MODERNIZATION OF WATER MEASUREMENT SYSTEMS IN THE TURLOCK IRRIGATION DISTRICT

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ABSTRACT

The Turlock Irrigation District (TID), California's first irrigation district, was established in 1887. In 1997, the TID began to investigate what improvements could be made to its water measurement facilities, some of which dated to the early part of the 20th century. The plan that was developed consisted of the installation of telemetry to existing concrete weirs, construction of new long-throated flumes, and installation of solid-state devices to replace existing systems. The data collected in the field is transmitted via a spread-spectrum radio to the District's operation center where it is loaded into the Irrigation SCADA system. Office staff can access the data and use it to monitor and analyze the operation of the irrigation system. The experience gained in data monitoring and collection will be used as the foundation for further improvements in operation of the TID canal system.

BACKGROUND AND HISTORY

The Canal System

The Turlock Irrigation District was established as California's first irrigation district on June 6, 1887. After building the diversion and distribution facilities, the TID made its first delivery of irrigation water from the canal system on March 9, 1900. Today the TID irrigates 150,000 acres of land that consist of 7,500 parcels of property and approximately 5,000 individual irrigators. The District extends from the foothills of the Sierra Nevada on the east to the San Joaquin River on the west. The Tuolumne River forms the TID's northern boundary, while the Merced River forms the southern boundary. The TID canal system stretches from La Grange in the foothills of the Sierra Nevada mountains where water is diverted from the Tuolumne River, to Lateral 8 which ends 2 miles from the confluence of the Merced and San Joaquin Rivers. The canal system consists of 250 miles of concrete-lined and unlined canals, 380 check structures or drops, and 43 points where flow is measured in the system. Operational spills can be made in 14 locations, where discharges reach the Tuolumne, San Joaquin, or Merced Rivers. The maximum diversion from the river to TID's regulating reservoir, Turlock Lake, is 3,200 cfs. Irrigation releases from Turlock Lake to the

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distribution system range from 600 cfs in the spring and fall to 2,100 cfs during the summer.

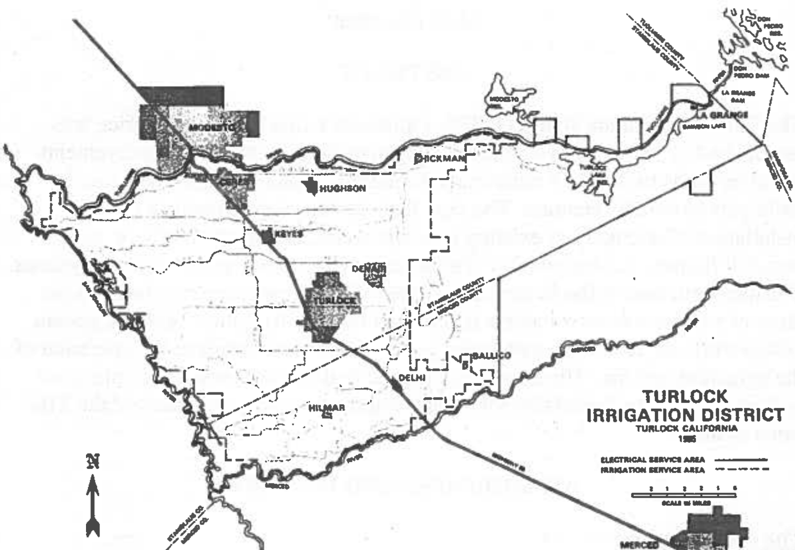

Figure 1 - Map of TID

Legacy Water Measurement System

To a great extent, the old water measurement system consisted of concrete Cippoletti weirs, some of which dated to the 1916 to 1923 period. Some of the older weir structures had wooden weir blades that required periodic replacement. The data recording system consisted mainly of Leopold Stevens chart recorders, which utilized a spring-operated mechanism that recorded float elevation as a pen line on a circular piece of paper. The recorders were placed in approximately 30 locations and recorded data for a one week period. One employee was assigned to change the paper charts in the recorders throughout the TID, a task that took 2-3 days each week to complete since many recorder stations required lubrication or other minor maintenance during the visit.

When the recorder sheets were returned to the office, the same employee was assigned to obtain flow data from the sheet and enter the data into the TID water tabulations. By the 1980's, the water tabulations had progressed to PC based spreadsheets thus making the data available in electronic format to other employees at the TID. Unfortunately, the time consuming nature of manually servicing the recorder stations, and other high priority assignments sometimes precluded the employee from timely reduction of the chart recorder data and entering it into the spreadsheets.

In the late 1980's, the District attempted to automate the reading of the flow measurement devices by installing twelve Telog instrumentation devices in the canal system. These devices used a solid-state probe connected to a local data recorder. Each site was visited on a weekly basis to transfer raw numbers to a portable data storage device, which was then connected to a PC for viewing and storage. Some of the problems with this system included not discovering problems with the data until it was downloaded and viewed on the PC, and the still time-consuming nature of the data collection and transfer work.

Other Problems with Water Measurement System

Along with the time consuming nature of collecting the data, the TID faced other problems with measuring the flow of water in the District. Many of the measuring structures were at the end of their useful life, having been built early in the 20th century. Concrete required patching and other maintenance procedures. Many of the measuring weirs were constructed too close to the headgates and were affected by high water velocity and turbulence. Some of the measuring weirs were too far away from the headgates which resulted in unacceptable time delays in setting up the canal for the needed flows. In other critical areas, there was no flow measurement available, and insufficient elevation drop was available to construct weirs.

In the mid 1990's, several outside forces also came to bear on the TID's methods of water measurement and record keeping. Government programs such as AB3616 increased outside scrutiny of the TID's operations and use of water. Irrigation customers expected higher levels of service than in the past. For example, they wanted more flexibility in delivery flow rate and time of delivery. In addition to these outside forces, TID managers questioned the resources assigned to obtain water measurements and other operating information for the canal system.

Turning Problems into Opportunities

TID staff came to the conclusion that major improvements would be required in the way water was measured and recorded. To determine the necessary improvements, TID staff discussed needs of the various stakeholders in the program. Customers were questioned to determine the service levels they required and the records needed to support their needs. TID canal system operators were asked to list their needs so that they might be able to operate the system more efficiently. TID staff visited other irrigation districts to learn what improvements had been successful. Staff also attended college and university workshops to determine the state of the technology available. Vendors were consulted to determine availability of devices and what budgets would be required to support the improvements needed.

TID staff developed a checklist of factors that would be used in evaluating new technology. The system must be user friendly, meaning it must be easy to learn and understand. The technology must be compatible with standard systems and protocols, and other applications already existing at the TID. In addition, the technology must have a proven track record and be operating in other similar applications. TID staff visited other irrigation districts to see first hand how well the various technologies functioned.

WATER MEASUREMENT IMPROVEMENT PLAN

The plan, finalized in 1997, consisted of a phased improvement program to the TID's water measurement activities. Improvements were scheduled over a 5-year period starting in the year 1998. Funding was requested as part of the capital budget for irrigation system improvements and with the TID Board of Directors approval, construction began in 1998. Forty-two sites were identified in the plan as sites that required water measurements to be transmitted to the central office, as shown in Figure 2. In order to accomplish this, improvements were needed in several areas such as structural improvements to water measuring devices in the canal system, installation of level transducers, installation of local electronics at each site to read the transducer, installation of a radio system to communicate with the remote devices, installation of base electronics to receive the data, and software to view and store the data. This comprehensive improvement plan became known as the Irrigation SCADA system and is scheduled for completion in 2002.

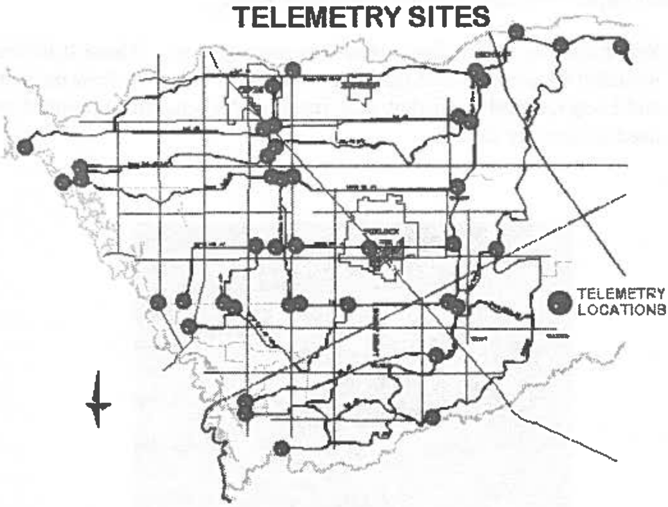

Figure 2 – TID Irrigation SCADA System

Structural Improvements

Structural improvements contained in the plan were:

- Rehabilitation of existing concrete measuring weirs. These structures included Cippoletti weirs that were installed strictly for flow measurement and Long Crested weirs that were installed for operational control and also used to measure flows.

Figure 3 - Cippoletti Weir

Figure 4 - Long Crested Weir

- Construction of five new long-throated flumes in locations where new measuring devices were needed and sufficient head existed for flumes to be constructed.

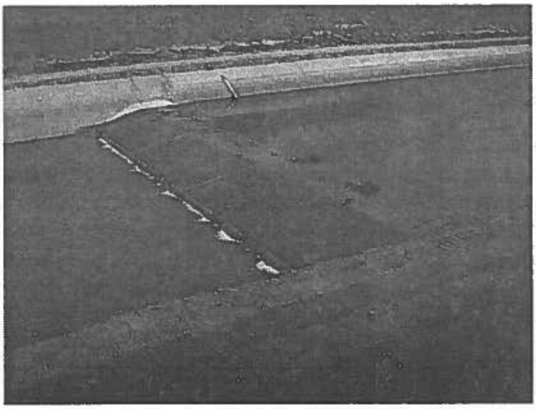

Figure 5 - Long Throated Flume

- Installation of six solid-state measuring devices where insufficient head was available for a weir or flume. The TID is currently installing measuring devices provided by Nivus. They consist of acoustic velocity sensors coupled with pressure transducers. One previous installation was provided by Accusonic, which utilizes acoustic velocity sensors coupled with an acoustic down-looking level sensor.

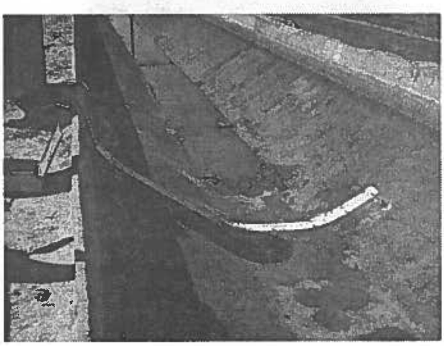

Figure 6 - Nivus Flow Measuring Device

Level Transducers

Several types of water level transducers are available commercially. Float-connected rotary transducers, ultrasonic down-looking devices and submersible pressure transducers were evaluated. The TID is currently using Druck PTX 1830 submersible pressure transducers because they have been found to be reliable and perform well in the TID's installations.

Local Electronics

The TID is using an RTU assembled by Sierra Controls. The RTU consists of a PLC, radio, antenna, operator interface/display, power supply and battery, lightning/surge protection, various terminal strips for input information, software and documentation. The RTU has the capability of 4 analog inputs, 3 digital inputs, and 2 digital outputs.

Radio System

The TID chose spread spectrum radios operating from 900 to 928 MHZ and are supplied by MDS. The TID has found the MDS radios reliable, with a favorable maintenance history.

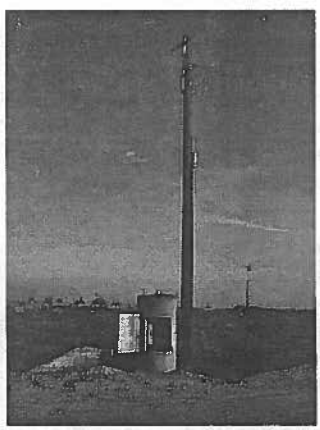

Figure 7 - Remote SCADA site

Base Electronics

The signal from the spread spectrum radios is received at a central electric substation and transmitted over the TID's microwave backbone to the operation headquarters. From there the data is transmitted via a telephone system to the SCADA system PC.

Software

The TID utilizes Lookout software from National Instruments to provide the operator interface to the irrigation SCADA system. Operational personnel in the field can access the real-time data by calling the operations center. For example, one way the real-time data is used is to determine whether scheduled water has reached critical points in the distribution system. Operational and engineering staff can access the real-time data on their personal computers in their offices.

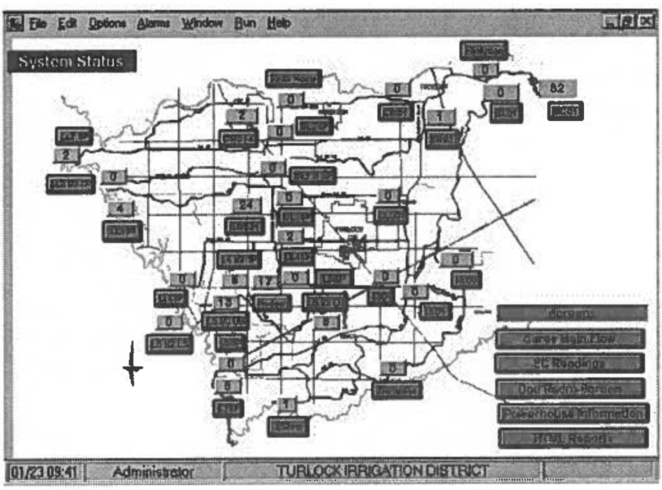

Figure 8 - Typical Operator Console for Irrigation SCADA

The software also provides the ability to download information as needed to a spreadsheet file, which is a key feature of the updated record keeping system. Flow data is generally downloaded on an hourly basis from the SCADA system to a spreadsheet. The hourly data is then manually averaged to provide daily flows for each site. Weekly and monthly reports are compiled in a similar fashion, with all data and computations in an electronic format. Reports are generated from the data and distributed to key personnel who use the information to make improvements in the management of irrigation water in the TID.

FUTURE PLANS

Completion of the Irrigation SCADA system in 2002 will fulfill the improvements envisioned for the Water Measurement System. The development of the Irrigation SCADA system provides a data collection and record keeping system that is timely and accurate. The system facilitates analysis and decision making to enable staff to efficiently operate the TID's irrigation system.

The TID is working on two improvements to the Irrigation SCADA system that will be implemented in the near future to improve communication with field operators. The software has the ability to send e-mail containing alarms and flow data to field personnel that can be received on their cellular phones. The other improvement is to convert HTML pages of flow data to web pages that can be read by web-enabled cellular telephones. It is anticipated that both these improvements will enable field personnel to improve the way they operate the TID irrigation system.