9940 Summers Ridge Road • San Diego, CA 92121-3091 • Telephone +1-858-546-8327 • Fax +1-858-546-8150 • www.sontek.com

Table of Contents

9940 Summers Ridge Road • San Diego, CA 92121-3091 • Telephone +1-858-546-8327 • Fax +1-858-546-8150 • www.sontek.com

Arkansas Stream Gauging Program using a SonTek/YSI FlowTracker

"We are definitely more efficient using the FlowTracker. This is of increasing importance as our human resources are decreasing."

-- Troy "Bubba" Brossett (Manager - USGS Arkansas Water Science Center)

June 2005 – The diverse range of environments found in Arkansas — from mountainous streams (below) to delta rivers to flood and drought conditions — provides significant measurement and procedural challenges for field hydrologists. To improve their level of service to the public, the U.S. Geological Survey's (USGS) Arkansas Water Science Center began using the SonTek FlowTracker as part of their stream-gauging program in 2001. The Science Center has nine Hydrographers who routinely make field trips as part of the data collection operation.

Common stream-gauging conditions in Arkansas. The FlowTracker's integrated display and processor let you easily compute streamflow on the fly.

In the past, all measurements had been made using mechanical propeller meters, such as the Price AA and Pygmy meters. By 2005, all mechanical meters were replaced with SonTek FlowTrackers. All the Hydrographers now use the FlowTracker exclusively for measuring discharge in wadeable streams (above). Use of the FlowTracker has not only increased the operational efficiency of the Water Science Center, it has also enhanced their ability to make measurements in environments previously thought immeasurable.

The key reasons behind the switch to the FlowTracker were:

- **Improved operational efficiency** – With the elimination of note taking, calibration, and manual calculations, field personnel can now make more stream measurements in the same amount of time.
- **Elimination of maintenance** – As the FlowTracker has no moving parts, there is no need for any ongoing maintenance by the user.

- **Reduce training times –** New field personnel can be trained in how to use the FlowTracker in less than half the time it used to take for mechanical equipment.
- **Higher measurement accuracy –** The high precision of the FlowTracker results in better rating definition.
- **Increased range of measurement conditions (extreme events) –** The FlowTracker is able to accurately measure stream flows in the shallow and slow-moving drought environment.

For information about the USGS policy on FlowTracker discharge measurements, the following link will take you to a Technical Memorandum issued by the U.S. Geological Survey's Office of Surface Water. This memorandum [pdf format] describes the USGS policy on the use of the FlowTracker for discharge measurements. The information presented in this memorandum is a courtesy from the USGS, and should not be construed as an endorsement. Additionally, this memorandum is provided "as-is"; that is, the USGS does not provide support for this memorandum outside its own agency.

http://hydroacoustics.usgs.gov/memos/OSW2004-04.pdf

Note: Use of this instrument by USGS personnel does not imply endorsement by the USGS.

9940 Summers Ridge Road • San Diego, CA 92121-3091 • Telephone +1-858-546-8327 • Fax +1-858-546-8150 • www.sontek.com

Model Verification with a FlowTracker Handheld ADV

The Hydraulics Laboratory at Colorado State University, in Fort Collins, Colorado, includes extensive facilities capable of operating numerous physical models. The laboratory undertakes modeling projects looking at issues including erosion, sediment transport, and structure design.

In one project, a physical model was constructed to study a portion of the South Platte River in Denver, Colorado. The goal of the study was to examine the feasibility of a diversion structure that would minimize the upstream floodplain boundary while maintaining the required amount of diversion flow. Of importance in determining these objectives is the hydraulics of the flow upstream and through the diversion structure. To obtain the hydraulics, a variety of equipment was used including a SonTek FlowTracker Handheld Acoustic Doppler Velocimeter. The FlowTracker (above) was used to collect two-dimensional flow velocities within the areas of interest.

9940 Summers Ridge Road • San Diego, CA 92121-3091 • Telephone +1-858-546-8327 • Fax +1-858-546-8150 • www.sontek.com

Shallow-Water Flow Measurements around Hot Springs

August 2001 – Within Yellowstone National Park, there are several hot springs and small streams where water depths are on the order of a couple of inches or less. Traditional methods of measuring water velocity are neither practical nor effective under these conditions. With this in mind, the Yellowstone Center for Natural Resources (YCNR) required a current measurement instrument that is portable enough to fit in a backpack (many of the sites are only accessible by foot), is readable in bright daylight, has sufficient internal recording capability, and is able to withstand the high water temperatures sometimes present in the hot springs.

In August 2001, a demonstration of the SonTek FlowTracker was set up to evaluate the feasibility of using this instrument for this application. Observing the demonstration were representatives from the U.S. Geological Survey, the University of Montana, and the National Park Service. SonTek's Chris Ward made the trip to Yellowstone for the field demonstration.

One site chosen for the evaluation was Beryl Spring, which is 15 miles south of Mammoth Hot Springs in Yellowstone. Normally accessible by the public, Beryl Springs was off-limits because park officials considered it to be an explosion hazard. As such, personnel from the YCNR make frequent observations of environmental parameters around the hot spring to better understand this phenomenon. One of the important parameters is discharge from the hot spring itself.

A wading rod was not necessary to make the measurements because the water is so shallow. Great care had to be taken in where one stood and where the ADV probe was placed so that hot steam from the ground did not burn the observers' skin (bottom left).

The ADV probe was positioned in several different sections. Usually, only one velocity measurement was possible in a cross-section as the water was so shallow. The observers were intrigued by the FlowTracker's ability to output two-dimensional velocity, water temperature, and reflected echo intensity to the LCD screen (bottom right).

By all accounts, the demonstration was a success, and the YCNR was satisfied with the FlowTracker performance. An order was soon placed by the YCNR.

Left: FlowTracker being used in hot spring
Right: Integrated display/processor lets you compute streamflow on the fly

9940 Summers Ridge Road • San Diego, CA 92121-3091 • Telephone +1-858-546-8327 • Fax +1-858-546-8150 • www.sontek.com

Streamflow Measurements with FlowTracker and Wading Rod

January 2001 – SonTek's FlowTracker Hand-held ADV (Acoustic Doppler Velocimeter) was used by U.S. Geological Survey (USGS) Indiana District personnel to measure discharge in eight local streams. Tag lines were set up, and the FlowTracker was mounted on a top-setting wading rod (right). The FlowTracker's ADV probe was mounted to the wading rod using the probe's built-in attachment (below). The FlowTracker's hand-held keypad/LCD display was mounted on a bracket near the top of the wading rod (bottom right).

Eight discharge measurements were made in different streams with stream flows ranging from 1.3 cfs to 400 cfs, and velocities from less than 0.1 ft/s to nearly 3 ft/s. Measurements were compared to conventional AA and Pygmy-style instruments with good overall agreement.

FlowTracker mounted on a top-setting wading rod

The probe is shown mounted to the wading rod. The unique 2D/3D design allows for 2D velocity measurements in water as shallow as one l, or 3D measurements in 3D water.

The integrated display and processor let you easily compute streamflow on-the-fly.

9940 Summers Ridge Road • San Diego, CA 92121-3091 • Telephone +1-858-546-8327 • Fax +1-858-546-8150 • www.sontek.com

FlowTracker and Wading Rod

January 2001 – SonTek's FlowTracker Handheld ADV (Acoustic Doppler Velocimeter) was tested at the U.S. Geological Survey (USGS) tow tank at Stennis Space Center, Mississippi. SonTek ADVs have been well established for many years as the preferred sensor for high-resolution 3D velocity measurements. The FlowTracker (Figure 1) provides ADV performance from a simple keypad/LCD interface that allows rapid data collection in any environment (no PC required). The purpose of these tests was to evaluate the accuracy of velocity measured by the FlowTracker ADV against the speed of the tow cart.

Figure 1

Figure 2

The USGS tow tank (Figure 2) is 450 feet long, 12 feet wide, and 12 feet deep. For this test, cart speeds from 0.1 to 5.0 ft/s were used. The FlowTracker ADV was mounted from a pole in the center of the cart at a depth of 12 inches, and data were collected with the probe rotated at several different angles (to ±40°) into and away from the flow.

Figure 3 shows FlowTracker ADV current speed vs. cart speed for runs perpendicular and 10° off perpendicular to the flow. A regression of all runs in Figure 3 gives a slope of 0.99 and an offset of 0.009 ft/s. This is well within the accuracy specifications of the ADV (<1%) as well as expected uncertainties due to residual currents in the tank (±0.01 ft/s).

The FlowTracker ADV's time response was also tested. Since the ADV records velocity data once per second (and each 1-second sample is completely independent), it is interesting to look at this data to determine the time required for the ADV to make an accurate measurement of velocity. Figure 4 shows the ADV velocity data for one run, with results typical for data at all cart speeds. In this run, the ADV mean velocity was 2.203 ft/s (difference of 0.7% from cart speed); the standard deviation of 1-second velocity data was 0.018 ft/s (0.8% of cart speed).

This demonstrates that the FlowTracker ADV can offer excellent performance for observing real variations in water flow on a 1-second time scale (accuracy is 1% of measured velocity for each 1-second sample). For the mean water velocity at a given location, the averaging time required will be strictly a function of the real variations in the flow. Uncertainty in the ADV velocity will have no significant impact.

The results of this test show that the FlowTracker ADV can offer excellent performance in measuring water velocity at various speeds and also on small time scales. For a full copy of the report, please contact SonTek.

Note: The results shown here, while made using USGS facilities and with support from the USGS, are presented by SonTek and do not imply any endorsement of this product by the USGS.

For information about the USGS policy on FlowTracker discharge measurements, go to http://hydroacoustics.usgs.gov/memos/OSW2004-04.pdf. This link is to a Technical Memorandum issued by the USGS Office of Surface Water that describes their policy on the use of the FlowTracker for discharge measurements. The information in the memorandum is a courtesy from the USGS, and should not be construed as an endorsement. It is provided "as-is"; the USGS does not provide support for this memorandum outside its own agency.

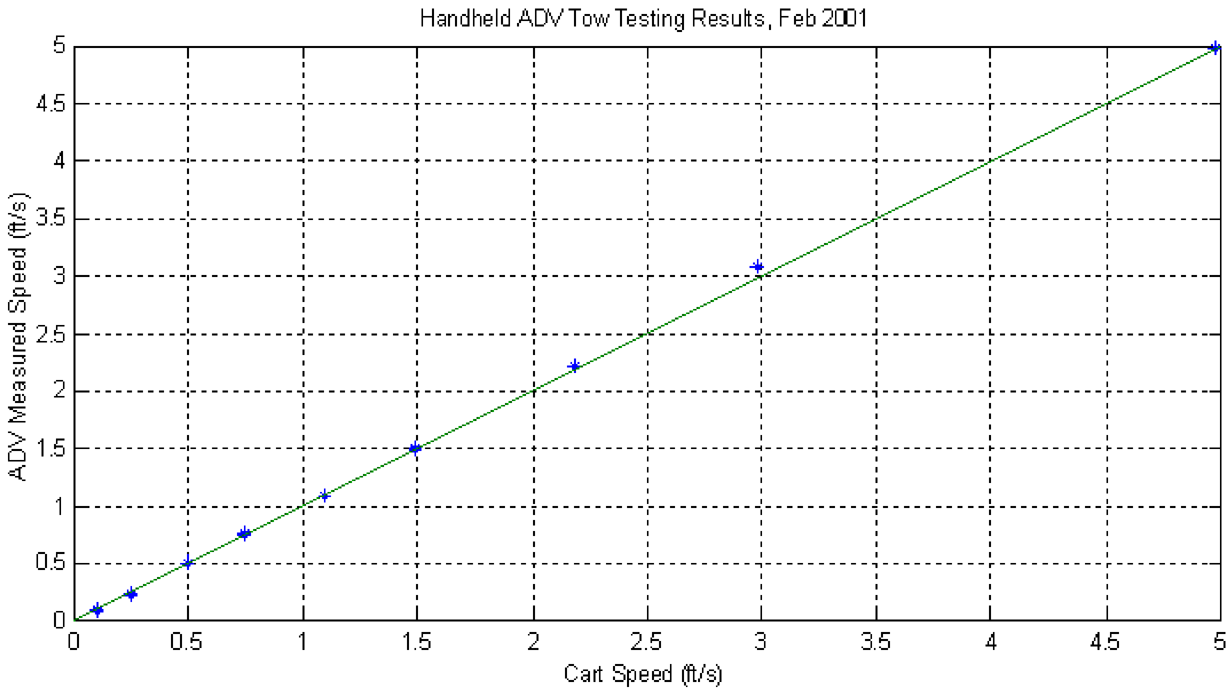

Figure 3

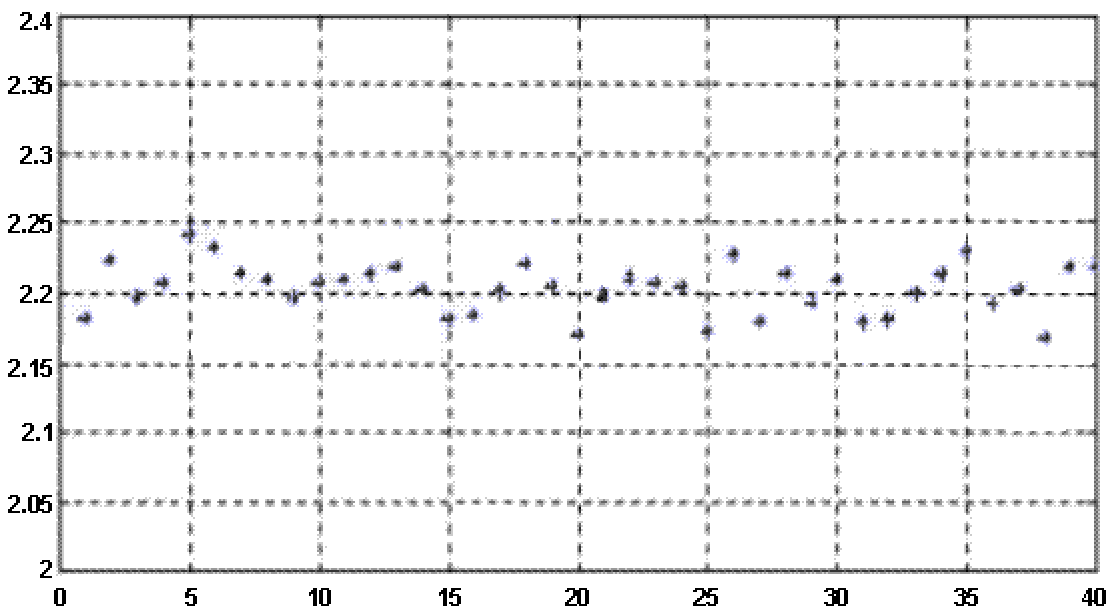

Figure 4

FlowTracker Used in Palenque Hydro-Archaeology Project

Chiapas, Mexico

Contributed by: Pennsylvania State University professor Dr. Christopher Duffy and PhD Candidate, Kirk French.

***Synopsis:** Ancient ruins serve as the backdrop for this study on how a "modern" Mayan culture may have altered the regions natural water cycle.*

Set in the foothills of the Tumbalá mountains of Chiapas Mexico, the ancient Maya site of Palenque is situated on a ledge overlooking the swampy plains that stretches northward all the way to the Gulf coast.

The Palenque Hydro-Archaeology Project (PHAP) is moving forward in its search for a better understanding of the site's hydrology. PhD Candidate, Kirk French, and his professor from Pennsylvania State University, Dr. Christopher Duffy, arrived at Palenque in early May, with goals to explore Palenque's watershed and scout locations for the installation of more stream sensors. Additionally, the team wished to test the viability of using SonTek/YSI FlowTracker Handheld ADV on Palenque's many waterways.

As a hydrologist in the Civil Engineering Department at Penn State, Duffy has ongoing projects in the southwestern U.S. and on the Susquehanna River in Pennsylvania. He is interested in testing his model for human impacts on hydrological processes at Palenque and believes the Maya of Palenque modified their landscape to such a degree that it possibly altered the areas hydrological cycle.

Although the site of Palenque originated at about 100 BC, it did not become a major population with importance in the Maya culture until 600 AD. Rulers during this period lead the construction of what is considered by historians the first sophisticated urban-water delivery system. Underneath the palace and through a long, corbel-vaulted tunnel, a stream ran through carrying a constant supply of running water. Flowing water through a monumental structure like that has been deemed a feat of engineering genius.

French and Duffy accomplished their goals and have since returned to Pennsylvania where they have analyzed the data gathered from the streams and weather station.

According to Duffy, the FlowTracker proved to be ideal for this study due to its portability, accuracy and efficiency in taking many measurements along stream profiles for assessing losing and gaining channel reaches. He says with this information the team is now able to construct a water and energy budget for the site and a weather station has been installed and now they are able to locate the stream gauge.

For more information on this application note, or the FlowTracker, email SonTek® at inquiry@sontek.com.

SonTek/YSI
9940 Summers Ridge Road
San Diego, CA 92121
Tel: +1 858 546 8327
Fax: +1 858 546 8150
Email: inquiry@sontek.com
Web: www.ysi.com