RD Instruments
Acoustic Doppler Solutions

StreamPro & ChannelMaster Application Note:

Index-Velocity Rating Development for Rapidly Changing Flows in an Irrigation Canal Using Broadband StreamPro ADCP and ChannelMaster Horizontal ADCP

SUMMARY: *Field data collection and regression analysis were conducted to develop Index-velocity rating for rapidly changing flows in an irrigation canal at Imperial Irrigation District, California. Discharges were measured using a RD Instruments broadband StreamPro ADCP on December 9, 2003. Index-velocities were measured concurrently with the discharge measurements using a RD Instruments 600 kHz broadband ChannelMaster Horizontal ADCP. Because of using broadband technology, the StreamPro and ChannelMaster were able to measure discharge and index-velocity accurately at short time span or intervals to accommodate rapidly changing flows. A total of 31 pairs of mean velocity and Index-velocity data were obtained for velocities ranging from 0.02 m/s to 0.42 m/s. The data were best fit with a linear regression equation with a correlation coefficient of 0.998. The developed Index-velocity rating can be used to accurately monitoring discharge in real-time at this site.*

Field Data Collection

Field data collections were conducted on December 9, 2003 in the Westside Main Canal near the Trifolium 13 Check site (Figure 1). The trapezoidal concrete lined canal had a bottom width of 3.05 meters (10 feet) and a slope of 1:1.5. The mean water depth over the canal bottom was around 1.4 meters (4.5 feet) during the test day. The canal serves as a flow diversion structure for the Westside Main Canal system. Therefore, its flow changed dramatically during a day from near zero to over 3 m^3/s (106 cfs).

The StreamPro ADCP was attached to a pulley system set-up at 57 meters (187 feet) upstream the check structure (Figure 1). A temporary mounting, modified from a steel shelf, was used to mount the 600 kHz ChannelMaster H-ADCP. The mounting location was at 7.6 meters (25 feet) upstream the StreamPro ADCP pulley (Figure 1), on the right bank of the canal.

StreamPro ADCP transects were made from 12:30 to 16:30. A total of 31 transect data files were obtained. Discharges were calculated in real-time by the StreamPro software and played back using WinRiver software.

In order to measure the rapidly changing flows at this site, the ChannelMaster was configured at an averaging interval of 37.4 seconds. The sampling interval was set to be the same as the averaging interval. Cell size was set at 0.5 meters and a total of 20 cells were used. The ChannelMaster continuously collected data from 12:34PM to 16:18PM. A total of 361 data points for velocity profile, water level, pitch and roll, acoustic intensity, etc. were obtained.

Organizing Data for Regression Analysis

The data from the StreamPro ADCP and ChannelMaster H-ADCP were organized to obtain data sets for Index-velocity, stage, canal cross-section area, and canal mean velocity.

Index-Velocity: In order to match the average transect time span (about 3 minutes) of the StreamPro ADCP discharge measurements, the time averaging interval for Index-velocity was chosen to be 187 seconds.

Note that the original sampling/averaging interval was 37.4 seconds. Therefore, the velocities for five ensembles collected within 187 seconds were averaged. In addition, velocities of the first 4 horizontal cells were averaged. Thus, the Index-velocity range averaging length was 2 meters and the sampling volume was located at the middle portion of the canal.

Stage: The transducer surface was assumed to be the stage reference level (datum). Therefore, the water level measured by the H-ADCP was taken as stage.

Cross-section area: The cross-section area at time *t* was calculated as a function of water level (or stage).

Canal Mean Velocity: The canal mean velocity was calculated by dividing the StreamPro ADCP measured discharge by the cross-section area.

Regression Analysis Results

A total of 31 data pairs for measured mean velocity vs. Index-velocity are obtained and plotted in Figure 2. It can be seen from the plot that the data can be well fitted by a straight line passing through the zero velocity point, indicating a linear relationship between the mean velocity and Index-velocity. Using the Excel built-in regression analysis tool, we obtain the regression coefficient and correlation coefficient. The following is the resulting regression equation:

$$V_{mean} = 0.8606 \times V_I \qquad (1)$$

with a correlation coefficient of 0.998.

Note that the regression does not include stage as a parameter. This was because the stage variation at this site was insignificant as compared to the mean water depth.

Implementing the Index-Velocity Rating

With the developed Index-velocity rating, the discharge in the Westside Main Canal near the Trifolium 13 Check site can be calculated from:

$$Q = 0.8606 \times V_I \times A \qquad (2)$$

where Q is the rated discharge, and A is the canal cross-section area .

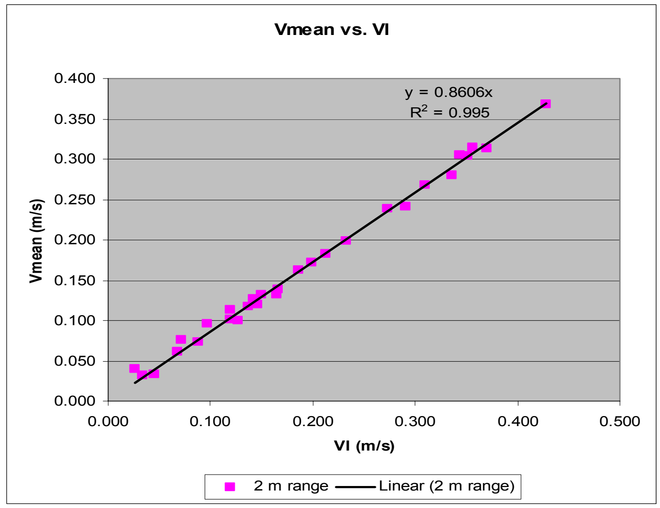

Figure 2 Measured mean velocity vs. Index-velocity: all data

Figure 3 shows the rated discharge time series by applying the rating equation (Equation 2) to all of the ChannelMaster data collected on December 9, 2003. The StreamPro ADCP measured discharges are also shown in Figure 3. It can be seen that the rated discharges agree very well with the measured discharges.

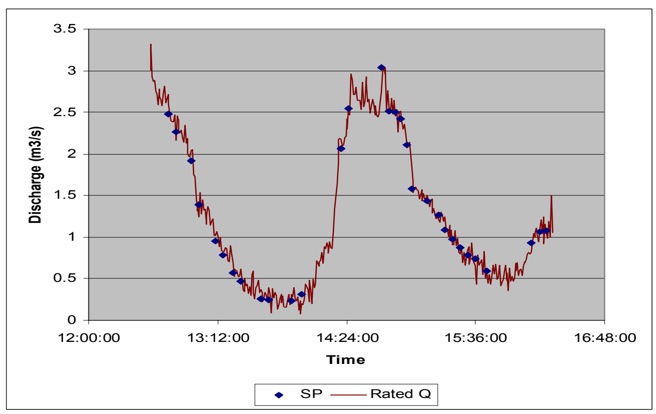

Figure 3 Time series of rated discharges and StreamPro measured discharges on December 9, 2003.