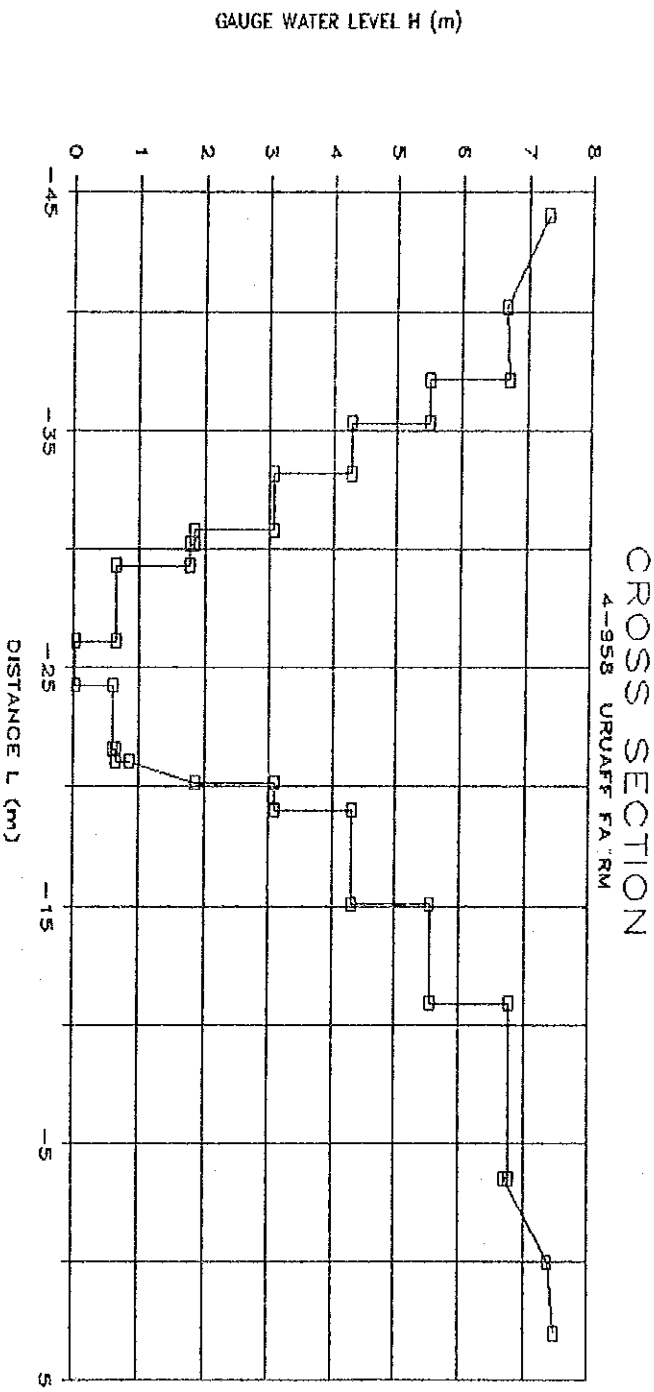
GAUGE PLATE ZERO (0) ELEVATION
1,020.15

Left Bank <---------

X	Y	H
(44.00)	1027.46	7.31
(40.20)	1026.82	6.67
(37.15)	1026.87	6.72
(37.15)	1025.65	5.50
(35.30)	1025.65	5.50
(35.30)	1024.44	4.29
(33.20)	1024.44	4.29
(33.20)	1023.22	3.07
(30.80)	1023.22	3.07
(30.80)	1021.99	1.84
(30.22)	1021.99	1.84
(30.22)	1021.92	1.77
(29.30)	1021.92	1.77
(29.30)	1020.79	0.64
(26.10)	1020.79	0.64
(26.10)	1020.17	0.02
(24.25)	1020.17	0.02
(24.25)	1020.74	0.59
(21.55)	1020.74	0.59
(21.55)	1020.79	0.64
(21.05)	1020.79	0.64
(21.05)	1021.01	0.86
(20.15)	1022.01	1.86
(20.15)	1023.23	3.08
(19.00)	1023.23	3.08
(19.00)	1024.45	4.30
(15.10)	1024.45	4.30
(15.10)	1025.69	5.54
(10.90)	1025.70	5.55
(10.90)	1026.92	6.77
(3.50)	1026.92	6.77
(3.50)	1026.85	6.70
0.00	1027.52	7.37
3.00	1027.62	7.47

--------->Right Bank

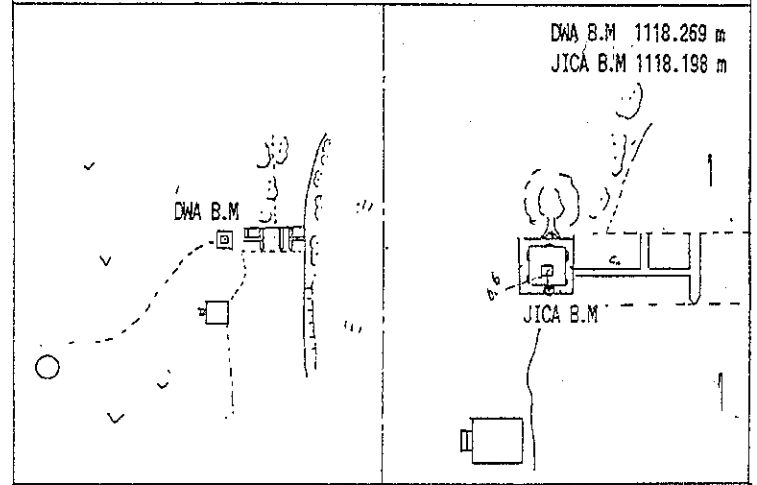
JICA B.M at R/B 1027.622 m



DESCRIPTION

STATION	5-030 Exchange Farm

ROUGH SKETCH



ROUGH SKETCH

Location

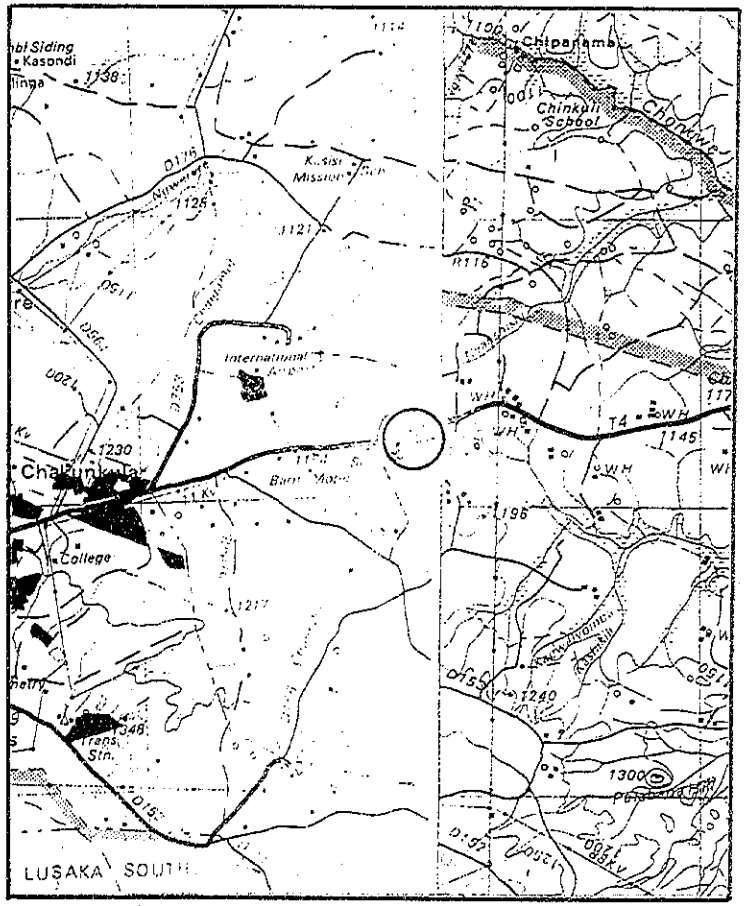


Fig.-1.3(18) Survey Result of St. 5-030 Exchange Farm

5-030 EXCHANGE FARM
CROSS SECTIONAL SURVEY DATA

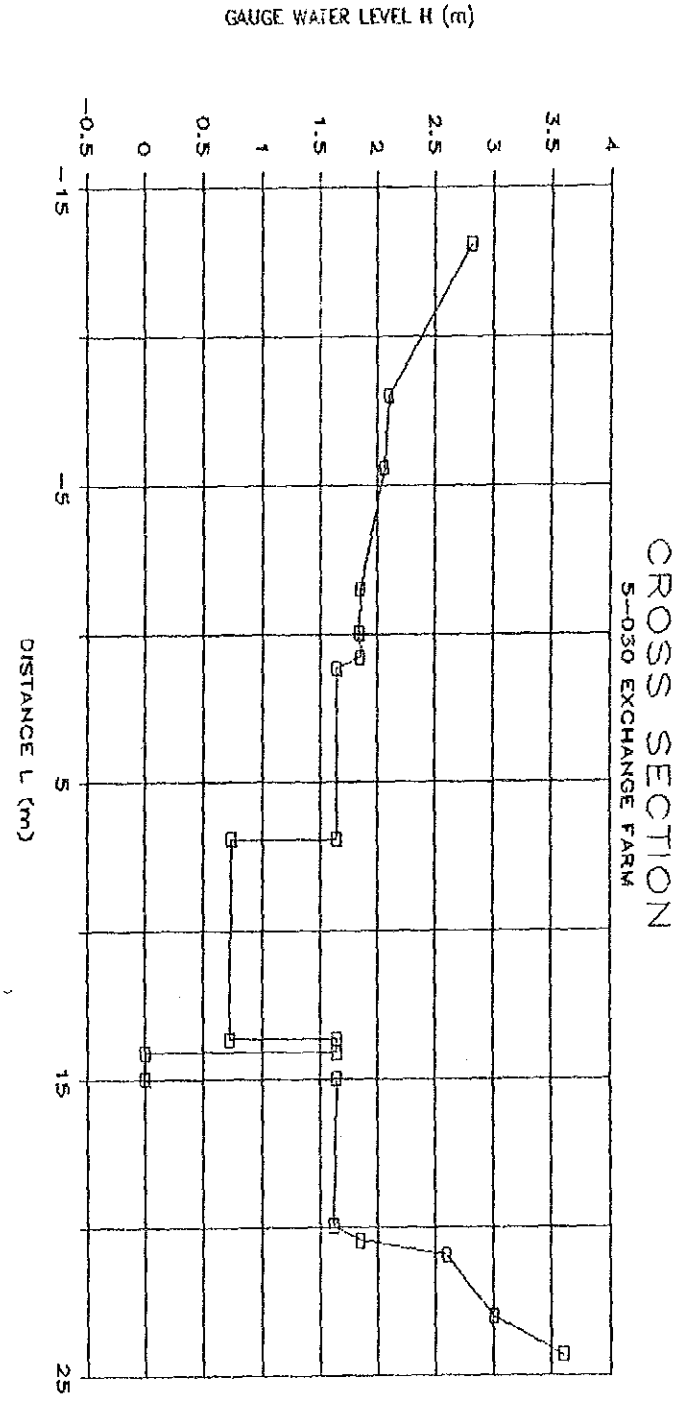
GAUGE PLATE ZERO (0) ELEVATION 1,116.16

Left Bank <---------

X	Y	
(13.10)	1118.98	2.82
(8.00)	1118.26	2.10
(5.60)	1118.22	2.06
(1.50)	1118.01	1.85
0.00	1118.00	1.84
0.80	1118.01	1.85
1.15	1117.80	1.64
6.90	1117.80	1.64
6.90	1116.89	0.73
13.65	1116.88	0.72
13.65	1117.80	1.64
14.10	1117.80	1.64
14.10	1116.15	(0.01)
15.00	1116.15	(0.01)
15.00	1117.80	1.64
19.95	1117.78	1.62
20.45	1118.01	1.85
20.95	1118.76	2.60
23.00	1119.17	3.01
24.30	1119.76	3.60

---------->Right Bank

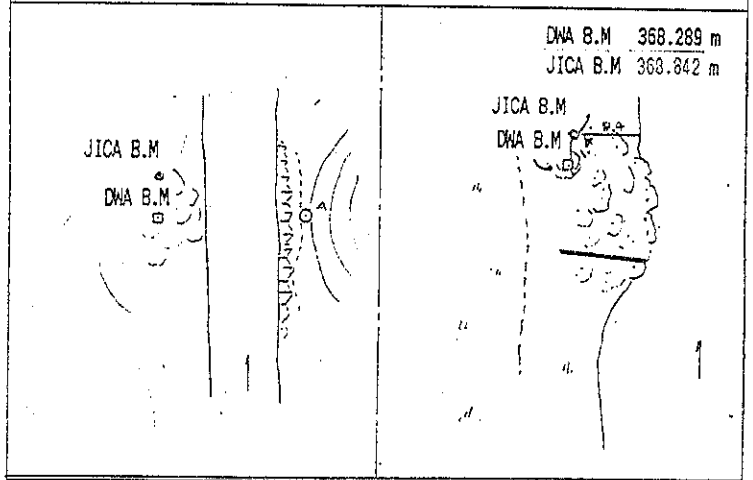
JICA B.M at L/B 1118.198 m



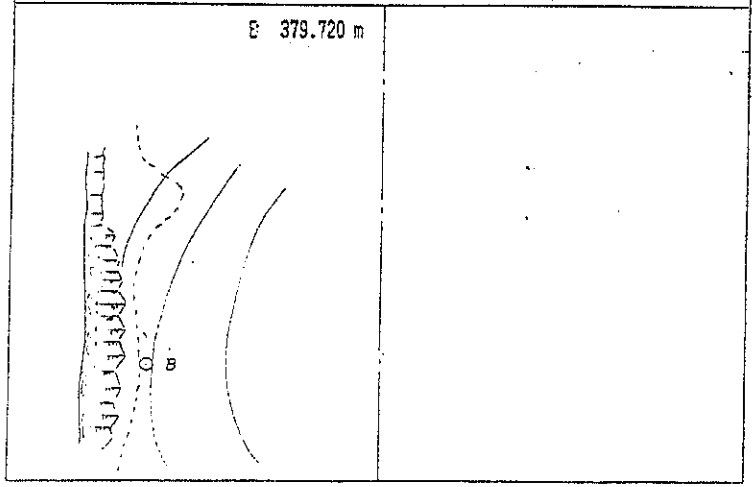
DESCRIPTION

STATION	S-940 Luangwa Bridge

ROUGH SKETCH



ROUGH SKETCH



Location

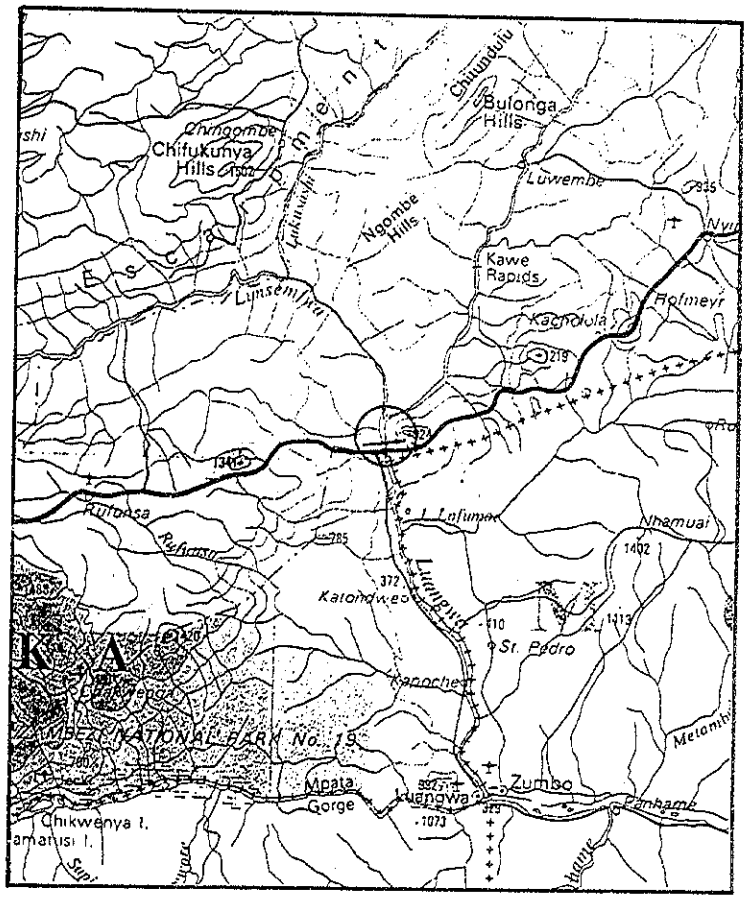
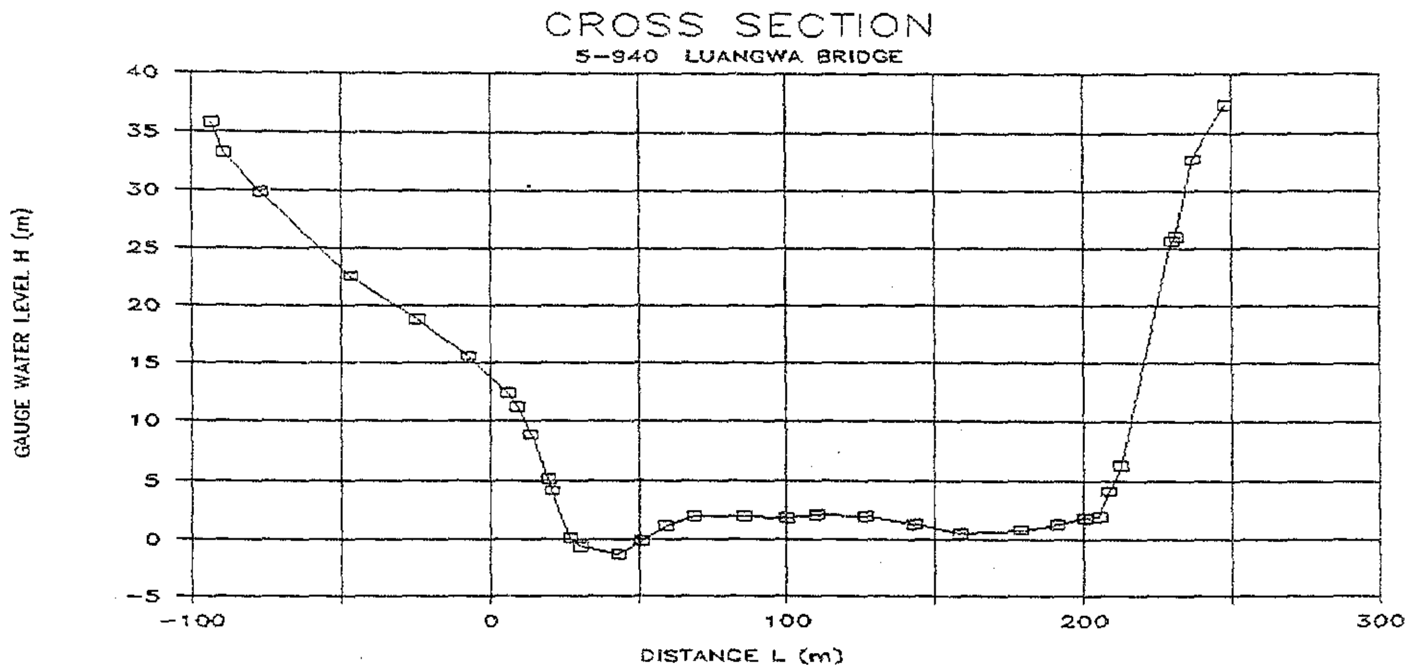


Fig.-1.3(19) Survey Result of St. 5-940 Luangwa Bridge



5-940 LUANGWA BRIDGE
CROSS SECTIONAL SURVEY DATA

GAUGE PLATE ZERO (0) ELEVATION
353.28

Left Bank <-------- --------->Right Bank

X	Y	H
(93.46)	389.03	35.75
(89.17)	386.55	33.27
(77.05)	383.25	29.97
(46.97)	375.88	22.60
(24.52)	372.15	18.87
(7.27)	368.89	15.61
5.81	365.71	12.43
9.17	364.44	11.16
13.79	362.15	8.87
19.60	358.36	5.08
20.66	357.40	4.12
26.79	353.42	0.14
30.57	352.60	(0.68)
43.06	351.90	(1.38)
51.20	353.10	(0.18)
59.23	354.40	1.12
68.94	355.25	1.97
85.62	355.25	1.97
99.88	355.05	1.77
110.31	355.30	2.02
126.76	355.20	1.92
143.26	354.60	1.32
158.52	353.80	0.52
179.05	354.10	0.82
191.19	354.60	1.32
200.10	355.10	1.82
205.39	355.20	1.92
208.73	357.40	4.12
212.69	359.59	6.31
229.90	378.98	25.70
231.51	379.43	26.15
237.12	386.08	32.80
247.77	390.64	37.36

JICA B.M L/B 368.842 m

1.3 Installation of Hydrometric Stations

Construction for nineteen (19) stations selected in Study was carried out by employing the local contractor under the supervision of Study Team. The construction includes the followings: (See Table-1.3)

1) Automatic Water Level Recording Stations .... 6 Stations
2) Water Level Gauge ..... 19 Stations
3) Bench Mark and Base Point ..... 19 Stations
4) Store House at Observation Station ..... 10 Stations

Table-1.3 Installation of Hydrometric Stations

S T A T I O N S	Recorder	W/L Gauge	B/M & B/P	Store H
(1) 1-150 Zambezi P/H		O	O	O
(2) 1-650 Kabompo Boma		O	O	O
(3) 1-950 Watopa Pont.		O	O	
(4) 2-030 Lukulu		O	O	O
(5) 2-250 Kalabo		O	O	
(6) 2-400 Senanga		O	O	O
(7) 4-050 Raglam Farm		O	O	
(8) 4-120 Mwambashi	O	O	O	
(9) 4-130 Smith's Bri.	O	O	O	
(10) 4-200 Mpatamato	O	O	O	
(11) 4-280 Machiya Ferry		O	O	O
(12) 4-350 Chilenga		O	O	O
(13) 4-450 Lubungu		O	O	O
(14) 4-560 Chifumpa Pont.		O	O	
(15) 4-669 Kafue H/B		O	O	O
(16) 4-941 Kaleya D/S	O	O	O	
(17) 4-958 Uruaff Farm	O	O	O	O
(18) 5-030 Exchange Farm	O	O	O	
(19) 5-940 Luangwa Bridge		O	O	O

1.3.1 Automatic Water Level Recording Station

The construction and installation of automatic water level recorder were carried out in accordance with the specifications stipulated below. The specifications were also applied to rehabilitation of the existing stations. Study Team provided to the Contractor five (5) float type water level recorders and one (1) pressure type water level recorder. The standard type of station is shown in Fig.- 1.4. Each component of station shall be constructed, rehabilitated and installed in the following manner.

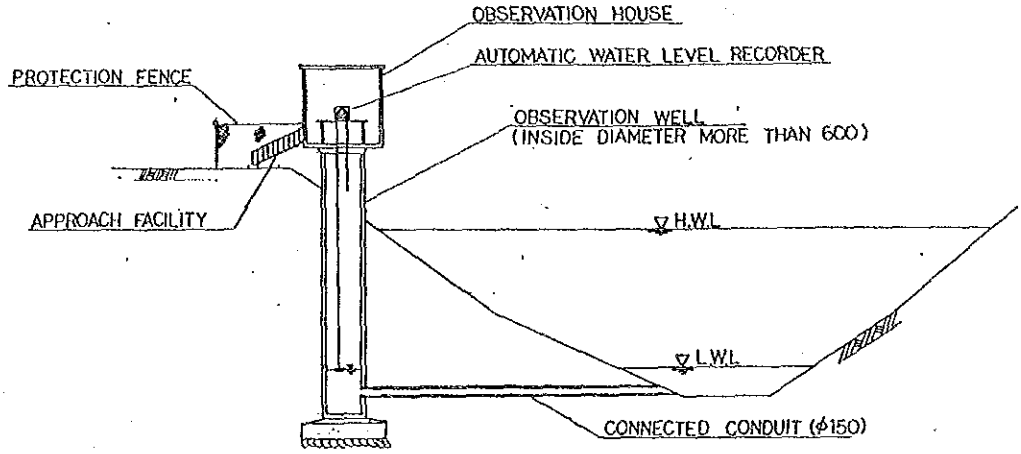
(1) Excavation

The excavation shall be made to enough depth to construct and/or rehabilitate observation well and connected conduit. The slope of excavation shall be appropriate one depending on soil condition to protect slope from collapsing. The coffer dam and/or drainage pump shall be furnished,if necessary, to dry up the floor of excavation. After construction of observation well and connected conduit, backfilling shall be carefully carried out by selecting good soil material and compacting well, especially around structures.

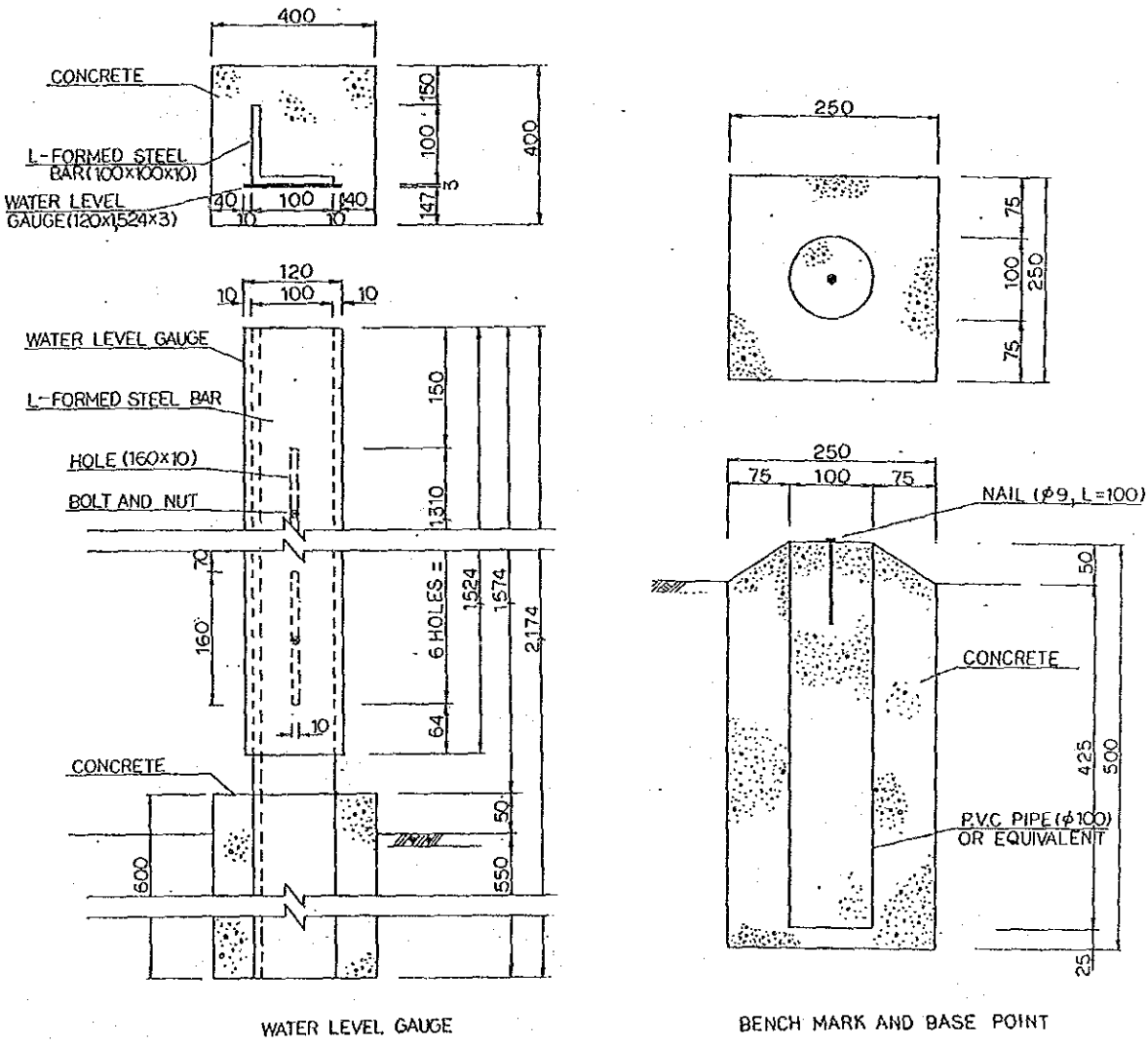
(2) Observation Well

The bottom level of observation well shall be less than the lowest water level by one (1) meter and top level more than maximum high water level in the past by two (2) meters. The inner diameter of well shall be more than sixty (60) centimeters for a float type water level recorder.

The well shall be constructed with steel pipe, concrete pipe, concrete or brick and strong enough against shock by flood water, drift wood and other obstacles. In case that the concrete is used, the mix proportion shall be cement:sand:gravel =1:2:4. In case of rehabilitation, the same material to the original shall be applied unless otherwise the Engineer approves. In case that the pressure type water level recorder is used, a sensor with cable shall be installed inside the observation well. The sensor and cable bound to a messenger wire to relieve tension on the cable shall be installed inside a casing pipe with inner diameter of ten (10) centimeters. The material of casing pipe shall be steel or PVC.



AUTOMATIC WATER LEVEL RECORDING STATION



WATER LEVEL GAUGE

BENCH MARK AND BASE POINT

Fig.- 1.4 Installation of Hydrometric Stations

(3) Connected Conduit >

The conduit which connects observation well and river channel shall be installed at the level less than the lowest water level by fifty (50) centimeters. The inner diameter of conduit shall be fifteen (15) centimeters. The material of conduit shall be steel or concrete with enough strength for earth pressure, river flow and damage caused by drift wood or other obstacles. In case of rehabilitation, sedimentation which blocks the pipe shall be cleared and the pipe shall be reinforced,if necessary.

(4) Observation House

The observation house shall be constructed or rehabilitated at the top of observation well in order to protect the water level recorder, and make observation and maintenance work. The house shall be made of steel, concrete or brick with enough space for the aforesaid works, one ventilation opening and steel door or equivalent with lock and burglar bars.

(5) Approach Facility

The approach facility to the observation house from river bank or land such as bridge, step, slope etc. shall be provided. The approach facility shall be made of steel, concrete, or brick with necessary width of one meter and railing.

(6) Protection Fence

To protect observation station against theft and mischief, the protection fence shall be installed around the station, if necessary. The fence shall be made of steel and with the height of 1.2 meters and with door with lock.

(7) Installation and Adjustment of Recorder

The automatic water level recorder shall be installed and adjusted under the guidance of the Engineer. However, required material,laborer and equipment shall be provided by the Contractor.

(8) Miscellaneous Works

All miscellaneous works such as access to station, clearing station, removal of debris and obstacles from river bank, protecting and refilling river bank, acquisition of land etc. shall be carried out for all type of water level gauging stations including staff gauge stations.

1.3.2 Water Level Gauge

The standard type of water level gauge in one unit shall be as shown in Fig. - 1.4. Excavation for concrete foundation shall be made to depth and width shown in Fig.- 1.4. Concrete with mix proportion of, cement :sand:gravel= 1:2:4,shall be placed as a

foundation of support. Steel support with required dimension shall be installed on the concrete foundation.

Gauge plate made of PVC shall be attached on the steel support with small scale bolt and nut or equivalent.Gauge scale shall be overlapped in half feet between lower gauge and upper gauge and length of one unit of gauge shall be 5 feet.

Installation of gauge shall be strictly carried out by applying leveling survey. Installation point of each unit of gauge shall be designated by the Engineer at Sites. PVC gauge plates excluding bolt and nut shall be provided by Study Team.

1.3.3 Bench Mark and Base Point

The standard type of bench mark and base point shall be as shown in Fig.- 1.3. One bench mark and one base point shall be installed at both banks of river along cross sectional line perpendicular to river flow. However,another base point shall be installed at either side of bank along the river in case of wide river so that triangle is formulated by these three points and it is easy to position a boat by using simple survey method in measurement of discharge.

Excavation shall be made to depth and width shown in Fig.- 1.4. Concrete with mix proportion of, cement:sand:gravel = 1:2:4, shall be placed in the excavated hole.

PVC pipe or steel pipe with inner diameter of ten (10) centimeters shall be installed into the concrete. Bolt or nail with ten(10) centimeters in length shall be embedded into the top of pipe. Installation points of bench mark and base point shall be designated by the Engineer at the sites.

1.3.4 Store House

The store house shall be constructed at some of observation stations in order to store spare parts and consumables of water level recorder and gauge, and equipment and tools for water flow measurement, and arrange raw data just observed and take a rest during observation and measurement.

The store house shall be made of brick with concrete flooring and slate roofing or equivalent and with space of fifteen (15) square meters. The store house shall be furnished with shelves and a set of desk and chair as well as window and entrance with lock and burglar bars.

The site for store house shall be provided by the Contractor at his cost. The detailed design of store house shall be proposed by the Contractor to the Engineer for his approval.

1.4 Observation and Flow Measurement

1.4.1 Observation Team

The three (3) observation teams for this study have been established as shown Fig.-1.5. The teams cover periodic flow measurement and daily observation of river water level.

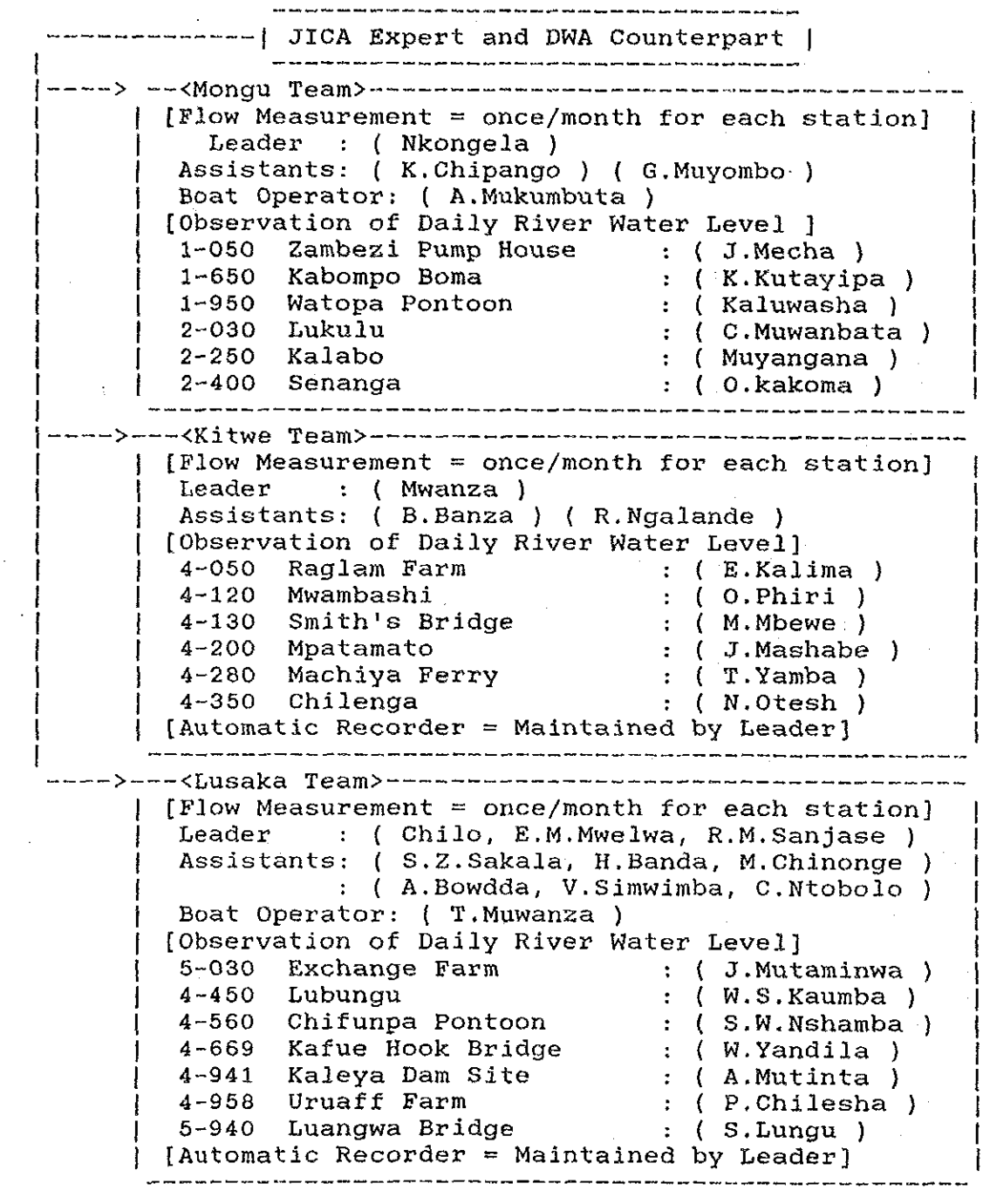


Fig.- 1.5 Hydrologic Observation Team

1.4.2 Observation of River Water Level

River water level indicators employed in Study are classified into 3 types: 1) Staff Gauge 2) Float Type Water Level Recorder 3) Pressure Type Water Level Recorder.

(1) Staff Gauge

W-881Z" model Staff Gauge, product of NAKAASA, Japan, is installed at the 19 stations. This gauge is a polyvinyl chloride board having 5 feet-long graduated in 0.1 feet increments. Observation with the staff gauge must be made everyday at 6:00 and 18:00. Read and record the time of the day and the water level in minutes and inches, respectively.

(2) Float Type Water Level Recorder

W-021-Z" model Water Level Recorder, product of NAKAASA, Japan, is installed at the 5 stations: Mwambashi,Mpatamato in Kafue River basin and Exchange Farm, Kaleya Dam Site, Uruaff Farm in Zambezi River basin. Changes in water level are transmitted from a float to 2 recording pens (S-pen, L-pen) via pulley and gear system. The S-pen records over a 2.5 feet span regardless of the actual measurement range, and the L-pen in turn indicates the appropriate units for reading the S-pen data.

(3) Pressure Type Water Level Recorder

"W-435-Z" model Water Level Recorder, product of NAKAASA, Japan, is installed at the Smith's Bridge station. Because the recorder operates by converting the water pressure to an electric signal, it consistently can produce outstanding, high accuracy measurements.

1.4.3 Measurement of Discharge

When executing discharge survey, either one of the following methods is used in Study: 1) Velocity measuring method 2) Float measuring method 3) Weir measuring method. Normally, the velocity measuring method is used when discharge is small, and the float measuring method is used during floods with a large amount of floatage or driftwood.

(1) Current Meter Measurement

Velocity measuring method using current meter is classified into the followings 3 types according to the manner in which the stream crossing is made : 1) By wading 2) By bridge 3) By boat.

Current meter used in this study are as shown below.

- "J-051-Z" model Water Current Meter, NAKAASA, Japan
- "J-072-Z" model Water Current Meter, NAKAASA, Japan

< Measurement Number and Lines >

As a rule, the water depth and the water velocity must be measured twice to confirm that the results are not greatly different from each other. (If they are, another measurement should be immediately performed again, except the case when the water level or velocity greatly fluctuated during flood.

Measurement lines should be established so that equal intervals are maintained in the traverse line. The standard ratio between the width of water surface and interval of measurement lines should be as shown in Table-1.4, but interval may be changed according to the field conditions.

Table- 1.4 Standard Interval of Measurement Lines

Width of Water Surface B(m)	Interval of Measurement Lines I(m)	B (m)	I (m)
Below 10	10 - 15 % of water surface width	60 to 80	8
		80 to 100	10
10 to 20	2	100 to 150	12
20 to 40	4	150 to 200	20
40 to 60	6	over 200	30

< Measurement by Wading >

If a stream is shallow and relatively slow moving, a wading measurement is indicated. The limit is determined by the water velocity to cross safely and to stand in position while making an observation. Experience indicates 1.0 m/s as an upper limit. In wading measurements the observer should stand in a position which will least affect the distribution of flow passing the current meter. With the meter rod at the tag line, the observer will face along the line toward the bank, standing downstream from the tag line.

< Measurement from Bridge >

Flow measurements are made using current meter from bridge. Measurements are generally made from the downstream side. This method is conducted at Smith's Bridge station.

< Measurement from Boat >

Measurements from a boat is a satisfactory way of determining stream discharge if conditions are favorable for its operation. The requirements are that the stream is safe for boats and suitable cross section is available. Flow measurements are made at the upstream side of boat. Cross section distance are established from a tagged rope stretched across the stream just above the water face at stations having width of water surface less than 100m. At stations having width of water surface more than 100m, cross section distances are established by Plane-table surveying.

< Calculation of Discharge >

Calculations of discharge should be performed in accordance with the following manner.

1) For the mean velocity, find the velocity at every measurement point by arithmetically averaging the measured values obtained by two times measurements, and then find the mean velocity at every survey point in accordance with the 2-point method.
2) Cross sectional area to be covered by a velocity measurement line should be up to the center between the velocity measurement line and adjacent one.
3) Discharge should be determined by summing the products of mean velocity and the vertical sections covered by the mean velocity for all measurement lines.

{(V11 + V12) / 2}	x	(a1 + a2)	=	q1
Mean velocity		Vertical area		Discharge

(2) Float Measurement

This method should be used only when more precise methods are not available. Approximate determinations of velocity can be made by floats. Observations must be taken along several ranges across the section and within the reach. If surface floats are used, a correlation of 0.85 is required to obtain the mean velocity. If a rod is floated with its lower end near the bottom, it indicates the mean velocity. Measurements using floats should be performed in accordance with the following manner.

1) Floats should be sequentially dropped at a predetermined interval from one side to the other.
2) Measure the time elapsed for the float to move from the first cross section to the second cross section, and divide the distance (L) between both the cross sections by time (T) in order to find the flow-down velocity of float(Vo).
3) Multiply (Vo) by correction coefficient in order to find the mean velocity (V).
4) Observe the water level at the start and end of the observation.

< Measurement Lines >

Measurement lines for velocity should be located along the stream between the first and second cross sections. The standard ratio between the width of water surface and the interval of measurement lines for float velocity at the first section should be as indicated in Table-1.5.

The values shown in Table-1.6 should be used in the case that it becomes necessary to urgently perform discharge observation during flood.

Table-1.5 Number of Measurement Lines (Float Method-1)

Width of water surface	Below 20 m	20 to 100 m	100 to 200 m	over 200 m
Number of measurement lines for float velocity	5	10	15	20

Table-1.6 Number of Measurement Lines (Float Method-2)

Width of water surface	Below 50 m	50 to 100 m	100 to 200 m	200 to 400 m
Number of measurement lines for float velocity	3	4	5	6

< Calculation of Discharge >

Calculation of discharge should be made in accordance with the provisions set forth below.

1) Width to be covered by a velocity measurement line should up to the center between the velocity measurement line and adjacent one.
2) At the cross section, find the sectional area covered by velocity measurement line, and then find the arithmetic mean of two sectional areas, and use it as the sectional area to be covered by the velocity measurement lines.
3) The sectional area may be used as it is, as long as there is no difference in the cross section at the start and end of the observation. However, if there is a difference in cross section due to a flood, then the large value of the sectional area should be used.
4) Discharge should be determined by summing the products of mean discharge and the sectional area covered by the mean discharge for all measurement lines.

(3) Weir Measurement

For a rectangular weir of the complete overflow type, the discharge should be calculated from the following formula:

$$Q = C*B*H^{(3/2)}$$

where,
Q : Discharge (m3/s)
C : Coefficient of overflow of weir
B : Width of weir (m), H : Overflow depth (m)

1.4.4 Observation Data

Number of flow measurement data obtained up to the end of September 1991 is summarized as shown in Table-1.7. The measured data during JICA study period is shown in Table-1.8.

Table-1.7 Number of Flow Measurement Data

STATIONS	Before Study	During Study 89/90	90/91	91/92	Period Total
(1) 1-150 Zambezi P.	0	5	7	2	14
(2) 1-650 Kabompo Boma	0	5	7	2	14
(3) 1-950 Watopa P.	173	7	7	2	16
(4) 2-030 Lukulu	0	5	7	2	14
(5) 2-250 Kalabo	45	5	6	1	12
(6) 2-400 Senanga	2	4	8	2	14
(7) 4-050 Raglam F.	127	2	8	2	12
(8) 4-120 Mwambashi	186	4	8	2	14
(9) 4-130 Smith's B.	226	3	8	2	13
(10) 4-200 Mpatamato	368	3	8	2	13
(11) 4-280 Machiya F.	261	3	7	2	12
(12) 4-350 Chilenga	220	2	6	2	10
(13) 4-450 Lubungu	216	3	7	2	12
(14) 4-560 Chifumpa	54	3	5	2	10
(15) 4-669 Kafue H/B	75	3	7	2	12
(16) 4-941 Kaleya D/S	15	2	5	2	9
(17) 4-958 Uruaff Farm	11	1	4	2	7
(18) 5-030 Exchange F.	22	2	5	2	9
(19) 5-940 Luangwa B.	133	3	7	2	12
TOTAL	2134	65	127	37	229

Table-1.8 Flow Measurement Data (JICA Study period)

T SUM NO.	ST SUM NO.	STATION No.	STATION Name	DATE	< M E A S U R E D > W.LEVEL (m)	DIS. (a) (m3/s)	VELO. (m/s)
1	1	1-150	ZAMBEZI P/H	07-Mar-90	3.08	495.94	0.52
2	2	1-150		27-Jun-90	1.74	204.43	0.37
3	3	1-150		30-Jul-90	1.23	123.17	0.28
4	4	1-150		23-Aug-90	0.98	105.25	0.28
5	5	1-150		27-Sep-90	0.61	65.06	0.19
6	6	1-150		26-Oct-90	0.55	59.54	0.18
7	7	1-150		07-Dec-90	0.97	128.75	0.31
8	8	1-150		04-Feb-91	6.54	1311.47	0.82
9	9	1-150		15-Mar-91	5.88	1398.51	0.92
10	10	1-150		06-Jul-91	1.30	114.55	0.37
11	11	1-150		19-Aug-91	0.81	59.34	0.20
12	12	1-150		13-Sep-91	0.62	52.30	0.19
13	13	1-150		05-Oct-91	0.50	48.05	0.18
14	14	1-150		13-Nov-91	0.73	74.08	0.25
15	1	1-650	KABOMPO BOMA	06-Mar-90	2.61	243.61	1.06
16	2	1-650		28-Jun-90	1.92	95.47	0.45
17	3	1-650		31-Jul-90	1.79	69.21	0.34
18	4	1-650		24-Aug-90	1.73	67.56	0.35
19	5	1-650		28-Sep-90	1.60	51.16	0.31
20	6	1-650		26-Oct-90	1.57	49.42	0.29
21	7	1-650		07-Dec-90	1.76	79.75	0.41
22	8	1-650		12-Jan-91	2.61	241.92	0.70
23	9	1-650		03-Feb-91	3.13	380.64	0.98
24	10	1-650		08-Jul-91	1.93	99.92	0.34
25	11	1-650		18-Aug-91	1.81	47.25	0.28
26	12	1-650		12-Sep-91	1.71	38.75	0.25
27	13	1-650		05-Oct-91	1.66	58.37	0.28
28	14	1-650		13-Nov-91	1.80	67.95	0.41
29	1	1-950	WATOPA PONTOON	09-Feb-90	3.03	257.30	0.56
30	2	1-950		08-Mar-90	3.26	251.32	0.56
31	3	1-950		08-May-90	3.03	257.30	0.56
32	4	1-950		26-Jun-90	2.13	86.95	0.24
33	5	1-950		29-Jul-90	2.01	65.64	0.21
34	6	1-950		22-Aug-90	1.92	55.28	0.20
35	7	1-950		26-Sep-90	1.71	46.04	0.15
36	8	1-950		25-Oct-90	1.70	49.88	0.17
37	9	1-950		06-Dec-90	1.88	66.89	0.21
38	10	1-950		12-Jan-91	3.08	211.73	0.51
39	11	1-950		04-Feb-91	4.29	514.11	0.78
40	12	1-950		07-Jul-91	2.30	115.16	0.29
41	13	1-950		20-Aug-91	1.93	45.17	0.17
42	14	1-950		11-Sep-91	1.82	54.31	0.20
43	15	1-950		04-Oct-91	1.72	45.59	0.17
44	16	1-950		12-Nov-91	1.92	59.35	0.21

T SUM NO.	ST SUM NO.	STATION No.	Name	DATE	< MEASURED W.LEVEL (m)	DIS. (a) (m3/s)	VELO. (m/s) >
45	1	2-030	LUKULU	09-Mar-90	2.77	887.96	0.68
46	2	2-030		16-Jun-90	1.45	566.77	0.43
47	3	2-030		01-Aug-90	0.93	313.79	0.27
48	4	2-030		25-Aug-90	0.75	310.51	0.28
49	5	2-030		29-Sep-90	0.57	269.71	0.26
50	6	2-030		25-Oct-90	0.58	238.83	0.23
51	7	2-030		06-Dec-90	0.80	327.45	0.29
52	8	2-030		05-Feb-91	4.27	2279.03	1.07
53	9	2-030		09-Mar-91	4.56	1357.40	0.96
54	10	2-030		05-Jul-91	0.97	288.76	0.27
55	11	2-030		17-Aug-91	0.68	178.79	0.16
56	12	2-030		11-Sep-91	0.55	199.00	0.18
57	13	2-030		04-Oct-91	0.58	249.05	0.25
58	14	2-030		12-Nov-91	0.65	299.31	0.28
57	1	2-250	KALABO	02-Mar-90	1.86	28.65	0.07
58	2	2-250		14-Jun-90	1.83	29.06	0.07
59	3	2-250		27-Jul-90	1.25	15.43	0.04
60	4	2-250		28-Aug-90	0.91	14.49	0.04
61	5	2-250		30-Sep-90	0.67	11.79	0.04
62	6	2-250		29-Oct-90	0.48	16.96	0.05
63	7	2-250		10-Dec-90	0.37	12.00	0.04
64	8	2-250		20-Jan-91	0.55	6.96	0.02
65	9	2-250		04-Jul-91	1.41	17.56	0.04
66	10	2-250		21-Aug-91	0.92	15.61	0.04
67	11	2-250		09-Sep-91	0.75	13.30	0.04
68	12	2-250		02-Oct-91	0.54	6.33	0.02
69	1	2-400	SENANGA	03-Mar-90	2.51	930.81	0.74
70	2	2-400		13-Jun-90	2.64	949.77	0.84
71	3	2-400		28-Jul-90	1.27	453.84	0.64
72	4	2-400		26-Aug-90	0.91	353.93	0.53
73	5	2-400		01-Oct-90	0.67	254.32	0.41
74	6	2-400		28-Oct-90	0.64	247.73	0.43
75	7	2-400		09-Dec-90	0.81	319.42	0.51
76	8	2-400		01-Feb-91	2.20	734.14	0.76
77	9	2-400		07-Mar-91	4.31	1662.38	1.05
78	10	2-400		03-Jul-91	1.44	609.25	0.53
79	11	2-400		22-Aug-91	0.91	233.32	0.39
80	12	2-400		10-Sep-91	0.78	224.99	0.32
81	13	2-400		03-Oct-91	0.64	245.60	0.43
82	14	2-400		15-Nov-91	0.80	244.08	0.36

T SUM NO.	ST SUM NO.	STATION No.	Name	DATE	< M E A S U R E D > W.LEVEL (m)	DIS. (a) (m3/s)	VELO. (m/s)
83	1	4-050	RAGLAM F.	17-Jul-90	0.87	6.35	0.14
84	2	4-050		21-Aug-90	0.67	3.60	0.09
85	3	4-050		13-Oct-90	0.43	1.32	0.05
86	4	4-050		06-Nov-90	0.38	1.25	0.05
87	5	4-050		24-Dec-90	0.55	3.84	0.12
88	6	4-050		14-Jan-91	1.26	13.73	0.21
89	7	4-050		14-Feb-91	3.19	60.72	0.37
90	8	4-050		08-Mar-91	3.20	56.31	0.35
91	9	4-050		27-Aug-91	0.70	3.63	0.12
92	10	4-050		16-Sep-91	0.55	4.18	0.13
93	11	4-050		18-Oct-91	0.45	1.27	0.05
94	12	4-050		25-Nov-91	0.45	2.01	0.08
95	1	4-120	MWAMBASHI	22-Feb-90	2.40	11.83	0.35
96	2	4-120		13-Jun-90	1.05	3.13	0.32
97	3	4-120		12-Jul-90	0.91	1.75	0.22
98	4	4-120		16-Aug-90	0.87	1.31	0.18
99	5	4-120		09-Oct-90	0.70	0.64	0.21
100	6	4-120		03-Nov-90	0.65	0.60	0.21
101	7	4-120		21-Dec-90	1.02	2.74	0.34
102	8	4-120		11-Jan-91	1.89	6.11	0.29
103	9	4-120		13-Feb-91	2.83	15.05	0.32
104	10	4-120		07-Mar-91	2.59	13.68	0.33
105	11	4-120		27-Aug-91	1.34	2.17	0.25
106	12	4-120		17-Sep-91	0.88	1.54	0.21
107	13	4-120		19-Oct-91	0.99	1.72	0.22
108	14	4-120		24-Nov-91	0.85	1.73	0.26
109	1	4-130	SMITH'S B.	19-Jun-90	2.01	28.20	0.68
110	2	4-130		16-Jul-90	1.49	15.63	0.55
111	3	4-130		21-Aug-90	1.20	10.98	0.47
112	4	4-130		13-Oct-90	0.88	6.46	0.35
113	5	4-130		06-Nov-90	0.81	4.75	0.30
114	6	4-130		21-Dec-90	1.29	9.06	0.46
115	7	4-130		15-Jan-91	3.89	70.83	0.53
116	8	4-130		13-Feb-91	5.28	165.74	0.66
117	9	4-130		08-Mar-91	5.45	164.21	0.63
118	10	4-130		29-Aug-91	1.34	13.18	0.52
119	11	4-130		17-Sep-91	1.12	10.72	0.44
120	12	4-130		19-Oct-91	1.21	11.42	0.45
121	13	4-130		25-Nov-91	1.29	10.23	0.48

T SUM NO.	ST SUM NO.	STATION No.	Name	DATE	< MEASURED W.LEVEL (m)	DIS. (a) (m3/s)	VELO. (m/s) >
122	1	4-200	MPATAMATO	18-Jun-90	1.44	46.28	0.47
123	2	4-200		16-Jul-90	0.98	17.55	0.30
124	3	4-200		20-Aug-90	0.73	12.47	0.24
125	4	4-200		10-Oct-90	0.54	3.24	0.17
126	5	4-200		03-Nov-90	0.46	5.73	0.16
127	6	4-200		21-Dec-90	1.13	13.74	0.22
128	7	4-200		11-Jan-91	2.62	66.45	0.63
129	8	4-200		15-Feb-91	5.49	176.53	0.53
130	9	4-200		07-Mar-91	4.08	145.75	0.77
131	10	4-200		28-Aug-91	0.94	17.49	0.31
132	11	4-200		18-Sep-91	0.72	13.02	0.25
133	12	4-200		20-Oct-91	0.89	17.00	0.29
134	13	4-200		23-Nov-91	0.79	8.91	0.23
135	1	4-280	MACHIYA F.	17-Jun-90	3.02	43.42	0.18
136	2	4-280		15-Jul-90	2.69	24.10	0.14
137	3	4-280		19-Aug-90	2.55	16.80	0.09
138	4	4-280		12-Oct-90	2.46	9.22	0.06
139	5	4-280		05-Nov-90	2.17	9.12	0.06
140	6	4-280		23-Dec-90	2.57	14.45	0.09
141	7	4-280		13-Jan-91	4.13	87.08	0.29
142	8	4-280		05-Mar-91	6.07	206.61	0.46
143	9	4-280		30-Aug-91	2.64	25.11	0.14
144	10	4-280		19-Sep-91	2.52	17.98	0.10
145	11	4-280		21-Oct-91	2.50	17.16	0.10
146	12	4-280		22-Nov-91	2.44	12.37	0.08
147	1	4-350	CHILENGA	13-Jul-90	1.65	25.22	0.11
148	2	4-350		17-Aug-90	1.35	27.24	0.08
149	3	4-350		11-Oct-90	1.06	17.43	0.07
150	4	4-350		04-Nov-90	0.97	15.86	0.06
151	5	4-350		22-Dec-90	1.42	19.64	0.07
152	6	4-350		13-Jan-91	3.20	94.61	0.17
153	7	4-350		31-Aug-91	1.47	20.25	0.07
154	8	4-350		20-Sep-91	1.22	24.21	0.08
155	9	4-350		22-Oct-91	1.12	22.16	0.07
156	10	4-350		23-Nov-91	1.07	14.69	0.06
157	1	4-450	LUBUNGU	13-Jul-90	1.64	38.25	0.22
158	2	4-450		10-Aug-90	1.52	26.15	0.19
159	3	4-450		13-Sep-90	1.34	18.27	0.13
160	4	4-450		11-Oct-90	0.80	15.62	0.13
161	5	4-450		27-Nov-90	1.14	11.75	0.11
162	6	4-450		15-Dec-90	1.35	13.94	0.11
163	7	4-450		20-Jan-91	2.38	127.05	0.42
164	8	4-450		07-Feb-91	3.19	235.04	0.52
165	9	4-450		10-Aug-91	1.61	36.28	0.21
166	10	4-450		20-Sep-91	1.39	18.31	0.11
167	11	4-450		15-Oct-91	1.27	10.75	0.07
168	12	4-450		16-Nov-91	1.28	11.72	0.09

T SUM NO.	ST SUM NO.	STATION No.	Name	DATE	< M E A S U R E D > W.LEVEL (m)	DIS. (a) (m3/s)	VELO. (m/s)
169	1	4-560	CHIFUMPA P.	14-Jul-90	0.62	24.64	0.07
170	2	4-560		11-Aug-90	0.61	17.69	0.05
171	3	4-560		12-Sep-90	0.46	17.28	0.05
172	4	4-560		10-Oct-90	0.45	18.89	0.06
173	5	4-560		16-Dec-90	0.43	14.99	0.04
174	6	4-560		07-Feb-91	2.35	151.72	0.29
175	7	4-560		10-Aug-91	0.55	1.80	0.05
176	8	4-560		20-Sep-91	0.43	11.13	0.03
177	9	4-560		06-Oct-91	0.39	14.04	0.04
178	10	4-560		16-Nov-91	0.43	11.48	0.03
179	1	4-669	KAFUE H/BRIDGE	12-Jul-90	1.83	48.09	0.06
180	2	4-669		09-Aug-90	1.71	34.31	0.04
181	3	4-669		11-Sep-90	1.64	69.07	0.08
182	4	4-669		09-Oct-90	1.56	60.10	0.07
183	5	4-669		26-Nov-90	1.55	24.64	0.03
184	6	4-669		14-Dec-90	1.58	35.05	0.04
185	7	4-669		19-Jan-91	2.34	231.97	0.22
186	8	4-669		08-Feb-91	2.84	406.87	0.36
187	9	4-669		11-Aug-91	1.78	77.04	0.09
188	10	4-669		19-Sep-91	1.65	28.31	0.03
189	11	4-669		06-Oct-91	0.63	33.86	0.04
190	12	4-669		15-Nov-91	1.63	24.70	0.03
191	1	4-941	KALEYA D/SITE	29-Mar-90	0.48	0.12	0.11
192	2	4-941		18-Jul-90	0.36	0.07	0.09
193	3	4-941		31-Dec-90	0.36	0.84	0.38
194	4	4-941		21-Jan-91	0.64	1.19	0.59
195	5	4-941		20-Feb-91	0.37	0.18	0.22
196	6	4-941		12-Aug-91	0.34	0.09	0.22
196	7	4-941		04-Sep-91	0.34	0.08	0.22
197	8	4-941		08-Oct-91	0.33	0.08	0.22
197	9	4-941		25-Nov-91	0.35	0.06	0.08
198	1	4-958	URUAFF FARM	18-Jul-90	0.02	0.02	0.02
199	2	4-958		31-Dec-90	0.03	0.02	0.02
200	3	4-958		15-Aug-90	0.00	0.00	0.00
201	4	4-958		04-Sep-91	0.00	0.00	0.00
202	5	4-958		03-Oct-91	0.00	0.00	0.00
203	6	4-958		08-Oct-91	0.02	0.02	0.02
204	7	4-958		25-Nov-91	0.03	0.02	0.02

T SUM NO.	ST SUM NO.	STATION No.	Name	DATE	< MEASURED W.LEVEL (m)	DIS. (a) (m3/s)	VELO. (m/s) >
205	1	5-030	EXCHANGE FARM	09-Feb-90	0.74	1.50	0.32
206	2	5-030		17-Jul-90	0.20	0.02	0.01
207	3	5-030		31-Dec-90	0.12	0.05	0.02
208	4	5-030		22-Jan-91	0.62	0.89	0.21
209	5	5-030		02-Feb-91	0.37	0.31	0.12
210	6	5-030		21-Feb-91	0.28	0.23	0.09
211	7	5-030		05-Sep-91	0.06	0.13	0.07
212	8	5-030		09-Oct-91	0.02	0.04	0.03
213	9	5-030		22-Nov-91	0.03	0.07	0.05
214	1	5-940	LUANGWA BRIDGE	09-Jul-90	2.62	117.72	0.66
215	2	5-940		08-Aug-90	2.42	72.72	0.61
216	3	5-940		18-Sep-90	2.12	38.75	0.53
217	4	5-940		12-Oct-90	2.03	34.30	0.51
218	5	5-940		30-Nov-90	2.01	47.81	0.57
219	6	5-940		18-Jan-91	5.57	1105.39	1.27
220	7	5-940		28-Feb-91	4.05	452.47	0.95
221	8	5-940		30-Jul-91	2.32	52.67	0.52
222	9	5-940		18-Sep-91	2.04	23.45	0.42
223	10	5-940		26-Sep-91	1.86	18.94	0.47
224	11	5-940		02-Oct-91	1.79	32.36	0.61
225	12	5-940		18-Nov-91	1.87	33.04	0.62