Standard Operating Procedures for under-ice discharge measurements using ADCPs

Water Survey of Canada

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Version 1.1

Revision History

Version	Date	Source	Description/Rational for Change
1.0	October 2013	PFC	
1.0b	December 2013	PFC	Various minor changes
1.1 pending HATWG review	February 2014	PFC	Updates to hardware (mount) information. Added guidance

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1 Introduction

Acoustic Doppler current profilers (ADCPs) are typically used for measuring river discharge from moving boats. Specialized software now allows these instruments to be deployed to measure discharge using the mid-section method.

There are several reasons for using an ADCP in mid-section mode, including;

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

This document presents guidance and standard operating procedures specific to deploying ADCPs for under-ice measurements.

It is important to note that the mid-section method standards and procedures defined in the ***Hydrometric Field Manual- Measurement of Streamflow*** *(*Terzi, 1981) apply to under-ice ADCP measurements unless otherwise stated in this document. Desirable characteristics of measurement cross sections for hydroacoustics under ice are similar to a good cross section for a mechanical ice meter measurement. The general metering criteria still apply such as required number of verticals for a measurement (minimum 20 to 25) and recommended percentage of total discharge per verticals (should be about 5% each or less). These remain unchanged for ADCP under-ice measurements .

Safety protocol for under-ice measurements are beyond the scope of this document. Readers are referred to the ***Water Survey of Canada Occupational Safety and Health Policy for Working on Ice*** and the ***Ice Surface Safety Training Manual*** for more complete references on ice safety. Current versions of these documents are available on the Water Survey of Canada (WSC) Intranet Library.

1.1 A note on instrumentation, software and firmware

A variety of ADCP types may be used for under-ice measurements, and depending on the manufacturer, the mid-section discharge measurement software will also vary. Currently (2013) the 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).*

Be aware that the specified minimum storage temperatures are -20°C for the TRDI RiverRay and -10°C for the SonTek M9/S5 so it is important to avoid exposing an uncovered ADCP to very cold air (-20°C or colder) for more than a few minutes at a time. Suggestions for protecting ADCPs in cold weather are included in section 4 of this document.

The procedures and guidelines presented in this document are described in the context 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 please consult the ***Approved Software and Firmware version for Selected Devices*** document, which can be 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 two examples of software that allow mid-section methods to be applied with ADCPs.

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 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 Section by Section Pro key to unlock the software for acquiring data. This key needs to be input into each PC operating Section-by-Section Pro Software for that ADCP. Open SxS Pro and select menu items Help/Register ADCP. It is recommended to display the Section-by-Section Pro key clearly on the exterior of any ADCP if a key exists for that instrument*

Note: From 2007 to 2010 Teledyne RDI had supported section by section software bundled with WinRiver II software. This WinRIver II section by section software is distinct from Section by Section Pro is unstable, no longer supported and has several identified bugs, therefore it is ***not*** *approved and* ***not*** *recommended for use.*

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

There are mobile and PDA versions of the mid-section method software for both SonTek and TRDI ADCPs. As of fall 2013, WSC does not recommend use of PDA/mobile/smart phone versions of the mid-section method software. Reasons for not recommending PDA based software for mid-section measurements include; difficulty in monitoring and reviewing measurements on smaller displays, limited technical support from manufacturers (no support from TRDI, little documentation from SonTek). Fewer software options will simplify the software testing process and reduce the number of problems around data quality and hardware compatibility. WSC will review this recommendation if feedback from the field test group identifies substantial advantages to using the PDA based software.

3 Prior to departure:

The following steps should be followed prior to data collection in the field:

1. Inspect ADCP transducer face(s), cables and connectors for damage.
2. Confirm:
    - communication with ADCP works
    - mid-section acquisition software is functioning
    - the ADCP is suitable for the expected effective depths. Minimum effective depths for the StreamPro and M9 are approximately 0.35m. (For the M9, it is recommended to use a screening distance = transducer depth + 0.16m) Minimum effective depth for the RiverRay is approximately 0.75m. In general, ADCPs with lower frequencies are suited for deeper water
    - firmware and software versions are up-to-date. Use labels on the ADCP to indicate the mid-section software key code (if necessary) and the firmware version
    - Auger flighting will drill holes large enough for the ADCP to be used
    - Batteries or battery packs are fully charged. For remote site visits, ensure eight hours battery capacity for computers and ADCPs. Use positive connections (no alligator clips) for all external batteries
3. Run system tests
4. Check the ADCP mount:
    - The mount should not allow the ADCP to spin or otherwise allow the ADCP orientation to change without the knowledge of the operator.
    - The mount should have a visual alignment tool (Fig. 2) to check orientation of ADCP with respect to the measurement section and a way to check that the rod is held in the vertical position with pitch and roll near zero degrees (e.g. a fish-eye bubble attached to the rod).
    - The mount must be constructed of non-ferrous material.
    - Depth markings, which should be offset relative to the transducer, must be accurate and easily readable.

Figure 1 – Example of a StreamPro mount. (Appendix C – WSC Under Ice Hardware System – Mark 1)When the horizontal plate is held up against the underside of the ice, the transducers are at a known depth below the ice.

Figures 2a and 2b– Example of a mount for the SonTek S5/M9 and RiverRay with the visual alignment tool (Appendix C – WSC Under Ice Hardware System – Mark 1), which is positioned perpendicular to the rod

SonTek: *A 90 degree connector cable for the SonTek M9/S5 will reduce the overall diameter of the instrument for insertion through the hole. Since the orientation of the pins on the face of the connector varies between individual ADCPs, it is necessary to have 90 degree communication cables fabricated for specific units. A standard, straight connector can be used but this will require drilling larger holes and possibly expose the connector to extra wear and tear with repeated use through the ice.*

The rechargeable battery pack within the PCM for the M9 may not be sufficient for winter operation. It is recommended to pack an external power supply and a cable with an external power supply connector to supplement or replace the PCM battery pack.

4 On arrival at site:

- The selected measurement cross section should have characteristics similar to a good conventional measurement section.
- Check battery voltages and replace if necessary
- Immerse the ADCP in water to acclimatize the transducers and temperature sensor. Note that it may take a half hour or longer for the ADCP to adjust to near freezing temperatures. As previously mentioned in section 1, the specified minimum storage temperatures are -20°C for the TRDI RiverRay and -10°C for the SonTek M9/S5 so it is important to avoid exposing an uncovered ADCP to very cold air (-20°C or colder) for extended periods of time (>15 minutes). Consider using an insulated container with a hand warmer to protect the ADCP during transport. In the case of the StreamPro, where the electronics are external to the transducer head, it is recommended to keep the electronics housing in an insulated pack during the measurement when air temperatures are below -5C.

The following is applicable to ADCPs with compasses integrated into the transducer heads (RiverRay, M9, S5 for example)

- Use a hand held compass to obtain an approximate instrument heading during deployment. This may be done by first sighting the tagline azimuth and adding or subtracting 90 degrees to obtain an expected instrument heading during deployment.
- Use composite toe boots instead of steel-toed boots. Keep electronics (Cell phones, tablets, notebook computers) and smaller ferrous objects at least a few meters away from the ADCP. Be aware of effects of nearby bridges, sheet piling and reinforced concrete on compass-performance. Try to select a measurement section away from ferrous materials but if this is not possible then the reference for the ADCP orientation will be based on visually orienting the transducers with respect to the cross section (instrument or XYZ reference) and not be dependent on the ADCP compass (east, north up or ENU reference). For further details on instrument orientation see section 5 below.

5 Prior to measurement:

- Folder and file naming conventions.
    - Convention for SxS Pro filenames: *StationID_YYYYMMDD.sxs.mmt.* *(folder can be named Station ID_YYYYMMDD.AQ#)*
    - Convention for *RiverSurveyor Stationary Live folder names: (Station ID_YYYYMMDD.SQ#)*
- Set the ADCP time to the PC time.
- Calibrate the compass as recommended for moving boat measurements (Not applicable for StreamPro under-ice measurements as they do not have a compass within the transducer head). Although a calibrated compass is not required for a successful under-ice measurement with TRDI instruments, a valid instrument heading provides useful information about instrument orientation with respect to the tagline should there be concerns about visually orienting the

ADCP. As of spring 2014, the compass calibration function within SxS Pro does not work for the ISM compass so the calibration is done within WinRiver II.

- Run diagnostic tests for ADCP
- Adjust ADCP data acquisition parameters according to prescribed values:
    - *Duration: Standard data collection duration for mechanical current meters is 40 seconds* (Terzi, 1982). The default sampling period for Section by Section Pro is also 40 seconds. *Section by Section Pro will prompt users to extend the sampling period if more than 25% of ensembles are missing.* ***Obtain a minimum sampling time of 40 seconds. If less than 40 valid and consistent ensembles at a station/vertical are obtained within that period, it is recommended to increase the sampling time to obtain the 40 valid ensembles.*** *You can read the number of valid ensembles in SxS Pro within the Acquire view, check tabular results for the vertical on the left side for good/bad ensembles and adjust the sampling period or duration within the MMT wizard to obtain 40 good ensembles. The sampling rate will vary between instruments and mode so the user will have to note the number of valid ensembles after the first station/vertical and adjust the sampling period accordingly. RiverSurveyor Stationary Live will take 40 samples during a 40 second sampling period and there is typically no rejection of samples.*

    - *ADCP depth: If the mount is designed to keep a consistent offset between the bottom of the ice and the transducer, input this value as ADCP depth. In the example shown in Figure 3, a default distance of 10 cm from the bottom of the ice to the centre of transducers will be displayed at each vertical form. In most conditions it is recommended to use at least 10 cm clearance below the bottom of the ice to reduce the chances of beam obstruction. However, 5 cm may be acceptable in some cases i.e. shallow conditions or smaller transducer heads. The profile plots showing SNR or intensity levels with depth should be monitored for obstructions, seen as rapid increases within the water column. The ADCP is lowered as required if interference in the profile is observed.*

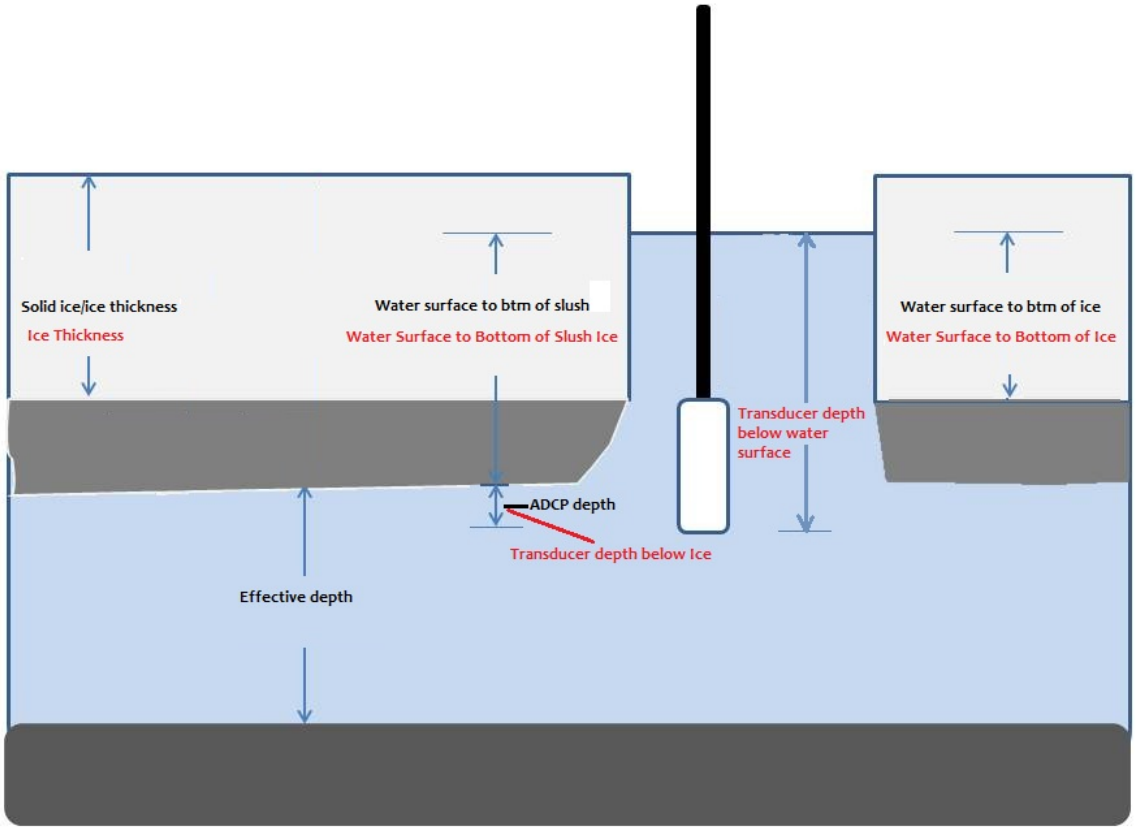

Figure 3 – Diagram of under-ice deployment
(SxS Pro Terms in black; RiverSurveyor Stationary Live Terms in red)

- *<u>Discharge method</u>: The two options for discharge method are mean-section method and mid-section method. Select mid-section method.*
- *<u>Orientation</u>: Always maintain the ADCP in the same direction for every station/vertical collected over the entire cross-section. A visual alignment tool (Appendix C - WSC Under Ice Hardware System – Page 4 - Rod Orientation Tool) on the instrument mount provides a reliable way of maintaining instrument orientation. Users are recommended to take extra steps to calibrate and use the internal compass then monitor heading values during the measurement as a backup method for ensuring proper orientation. This recommendation is not applicable to the StreamPro.*
- *<u>Vertical Sample</u>: A **minimum of 2 depth cells** must be obtained at every vertical and ensure that velocity and depths are measured to the bottom. For non-auto adapting TRDI ADCPs, it may be necessary to change the configuration at some shallow verticals. A note on changing configurations during a measurement is in the dialog box below.*

TRDI: ***Measurement configuration***

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

Note that 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). Once the information has been entered, press F3 (or from Menu select Configure/Processing).

Measurement name: Manually type the station ID and the measurement date (yyyymmdd) separated by an underline delimiter (see Figure 5 for example). Naming conventions do not require the automated addition of measurement number or other features in order to respect all WSC naming conventions.

Data Acquisition Parameters setup in Measurement Wizard

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 40 valid and consistent ensembles at a station/vertical. A 40 second sampling period will be sufficient for most deployments but for instruments and modes operating with sampling rates less than 1Hz and for cases where there are missing ensembles, it is recommended to increase the sampling time to obtain the 40 valid ensembles.

Velocity method: There are two ways in which flow directions are referenced in Section by Section Pro; Magnitude and Y-velocity. ***Use the Y-velocity method for under-ice measurements****.* ***Magnitude*** *method is used when the ADCP is free to rotate with the 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 other situations where the transducer is fixed and no rotation with respect to the measurement section is allowed.* ***TRDI's convention for Section by Section Pro measurements is to hold beam 3 perpendicular to the tagline, oriented in the downstream direction*** *(Figure 4). If another orientation is used for a measurement, this can be corrected in post processing by inputting a beam 3 misalignment (in degrees).*

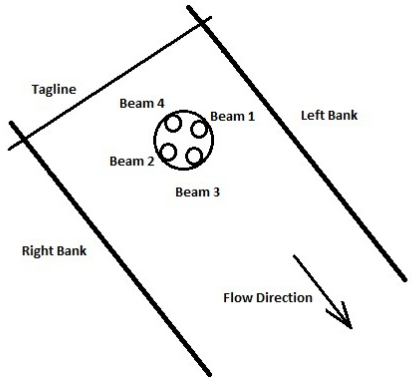

Figure 4 -*Illustration of conventional beam orientation for TRDI Section by Section Pro applications*

<u>Orientation</u>: Never select "use compass" for under-ice StreamPro measurements. The compass is separate from the transducer head and will therefore not rotate with it. If the compass is enabled, so too are the pitch and roll sensors however these are active within the electronics housing of the StreamPro and not representative of the orientation of the transducer head.

<u>ADCP setup and Processing</u>

Examples of ADCP setup options in Measurement Wizard are shown in Figure 5.

The options for ADCP setup will vary based on the instrument. Example setup options for the StreamPro (Figure 5), Rio Grande (Figure 6) and RiverRay are shown or described below.

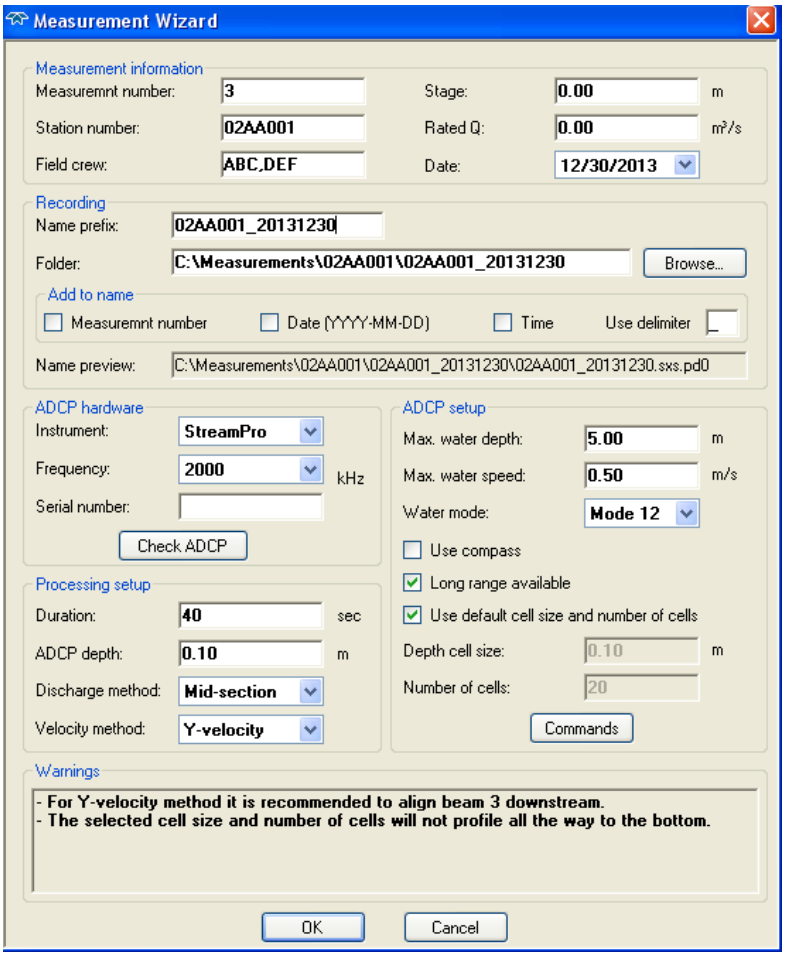

Figure 5 – Measurement Wizard form in SxS Pro with ADCP setup for StreamPro

Figure 6 – ADCP setup for Rio Grande
The ADCP setup form for a RiverRay deployment
has only the "Commands" button at the bottom

At any time, a processing form can be viewed by hitting F3. It is not recommended to use the secondary depth field for the Rio Grande setup (Figure 7). Instead, a user can optimize the Rio Grande configuration for varying conditions. For example it is possible to set smaller bins sizes in shallow parts of a cross section. This can be done during the measurement by stopping the ADCP pinging and changing the maximum water depth value or maximum water speed as needed. It should not be necessary to change the configuration at every vertical but it can be changed on occasions where depths and/or velocities change significantly, for example if a sudden decrease in depth results in only one bin sampled.

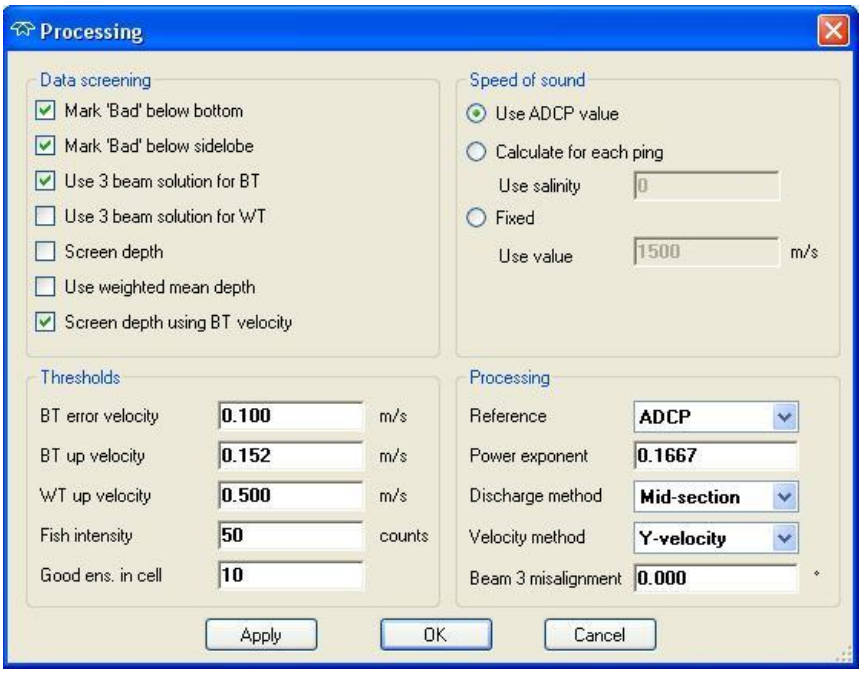

Figure 7 – Processing interface for SxS Pro

<u>The default setting for minimum number of good ensembles for a cell is 1. Change this to 10.</u>

The default setting for 3 beam solution for water tracking (WT) is" not activated". It may be useful to activate 3 beam solution for water tracking if there is suspected interference with one of the 4 beams (for example irregular slush/ice depths or vertical walls).

Beam 3 misalignment: The convention for the Y-velocity method in Section by Section Pro is to hold the ADCP with beam 3 facing downstream (Figure 4). If, for example, a user inadvertently set beam 3 facing upstream, they could correct for the misalignment by setting the beam 3 misalignment to 180 degrees either during the measurement or in post processing. Since the transducer for the RiverRay is oriented 45 degrees from the direction of the impulse connector, a beam three misalignment of 45 degrees or 320 degrees may be required, depending on the deployment.

<u>SonTek:</u> *When creating a new measurement in SonTek's RiverSurveyor Stationary Live, you are presented with the main page from which you select connect to RiverSurveyor system. Once connected, the Start Page appears (Figure 8). Enter the site information.*

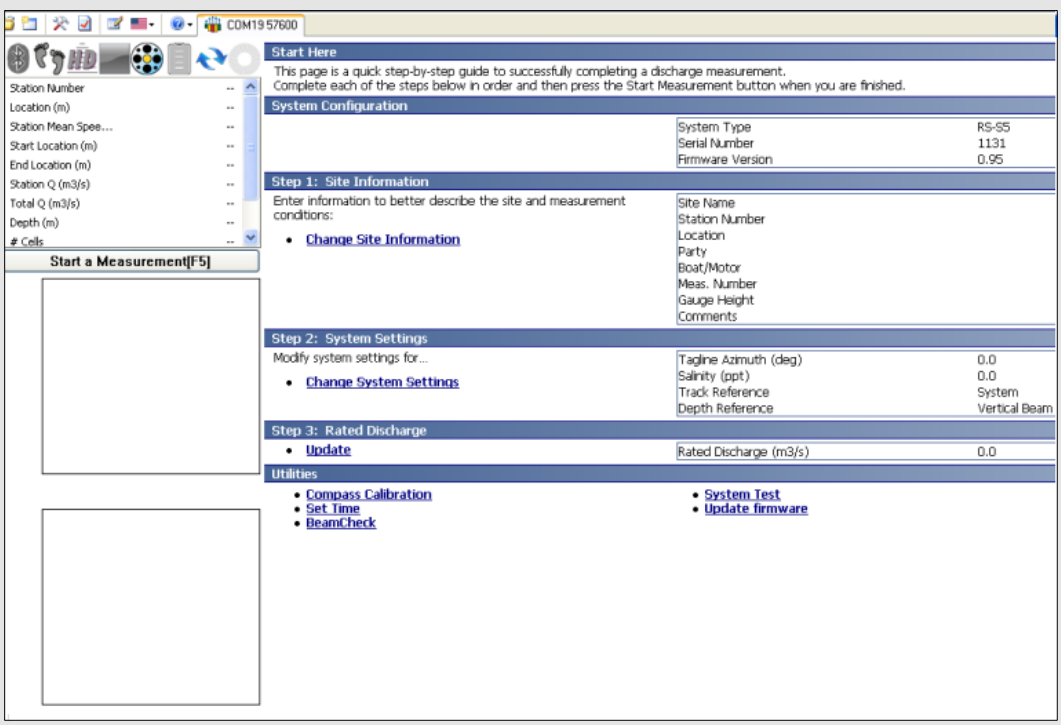

Figure 8 – RSSL Start Page

<u>Orientation</u>: After getting a valid compass calibration, you may obtain the tagline azimuth using the system compass following the software instructions but always confirm the tagline azimuth using a handheld compass reading as this value can later be used as part of the measurement quality controls. Tagline azimuth is with respect to magnetic North. The following illustration (Figure 9) shows the correct orientation of the M9/S5 with the connector pointing downstream.

While operating in ENU (earth) reference with a valid compass calibration, it is possible to achieve a valid discharge without worrying about the instrument orientation with respect to the tagline. However, it is recommended to maintain a consistent orientation with respect to the tagline and use the XYZ (instrument) reference as the default coordinate system for under ice measurements. This will prevent errors in compass outputs translating into erroneous flow angles. The reference setting for orientation can be changed in the station details form during the measurement or in post processing.

If it is not possible to obtain a valid calibration after two attempts, continue with a measurement in XYZ reference maintaining a consistent orientation with respect to the cross section, something that is done in all cases anyways. Keep any external power supplies a few meters away from the ADCP during compass calibration and during the measurement.

*The extra work required for calibrating the compass **AND** keeping a consistent instrument orientation is to ensure redundancy for determining the angle of flow. Should problems be discovered later with either the compass or ADCP mount, there will be an alternate reference to validate the angle of flow.*

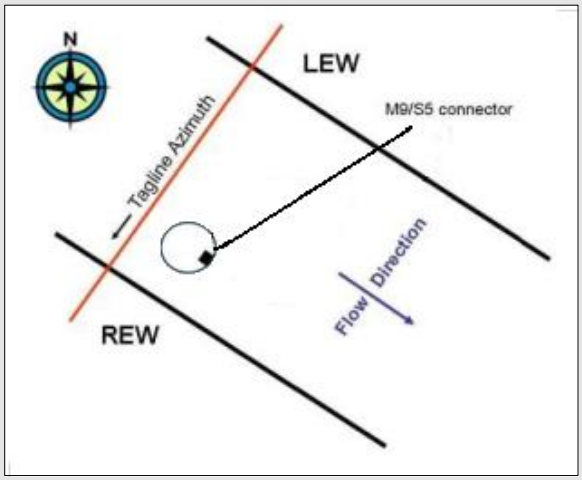

Figure 9 – Orientation for SonTek S5/M9 in mid-section mode

Image source: SonTek Stationary Measurement User Guide

Set the ADCP time. Run the system test. Under "Change System Settings", recommended settings are "System" for track reference and "Vertical Beam" for depth reference, Mid-Section for discharge method and Smart Pulse is enabled.

Once the transducer is set through the first hole, run the beam check feature to confirm if SNR values are consistent between the different beams and there are no obvious obstacles near the face of the transducers. Users would select the 3MHz frequency in shallow conditions for the beam check.

6 Start Measurement

For under ice conditions, confirm ADCP reported water temperature reads between -2 and 2 degrees Celsius of water temperature. If the ADCP displayed temperature does not fall within this range, wait until the ADCP temperature stabilizes to within this range. If there is a suspected broken thermistor, confirm water temperatures independently with a thermometer and override the ADCP temperatures with a manually input value.

Once ***Start Measurement*** is selected, you are prompted for starting edge information. Both SxS Pro and RSSL prompts for starting bank (left or right), distance from IP, 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. This factor is zero for the edge of a sloping banks and increases towards one with decreasing effects of roughness at the pier/wall. **As with moving boat measurements, it is recommended to maintain a distance from a vertical wall equal to or greater than the depth at the wall.** For this reason, a cross section with several piers or vertical walls may have significant portions of unmeasured velocities and therefore higher uncertainty related to the discharge value.

TRDI: *SxS Pro labels the starting edge as Vertical 1.*

SonTek: *RSSL labels the starting edge as Station 1. Users will be prompted to input the water surface type (i.e. open water or under -ice measurement) only after inputting the starting bank information.*

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

Figure 10: Efficient coordination of tasks is key to produce a quality measurement under cold conditions

Figure 11: Holding the instrument in steady position.

You are prompted for tagline position, ice thickness, depth to bottom of ice, depth to bottom of slush (if applicable) and distance of ADCP below ice/slush horizon. Although a final discharge requires only the distance below the ice, it is recommended to complete all applicable fields. This will ensure graphics are consistent with actual conditions.

Do not use the winter rod assembly with an ADCP adapter (StreamPro, RiverRay or SonTek M9/S5) to measure ice thickness. Although the WSC standard winter rod has graduations that would permit measurement of ice thickness, use a slush remover (Figure 12) to avoid damaging communication cables.

Figure 12 - WSC 1.5m Slush Remover with depth markings

If slush is present, it will be necessary to lower the ADCP into the water while pinging until valid data is generated. It is assumed that water velocities are sufficient to clear the slush from the ADCP transducer head. Depending on the mount, the user might feel the resistance of the slush on the horizontal part of the transducer bracket, indicating the depth of the slush below the water surface. Try not to pull the instrument back up into the slush once a clear signal is seen. Users need to be aware that the transducer face is potentially the first surface in contact with a hard, unseen object. When probing through slush or in shallow conditions, be careful to not impact the transducer face on rock or ice surfaces.

If velocities can be measured but an accurate depth cannot be obtained due to weeds or high suspended sediment concentrations, both RSSL and SxS Pro have 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.

Prior to starting data collection, set the ADCP to the upstream side of the hole, confirm alignment with the visual alignment tool and check that mount is plumb. If an internal compass is also being used, you can also check the ADCP heading at each station/vertical to ensure consistency. Select velocity profile for Ice and input the applicable thickness and depth measurements.

TRDI:

There may be cases where the estimated depths input into the Measurement Wizard are significantly deeper than the actual depth at a vertical, resulting in larger, and fewer, bins. If there are less than five bins at a vertical, the user should consider changing the max depth setting in the Measurement Wizard. To do this, stop pinging (F4) and open the measurement wizard (F2) and change the max depth setting.

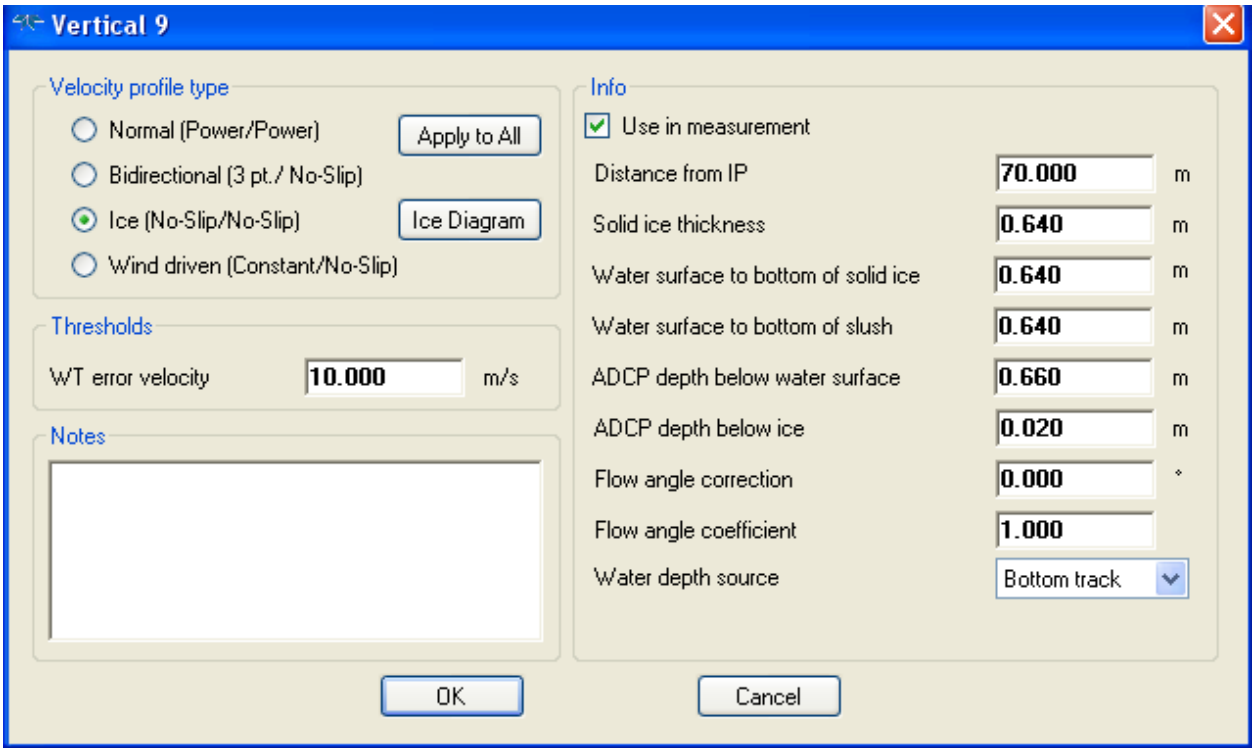

Figure 13 – setup form for typical vertical

It is recommended to obtain a minimum of 2 depth cells at a vertical. 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.

Monitor the individual beam intensity profiles in Section by Section Pro. Where one or more beams show spikes in intensity between the riverbed and underside of the ice, there may be blockage caused by a stationary object.

Each vertical form has space for notes specific to that vertical.

Flow angle correction and flow angle coefficient are typically used for open water measurements where the instrument is free to rotate with changing flow directions.

Dealing with Low backscatter: *Figures 14 and 15 below show a measurement where the threshold setting for the number of good ensembles for each cell is set at the default setting of 1(Figure 14) and at the recommended setting of 10 (Figure 15). There are fewer valid cells visible in Figure 15 but this is*

partially corrected when the sampling time is increased from 40 seconds to 80 seconds at the 40m mark where a larger portion of the velocity profile is sampled.

Using the default setting of accepting cell velocities with only 1 successful sample over the entire sampling period can result in unrealistic extrapolations as seen in the velocity profile in the upper right corner of figure 14 where the lower extrapolated velocities do not appear to represent the measured velocities near the top. For a case like this, it would be advisable to repeat the measurement with a 120 second sampling period using the recommended threshold of 10 good ensembles in cells along with increasing the bin size. The transducer can be lowered further into the water column to better represent velocities in the middle portion of the water column. Another possible solution in the case of the StreamPro is increasing the supply voltage to 18v. .

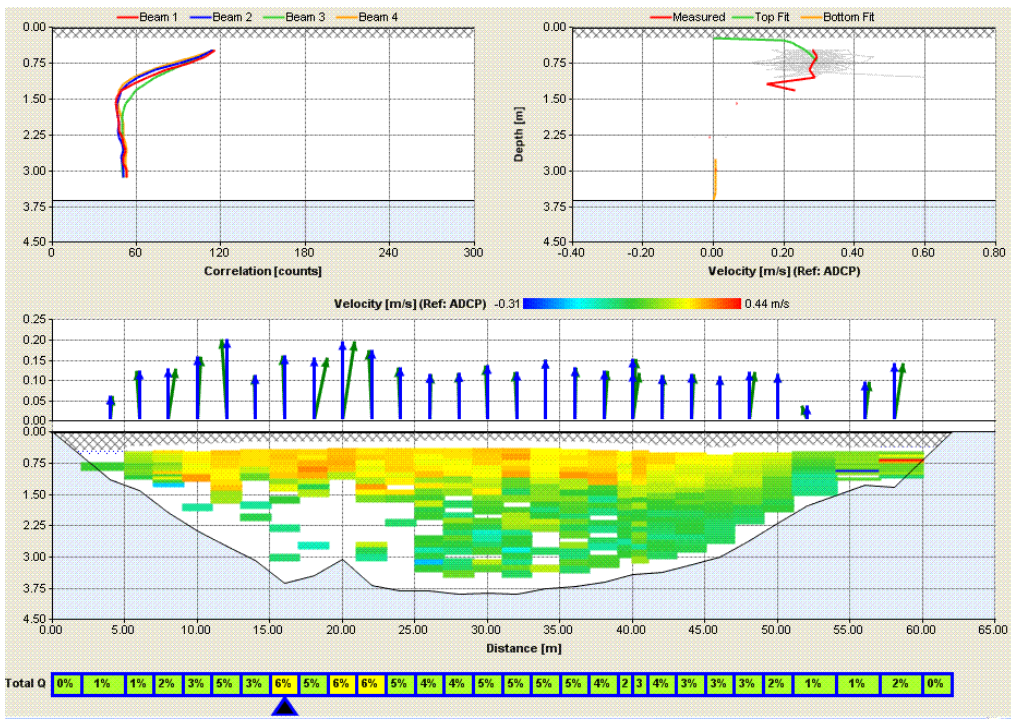

Figure 14: Example of a StreamPro measurement in clear water with threshold setting of good ensembles in each cell = 1

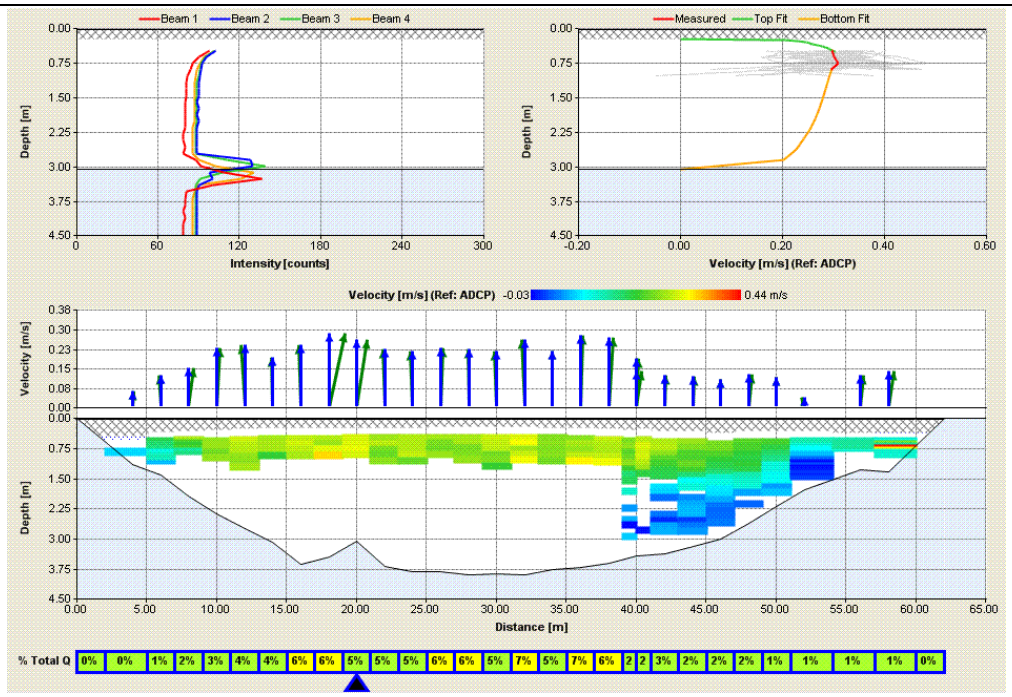

Figure 15: Example of a StreamPro measurement in clear water with threshold setting of good ensembles in each cell = 10. In this example, the vertical sampling times were changed from 40 seconds to 80 seconds around the 39m mark.

Further tips for Section by Section Pro:

Monitor tagline position and incrementing discharges from vertical to vertical as a check against unexpected changes, especially as you are ending the measurement.

Even in cases where there is no slush present you may need to update the depth to bottom of slush field.

In verticals with slush and sufficient effective depth, consider increasing ADCP depth below slush to 20cm to be sure to avoid beam blockage.

SonTek: *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 or presence of slush.*

Set: ***Screening Distance****: transducer depth + 0.16m* ***Coordinate System****: XYZ*

Water Surface Type *options are; "Open Water"; "Ice" and "Ice with Slush"* ***Confirm the depth to the slush horizon at each hole ("Water Surface to Bottom of Slush Ice") since this field may not be automatically filled with the value at the previous hole. At deeper sections consider increasing clearance below the slush horizon (e.g. 10cm to 20cm) to avoid beam blockage.***

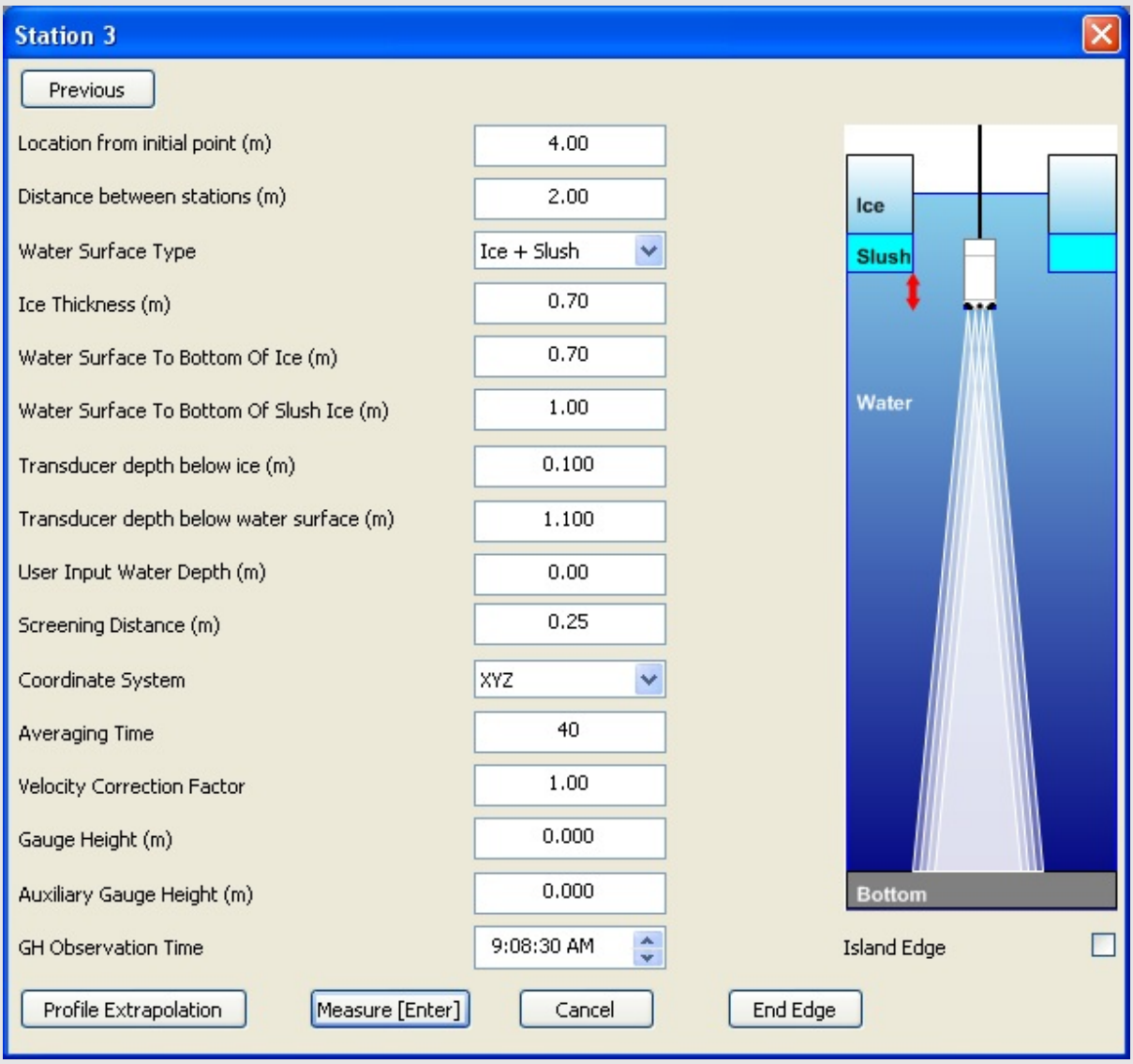

Figure 16 – Station details within RSSL

<u>SonTek:</u> *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.*

What does slush look like? *It may be simply invalid data or it can look like the example below (Figure17). For comparison purposes, a similar station without slush is shown in Figure 18, both courtesy of WSC Fort Simpson.*

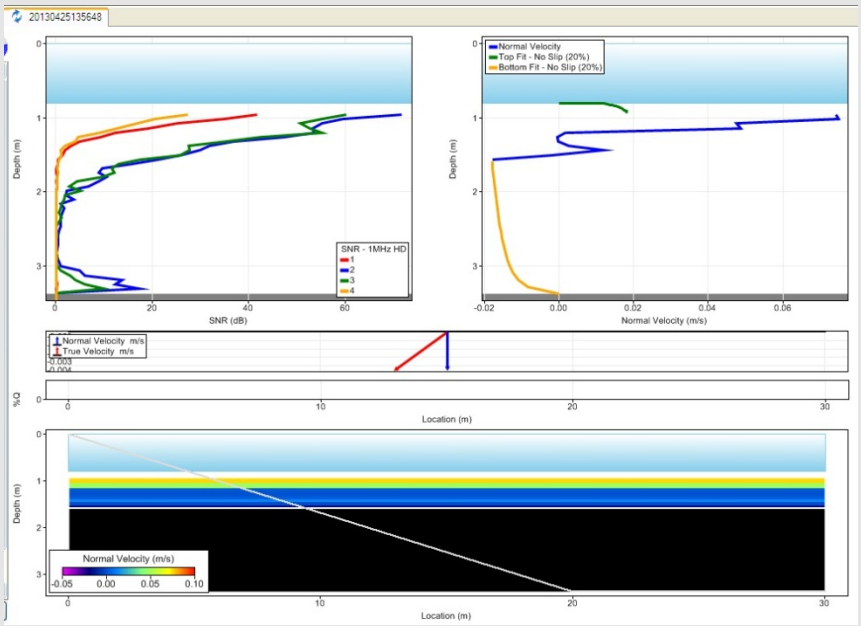

Figure 17: Example of M9 display with slush. Note high SNR levels that drop rapidly with depth. Slush is frequently seen as invalid data until the transducers are pushed through the slush horizon.

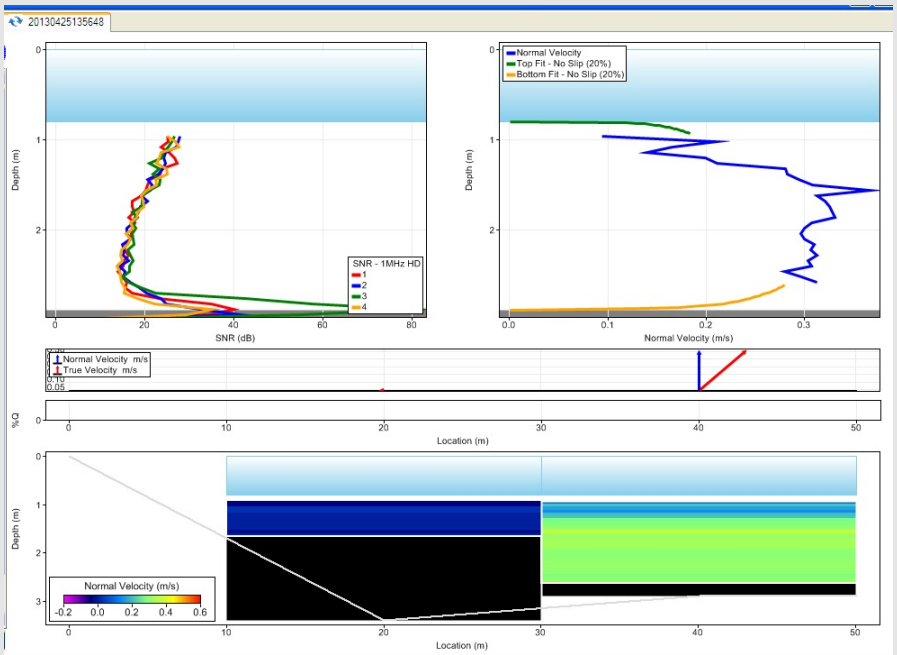

Figure 18: An example of M9 output without slush

<u>SonTek:</u> Dealing with low backscatter (low SNR)

In RSSL there is no setting for a minimum number of samples in a given depth cell so in the case of low backscatter, a few noisy data points can affect the extrapolated velocities and therefore the final discharge. In the example shown in Figure 19, one data point near the riverbed significantly affects the discharge for the panel. Increase the sampling time, observe the extrapolations and flow directions, and repeat panels whenever necessary. It may be useful to lower the ADCP into the water column to observe velocities closer to the centre of the profile.

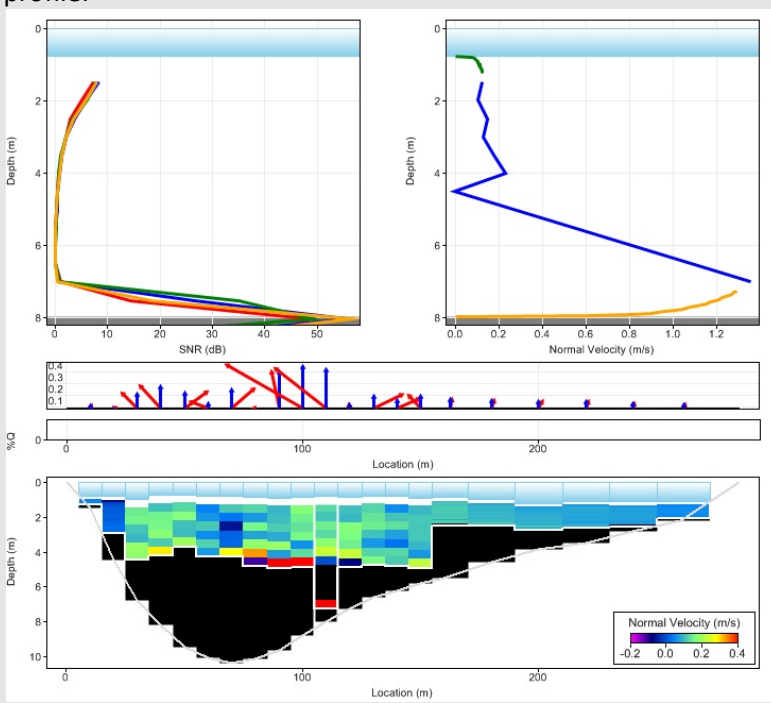

Figure 19 - Example of SNR profile in RSSL without beam obstructions

Be aware of other obstructions within the water column by monitoring the SNR levels. In the case of TRDI ADCPs, monitor the intensity profiles.

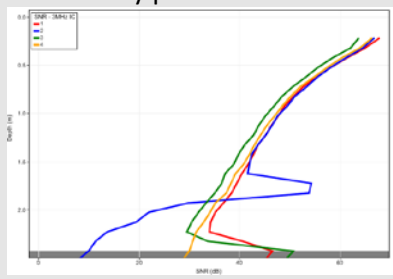

Figure 20 - Example of SNR profile in RSSL with beam obstruction (open water conditions)

o **TRDI:** Intensity for SxS Pro

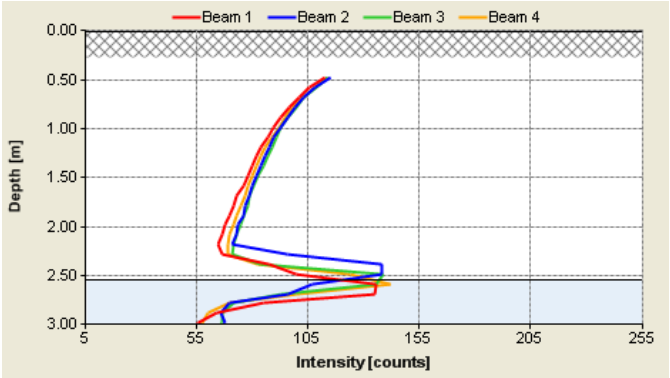

Figure 21 -Example of Intensity Profile in SxS Pro without beam obstructions

During data acquisition, monitor the following:

- profile plots for beam blockage(see figure 21).
- contour plots for obvious input errors in depths.
- flow directions: If they change rapidly between stations/verticals or otherwise show unexpected patterns, double check the instrument alignment against the tagline and check the orientation guides on the mount to ensure the mount or alignment guide has not rotated.

Once the station (vertical) is complete, a Measurement Results dialog will show a summary of the station for review and you will be prompted to **Accept,** to proceed to the next station or **Repeat (SonTek) / Reject (TRDI)** 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.

If necessary, you can insert a station/vertical at any time during the measurement. Neither SxS Pro nor RSSL will allow two active stations/verticals at the same location. SxS Pro will allow users to replace one station with another station at the same location keeping only one active.

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.

TRDI:
***Question:* I am in the middle of my measurement and I want to change cell size or increase sampling duration beyond 40 seconds etc. How do I do this again?**
Stop pinging (F4 or Acquire/stop pinging) then open measurement wizard (F2 or Configuration/ Measurement Wizard) change the configuration setting and start pinging again.
SxS Pro allows users to change cell sizes by changing maximum depth values.
Users can also change water modes, and even instruments midway through a measurement.

SonTek: *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*

TRDI: *SxS Pro uses manual verticals for islands/piers. Further recommendations on how to use manual verticals for different scenarios will be investigated in future versions of this SOP.*

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.

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

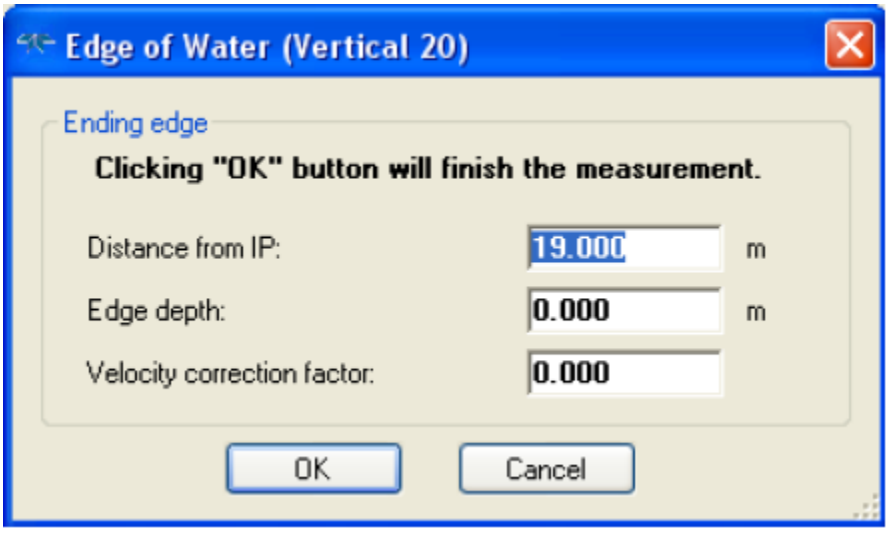

Figure 22: End measurement form

SxS Pro allows the user to temporarily abort a partially completed measurement and continue the measurement at a later time.

7 Data Review

Data must be first thoroughly reviewed while still in the field to identify and correct any potential acquisition error.

Check:

- Diagnostic test results OK and logged. ADCP clock set. Compass calibrated (not applicable for StreamPro)
- Review contour plot as a visual check on input errors for ice thickness, depths, ADCP depth etc.
- Look at flow vectors/flow direction to detect obvious inconsistencies or errors that may be caused by procedural errors or problems with the ADCP mount.
- (SxS Pro only) Are there several missing cells within station/vertical? If so, check to see the velocities measured allow reasonable extrapolations at the top and bottom. In clear water, there may be several missing cells. This is shown as intensity profiles dropping to noise floor level and staying at those levels (60 counts or lower for RiverRay, 85 or lower for StreamPro) It may be necessary to repeat the measurement with longer sampling times at each panel and/or increasing the size of the bins or changing the water mode.
- SNR/intensity. Look for spikes caused by obstructions.
- Click on individual stations/verticals to view extrapolated portions of profiles. Is there a discontinuity of the measured profile? If not 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 under ice is **no slip top /no slip bottom**. The no slip method of extrapolation uses a power fit to force the upper or lower portion of the measured velocities to a zero velocity at the upper or lower boundary. The no-slip method of extrapolation is suitable for under ice velocity profiles as it allows independent extrapolations for the upper and lower portions of the profile resulting from different roughness effects from the upper and lower boundaries.

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.*
*The station details form will appear. If applying a change to all profiles don't forget to hit "****Apply to All****".*
A commonly seen problem with RSSL v2.50 is an apparent insensitivity to adjusting the number of cells or % of vertical for the application of the top extrapolation.

In some cases there may be little friction under ice and maximum velocity may be close to the underside of the ice. In other cases, the underside of the ice may have a high roughness with large effects on the velocity profile.

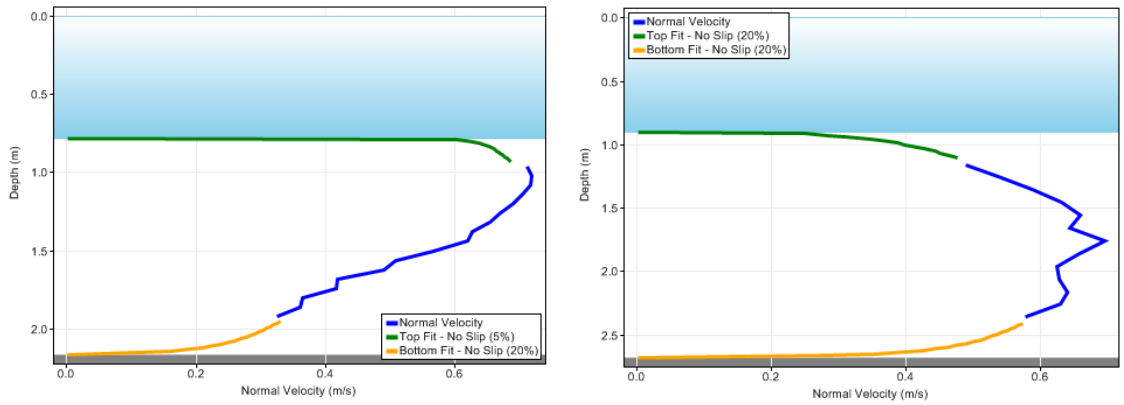

Figure 23 - Example of velocity profiles from two different under -ice measurements. The left image shows the effect of a smooth under ice surface and the right image indicates a higher under ice roughness. In these cases, parameters for the upper no-slip extrapolation can be modified to suit.

Figure 24– Operators must analyze velocity profiles and conditions to determine the velocity profile best suited for the conditions. For example, varying ice roughness will influence how fast the top profile will approach zero.

<u>TRDI:</u> *In SxS Pro, it is important to visually review the top and bottom extrapolations. Check the contour plot for consistency between vertical in velocities, flow directions and effective depths and ice thickness. 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.*

- 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

KEY	Description
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)

KEY	Description
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 – Suggested WT Error threshold values for StreamPro

When first configuring the ADCP for an under ice measurement, use the settings set by SxS Pro. If, however, you change the mode or bin size during a measurement, this table can be used as a rough guide to modify WT error settings for the following verticals.

These are estimates based on setting an error threshold between 3 and 4 times the expected standard deviations of velocities. For bin sizes that fall between those listed in the table, refer to the next smaller bin size. These are suggested guidelines.

Mode	Bin size (cm)	WT error velocity (m/s)
WM13		0.06
WM12	2	0.6
	3	0.5
	5	0.4
	8	0.3
	10	0.2
	15	0.15
	20	0.1

Appendix C – WSC Under Ice Hardware System – Mark 1

The WSC Under Ice Hardware system was designed to provide a complete suite of deployment options for all under ice velocity measurement sensors currently available for use by Water Survey of Canada. This integrated system is designed around the WSC standard winter rod system that has been the long standing deployment base for the Price current meter.

This system continues to allow for deployment of the Price current meter but also includes mounts and adapters for use of;

1. SonTek YSI FlowTracker ADV

2. Teledyne RDI StreamPro ADCP

3. Teledyne RDI RiverRay ADCP

4. SonTek YSI S5/M9 ADP

Important Note: All new components and hardware are made of aluminum and stainless steel (non-ferrous/ non-magnetic material). Any replacement connectors or welded repairs must maintain the same material standard.

Along with the adaptive tools for velocity measurement, the Mark 1 system also incorporates improvements to ensure proper orientation of profiling sensors during the velocity measurement process. This includes:

- A flat machine surfaced face into the aluminum winter rod on the full length of all rod sections that ensures accurate upstream/downstream orientation/alignment of ADCP sensors. The rod sections are keyed/matched by a coloured “dot” key as part of the overall kit design to ensure this orientation/alignment is always guaranteed. Although the Price Current Meter and the SonTek FlowTracker can easily be deployed with this system, use of the machined surface for orientation does not necessarily apply to sensors that are threaded on to the adaptor. Extra care should be exercised to ensure proper instrument orientation when using either the SonTek FlowTracker or the Price Current Meter with this system.

- A new orientation tool that seats against the machined surface of the winter rod provides a visual aid for ensuring correct alignment along the cross section. Also included is an integrated fish eye bubble for maintaining vertical orientation (Z coordinate) during measurement.

1. Rod System

- The rod system is a modification of the standard WSC winter rod set; three (3) one (1) meter upper sections and one (1) lower section, all with machined surfaced orientation lines. The machined surface orientation line is specific to each rod set. The rod sections all use coloured dots to ensure proper alignment of the orientation line during use.

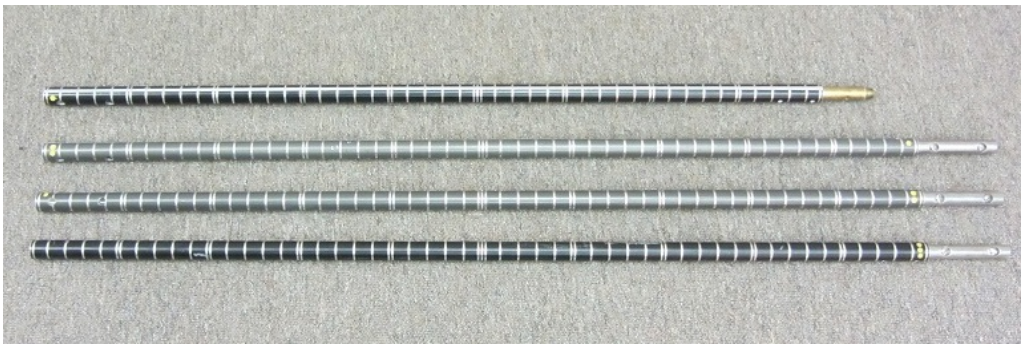

Figure 2 - Keyed winter rod set

Figure 3 - Base section with threaded meter mount.

Figure 4 - First section single "dot" key.

Figure 5 - Second section double "dot" key.

Figure 6 - Third section triple "dot" key

Figure 7 - First section "dot" key and upstream/downstream orientation line.

2. **Rod Orientation Tool**

- The Rod Orientation Tool assists the user in maintaining proper; horizontal (X,Y), and vertical orientation for all velocity measurement sensors. The aluminum and stainless steel tool slides on the winter rod assembly, adjusting for varying ice thicknesses. The tool is set on the winter rod assembly with a tightening/locking nut that is placed on the machined face (the machined face feature applies to ADCPs only and not sensors that are threaded on as their final orientation will vary). This locks the tool in vertical (Z) alignment with the rod, and horizontal (X,Y) alignment with the measurement cross section.

Figure 8 - Rod Orientation tool

Figure 9 - Tool aligned with upstream/downstream orientation line.
The right-angled visual alignment pin is held parallel to the measurement section.

3. **Velocity Sensor Mounts/Adaptors**

Velocity sensor mounts/adapters are designed to attach to the threaded base section of the WSC standard winter rod. The Price current meter and SonTek FlowTracker ADV point velocity sensors attach via the threaded connector to the base section of the winter rod. In the case of the SonTek FlowTracker ADV this is done using an adaptive mount (Figure 10). Unlike with the ADCPs/ADPs, users should not assume that they can determine the orientation of the point velocity meter by referring to the machined line on the face of the rod (the orientation line).

The three ADCP/ADP sensor mounts/adapters slide over the threaded connector of the base section of the winter rod. These mounts/adapters are secured to the base section of the winter rod by a lock-thread nut & bolt to ensure no potential of equipment loss. All three of these adapters place the bottom of the sensor/vertical beam at the zero (0.0) point relative to the winter rod increments.

a. Price Current Meter

Figure 10 - Price Current Meter attached to threaded base section of winter rod. Horizontal axis of meter cups at 0.0 metres. Winter rod foot is in place for measurement of ice thickness (upper hook) and depth sounding (base foot).

b. SonTek FlowTracker

Figure 11 - SonTek FlowTracker ADV mount.

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Figure 12 - SonTek FlowTracker ADV and mount attached to threaded base section of winter rod. Sensor face at 0.0 metre

c. Teledyne RDI StreamPro

This adapter is secured to the base section of the winter rod by a lock-thread nut & bolt to ensure no potential of equipment loss. The zeroing of the bottom of the StreamPro sensor is made through the vertical adjustment of the sensor in the collar. The sensor is locked in place with one of the two 45 degree set screw aligned with groove in the transducer head such that beam 3 is aligned directly downstream.

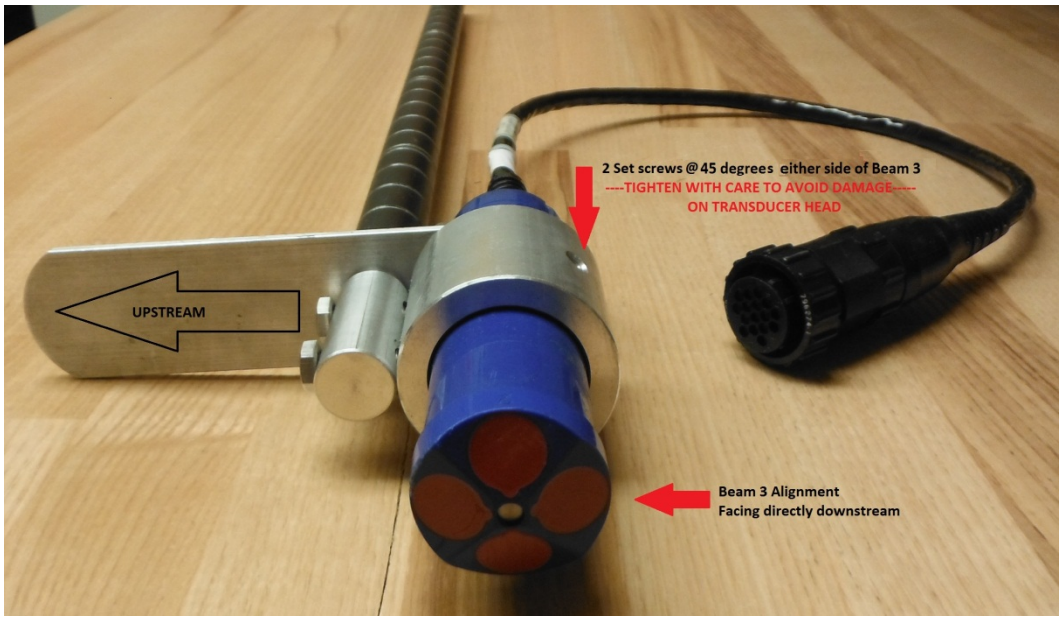

Figure 13 - StreamPro adapter. Sensor locked in collar with beam 3 aligned downstream; set screws at 45 degrees from beam 3 .

Figure 14 - StreamPro mounted with orientation tool in place.

Teledyne RDI RiverRay

This adapter is secured to the base section of the winter rod by a lock-thread nut & bolt to ensure no potential of equipment loss. Sensor mount marked with downstream (3/DS) orientation indicator for proper beam 3 alignment. The face of the transducer is located at 0.00 metre. Some RiverRay mounts have been further modified to accommodate a 90 degree communication cable connector.

Figures 15a and b: RiverRay mount both showing beam 3/DS alignment stamp. With and without upper flange coped to suit 90 degree RiverRay connector

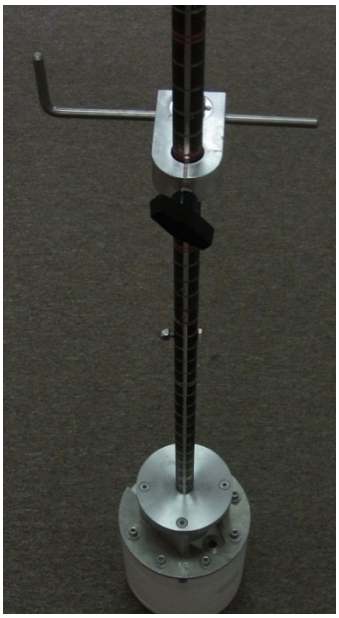

Figure 16 - RiverRay mount with orientation tool in place.

d. SonTek S5/M9

This adapter is secured to the base section of the winter rod by a lock-thread nut & bolt to ensure no potential of equipment loss. Sensor secured in adapter with four (4) top mount stainless steel bolts and adjustable clam shell collar. The vertical beam face is located at 0.00 metre.

Figure 16 - SonTek S5/M9 adapter

4. **Transport Case**

This is an integrated system and as such all components **must be** maintained as part of each kit. A Pelican transport case is supplied to ensure the maintenance of all matched/keyed components.

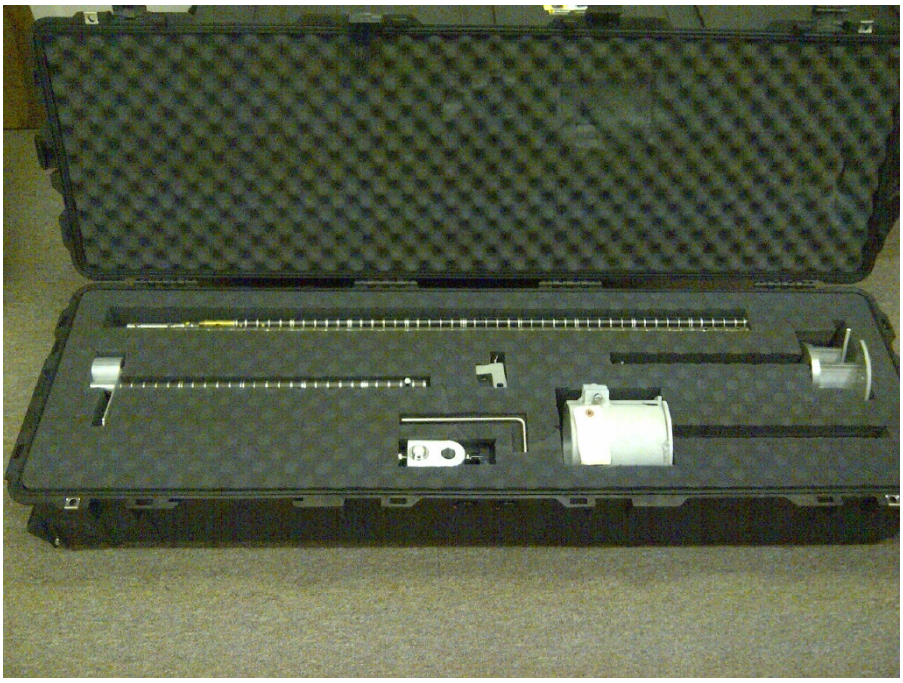

Figure 17 - Standard transport case configuration for all adapters.