

**Project for the Improvement of
Water Supply, Sewerage and Drainage System
in Yangon City**

Final Report

**Volume III
Water Supply System Master Plan**

Appendix

Appendix

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A. HOUSEHOLDS INTERVIEW SURVEY

Table A.1 No. of Samples for Household Interview Survey

Township	Area (sq.mile)	Population	Household	No. of Samples	Sample Rate (%)	No. of Wards	HIS Zone	
Latha	0.31	34,125	5,368	66	1.2	10	A	CBD
Lanmadaw	0.54	43,137	7,334	89	1.2	12		
Pabedan	0.28	37,551	5,366	66	1.2	11		
Kyauktada	0.28	34,797	6,078	74	1.2	9		
Botahtaung	0.96	49,134	8,148	99	1.2	10		
Pazuntaung	0.39	53,648	8,258	101	1.2	9		
CBD Area	2.76	252,392	40,552	495	1.2	61		
Ahlonge	1.04	65,510	9,021	90	1.0	11	B	Inner Urban West
Kyeemyindaing	4.81	115,841	20,215	202	1.0	22		
Sanchaung	0.96	105,208	17,242	212	1.2	18		
Dagon	1.96	24,492	3,682	37	1.0	5		
Bahan	3.41	100,695	16,339	163	1.0	22	C	Inner Urban North
Tarmwe	1.71	191,114	32,505	393	1.2	20		
Mingalar Taung Nyunt	1.96	155,767	22,732	275	1.2	20	D	Inner Urban East
Seikkan	6.41	2,241	433	5	1.2	3	B	Inner Urban West
Dawbon	1.47	87,284	13,603	136	1.0	14	D	Inner Urban East
Inner City	23.73	848,152	135,772	1,513	1.1	135		
Kamaryut	2.40	87,881	13,663	137	1.0	10	E	Outer Ring West
Hlaing	5.26	151,014	25,969	260	1.0	16		
Yankin	1.94	125,909	13,921	139	1.0	16	F	Outer Ring East
Thingangyun	4.40	231,621	35,335	353	1.0	39		
Outer City	14.00	596,425	88,888	889	1.0	81		
Mayangone	9.78	205,403	33,738	337	1.0	10	G	Older Suburb Middle
Insein	13.52	311,200	53,324	533	1.0	21	H	Suburb North West
Mingalardon	43.57	288,858	48,896	489	1.0	32	I	Suburb North
North Okkalapa	10.32	333,484	57,101	571	1.0	19	J	Older Suburb North
South Okkalapa	3.93	191,388	33,800	338	1.0	13	G	Older Suburb Middle
Thaketa	4.93	253,284	43,076	431	1.0	19	K	Older Suburb South
Dala	3.90	181,087	31,192	312	1.0	46	L	South of CBD
Seik gyi Kha Naung To	2.27	38,425	6,804	68	1.0	9		
Old Suburbs	92.22	1,803,129	307,931	3,079	1.0	169		
Shwe Pyi Thar	25.76	295,993	38,636	386	1.0	27	M	New Suburb West
Hlaing Thar Yar	26.32	488,768	73,668	737	1.0	29		
North Dagon	23.27	221,200	36,919	369	1.0	27	N	New Suburb East
South Dagon	30.55	370,403	58,779	588	1.0	39	O	New Suburb South
East Dagon	35.15	145,505	22,734	227	1.0	60	N	New Suburb East
Dagon Seikkan	32.97	120,161	21,741	217	1.0	48	O	New Suburb South
New Suburbs	174.02	1,642,030	252,477	2,524	1.0	230		
Kyauktan*		48,473	11,615	200	1.7	13	P	Outer Suburb South
Thanlyin*		181,959	38,863	500	1.3	36		
Hlegu*		50,793	11,642	200	1.7	14	Q	Outer Suburb North East
Hmawbi*		83,719	17,697	300	1.7	18		
Htantabin*		40,234	9,200	150	1.6	18	R	Outer Suburb West
Twantay*		24,936	5,198	150	2.9	10		
Periphery Area		395,760	86,436	1,500	1.7	109		
Total in Study Area		5,537,888	912,056	10,000	1.1	785		

* The population and the number of households in Adjoining Areas are sourced from Population by Ward reported to Township Office as of July 2012

Source: JICA Urban Plan Study, 2012

Table A.2 Q47i Source of Water by Purpose

			Source of Water by Purpose									
			Piped Water Supply System by YCDC	Public Well/Tap	Private Tube Well	Neighbors' Well/Tap (Free of Charge)	Bottled Water	Water Vender	Rain/Creek/Canal/Pond	None	No Answer	Total
No.	For Drinking	Main Source	1,209	169	1,700	528	4,517	709	1,212	21	4	10,069
		Supplemental Source (Multiple Choice: 2)	6	9	31	15	44	39	72	10,040	0	10,256
	For Other Uses	Main Source	3,370	236	3,738	900	12	873	899	41	0	10,069
		Supplemental Source (Multiple Choice: 2)	19	10	93	23	6	63	25	10,024	0	10,263
% of Total	For Drinking	Main Source	12.0	1.7	16.9	5.2	44.9	7.0	12.0	0.2	0.0	100.0
		Supplemental Source (Multiple Choice: 2)	0.1	0.1	0.3	0.1	0.4	0.4	0.7	97.9	0.0	100.0
	For Other Use	Main Source	33.5	2.3	37.1	8.9	0.1	8.7	8.9	0.4	0.0	100.0
		Supplemental Source (Multiple Choice: 2)	0.2	0.1	0.9	0.2	0.1	0.6	0.2	97.7	0.0	100.0

Table A.3 Q47ii Expenditure by Purpose

		For Drinking	For Other Use
Main Source	No. of Household who Answered	5,567	5,376
	Maximum	150,000	270,000
	Minimum	0	0
	Average	5,636	4,477
	Median	1,200	700
Supplemental Source (Multiple Choice: 2)	Number of Household who Answered	77	116
	Maximum	90,000	36,000
	Minimum	0	0
	Average	3,997	6,102
	Median	0	0

Table A.4 Q48a: Payment Mode, To Whom Answered "Piped Water Supply System by YCDC" to Q47

	Payment Mode			
	Flat Rate	Metered	No Answer	Total
No.	1,041	1,790	570	3,401
%	30.6%	52.6%	16.8%	100.0%

Table A.5 Q48b: Ownership of Meter, To Whom Answered "Piped Water Supply System by YCDC" to Q47

	Ownership of Meter			
	Yes	No	No Answer	Total
No.	2,132	702	567	3,401
%	62.7%	20.6%	16.7%	100.0%

Table A.6 Q48b: Operationality of Meter, To Whom Answered "Piped Water Supply System by YCDC" to Q47

	Operationality of Meter			
	Yes	No	No Answer	Total
No.	2,003	125	4	2,132
%	93.9%	5.9%	0.2%	100.0%

Table A.7 Q48d: Duration of Water Supply Hour (Hours), To Whom Answered "Piped Water Supply System by YCDC" to Q47

	Duration of Water Supply Hour (Hours)						
	Less than 3	4 ~ 6	7 ~ 12	13 ~ 18	19 ~ 24	No Answer	Total
No.	1,223	334	321	144	809	570	3,401
%	36.0%	9.8%	9.4%	4.2%	23.8%	16.8%	100.0%

Table A.8 Q48e: Usage of Water Pump Tank, To Whom Answered "Piped Water Supply System by YCDC" to Q47

	Usage of Water Pump Tank			
	Yes	No	No Answer	Total
No.	1,342	1,492	567	3,401
%	39.5%	43.9%	16.7%	100.0%

Table A.9 Q48f: Average Water Consumption (Gallon), To Whom Answered "Piped Water Supply System by YCDC" in Q47

	Average Water Consumption (Gallon)							
	Less than 50	51 ~ 100	101 ~ 200	201 ~ 300	301 ~ 400	More than 400	No Answer	Total
No.	580	1,344	608	183	71	48	567	3,401
%	17.1%	39.5%	17.9%	5.4%	2.1%	1.4%	16.7%	100.0%

Table A.10 Q48g: Satisfaction of Current Service Level of Water, To Whom Answered "Piped Water Supply System by YCDC" to Q47

Satisfaction of Current Service Level of Water								
		Highly Unsatisfied	Unsatisfied	So-so	Satisfied	Highly Satisfied	No Answer	Total
Number	Water Pressure	48	476	773	1,520	9	575	3,401
	Hours of Supply	51	515	693	1,540	36	566	3,401
	Water Quantity	30	346	777	1,664	17	567	3,401
	Water Quality	80	673	573	1,479	30	566	3,401
	Price	30	186	1,015	1,547	42	581	3,401
% of Total	Water Pressure	1.4%	14.0%	22.7%	44.7%	0.3%	16.9%	100.0%
	Hours of Supply	1.5%	15.1%	20.4%	45.3%	1.1%	16.6%	100.0%
	Water Quantity	0.9%	10.2%	22.8%	48.9%	0.5%	16.7%	100.0%
	Water Quality	2.4%	19.8%	16.8%	43.5%	0.9%	16.6%	100.0%
	Price	0.9%	5.5%	29.8%	45.5%	1.2%	17.1%	100.0%

Table A.11 Q48h: Reason of Non Satisfaction to Water Quality, To Whom Answered "Highly

Unsatisfied" or "Unsatisfied" for Water Quality in Q48g

	Reason of Non Satisfaction to Water Quality						Total
	Color	Turbidity	Odor	Taste	Unsanitized	No Answer	
No.	127	255	88	16	242	773	1,501
%	8.5%	17.0%	5.9%	1.1%	16.1%	51.5%	100.0%
%	17.4%	35.0%	12.1%	2.2%	33.2%		

Table A.12 Q49a: Time to Walk to Water Source (Minutes), To Whom Answered Not Connected "Piped Water Supply System by YCDC" in Q47

	Time to Walk to Water Source (Minutes)							No Answer	Total
	None	Less than 5	6 ~ 10	11 ~ 15	16 ~ 20	21 ~ 30	More than 30		
No.	4,958	1,171	346	90	74	3	19	42	6,703
%	74.0%	17.5%	5.2%	1.3%	1.1%	0.0%	0.3%	0.6%	100.0%

Table A.13 Q49b: Frequency of Draw Water (Times), To Whom Answered Not Connected "Piped Water Supply System by YCDC" in Q47

	Frequency of Draw Water (Times)								Total
	None	1	2 ~ 3	4 ~ 5	6 ~ 7	8 ~ 9	More than 10	No Answer	
No.	4,695	251	461	227	223	144	672	30	6,703
%	70.0%	3.7%	6.9%	3.4%	3.3%	2.1%	10.0%	0.4%	100.0%

Table A.14 Q49c: Type of Container, To Whom Answered Not Connected "Piped Water Supply System by YCDC" in Q47

	Type of Container						No Answer	Total
	Bucket	Water Bag	Polly-tank	Piped	Others			
No.	1,815	7	136	4,542	169		34	6,703
%	27.1%	0.1%	2.0%	67.8%	2.5%		0.5%	100.0%

Table A.15 Q49d: Water Volume per 1 Time Drawing (Gallon), To Whom Answered Not Connected "Piped Water Supply System by YCDC" in Q47

	Water Volume per 1 Time Drawing (Gallon)						No Answer	Total
	Less than 10	11 ~ 20	21 ~ 30	31 ~ 40	More than 40			
No.	6,167	11	19	32	340		134	6,703
%	92.0%	0.2%	0.3%	0.5%	5.1%		2.0%	100.0%

Table A.16 Q49e: Average Water Consumption (Gallon), To Whom Answered Not Connected "Piped Water Supply System by YCDC" in Q47

	Average Water Consumption (Gallon)							Total
	Less than 50	51 ~ 100	101 ~ 200	201 ~ 300	301 ~ 400	More than 400	No Answer	
No.	1,813	3,190	1,198	277	110	74	41	6,703
%	27.0%	47.6%	17.9%	4.1%	1.6%	1.1%	0.6%	100.0%

Table A.17 Q49f: Satisfaction of Current Service Level of Water, To Whom Answered Not Connected "Piped Water Supply System by YCDC" in Q47

		Satisfaction of Current Service Level of Water						Total
		Highly Unsatisfied	Unsatisfied	So-so	Satisfied	Highly Satisfied	No Answer	
Number	Water Quantity	17	307	1,069	5,145	132	33	6,703
	Water Quality	36	927	825	4,720	153	43	6,704
	Price	12	266	1,704	4,117	270	335	6,704
	Access to Water	36	332	947	5,150	178	61	6,704
% of Total	Water Quantity	0.3%	4.6%	15.9%	76.8%	2.0%	0.5%	100.0%
	Water Quality	0.5%	13.8%	12.3%	70.4%	2.3%	0.6%	100.0%
	Price	0.2%	4.0%	25.4%	61.4%	4.0%	5.0%	100.0%
	Access to Water	0.5%	5.0%	14.1%	76.8%	2.7%	0.9%	100.0%

Table A.18 Q49g: Reason of Non Satisfaction to Water Quality, To Whom Answered Not Connected "Piped Water Supply System by YCDC" in Q47

	Reason of Non Satisfaction to Water Quality						Total
	Color	Turbidity	Odor	Taste	Unsanitized	No Answer	
No.	244	118	136	233	143	104	978
%	24.9%	12.1%	13.9%	23.8%	14.6%	10.6%	100.0%
%	27.9%	13.5%	15.6%	26.7%	16.4%		

Table A.19 Q50: Ideal Water Consumption Volume (Times)

	Ideal Water Consumption Volume (Times)							Total
	1.0	1.25	1.5	2.0	3.0	More than 3.0	No Answer	
No.	7,432	778	424	1,125	131	178	1	10,069
%	73.8%	7.7%	4.2%	11.2%	1.3%	1.8%	0.0%	100.0%

Table A.20 Q51: Treatment of Drinking Water

	Treatment of Drinking Water							Total
	Boiled	Filtered	Boiled and Filtered	Buy Mineral Water	No Treatment	Purification Equipment	No Answer	
No.	417	4,111	785	4,500	47	208	1	10,069
%	4.1%	40.8%	7.8%	44.7%	0.5%	2.1%	0.0%	100.0%

Table A.21 Q52: Water-borne Disease

		Water-borne Disease			
		Yes	No	No Answer	Total
Number	Diarrhea	141	9,927	1	10,069
	Dysentery	61	10,007	1	10,069
	Cholera	6	10,062	1	10,069
	Infectious Hepatitis	15	10,053	1	10,069
	Typhoid or Paratyphoid	10	10,058	1	10,069
	Malaria	8	10,060	1	10,069
	Dengue Fever	42	10,026	1	10,069
	Others	38	10,020	11	10,069
% of Total	Diarrhea	1.4%	98.6%	0.0%	100.0%
	Dysentery	0.6%	99.4%	0.0%	100.0%
	Cholera	0.1%	99.9%	0.0%	100.0%
	Infectious Hepatitis	0.1%	99.8%	0.0%	100.0%
	Typhoid or Paratyphoid	0.1%	99.9%	0.0%	100.0%
	Malaria	0.1%	99.9%	0.0%	100.0%
	Dengue Fever	0.4%	99.6%	0.0%	100.0%
	Others	0.4%	99.5%	0.1%	100.0%

Table A.22 Q53: Frequency of Infection

	Frequency of Infection						Total
	1	2 ~ 5	6 ~ 10	11 ~ 20	More than 20	No Answer	
No.	121	109	7	1	1	1,391	1,630
%	7.4%	6.7%	0.4%	0.1%	0.1%	85.3%	100.0%

Table A.23 Q54: Willingness to Pay for Water Services (kyat/month)

		Willingness to Pay for Water Services (kyat/month)								Total
		Less than 500	501 ~ 1,000	1,001 ~ 2,000	2,001 ~ 3,000	3,001 ~ 5,000	5,001 ~ 7,000	More than 7,000	No Answer	
Number	For 24 Hours' Water Supply (Untreated)	2,680	2,737	1,461	1,124	692	143	1,231	1	10,069
	For 24 Hours' Drinkable Water Supply	2,279	2,191	1,557	1,221	1,040	264	1,516	1	10,069
% of Total	For 24 Hours' Water Supply (Untreated)	26.6%	27.2%	14.5%	11.2%	6.9%	1.4%	12.2%	0.0%	100.0%
	For 24 Hours' Drinkable Water Supply	22.6%	21.8%	15.5%	12.1%	10.3%	2.6%	15.1%	0.0%	100.0%

B. WATER SOURCE SURVEY

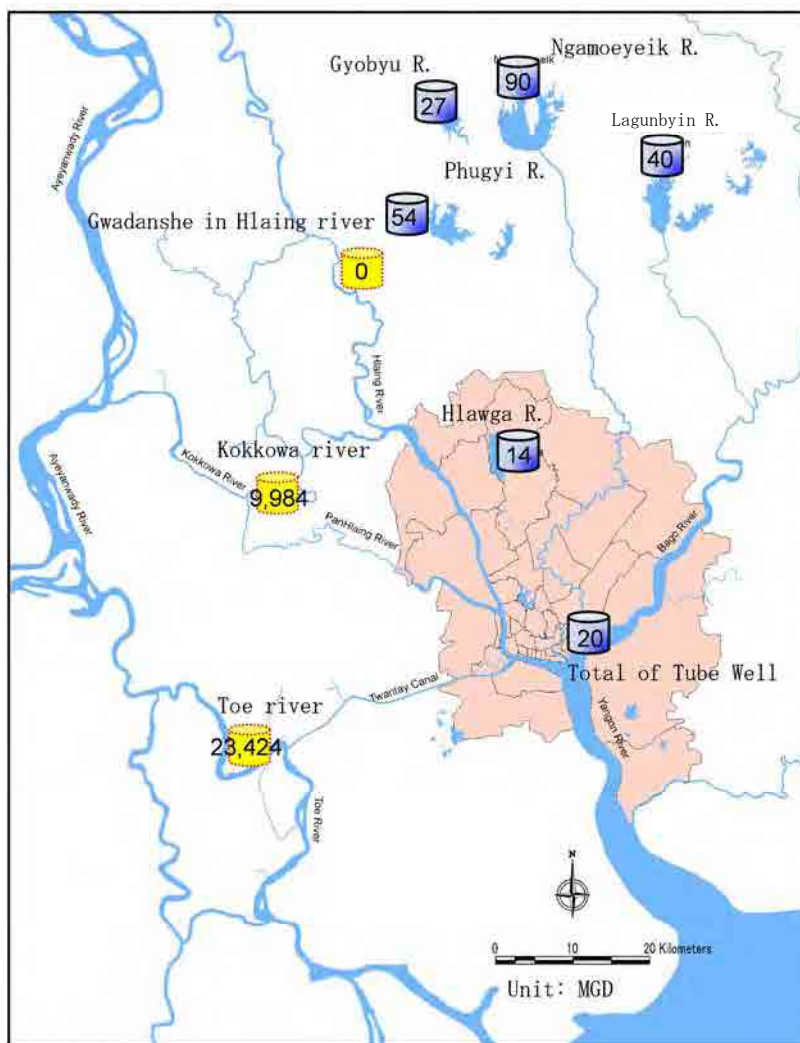
1. Development of Potential Surface Water (Reservoir and River)

Table B.1 shows the list of water supply sources while Figure B.1 shows the map of water sources around Yangon City. The current water supply source of 215 MGD (977,400 m³/day) are utilized continually. To meet future increased water demand, the potential of Kokkowa river and Toe river as new sources of water are studied. The existing ground water source (20 MGD) shall be gradually abolished after the development of river water source and distribution facilities.

Table B.1 List of Water Supply Sources

Name	Water Supply Volume	
	m ³ /day	MGD
1) Existing Water Resource		
Gyobyu Reservoir (Surface water)	121,500	27
Hpugyi Reservoir (Surface water)	243,000	54
Hlawgar Reservoir (Surface water)	63,000	14
Ngamoeyeik (Surface water: First + Second Phase)	405,000	90
Sub-Total	832,500	185
2) Planned Water Resource		
Lagunbyin Reservoir (Surface water)	135,000	30
Total-Existing fixed sources	977,400	215
3) Required river source		
Kokkowa River		
Toe River	1,909,300	420
Total 1) + 2) + 3)	2,886,700	635

Source: JICA Study Team



Source: JICA Study Team

Figure B.1 Map of Water Resource for Water Supply around Yangon City

2. Evaluation of Existing Reservoirs

In 2002 JICA-M/P study, the water balance study was carried out for Gyobyu, Phugyi, Hlawga, and Ngamoeyeik reservoirs (drinking water sources) and Lagunbyin reservoir (an exclusive irrigation reservoir). The simulation period was adopted as the last six years (May 1995–December 2000) with a 10-year return period, which covers the severe drought year of 1998. Table B.2 shows the results of analysis of the water balance study in the 2002 JICA study. The capacity of the current reservoir for water supply was recognized as 868,600 m³/day (186.5 MGD) approximately, on condition of maintaining the low water level in each reservoir during the drought year. In addition, it was analyzed that Lagunbyin reservoir will enable to divert 10 MGD for drinking water source.

Table B.2 Results of Reservoir Water Balance Study

Name	Low Water level Unit: ft	Water Supply Unit: m ³ /day (MGD)
Gyobyu Reservoir	138.0	118,300 (27.0)
Hpugyi Reservoir	90.0	245,700 (54.0)
Hlawgar Reservoir	47.0	75,075 (16.5)
Ngamoeyeik (First + Second stage)	81.0	409,500 (90.0)
Lagunbyin Reservoir	46.0	45,000 (10.0)

Source: JICA Study Team

To evaluate the results of water balance study in the 2002 JICA survey, an examination was made for the applicability of the 2002 JICA survey to the existing conditions based on comparing the rainfall data of the previous study with the recent rainfall data. The methods of evaluation are summarized below.

a. Long term fluctuation

The rainfall data used in the 2002 JICA survey rainfall data was compared with the rainfall data of years from 2001 to 2010. As a result of comparison, it is observed that the average rainfall in 2001 to 2010 was higher than the average rainfall in 1965 to 2000. It was also found out that little rainfall during 2001-2010 has not been renewed from any observatories.

b. Non-exceedance probability

In the 2002 JICA study, the probability by annual rainfall has been studied using the rainfall from January to December in Bago, Tharrawaddy, and Kaba Aye. Table B.3 shows the non-exceedance probability of annual rainfall at these stations as estimated by Gumbel's Minimum Values method.

Table B.3 List of Non-Exceedance Probability Annual Rainfall

Station Name	2 years	5 years	10 years	20 years	50 years	100 years	Number of Records
Bago	3,284.9	2,922.3	2,740.0	2,598.7	2,454.5	2,369.3	36
Tharrawaddy	2,206.1	1,963.4	1,829.9	1,719.1	1,597.1	1,519.2	36
Kaba Aye	2,680.7	2,413.8	2,296.5	2,214.5	2,139.7	2,100.4	33

Source: 2002 JICA Study

Table B.4 shows the list of non-exceedance probability estimation by the latest annual rainfall from 2001 to 2010. There are no large differences in the past ten years for non-exceedance probability rainfall in each station, and no changes in water trend were also determined.

Table B.4 List of Non-Exceedance Probability Annual Rainfall from 2001 to 2010

Station Name	2 years	5 years	10 years
Bago	3,386.0	2,854.0	2,513.0
Tharrawady	2,165.0	1,847.0	1,831.0
Kaba Aye	2,757.0	2,478.0	2,315.0

Source: JICA Study Team

The results of water balance study in the 2002 JICA Survey (Table B.2) enabled the utilization of the current surface water supply sources (Table B.1).

3. Evaluation of Potential Water Sources

3.1 Water Flow Measurement Survey

Hlaing (Gwedanshe), Kokkowa, and Toe rivers were initially considered as potential water sources. Bago River was not considered because it has relatively low water availability according to the 2002 JICA survey. Available amounts of water intake from these water sources depend highly on the river flow from January to April which is lowest during dry season. From the river flow data in Hlaing and Bago rivers, the minimum flow is dropping to approximately one-hundredth of the maximum value.

Currently, no water flow but water level is monitored for both rivers. To convert the water level to water flow, the JICA Study team requested MOAI to measure flow rate and cross section of the rivers. The MOAI carried out the measurement in November 2012 in Kokkowa river and in December 2012 in Toe river. Also, to measure the minimum flow rate, measurement was made in March 2013 in both rivers. In addition, planned irrigation plans were confirmed with MOAI. The following are measurement results.

River	Flow rate (Date)	
	2012	2013
Kokkowa	1,941m ³ /s(24 Nov.)	1,233 m ³ /s (20 Mar.)
Toe	2,572m ³ /s(11 Dec.)	1,930m ³ /s (18 Mar.)

Source: MOAI

3.2 River Maintenance Flow

While planning water intake from the river, maintenance of minimum flow is considered taking into account the protection of nearby flora and fauna, fishing, and landscape. The definition of normal flow is combined with the maintenance flow, viable water source amount, flow discharge for maintaining normal flow functions of water, and target flow discharge on the management of low water level through the year.

Maintenance flow is the part of flow in river which cannot be utilized as water available for intake from the source. Following its characteristic, it is necessary to assess the distinction of each river and season in terms of fishing, landscape, and saltwater intrusion. However, the available information is insufficient to determine the ideal maintenance flow in this study. In response to this situation, maintenance flow is assumed to be half of the 10-year minimum drought discharge as referred to the Japanese manual. In the case of Japan, there was a tendency where the maintenance flow was between the 10-year average drought discharge and the 10-year minimum drought discharge. Though the characteristics of rivers in Yangon is very different from the rivers in Japan, it is assumed that: 1) Water levels in target rivers use a minimum value in daily fluctuations, and 2) the characteristic of river flow is applicable to its maintenance flow which is lower than the 10-year minimum drought discharge.

The 10-year average drought discharge in the Kokkowa River was estimated using the following processes presented below, as well as the background of available amounts of direct river intake.

Table B.5 Estimation of 10-year Minimum Drought Discharge in the Kokkowa River

Process	Subject	Remarks
A	Set of Basic Condition (River Cross Section of Target River)	Refer: Actual river cross section
B	Set of Basic Condition (Characteristics of Minimum Rainfall over the Past 10 years)	Target year: 2001-2010
C	Set of Cross Section Area (A) and Velocity (V) in 10-year minimum drought discharge	Refer: Measurement of river flow discharge on site
D	Calculation of 10-year minimum drought discharge (Q)	$Q = A \times V$

Source: JICA Study Team

3.3 Water Source Evaluation

3.3.1 Hlaing River (Gwedanshe)

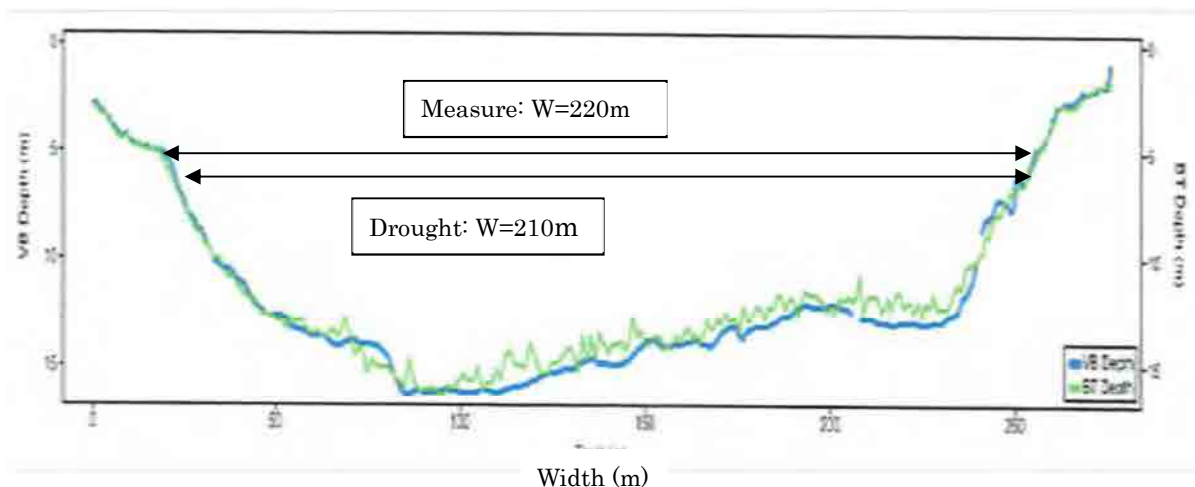
Hlaing River's flow (10-year average drought discharge) in the dry season was applied as 11.4 m³/s, the data for Gwedanshe. This is same as the considerations made in the 2002 JICA survey for rainfall from 2001 to 2010. However, the possibility of the Hlaing River's direct water intake in the dry season does not exist. The current water intake facilities for irrigation (2.287 m³/s,) were confirmed near the intake point and alternative irrigation projects (4.67 m³/s, 89.64 MGD) as reported by the MOAI. The maintenance flow in this river, assumed to be 4.0 m³/s, was considered.

3.3.2 Kokkowa River

a. Set of Basic Condition (River Cross Section of Target River)

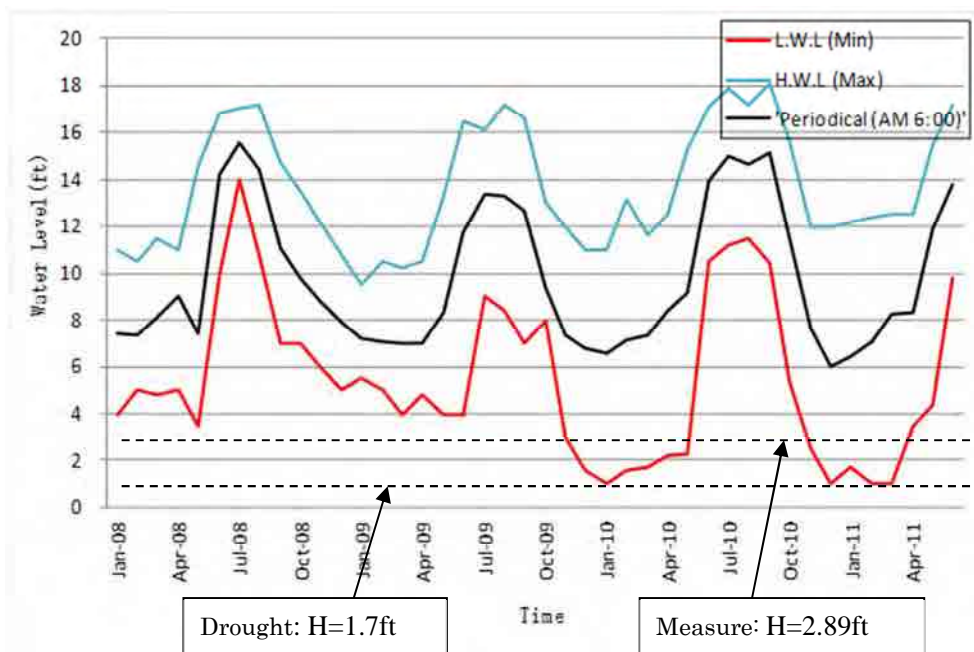
Figure B.2 shows the river cross section of Kokkowa River, which was obtained from the MOAI. The

cross section area was approximately 2,170 m² at a water level of 2.89 ft in the river which was close to the minimum water level in the past



Source: MOAI

Figure B.2 Cross Section at Pan Taing in Kokkowa River



Source: JICA Study Team based on MOAI Data

Figure B.3 Water Level at Pan Taing, Kokkowa River (2008 – 2011)

b. Set of Basic Condition (Characteristics of Minimum Rainfall over the Past 10 years)

The annual minimum rainfall occurred in 2010 during the period of 2001-2010. Table B.6 shows the water level changes from January 2008 to August 2011 (including 2010) in Kokkowa River. Maximum water level (rainy season) was 18.0 ft, the 355th day water level was 1.7 ft and the minimum water level (dry season) was 1.0 ft. The low water level in 2010 was the lowest. So, the 10-year minimum drought flow is assumed to occur in 2010, when the minimum rainfall occurred over the past ten years.

Table B.6 Water Level in Kokkowa River (FY 2008-2011)

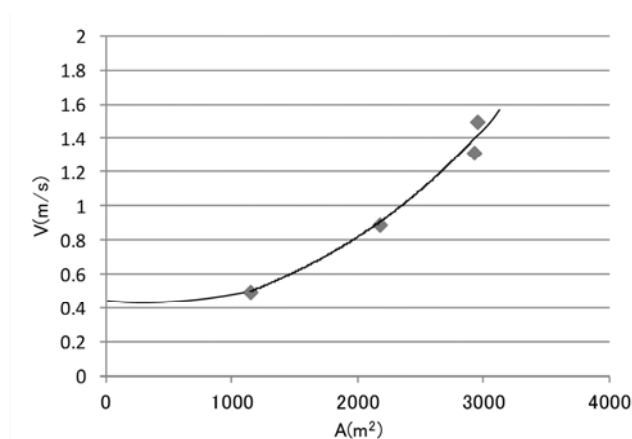
	Max	95 th day	185 th day	275 th day	355 th day	Min	Mean
FY 2008	17.2	10.0	8.0	6.2	4.5	3.5	8.8
FY 2009	17.2	10.3	7.0	5.8	4.0	3.0	8.0
FY 2010	18.1	12.2	6.0	3.6	1.7	1.0	7.6
FY 2011*	17.2	12.2	7.2	4.5	1.2	1.0	8.1

*FY2011: August 2010 – July 2011

Source: JICA Study Team

c. Set of Cross Section Area (A) and Velocity (V) for 10-year minimum drought discharge

- Water level in case of the 10-year minimum drought discharge was assumed as 1.7 ft. from the above.
- River width in case of the 10-year minimum drought discharge was assumed as 210 m.
- The cross-sectional area in case of the 10-year minimum drought discharge was assumed as 780 m², ($A = \frac{W^2}{2} - H(2.89 - 1.7) \text{ft} \times W(210 + 220) \text{m} / 2$)
- Flow rate of the 10-year minimum drought discharge is shown as the relationship between the cross-sectional area (A) and the velocity (V) (see Figure B.4) taken from the results of the cross-sectional survey in Figure B.2. Thus, the flow rate in the dry season was assumed as 0.5 m/s which is about one-third of the HWL during rainy season.



Source: JICA Survey Team

Figure B.4 Relation Between the Cross Section (A) and Velocity (V) of Kokkowa River

d. Calculation of the 10-Year Minimum Drought Discharge

$$\begin{cases}
 Q_{\min K} = A \times V \doteq 1,045 \text{ m}^3/\text{s} \\
 A = 2,090 \text{ m}^2: \text{ Cross-sectional area for the 10-year average drought discharge} \\
 V = 0.5 \text{ m/s}: \text{ Velocity for the 10-year average drought discharge}
 \end{cases}$$

e. Flow Measurement on 20 March 2013, the Drought Period

Flow was measured as 1,233m³/s at the water level of 0.23ft which is nearly the same as the estimated

value. Flow measured on 24 November 2012 was 1,941 m³/s at a water level of 2.89 ft.

f. Water Intake Amount for YCDC

Water amount available for YCDC is at least 520 m³/s, half of the 10-year minimum drought discharge, considering the river maintenance flow and water required for other irrigation projects of MOAI. Total of 153 MGD (12.0m³/s) water is planned for irrigation schemes according to MOAI, 10.12MGD for Pantaing Sluice (1), 52.85MGD for Pantaing Sluice (2), 47.98MGD for Khunnaingtang Sluice, and 42.47MGD for Chaungnyiako Sluice.

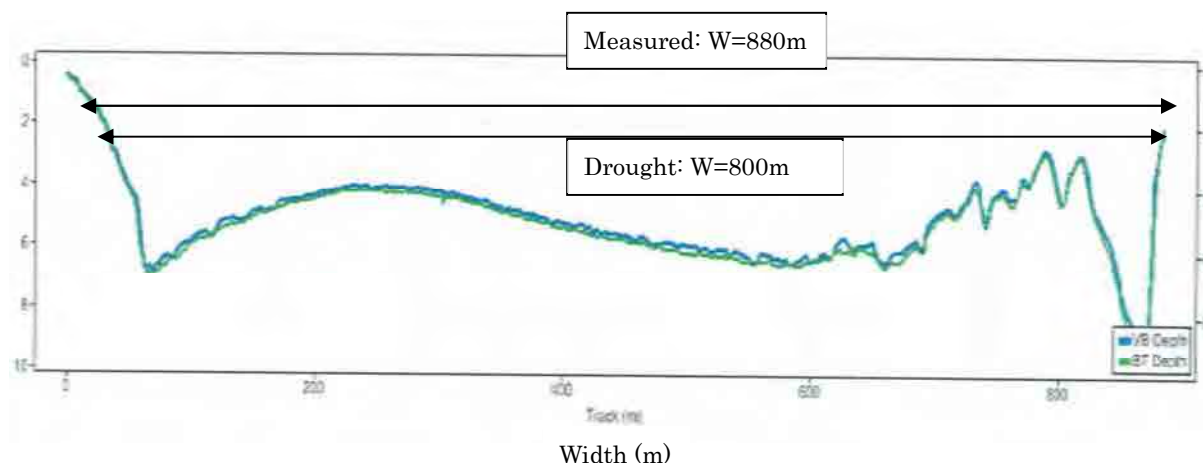
3.3.3 Toe River

The 10-year minimum drought discharge was estimated using the same process as used in case of the Kokkowa River.

Figure B.5 shows the river cross section of Kokkowa River, which was obtained from the MOAI. The underwater cross section area was approximately 2,170 m² at the water level of 2.89 ft which was close to the minimum water level in the past

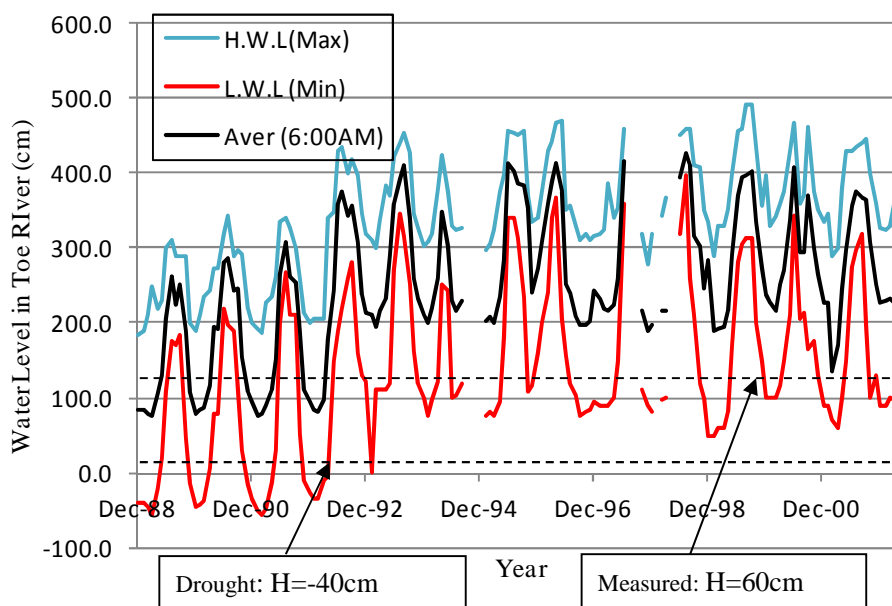
a. Set of Basic Condition (River Cross Section of Target River)

Figure B.5 shows the cross section at the proposed intake point in the Toe River measured on 11 December 2012. This cross section area was determined as 4,340 m² at the water level of 60 cm, which was almost the lowest water level.



Source: JICA Study Team

Figure B.5 Cross Section in Toe River



Source: JICA Study Team based on MOAI Data

Figure B.6 Water Level at Pann Hlaing, Toe River (1989-2002)

b. Set of Basic Condition (Minimum Drought Flow Discharge)

Ten-year drought flow is estimated assuming it occurred in 2010 same as in case of the Kokkowa River. However, water level data in 2010 was not available so that water level data continuously available (between January 1989 and April 2002, March 2011 and August 2012) was alternatively used.

- Water level data between January 1989 and April 2002 is shown in Table below. Water level data of 355th day and minimum was not estimated due to lack of data during dry period.
- The highest water levels in the years ranged from 354 to 486 cm while the lowest ranged from 80 to 300 cm according to the latest data (between March 2011 and August 2012). These levels are similar to the past records (January 1989 to April 2002). So all data were judged effective.
- The lowest and the 355th day water levels were -46 cm and -40cm, respectively, both in 1989 during period from January 1989 to April 2012. Thus, -46 cm water level was judged as a 10-year drought water level.

Figure B.7 Water Level in the Toe River (1989-2001 and 2011-2012)

	Max	95th day	185th day	275th day	355th day	Min	Mean
FY 1989	273	190	46	-20	-40	-46	77.1
FY 1990	312	216	84	-14	-38	-45	104.2
FY 1991	312	220	56	-18	-46	-56	101.1
FY 1992	386	296	160	0	-29	-34	158.6
FY 1993	426	292	178	127	113	100	221.1
FY 1994	314	127	105	--	--	--	153.9
FY 1995	430	344	186	92	--	--	234.1

unit : cm

	Max	95th day	185th day	275th day	355th day	Min	Mean
FY 1996	432	320	190	116	85	76	218.3
FY 1997	426	168	120	96	--	--	178.9
FY 1998	430	296	130	--	--	--	234.6
FY 1999	690	321	180	90	60	50	211.4
FY 2000	398	270	188	140	110	100	214.1
FY 2001	376	300	180	100	60	60	201.9

Source: JICA Study Team based on MOAI Data

c. Set of Cross Section Area (A) and Velocity (V) for 10-year minimum drought discharge

- Water level for the 10-year minimum drought discharge was lower by 1 m than the water level measured on 11 December 2012. Width is assumed as 800 m.
- The cross-sectional area for the 10-year minimum drought discharge was assumed as 4,080 m², ($A \doteq A'4,340 - H(0.6+0.4)ft \times W(880 + 850)m / 2$).
- The flow velocity of 0.6 m/s was measured on 11 December 2012 which is regarded as low flow discharge. So, this flow velocity is also the same as for 10-year drought flow.

d. Calculation of the 10-Year Minimum Drought Discharge

$$\left[\begin{array}{l} Q_{\min T} = A \times V \doteq 2,448 \text{ m}^3/\text{s} \\ A = 4,080 \text{ m}^2: \text{ Cross-sectional area in case of the 10-year drought discharge} \\ V = 0.6 \text{ m/s}: \text{ Velocity for the 10-year drought discharge} \end{array} \right.$$

e. Flow Measurement on 18 March 2013, the Drought Period

Flow was measured as 1,930 m³/s at a water level of 52 cm which is nearly the same as the above estimated value. Flow measured on 11 December 2012 was 2,573 m³/s at a water level of 60 cm.

f. Water Intake Amount for YCDC

Water amount available for YCDC is at least 1,220 m³/s, half of the 10-year minimum drought discharge, considering the river maintenance flow. There are no irrigation projects around here.

The followings are attached to Annex.

Flow measurement in Kokkowa river (10th August 2012, 30th November, 20th March 2013, MOAI)

Flow measurement in Toe river (30th November, 18th March 2013, MOAI)

ပြည်ထောင်စုသမ္မတမြန်မာနိုင်ငံတော်အစိုးရ
လယ်ယာစိုက်ပျိုးရေးနှင့်ဆည်မြောင်းဝန်ကြီးဌာန
ဆည်မြောင်းဦးစီးဌာန

ရန်ကုန်တိုင်းဒေသကြီး၊ ထန်းတပင်မြို့၊ ကုက္ကိုမြစ် နှင့်
ကတွယ်ကျွေ့ဖြတ်မြောင်းတွင် River Surveyor M9 ဖြင့်
မြစ်ရေစီးဆင်းမှု တိုင်းတာရရှိသည့် အစီရင်ခံစာ

လေ့လာရေးဌာနခွဲ
၂၀၁၂ ခုနှစ်၊ ဩဂုတ်လ (၁၃) ရက်

**ရန်ကုန်တိုင်းဒေသကြီး၊ ထန်းတပင်မြို့၊ ကုက္ကိုမြစ်နှင့် ကတွယ်ဖြတ်မြောင်းတွင်
(River Surveyor M9) ဖြင့် မြစ်ရေစီးဆင်းမှု တိုင်းတာရရှိသည့် အစီရင်ခံစာ**

၁။ နိဒါန်း

ကတွယ်ဖြတ်မြောင်းသည် ရန်ကုန်တိုင်းဒေသကြီး၊ ထန်းတပင်မြို့နယ်၊ အညာစုကျေးရွာ အနီးတွင် တည်ရှိ ပါသည်။ ပန်တိုင်ဒေါင့်ကြီးတာကတွယ်ကွေ့တွင် ကမ်းစားနှုန်းများပြားမှုကြောင့် ကတွယ်ဖြတ်မြောင်းအား ၁၉၉၄ ခုနှစ်တွင် ပေ (၃၀) အကျယ်၊ အနက် (၁၀) ပေ ဖြင့် စတင် ဖောက် လုပ်ခဲ့ပြီး ၁၉၉၆ ခုနှစ်တွင် ထပ်မံ၍ ပေ (၅၀) အထိ ရရှိရန် ချဲ့ခဲ့ပြီး ၁၉၉၉ ခုနှစ်မှ ၂၀၀၁ ခုနှစ်အထိ ရေလမ်းထိန်းသိမ်းရေးဌာနခွဲမှ သောင်တူးစက်များဖြင့် အနက်ရရှိအောင် ဆောင်ရွက်ခြင်းတို့ကို ဆောင်ရွက်ခဲ့ပါသည်။ ယခုအခါတွင် ဖြတ်မြောင်းမှာ ပိုမိုဖွံ့ဖြိုးမှုဖြစ်လာခဲ့ပြီး မြစ်ရေစီးဆင်းမှု ရေပမာဏ၏ အကျိုးသက်ရောက်မှု သိနိုင်ရန်အတွက် River Surveyor M9 ဖြင့် သွားရောက် တိုင်းတာခဲ့သည်ကို အစီရင်ခံစာ တင်ပြခြင်း ဖြစ်ပါသည်။

၂။ ခရီးစဉ်

ဇလဗေဒဌာနခွဲမှ လက်ထောက်ညွှန်ကြားရေးမှူးနှင့်အဖွဲ့သည် (၁၀.၈.၂၀၁၂)နေ့ နံနက် (၇:၃၀) နာရီတွင် ရန်ကုန်မှ ထွက်ခွာလာပြီး နံနက် (၉:၃၀) တွင် အညာစု ကျေးရွာအနီးသို့ ရောက်ရှိပါသည်။ နံနက်(၁၀:၀၀)နာရီတွင် ဖြတ်မြောင်း အပေါ်ဘက် ကုက္ကိုမြစ် (RD 7800') တွင်လည်းကောင်း၊ ကတွယ်ဖြတ်မြောင်းအလယ် (RD 12500 ft) နှင့် D/S ဘက် (RD 29600 ft) တွင်လည်းကောင်း၊ စသည့်နေရာများတွင် စက်လှေကို အသုံးပြုကာ (River Surveyor M9) ဖြင့် တိုင်းတာပါသည်။ ကုက္ကိုမြစ် နှင့် ကတွယ်မြစ်ဖြတ်မြောင်းတွင် တိုင်းတာခဲ့သည့် နေရာပြ မြေပုံကို (နောက်ဆက်တွဲ-၁) တွင် ဖော်ပြထားပါသည်။ နေ့လည် (၁:၀၀) နာရီတွင် တိုင်းတာမှုပြီးခဲ့ ပါသည်။

၃။ တိုင်းတာဆောင်ရွက်ခြင်း

ကုက္ကိုမြစ်၊ အညာစုကျေးရွာအနီးတွင် စက်လှေဘေးမှ M9 ကို ဝါးလုံးနှင့်ကြိုး အသုံးပြု၍ ဆွဲပြီး မြစ်ကို ဖြတ်ကာတိုင်းပါသည်။ မြစ်ရေစီးဆင်းမှုအလျင် (1.502 m/sec) (4.9 ပေ/စက္ကန့်) ခန့်သာရှိပြီး စက်လှေဖြင့် တိုင်းတာရာတွင် အဆင်ပြေပါသည်။ ၎င်းနောက် ကတွယ်ဖြတ်မြောင်း အတွင်းဘက် ဆင်းလာကာ (RD 12500 ft)ခန့်တွင် စက်လှေဖြင့် M9 ကို ဝါးလုံး/ကြိုးဖြင့် ဆွဲကာ ကန့်လန့်ဖြတ် တိုင်းတာပါသည်။ ရေစီးနှုန်းအလျင် (1.319 m/sec) (4.3 ပေ/စက္ကန့်) ရှိနေသဖြင့် ဖြတ်မြောင်းကို ကန့်လန့်ဖြတ် တိုင်းရာ၌ စက်လှေကို ရေစီးအရှိန်ဖြင့် မျောပါမသွားစေရန်

ထိန်းသိမ်းပြီး (၅၊ ၆) ကြိမ် တိုင်းတာနိုင်ခဲ့ပါသည်။ ဖြတ်မြောင်း D/S ဘက်ရှိ (RD 29600 ft) ခန့်တွင် ထပ်မံတိုင်းတာခဲ့ရာ မြစ်ရေစီးဆင်းမှုအလျင် (0.5 m/sec) (1.6 ပေ/စက္ကန့်)ခန့်ရှိပါသည်။
 ၄။ တိုင်းတာရရှိမှုရလဒ်သုံးသပ်ချက်

River Surveyor M9 ဖြင့် ဖြတ်မြောင်းအထက် ကုက္ကိုမြစ်၊ U/S (အညာစု ကျေးရွာ အနီး) (R.D 7800 ft) ၊ ကတွယ်ဖြတ်မြောင်းအတွင်း (R.D 12500 ft)၊ ဖြတ်မြောင်းအထက် (R.D 29600 ft)၊ စသည့် (၃)နေရာတွင် တိုင်းတာရရှိခဲ့သော အချက်အလက်များမှာ အောက်ပါ အတိုင်း ဖြစ်ပါသည်။

SR. No	Station	Width (m)	Area (m ²)	Mean Speed (m/s)	Total Discharge(Q) (m ³ /sec)	Total Discharge(Q) (ft ³ /sec)
1.	ကတွယ်ဖြတ်မြောင်းမဝင်မီ U/S ကုက္ကိုမြစ်၊အညာစုကျေးရွာအနီး (နောက်ဆက်တွဲ-၂)	259.72	2946.2	1.502	4423.886	156225.11
2.	ကတွယ်ဖြတ်မြောင်း (R.D 12500 ft) (နောက်ဆက်တွဲ-၄)	184.49	2920.5	1.319	3852.217	136037.19
3.	ကတွယ်ဖြတ်မြောင်းထွက် D/S (R.D 29600 ft) (နောက်ဆက်တွဲ-၆)	209.45	1141.8	0.5	570.758	20155.75

[မှတ်ချက်- ကတွယ်ဖြတ်မြောင်း၏ (၁၀.၈.၂၀၁၂) ရက်နေ့ရှိ ရေမှတ်သည် (၁၅) ပေ ဖြစ်ပါသည်။]

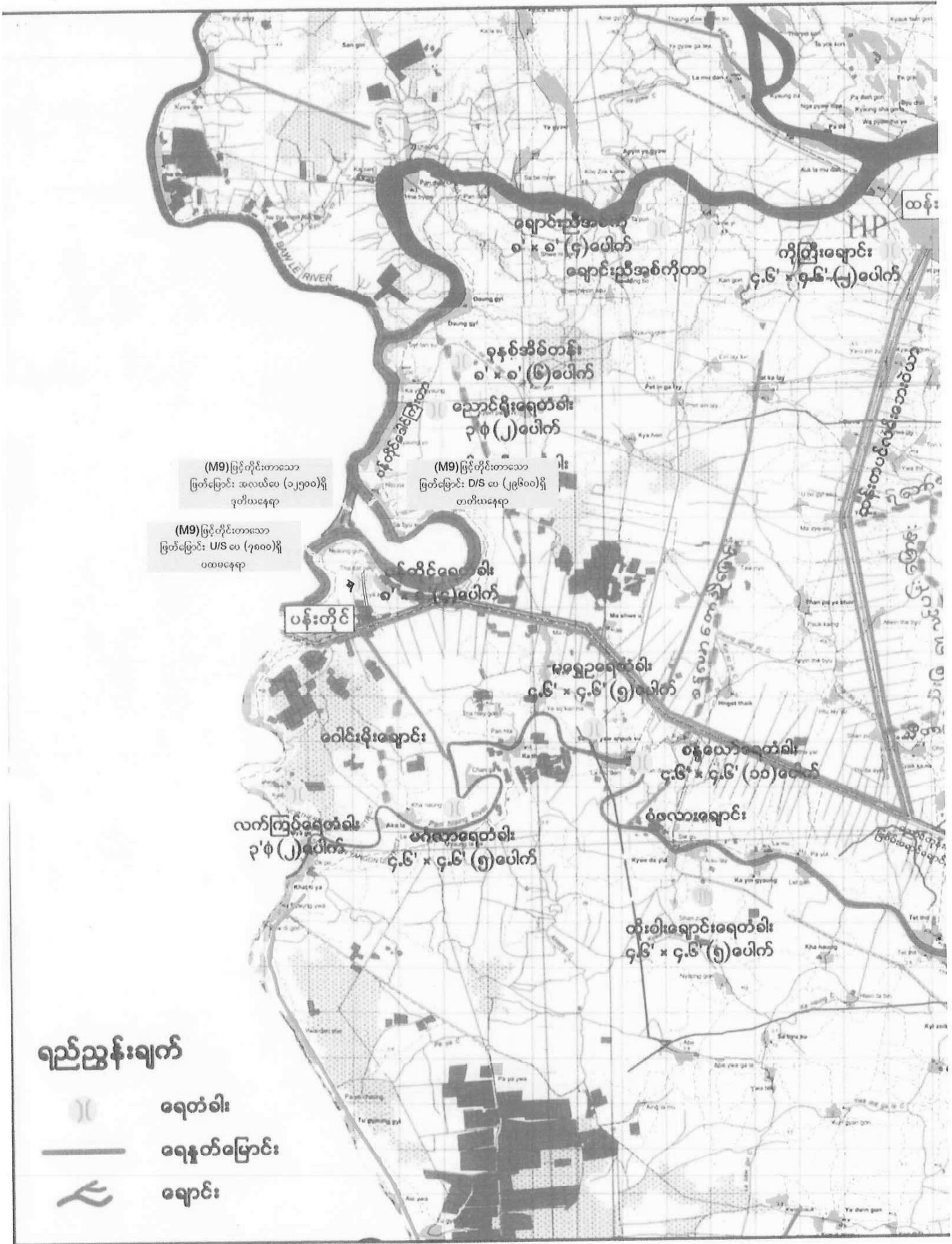
အထက်ပါ တိုင်းတာတွေ့ရှိချက်အရ ကတွယ်ဖြတ်မြောင်းထဲ မဝင်မီ ကုက္ကိုမြစ်၏ ရေ ထုထည်စီးနှုန်း(Q)သည် 4423.886≅4424 m³/sec ရှိပြီး ဖြတ်မြောင်းထဲတွင်ရှိ ရေထုထည် စီးနှုန်း(Q)သည် ပျမ်းမျှ 3852 m³/sec ရှိ၍ ဖြတ်မြောင်းအထက်၏ အထက်ဘက် ကုက္ကိုမြစ် D/S ဘက်နေရာတွင် 570.758≅571 m³/sec ရရှိပါသည်။ သို့ဖြစ်၍ ကတွယ်ဖြတ်မြောင်းသည် လက်ရှိ အခြေအနေအရ စီးဆင်းနေသည့် ကုက္ကိုမြစ်၏ (၈၇%) ဖြတ်သန်းစီးဆင်းနေကြောင်း တွေ့ရှိ သုံးသပ်ရပါသည်။

၅။ နိဂုံး

အထက်ဖော်ပြပါ တိုင်းတာတွေ့ရှိချက်များအရ ထန်းတပင်မြို့၊ ကတွယ်ဖြတ်မြောင်းတွင် ကုက္ကိုဝမြစ်၏ စီးဆင်းနေသည့် ရေစီးဆင်းမှု၏ ၈၇ ရာခိုင်နှုန်းသည် ဖြတ်မြောင်းအတွင်းသို့ စီးဆင်း ဖြတ်သန်းနေပါသဖြင့် Function ကောင်းကြောင်း သုံးသပ်တင်ပြ အစီရင်ခံအပ်ပါသည်။

ထန်းတပင်မြို့၊ ကုက္ကိုဝမြစ်၊ ကတွယ်ဖြတ်မြောင်းတွင် River Surveyor M9 ဖြင့် မြစ်ရေစီးဆင်းမှု တိုင်းတာရာတွင် လိုက်ပါသည့် အရာထမ်း၊ အမှုထမ်းများစာရင်း

စဉ်	အမည်	ရာထူး	ရုံးအမည်
၁။	ဒေါ်သန်းဝင်း	လက်ထောက်ညွှန်ကြားရေးမှူး	လ/ထညွှန်ကြားရေးမှူးရုံး၊ လေဗေဒဌာနခွဲ ဆည်မြောင်းဦးစီးဌာန၊ ရန်ကုန်မြို့
၂။	ဦးအောင်မြင့်	ဦးစီးအရာရှိ	။
၃။	ဦးသက်မောင်မောင်	ဦးစီးမှူး	။
၄။	ဦးစိန်လွင်	လ/ထ ဦးစီးမှူး	။
၅။	ဦးဆန်းလင်းမြင့်	လ/ထ ဦးစီးမှူး	။
၆။	ဒေါ်လွင်မာကြွယ်	လ/ထ ဦးစီးမှူး	။
၇။	ဒေါ်ဖြူနှင်းဆု	လ/ထ ဦးစီးမှူး	။



Discharge Measurement Summary

Date Measured: Friday, August 10, 2012

Site Information		Measurement Information	
Site Name	Kokkova River U/S	Party	Hydro SO4
Station Number	1	Boat/Motor	Boat
Location	Kathwekwe	Meas. Number	6

System Information		System Setup		Units	
System Type	RS-M9	Transducer Depth (m)	0.08	Distance	m
Serial Number	2365	Salinity (ppt)	0.0	Velocity	m/s
Firmware Version	2.00	Magnetic Declination (deg)	0.8	Area	m ²
Software Version	2.70			Discharge	m ³ /s
				Temperature	degC

Discharge Calculation Settings				Discharge Results	
Track Reference	Bottom-Track	Left Method	Sloped Bank	Width (m)	259.72
Depth Reference	Vertical Beam	Right Method	Sloped Bank	Area (m ²)	2,946.2
Coordinate System	ENU	Top Fit Type	Power Fit	Mean Speed (m/s)	1.502
		Bottom Fit Type	Power Fit	Total Q (m ³ /s)	4,423.886

Measurement Results																		
Tr	Time	Duration	Temp	Distance			Mean Vel			Discharge					%			
#	Time	Duration	Temp	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	MBTotal	Measured	
1	R 9:58:56 AM	0:08:08	27.4	291.21	233.70	250.70	2,925.8	0.597	1.505	1.33	0.39	254.45	3,264.18	882.32	4,402.658	--	74.1	
2	L 10:07:12 AM	0:07:05	27.5	278.73	243.06	260.06	2,933.2	0.656	1.549	0.96	1.08	255.74	3,335.39	951.54	4,544.709	--	73.4	
3	R 10:16:10 AM	0:17:26	27.6	295.87	246.71	263.71	2,992.4	0.283	1.441	0.23	0.27	241.98	3,175.53	893.01	4,311.013	--	73.7	
4	L 10:37:21 AM	0:05:22	27.7	273.51	245.48	262.48	2,930.4	0.849	1.538	0.00	0.31	255.19	3,319.56	932.75	4,507.817	--	73.6	
5	R 10:42:54 AM	0:05:33	27.7	261.61	244.13	261.13	3,028.6	0.786	1.432	0.90	0.52	237.43	3,179.85	918.55	4,337.257	--	73.3	
6	L 10:48:42 AM	0:07:19	27.7	360.27	243.25	260.25	2,866.5	0.821	1.549	-0.41	0.60	253.07	3,267.71	918.90	4,439.860	--	73.6	
			Mean	27.6	293.53	242.72	259.72	2,946.2	0.665	1.502	0.50	0.53	249.64	3,257.04	916.18	4,423.886	0.000	73.6
			Std Dev	0.1	31.90	4.23	4.23	51.8	0.193	0.049	0.61	0.27	7.20	61.66	23.17	84.255	0.000	0.3
			COV	0.0	0.109	0.017	0.016	0.018	0.290	0.033	1.212	0.516	0.029	0.019	0.025	0.019	0.000	0.004

Exposure Time: 0:50:53
 Tr1=20120810095857r.rivr; Tr2=20120810100712r.rivr; Tr3=20120810101609r.rivr; Tr4=20120810103720r.rivr; Tr5=20120810104253r.rivr; Tr6=20120810104841r.rivr;

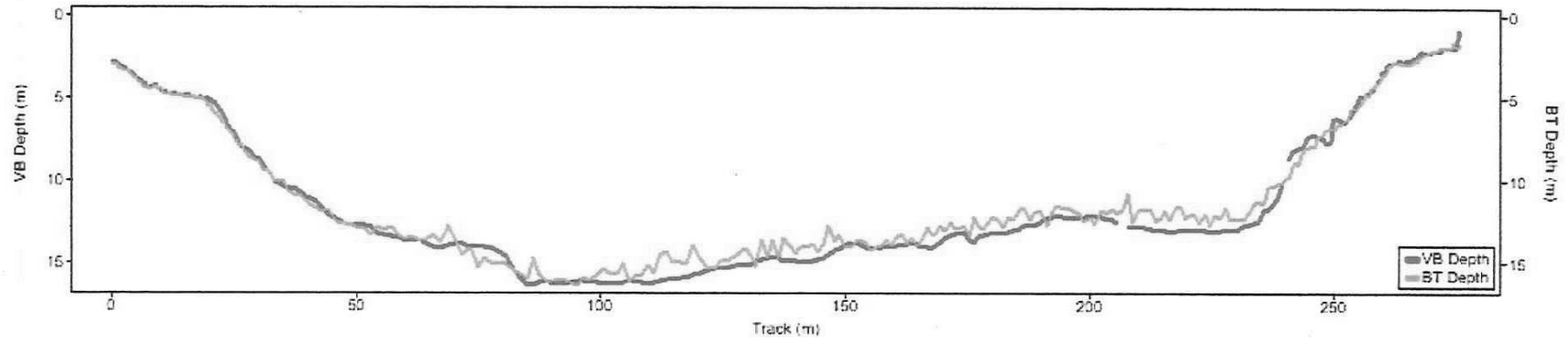
Comments
 Tr1=20120810095857r.rivr - 16 ft; Tr2=20120810100712r.rivr - 16 ft; Tr3=20120810101609r.rivr - 16 ft;
 Tr4=20120810103720r.rivr - 16 ft; Tr5=20120810104253r.rivr - 16 ft; Tr6=20120810104841r.rivr - 16 ft;

Compass Calibration
 Results: PASS
 Score is excellent.
 Magnetic interference is very low.
 Calibration score: M5.00Q9

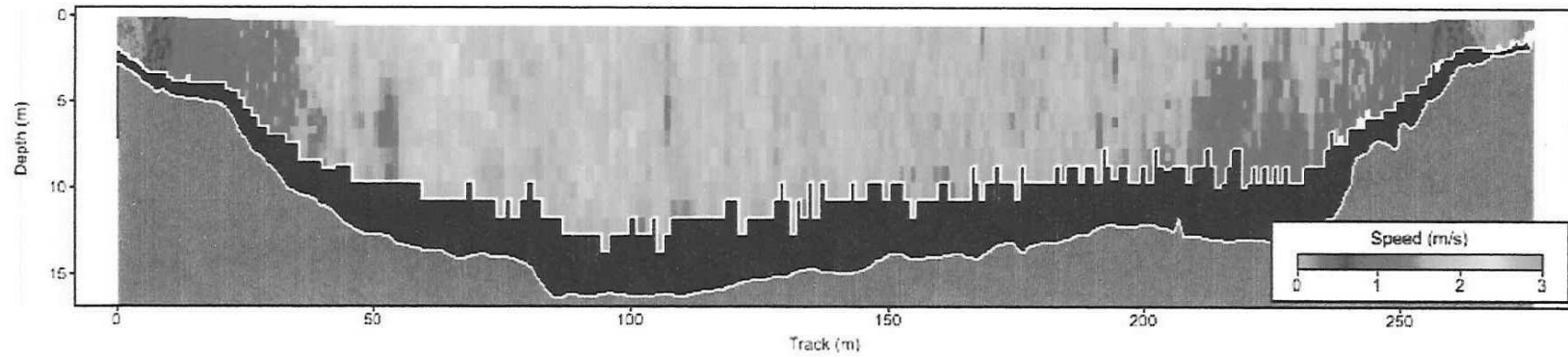
System Test
 System Test: PASS

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Kokowa River U/S @ RD 7800'



Cross Section of Kokowa River U/S @ RD 7800'



Velocity Distribution of Kokowa River U/S @ RD 7800'

Discharge Measurement Summary

Date Measured: Friday, August 10, 2012

Site Information		Measurement Information	
Site Name	Kokkowa River	Party	Hydro SO4
Station Number	2	Boat/Motor	Boat
Location	Cut Channel mid	Meas. Number	4

System Information		System Setup		Units	
System Type	RS-M9	Transducer Depth (m)	0.08	Distance	m
Serial Number	2365	Salinity (ppt)	0.0	Velocity	m/s
Firmware Version	2.00	Magnetic Declination (deg)	0.8	Area	m ²
Software Version	2.70			Discharge	m ³ /s
				Temperature	degC

Discharge Calculation Settings				Discharge Results	
Track Reference	Bottom-Track	Left Method	Sloped Bank	Width (m)	184.49
Depth Reference	Vertical Beam	Right Method	Sloped Bank	Area (m ²)	2,920.5
Coordinate System	ENU	Top Fit Type	Power Fit	Mean Speed (m/s)	1.319
		Bottom Fit Type	Power Fit	Total Q (m ³ /s)	3,852.217

Measurement Results																	
Tr	Time		Distance				Mean Vel		Discharge						%		
#	Time	Duration	Temp	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	MBTotal	Measured
1	R 11:13:10 AM	0:03:57	27.7	198.56	180.81	185.81	2,993.7	0.838	1.283	1.23	0.19	193.62	2,815.76	829.15	3,839.961	--	73.3
2	L 11:17:25 AM	0:19:04	27.8	195.88	177.40	183.40	2,901.9	0.171	1.331	0.42	2.55	191.88	2,803.77	863.46	3,862.077	--	72.6
3	L 11:46:26 AM	0:06:36	27.8	198.33	180.66	185.66	2,917.0	0.501	1.329	0.18	0.46	191.38	2,817.13	868.99	3,878.145	--	72.6
4	L 11:58:06 AM	0:05:09	27.8	197.55	178.07	183.07	2,869.2	0.639	1.334	0.30	0.26	197.79	2,812.07	818.26	3,828.684	--	73.4
		Mean	27.8	197.58	179.24	184.49	2,920.5	0.537	1.319	0.53	0.87	193.67	2,812.18	844.97	3,852.217	0.000	73.0
		Std Dev	0.0	1.05	1.52	1.25	45.7	0.243	0.021	0.41	0.97	2.52	5.20	21.69	19.193	0.000	0.4
		COV	0.0	0.005	0.008	0.007	0.016	0.452	0.016	0.770	1.125	0.013	0.002	0.026	0.005	0.000	0.005

Exposure Time: 0:34:46
 Tr1=20120810111310r.rivr; Tr2=20120810111724r.rivr; Tr3=20120810114626r.rivr; Tr4=20120810115805r.rivr;

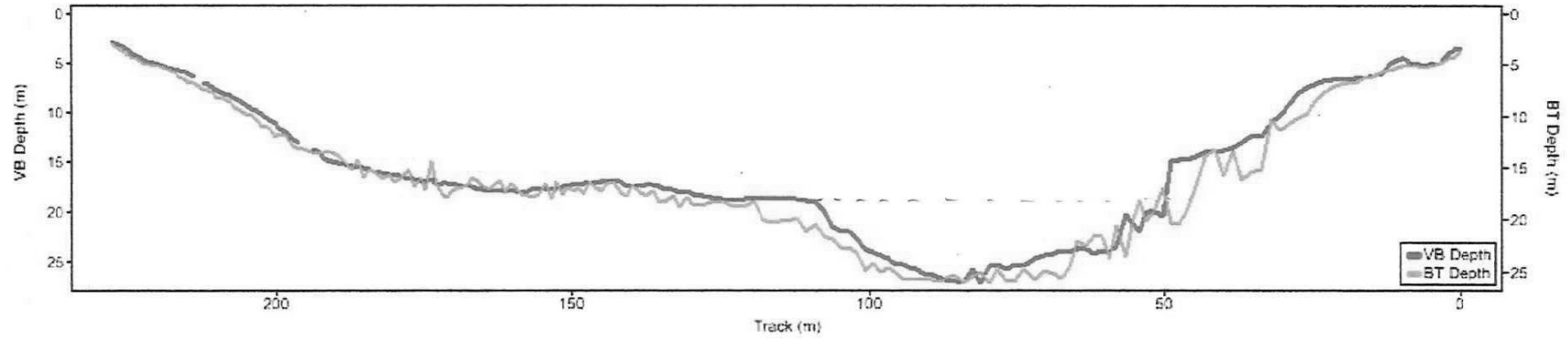
Comments
 Tr1=20120810111310r.rivr - 15 ft; Tr2=20120810111724r.rivr - 15 ft; Tr3=20120810114626r.rivr - 15 ft;
 Tr4=20120810115805r.rivr - 15 ft;

Compass Calibration
 Results: PASS
 Score is excellent.
 Magnetic interference is very low.
 Calibration score: M5.00Q9

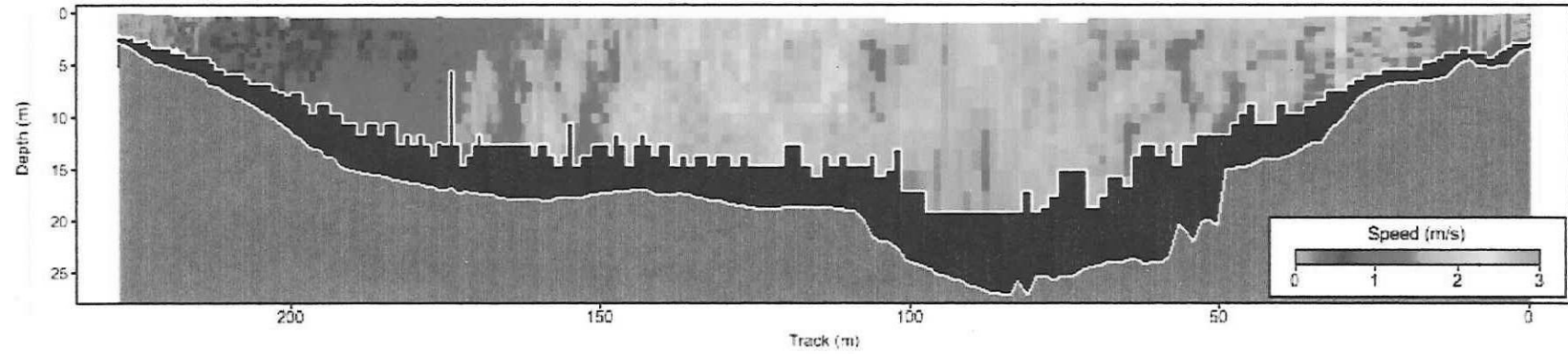
System Test
 System Test: PASS

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Kokowa River Cut Channel @ RD 12500'



Cross Section of Kokowa River Cut Channel @ RD 12500'



Velocity Distribution of Kokowa River Cut Channel @ RD 12500'

B-19

Discharge Measurement Summary

Date Measured: Friday, August 10, 2012

Site Information		Measurement Information	
Site Name	Kokkowa River D/S	Party	Hydro SO4
Station Number	3	Boat/Motor	Boat
Location	Kathwekwe Out	Meas. Number	6

System Information		System Setup		Units	
System Type	RS-M9	Transducer Depth (m)	0.08	Distance	m
Serial Number	2365	Salinity (ppt)	0.0	Velocity	m/s
Firmware Version	2.00	Magnetic Declination (deg)	0.8	Area	m ²
Software Version	2.70			Discharge	m ³ /s
				Temperature	degC

Discharge Calculation Settings				Discharge Results			
Track Reference	Bottom-Track	Left Method	Sloped Bank	Width (m)	209.45		
Depth Reference	Vertical Beam	Right Method	Sloped Bank	Area (m ²)	1,141.8		
Coordinate System	ENU	Top Fit Type	Power Fit	Mean Speed (m/s)	0.500		
		Bottom Fit Type	Power Fit	Total Q (m ³ /s)	570.758		

Measurement Results																		
Tr	Time	Duration	Temp	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	MBTotal	%	
1	R 12:14:37 PM	0:05:33	28.4	226.15	207.23	211.23	1,151.0	0.679	0.489	0.15	0.00	38.42	435.47	88.50	562.546	--	77.4	
2	L 12:20:35 PM	0:04:58	27.9	218.93	204.57	208.57	1,145.5	0.735	0.494	0.09	-0.03	37.84	438.83	88.77	565.502	--	77.6	
3	R 12:26:06 PM	0:07:09	28.0	220.43	199.58	207.58	1,149.1	0.514	0.496	0.12	-0.01	38.88	440.01	91.50	570.499	--	77.1	
4	L 12:33:26 PM	0:05:08	27.9	214.24	202.88	210.88	1,136.6	0.696	0.499	0.12	0.06	37.76	440.44	88.89	567.269	--	77.6	
5	R 12:38:51 PM	0:04:23	28.0	213.89	200.78	208.78	1,139.3	0.813	0.513	0.31	0.05	39.92	452.06	91.67	583.999	--	77.4	
6	L 12:43:24 PM	0:04:54	27.9	217.22	201.67	209.67	1,129.3	0.739	0.509	0.19	-0.06	38.66	446.41	89.53	574.734	--	77.7	
			Mean	28.0	218.48	202.78	209.45	1,141.8	0.696	0.500	0.16	0.00	38.58	442.20	89.81	570.758	0.000	77.5
			Std Dev	0.2	4.15	2.53	1.29	7.6	0.092	0.008	0.07	0.04	0.72	5.47	1.29	7.053	0.000	0.2
			COV	0.0	0.019	0.012	0.006	0.007	0.132	0.017	0.445	10.122	0.019	0.012	0.014	0.012	0.000	0.002

Exposure Time: 0:32:05

Tr1=20120810121438r.rivr; Tr2=20120810122034r.rivr; Tr3=20120810122605r.rivr; Tr4=20120810123326r.rivr; Tr5=20120810123850r.rivr; Tr6=20120810124324r.rivr;

Comments

Tr1=20120810121438r.rivr - 15 ft; Tr2=20120810122034r.rivr - 15 ft; Tr3=20120810122605r.rivr - 15 ft; Tr4=20120810123326r.rivr - 15 ft; Tr5=20120810123850r.rivr - 15 ft; Tr6=20120810124324r.rivr - 15 ft;

Compass Calibration

Results: PASS
Score is excellent.
Magnetic interference is very low.

Calibration score: M5.00Q9

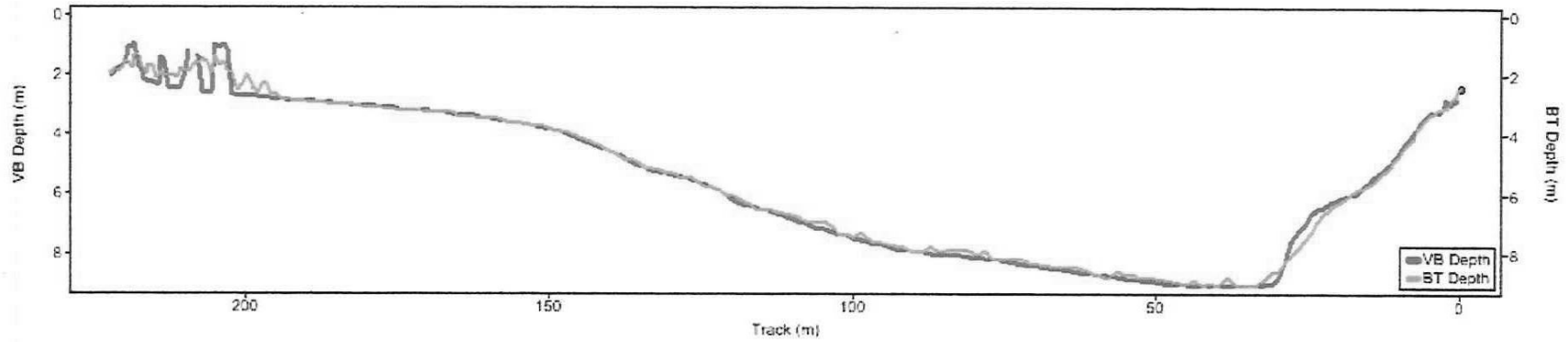
System Test

System Test: PASS

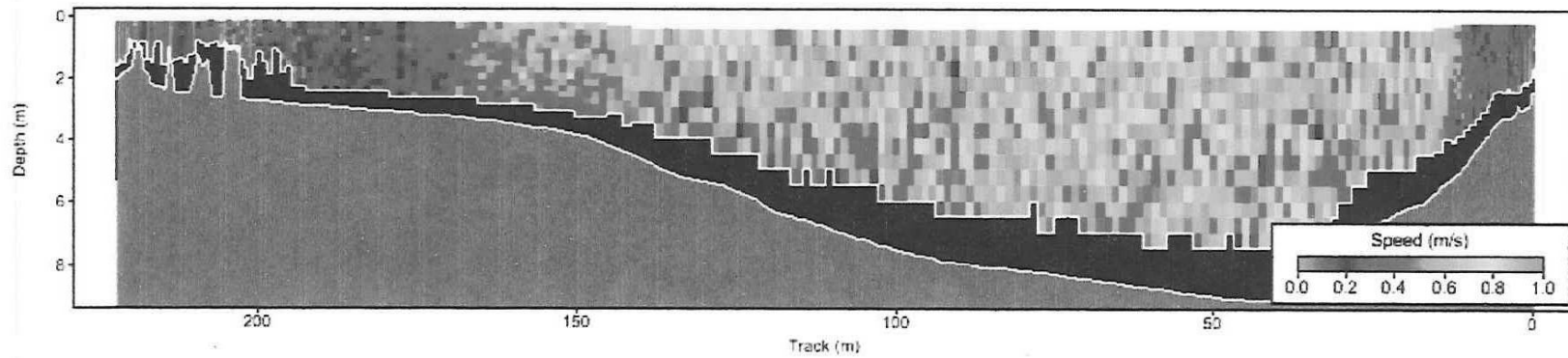
Parameters and settings marked with a * are not constant for all files.

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Kokowa River D/S @ RD 26900'



Cross Section of Kokowa River D/S @ RD 26900'



Velocity Distribution of Kokowa River D/S @ RD 26900'



M9 ကိုစက်လှေဖြင့်ဆွဲ၍ ရေစီနှုန်းတိုင်းတာနေစဉ် Laptop ဖြင့် Monitoring ကြည့်ရှုစစ်ဆေးပုံ



M9 ကိုစက်လှေဖြင့်ဆွဲ၍ ရေစီနှုန်းတိုင်းတာနေစဉ် Laptop ဖြင့် Monitoring ကြည့်ရှုစစ်ဆေးပုံ



ကတွယ်ကျွေဖြတ်မြောင်းတွင်တိုင်းတာနေပုံ



ကတွယ်ကျွေတွင်တိုင်းတာနေပုံ