SUSTAINABLE WATER MANAGEMENT OF THE LAKE CHAD BASIN

Discharge Measurements at Chari, Logone and Koulambou River, Chad

Report N° 5

July 2013

Lake Chad Basin Commission

Rond Point des Grandes Armes
N'Djamena, Chad

Federal Institute of Geosciences and Natural Resources

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Abbreviations

A	Area [m²]
ADCP	Acoustic Doppler Currentmeter Profiler
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe *Federal Institute for Geosciences and Natural Resources*
CBLT	Lake Chad Basin Commission
DREM	Meteorological Institute of Chad
DVWK	now: DWA – German Association for Water, Wastewater and Waste
Q	Discharge [m³/s]

Timetable of the Mission

15.02.2013	Arrival of T. Krekeler at the Airport N'Djamena
16.02.2013	Discharge measurements at the Chari River, Mailao gauging station (BGR ADCP)
17.02.2013	Presentation and explanation of Infiltrometer
18.02.2013	Gauging station installation at Logone-Gana and discharge measurements with BGR ADCP device at a tributary of the Logone River (BGR ADCP)
19.02.2013	Finishing gauging station at Logone-Gana and discharge measurements at the Logone River (BGR and DREM ADCP)
20.02.2013	Discharge measurements at Logone River, Bongor gauging station (BGR and DREM ADCP)
21.02.2013	On the job training of the DREM hydrologist in using the associated software
	Discharge measurements at Chari-Logone River, N'Djamena-TP gauging station (BGR and DREM ADCP)
	Departure of T. Krekeler

1 Summary

Authors: Torsten Krekeler, Kristin Seeber

Title: *Discharge Measurements at Chari, Logone and Koulambou River, Chad*

Keywords: Lake Chad Basin, hydrology, discharge, flow measurement, rating curve

In February 2013 discharge measurements at Logone, Chari and Koulambou River were conducted.

Discharge and water levels at four gauging stations were measured during the mission and one gauging station could be reinstalled. The ADCP device of DREM could be set into operation after it was not used for about six years.

The ADCP measurements show generally lower discharges than the values taken from the rating tables that were provided by CBLT, originating from DREM. The differences between these values account to 10 – 50 %. Some of the measurements, on which the rating curves are based on, are rather old; e.g. from 1983.

It is recommended to use the ADCP frequently to check the existing rating curves.

The reach of Logone River where the measurements were carried out was found in loosing stream conditions.

2 Participants

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Kristin Seeber, BGR-CBLT Project, N'Djamena
Torsten Krekeler, BGR Headquarters, Hannover

3 Objective

One of the activities of the BGR-CBLT project in 2013 is to improve the scientific understanding of the interaction between surface water and groundwater in Lake Chad Basin. Therefore, a pilot project area, the inundation zones of the Logone River, was defined at the planning workshop in November 2012. To understand the interaction between surface water and groundwater in that zone information not only about the hydrogeological but also about the hydrological system, hence quantities of water volumes, are necessary to know.

Discharge values of the Logone and Chari River are transmitted by DREM which is responsible for maintaining all gauging stations in Chad only on request of the CBLT members.

As there was no evidence about the quality of the data, it was decided to carry out measurements at five priority gauging stations in the pilot area with the BGR owned ADCP. The objective of these measurements was to get reliable data of discharges in February 2013 at the priority stations and to verify rating curves and hence the discharge values given by DREM. Furthermore the DREM owned ADCP was set into operation and a hydrologist of DREM was trained in handling the device and associated software.

4 Locations of Measurements and Gauging Stations

Discharge measurements were carried out with both ADCP instruments in the Chari River at N'Djamena TP as well as in the Logone River at Logone-Gana and at Bongor (Figure 1). Additionally the Logone tributary Koulambou was measured at Gana station. The Chari River at Mailao was measured only with the SonTec ADCP of BGR.

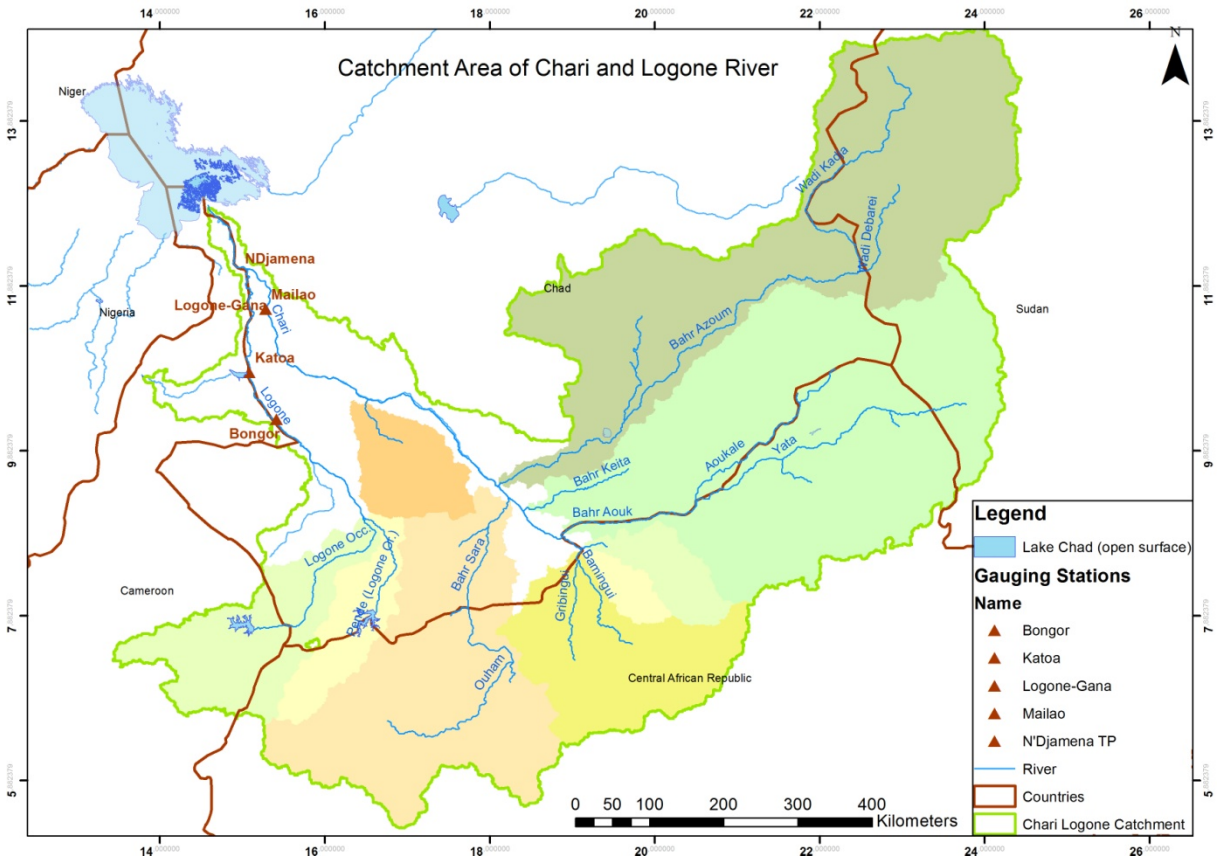


Figure 1 Catchment area of Logone and Chari River and selected gauging stations

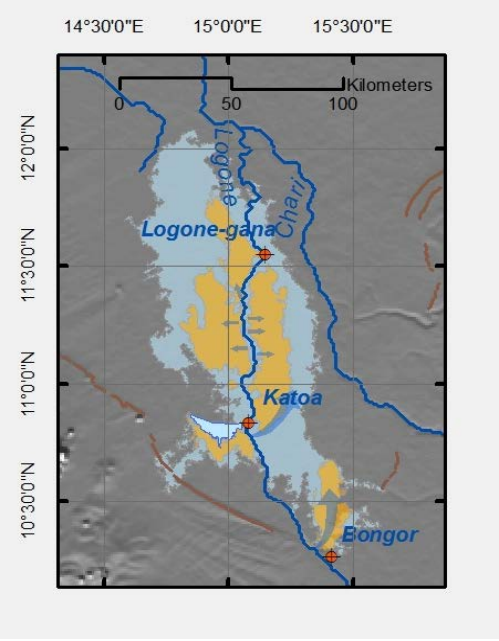


Figure 2 Inundation Zone of Logone River

The stations were selected mainly to achieve reliable data on the discharge close to the inundation zone of Logone. As shown in Figure 2 the inundation zone of the Logone River extends from Bongor to N'Djamena and further north depending on the intensity of rainfall. Four gauging stations within this zone are operated by DREM: in Bongor, in Katoa, in Logone-Gana and in N'Djamena. Unfortunately the gauging stations in Logone-Gana and Katoa were inoperable. During the mission, the gauging station in Logone-Gana could be renewed, but it was not possible to also reinstall the station in Katoa and to carry out discharge measurements there.

Furthermore the Koulambou, a tributary of the Logone River, was measured at the Logone-Gana gauging station.

The gauging station of the Chari River in Mailao, located at the same latitude as the Logone-Gana station, is the last gauging station upstream of the confluence of Chari and Logone River in N'Djamena and thus gives information about the water volumes coming from Chari.

At all measured stations, the discharge were measured several times in order to have reliable and comparable results.

5 Materials and Methods

Water Level Measurement

In general the water level was measured with gauge plates (Figure 3). A gauge reader records the water level on a daily basis.

Figure 3 Chari gauging station at Mailao

ADCP Instrument of BGR

The SonTec River Surveyor M9 instrument (Figure 4 and Figure 5) comes along with a floating platform and a mobile operation unit making the system operation simple. Data are analysed with the easy to use RiverSurveyor LIVE software.

For more technical details see the instrument data sheet in the Annex.

Figure 4 BGR ADCP at N'Djamena TP gauging station

Figure 5 Core of the BGR instrument: SonTec M9 Probe (Source: SonTec)

ADCP Instrument of DREM

The Rio Grande ADCP instrument (Figure 6 and Figure 7) is designed to operate from a moving boat. During the measurements it is connected and operated via a serial RS-232 cable with a computer. The data are analysed by the easy to use WinRiver II Software.

For more technical details see the instrument data sheet in the Annex.

Figure 6 DREM ADCP fixed on a Zodiac boat

Figure 7 Core of the DREM instrument: RDI Workhorse Rio Grande (Source: RDI)

6 Results

In the following, the ADCP measurements with both instruments at each station are summarized. Furthermore, the measured average discharge values are shown in the actual discharge curves of each station.

Chari River, N'Djamena TP Gauging Station

This station is located downstream of the confluence with Logone. The observed gauge height at N'Djamena TP station was 1.78 m. The water level was falling very slowly as typical during the dry season (Figure 8). The daily changes in the water level were 1 – 2 cm. This is considered a nearly stable water level where hysteresis effects are not likely to occur.

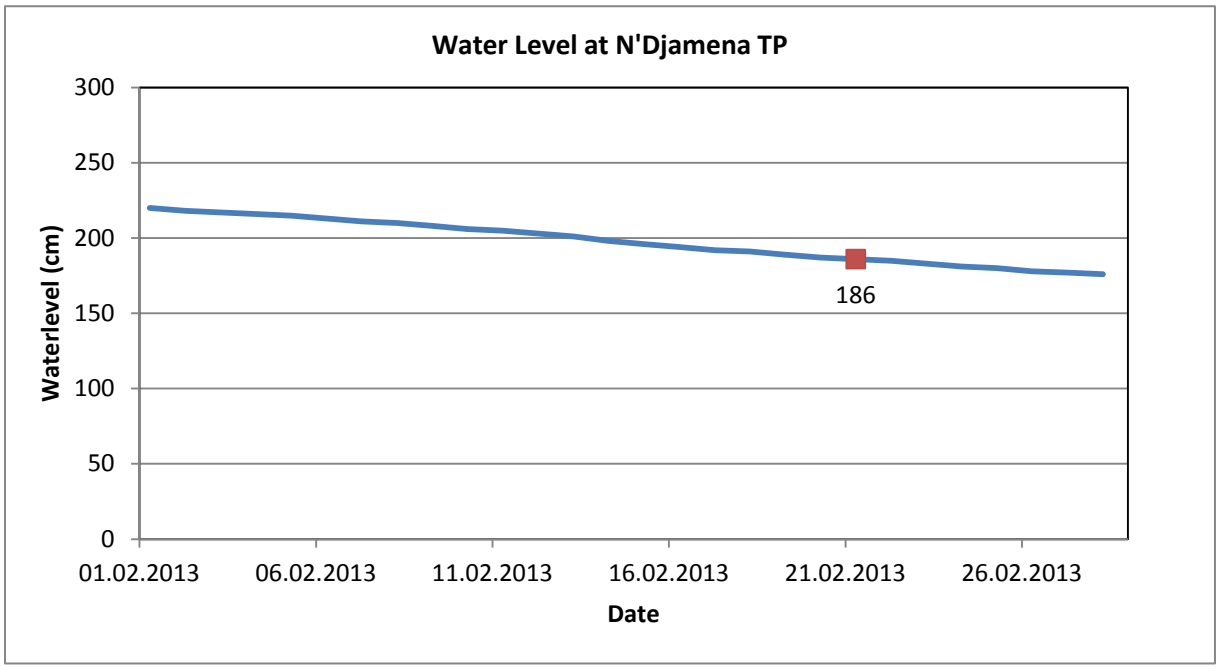


Figure 8 Water level at N'Djamena TP station

The mean discharge of four discharge measurements with the DREM instrument (Figure 9) was 226 m³/s.

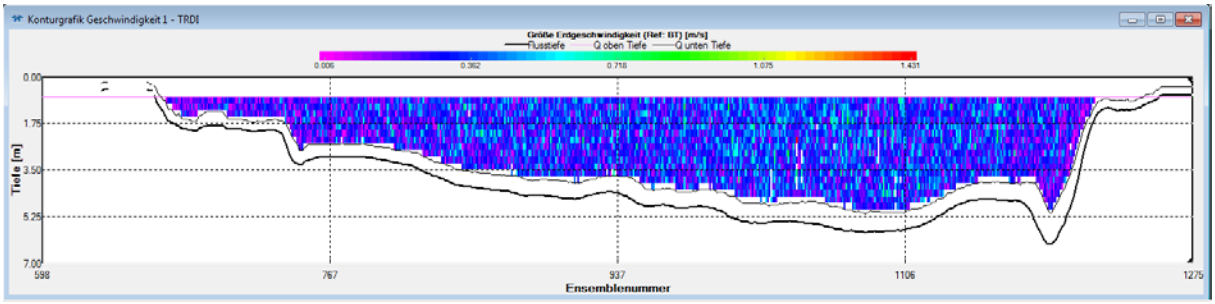


Figure 9 Cross section and distribution of velocity measured with DREM instrument

The four measurements carried out with the BGR owned SonTec ADCP (Figure 10) yield a mean discharge of 229 m³/s.

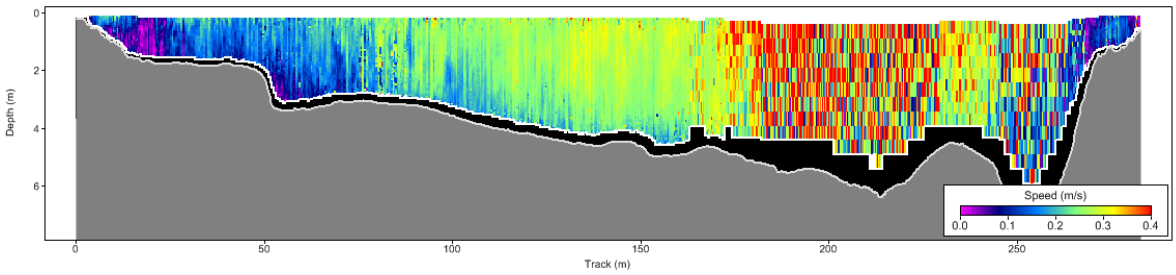


Figure 10 Chari River cross section and distribution of flow velocity from BGR instrument

The corresponding discharge to a gauge height of 1.78 m was calculated from the rating table to 300 m³/s (Figure 11). The measured discharge is about 24 % lower than the value from the rating table. This difference is in the same range as the values that were formerly measured by DREM.

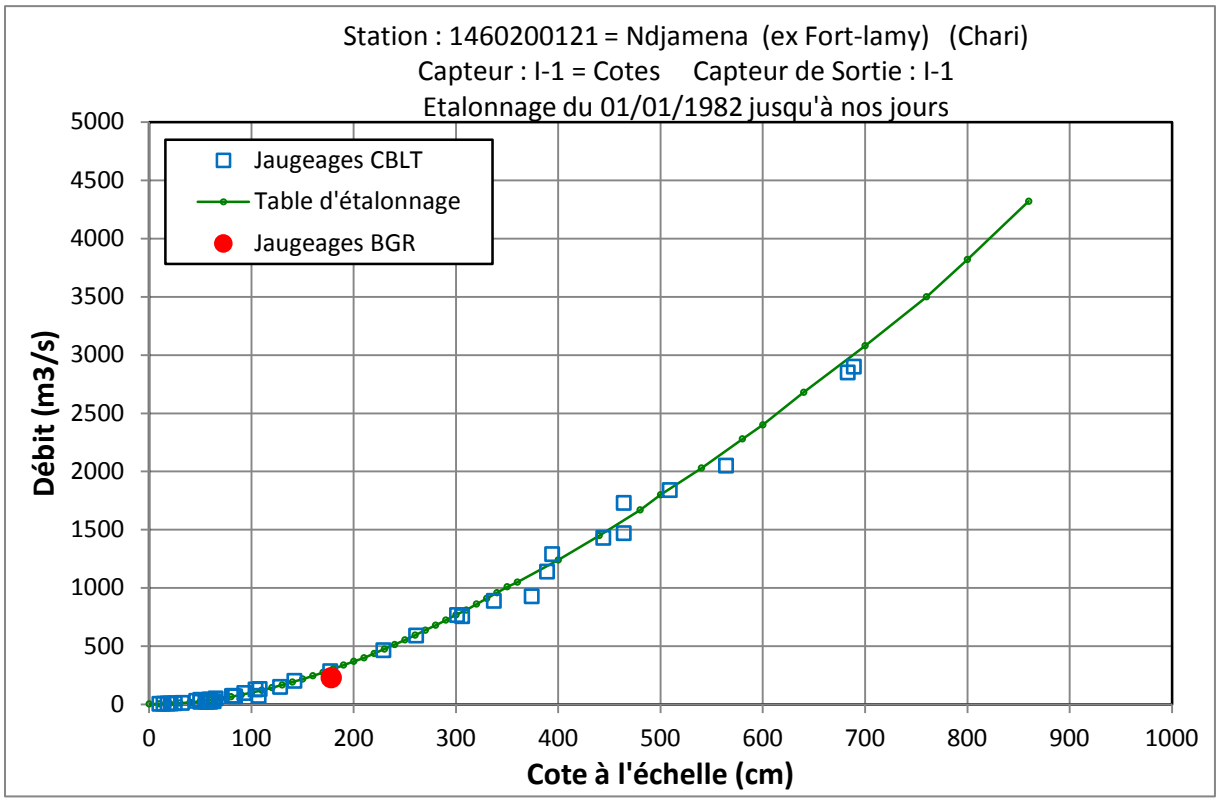


Figure 11 Rating curve of N'Djamena TP station

Chari River, Mailao Gauging Station

The water level at Mailao gauging station was falling 1 – 3 cm daily (Figure 12). This is considered nearly constant, thus no hysteresis effects were expected during the measurement.

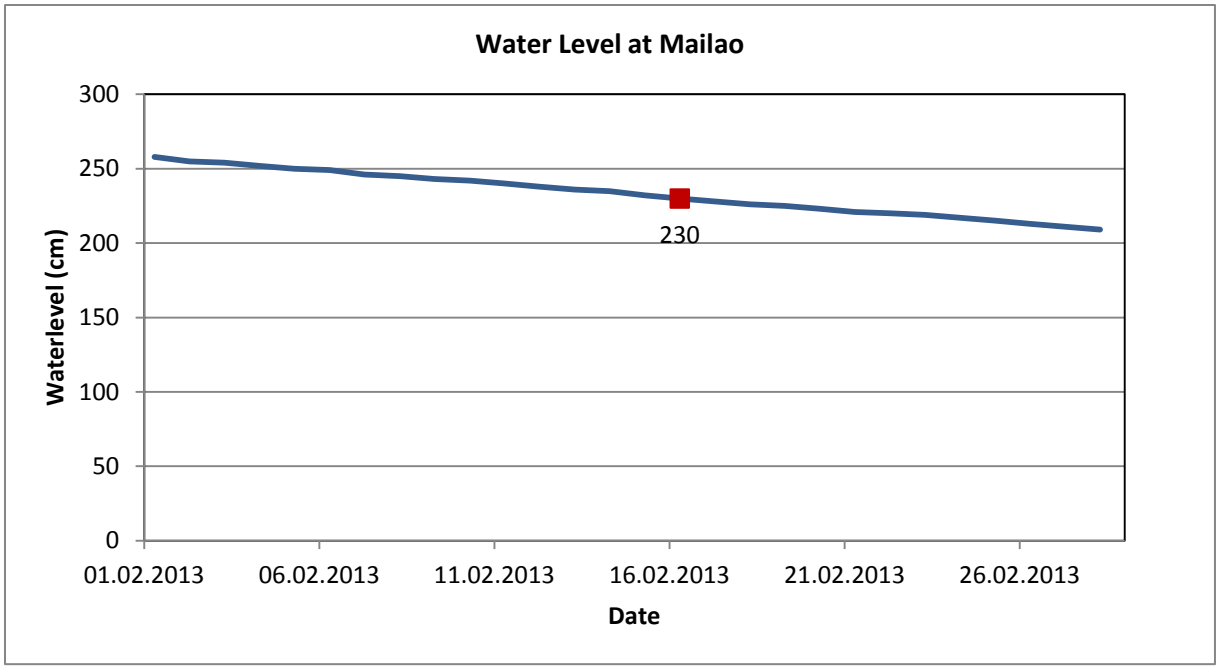


Figure 12 Water level at Mailao station

For the measurements at Mailao station only the BGR instrument was used (Figure 13). The mean discharge of six measurements was 171 m³/s for a slightly falling water level of 2.31 to 2.30 m.

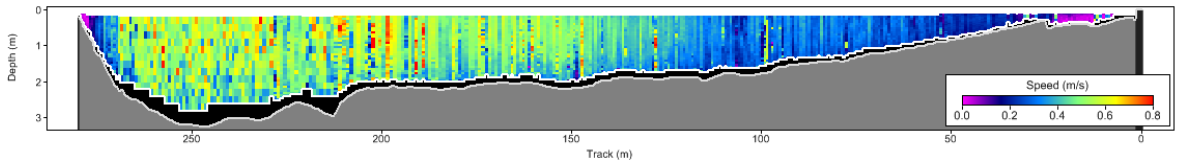


Figure 13 Cross section and velocity distribution of Chari River at Mailao station

For a gauge height of 2.30 m the rating table gives a discharge of 190.2 m³/s and for 2.31 m a value of 192.7 m³/s (Figure 14). The measured discharge is about 11 % lower. The deviance is in an acceptable limit and in the same range as the values that were formerly measured by DREM.

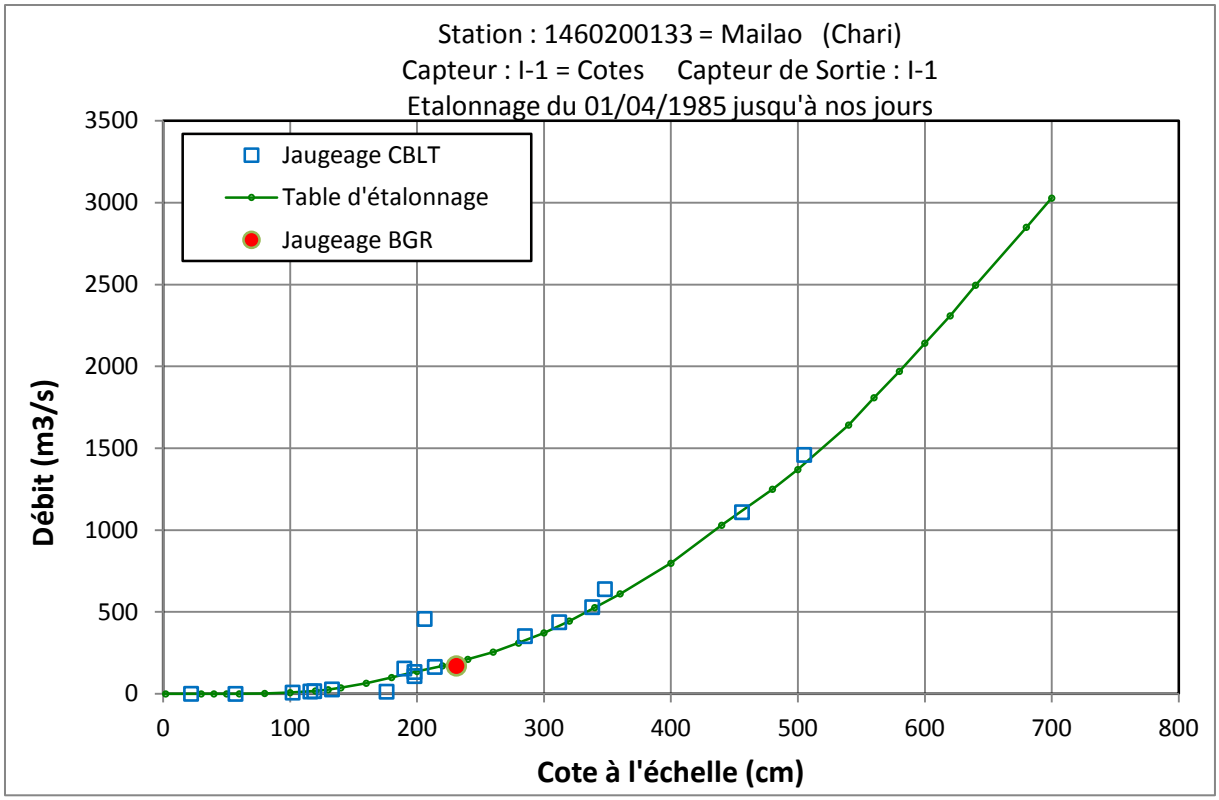


Figure 14 Rating curve of Chari River at Mailao station

Logone River, Logone-Gana Gauging Station

At Logone-Gana a gauge height of 1.48 m was observed. Here, as well, the water level was slightly falling during the period of the measurements (Figure 15). The drop of the water level was between 0 and 2 cm daily. This is considered a nearly stable gauge height, where no hysteresis effects are likely to occur.

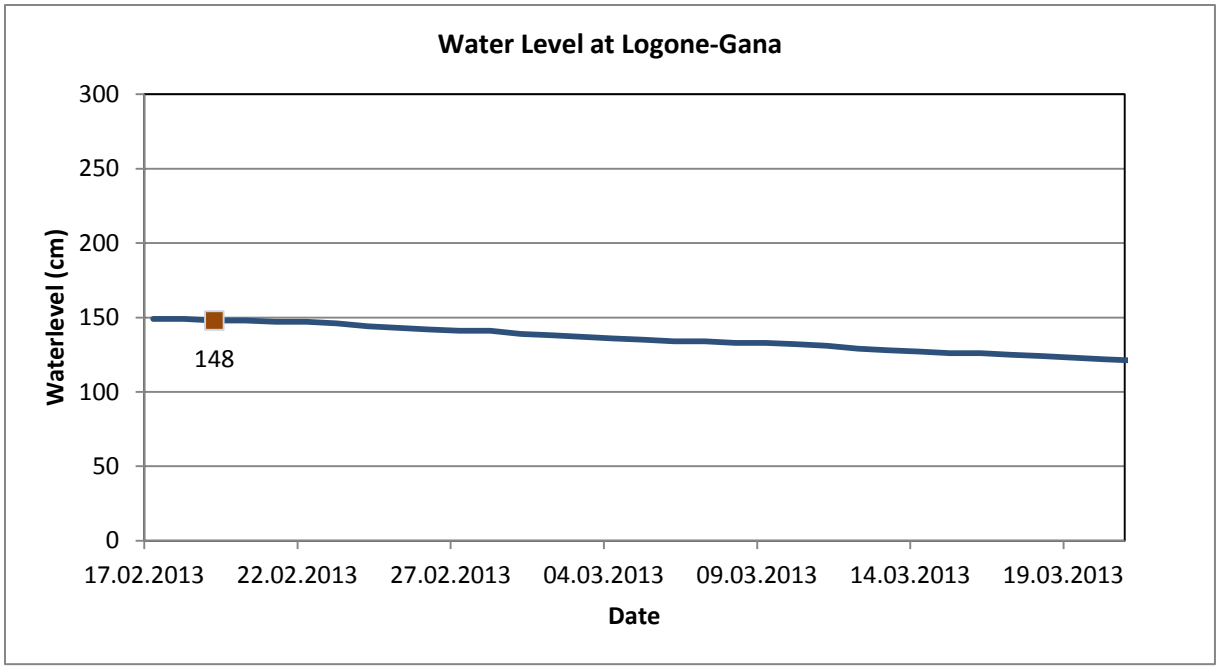


Figure 15 Water level at Logone-Gana station

Only two discharge measurements were carried out with each instrument. Due to security reasons it was necessary to break up the measurements.

The DREM instrument yielded the following results: 63.2 and 79.0 m³/s. These values differ more than 5 %. Hence, the values cannot be taken into account for a final analysis. Usually the measurements had to be repeated, what was impossible in this case.

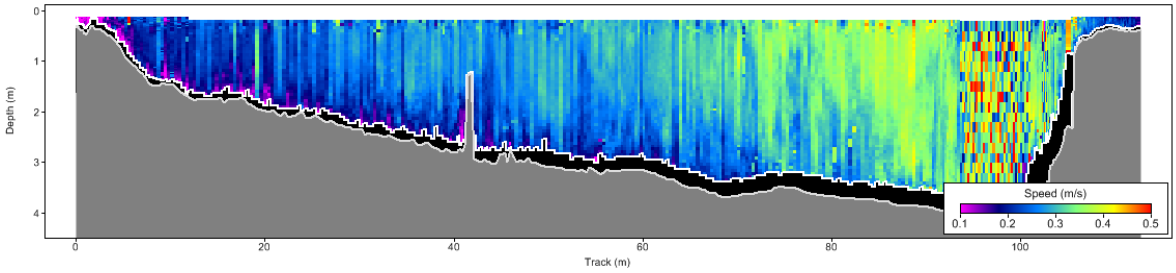


Figure 16 Cross-section from BGR instrument at Logone-Gana station

The discharge rates of the two measurements carried out with the BGR instrument (Figure 16) were 72.1 and 72.7 m³/s. In general two measurements are not enough to clearly determine the discharge. As a general rule, at least four measurements are carried out. The deviation of the single results from the mean must be within the limit of 5 %. The discharge is given by the mean of the single measurements. As there is currently no possibility to repeat the measurements and the difference between the values is very small, the results are used for further analysis here.

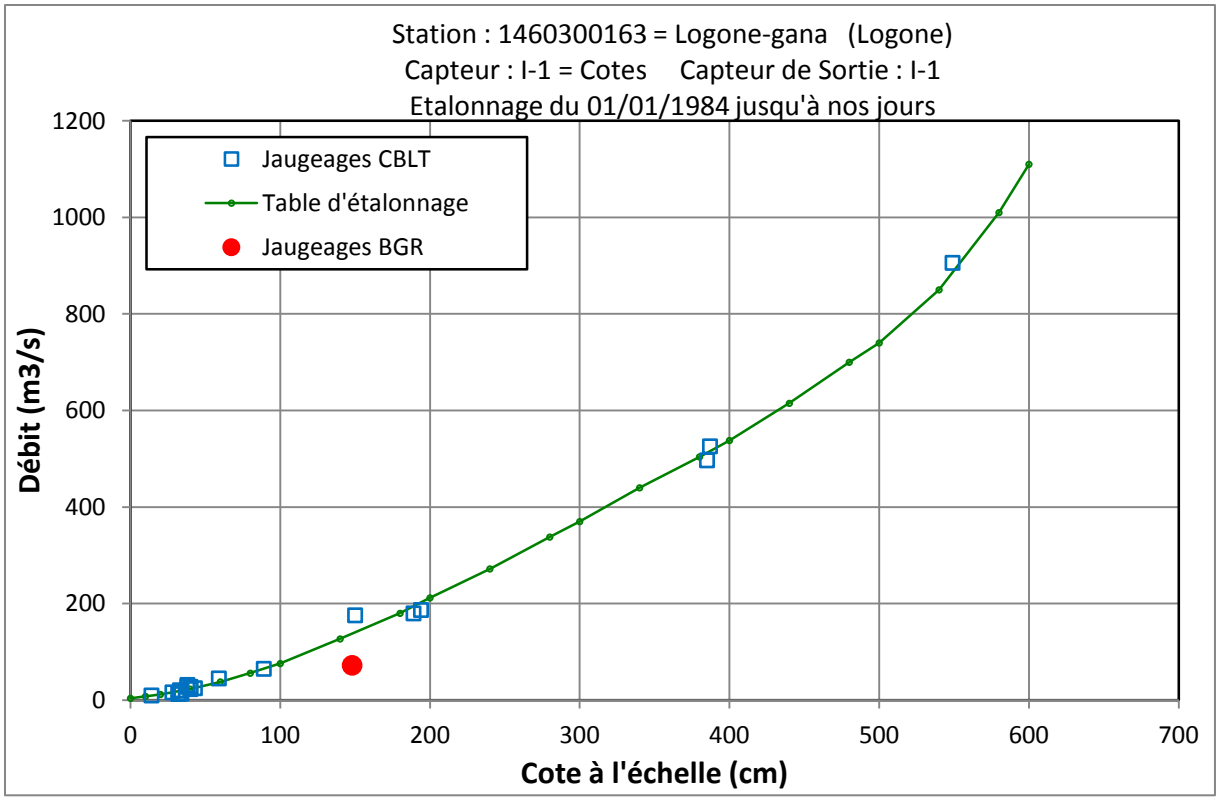


Figure 17 Rating curve of Logone River at Logone-Gana station

According to the rating curve (Figure 17) the discharge corresponding to a water level of 1.48 m is 138 m³/s. The difference between the rating table and the measured value of 72.4 m³/s is 47.5 %. Further measurements are necessary to get a clearer picture.

Koulambou River at Logone-Gana Gauging Station

The Koulambou is a tributary to the Logone River. The Logone-Gana gauging station is located on this river about 150 m upstream of the confluence with Logone. The measured gauge height was 1.50 m.

Two measurements with the DREM owned RDI instrument (Figure 18) result to a mean discharge of 22 m³/s.

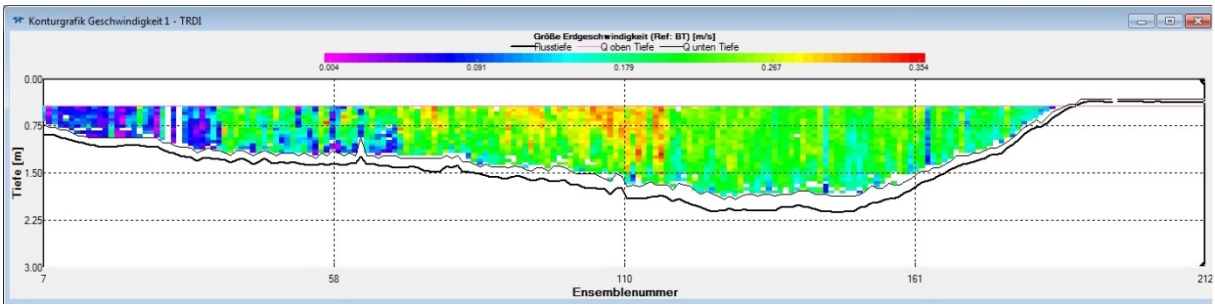


Figure 18 Cross-section of Koulambou River at Logone-Gana station measured with RDI instrument

Six measurements were carried out with the BGR instrument (Figure 19). The mean discharge was 21.4 m³/s.

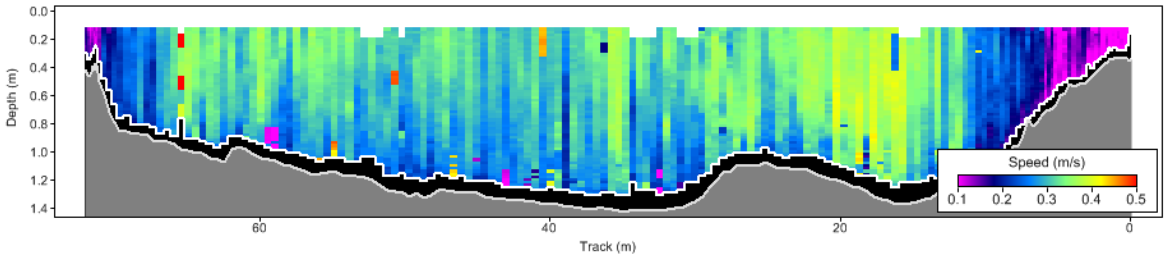


Figure 19 Cross-section of Koulambou River at Logone-Gana station

No rating curve of Koulambou River exists yet.

Logone River, Bongor Gauging Station

A gauge height of 1.18 m was measured on the gauge plate at Logone Bongor station. During the period where the measurements were carried out, the gauge height was falling between 0 and 1 cm daily (Figure 20). This is a very low fluctuation where no hysteresis effects are expected.

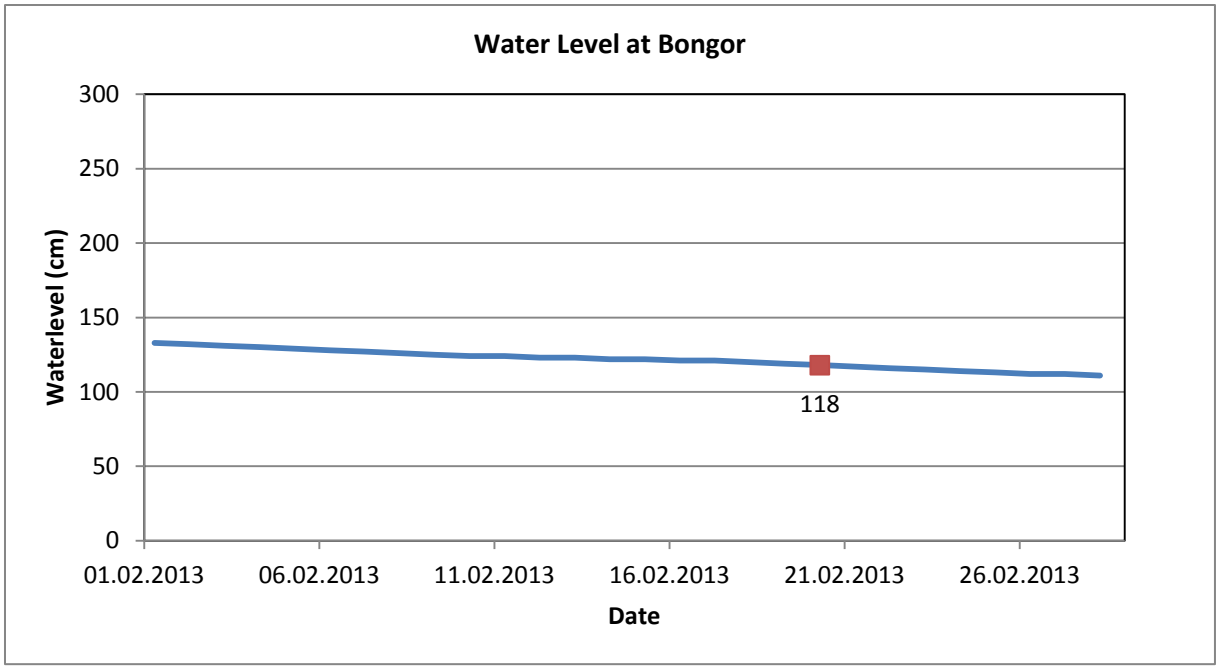


Figure 20 Water level at Bongor station

Six measurements were carried out with the DREM instrument (Figure 21). Two of the results differ more than 5 % from the mean and were excluded from further analysis. The mean result of four measurements that range within the acceptable limits is 72.1 m³/s.

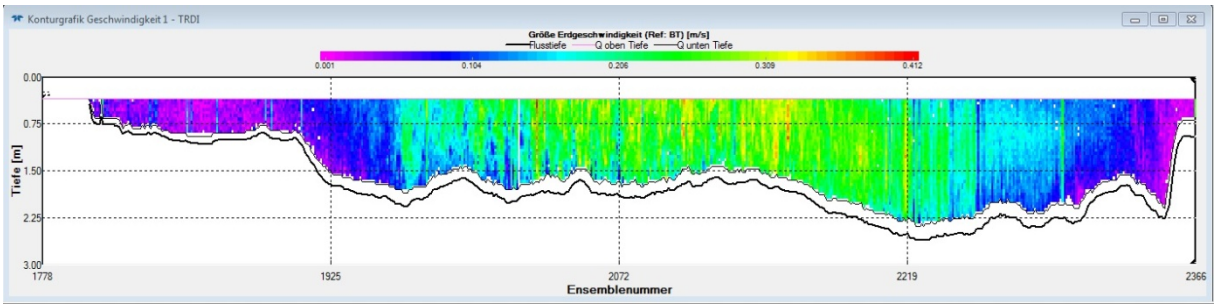


Figure 21 Cross-section of Logone River at Bongor station

Five measurements with the BGR owned SonTec River Surveyor were carried out at Bongor station (Figure 22). All of them range within the acceptable limits. The mean of the measured values is 73.3 m³/s.

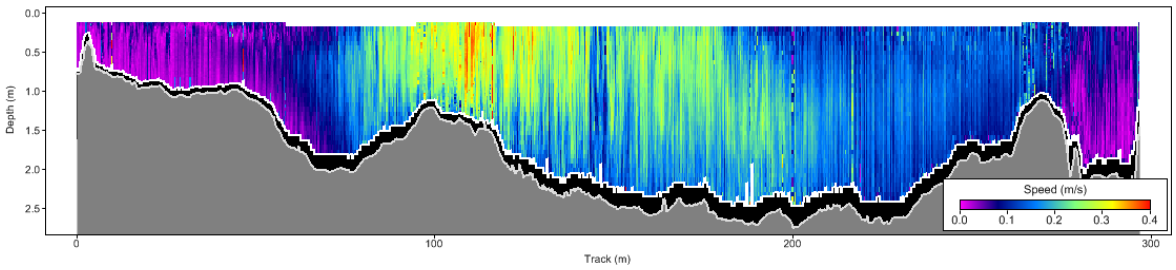


Figure 22 Cross section at Bongor station measured with BGR instrument

According to the rating curve (Figure 23), the discharge corresponding to a gauge height of 1.18 m is 89 m³/s. The measured discharge is about 18 % lower.

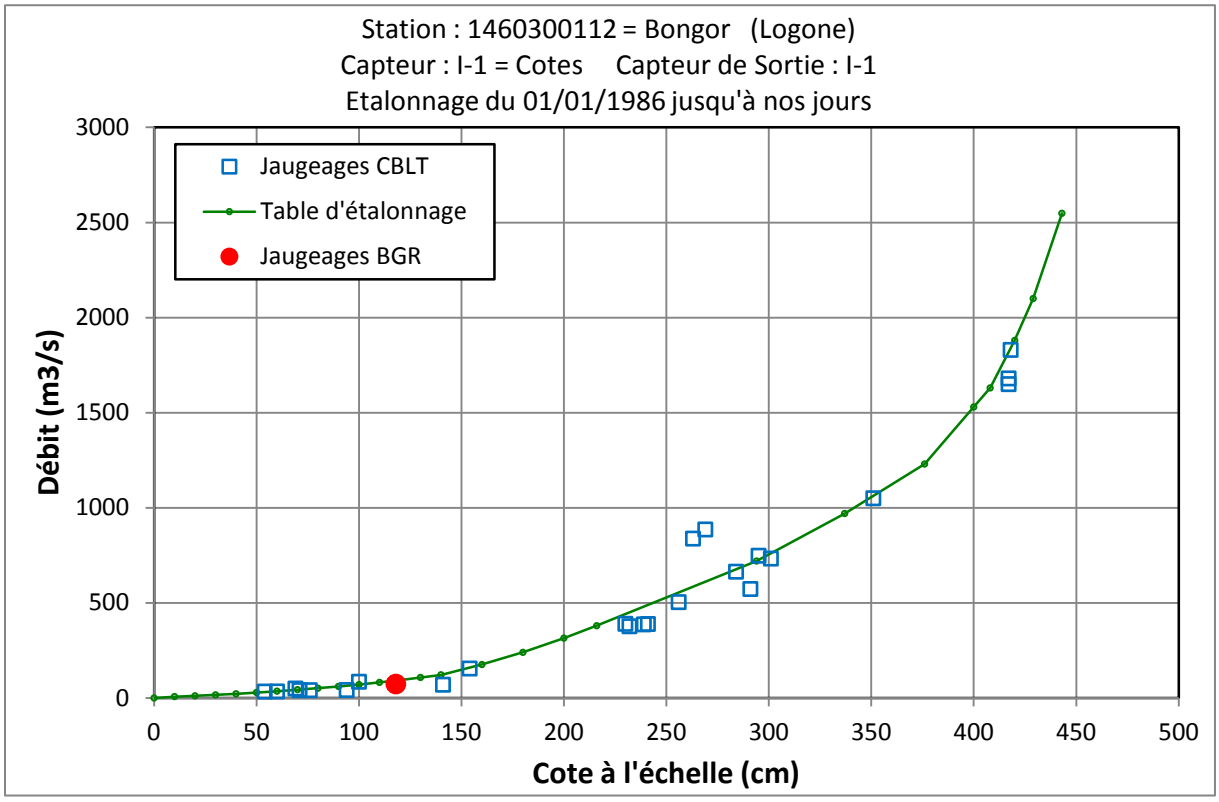


Figure 23 Rating curve of Logone River at Bongor station

7 General Findings

The discharges measured during this mission are generally lower than the values that were read from the existing rating tables.

The discharges measured with two different ADCP instruments of DREM and BGR respectively using a Zodiac rubberboat with engine or by paddling as well as the values from the rating tables are compared in the following table.

Table 1 Comparison of results

Stations	Rating Table (m³/s)	ADCP(DREM) (m³/s)	ADCP(BGR) (m³/s)	Observations
N'Djamena TP	300	226.023	228.980	Rating Table > BGR > DREM
Mailao (Chari)	191.5	-	171	Rating Table > BGR
Logone-Gana	138	63.152 – 79.039	72.430	Rating Table > BGR, DREM invalid
Koulambou (Gana)	-	21.956	21.355	DREM > BGR
Bongor	89	72.109	73.255	Rating Table > BGR > DREM

The measured values do not show significant differences from one measurement to another. No typical or noticeable divergence of the results gained from different instruments could be detected.

Rating curves were partly developed from rather old measurements (some values are from 1983).

During the season and within the area where the measurements were carried out, Logone River shows loosing stream conditions. At Logone-Gana, the measurement was carried out downstream of the confluence of Logone and Koulambou. Upstream at Bongor, 73.3 m³/s was measured as Logone discharge, while Koulambou carries further 21.4 m³/s. When summing up the two river flows, a total discharge of 94.7 m³/s could be expected downstream of the confluence assuming no further influence. But at Logone-Gana only 72.4 m³/s was measured, which is 22.3 m³/s less. Further on, the 72.4 m³/s from Logone at Logone-Gana station plus 171 m³/s from Chari at Mailao gauging station lead to 243.4 m³/s which one can expect downstream of the confluence of the two rivers. At N'Djamena TP gauging station 229 m³/s was measured, which is 14.4 m³/s lower than the sum of the discharge of the two rivers upstream.

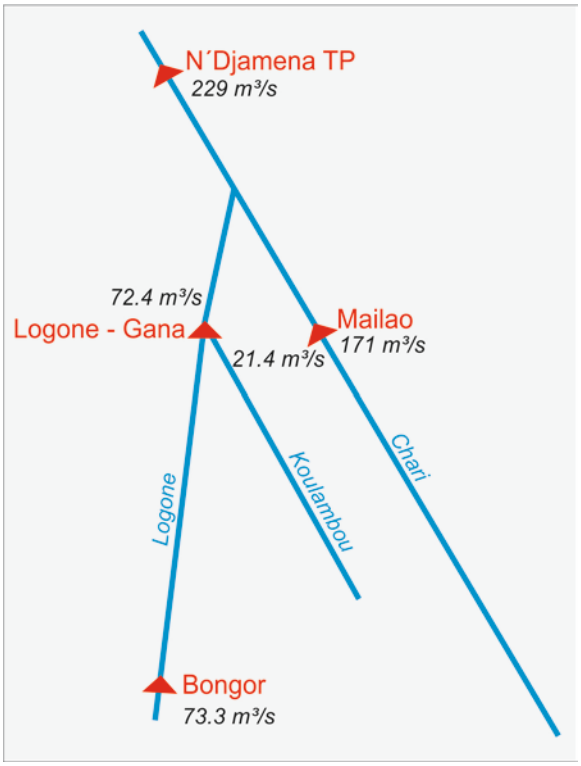


Figure 24 Loosing stream conditions at Logone

8 Recommendations

Given that the gauging stations are exposed to a risk of damage during high waters in the rainy season and the utilization by the population, the gauge plates should be checked after each rainy season. It must be made clear, that the gauge plates are properly fixed on the poles. Furthermore, the correct fit should be checked by levelling in accordance to one or better two benchmarks that are part of each gauging station.

Since the rating curves are partly developed from rather old measurements and all discharge measurements of this mission are generally lower than the values from the rating curves it is recommended to check the rating curves more frequently by further discharge measurements.

Generally the validity of rating curves is limited in time. River morphology frequently changes and the rating curves need to be adjusted to give correct values. According to the German DVWK Guideline *Manual for Water Level Gauging and Discharge Measurements*, discharge measurements are necessary:

- *at least every three months*
- *at gauges where water levels are subject to variable influences, e.g. severe aquatic vegetation, at least once a month*
- *after each flood if the river bed tends to change*
- *shortly after and if possible before each removal of aquatic vegetation on the river reach*
- *additionally during low water periods and, if possible several times during each flood*
- *at gauges with fixed weirs and free overfall once or twice a year as a control*

If it can be assumed, that aquatic vegetation is not removed in these rivers and is not of variable influence on the water level, these points can be neglected.

It is very important to carry out measurements after the rainy season. From the results it can be determined, if the river bed changed during the floods and if the existing rating curve is still valid.

If any modifications on the river cross-sections were carried out, additional measurements are necessary.

As the ADCP of DREM is now ready for use and the operator is introduced in the procedure, the discharge values from the existing rating tables should be reviewed further on and rating tables for the Koulambou River should be established. Furthermore it is recommended to reinstall the Katoa gauging station before the rainy season begins.

It is very important to carry out measurements at high water levels while the water level is stable. Rapidly changing water levels lead to hysteresis effects. Hysteresis effects produce water level / discharge relations that are not applicable to develop rating curves.

9 Extended Summary

Between the 15th and the 21st of February 2013 discharge measurements with two different ADCP (Acoustic Doppler Currentmeter Profiler) one from BGR and one from DREM (Meteorological Institute of Chad) were conducted at Logone and Chari River. The measurements were carried out by the authors and by experts of CBLT and DREM.

Discharge and water levels at four gauging stations were measured during the mission and one gauging station could be reinstalled. The ADCP device of DREM could be set into operation after it was not used for about six years.

The ADCP measurements show generally lower discharges than the values taken from the rating table that was provided by the hydrologist of the CBLT, originating from the DREM. The differences between these values account to 10 – 50 %. Some of the measurements, on which the rating curves are based on, are rather old; e.g. from 1983.

It is recommended to use the ADCP frequently to check the existing rating curves.

Logone River was found in loosing stream conditions. This counts only for the reach where the measurements were carried out and for the season when they were carried out. The summation of the upstream discharges of Chari at Mailao, Logone at Bongor and Koulambou at Logone-Gana lead to a total discharge of 265.7 m³/s downstream of the confluence, but at N'Djamena TP only 229 m³/s was measured.

Hannover and N'Djamena, 10.07.2013

Torsten Krekeler
BGR Monitoring Expert

Kristin Seeber
CBLT – BGR Project

10 References

DVWK, 1990 (now: DWA – German Association for Water, Wastewater and Waste) Guidelines 301/1990. Manual for Water Level Gauging and Discharge Measurements, Hennef 1990

ANNEX

Discharge Measurement Summary

Date Measured: 21 February 2013

Site Information

Site Name	N'Djamena TP
Station Number	-
Location	Chari

Measurement Information

Party	BGR/CBLT
Boat/Motor	Zodiac/OE
Meas. Number	4

System Information

System Type	RS-M9
Serial Number	2456
Firmware Version	2.00
Software Version	2.50

System Setup

Transducer Depth (m)	0.06
Salinity (ppt)	0.0
Magnetic Declination (deg)	0.5

Units

Distance	m
Velocity	m/s
Area	m2
Discharge	m3/s
Temperature	degC

Discharge Calculation Settings

Track Reference	Bottom-Track	Left Method	Sloped Bank
Depth Reference	Vertical Beam	Right Method	Sloped Bank
Coordinate System	ENU	Top Fit Type	Power Fit
		Bottom Fit Type	Power Fit

Discharge Results

Width (m)	276.80
Area (m2)	1,018.3
Mean Speed (m/s)	0.226
Total Q (m3/s)	228.980

Measurement Results

Tr		Time			Distance				Mean Vel		Discharge							%
#		Time	Duration	Temp.	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	LCTotal	Measured
1	R	13:40:27	0:10:18	25.3	305.14	297.41	301.41	1,147.3	0.494	0.203	0.08	-0.01	18.22	188.96	25.38	232.626	--	81.2
2	L	14:07:59	0:09:02	25.4	272.05	266.38	270.38	969.3	0.502	0.231	-0.01	-0.04	16.78	183.95	22.98	223.664	--	82.2
3	R	14:25:34	0:15:32	25.6	270.80	263.45	266.95	924.5	0.291	0.250	0.03	-0.01	17.60	189.64	23.63	230.889	--	82.1
4	L	14:44:44	0:14:19	25.6	282.77	265.94	268.44	1,032.0	0.329	0.222	0.00	0.00	15.97	189.33	23.44	228.741	--	82.8
			Mean	25.5	282.69	273.30	276.80	1,018.3	0.404	0.226	0.03	-0.01	17.14	187.97	23.86	228.980	0.000	82.1
			Std Dev	0.1	13.77	13.97	14.26	83.7	0.095	0.017	0.04	0.01	0.85	2.33	0.91	3.363	0.000	0.6
			COV	0.0	0.049	0.051	0.052	0.082	0.235	0.075	1.401	-0.901	0.049	0.012	0.038	0.015	0.000	0.007

Exposure Time: 0:49:11

Tr1=20130221134025.riv; Tr2=20130221140758.riv; Tr3=20130221142532.riv; Tr4=20130221144444.riv;

Comments

Tr1=20130221134025.riv - ; Tr2=20130221140758.riv - ; Tr3=20130221142532.riv - ; Tr4=20130221144444.riv - ;

Compass Calibration

Not Loaded

System Test

Not Loaded

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

Report generated using SonTek RiverSurveyor Live v2.50

Station Number: 6
Station Name: Ndj.TP

Meas. No: 1
Date: 02/21/2013

Party:	Width: 263.4 m	Processed by:
Boat/Motor:	Area: 1030.0 m²	Mean Velocity: 0.221 m/s
Gage Height: 1.850 m	G.H.Change: 0.000 m	Discharge: 226 m³/s

Area Method: Avg. Course	ADCP Depth: 0.250 m	Index Vel.: 0.00 m/s	Rating No.: 1
Nav. Method: None	Shore Ens.:10	Adj.Mean Vel: 0.00 m/s	Qm Rating: U
MagVar Method: None (0.0°)	Bottom Est: Power (0.1667)	Rated Area: 0.000 m²	Diff.: 0.000%
Depth Sounder: Not Used	Top Est: Power (0.1667)	Control1: Unspecified	
		Control2: Unspecified	
		Control3: Unspecified	

Screening Thresholds:

BT 3-Beam Solution: YES	Max. Vel.: 4.84 m/s	Type/Freq.: Rio Grande / 1200 kHz
WT 3-Beam Solution: NO	Max. Depth: 8.13 m	Serial #: 8547 Firmware: 10.16
BT Error Vel.: 0.10 m/s	Mean Depth: 3.91 m	Bin Size: 25 cm Blank: 25 cm
WT Error Vel.: 1.07 m/s	% Meas.: 65.59	BT Mode: 5 BT Pings: 1
BT Up Vel.: 0.30 m/s	Water Temp.: None	WT Mode: 1 WT Pings: 1
WT Up Vel.: 1.50 m/s	ADCP Temp.: 25.4 °C	WV : 175
Use Weighted Mean Depth: YES		

ADCP:

Performed Diag. Test: NO
Performed Moving Bed Test: NO
Performed Compass Test: NO
Meas. Location:

Project Name: Ndjam_1.mmt
Software: 2.08

Tr.#		Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
000	R	1.50	2.00	337	41.8	144	29.5	0.209	-0.095	215	266.8	1154.2	13:43	13:50	0.73	0.19	27	3
004	L	2.00	2.00	321	49.2	155	31.3	0.088	-0.095	235	256.3	973.4	14:09	14:16	0.64	0.24	5	1
005	R	2.00	2.00	523	48.8	142	33.1	0.174	-0.096	224	252.5	950.5	14:31	14:42	0.40	0.23	39	2
006	L	2.00	2.00	678	46.1	153	30.9	0.143	0.088	230	277.8	1041.9	14:44	14:58	0.34	0.22	19	0
Mean		1.88	2.00	464	46.5	148	31.2	0.154	-0.050	226	263.4	1030.0	**Total**	01:15	0.53	0.22	22	2
SDev		0.25	0.00	169	3.43	6.46	1.49	0.051	0.092	8.56	11.4	91.5			0.19	0.02		
SD/M		0.13	0.00	0.36	0.07	0.04	0.05	0.33	1.85	0.04	0.04	0.09			0.35	0.11		

Remarks:

Discharge Measurement Summary

Date Measured: 16 February 2013

Site Information

Site Name	Mailao
Station Number	-
Location	Chari

Measurement Information

Party	BGR/CBLT
Boat/Motor	Piriogue
Meas. Number	6

System Information

System Type	RS-M9
Serial Number	2456
Firmware Version	2.00
Software Version	2.50

System Setup

Transducer Depth (m)	0.06
Salinity (ppt)	0.0
Magnetic Declination (deg)	0.5

Units

Distance	m
Velocity	m/s
Area	m2
Discharge	m3/s
Temperature	degC

Discharge Calculation Settings

Track Reference	Bottom-Track	Left Method	Sloped Bank
Depth Reference	Vertical Beam	Right Method	Sloped Bank
Coordinate System	ENU	Top Fit Type	Power Fit
		Bottom Fit Type	Power Fit

Discharge Results

Width (m)	256.13
Area (m2)	439.4
Mean Speed (m/s)	0.390
Total Q (m3/s)	171.079

Measurement Results

Tr		Time			Distance				Mean Vel		Discharge						%
#		Time	Duration	Temp.	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	LCTotal	Measured
1	L	12:13:15	0:10:09	25.9	267.14	257.86	261.46	451.5	0.439	0.376	0.00	0.00	17.61	135.26	16.86	169.737	--	79.7
2	R	12:25:53	0:07:07	24.3	280.02	251.20	254.80	451.6	0.656	0.378	0.01	0.00	17.84	138.97	13.89	170.707	--	81.4
3	L	12:39:14	0:08:09	25.5	263.57	258.09	260.19	465.6	0.539	0.367	0.00	0.00	17.37	137.16	16.19	170.720	--	80.3
4	R	12:48:09	0:09:33	24.2	260.81	256.85	258.95	447.8	0.455	0.382	0.00	0.00	17.12	138.35	15.66	171.132	--	80.8
5	L	13:01:23	0:08:38	24.7	243.57	240.43	251.03	406.8	0.470	0.423	0.00	0.00	17.78	142.06	12.03	171.865	--	82.7
6	R	13:10:54	0:07:57	24.1	249.60	239.76	250.36	412.9	0.523	0.417	0.00	0.00	19.17	136.04	17.11	172.316	--	78.9
			Mean	24.8	260.79	250.70	256.13	439.4	0.514	0.390	0.00	0.00	17.81	137.97	15.29	171.079	0.000	80.6
			Std Dev	0.7	11.83	7.84	4.36	21.7	0.073	0.021	0.00	0.00	0.65	2.22	1.79	0.839	0.000	1.2
			COV	0.0	0.045	0.031	0.017	0.049	0.142	0.055	2.236	3.158	0.037	0.016	0.117	0.005	0.000	0.015

Exposure Time: 0:51:33

Tr1=20130216121315.riv; Tr2=20130216122553.riv; Tr3=20130216123914.riv; Tr4=20130216124808.riv; Tr5=20130216130124.riv; Tr6=20130216131053.riv;

Comments

Tr1=20130216121315.riv - ; Tr2=20130216122553.riv - ; Tr3=20130216123914.riv - ; Tr4=20130216124808.riv - ;
Tr5=20130216130124.riv - ; Tr6=20130216131053.riv - ;

Compass Calibration

Not Loaded

System Test

Not Loaded

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

Report generated using SonTek RiverSurveyor Live v2.50

Discharge Measurement Summary

Date Measured: 19 February 2013

Site Information

Site Name	Logone Gana
Station Number	-
Location	Logone

Measurement Information

Party	BGR/CBLT
Boat/Motor	Zodiac/Paddle
Meas. Number	2

System Information

System Type	RS-M9
Serial Number	2456
Firmware Version	2.00
Software Version	2.50

System Setup

Transducer Depth (m)	0.06
Salinity (ppt)	0.0
Magnetic Declination (deg)	0.5

Units

Distance	m
Velocity	m/s
Area	m2
Discharge	m3/s
Temperature	degC

Discharge Calculation Settings

Track Reference	Bottom-Track	Left Method	Sloped Bank
Depth Reference	Vertical Beam	Right Method	Sloped Bank
Coordinate System	ENU	Top Fit Type	Power Fit
		Bottom Fit Type	Power Fit

Discharge Results

Width (m)	101.67
Area (m2)	301.7
Mean Speed (m/s)	0.245
Total Q (m3/s)	72.430

Measurement Results

Tr		Time			Distance				Mean Vel		Discharge							%
#		Time	Duration	Temp.	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	LCTotal	Measured
1	R	16:29:11	0:10:19	23.6	101.77	95.88	97.38	342.2	0.164	0.211	0.03	0.00	5.24	59.37	7.47	72.111	--	82.3
2	L	16:41:24	0:09:20	23.6	116.13	100.86	105.96	261.1	0.207	0.279	0.01	0.07	5.08	62.34	5.26	72.749	--	85.7
			Mean	23.6	108.95	98.37	101.67	301.7	0.186	0.245	0.02	0.03	5.16	60.85	6.36	72.430	0.000	84.0
			Std Dev	0.0	7.18	2.49	4.29	40.5	0.021	0.034	0.01	0.04	0.08	1.48	1.10	0.319	0.000	1.7
			COV	0.0	0.066	0.025	0.042	0.134	0.116	0.139	0.729	1.152	0.016	0.024	0.174	0.004	0.000	0.020

Exposure Time: 0:19:39

Tr1=20130219162910.riv; Tr2=20130219164122.riv;

Comments

Tr1=20130219162910.riv - ; Tr2=20130219164122.riv - ;

Compass Calibration

Not Loaded

System Test

Not Loaded

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

Report generated using SonTek RiverSurveyor Live v2.50

x

Station Number: 2 | Meas. No: 0

Station Name: Logone Gana | Date: 02/19/2013

Party: Abba/Torsten	Width: 107.7 m	Processed by: Abba/Torsten
Boat/Motor: Zodiac/Paddle	Area: 363.0 m²	Mean Velocity: 0.201 m/s
Gage Height: 1.480 m	G.H.Change: 0.000 m	Discharge: 71.1 m³/s

Area Method: Avg. Course	ADCP Depth: 0.100 m	Index Vel.: 0.00 m/s	Rating No.: 1
Nav. Method: None	Shore Ens.:10	Adj.Mean Vel: 0.00 m/s	Qm Rating: U
MagVar Method: None (0.5°)	Bottom Est: Power (0.1667)	Rated Area: 0.000 m²	Diff.: 0.000%
Depth Sounder: Not Used	Top Est: Power (0.1667)	Control1: Unspecified	
		Control2: Unspecified	
		Control3: Unspecified	

Screening Thresholds:

BT 3-Beam Solution: YES	Max. Vel.: 0.877 m/s	
WT 3-Beam Solution: NO	Max. Depth: 7.43 m	
BT Error Vel.: 0.10 m/s	Mean Depth: 3.39 m	
WT Error Vel.: 1.07 m/s	% Meas.: 67.65	
BT Up Vel.: 0.30 m/s	Water Temp.: None	
WT Up Vel.: 0.50 m/s	ADCP Temp.: 23.1 °C	
Use Weighted Mean Depth: YES		

ADCP:

Type/Freq.: Rio Grande / 1200 kHz	
Serial #: 8547	Firmware: 10.16
Bin Size: 25 cm	Blank: 25 cm
BT Mode: 5	BT Pings: 1
WT Mode: 1	WT Pings: 1
WV : 175	

Performed Diag. Test: NO

Performed Moving Bed Test: NO

Performed Compass Test: NO

Meas. Location: downstream of gauging station

Project Name: 2_0.mmt

Software: 2.08

Tr.#		Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
000	*R*	***2.00***	***2.00***	***472***	***8.39***	***49.0***	***5.26***	***0.228***	***0.239***	***63.2***	***103.2***	***402.5***	***16:32***	***16:38***	***0.29***	***0.16***	***34***	***2***
001	*L*	***1.70***	***5.00***	***602***	***16.2***	***47.2***	***13.9***	***0.119***	***1.68***	***79.0***	***112.1***	***323.5***	***16:41***	***16:49***	***0.21***	***0.24***	***38***	***0***
Mean		1.85	3.50	537	12.3	48.1	9.59	0.174	0.960	71.1	107.7	363.0	**Total**	00:17	0.25	0.20	36	1
SDev		0.21	2.12	92	5.50	1.32	6.12	0.077	1.02	11.2	6.3	55.9			0.05	0.06		
SD/M		0.11	0.61	0.17	0.45	0.03	0.64	0.44	1.06	0.16	0.06	0.15			0.21	0.31		

Remarks:

Discharge for transects in *italics* have a total Q more than 5% from the mean

Discharge Measurement Summary

Date Measured: 18 February 2013

Site Information

Site Name	Koulambou Gana
Station Number	-
Location	Koulambou

Measurement Information

Party	BGR/CBLT
Boat/Motor	Zodiac/Paddle
Meas. Number	6

System Information

System Type	RS-M9
Serial Number	2456
Firmware Version	2.00
Software Version	2.50

System Setup

Transducer Depth (m)	0.06
Salinity (ppt)	0.0
Magnetic Declination (deg)	0.5

Units

Distance	m
Velocity	m/s
Area	m2
Discharge	m3/s
Temperature	degC

Discharge Calculation Settings

Track Reference	Bottom-Track	Left Method	Sloped Bank
Depth Reference	Vertical Beam	Right Method	Sloped Bank
Coordinate System	ENU	Top Fit Type	Power Fit
		Bottom Fit Type	Power Fit

Discharge Results

Width (m)	71.27
Area (m2)	84.5
Mean Speed (m/s)	0.258
Total Q (m3/s)	21.355

Measurement Results

Tr		Time			Distance				Mean Vel		Discharge							%
#		Time	Duration	Temp.	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	LCTotal	Measured
1	R	17:03:57	0:03:40	24.9	68.58	66.90	68.70	101.4	0.312	0.206	0.01	0.00	2.59	16.99	1.26	20.844	--	81.5
2	L	17:08:21	0:03:54	24.7	71.11	69.17	70.37	97.5	0.304	0.221	0.01	0.00	2.64	17.54	1.40	21.589	--	81.3
3	R	17:12:32	0:02:55	24.3	67.86	67.27	68.47	84.2	0.388	0.258	0.00	0.00	3.35	16.83	1.54	21.720	--	77.5
4	L	17:15:53	0:03:23	24.1	71.11	68.55	69.75	84.1	0.350	0.255	0.00	0.00	2.70	17.24	1.53	21.464	--	80.3
5	R	17:26:36	0:03:37	23.7	72.30	67.18	68.78	72.7	0.333	0.288	0.01	0.00	2.61	17.04	1.25	20.915	--	81.5
6	L	17:31:45	0:04:03	23.6	82.17	80.36	81.56	66.9	0.338	0.323	0.01	0.00	2.79	17.52	1.27	21.596	--	81.1
			Mean	24.2	72.19	69.90	71.27	84.5	0.338	0.258	0.01	0.00	2.78	17.19	1.37	21.355	0.000	80.5
			Std Dev	0.5	4.72	4.75	4.65	12.3	0.027	0.039	0.00	0.00	0.26	0.27	0.12	0.345	0.000	1.4
			COV	0.0	0.065	0.068	0.065	0.145	0.081	0.151	0.538	0.000	0.095	0.016	0.088	0.016	0.000	0.018

Exposure Time: 0:21:32

Tr1=20130218170357.riv; Tr2=20130218170820.riv; Tr3=20130218171232.riv; Tr4=20130218171551.riv; Tr5=20130218172636.riv; Tr6=20130218173144.riv;

Comments

Tr1=20130218170357.riv - ; Tr2=20130218170820.riv - ; Tr3=20130218171232.riv - ; Tr4=20130218171551.riv - ;
Tr5=20130218172636.riv - ; Tr6=20130218173144.riv - ;

Compass Calibration

Not Loaded

System Test

Not Loaded

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

Report generated using SonTek RiverSurveyor Live v2.50

Station Number: 1 Meas. No: 0

Station Name: Logone gana - Koulamban Date: 02/19/2013

Party: Torsten/Djoret	Width: 69.8 m	Processed by: Torsten/Djoret
Boat/Motor: Zodiac/Paddle	Area: 101.9 m²	Mean Velocity: 0.216 m/s
Gage Height: 1.500 m	G.H.Change: 0.000 m	Discharge: 22.0 m³/s

Area Method: Avg. Course	ADCP Depth: 0.150 m	Index Vel.: 0.00 m/s	Rating No.: 1
Nav. Method: None	Shore Ens.:10	Adj.Mean Vel: 0.00 m/s	Qm Rating: G
MagVar Method: None (0.5°)	Bottom Est: Power (0.1667)	Rated Area: 0.000 m²	Diff.: 0.000%
Depth Sounder: Not Used	Top Est: Power (0.1667)	Control1: Unspecified	
		Control2: Unspecified	
		Control3: Unspecified	

Screening Thresholds:

BT 3-Beam Solution: YES	Max. Vel.: 1.70 m/s	Type/Freq.: Rio Grande / 1200 kHz
WT 3-Beam Solution: NO	Max. Depth: 2.12 m	Serial #: 8547 Firmware: 10.16
BT Error Vel.: 0.10 m/s	Mean Depth: 1.47 m	Bin Size: 5 cm Blank: 25 cm
WT Error Vel.: 0.15 m/s	% Meas.: 60.24	BT Mode: 5 BT Pings: 1
BT Up Vel.: 0.30 m/s	Water Temp.: 28.0 °C	WT Mode: 11 WT Pings: 1
WT Up Vel.: 0.50 m/s	ADCP Temp.: 23.1 °C	WZ : 5
Use Weighted Mean Depth: YES		

ADCP:

Performed Diag. Test: NO

Performed Moving Bed Test: NO

Performed Compass Test: NO

Meas. Location: Downstrem of Gauge Station

Project Name: gana1_0.mmt

Software: 2.08

Tr.#		Edge Distance L	Edge Distance R	#Ens.	Discharge Top	Discharge Middle	Discharge Bottom	Discharge Left	Discharge Right	Discharge Total	Width	Area	Time Start	Time End	Mean Vel. Boat	Mean Vel. Water	% Bad Ens.	% Bad Bins
000	R	2.00	5.00	190	7.09	12.9	2.05	0.028	-0.004	22.1	74.7	98.2	13:19	13:24	0.30	0.23	17	3
001	L	1.50	1.50	206	6.11	13.5	2.09	0.034	0.070	21.8	65.0	105.6	13:25	13:30	0.26	0.21	14	3
Mean		1.75	3.25	198	6.60	13.2	2.07	0.031	0.033	22.0	69.8	101.9	**Total**	00:10	0.28	0.22	15	3
SDev		0.35	2.47	11	0.694	0.429	0.033	0.004	0.052	0.175	6.8	5.3			0.03	0.01		
SD/M		0.20	0.76	0.06	0.11	0.03	0.02	0.14	1.59	0.01	0.10	0.05			0.12	0.06		

Remarks:

Discharge Measurement Summary

Date Measured: 20 February 2013

Site Information

Site Name	Logone Bongor
Station Number	-
Location	Logone

Measurement Information

Party	BGR/CBLT
Boat/Motor	Zodiac/Paddle
Meas. Number	5

System Information

System Type	RS-M9
Serial Number	2456
Firmware Version	2.00
Software Version	2.50

System Setup

Transducer Depth (m)	0.06
Salinity (ppt)	0.0
Magnetic Declination (deg)	0.5

Units

Distance	m
Velocity	m/s
Area	m2
Discharge	m3/s
Temperature	degC

Discharge Calculation Settings

Track Reference	Bottom-Track	Left Method	Sloped Bank
Depth Reference	Vertical Beam	Right Method	Sloped Bank
Coordinate System	ENU	Top Fit Type	Power Fit
		Bottom Fit Type	Power Fit

Discharge Results

Width (m)	274.68
Area (m2)	480.9
Mean Speed (m/s)	0.153
Total Q (m3/s)	73.260

Measurement Results

Tr		Time			Distance				Mean Vel		Discharge							%
#		Time	Duration	Temp.	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	LCTotal	Measured
1	L	12:38:43	0:14:45	25.7	297.27	273.84	275.94	498.7	0.336	0.146	-0.01	0.00	7.29	61.02	4.71	73.009	--	83.6
2	R	12:55:48	0:12:10	25.7	281.73	269.80	271.90	455.8	0.386	0.157	-0.01	0.00	8.12	58.88	4.79	71.789	--	82.0
3	L	13:08:33	0:18:30	25.9	302.21	272.39	273.99	481.2	0.272	0.154	0.00	0.00	8.04	61.47	4.83	74.347	--	82.7
4	R	13:35:13	0:16:12	26.3	304.19	272.85	275.85	449.3	0.313	0.161	-0.01	0.01	8.17	59.39	4.83	72.398	--	82.0
5	L	13:53:57	0:17:12	26.1	299.05	272.19	275.69	519.2	0.290	0.144	-0.01	0.00	7.14	62.85	4.78	74.758	--	84.1
			Mean	25.9	296.89	272.22	274.68	480.9	0.319	0.153	-0.01	0.00	7.75	60.72	4.79	73.260	0.000	82.9
			Std Dev	0.2	7.95	1.33	1.56	26.1	0.040	0.007	0.00	0.01	0.45	1.44	0.04	1.131	0.000	0.8
			COV	0.0	0.027	0.005	0.006	0.054	0.124	0.043	-0.361	3.483	0.057	0.024	0.009	0.015	0.000	0.010

Exposure Time: 1:18:49

Tr1=20130220123841.riv; Tr2=20130220125547.riv; Tr3=20130220130831.riv; Tr4=20130220133512.riv; Tr5=20130220135355.riv;

Comments

Tr1=20130220123841.riv - ; Tr2=20130220125547.riv - ; Tr3=20130220130831.riv - ; Tr4=20130220133512.riv - ; Tr5=20130220135355.riv - ;

Compass Calibration

Not Loaded

System Test

Not Loaded

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

Report generated using SonTek RiverSurveyor Live v2.50

Station Number: 1 | Meas. No: 0

Station Name: Bongor | Date: 02/20/2013

Party: Tapsala	Width: 277.5 m	Processed by: Tapsala
Boat/Motor: Zodiac Padle	Area: 477.8 m²	Mean Velocity: 0.151 m/s
Gage Height: 1.180 m	G.H.Change: 0.000 m	Discharge: 72.1 m³/s

Area Method: Avg. Course	ADCP Depth: 0.070 m	Index Vel.: 0.00 m/s	Rating No.: 1
Nav. Method: None	Shore Ens.:10	Adj.Mean Vel: 0.00 m/s	Qm Rating: U
MagVar Method: None (0.5°)	Bottom Est: Power (0.1667)	Rated Area: 0.000 m²	Diff.: 0.000%
Depth Sounder: Not Used	Top Est: Power (0.1667)	Control1: Unspecified	
		Control2: Unspecified	
		Control3: Unspecified	

Screening Thresholds:

BT 3-Beam Solution: YES	Max. Vel.: 0.601 m/s	
WT 3-Beam Solution: NO	Max. Depth: 2.99 m	
BT Error Vel.: 0.10 m/s	Mean Depth: 1.72 m	
WT Error Vel.: 0.15 m/s	% Meas.: 71.32	
BT Up Vel.: 0.30 m/s	Water Temp.: 26.0 °C	
WT Up Vel.: 0.50 m/s	ADCP Temp.: 25.1 °C	
Use Weighted Mean Depth: YES		

ADCP:

Type/Freq.: Rio Grande / 1200 kHz	
Serial #: 8547	Firmware: 10.16
Bin Size: 5 cm	Blank: 25 cm
BT Mode: 5	BT Pings: 1
WT Mode: 11	WT Pings: 1
WZ : 5	

Performed Diag. Test: YES

Performed Moving Bed Test: NO

Performed Compass Test: NO

Meas. Location: Gage station

Project Name: Bongor_0.mmt

Software: 2.08

Tr.#		Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
001	L	1.50	1.00	463	14.6	52.4	5.83	-0.002	0.007	72.8	275.1	500.6	12:39	12:52	0.36	0.14	4	1
002	R	0.30	2.00	383	14.8	50.0	5.58	-0.001	0.037	70.5	269.7	461.0	12:55	13:06	0.42	0.15	5	2
003	L	0.50	1.00	589	14.3	53.8	5.92	-0.005	-0.003	74.0	288.6	504.1	13:09	13:26	0.31	0.15	5	1
004	R	1.00	1.00	499	15.8	49.5	5.94	-0.002	0.003	71.2	276.4	445.6	13:35	13:50	0.34	0.16	3	1
Mean		0.83	1.25	483	14.9	51.4	5.82	-0.003	0.011	72.1	277.5	477.8	**Total**	01:11	0.36	0.15	4	1
SDev		0.54	0.50	85	0.642	2.02	0.164	0.002	0.018	1.60	8.0	29.0			0.05	0.01		
SD/M		0.65	0.40	0.18	0.04	0.04	0.03	0.69	1.62	0.02	0.03	0.06			0.14	0.04		

Remarks:

Teledyne RD Instruments

Workhorse Rio Grande

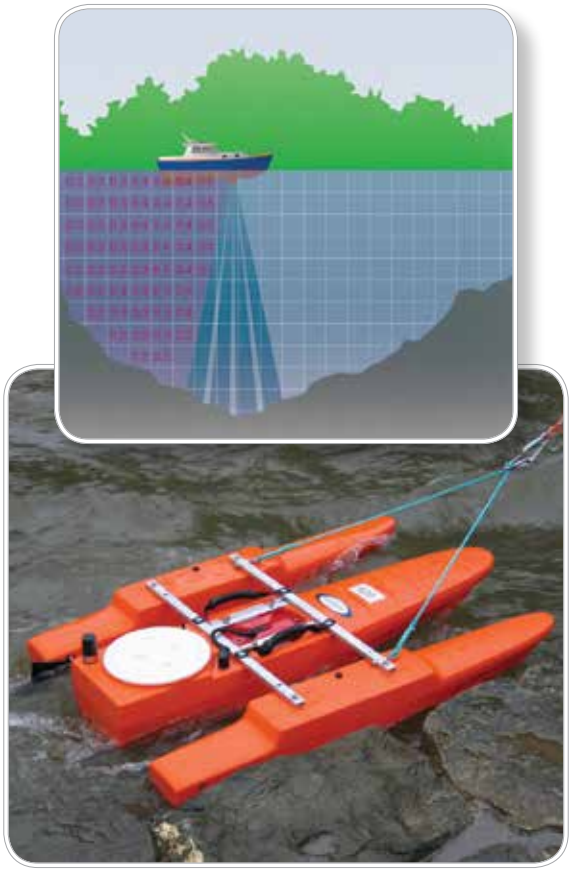
Versatile River Discharge Measurement System

The Industry Standard

The WORKHORSE RIO GRANDE ADCP (Acoustic Doppler Current Profiler) is an accurate, rapid-sampling current profiling system designed to operate from a moving boat. The result is the fastest, safest, and most flexible method for measuring discharge.

The Rio Grande can be used for a wide range of river conditions, from shallow 0.5m deep streams to rushing rivers and tidal estuaries where no prior discharge data exists.

The advantages will revolutionize the way you collect data, resulting in more productive, diverse, and cost-effective river surveys; reduced lifetime equipment costs; and the highest-quality data sets available.



Teledyne RDI's Rio Grande ADCP allows you to collect real-time discharge measurements from any moving platform—from small tethered boats to inland survey vessels.

PRODUCT FEATURES

- **Accurate:** Teledyne RDI's Broadband technology allows for small depth cells and fast transects, allowing for highly accurate and repeatable velocity and discharge measurements.
- **Compatible:** The Rio Grande is designed to integrate with external sensors including GPS, depth sounder, and an external compass via WinRiver II Windows-based software.
- **Robust:** The Rio Grande boasts low flow or weak current measurement capability with high-precision modes (equipped as standard).
- **Versatile:** The unit's large depth range profiling capability that allows one unit to be used in both dry season (shallow and low flow) and flood season (high stage and strong flow) for the same site.
- **User-friendly:** The system includes comprehensive and multi-language data acquisition and processing software with standard discharge summary table.

Workhorse Rio Grande

Versatile River Discharge Measurement System

TECHNICAL SPECIFICATIONS

		WHR600 600kHz	WHRZ1200 1200kHz
Water Velocity Profiling	Profiling range	0.7m[1] to 75m[2]	0.3m[1] to 25m[2]
	Velocity range	±5m/s default, ±20m/s maximum	
	Accuracy	±0.25% of water velocity relative to ADCP, ±2mm/s	
	Resolution	1mm/s	1mm/s
	Number of cells	1-128	1-128
	Cell size	0.1m to 4m	0.05m to 2m
	Blanking distance	0.25m	0.05m
	Data output rate	1-2Hz (typical)	1-2Hz (typical)
Bottom Tracking	Velocity range	±9.5m/s	±9.5m/s
	Depth range	0.8m to 90m[2]	0.5m to 30m[2]
	Accuracy	±0.25% of bottom velocity relative to ADCP, ±2mm/s	
	Resolution	1mm/s	1mm/s
Depth Measurement	Range	0.8m to 90m[2]	0.5m to 30m[2]
	Accuracy	±1%[3] ±1cm	±1%c ±1cm
	Resolution	1mm/s[4]	1mm/s[4]

Standard Sensors		Temperature	Tilt (pitch and roll)	Compass
	Range	-5°C to 40°C	±15°	0-360°
	Accuracy	±0.4°C	±0.5°	±2°
	Resolution	0.01°C	0.01°	0.01°

Operation Modes	Standard profiling mode (Broadband)	Mode 1
	High precision profiling mode (included)	Mode 5 and Mode 11
	High ping profiling mode (optional)	Mode 12
	Shallow water bottom tracking mode (optional)	Bottom tracking Mode 7
Transducer and Hardware	Configuration	Janus four beams at 20° beam angle
	Internal memory	Optional flash PC card up to 2GB
Software[5]	• WinRiver II (standard) for moving-boat measurement • SxS Pro (optional) for stationary measurement; comes with an uncertainty model for in situ quality evaluation and control	
Communications	Serial (standard)	RS-232, 1200 to 115,200 baud rate
	Radio modem (optional)	Range >30km (line of sight)
Integration	With GPS, depth sounder, or external gyrocompass: available through RS232 to PC with WinRiver II software	
Power	Input voltage	10.5–18V DC
	Power consumption	1.5W typical
Float (optional)	Configuration	Three hulls (trimaran)
	Material	Polyethylene
	Dimensions	Length 120cm, width 80cm, height 18cm
	Weight	10kg bare; 17kg with instrument and battery
Environmental	Operating temperature	-5°C to 45°C
	Storage temperature	-20°C to 50°C

1 Assume one good cell (minimum cell size) with high-precision profiling mode; range measured from transducer surface.
2 Assume fresh water; actual range depends on temperature and suspended solids concentration.
3 Assume uniform water temperature and salinity profile.
4 For averaged depth data.
5 For system setup, data acquisition, discharge calculation, data display, and summary report

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RiverSurveyor

Useful options and accessories make the RiverSurveyor a complete, turn-key solution!

Mobile Handheld:
RiverSurveyor Live! Mobile running on a SonTek-provided handheld device makes one-man system operation simple. (Model subject to change.)

Power/Communications:
The Power/Communications Module (PCM) for the S5 and the M9 features rechargeable battery packs. It can be factory-configured with Bluetooth®, spread spectrum radio, SBAS-GPS, or RTK GPS.

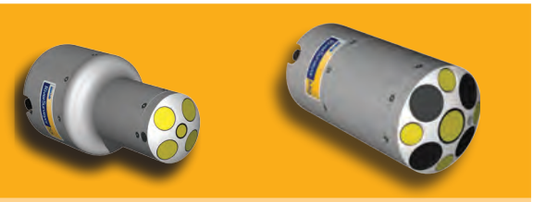
RTK GPS:
The optional SonTek RTK GPS[3] solution is easy to use and offers an incredibly precise, fully integrated boat speed solution to augment, or be an alternative to, bottom tracking.

SonTek HydroBoard:
All-in-one, rugged and easy to transport, choose from two laminated foam HydroBoard options:
- Short: 36" (91cm)
- Long: 48" (122cm)

HydroBoard Bags:
Outfitted with back pack and shoulder straps, these bags offer the perfect transportation option for both the short and long HydroBoards.

Boat Mount:
Delrin/aluminum fixture that is custom designed for the M9 or S5 to facilitate mounting over the side of a boat.

Trimaran:
Contact SonTek for trimaran solutions to fit special applications.



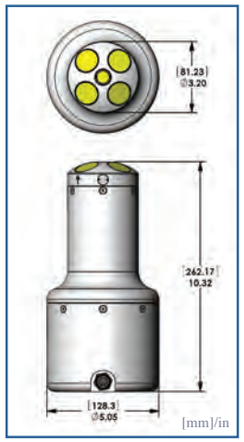
SPECIFICATIONS	S5	M9
Velocity Measurement		
-Profiling Range (Distance)	0.06m to 5m	0.06m to 40m
-Profiling Range[1] (Velocity)	+/- 20 m/s	+/- 20 m/s
-Accuracy[1]	Up to +/- 0.25% of measured velocity; +/- 0.2cm/s	Up to +/- 0.25% of measured velocity; +/- 0.2cm/s
-Resolution	0.001 m/s	0.001 m/s
-Number of Cells	Up to128	Up to 128
-Cell Size	0.02m to 0.5m	0.02m to 4m
Transducer Configuration	Five (5) Transducers; 4-beam 3.0 MHz Janus at 25° Slant Angle; 1.0 MHz Vertical Beam	Nine (9) Transducers; Dual 4-Beam 3.0 MHz/1.0 MHz Janus at 25° Slant Angle; 0.5 MHz Vertical Beam
Depth Measurement		
-Range	0.20m to 15m	0.20m to 80m
-Accuracy	1%	1%
-Resolution	0.001m	0.001m
Discharge Measurement		
-Range with Bottom-Track	0.3m to 5m	0.3m to 40m
-Range with RTK GPS or DGPS	0.3m to 15m	0.3m to 80m
-Computations	Internal	Internal

S5/M9 Additional Specifications

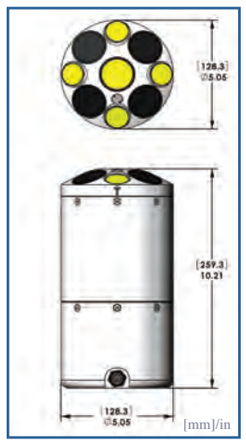
- Temperature Sensor
  - Resolution: ± 0.01° C
  - Accuracy: ± 0.1° C
- Compass/Tilt (Solid State Type)
  - Range: 360°
  - Heading Accuracy: ± 2°
  - Pitch/Roll: ± 1°
- Internal Recorder Size: 8GB
- Power/Communications
  - 12 - 18v DC
  - RS232 Communications
  - RS232 Serial GPS Input
  - Max Data Output Rate: 2 Hz
  - Internal Sampling Rate: Up to 70 Hz
- Physical/Environmental
  - Depth Rating: 50m
  - Operating Temperature: -5° to 45° C
  - Storage Temperature: -10° to 70° C

Power Communications Module

- Batteries
  - Type: Rechargeable
  - Capacity/duration: 8 hours of continuous operation (4 hours with RTK GPS enabled)
- Telemetry Options/Range
  - Bluetooth (Mobile Device): 75m
  - Bluetooth (Laptop): 300m
  - Spread Spectrum Radio: 1000m
- GPS Options
  - SBAS GPS Horizontal Accuracy[2]: <1.0m
  - RTK GPS Horizontal Precision[2,3] (repeatability): <0.03m



RiverSurveyor-S5
- Weight in Air: 1.1 kg (2.5 lb)
- Weight in Water: -0.3 kg (-0.7 lb)



RiverSurveyor-M9
- Weight in Air: 2.3 kg (5.0 lb)
- Weight in Water: -0.6 kg (-1.3 lb)

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SonTek/YSI, founded in 1992 and advancing environmental science in over 100 countries, manufactures affordable, reliable acoustic Doppler instruments for water velocity measurement in oceans, rivers, lakes, harbors, estuaries, and laboratories.

Lit. S05-02-1110.

sontek.com

[1]Please contact SonTek/YSI for accuracies better than 1%, or velocities >10 m/s.
[2]Depends on multipath environment, antenna selection, number of satellites in view, satellite geometry, and ionospheric activity.
[3]Contact SonTek for details about RTK GPS performance and specifications.

RiverSurveyor®

Instant Discharge Measurements

Complete 3-D velocity profiling, bathymetric measurement and discharge calculation as you transect the channel!

RiverSurveyor®

Instant Discharge Measurements

Sound Principles. Good Advice.

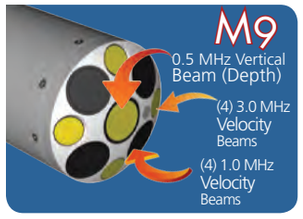
Discharge
Bathymetry
Current Profiling

Taken to Incredible Extremes.

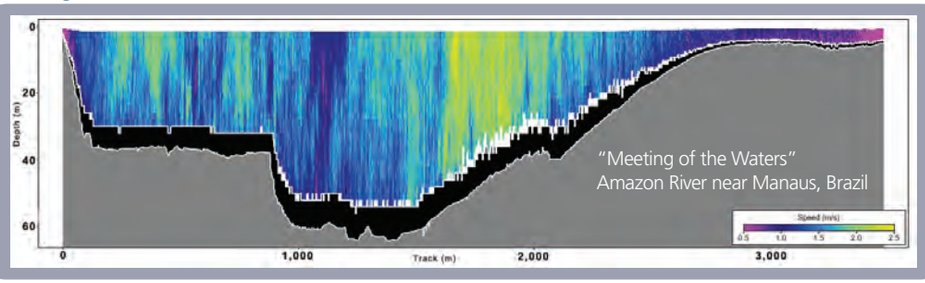
It's an immense goal - to build a river discharge measurement system without the traditional limitations. It had to be small, portable and easy to use. It had to be so robust that it could measure in extreme flood or drought situations without changing instruments or user settings. It had to provide high definition data for critical decision making. And the data had to be immediately recognizable in the palm of your hand. The results speak for themselves, the SonTek RiverSurveyor S5 and M9 are revolutionizing the way discharge is measured in rivers and canals.

It's a SonTek exclusive - multiple acoustic frequencies with **SmartPulseHD™** make for the most robust and continuous shallow-to-deep measurements ever. An array of four deterministic microcontrollers expertly apportion the proper acoustics, pulse scheme, and cell size so you can focus on the measurement - not the instrument setup. The system even has a vertical beam for accurate channel definition - and it's all designed to work intuitively. Slow to fast, shallow to deep, RiverSurveyor handles it all on the fly.

Leading edge technologies such as Bluetooth®, spread spectrum radio, handheld computers, and RTK (Real-Time Kinematic) GPS are all incorporated to elevate performance and expand utility.



(Below) Harness the shallow-to-deep capability, as seen in this data set showing profile range to over 40m.

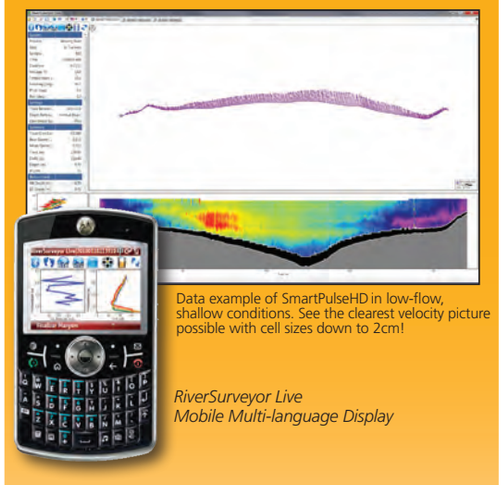


Display. Process. Analyze.

Exceed your expectations both during and after the measurement with the RiverSurveyor Live! software suite for both PC and mobile platforms. All programs take full advantage of SmartPulseHD™ and the intelligent software ensures no loss of data during telemetry dropouts. Easily switch between computer or mobile devices during mid-measurement. Several quality indicators and statistics with selectable graphics provide instant feedback on data collection. Multi-language support includes Afrikaans, Catalan, Chinese, English (UK & US), French, German, Hungarian, Italian, Japanese, Korean, Portuguese, Spanish and Turkish. Need your language? Let us know at inquiry@sontek.com.

Moving Boat

Standard with every system and used for underway measurements that calculate discharge from a moving vessel.



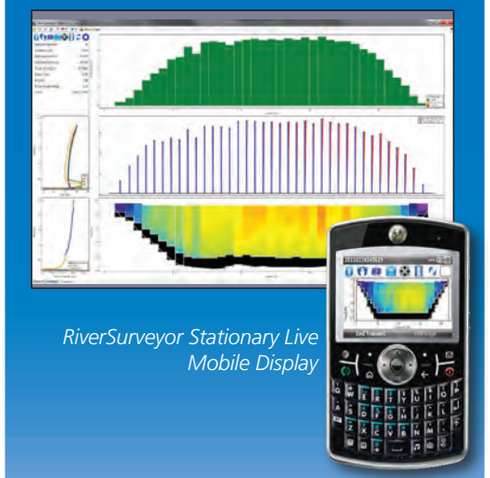
Data example of SmartPulseHD in low-flow, shallow conditions. See the clearest velocity picture possible with cell sizes down to 2cm!

RiverSurveyor Live Mobile Multi-language Display

- Enables you to efficiently transect from one bank to the other with a full contour plot of the water velocity profile and bottom bathymetry.
- View multiple data results (bottom-track-vertical beam, GPS-GGA, and GPS-VTG) simultaneously.
- Supports USGS Loop Correction Method for moving bed conditions.

Stationary (Section-by-Section)

Optional add-on program that uses traditional USGS/ISO mid section or mean section methods.



RiverSurveyor Stationary Live Mobile Display

- An alternative to moving boat method for highly turbulent areas or moving bed environments where DGPS is unavailable.
- Supports discharge measurements through ice holes.
- Supports sections that are braided or have islands.

*Hydroboard design and color subject to change.

Features	Benefits
Multi-band* (Multiple acoustic frequencies)	Balances the highest resolution with the greatest range of depths.
Vertical acoustic beam*	Superior channel definition for both bathymetric and discharge applications. Extends maximum discharge depth when bottom-tracking is out of range.
SmartPulseHD™*	An intelligent algorithm that looks at water depth, velocity and turbulence, and then acoustically adapts to those conditions using pulse-coherent, broadband, and incoherent techniques. High-def cell sizes down to 2 cm.
Microprocessor computed discharge and secure data*	All discharge computations are simultaneously done both within the S5 or M9, and on the host computer. No lost data if communications drop out.
Standard 360° compass and two-axis tilt sensor	Compensates for vessel motion due to surface conditions.
Reverberation control with ping rates to 70Hz	High ping rates ensure extremely robust data collection.
Bottom-tracking	Acoustically track vessel speed over ground independent of DGPS. Also supplies redundant depth measurement.
RTK GPS (optional)	Ultra precise positioning as an alternative to bottom tracking in moving bed or other difficult situations.

*Patents pending

River Discharge and Flow

Irrigation Canals

Natural Streams

SonTek
YSI incorporated®

sontek.com