In Reply Refer To: June 27, 2005
Mail Stop 415

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM 2005.05

Subject: Guidance on the use of RD Instruments StreamPro Acoustic Doppler Profiler

RD Instruments (RDI) introduced a new acoustic Doppler current profiler (ADCP) known as the StreamPro for shallow water discharge measurements in the summer of 2003. The StreamPro is designed to make a "moving boat" discharge measurement in streams with depths between 0.5 and 6.6 feet. The profiler is deployed from a specially designed tethered boat (figure 1). Bluetooth radio telemetry is used for communication between the StreamPro and a hand-held computer with the Pocket PC operating system. Software on the hand-held computer saves the data transmitted by the StreamPro and computes the discharge.

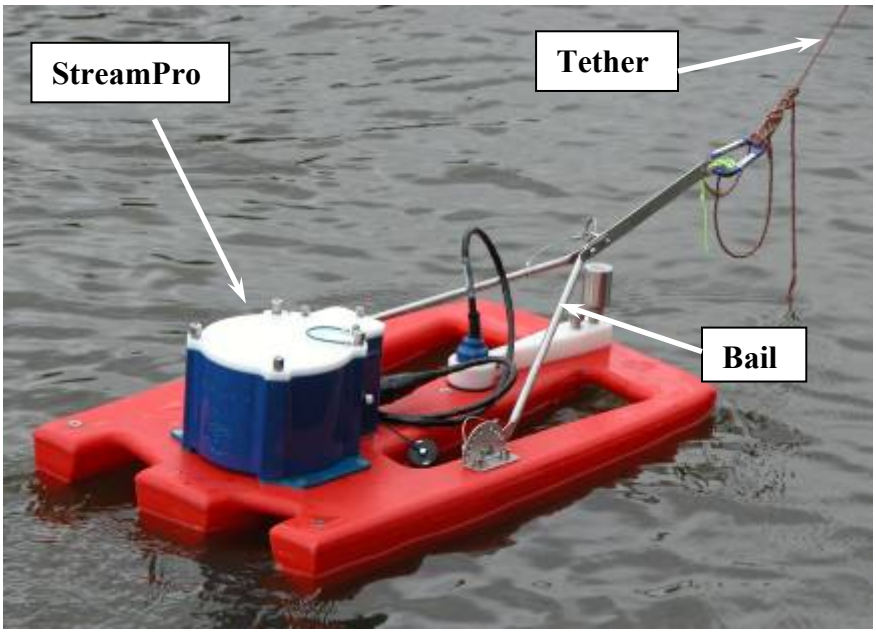

Figure 1.--StreamPro acoustic Doppler current profiler.

In July 2004, Office of Surface Water (OSW) staff and other USGS employees began testing the StreamPro. A plan for testing the StreamPro was prepared and used for the field tests (http://hydroacoustics.usgs.gov/policy/StreamProTestPlan.pdf). Evaluation sites were chosen to test the StreamPro in a range of stream conditions. Concurrent measurements of discharge were made with the StreamPro, mechanical current meters (AA and pygmy), and other acoustical meters. In some cases, comparison discharges were obtained from established USGS

streamflow-gaging stations with stable rating curves. Following USGS policy for other ADCPs in OSW Technical Memorandum 2002.02, the mean of four or more transects were used to obtain the measured StreamPro discharge.

Analysis of the test measurements made to date (May 2005) indicate that discharges measured using the StreamPro compare favorably to the discharges measured with the other meters when the mean channel velocity is greater than 0.8 ft/s. Of the 13 measurements where the mean channel velocity was greater than 0.8 ft/s, 10 of the StreamPro-measured discharges were within 5 percent of the comparison discharge and all 13 were within 7 percent of the comparison discharge (figure 2).

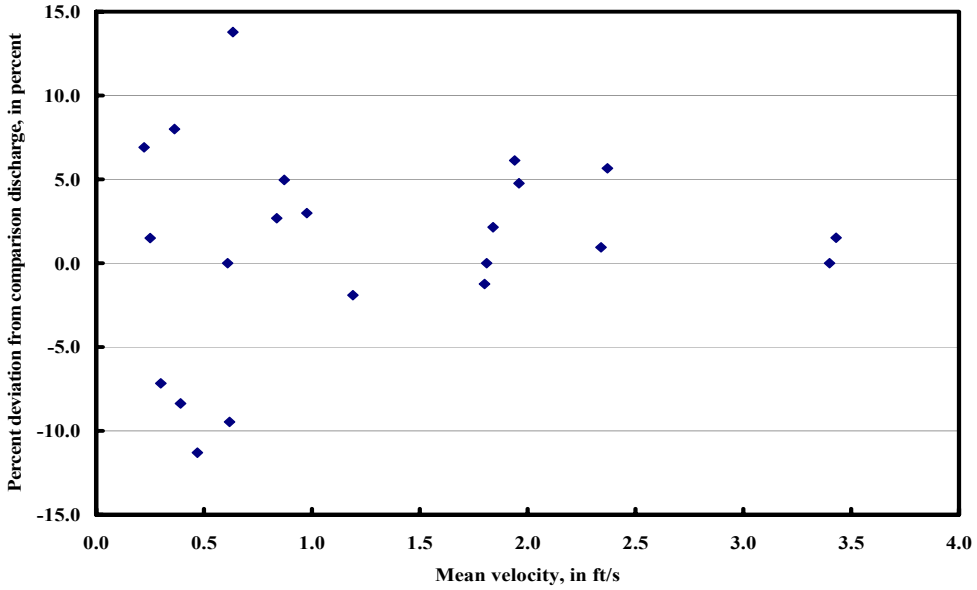

Figure 2.—Mean channel velocity and deviation of StreamPro discharges from comparison discharges, in percent.

When the mean channel velocity is less than 0.8 ft/s, the StreamPro discharge measurements for individual transects have much greater variability than those StreamPro measurements where the mean channel velocity is greater than 0.8 ft/s. Measurements with mean velocities less than 0.8 ft/s had an average coefficient of variation for individual transect discharges of 12 percent, whereas measurements with mean velocities greater than 0.8 ft/s had an average coefficient of variation of 2.5 percent (figure 3). Despite this larger variation, there is no indication that the measured discharges (the mean discharge for all the transects) are biased, provided that enough transects are included in the mean discharge. The results of testing showed that the variation can be so great that even if eight or more transects are collected as specified in OSW Technical Memorandum 2002.02, the measurement quality may be affected. This result means that using the StreamPro to make discharge measurements under these low velocity flow conditions may not be practical because of the time required to obtain additional transects. More testing is needed to determine how many transects are needed in low-velocity conditions to make an accurate discharge measurement and whether an accurate measurement under these conditions is even possible.

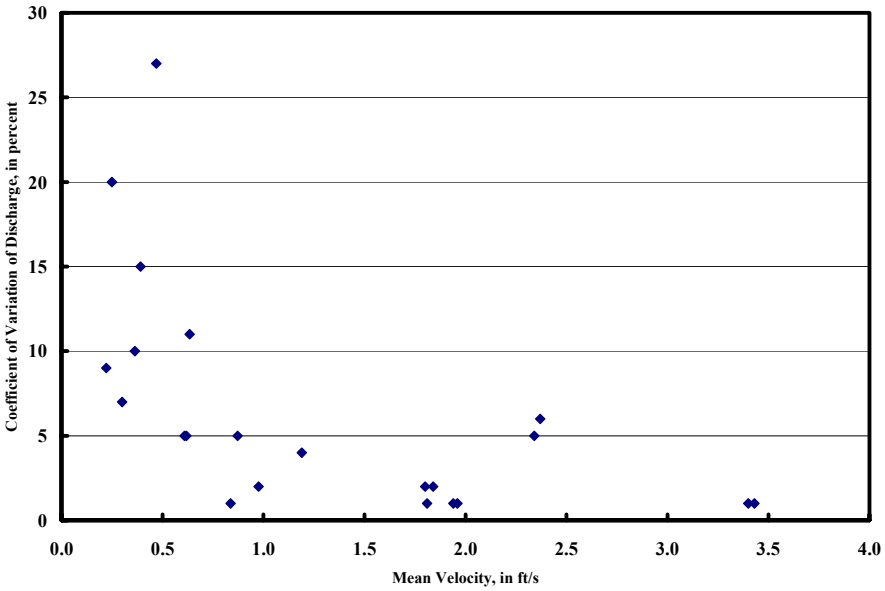

Figure 3.--Mean channel velocity and coefficient of variation for StreamPro discharge measurements.

RD Instruments is exploring the possibility of using a different water-measurement mode in the StreamPro for low-velocity measurements. If and when this water-measurement mode becomes available, it will be included in the OSW testing program.

A number of StreamPro users have experienced problems with the StreamPro in velocities greater than 4 ft/s, especially when surface waves are present. At these high velocities, a wave may catch the bow of the boat and cause the StreamPro to be pulled under by the current. The manufacturer has redesigned the boat to help minimize this problem. However, it is important that users set the bail properly (see figure 1). When the bail is improperly set at a large angle relative to the water surface (greater than 45 degrees), the nose of the StreamPro may be pushed down into the flow. We have little information to-date regarding the accuracy of discharge measurements made where the mean velocity is greater than 3.5 ft/s. However, there is no reason to believe that the StreamPro will not accurately measure velocities greater than 3.5 ft/s and less than it's maximum measurable velocity, 6.6 ft/s. Users should be aware that the possibility of a moving bed condition affecting the measurement will be greater at these higher velocities.

Based on our current knowledge, the OSW recommends the following practices regarding the use of StreamPros.

1. Standard ADCP data collection techniques as outlined in OSW Technical Memorandum 2002.02 should be followed. This includes such things as always performing a moving bed test, minimizing erratic boat motion during transects, accurately measuring edge distances, and keeping boat speed less than or equal to water speed.
2. When the mean channel velocity is less than 0.8 ft/s, the StreamPro may be used to make discharge measurements; however, the following guidance should be observed.

- Eight transects or more may be necessary because of the high coefficient of variation between transect discharges. Generally, as the mean channel velocity approaches zero, more transects will be needed to obtain an accurate measured mean discharge.
- If the coefficient of variation for individual transect discharges is greater than 10 percent, OSW recommends that the discharge measurement quality be considered poor. This recommendation is based on currently available test data and may be revised when more test data are available.
- If the difference between the discharge measured with the StreamPro and the rating discharge is excessive (much greater than five percent), OSW recommends that a comparison discharge measurement be made using a different instrument (for example, a mechanical current meter or Flowtracker).

3. Whenever feasible, OSW recommends that a temporary bank operated cableway or rope-and-pulley system be used to move the StreamPro back and forth across the stream during discharge measurements. Bank operated cableways or rope-and-pulley systems allow for more uniform boat motion and help reduce variability in measured discharges.
4. Although a discharge is reported on the hand-held computer as the measurements are made, OSW recommends that the discharge measurement be loaded into WinRiver software in order to review each StreamPro discharge measurement for quality-assurance purposes. This process should include such things as the review of the edge distances, types, and discharges; velocity-profile extrapolations used to compute discharge in the unmeasured top and bottom zones of the transect; and boat speed versus water speed.
5. The OSW recommends that the elapsed time for a single transect be three minutes or more, whenever possible.
6. The OSW also suggests that StreamPro users make periodic comparison measurements with mechanical current meters (AA and pygmy) or FlowTrackers over the range of flow conditions the StreamPro measurements are made. This action will provide quality-assurance and quality-control data, and aid OSW's efforts to collect comparison measurements over a wide range of conditions.

The OSW requests that StreamPro users share results of their experiences in using the StreamPro. Please send information to the USGS Hydroacoustics Work Group (hawg@simon.er.usgs.gov) or to Mike Rehmel, USGS Indiana Water Science Center, (msrehmel@usgs.gov), 317-290-3333 ext. 158. OSW is interested in receiving information regarding measurement comparisons, problems identified with the instrument or software, possible hardware or software enhancements, and other issues important to users. Tests of these instruments are continuing and test results will be communicated in future memorandums, on the OSW Hydroacoustics Web pages (http://hydroacoustics.usgs.gov/), and through the Acoustics mailing list.

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