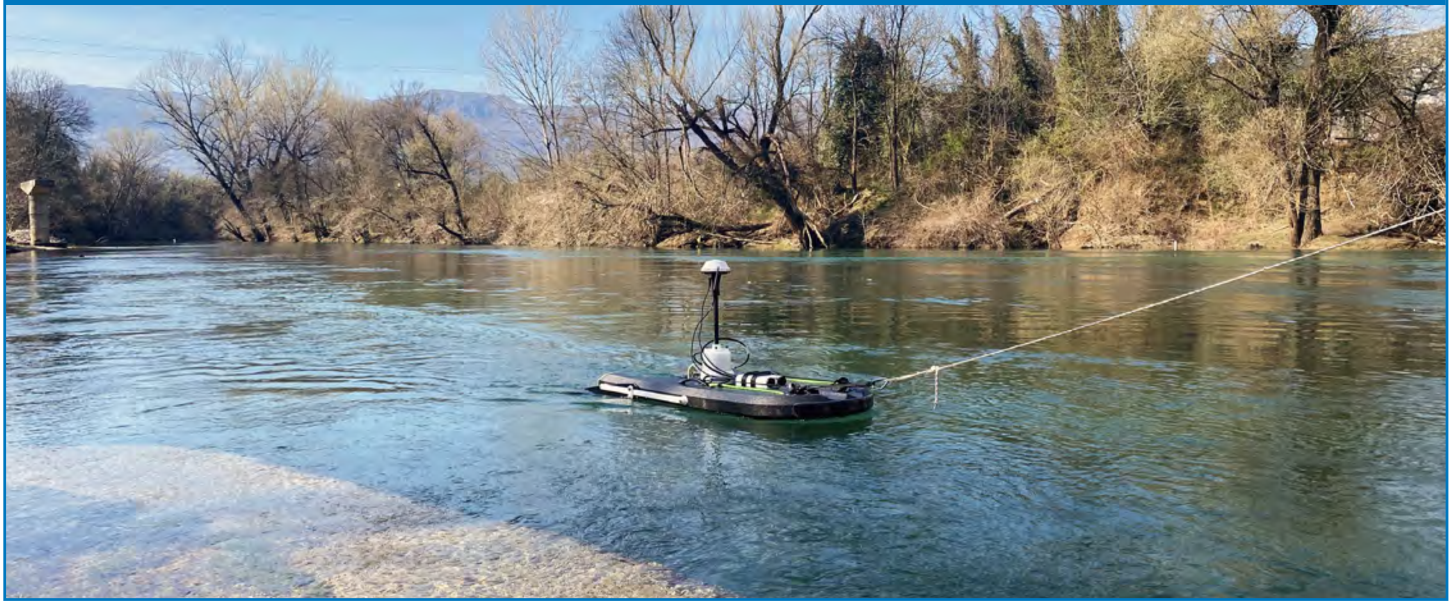
Understanding the Importance of Transducer Depth

ADCP Discharge Data Collection Fundamentals



Introduction

When using an Acoustic Doppler Current Profiler (ADCP) to make a discharge measurement, there are several factors that can impact the accuracy and quality of the data. Making a good measurement is no small task, and it requires attention to detail and knowledge of how the measurement, instrumentation, and software work. This technical note will take a close look at one of the essential measurement inputs – transducer depth.

The transducer depth is the vertical distance that the center (vertical) beam is submerged below the water surface. For the acoustic signal to propagate through the water column, all the transducers must be submerged in the water during a measurement.

Figure 1 depicts a typical ADCP setup for a discharge measurement.

Figure 1. Transducer depth shown with the SonTek-RS5 on a HydroBoard II – Micro.

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Importance of Transducer Depth

The transducer depth directly influences the calculated discharge. The face of each acoustic beam must be completely below the water surface to ensure that the acoustic signal can propagate through the water column. At sites with higher flows or surface turbulence, the ADCP may be pushed farther down into the water to prevent air entrainment around the transducers. Considering this, there will always be a section of water that the ADCP does not directly measure.

This unmeasured layer of water is the horizontal slice closest to the water surface, as illustrated in Figure 2.

This unmeasured section consists of two components - the transducer depth and the blanking distance. The space directly in front of the transducers where no measurement is physically made is the blanking distance. The blanking distance is a dynamic value automatically determined by the instrument firmware and is based on frequency, acoustic ping type, sample depth, and other factors.

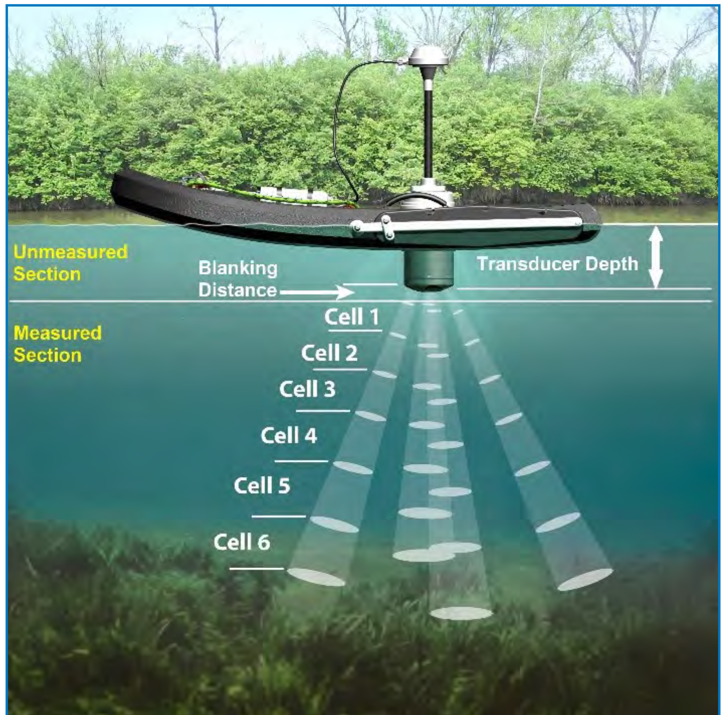

Figure 2. Unmeasured and measured section. Pictured: SonTek-M9 and HydroBoard II – Max.

Transducer Depth in Operation

When a user establishes connection with a SonTek ADCP and starts a new measurement in RSQ or RSL (RiverSurveyor Live), the program will first display the Smart Page. The Smart Page allows users to enter all relevant information and instrument configurations prior to starting the measurement. While some of the inputs are optional, there are a few input values that will directly influence calculations.

On the Smart Page, these critical items are highlighted in red text. Each section in the Smart Page will also display a large red warning icon until all the red items are completed by the user. Figure 3 shows the System Configuration section of the Smart Page.
One of the critical items is the transducer depth. While it may seem trivial, the transducer depth can make a significant difference to the calculations. It is easy to gloss over inputting an accurate transducer depth for each measurement. After taking hundreds of discharge measurements, the user may fall into a pattern and enter an estimated value despite the possibility of different ADCP setups and platforms.

The depth at which the ADCP begins profiling can be defined by:

Profile Starting Depth =
Transducer Depth + Blanking Distance

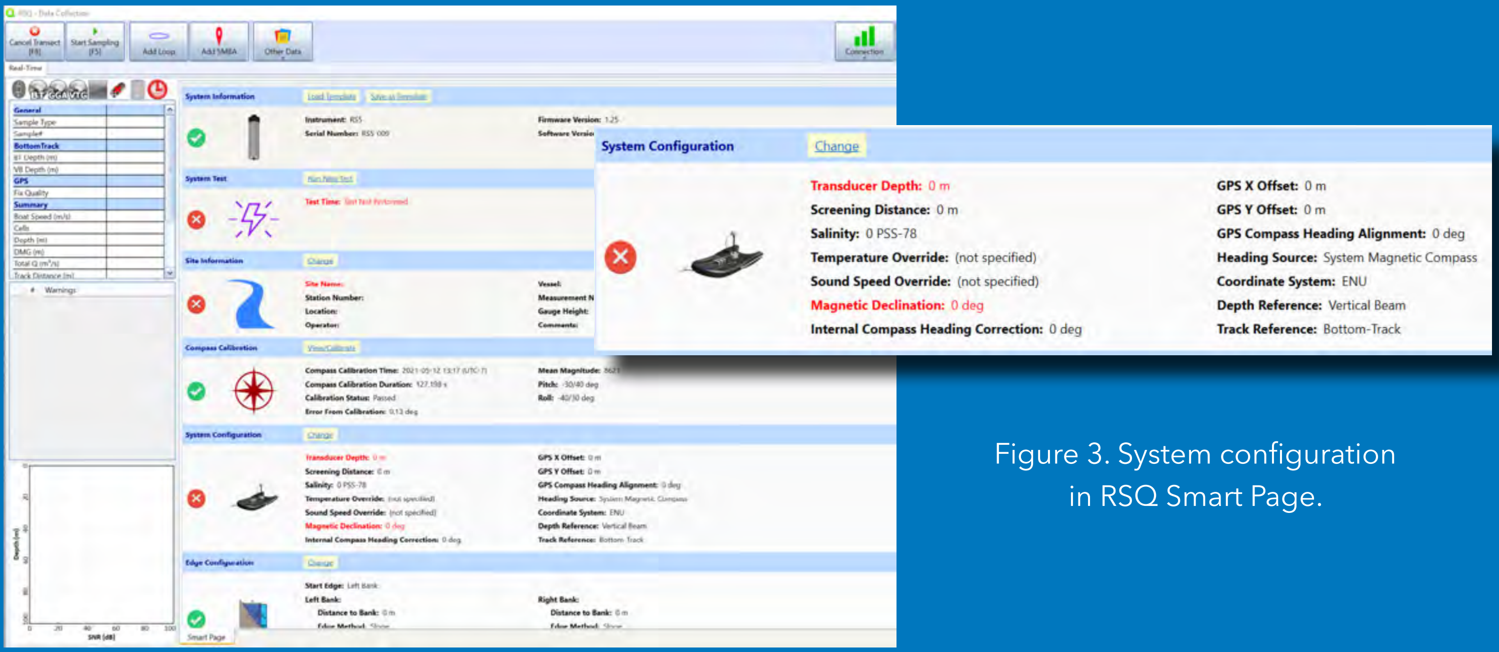

Figure 3. System configuration in RSQ Smart Page.

It is generally acceptable to input the same transducer depth if the user is going to repeatedly use the same exact hardware setup (i.e., same accessories, floating platform, and GNSS receiver) and secure the ADCP to the board in the exact, repeatable configuration. Once the user has carefully measured the transducer depth for their regular ADCP setup, they will not need to re-measure each time they make a measurement with this standard setup. However, if the ADCP hardware changes or if the user moves the ADCP up or down in the board, the transducer depth should be re-measured.

The software's QA/QC warning system generates a warning if the transducer depth is set to 0 and subsequently prompts the user to enter a non-zero value on the Smart Page. If the user forgets to input a transducer depth or inputs an incorrect value before measuring, the transducer depth can be modified during post-processing. Note that if no transducer depth or a wrong value is entered prior to the measurement, the data values shown during live data collection will not be accurate.

Transducer Depth and Data Calculations

Just how much of a difference can the transducer depth make? The answer is site dependent. Let's walk through an example. This site is relatively shallow with a mean depth of 0.54 m (1.78 ft) and a width of 44.7 m (146.6 ft). Figure 4 below shows the transect contour from the RS5 moving boat discharge measurement.

The transducer depth is reported to be 4.5 cm (0.147 ft). The calculated discharge using bottom track is 6.2 cms (220.7 cfs). Discharge is calculated as the product of mean channel velocity and channel cross-sectional area. To calculate the area, the ADCP uses the depth and ship track movement to determine width. The depth reported by the ADCP encompasses the user-input transducer depth value. Therefore, changes in the transducer depth value will propagate through the depth, area, and thus discharge calculations. Table 1 below shows the calculated area and discharge

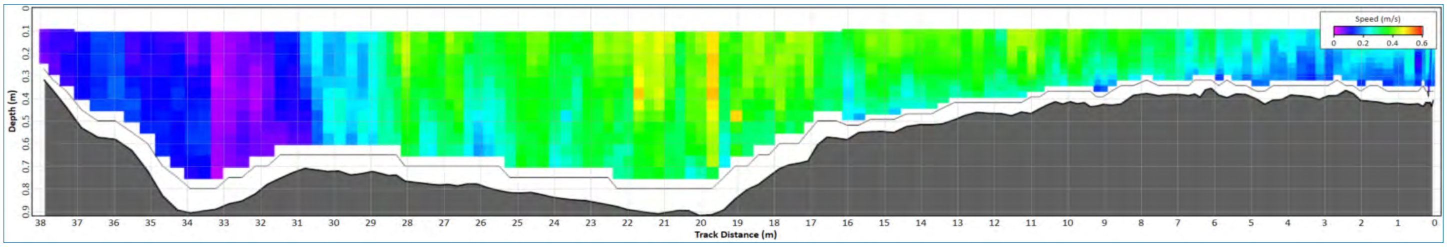

Figure 4. Water speed contour of a transect in RSQ.

values for different transducer depth values entered in post-processing. As Table 1 illustrates, the transducer depth directly impacts the calculated area and consequently the calculated discharge. Here, a small change in transducer depth equates to a 3.8% change in average discharge. Note that this percentage difference is not constant throughout all sites.

Transducer Depth	Average Area	Average Q	% Difference
2.5 cm (0.082 ft)	23.5 m^2 (252.6 ft^2)	6.0 m^3/s (212.4 ft^3/s)	-3.8%
4.5 cm (0.147 ft)	24.3 m^2 (261.1 ft^2)	6.2 m^3/s (220.7 ft^3/s)	------
6.5 cm (0.213 ft)	25.1 m^2 (269.8 ft^2)	6.5 m^3/s (229.0 ft^3/s)	3.8%

Table 1. Calculated area and discharge for different transducer depths.

The wider the channel is, the greater the impact a transducer depth error can have on the calculated discharge. This is because the difference can propagate through a longer distance. Similarly, a shallower channel means that the transducer depth will account for a larger portion of the total depth; any variation in the transducer depth can change the reported depth. Therefore, it is critical to measure and input a transducer depth that is accurate to the best of the user's ability. A slight deviation or guesswork in the transducer depth value can skew the final discharge.

How to Measure Transducer Depth

Despite the straightforward definition of the transducer depth, there is no procedure to accurately measure this distance. There are no right or wrong methods, as long as the user obtains the correct reading. In this section we will discuss the various options for measuring the transducer depth.

Small Boards

For small boards, it is recommended to measure with a carpenter square (e.g. a steel square, framing square, or a combination of the above). This is a useful tool for smaller boards designed to house the RS5, such as the Hydroboard II-Micro or Torrent Board Micro (TBX). Figure 5 shows a common carpenter square.

There are two factors that can affect the transducer depth: how deep the boat is sitting in the water, and hardware accessories mounted on the boat itself. The board's submergence can shift slightly depending on water speed and turbulence. Additionally, having a GNSS receiver and mounting bracket on board can also lower the boat due to added weight.

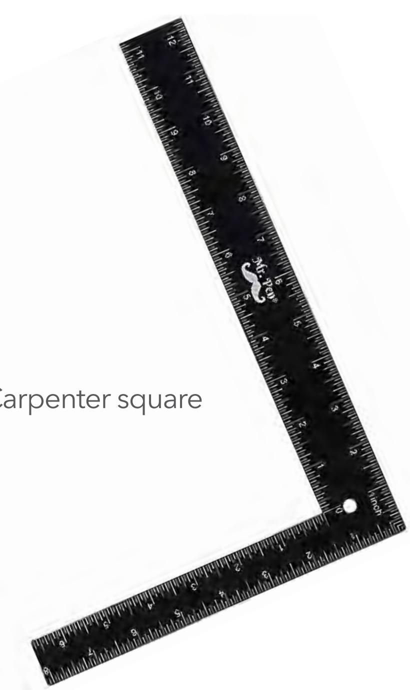

Figure 5. Carpenter square

To mark where the waterline is on the board, place the complete set up in the water to be measured. Mark the waterline on the board with a piece of tape, a marker, etc. Figure 6 shows a full ADCP set up in the water with the waterline marked by a piece of tape.

Figure 6. Waterline marking on HydroBoard II - Micro equipped with the SonTek-RS5 and SonTek RTK rover.

Take the board out of the water. Place the carpenter square against the long side of the board so that one arm is parallel to the vertical beam, and the other arm is perpendicular to the board. Figure 7 shows how to line up the carpenter square. Take care to line the square up properly, as some boards may have a slight curvature at the bottom that can skew the perception of what is parallel to the vertical beam. One helpful tip to aid alignment is to lean back and look at the alignment of the carpenter square as a whole. Or, have a second person verify that the carpenter square is lined up properly.

Read the vertical distance between the vertical beam transducer and where the perpendicular carpenter square arm hits the waterline marking. Enter this value as the transducer depth on the Smart Page in the ADCP software.

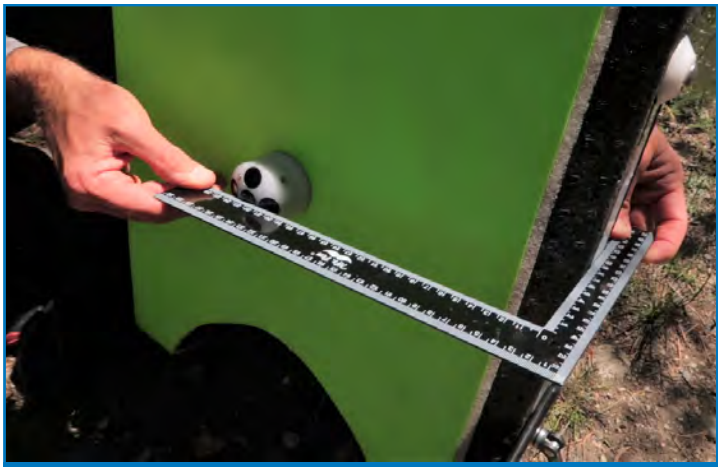

Figure 7. Lining up a carpenter square to the vertical beam.

Larger Boards

For larger boards such as the Hydroboard II-Max or the standard Torrent Board, a regular carpenter square is likely not long enough. If the right-angle method is preferred, the user can utilize a fiberglass folding ruler that has 90° positive stop joints. The stiffness of this ruler enables it to act like an elongated carpenter square while allowing the user to set 90° bend at a chosen point and the length. Additionally, this expandable ruler is useful for measuring edge distances for each transect. Figures 8 and 9 show a fiberglass folding ruler, compact and expanded.

Figure 8. Fiberglass folding ruler folded.

Figure 9. Fiberglass folding ruler expanded.

The folding ruler may not always be convenient, in particular with large remote-controlled surface vehicles. Another popular method involves reading the waterline in the ADCP hole of the surface vehicle or floating platform. Set up the ADCP board with all necessary accessories and lay the ADCP itself across the board. Figure 10 below shows a tethered boat set up on water, with the M9 ADCP laying on top.

The user should look in the mounting hole and mark the waterline for measurement. Figure 11 shows the waterline inside the mounting hole designed to house an M9. Measure the distance between the waterline and the bottom of the board, as shown in Figure 12.

Figure 10. ADCP setup with M9 on Torrent Board.

Figure 11. Waterline inside the ADCP hole.

Figure 12. Measuring distance between bottom of the board and waterline.

Set the ADCP in the hole to prepare for data collection. Lastly, measure how much the ADCP's vertical beam surface protrudes from the bottom of the board; this is shown in Figure 13. Add these two measurements together for the final transducer depth.

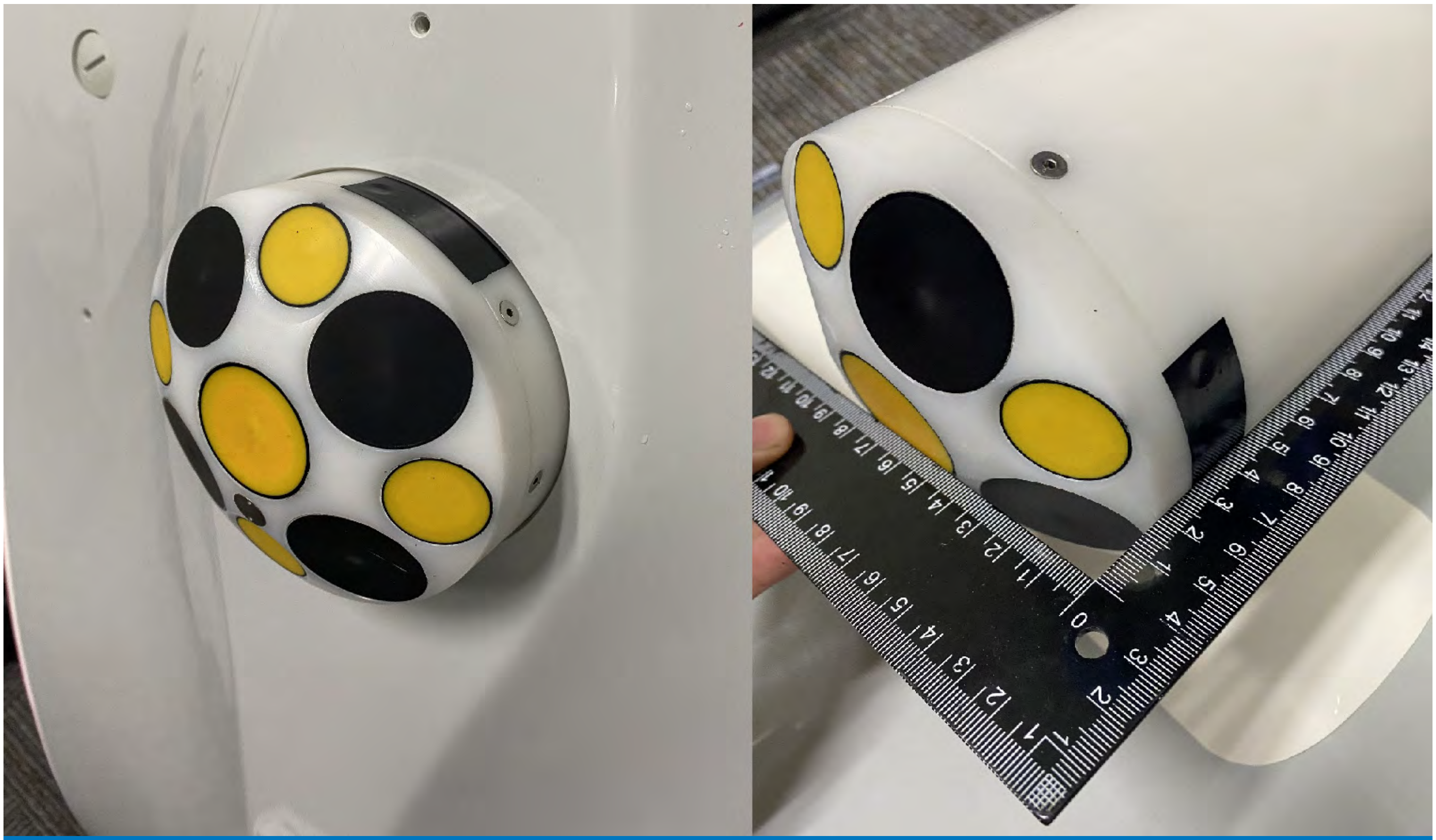

Figure 13. Measuring the distance between vertical beam face to bottom of board.

Crewed Boats

The above techniques work well for boards small enough to be picked up by one or two people. However, not every board or floating platform is easy to measure directly by manipulating the boat. Larger scale applications that use ADCPs on crewed boats may make physically measuring the transducer depth a bit more challenging. Depending on the setup, the user can consider using a combination of techniques utilizing a fiberglass folding ruler, adding separate boat and ADCP measurements, and other safe methods they may see fit.

One solution the user can implement is putting a graduated ruler sticker on the side of the ADCP. Locate where the "0" marking on the sticker ruler is and align this point with the top seam of the ADCP; the top seam is where the conical body of the instrument stops and the rounded transducer face begins. Figure 14 shows an M9 with a graduated sticker ruler. The user will also need to add the distance from the vertical beam to the beginning of the ruler. This measurement can be done with a carpenter square. Next, load the boat with all the necessary equipment and personnel. From there, someone can read where the waterline hits the ruler sticker. Be careful not to lean over the boat, as this can tilt the boat and cause the ADCP to submerge more.

Regardless of the method, the goal is to capture the transducer depth to the best of the user's ability. Remember that an error in transducer depth can propagate through the measurement calculations, and the difference can be drastic depending on site characteristics. Understanding how the transducer depth contributes to various aspects of a discharge measurement can help the user make more accurate measurements and ensure the best data quality.

Figure 14. SonTek-M9 with graduated sticker ruler.

SonTek, founded in 1992 and advancing environmental science in over 100 countries, manufactures affordable, reliable acoustic Doppler instrumentation for water velocity measurement in oceans, rivers, lakes, harbors, estuaries, and laboratories. Simply put, our instruments use sound waves to tell you how fast water is moving, where it is moving, and even if it is not moving at all. Our customers are scientists, engineers, hydrologists, research associates, water resource planners and anyone that needs to collect velocity (speed) data in every kind of body of water imaginable. SonTek is located in San Diego, California and is a brand of Xylem Inc.

SonTek, a Xylem brand
9940 Summers Ridge Rd.
San Diego, CA 92121

+1.858.546.8327
sontek@xylem.com
SonTek.com

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