Introduction

There is a growing recognition by irrigation districts and farmers of the need for very accurate and low-cost flow measurement technologies. The goal of this project was to contribute to the development of practical means of measuring the volumes of irrigation water delivered, spilled, reused, etc.

This research addressed the conditions for which commercially viable solutions does not presently exist. Specifically, the need exists for an affordable, practical, and permanent solution for measuring flows at the individual farm turnout level. Magnetic, Doppler, vortex shedding, and ultrasonic devices were examined in order to determine the feasibility, reliability and suitability of such technologies in the desired small-scale application. Some irrigation districts have recently installed similar electronic flow meters in large canals and pipelines.

The Irrigation Training and Research Center (ITRC) at California Polytechnic State University, San Luis Obispo was awarded a contract to perform Task 5 of the California Energy Commission PIER project titled “Optimization of Water and Energy Resources Associated with Irrigation Water Delivery and Management.” Task 5 deals with this most critical component of the project – water measurement. The contract requires the use of facilities to test and monitor flow measurement equipment in addition to testing the equipment in the field. Rather than contract with an out-of-state laboratory to perform the testing, ITRC constructed new facilities at the existing water delivery facilities under construction.
facility located next to the Drumm Reservoir; the concrete structures necessary for the testing facilities and the labor to install the structures were funded through this project.

ITRC met with manufacturers that already have units that lend themselves to this work, or which can quickly modify their units for irrigation applications. ITRC also met irrigation districts that have tested various applications of these technologies. A set of standardized specifications was delivered to each manufacturer considering participating in this study. Numerous manufacturers were visited in order to familiarize the key staff with the study objectives. Of the manufacturers interested in participating, ITRC selected the companies to utilize for the next stage of the project to provide funding for product modifications. Each was set up with a subcontract for $20,000 through the CEC contract. ITRC made selections of companies whose existing technologies were to be used without any modifications. In addition, two irrigation districts, Patterson Irrigation District and Truckee-Carson Irrigation District, agreed to participate for field testing of the selected equipment.

Site visits were made to the hydraulic facility at Utah State University in Logan, the USBR's hydraulics lab in Denver, Colorado, and the hydraulic facility at Colorado State University in Fort Collins. These visits helped ITRC plan the new hydraulic facility improvements at ITRC.

The design stage of the Water Delivery Facility Flow Measurement Project began next. The main design concepts include a multi-cell tank structure, a new elevated canal structure, and a diversion structure at the canal's end. Demolition and construction of the instrumentation test apparatus for the volumetric tanks and elevated flume at the water delivery facility are part of the NIST-traceable flow measurement program will be completed in 2003. Testing of the electronic flow meters at this new facility is ready to begin.

ITRC installed and monitored the various electronic flow meters obtained from participating manufacturers in a variety of test conditions in the field. Detailed analysis of the data collected at participating districts was done in combination with an evaluation of each device's operation characteristics in order to make an assessment of the strengths and areas for improvement of each flow meter. A set of standard operating guidelines and deployment instructions for each device was developed after the first year of testing and used in the next round of field tests.

The first two seasons of field testing for ultrasonic and magnetic flow meters began at Patterson Irrigation District (PID). A comprehensive field testing report has been prepared that summarizes the design, installation and operation of the McCROMETER Ultra Mag, MACE AgriFlo, SONTEK Argonaut SL and UNIDATA Starflow meters installed at three farm turnouts in PID. The performance of each device was assessed based on factors such as sensor calibration, ease of installation, performance in the field, maintenance requirements, and accuracy over a range of conditions, and costs.

Information from the testing at PID and other irrigation districts will be used to develop the final detailed evaluation of each flow meter based on actual field applications, in addition to information gathered from the manufacturers and project participants.

The units were installed in similar concrete turnout boxes. Delivery data is being logged and will be compared to PID billing records at the end of the irrigation seasons. In addition to Patterson ID, the following sites were evaluated as part of this project:
♦ The SonTek Argonaut SL (similar to the SW model) was deployed at the Anderson-Cottonwood Irrigation District (ACID) from August 9 to October 4, 2001. The ITRC deployed the SonTek Argonaut SL acoustic Doppler current meter at the USGS gauging site in Redding, California. The average daily flow volume measured with the unit was compared to records for an adjacent USGS monitoring station.

♦ The ITRC visited Biggs-West Gridley Water District (BWGWD) to examine their installations of the Unidata Starflow ultrasonic flow meter. Bernoy Bradford, General Manager, has been working with several different installations of the Unidata Starflow meters. The district currently has five devices in the field, one in a flume and the other four in pipelines. The ITRC has cooperated with BWGWD in making recommendations to improve site conditions and to evaluate the overall performance of the units.

♦ The portable MGD ADFM unit was deployed in the field at Madera Irrigation District (MID) from August 13, 2001 until August 29, 2001. It was installed in the Main Canal, Recorder Station # 6. The district also current metered the site on two separate occasions, August 15, 2001 and August 25, 2001.

♦ The ITRC conducted a site visit to the Natomas Mutual Water Company (NMWC) in June 2001. During this site visit, a portable SCADA demo unit was installed to demonstrate SCADA and the MGD ADFM at the Elkhorn Lift pump site.

♦ The SonTek Argonaut SL was deployed at the Sutter-Mutual Water Company (SMWC) from April to July 2001. The flow rate was measured using the SonTek Argonaut in 10 minute intervals and the daily flow volume was calculated. The daily flow volume measured by the SonTek Argonaut SL was compared to data provided by SMWC. SMWC provided data for the Sacramento River diversions, the Tisdale Pumping Station diversions, the Portuguese Bend Pumping Station diversions, and the total amount of water diverted by the SMWC.

♦ Field tests were conducted in December 2001 with the Unidata Starflow at the Sutter-Mutual Water Company (SMWC) using a unit that had the new LCD digital display screen and upgraded software. The Starflow unit was deployed for three days in a medium size canal at Portuguese Bend to collect flow rate and velocity data measurements on 1-minute intervals. The unit was field calibrated with a Panametrics flow meter at the Portuguese Bend pumping plant.

♦ The ITRC conducted a site visit to the Turlock Irrigation District (TID) in October 2001 to install the following electronic flow meters in Lateral 5½: SonTek Argonaut SL, Unidata Starflow and MGD ADFM. These three acoustic Doppler flow meters were setup in a lateral canal to examine their relative performance in the ‘clean’ water conditions at TID. The results from the field tests conducted at TID were reviewed with the district representatives who attended the ITRC’s short courses in October 2001.

♦ The ITRC conducted a site visit to Reclamation District 108 (RD 108) in August 2001. During the visit, a Panametrics PT-868 Ultrasonic Transit-Time flow meter was installed at the Rough and Ready pumping plant.

♦ The MGD ADFM and Unidata Starflow acoustic Doppler meters were demonstrated during the field exercises of the ITRC Flow Measurement short courses held in October and December 2001. The operation of each device was explained to the course participants while they took sample readings in the canal at the Water Delivery Facility.

One of the major accomplishments of this research was the development of the new Doppler meter - the SONTEK Argonaut SW. The original goal was that the SONTEK unit could be marketed for less than $3,000. The current retail price is closer to $5,000. While this is not what was desired for this application, the SONTEK unit has proven to be a good unit for larger canals (50 cfs to 1000 cfs) as a bottom mounted Doppler device. This unit was recognized as the agriculture winner of the exhibitor new product contest at the Irrigation Association’s 24th Annual International Irrigation Show and Conference in San Diego, California.
Another significant accomplishment is the introduction and dissemination of information on the new MACE Agriflow Doppler meter. Through this research, the unit has been upgraded to correctly calculate non-metric units (feet, cfs, acre-feet, etc.). The unit is also very popular with those in the field. It continues to provide good results that have been field verified. The unit cost is well under $2,000 and 10 units have recently been purchased by Imperial Irrigation District for field testing.

Lastly, the ARI funding provided much needed funds to completed the flow measurement instrumentation at the Cal Poly ITRC Water Delivery Facility. The ITRC began the demolition and construction work for the new facility in 2001.

Impact Statements

This research will impact many energy and water management issues, including the following:

- Reduction in groundwater pumping (because surface water deliveries will be more flexible, and water tables will remain at higher levels), thus reducing electricity consumption.
- Elimination of future increases in groundwater pumping which will occur if the present water delivery infrastructure is not significantly improved, thus reducing escalations in energy consumption.
- Increased yield per unit of energy consumed, thus improving efficiency ratios. More efficient fertilizer practices, thus reducing indirect energy consumption.
- Planning for water transfers throughout the state.
- Reduced vehicular travel (due to automatic systems and remote monitoring), thus reducing fuel energy use and reducing engine emissions.
- Reduced deterioration of groundwater quality and quantity.

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For More Information

This research report contains summarized results of Stuart Styles’ study entitled “New Electronic Technologies for Volumetric Metering of Delivered Water – Magnetic, Doppler, Vortex Shedding and Ultrasonic Flow Measurement,” ARI Project No. 01-3-016 (Research Focus Area: Water and Irrigation Technology). To view and/or obtain a copy of the complete final report, or to obtain additional information about this or other research projects, visit the ARI website at ari.calstate.edu. For information on projects specific to Cal Poly San Luis Obispo, visit the Cal Poly ARI website at ari.calpoly.edu.

The Agricultural Research Initiative (ARI) is a California State University (CSU) multiple campus collaborative partnership between the CSU colleges of agriculture and the state’s agriculture and natural resources industries and allied business communities. ARI provides public funds that are matched with industry resources to fund high impact applied agricultural and natural resources research, development, and technology transfer, as well as related public and industry education and outreach. ARI projects and programs improve the economic efficiency, productivity, profitability, and sustainability of California agriculture while providing for consumer sensitive and environmentally sound food and agriculture systems and fostering public confidence in food safety and agricultural research and production systems.