Flow Report No. F 21-004

Date:	March 4, 2021
To:	Anna Sutton – USBR Water Conservation
From:	Jack Evans and Stuart Styles, ITRC
Subject:	**Banta Carbona Irrigation District**
	Field Evaluation of Non-Contact Flow Measurement Device

Summary

The Irrigation Training and Research Center (ITRC) is currently testing several non-contact volumetric flow meter models under their technical services contracts with the California Department of Water Resources (DWR) and the United States Bureau of Reclamation (USBR). In April 2020, a Sommer RQ-30A non-contact flow meter was installed at Banta Carbona Irrigation Districts (BCID) Main Canal approximately 180 ft downstream of the discharge from Pumping Plant 1. The meter was mounted at midspan along a footbridge that crosses the throat of an ITRC designed subcritical contraction structure (see Figure 1). An existing SonTek Acoustic Doppler Flow Meter (ADFM) was installed on the invert of the structure and positioned directly beneath the non-contact meter installation. After the initial installation, current metering was performed to gauge the "out-of-the-box" accuracy of the RQ-30A sensor. Over the course of the study, ITRC periodically performed current metering using a SonTek RiverSurveyor M9 to evaluate the accuracy of SonTek ADFM. The SonTek ADFM was used as the standard device for comparing the non-contact meter measurements.

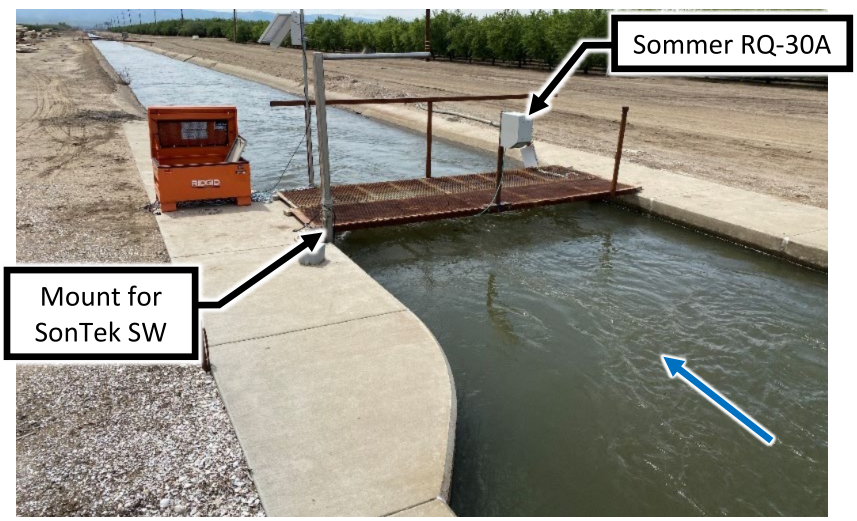

Figure 1. BCID Main Canal subcritical contraction structure with Sommer RQ-30A and SonTek SW

In July 2020, the RQ-30A sensor was integrated into the district SCADA system to allow remote data monitoring at the site. The Sommer RQ-30A and SonTek ADFM data was collected over one irrigation season to assess the accuracy of the non-contact meter and the potential for implementing this model in open-channel flow measurement applications. The ranges of overlapping data available for the non-contact flow meter and the standard SonTek ADFM is listed in Table 1. Within these date ranges, there were periodic gaps in the data where the sensor(s) did not log measurements; these gaps were excluded from the analysis.

Table 1. Date ranges over which the data from the Sommer RQ-30A non-contact flow meter was analyzed

Device	Start Date	End Date
Sommer RQ-30A	10-Jul-2020	3-Mar-2021

For both the SonTek ADFM and RQ-30A data sets, all measurements recorded when the SonTek ADFM reported less than 20 CFS were filtered out to ensure the RQ-30A measurements were only compared against reliable flow data from the standard device. Table 2 lists the average percent error, standard deviation of percent error, and average absolute percent error of the Sommer RQ-30A non-contact meter in comparison to the SonTek ADFM.

Table 2. Statistical metrics of RQ-30A non-contact meter performance in comparison to the standard device

Device	Average Error (%)	Standard Deviation (%)	Average Absolute Error (%)
Sommer RQ-30A	-1.5	6.8	5.3

Non-Contact Flow Meters

Non-contact flow meters are often used to measure flows in municipal pipelines with well-defined cross-sections, however, the potential for using these devices in open channel flow measurement applications has not been extensively researched. One of the advantages of using non-invasive flow measurement devices is the ability to access and perform maintenance on the sensors year-round. Periodically retrieving and cleaning submersible sensors can be time consuming and costly for irrigation districts.

ITRC acquired a Sommer RQ-30A non-contact flow meter to evaluate the accuracy of the meter in comparison to an existing SonTek ADFM installed at BCID. The Sommer RQ-30 is a non-contact flow measurement device that uses radar to obtain surface water velocity and water level measurements. These two measurements, combined with channel geometry, are used to calculate the flow rate in a defined channel. The device is available with either digital (RQ-30) or analog (RQ-30A) outputs and can be connected to SCADA systems for remote monitoring. The manufacturer specifications for the non-contact meter tested are listed in Table 3.

Table 3. Manufacturer specifications for the non-contact meter installed at BCID

Manufacturer	Sommer
Model	RQ-30A
Power Supply	6 to 30V DC
Velocity method	Doppler radar
Velocity measurement location	Water surface
Maximum water velocity	±49 ft/s
Minimum water velocity	±0.3 ft/s
Water level method	Radar
Water level range	0-50 ft
Flow measurement accuracy	±5%
SCADA integration (Y/N)	Yes

Site Overview

The non-contact meter was installed at the BCID Main Canal, approximately 180 ft downstream from the discharge of Pumping Plant 1. The sensor was mounted midway across a suspended walkway that crosses the throat of an ITRC designed subcritical contraction structure. Subcritical contraction structures are specifically designed to improve the accuracy of ADFM sensors by creating a uniform velocity profile at the throat of the contraction. The SonTek ADFM was mounted to the bottom of an L-shaped stainless-steel pole and positioned on the invert of the structure, directly beneath the non-contact meter. There was a straight reach of canal both upstream and downstream of the sensor's location. An aerial map view of the BCID Main Canal non-contact meter installation location is shown in Figure 2. The configuration of the sensors on the subcritical contraction structure is shown in Figure 3.

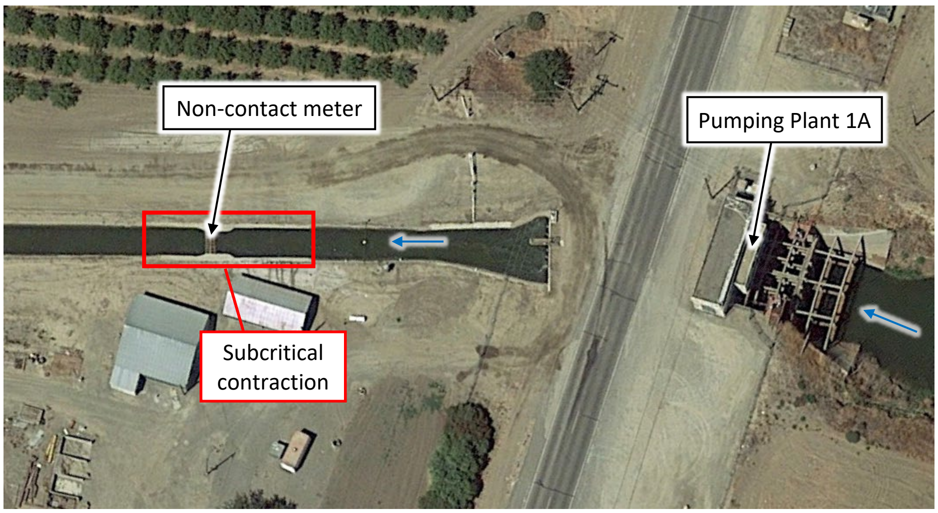

Figure 2. Aerial map view of BCID Main Canal and non-contact meter installation

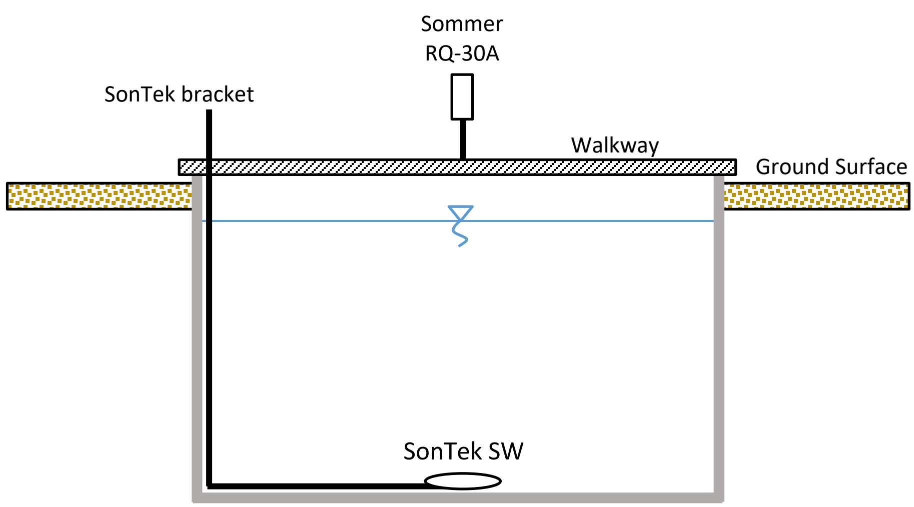

Figure 3. Cross-section view of the subcritical contraction structure showing the positions of the measurement devices, looking downstream

Standard Device and Quality Control

In the first six months of the study, ITRC performed three stationary discharge measurements at the site using a SonTek M9 acoustic Doppler profiler. These measurements were used to evaluate the accuracy of the existing SonTek Argonaut SW ADFM and gauge its suitability for use as a standard device for comparing the RQ-30A measurements. Figure 4 shows the regression analysis performed to compare the SonTek M9 and SonTek ADFM measurements. Both the slope of the regression trendline and the R^2 value are very close to 1.0, indicating a strong correlation between the SonTek M9 and SonTek ADFM measurements.

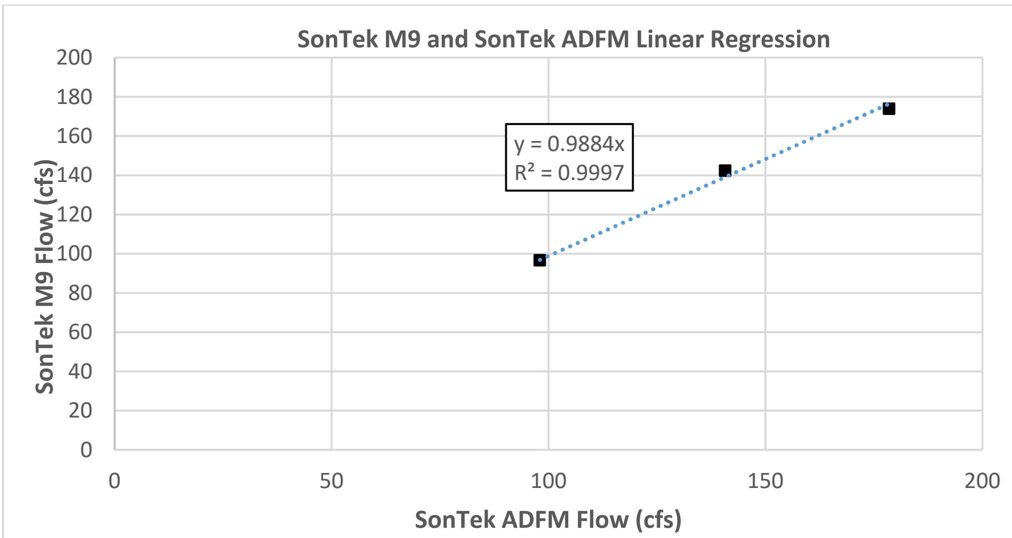

Figure 4. Chart showing SonTek M9 and SonTek ADFM data with regression equation and trendline

Minimal data filtering was performed on the raw SonTek and RQ-30A data sets. All data from the test and standard devices was omitted during periods when the standard device reported flow rates less than 20 CFS. There is minimal water level fluctuation at this site, and flow rates less than 20 CFS correspond with water velocities that do not meet the minimum manufacturer specifications for the RQ-30A meter. This filter omitted approximately 29% of the cumulative data for each sensor.

Results

The results of the study show that, on average, the Sommer RQ-30A non-contact flow meter was measuring the flow with excellent accuracy. With minimal raw data filtering, the average percent error was within ±2% and the average absolute error was approximately 5%. The standard deviation of the percent error was 6.8%, indicating that there was minimal variability in the percent error of the RQ-30A measurements. Table 4 summarizes the results of the study.

Table 4. Summary of results from non-contact meter testing at BCID

Device	Average Error (%)	Standard Deviation (%)	Average Absolute Error (%)
Sommer RQ-30A	-1.5	6.8	5.3

Figure 6 shows the time series of the SonTek ADFM and RQ-30A flow data, and the SonTek M9 discharge measurements over course of the study.

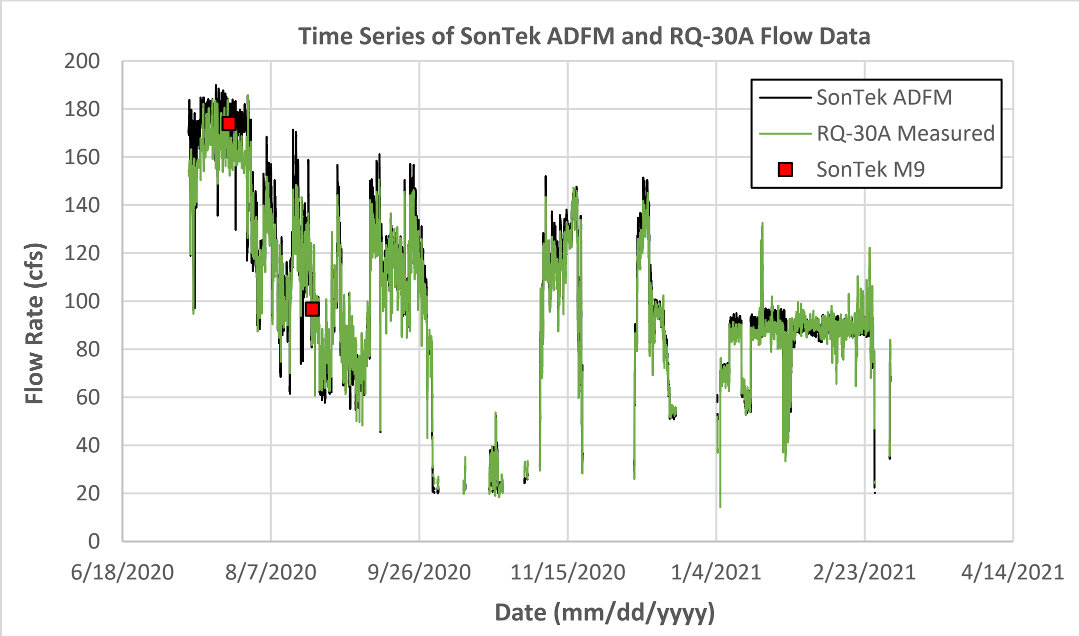

Figure 5. Cumulative data collected at BCID on approximately 15-minute intervals and current metering data (the gaps indicate periods when the flow was below 20 CFS or the sensor(s) did not report flow data).

The histogram in Figure 6 was developed to better illustrate the frequency and magnitude of difference between the SonTek SW and the unadjusted Sommer RQ-30A data over the entire time series. Over 90% of the RQ-30A measurements were within 10% of the SonTek ADFM.

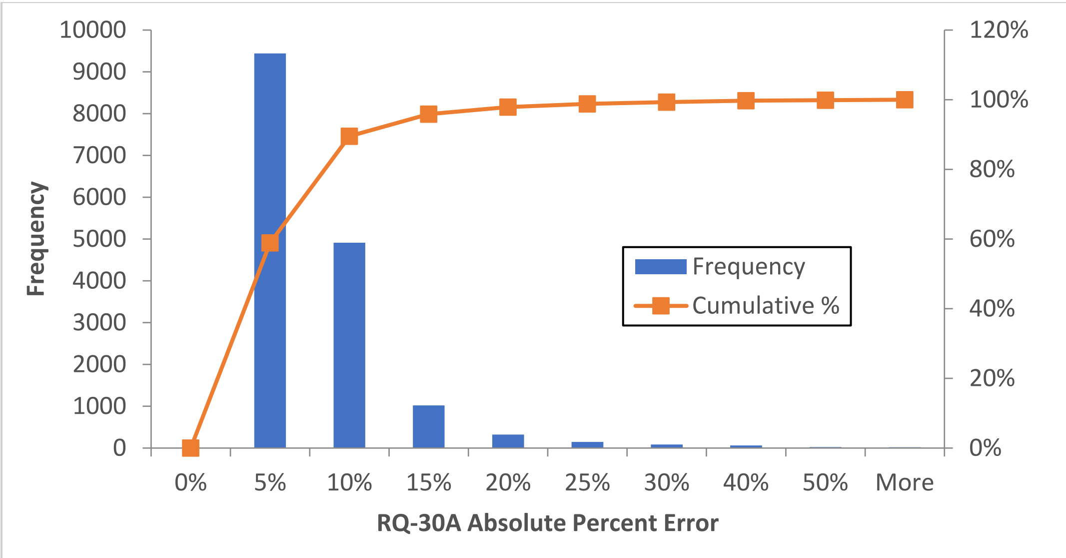

Figure 6. Histogram chart comparing the absolute percent error of the Sommer RQ-30A to the SonTek ADFM

Discussion

The results of this study indicate that Sommer RQ-30A non-contact meters are capable of providing excellent flow measurement accuracy. ITRC is currently studying four other non-contact meter installations with meters from different manufacturers and has not observed this level of accuracy at any of those installations. Looking beyond the possibility that the RQ-30A sensor is simply "better", there are several considerations specific to the BCID installation that may have contributed to the performance of this sensor.

The lift station just upstream of the non-contact meter installation is operated under manual flow control, with only negligible fluctuations in discharge throughout the day due to limited tidal influences affecting the pump TDH and discharge flow rate. The 15-minute averaging period the RQ-30A is configured with may be beneficial with such stable flows, however, this averaging may not be beneficial at sites with larger daily flow fluctuations. Additionally, installing the RQ-30A sensor in the throat of the subcritical contraction structure may have improved both the water surface level and velocity measurements. Subcritical contractions create a more uniformity velocity profile through the structure and are designed specifically for improving the accuracy of ADFM's. Although non-contact meters measure velocity at or just below the water surface, the uniform velocities through the contraction structure may have improved the overall accuracy as well. Lastly, contractions structures tend to create small ripples on the water surface as the velocity profile changes through the structure. Non-contact meters have minimum wave (ripple) height requirements to accurately measure the water surface level and compute the flow area.