

---

# *Standard Operating Procedures for Mid-section open water discharge measurements using ADCPs*

## *Water Survey of Canada*

---

P Campbell, Water Survey of Canada, Environment Canada, Ottawa, 2015

Version 1.0



## Revision History

Version	Date	Source	Description/Rational for Change
1.0	March 2015	PFC	

## Table of Contents

1	Introduction.....	2
1.1	Note on instrumentation, software and firmware .....	5
2	Getting Started with Mid-Section Method Software .....	6
3	Prior to departure: .....	7
4	On arrival at site: .....	8
5	Start measurement: .....	10
6	Data Review .....	26

## *Acknowledgements:*

This document was written with the assistance of people both within and external to the Water Survey of Canada. Curt Naumann, Andrew Creighton, Francois Rainville, Alain DuCap, Elizabeth Jamieson, Scott Hill, Jeff Woodward, Murray Jones, Paul-Emile Bergeron either contributed material, reviewed technical information or contributed to the development of the mid-section software. Some material was adapted from previously existing training material created by the USGS Hydroacoustics Working Group (HaWG). The WSC has benefitted from investigations and recommendations related to mid-section ADCP measurements originating from the HaWG.

# 1 Introduction

Acoustic Doppler current profilers (ADCPs) are typically used for measuring river discharge from a floating platform or boat that is continuously moving across the river from one bank to the other. A hydrographer can also use ADCP's to measure river discharge using the mid-section method in which the ADCP is held in place for a specified duration at multiple discrete locations, or verticals<sup>1</sup>, across the stream. Water velocity data is captured throughout the depth of flow and averaged to obtain a mean velocity estimate integrated over the full depth at each vertical. The depth for each vertical is determined with the ADCP, and representative areas and discharges for each vertical are calculated and summed to obtain a total discharge.

This document presents guidance and standard operating procedures specific to deploying ADCPs for open water mid-section measurements. ***To learn more about WSC Standard operating procedures for ADCP winter measurements, see qSOP-NA041-2014 Under Ice Discharge Measurements using ADCPs.***

## 1.1 When to do a mid-section ADCP measurement

A mid-section ADCP measurement may be a second or third attempt at a discharge measurement that cannot be completed using the moving boat method. If there is moving bed and the compass is not functioning as required, alternate ADCP measurement options are mid-section method or stationary moving bed analysis (SMBA). Figure 1 presents a decision tree diagram to aid the hydrographer in deciding what type of discharge measurement to carry out for non-wading conditions.

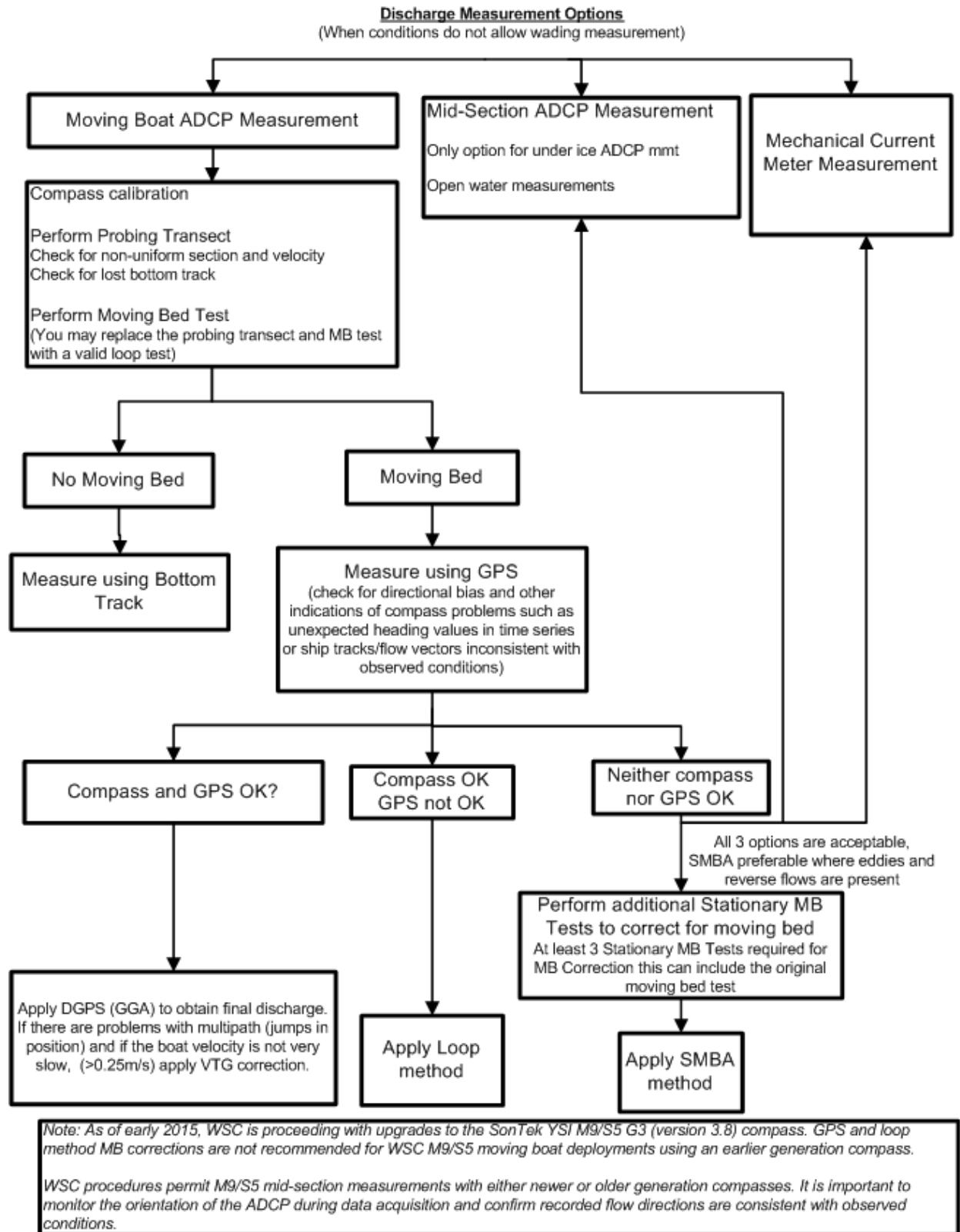
Reasons for using an ADCP in mid-section mode include;

- Under- ice measurements
- Poor bottom tracking performance combined with poor GPS reception or suspect compass performance
- Difficulty completing moving boat transects
- Confirming bank overflow discharges
- Check measurements

The mid-section method is not biased by moving-bed conditions because the ADCP is assumed to be held stationary for each measurement location. Bottom tracking is not referenced, only water velocity is measured by the ADCP. **This means that moving bed tests are not required as part of a mid-section ADCP measurement.**

---

<sup>1</sup> "Verticals" and "panels" are terms used within WSC for the sub-sectioned areas across a stream, each represented by a water velocity and depth observation at its centre. RiverSurveyor Stationary Live uses "station" to describe the same thing.



**Figure 1: Decision tree for discharge measurement options.**  
(Note: MB = Moving Bed; SMBA = Stationary Moving Bed Analysis)

Some advantages to using the mid-section method for open water hydroacoustic measurements include;

- a valid boat speed reference (bottom track or GPS) is not required, eliminating a source of uncertainty
- discharge measurement procedures are familiar to hydrographers and
- software is available to assist in the procedure.

There are also some disadvantages, such as;

- a requirement to manually measure positions,
- operators need to be careful to account for angled flow (flow not perpendicular to tagline orientation)
- the procedure assumes ADCP movement is negligible. Therefore the ADCP must be kept stationary for a valid measurement.<sup>2</sup>

## 1.2 Basic Principles of the ADCP Mid-Section Method

Many of the mid-section method standards and procedures defined in the *Hydrometric Field Manual-Measurement of Streamflow* (Terzi, 1981) written for mechanical current meters also apply to open water and under-ice ADCP mid-section measurements. Desirable characteristics of measurement cross sections for hydroacoustics are the same as a good cross section for a current meter measurement.

These characteristics include:

- a measurement section normal or perpendicular to the predominant direction of flow,
- a section that has relatively straight and parallel streamlines,
- low levels of turbulence (for example, strong eddy lines downstream of bridge piers are not desirable),
- very little to no reverse flows,
- regular streambed geometry with few abrupt changes in elevation

A good rule of thumb is to select a measurement location with straight and uniform river banks and bed for a distance of approximately five times the river width upstream of the section and two times the width downstream.

The hydrographer must have a method of determining the tagline location of each vertical, referenced to an initial point on shore and use a deployment platform that will keep the ADCP in a stable position minimizing rotation/swimming/lateral movements during sampling. A measurement will have a minimum of 20 verticals (or panels). The locations of each vertical should be distributed such that large changes in river depths and water velocity are represented. If verticals are correctly located, they should each represent approximately 5% of total discharge. It is strongly recommended to add an extra vertical or two where 10% or more of total discharge is represented in a single vertical.

The ADCP provides velocity and depth data for each vertical. The vertical (or panel) width is half the distance from the current vertical to the previous vertical plus half the distance from the current vertical

---

<sup>2</sup> qSOP NA038-010-2013 *Measuring Discharge Using Acoustic Doppler Current Profilers from a moving boat adapted from USGS Techniques and Methods 3-A22*

to the next vertical. Vertical area is vertical width multiplied by the depth measured during the velocity sampling period. Discharge for each vertical is computed by multiplying the mean water velocity by the vertical area and incremental discharges are summed to determine the total discharge.

### 1.3 A note on instrumentation, software and firmware

A variety of ADCP types may be used for mid-section measurements, and depending on the manufacturer, the mid-section discharge measurement software will also vary. Software approved for under-ice ADCP measurements for WSC operations are SonTek YSI's *RiverSurveyor Stationary Live (RSSL)* and Teledyne RDI's *Section by Section Pro (SxS Pro)*.

The procedures and guidelines presented in this document are described in the help sections of each of the two primary software packages. Both have detailed, searchable user guides and help functions accessible within the software. Consult them regularly to learn more beyond this document. For a list of the current versions of approved software and firmware, see the ***Recommended Software and Firmware for Hydroacoustic Instrumentation*** document (qREC-NA058--201x), found on the WSC intranet Library.

## 2 Getting Started with Mid-Section Method Software

SonTek YSI's *RiverSurveyor Stationary Live (RSSL)* and Teledyne RDI's *Section by Section Pro (SxS Pro)* are software that allow ADCP discharge measurements to be run in accordance to mid-section procedures.

*NOTE: Information specific to SonTek YSI (**SonTek**) and Teledyne RDI (**TRDI**) are identified in separate boxes. **SonTek** information is highlighted in grey. Information specific to **TRDI** is not highlighted.*

Both RSSL and SxS Pro software are free, allowing review of existing measurements by anyone with a personal computer (PC). However some form of registration key is required for RSSL and SxS Pro to acquire data in mid-section mode.

**TRDI:** *Each ADCP is assigned a unique SxS Pro key to unlock the software for acquiring data. This key needs to be input into each PC operating SxS Pro Software for that ADCP. Open SxS Pro and select menu items Help/Register ADCP. The user will be prompted to enter the ADCP serial number and the SxS software key assigned for that ADCP by TRDI. All WSC RiverRay ADCP's would have been assigned SxS Pro keys as standing offer requirement since 2011. **It is recommended to display the SxS Pro key clearly on the exterior of any ADCP if a key exists for that instrument.***

**SonTek:** *To acquire data with RSSL software, a key is input into the ADCP firmware using utility software (SonUtils4). Afterwards any PC with RSSL software will function with the M9/S5 ADCP.*

### 3 Prior to departure:

Pre-departure checks and tasks are almost identical to what is done for a moving boat ADCP measurement. These are described in detail in our standard operating procedures, qSOP-NA038-01-2013 **Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat.**

The following is a summary of pre-departure tasks.

- Inspect ADCP transducer face(s), cables and connectors for damage.
- Confirm communication with the ADCP works. For detailed instructions on setting up Sena Parani SD1000U Bluetooth communications consult qTEC-NA018-01-2013 *Recommended WSC Bluetooth Com Device* in the WSC library.
- Check that mid-section acquisition software is up to date and the ADCP key code(s) are recognized:
  - For SxS Pro, open the software select from upper menu, configure/ADCP port settings. Select the COM port number as determined previously (115200 baud, no parity, one stop bit) then check port by selecting TEST option. It should indicate a good connection with a green checkmark.
  - The listing of the latest firmware and software versions are available in the WSC library (qREC-NA058201x: Recommended Software and Firmware for Hydroacoustic Instrumentation)
- Assess if the ADCP is suitable for the expected effective depths,
  - The TRDI RiverRay typically requires 0.75m depth or more, the SonTek M9 requires at least 0.4m depth using a screening distance of 16 cm beyond the transducer face.
  - StreamPro or S5 are best for consistently shallow depths but like all ADCP's they can experience attenuation of signals in cold, clear water. Although a StreamPro may profile to 6m depths in ideal conditions, in very clear water the range may be limited to less than 2.5m.
  - Be aware that users can switch water modes for ADCPs such as the StreamPro or Rio Grande to adapt to changing conditions at different verticals within the same measurement.
- Check that batteries or battery packs are fully charged
- Ensure the measurement platform is suited for the conditions expected. For example, if expected water velocities are above 3m/s a standard tethered boat may not be sufficient. However a high speed tethered boat or remotely operated boat may work better.
- Run ADCP system tests. If possible, conduct the test in relatively still water, for example, near the shore. Some tests require little or no water motion relative to the ADCP and some tests may fail when not submersed in water.



## 4 On arrival at site:

- The selected measurement cross section should have characteristics similar to a good conventional measurement section.
  - Look for a measurement section on a location of the river with relatively straight streamlines not significantly influenced by upstream changes in river alignment.
  - In tethered boat deployments, avoid sections with strong eddy lines/shear layers that may cause rotation and horizontal movement of the ADCP or potentially flip a tethered boat. Tethered boats cannot be controlled where the flow reverses. Sometimes the effects of pier disturbance can be reduced by paying out the tether further downstream but usually it is difficult to obtain a good quality measurement where strong shear effects are visible on the surface.
  - Do not take unnecessary risks to recover a lost tethered boat. Ensure in advance that contact information is inside the hull or attached to the tethered boat.
  - A measurement section allowing the hydrographer to be positioned so they can measure the direction of flow relative to the tagline (angle of flow) is preferred but not absolutely necessary. There are methods to measure the angle of flow using the ADCP internal compass but it is preferable to be able to visually estimate/confirm the angle of flow from a position directly upstream or downstream of the ADCP. However do not choose this option if it means selecting a location with significantly more turbulence, strong eddy lines or significant reverse flow.
- Check battery voltages and replace if necessary
- Obtain an independent water temperature to check against the ADCP measured water temperature.

***Don't forget that mid-section software such as SxS Pro and RSSL have complete help features integrated into the software. Take the time to learn about it.***

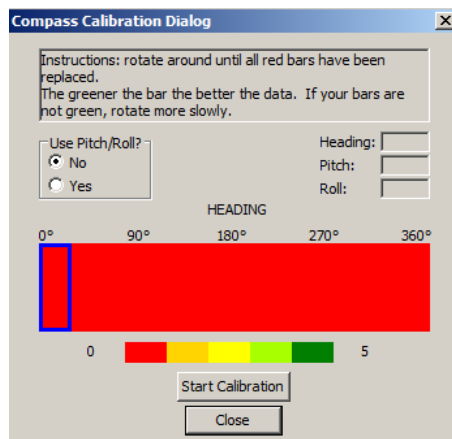
- If you are using a RiverRay or compass-equipped StreamPro TRDI instrument, this is a good time to calibrate the compass. Although there is a ***compass calibration option within SxS Pro, this will only function for a Rio Grande compass. The ISM compass in a Water Survey of Canada RiverRay or compass-equipped StreamPro can be calibrated only within WinRiver II.***

Since the compass for a Rio Grande ADCP can be calibrated within SxS Pro, the compass calibration routine can be done after the initial measurement information is input and the ADCP test is run. The compass calibration routine in SxS Pro is found under the menu options Tests/Compass Calibration.

**TRDI: Compass calibration (River Ray and compass-equipped StreamPro)**

Establish communications between the ADCP and the PC as for a moving boat method either through radio (i.e. Bluetooth) or direct cable connection for manned boat measurements. For details on establishing reliable BT communication with RiverRay ADCPs, see qTEC-NA018-01-2013 Recommended WSC BlueTooth Com Device in the WSC library. Once communication is working within WR II, compass calibration (accessed through **Acquire/Execute Compass Calibration**).

Click on the **Calibrate** button. There is a prompt **"Use Pitch/Roll?"** Unless significant pitch and roll is expected, select **No**. The "No" or "flat" calibration requires two rotations (one for calibration and one for verification).



**Figure 2: example of compass calibration dialog for flat calibration**

The bars will change color as the RiverRay or StreamPro is rotated. Colours indicate the following: Green(Good), Light Green(Acceptable), Yellow(Within parameters- one or two yellow bars for the entire rotation is OK) Orange (Unacceptable - Rotate slower), Red(Not measured). The calibration error should be less than 1 degree. The results will be displayed but will not be recorded within the measurement file so it is important to record the results after the evaluation in the field notes.

**Why are we doing this again?** The calibrated compass will be used to account for rotation of the instrument during velocity sampling periods.

If Pitch/roll is selected, the calibration will require up to eight rotations (four for calibration and four for verification) while pitching the RiverRay or StreamPro up and down.

After a successful calibration, close WinRiver II and open SxS Pro to start the measurement.

## 5 Start measurement:

The following are some common elements for starting a new measurement in both SxS Pro and RSSL.

- Use WSC folder and file naming conventions.
  - The convention for SxS Pro filenames: *StationID\_YYYYMMDD.sxs.mmt*.  
(folder can be named *Station ID\_YYYYMMDD.AQ#*)
  - The convention for RSSL folder names: *(Station ID\_YYYYMMDD.SQ#)*
  
- ADCP data acquisition parameters :
  - Duration: The default sampling period for ADCP mid-section software is 40 seconds. Depending on the quality of the acquired data the user may be prompted to extend the sampling period. More details are in the software specific instructions below. If experience shows that 40 seconds is frequently not enough time to obtain a minimum 30 valid samples, you may choose to use a 50 second sampling duration.
  - ADCP depth: *Set the ADCP depth/draft as for a moving boat measurement. If there is any uncertainty about the ADCP draft, for example, a GPS or radio modem is removed from the tethered boat, re-measure the draft with a measuring tape.*
  - Discharge method: *The two options for discharge method are mean-section method and mid-section method. **Select mid-section method.***

### **TRDI: (SxS Pro) Measurement configuration**

**Get azimuth:** Prior to starting a measurement in SxS Pro,

1) get the azimuth of the measurement section (or tagline azimuth) with a handheld compass by sighting down the bridge or tagline. Ensure to avoid interference from ferrous materials or electronics.

2) Then calculate heading perpendicular to the tagline/bridge in the downstream direction. During the measurement this value can be compared to “boat heading” value in SxS Pro. The difference in the two values is the flow angle.

Using boat heading to estimate flow angles may not be necessary where the boat angle can be directly observed but when a tethered boat is deployed with a bank operated cableway, this can be a useful way to indirectly observe flow angles.

When starting a new measurement in SxS Pro, the Measurement Wizard form appears for user input of measurement information.

**Note the Measurement Wizard does not contain fields for station name or observed field conditions. To enter such information, press F11 (or from Menu select View/Measurement Info).**

The screenshot shows the SxS Pro Measurement Wizard interface. The menu bar includes File, Configure, View, Tests, Acquire, Playback, Tools, and Help. The toolbar contains icons for file operations, settings, and playback. The main form is organized as follows:

- Site information:** Station name (Grey River nr Hwy 22 bridge), Station number (01AA001), River name (Grey River).
- Measurement information:** Measurement number (1), Date (10/09/2014), Field crew (DEC), Location (100 u/s gauge), Grid reference, Weather conditions (sunny, calm winds).
- Agency data:** Agency (WSC), Country (Canada), State (Ontario), County, District, Hydrologic unit.
- Station data:** Stage (0.000 m), Rated Q (0.000 m<sup>3</sup>/s), Tail water level (0.000 m), Air temperature (20 °C), Water temperature (18 °C).
- ADCP hardware and firmware:** Instrument (Rio Grande), Frequency (1200 kHz), Beam angle (20), CPU firmware (10.17), ADCP serial number (3206).
- ADCP setup:** Number of colla (25), Depth cell size (0.25 m), Blank (0.25 m), Water mode (12), Water pings (1), Bottom mode (5), Bottom pings (1).
- Measurement notes:** A large empty text area.
- Fixed commands:** A list of commands including CR1, Cj11110, BAS0, BC220, RR100, BP1, BR2, ES0, EX10111.
- Wizard commands:** A list of commands including TP000009, BX123, EMS, WPT6, WV175, WN25, WS25, WO2,4, WM12.
- Learn commands:** An empty list.

**Figure 3: SxS Pro Measurement Information Screen**

## **TRDI:cont'd**

The rated discharge value can be input at any time during the measurement. This is used to estimate % discharge per panel, optimizing panel spacing during the measurement and ensuring no single panel represents more than 10% of total flow at the end of the measurement.

Input the independently observed water temperature.

Once the measurement information form is complete,

**Set the ADCP time to the PC time.** (see menu option Acquire or Shift-F4)

**Run ADCP tests** (see menu option Tests/ADCP tests or Shift-F8)

Press ctrl-W (or from Menu select File/New Measurement) to open the New Measurement Form.

The image displays two side-by-side screenshots of the 'New Measurement' dialog box. The left window is for a measurement at 'Rio Grande' with the following details: Measurement number 1, Station number 01AA001, Field crew DEC, Date 10/09/2014, Stage 0.00 m, and Rated Q 0.00 m<sup>2</sup>/s. The ADCP hardware is 'Rio Grande' with a frequency of 1200 kHz and serial number 3206. The right window is for a measurement at 'RiverRay' with the following details: Measurement number 1, Station number 02CE002, Field crew ABC, DEF, Date 08/09/2014, Stage 0.00 m, and Rated Q 0.00 m<sup>2</sup>/s. The ADCP hardware is 'RiverRay' with a frequency of 600 kHz and serial number 48344. Both windows show recording information, folder selection, ADCP hardware setup, processing setup, and a warnings section.

**Figure 4: Examples of new measurement forms for Rio Grande and RiverRay**

## TRDI:cont'd

The screenshot shows a software interface for configuring a measurement. It is divided into several sections:

- Measurement information:** Measurement number (3), Station number (01AA001), Field crew (FCC), Stage (0.00 m), Rated Q (0.00 m<sup>3</sup>/s), and Date (10/09/2014).
- Recording:** Name prefix (01AA002), Folder (C:\Measurements\01AA002), and options to add measurement number, date, and time to the name. The name preview is C:\Measurements\01AA002\01AA002\_20140910.sxs.pd0.
- ADCP hardware:** Instrument (StreamPro), Frequency (2000 kHz), and Serial number (500). A "Check ADCP" button shows a green checkmark.
- ADCP setup:** Max. water depth (3.00 m), Max. water speed (1.20 m/s), Water mode (Mode 12), and checkboxes for Use compass, Long range available, and Use default cell size and number of cells.
- Processing setup:** Duration (40 sec), ADCP depth (0.08 m), Discharge method (Mid-section), and Velocity method (Magnitude). Depth cell size is 0.10 m and Number of cells is 30.
- Warnings:** A message states: "In ice measurement do not use compass unless the electronics is mounted on the winter rod appropriately."

Buttons for "OK" and "Cancel" are at the bottom.

**Figure 5: Example of new measurement form for StreamPro**

**Measurement name:** To match WSC file naming convention, select YYYYMMDD date option and underscore symbol as the delimiter. When the Station ID is typed into the Station number field, it is automatically set as a name prefix.

**Duration:** If less than 75% of ensembles are valid at the end of a sampling period, the operator will be asked if they wish to extend the duration of the data collection period. **It is recommended to obtain a minimum of 30 valid and consistent ensembles at a station/vertical.** A 40 second sampling period will be sufficient for most deployments.

**Discharge method:** There are two options for discharge method; Mean-section and Mid-section. **Select Mid-section.**

**Velocity method:** There are two ways in which flow directions are referenced in SxS Pro; 1) Magnitude and 2) Y-velocity. **The magnitude method is used in the large majority of open water mid-section measurements. Magnitude** method is used when the ADCP is free to rotate with the changing angle of flow (i.e. a tethered boat deployment with a single point of attachment). The **Y-velocity** method measures the horizontal water velocity parallel to beam 3 and is used in under-ice measurements or when the transducer orientation is fixed (i.e. no rotation with respect to the measurement section). Magnitude velocity method is usually used for open water measurements but if y-velocity is used for a fixed-orientation platform, the user should be aware that the TRDI convention for SxS Pro is to hold beam 3 downstream (perpendicular to tagline, facing downstream to be more precise). In this case, it may be necessary to use a beam 3 misalignment factor of 180, 240 or 320 degrees to re-orientate beam 3 so it is facing in the predominant downstream direction.

## **TRDI:cont'd**

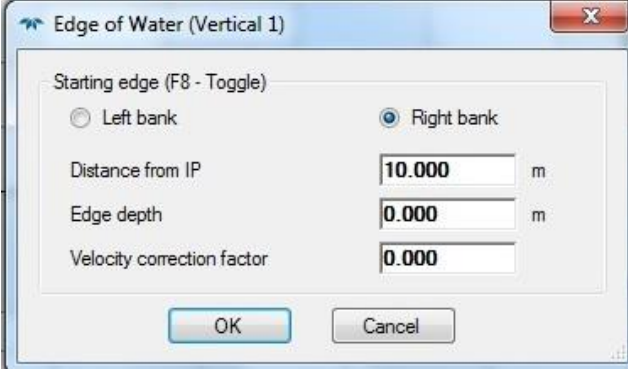
***If a velocity method other than magnitude is used for an open water measurement, justify the reason in the comments section and also in the field notes.***

*For the Rio Grande and Stream Pro it is recommended to input maximum water depth and maximum water speed but it is not recommended to complete the secondary depth field for the Rio Grande form. Instead, at changes of water depth and/or velocity, the user should stop pinging change the depth/velocity settings and restart pinging. Use the auto water mode setting.*

*After completing the new measurement form/ Measurement Wizard form, address any warnings in the text box at the bottom and correct as necessary.*

*The software prompts the user for information about the starting edge of the water. SxS Pro labels the starting edge as Vertical 1.*

*Select right or left bank starting edge as per convention (looking D/S), input the distance from IP to the edge of water. In many cases, distance from IP may be zero. If there is a vertical wall at the starting edge, the depth at edge must be input at this time as well as a velocity correction factor. The default velocity correction factor is 0.00 for SxS Pro. A measured vertical would be at a distance approximately equal to the depth at the wall and in this case a typical correction factor for the velocity at the wall or pier with a smooth surface is 0.65. This correction factor would be reduced with increasing wall/pier roughness. (VALIDATE coefficient with reference)*



**Fig 6 – Input initial edge information (SxS Pro)**

*Once the starting edge information is complete and the user selects “OK”, commands are sent to the ADCP. The ADCP is pinging but not yet recording, providing depth and quality of signal information. Before hitting the “Next” vertical button (or F5 start recording) choose a location for vertical 2 with at least 2 good depth cells. Monitor the intensity profile for irregular spikes in one or more beams at varying depth potentially indicating static objects like submerged branches. If contamination from static objects is suspected, change the location of the vertical.*

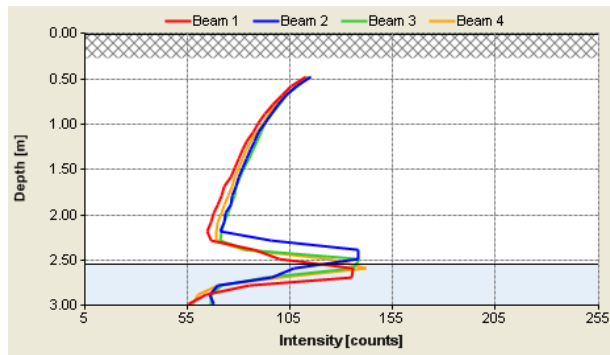


Figure 7 - Example of Intensity Profile in SxS Pro without beam obstructions

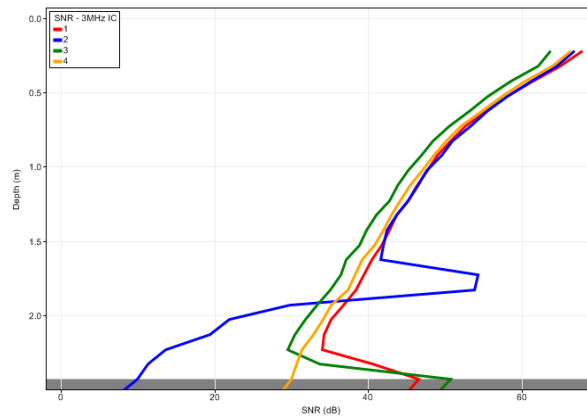


Figure 8 - Example of SNR profile with beam obstruction (RSSL)

When the location for vertical 2 looks suitable, push F5 or the “Next” button. This will be the first vertical with a measurable water velocity. Each vertical form has space for notes specific to that vertical. Notes can be input prior to recording. To insert a note on a previously recorded vertical, double click on that vertical.

Figure 9 – Vertical detail form



## **TRDI:cont'd**

Input the tagline position as distance from IP and select the velocity profile type. The Water tracking error velocity is a function of the previously input maximum depths/velocity values (for Rio Grande and StreamPro).

Flow angle: If the hydrographer is in a good position to directly measure the angle of flow now is a good time to measure and input the angle. Flow angle can be input as either 1) angle in degrees from the expected perpendicular from tagline or 2) coefficient such as 0.99 based on the cosine.

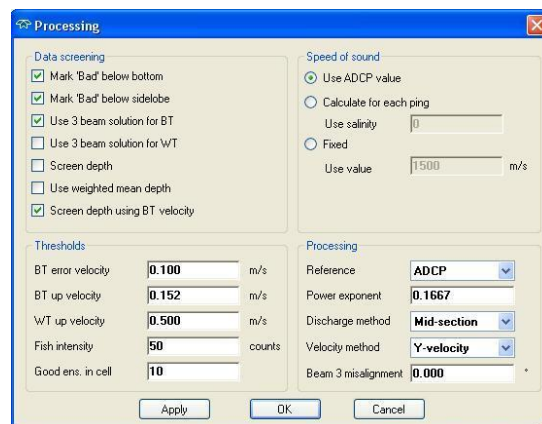
**After inputting a flow angle correction or coefficient value, check to ensure it is not inadvertently repeated in subsequent verticals. This has been a reported issue within SxS Pro.**

**Water Depth Source:** The default method to determine depth at the current vertical is by Bottom Track, which is the average depth measured by the 4 beams. Other options include vertical beam and composite for instruments equipped with vertical beams. The composite depth method will use the vertical beam if it is generating acceptable data and use bottom track otherwise. It is recommended to use the default setting of composite depth for ADCPs equipped with vertical beams.

If the ADCP is having issues detecting the bottom, use **manual depth** by sounding with a wading rod, survey rod, weighted line, or some other method. Intermittent valid pings from SxS Pro might also be used. Once the manual depth has been measured, select manual depth as the source and enter the value. There are many cases where the ADCP can't measure a depth, but with a manual depth, can still measure a valid water profile.

At any time, a **processing form can be viewed by hitting F3.**

If there are less than five bins at a vertical, the user should consider changing the max depth setting in the Measurement Wizard (this is not applicable to RiverRay deployments where the bin sizes are automatically selected). To do this, stop pinging (F4), open the measurement wizard (F2) and change the max depth setting. It is not advisable to change the configuration at every vertical but this setting can be changed on occasions where depths and/or velocities change significantly. Selecting smaller bin sizes will introduce greater noise in bin velocities. You might try fewer and larger bins when the velocities appear too noisy.



**Figure 10 – Processing interface for SxS Pro**

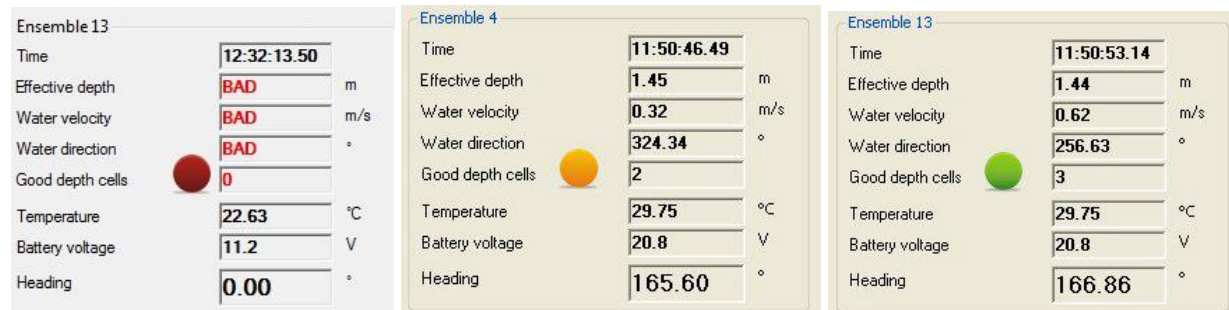
## **TRDI:cont'd**

The default setting for minimum number of good ensembles for a cell is 1. This means that if only one velocity sample over 40 seconds is available for a given cell depth, this cell will still be used in the determination of the average water velocity for the vertical. This can be adjusted in post processing to get rid of anomalous velocities.

The default setting for 3 beam solution for water tracking (WT) is off. If there is suspected interference with one of the 4 beams (for example vertical walls), turn on 3 beam solution to see if there is an improvement.

**Check thermistor:** If the ADCP measured temperature is not within 2 degrees of the independent temperature, wait until the ADCP thermistor stabilizes to within this range. If there is a suspected broken thermistor, override the ADCP temperatures with a manually input value, noting the discrepancy in the measurement field notes. Tag the ADCP for suspected faulty thermistor and have the ADCP thermistor checked by the manufacturer.

As with moving boat measurements a **minimum of 2 depth cells** must be obtained at every vertical.



**Figure 11 - SxS Pro acquire view with red circle (<2 good depths cells), yellow circle ( 2 good depth cells) and green circle (>2 good depth cells)**

Once the station (vertical) is complete, a Measurement Results dialog shows a summary of the station for review and prompts to **Accept** to proceed to the next station or **Reject** to measure the same station again. Continue this process for the entire cross section. If a station is inadvertently accepted, it cannot be deleted but instead it can be “unselected” at any time so it will not be used in the final measurement results. This capability applies to both SxS Pro and RSSL. To “unselect” a desired vertical simply navigate to the discharge summary page and “unselect/uncheck” a vertical in SxS Pro this is done within the vertical/details selection view, accessed through F12 or select view/vertical details selection from the main menu.

**Inserting stations/verticals:** If necessary, a station/vertical can be inserted at any time during the measurement. Neither SxS Pro nor RSSL will allow two active stations/verticals at the same location. SxS Pro allows replacing one station with another station at the same location, keeping only one active.

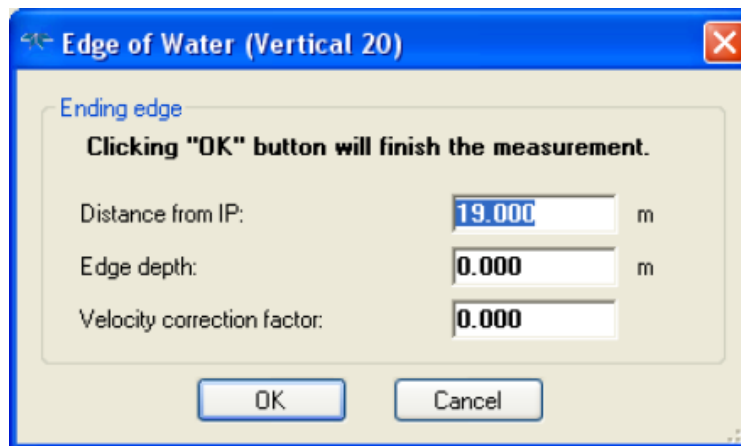
If velocity data cannot be obtained, a manual vertical can be inserted (F8). A manual vertical requires user input for depth and water velocity which may be estimated or obtained from another instrument such as a FlowTracker.

**TRDI:cont'd**

*SxS Pro uses manual verticals for islands/piers. A pier can be represented clearly by using manual verticals in the following way. If the width of the pier is relatively narrow compared to the panel widths, set a panel on either side of the pier equal to ½ the pier's width. For instance if you are collecting at 10m intervals and there is a 4m wide pier, set a measurement at 2m from either edge of the pier. If it is not deep enough at these locations, you can make a manual estimate of velocity at those locations. Set a manual measurement at the centerline of the pier with a depth of 0.00m and a velocity of 0.00m/s. There should be a clear representation of the pier in the contour plot.*

*Users can **temporarily abort** a partially completed measurement and continue the measurement at a later time.*

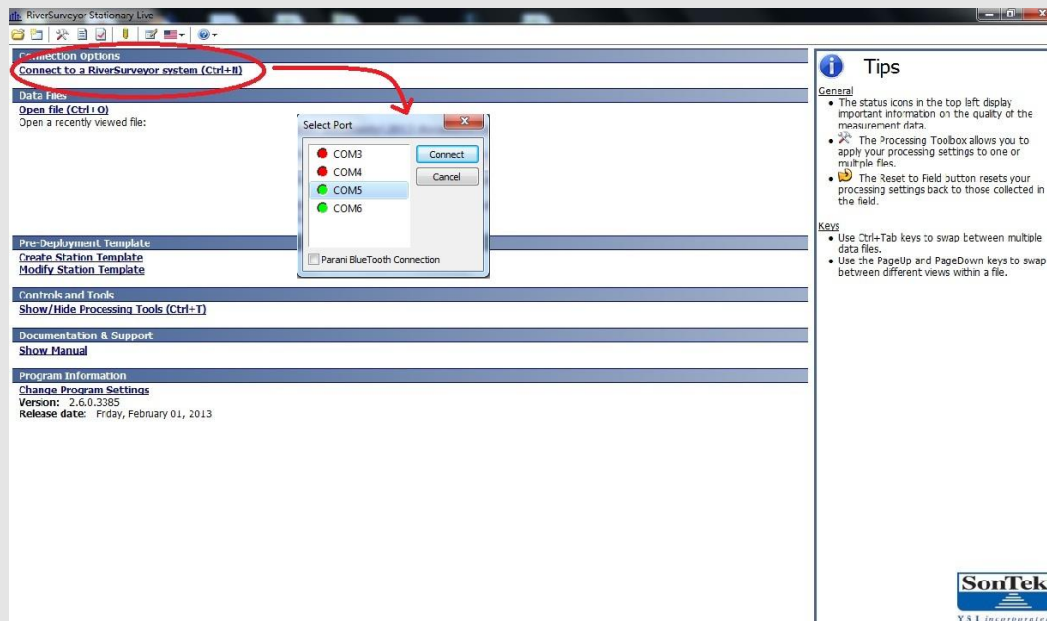
**Press<F6> to end the measurement. The following dialog box opens**



**Figure 12: End measurement form**

## **SonTek: (RSSL)**

When creating a new measurement in SonTek RiverSurveyor Stationary Live, connect to the ADCP by clicking on the connection command or Ctrl+N shortcut. Select the appropriate COM port number, if unsure which COM port checking under Control Panel/Device Manager/Ports (COM & LPT).



**Figure 13: RSSL Initial connection to ADCP**

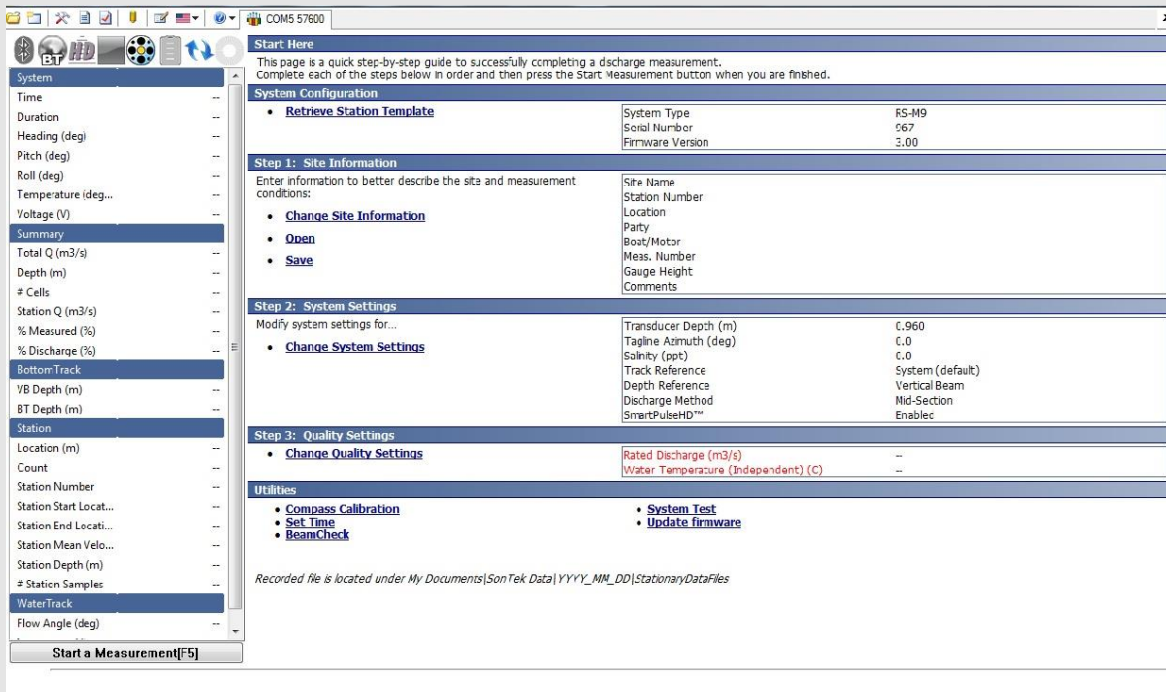
Once connected, the Start Page appears (Figure 14). There is an option to retrieve a station template. A station template contains the ADCP measurement location information (i.e. tagline location of start/end edges and all panels, transducer depth at each panel etc.) typically saved from a previous measurement at the same site. Site information such as the station name and ID can also be saved and retrieved for future measurements. If no site information file is available, the site information can be easily input manually. The start page directs users to follow many of the necessary steps prior to starting a measurement.

**Set the time** from the PC/tablet.

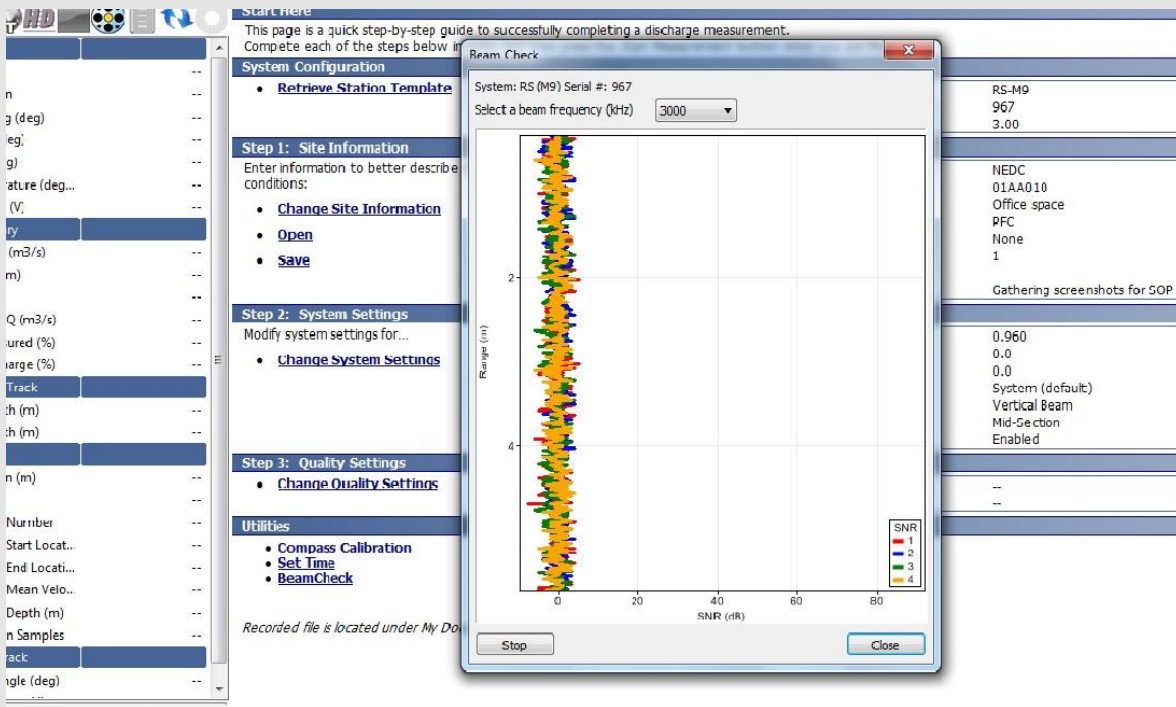
**Run a beam check** and confirm there are no unusual artifacts or separation of beams at the different frequency options. An example of an expected beam check result for the 3MHz transducers is shown in Figure 15.

**Run System tests.**

**SonTek: (cont'd)**



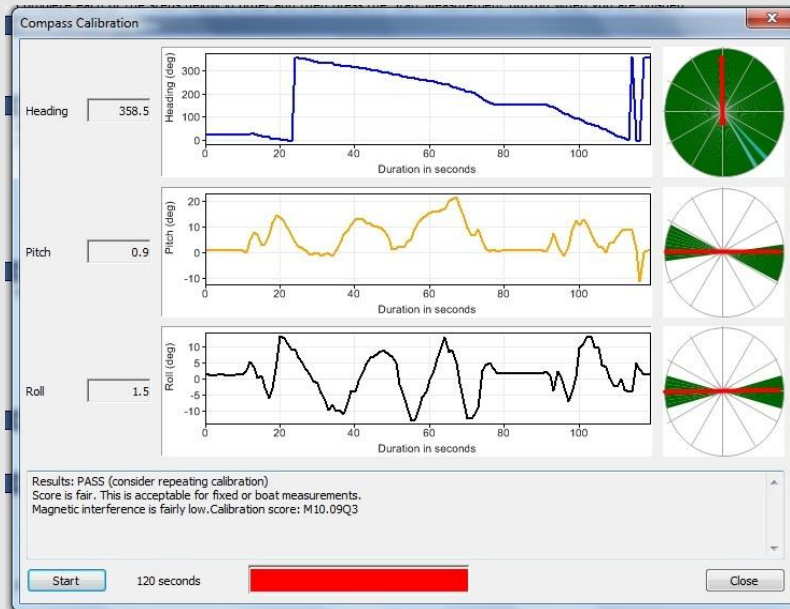
**Figure 14 – RSSL Start Page**



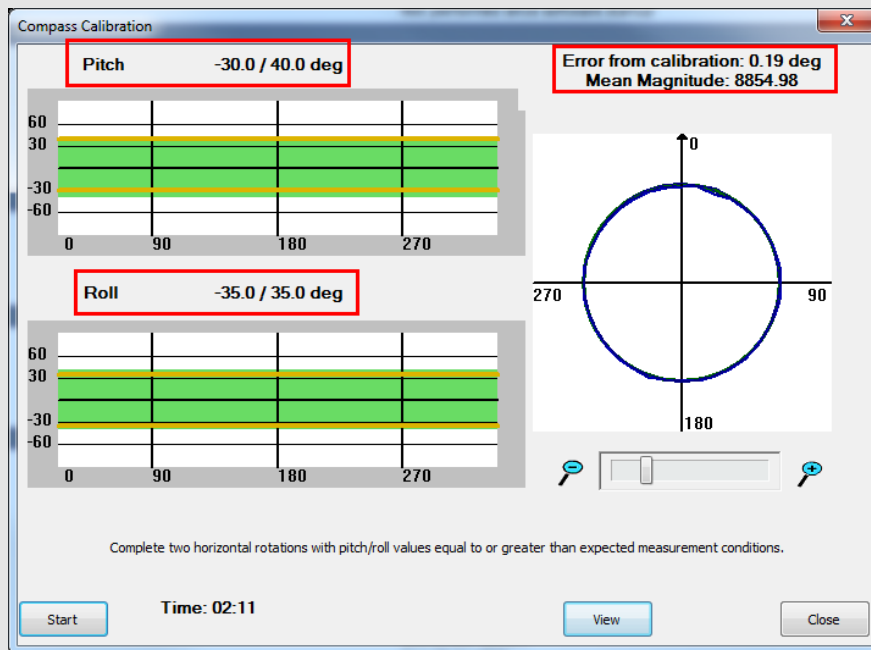
**Figure 15 – RSSL Beam Check test**

**SonTek: (cont'd)**

For under ice measurements the M9/S5 is deployed using XYZ (or instrument reference) for orientation but **for open water RSSL deployments, the ADCP is usually free to rotate with the changing flow angles. To account for these changes in orientation, the M9/S5 compass is calibrated, the tagline azimuth is determined and ENU (or earth) reference is used.**



**Figure 16 – Example of RSSL Compass Calibration output (RSSL version 2.6)**



**Figure 17 – Example of RSSL Compass Calibration output (RSSL version 3.8)**

Review compass calibration instructions in the software documentation prior to calibrating the compass.

## SonTek: (cont'd)

Calibrate the compass at a location representative of the magnetic environment at the measurement section. For example, do not calibrate the compass next to bridge wing-wall containing rebar and attempt to measure several meters downstream of the bridge. Ensure no electronics or ferrous materials are near the instrument during calibration. Vary the pitch and roll enough during the calibration to cover the expected range the ADCP will experience during the measurement and induce pitch and roll slowly during calibration. Note that calibration criteria for the G3 compass (firmware and software versions 3.8 and later) are different than previous versions of RSSL and RSL. The recommended passing compass calibration error is 0.5 degrees or less.

Water Survey of Canada had placed restrictions on the use of the M9/S5 using a compass not yet upgraded to version G3 compass (2014 or later using version 3.8 firmware and software). All versions of the M9/S5 compass can be used for open water mid-section deployment provided the user closely monitors the orientation of the ADCP during acquisition for flow directions inconsistent with observed conditions. In the interim, it is recommended that all M9s and S5s be upgraded to the G3 compass.

After calibrating the compass, set the tagline azimuth. To do this you can select “change system settings” command/get tagline azimuth then follow the software instructions. The tagline azimuth value is obtained by setting the ADCP in the flow typically near the center of the river where the streamlines are likely parallel to the riverbanks. The tagline azimuth value will automatically update after running the azimuth routine. This routine assumes that the tagline is perpendicular to flow, which is often the case but **in cases where tethered boats are deployed from a bridge that is not perpendicular to flow, obtain an independent value of tagline azimuth with a hand held compass** and input that value. This should also be validated against the ADCP compass by comparing the measured instrument heading to an observed heading from a handheld compass.

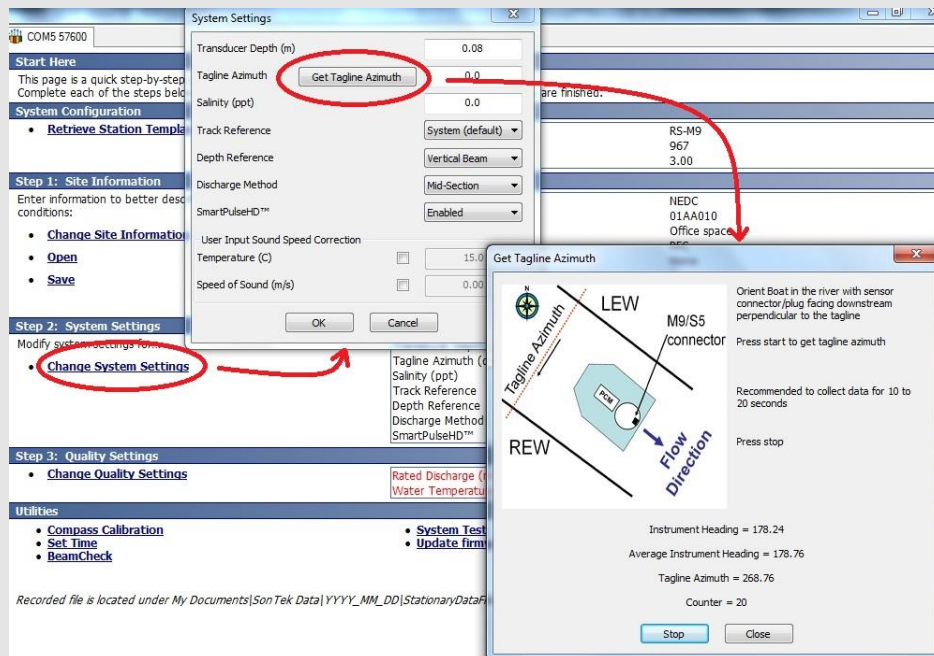


Figure 18 – Steps to obtain tagline Azimuth using M9/S5 compass

**SonTek: (cont'd)**

Other recommended system settings are; “System” for track reference, “Vertical Beam” for depth reference, **Mid-Section for discharge method** and Smart Pulse enabled.

Start Edge	LEW(left bank)
Location from initial point (m)	0.00
Distance between stations (m)	0.00
Water Surface Type	Open Water
Ice Thickness (m)	0.00
Water Surface To Bottom Of Ice (m)	0.00
Water Surface To Bottom Of Slush Ice (m)	0.00
Transducer depth below ice (m)	0.000
Transducer depth below water surface (m)	0.960
User Input Water Depth (m)	0.00
Screening Distance (m)	0.00
Coordinate System	ENU
Averaging Time	40
Velocity Correction Factor	1.00
Gauge Height (m)	0.000
Auxiliary Gauge Height (m)	0.000
GH Observation Time	12:44:14 PM
Island Edge	<input type="checkbox"/>

Profile Extrapolation    OK [Enter]    Cancel

**Figure 19: RSSL Start Edge form**

Once **Start Measurement** is selected, there is a prompt for starting edge information. RSSL prompts for starting bank (left or right), distance from an Initial point to the water’s edge, edge depth and velocity correction factor. The velocity correction factor allows the user to input an estimated water velocity at an edge section as a percentage of the closest measured velocity. The default velocity correction factor is 1.00 for RSSL. When a starting or terminating edge is a vertical wall, the nearest measured station would be at a distance approximately equal to the depth at the wall. In this case a typical correction factor for the velocity at the wall or pier with a smooth surface is 0.65. This correction factor would be reduced with increasing wall/pier roughness. (VALIDATE coefficient with reference)

If the ADCP measured temperature is not within 2 degrees of the independent temperature, wait until the ADCP thermistor stabilizes to within this range. If there is a suspected broken thermistor, override the ADCP temperatures with a manually input value, noting the discrepancy in the field notes. Tag the ADCP for suspected faulty thermistor and have the ADCP thermistor checked.

RSSL labels the starting edge as Station 1. Users will be prompted to input the water surface type, open water in this case, **after** inputting the starting bank information.



**SonTek: (cont'd)**

When edge information is complete, go to the first vertical beyond the edge of water.

In RSSL, once the edge (Station 1) is complete and you have moved the instrument to the first measurement location (Station 2), the station dialog opens, the instrument starts pinging and you can monitor the SNR (signal to noise ratio) profile plot for obstructions on individual beams.

Set **Screening Distance**: transducer depth from water surface + 0.16m    **Coordinate System**: ENU

**Water Surface Type** select "Open Water".

The screenshot shows a 'Station' dialog box with the following fields and values:

Location (m)	2
User Input Water Depth (m)	0.00
Transducer Depth (m)	0.24
Screening Distance (m)	0.40
Coordinate System	ENU
Averaging Time	40
Velocity Correction Factor	1.00
Gauge Height (m)	0.000
Auxillary Gauge Height (m)	0.000
GH Observation Time	11:51:27 AM
Water Surface Type	Open Water
Ice Thickness (m)	0.00
Water Surface To Bottom Of Ice (m)	0.00
Water Surface To Bottom Of Slush Ice (m)	0.00
Island Edge	<input type="checkbox"/>

Buttons at the bottom: Measure [Enter], Cancel, End Edge.

**Figure 20 – Station details within RSSL**

Press the **Measure** button to begin collecting data, **Cancel** to go back to review the measured station information, or **End Edge** to input the end edge location information. If you had pressed Cancel and now wish to proceed with the measurement, look for the Next Station (F5) on raw sample display form.

As with moving boat measurements a **minimum of 2 depth cells** must be obtained at every vertical to ensure the velocity profile is more accurately represented.

### **SonTek: (cont'd)**

*If water velocities can be measured but an accurate depth cannot be obtained due to weeds or high suspended sediment concentrations, RSSL has an option to manually input depths at a vertical/station. This depth value might be obtained by manual sounding or observing intermittent valid depths while pinging.*

*Be aware of obstructions within the water column by monitoring the SNR levels.*

*During data acquisition, monitor the following:*

*profile plots for beam blockage(see figure 8).*

*contour plots for obvious input errors in depths.*

***Inserting stations/verticals:*** *If necessary, a station/vertical can be inserted at any time during the measurement. Neither SxS Pro nor RSSL will allow two active stations/verticals at the same location.*

***Temporarily Interrupting a measurement:*** *If it is necessary to temporarily stop collecting data, shut down the software or change instruments prior to ending the measurement, the measurement can be reopened and restarted at a later time as long as end measurement/end transect was not confirmed. When a user reopens a measurement without an ending edge they will be prompted to either end the measurement or continue with data collection.*

*Islands or Piers Edges are handled in RSSL through the **Island Edge** box at the bottom of the station dialog window. The user will be prompted for all information once selecting this option.*

***End Edge*** *to input the ending edge location. Beware that once the measurement has ended you will not be allowed to insert any additional stations/verticals. If a station/vertical has more than 5% of the flow, now is time to insert the extra panel prior to selecting End Edge.*

*Finally you will be prompted to end the measurement. Press the **End Transect** button to complete the measurement.*

## 6 Data Review

Data must be thoroughly reviewed **while still on site** to identify and correct any potential acquisition error.

### Use the Hydrometric survey notes to conduct a thorough field review.

Among the listed items within the survey note, check:

- Diagnostic test results OK and logged.
- ADCP clock set.
- Temperature sensor valid
- Review contour plot as a visual check on input errors for ADCP draft, water depths widths of verticals etc.
- Suitable number of panels and % of discharge per panel not excessive
- Look at flow vectors/flow direction to detect obvious inconsistencies or errors.
- Minimum number of valid number of ensembles and sampling duration achieved
- *(SxS Pro only) Are there several missing cells within station/vertical? If so, check to see if there are enough bins measured to allow reasonable extrapolations at the top and bottom. In clear water, there may be several missing bins. This is displayed as intensity and correlation profiles drop to noise floor level and staying at those levels (60 counts or lower for RiverRays, 85 or lower for StreamPro) It may be necessary to increase sampling times at each panel, increase the size of the bins or change the water mode. Another possible solution to increase the range of the StreamPro is to increase the supply voltage. The StreamPro will handle up to 19VDC. WSC offices are investigating options to boost voltage to 18v.*
- SNR/intensity. Look for spikes caused by obstructions.
- Click on individual stations/verticals to view extrapolated portions of profiles Do the top and bottom extrapolations look like reasonable extensions of the measured portions or are there discontinuities between the measured and estimated portions? You may need to adjust the exponents (to do this, see explanation below). In most cases, extrapolation settings are consistent among stations/verticals.

The typical **extrapolation method for open water** is  $1/6^{\text{th}}$  power law. If there are strong wind effects or bidirectional flow, the upper extrapolation methods can be changed to constant and no slip in RSSL or constant and 3 point in SxS Pro. Operators should obtain previous extrapolation settings used in the application of the USGS EXTRAP program for moving boat measurements at that site as a point of reference for setting extrapolation settings in mid-section measurements. The exponent can be changed from the default  $1/6$  value to another by accessing the processing form (F3). These alternate top profile extrapolations are a reflection of the site conditions observed by the hydrographer at the time of the measurement.

**SonTek:** *To edit extrapolation settings (or other profile information like depths/offsets or reference system) double click on any station within the contour plot or select **Edit Station** within the samples tab view. There is a **Profile Extrapolation** button in the bottom left corner of the dialogue to make changes. The station details form will appear. If applying a change to all profiles don't forget to check "**Apply to All**".*

*A commonly seen problem with recent versions of RSSL is an apparent insensitivity to adjusting the number of cells or % of vertical for the application of the top extrapolation.*

***TRDI:*** In SxS Pro, it is important to visually review the top and bottom extrapolations. Check the contour plot for consistent velocity profiles, flow directions and effective depths between verticals. The tabular view is also very helpful for checking consistency in data such as large changes in flow directions between verticals as well as detecting input errors. To change the extrapolation settings, hit F3 for the processing form. And change the power exponent value. This value applies to all verticals not individual verticals. Do not spend time trying to optimize the extrapolation for every vertical. Instead choose the extrapolation method and exponent that fits best with the most verticals. You may check to see how sensitive the final discharge is to changes in extrapolation settings. Changing exponents often result in insignificant changes to final discharge.

- When on site review is finished, lock measurement.
- Backup the measurement file to a USB key

## Appendix A – Shortcuts/Quick keys

### ***Section by Section Pro Shortcuts***

<b>KEY</b>	<b>Description</b>
F1	Help
F2	Configure Measurement Wizard
F3	Configure Processing Parameters
F4	Start/Stop Pinging
F5	Start/Stop collecting verticals data
F6	Create Start/End edge
F7	Configure (edit) current vertical
F8	Toggle left or right bank
F11	Toggle Measurement Info view
F12	Toggle Verticals Details/Selection view
Ctrl + C	Copy table when in verticals details/selection view
Ctrl + E	Close measurement file
Ctrl + L	Lock/Unlock measurement file
Ctrl + O	Open measurement file
Ctrl + S	Save measurement file
Ctrl + W	Create new measurement file
Ctrl + M	View Summary XML file
Ctrl + E	View Summary CVS
Ctrl + A	View Summary ASCII file
Shift + F4	Set ADCP clock
Shift + F8	Execute or view ADCP tests
Shift + F9	Execute or view compass calibration
Ctrl + ←	Move to the previous vertical
Ctrl + →	Move to the next vertical

### ***RiverSurveyor Stationary Live Shortcuts (partial list)***

<b>KEY</b>	<b>Description</b>
Ctrl + O	Select stationary measurement file to open
Ctrl + T	Toggle Processing tools menu options
Ctrl + N	Connect to ADCP
Ctrl + N	
Page up/down	Toggle through view tabs (System/Samples/Time series/Transect)
Arrow up/left	Toggle back through stations
Arrow down /right	Toggle forward through stations

# Appendix B Example of Hydrometric Survey Notes for Mid-Section method

For complete copies of the survey notes, see WSC Library;



## HYDROMETRIC SURVEY NOTES - MID-SECTION METHOD

Data Entered In HWS

Station Number: 05GG001 Date: MARCH 19 20 14

Station Name: North Saskatchewan River at Prince Albert

Start Time (hh:mm)	End Time (hh:mm)	Air Temp (°C)	W. Temp (°C)	Width (m)	Area (m <sup>2</sup> )	Mean Vel. (m/s)	Corr M.G.H. (m)	Discharge (m <sup>3</sup> /s)
14:08	15:13	2	0.5	245	364	0.348	2.169	127
Mmt Mean Time (hh:mm)	14:41	Calc. Shift Base Curve (m)	-0.725	Difference Base Curve (%)	-64%	Curve #	No. 13	

Time	HG	HG2	W.L. Reference	Sensor Reset	Levels DWL - Referenced to 586-592
			DWL	Corrosion S.R.C.	
14:10	2.182				Weather Partly Cloudy
15:15	2.182				
16:30	2.183		2.170	0.013	Wind (km/h) 5 kph / Cross
					u/s, d/s, crosscurrent
					Battery Voltage (VB) 12.9
					Gas System: Cyl. 1750 psi
					Feed 35 psi BPM/Rot 50 rpm
Weighted M.G.H.	2.182				Intake Flushed <input type="checkbox"/> Orifice Purged <input checked="" type="checkbox"/>
S.R.C.	0.013				Downloaded Program <input checked="" type="checkbox"/> Downloaded Data <input checked="" type="checkbox"/>
G.C.					Data Period: Jan 01 to Mar 19
Corrected M.G.H.	2.169				

Time	Sensor Reference	TW				
14:00	Observed Value	0.5				

Deployment:  Wading  Bridge (u.s./d.s.)  Cableway  Boat  Ice Cover  
50 m, km, above/below gauge Position Method: X, Y, Z

Method: ADCP Flow Angle: Variable Coefficient: \_\_\_\_\_ No. Panels: 26

Serial/Meter #: RR-64040 Located: \_\_\_\_\_ metres above \_\_\_\_\_ lb/kg above weight

ADCP Type: River Ray Frequency: 600kHz Firmware: 44.14 Software: WinR II

Config.: Vary/Panel Auto, Manual: \_\_\_\_\_ ADCP Set to Clock  Diagnostic Test

ADCP Depth\*(m): 0.1 Magnetic Decl.\*: 9° Compass Calibration  Passed Field Review

Remarks: - Channel - C.I.C. (Complete Ice Cover)  
- Velocity profile Type - Ice (No-Slip/No-Slip)

Party: C. Garbutt / D. Dewulf Completed by: C.G. Checked by: D.D.

### LEVEL NOTES

STATION	B.S.	HT. INST.	F.S.	ELEVATION	
586-592	2.398	8.499		6.101	
TP #1	0.301	5.709	3.091	5.408	
TP #2	3.733	5.745	3.697	2.012	CUT ON REP = 0.158 M @ 16:30
TP #1	3.088	8.495	0.338	5.407	
			2.393	6.102	586-592 AF
				6.101	586-592
				0.001	CLOSURE / OK
~~~~~					
Level	TP #2	2.012	Elev.		
		+ 0.158	CUT		
		<u>2.170</u>	FWL @	16:30	

SKETCHES

FIELD REVIEW	Pass <input checked="" type="checkbox"/>	Review	Check	Review Comments	Review Applies To :
		Yes	Yes		
Passed All Instrument QAQC?		<input checked="" type="checkbox"/>	<input type="checkbox"/>		
Software Input Same as Notes?		<input checked="" type="checkbox"/>	<input type="checkbox"/>		
Diff in ADCP and Water T < 2°C?		<input checked="" type="checkbox"/>	<input type="checkbox"/>	Measured TW = 0.5°C	
Signal to Noise Ratio > 4?		<input type="checkbox"/>	<input type="checkbox"/>	NA	
Flow Angles Accounted for?		<input type="checkbox"/>	<input type="checkbox"/>	NA	
Exposure Time / Location > 40 s?		<input checked="" type="checkbox"/>	<input type="checkbox"/>	40 s	
Valid Ensembles / Panel > 30?		<input checked="" type="checkbox"/>	<input type="checkbox"/>		
No Boundary or Spike Problem?		<input type="checkbox"/>	<input type="checkbox"/>	NA	
Bed Contour as Expected for Site?		<input checked="" type="checkbox"/>	<input type="checkbox"/>		
Ice/Slush Depth as Expected?		<input checked="" type="checkbox"/>	<input type="checkbox"/>	0% slush throughout section	
Velocity Profile Suitable?		<input checked="" type="checkbox"/>	<input type="checkbox"/>		
# Panels > 20?		<input checked="" type="checkbox"/>	<input type="checkbox"/>	26 panels	
No Panel Q > 10%?		<input checked="" type="checkbox"/>	<input type="checkbox"/>	Max. 9.11%	
<b>Notes on Site Conditions Affecting Measurement Quality:</b>					



.0 .10 .20 .30 .40 .50 .60 .70 .75 .80

Meter no.: \_\_\_\_\_ Meter equation: \_\_\_\_\_ Calibration date: \_\_\_\_\_

Distance from initial point	Width	Total depth		Depth under ice		Revolutions	Time	Velocity		Area	Discharge
		W.S. to bottom ice	Of water	Of observation	At point			Mean			
											.85
											.90
											.92
											.94
											.96
											.97
											.98
											.99
											1.00
											.99
											.95
											.97
											.96
											.94
											.92
											.90
											.85