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Hydroacoustic Applications in South Carolina: Technological Advancements in the Streamgaging Network

Acoustic Doppler Current Profiler

Until the 1990s, the U.S. Geological Survey (USGS) had been making streamflow measurements using the same type of equipment for more than 100 years. The Price AA current meter (fig. 1) was developed by USGS engineers in 1896.

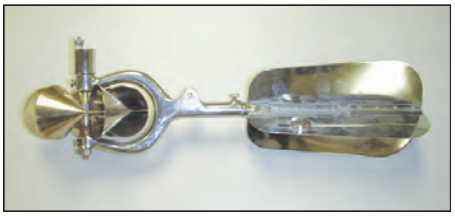

Figure 1. Price AA current meter used by USGS to measure streamflow. Photograph by J.M. Shelton, USGS.

Until recently, the majority of all streamflow measurements made by the USGS were made using this instrument (fig. 2). In the mid-1990s, a new technology emerged in the field of inland streamflow monitoring. The acoustic Doppler current profiler (ADCP), originally developed for oceanographic work, was adapted for inland streamflow measurements (fig. 3). This instrument is transforming the USGS streamgaging program.

Figure 2. USGS hydrographer making a streamflow measurement. Photograph by J.M. Hall, USGS.

The ADCP transmits an acoustic pulse through the water column. A “Doppler shift” is measured as the signal is reflected off of particles in the water, such as sediment and microorganisms. Based on the assumption that the particles in the water are traveling at the same velocity as the water itself, a water velocity is computed.

Figure 3. Acoustic Doppler current profiler (ADCP), mounted on side of inflatable raft, is connected to an onboard computer to measure streamflow. Photograph by J.M. Hall, USGS.

The ADCP calculates its location relative to a starting point using “bottom-tracking” technology. The bottom-tracking measurement is made when the ADCP transmits an acoustic pulse through the water column to “locate” the streambed and measure water depth. Based on the assumption that the streambed is stationary and using an internal compass and pitch and roll sensors, the ADCP computes the speed and direction of the boat movement. During periods of high flow, the rocks and sediment along the streambed may be transported by the higher velocities. During these “moving-bed” conditions, a global positioning system (GPS) can be integrated with the system for a geo-referenced location to correct for an erroneous bottom-tracking computation. With measured velocity, depth, and speed, the software computes a total discharge for a cross section in real time (fig. 4).

The ADCP has enabled USGS hydrographers to make faster, more accurate streamflow measurements in a wider range of conditions than previously possible. The USGS South Carolina Water Science Center incorporates the use of ADCPs in its streamgaging program from mountain rivers in the upstate Blue Ridge to tidal canals in the Atlantic Coastal Plain.

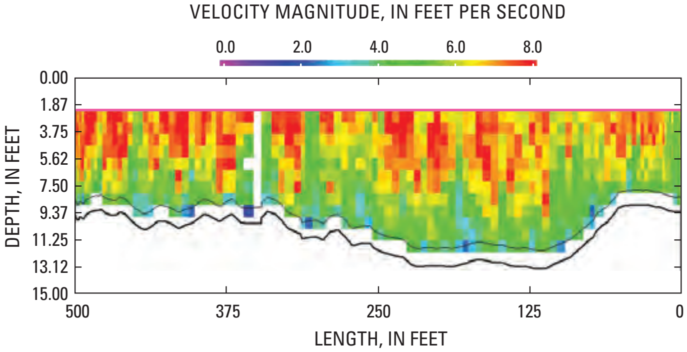

Figure 4. Acoustic Doppler current profiler software displays streamflow in real time.

In situ Index Velocity Measurements

Acoustic Doppler technology also has been developed for in situ deployments (fig. 5). Many streams do not have a direct streamflow-to-gage height (water-surface elevation referenced to a datum) relation (fig. 6). These sites include streams influenced by control structures, aquatic plant growth, general backwater effects, and tidal effects. Historically, computation of streamflow at these sites has been difficult. Deploying in situ acoustic Doppler instruments allows the USGS to "index" the mean channel velocity. At these "index-velocity" sites, a mean channel velocity is computed by dividing the measured streamflow by the cross-sectional area (from a standardized area rating). The computed mean velocity then is compared to the velocity reported by the in situ velocity meter. Multiple measurements can be used to produce an index-velocity rating (fig. 7).

The USGS South Carolina Water Science Center uses index-velocity methods at multiple sites. In the upstate Piedmont region, backwater effects from lakes necessitate the use of index-velocity methods to compute streamflow in the Pacolet River. In most of the Coastal Plain, in situ velocity meters are required to compute streamflow in the tidally affected areas.

The use of hydroacoustic instrumentation for real-time streamflow measurements, in addition to fixed installations for the computation of long-term record, has enabled the USGS South Carolina Water Science Center to collect quality hydrologic data for diverse hydrologic settings.

Acoustic Doppler current profilers have enabled hydrographers to measure streamflow in extreme conditions. Broad River below Ninetynine Island Reservoir, South Carolina. Photograph by J.M. Shelton, USGS.

Figure 5. In situ acoustic Doppler equipment mounted to USGS streamgaging station. Photograph by J.M. Shelton.

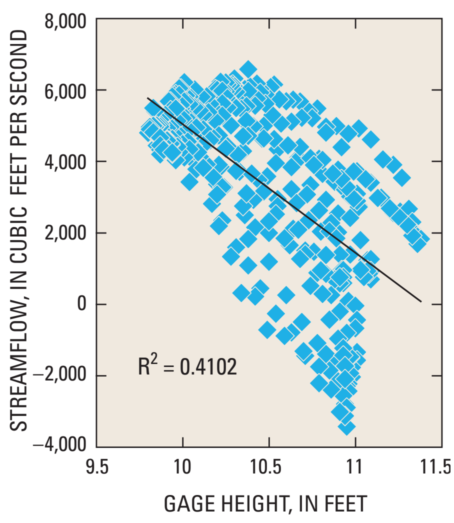

Figure 6. Example of the stage-to-streamflow relation at a tidally influenced creek.

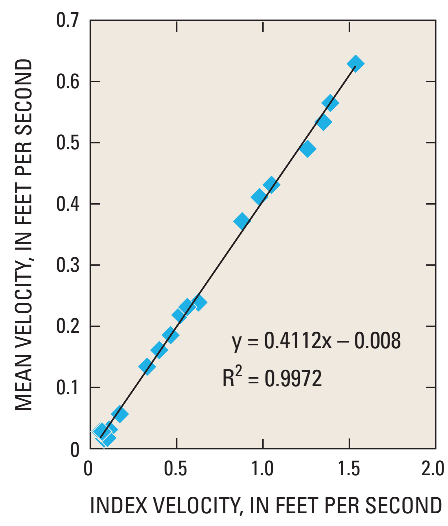

Figure 7. Example of index-velocity rating at a tidally influenced creek.

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