INITIATING SCADA PROJECTS IN IRRIGATION DISTRICTS

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ABSTRACT

Delivering water efficiently through distribution networks is a priority for irrigation districts but often is a difficult goal to achieve. SCADA shows promise of improving operational efficiency, increasing flexibility in the amount and timing of water deliveries, and reducing spills and other losses in distribution networks.

However, implementing SCADA in a district for the first time is a difficult process. Districts often do not understand or are distrustful of the technology. They often do not know or understand how their system actually operates, thus making it difficult to design SCADA systems and to determine operational parameters and control algorithms.

Selecting equipment that is easy to integrate into district operations is not a simple decision. Simple tasks such as selection of sensors and communication hardware become time consuming because of the need to explain advantages and disadvantages of each component. District boards of directors are normally reluctant to spend money, which further complicates the process. Once SCADA is installed, district personnel have to be trained on how to use the equipment to perform daily operations.

In this paper we discuss the process of implementing SCADA projects for the first time in a district that had no previous experience with such technology or control systems. The paper will cover both hardware aspects as well as human consideration, and discuss some of the many lessons learned.

INTRODUCTION

Implementation of SCADA technologies for irrigation districts to improve real time water measurement, and control and monitoring have been significantly increased in recent years. This is partly due to the cost of SCADA hardware, software and operation and maintenance that is becoming cheaper, and the availability of funding to implement such projects. However, challenges remain on the implementation process. Many irrigation districts in Texas have little experience using such technology and need training on selection, setup, operation, and maintenance of SCADA equipment.

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Out of the 28 irrigation districts that reside in the Lower Rio Grande Valley (LRGV) of Texas, only a handful of those districts have implemented various levels of SCADA. For the most part, many of the districts operate completely technology free; gates and pumps are controlled manually based on a combination of experience, water levels, and the use of the spill structures. The canal riders operate the gates based on the logic that a certain number of turns of the gate wheel equal a “head” of water. The only mandatory flow measurement takes place at the main intake pumps on the Rio Grande River, which is required by Texas Commission on Environmental Quality (TCEQ).

The Irrigation District Engineering and Assistance (IDEA) team of The Irrigation Technology Center has been working with several irrigation districts to implement SCADA demonstration projects in an attempt to familiarize them with the use of the technologies.

The IDEA team has learned about different types of hardware and software regarding to SCADA through training courses, conferences, and several visits to the districts in California, Oklahoma, Colorado and Texas where these systems have being utilized in daily operations. In addition, the IDEA team has gained valuable experience designing and implementing SCADA demonstration projects with Hidalgo County Irrigation District No.6 (HCID6 or ‘District’) and United Irrigation Districts and through the collaborative work with other districts and their consulting engineers.

In this paper we discuss the process of implementing a SCADA project for the first time in HCID6 of Texas, which had had no previous experience with such technology or control systems. The paper will cover both hardware aspects as well as human consideration; and discuss some of the many lessons learned.

BACKGROUND

Hidalgo County Irrigation District No.6 is located at the most southern tip of Texas in an area called the Lower Rio Grande Valley (LRGV). The LRGV has been experiencing significant urban growth over the past decade causing considerable fragmentation of the agricultural lands and putting increased pressure on the irrigation districts to improve overall water use efficiency. Of the counties that comprise the LRGV, Hidalgo County had the highest percent increase in urban area with 35% (Leigh et al., 2009). Figure 1 shows Hidalgo County Irrigation District No.6 with distribution network and expansion of urban area.

The District, located in the western part of Hidalgo County, has authorized water rights of 40,729 acre-feet of water from the Rio Grande River and serves approximately 18,900 acres, as well as provides raw water for industrial and municipal uses. The distribution network consists of approximately 23 miles of main and 41 miles of secondary and tertiary lined canals, and 60 miles of gravity fed pipelines. In addition, there are three main re-lift stations on main canal and several small lift stations throughout the district. The District operates two reservoirs at the start of the main system: Walker (116 acre) and District Lake (60 acres), which are maintained in maximum storage capacities to absorb changes from municipal and irrigation demands.

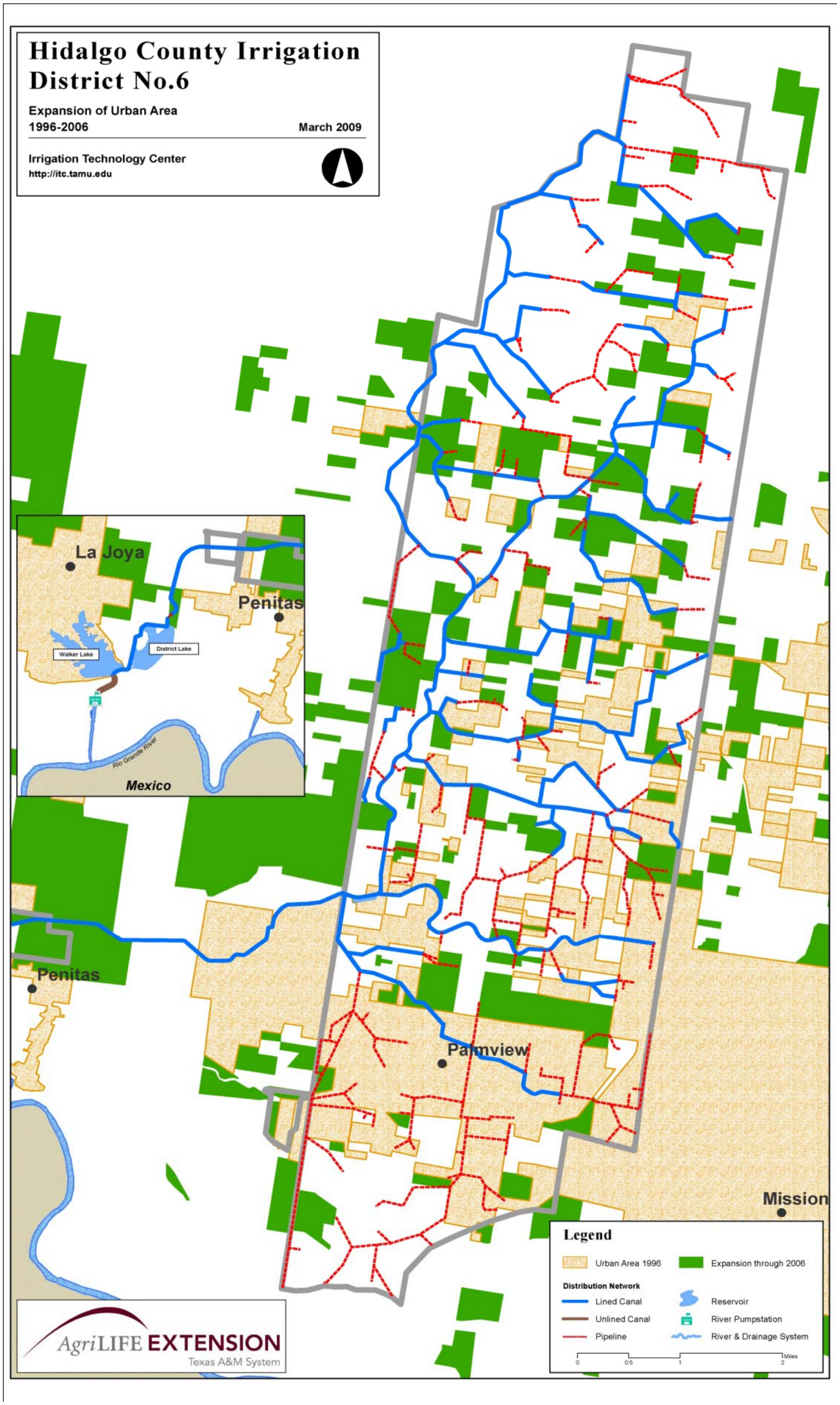

Figure 1. HCID 6 service area with urbanization

PROJECT DESCRIPTION

During large rainfall events, the District must release excess water out of the two reservoirs, more specifically Walker Lake, and back into the main canal to prevent flooding of the surrounding neighborhoods. The water level in the main canal is normally kept at the same level as the reservoirs and also requires lowering. A steel 36-inch round slide gate (refer to as the “emergency gate”) near the main pumping plant must be opened in order to drain the water from the main canal and back into the Rio Grande River.

While the reservoir gates are relatively close to the district employee’s home who manages the area, the emergency gate is located several of miles away. The unpaved roads to the gate can become impassable during rain events, requiring the district employee to walk, often at night, to open the gate.

The district manager requested assistance from the IDEA team on combating the problem. He understood theoretically that some type of automatic control system could be used, but did not know about the specific types of equipment, components, or setup requirements that would be needed. The IDEA team first worked with the district to understand their overall goals and to evaluate potential project sites.

Next, the team developed a range of options including the hardware, software, telemetry equipment and the control logic for the system that would provide the best benefit for remote and automatic control operations. The project was divided into two phases: Phase I: design and implement a SCADA system for the emergency gate on the main canal; Phase II: implement the developed SCADA system (from Phase I) for the gates of Walker and District Lakes.

METHODS AND PROCEDURES

Hardware and Software

Actuator AUMA brand actuators were selected for use in these projects. A basic 1/3 horsepower actuator is used at the emergency gate site. One horsepower actuators with built-in 4-20 mA gate position feedback are used for the radial gate at Walker Lake and the vertical slide gates at the District Lake.

Programmable Logic Controller (PLC) A SCADAPack controller by Control Microsystems are used for all project sites. These PLCs have 14 digital and 8 analog inputs with 2 additional analog output ports. This brand was chosen due to its current use by other districts and their engineers.

Water Level Sensor A Stevens float and pulley with 4-20 mA output signal are used as water level sensors on the main canal, and Walker and District Lakes. They are enclosed in a 24-inch PVC pipe that serves as the stilling well. A float and pulley sensor was chosen due to the easy of calibration, installation and use, as well as low operation and maintenance cost. In addition, vandalism was the main factor on eliminating the use of ultrasonic sensors, and the high salinity content of the water prevented the use of pressure transducers.

Communication system A dedicated phone line was set up as main telemetry system between RTU and Master station while site evaluations for radios were investigated. Once a clear line of sight was verified, 915 MHz Transnet (also known as a spread spectrum) radios were selected for the telemetry system (Figure 2).

Operation Parameters Control logic for the gate had to be developed in order to maintain normal water levels in the system during flooding situations. The main challenge was to determine a water level set point for automatic control of the gate. Since this emergency gate is located on the main canal next to the main pump station, the water level set point cannot overlap with high water level in the canal during peak irrigation season, as it would create an artificial emergency situation. Therefore, all frequency of high water level scenarios had to be considered in order to develop optimal operation parameters for the gate.

Programming In the region, Ladder logic and C are commonly used in programming the input and output signals from hardware into PLC in other districts. We worked with a local consultant engineering company to finalize control logic that was developed using C language.

Human Machine Interface (HMI) ClearSCADA of Control Microsystems was used as HMI software, which resides on a dedicated computer at the district office. The other software used in the region are LookOut and Wonderware. ClearSCADA was chosen because of costs, availability of local technical support, ease of use, interface and simple graphical displays. The LookOut software was eliminated due to the lack of local technical support, while Wonderware needed a specialist for initial integration due to complexity of the software.

Implementation

Remote Terminal Unit (RTU) Three Nema enclosure boxes were installed at the emergency gate, and at Walker and District Lakes; one for the PLC, radio, power converter and terminal blocks, and the other for the main power supply (Figure 3). The actuator was installed, wired and programmed into PLC, along with radios.

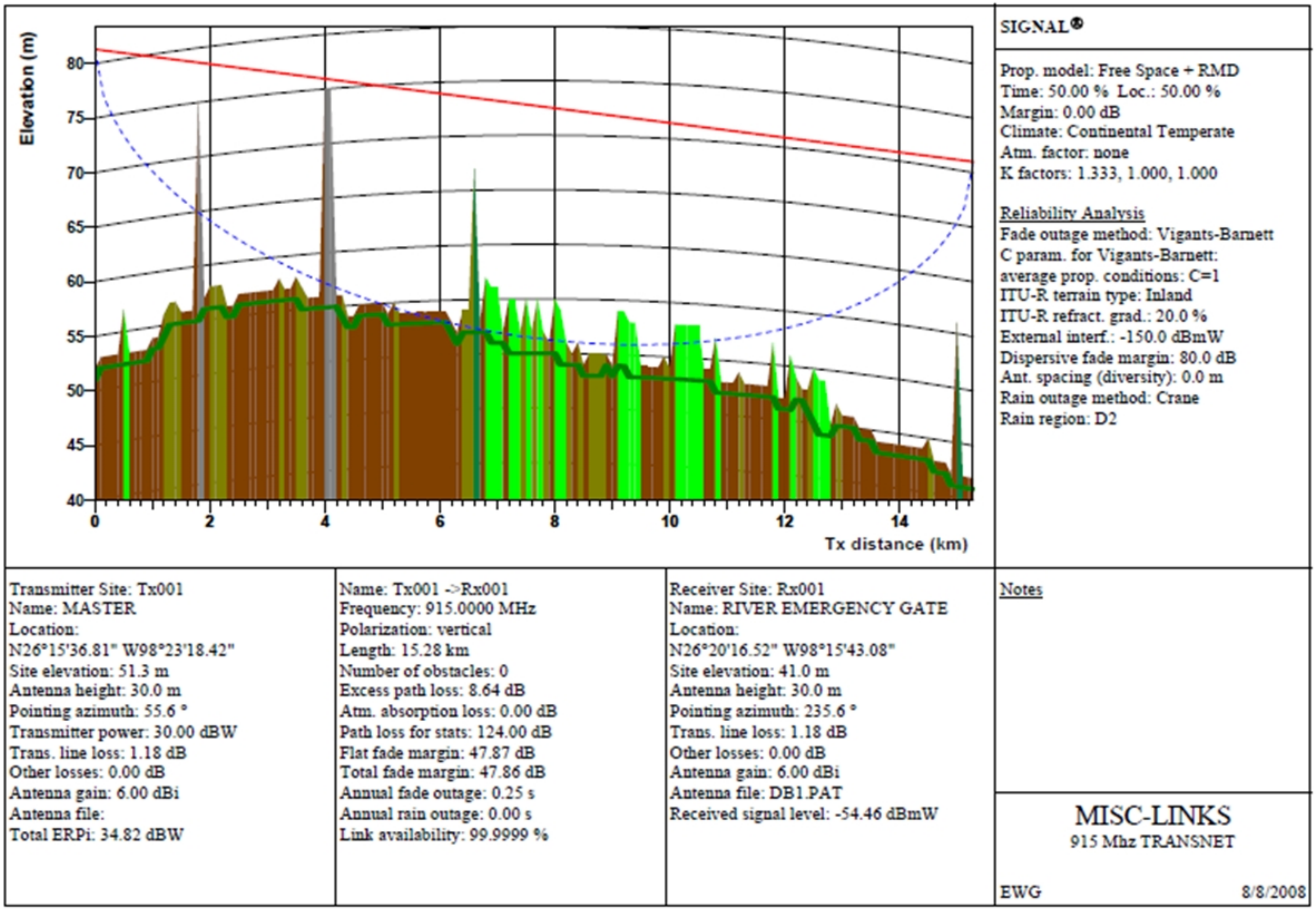

Figure 2. Determination of line of sight using SIGNAL software

Figure 3. The Remote Terminal Unit (RTU), which consists of PLC, radio, power converter, fuses and terminals and actuator at the Emergency Gate site.

<u>Radio Telemetry System</u> Line-of-sight availability for radio communication was determined using SIGMA software which generated detailed recommendation based on latitude/longitude coordinates of the Master station and RTU. Based on the software results, we used a 30 db Yagi antenna at a height of 30 ft at the RTU and a 7 db Omni antenna at a height of 40 ft at the Master station. We also established the available range of communication using diagnostics software of the radio.

For the emergence gate site, the radio signal at the site ranges from -92 db to -97 db where -40 db is the best and -120 db is the worst. But according to technical specs of this particular radio, the max range is -100 db.

<u>Control Logic</u> Control algorithm for the gate was developed for remote and automatic control options based on a pre-determined water level set point. Since the main purpose of the project was to release excess amount of water from Walker Lake during heavy rains, the emergency set point was based on the maximum water level reading at the lake. Both Walker and District lakes had staff gauges that were calibrated to sea level.

The district operates both lakes at a maximum level of 132.2 ft. If rainfall occurs, the lakes can handle another depth of 4 inches (free board) before it spills over into a residential area surrounding Walker Lake. Therefore, based on the managers' recommendation, we developed a control logic based on the 132.2 ft pre-set water level, the "emergency level". When water level exceeds 132.2 ft, the PLC receives a signal from the water level sensor and sends a signal to the actuator to open the gate. The gate stays open until water level at the canal drops to 132.1 ft, and then closes.

Master Station The master station consists of a radio and antenna to receive and send signal to/from remote sites and a dedicated computer, which hosts the ClearSCADA HMI software. All the register addresses in PLC, such as gate position, water level readings and set points, and automatic/remote control options were programmed into HMI software. Graphical displays showing real-time operation and monitoring, and alarming capabilities were implemented into the HMI in a simple manner so the district personnel can easily understand and utilize the system efficiently (Figure 4 and 5).

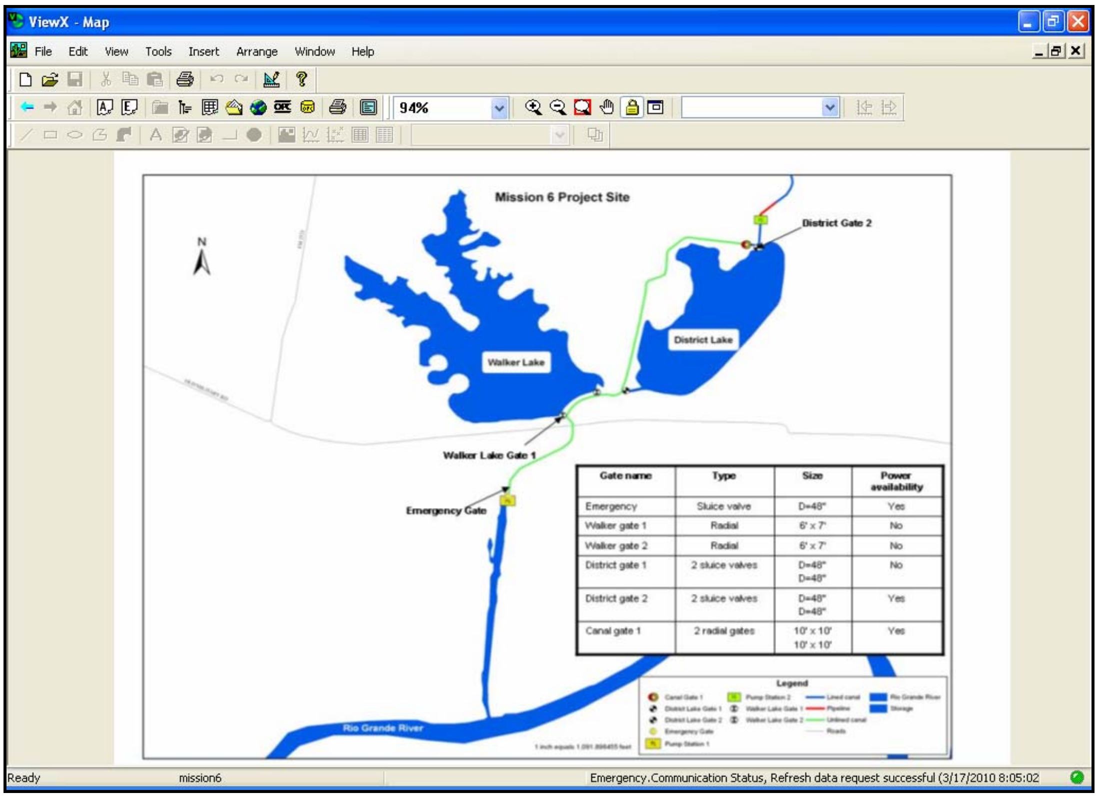

Figure 4. Remote Terminal Units at emergency gate, Walker and District Lakes on HMI software display on district computer at the office.

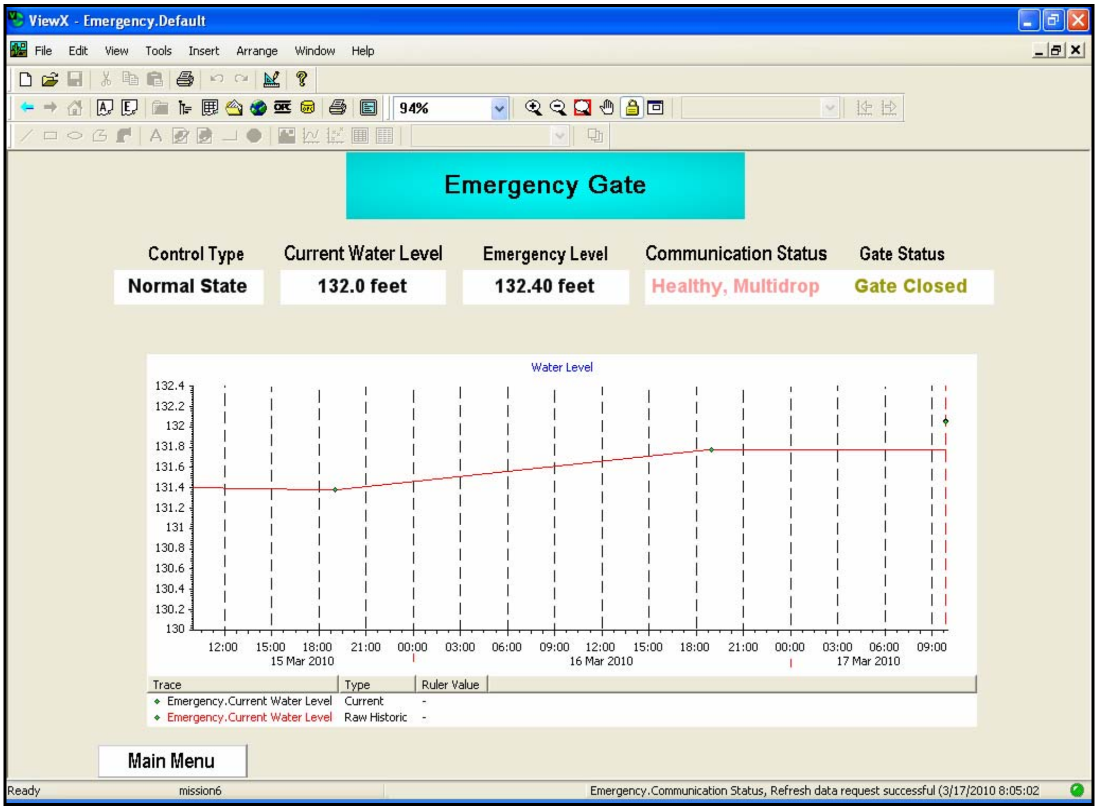

Figure 5. Emergency gate RTU display and control on Clear SCADA at the office computer

<u>Test of the system</u> We performed series of control scenarios to test reliability, accuracy and correctness of logic to control the gate. For instance, an artificial flood situation was created to test reliability of automatic control with increasing water level set point to examine how gate supposed to react to the given command from the sensor. As soon as water level reading exceeded the emergency set point of 132.2 ft, the gate opened immediately and stayed open until set point was decreased below 132.1 ft.

The system was also tested for remote control operation by simply changing control type on HMI without changing water level set point. This option is particularly designed and programmed for high water level in the canal system during which max water is pumped from the river to meet the demand at downstream water users. In that case, the district personnel will change the control type from automatic to remote on HMI to eliminate flooding in the system.

<u>Training District Personnel</u> We provided training on operation and use of HMI software, since this gate is designed for automatic control purpose; it's not operated frequently. In addition, wiring diagrams for actuator, sensor, radios and power for RTU along with customized manuals on operation of HMI and radios were provided.

RESULTS AND DISCUSSION

At the start of Phase I, the actuator installed for the emergency gate had initial operational problems due to the rust build up on the stem, threads, and guide frame from infrequent use. In the beginning we thought that the gate supports and stem were not capable of supporting the torque force from the actuator. Additional steel supports were added to the structure but the problem persisted. For further evaluation, the concrete section containing the gate was then blocked from the main canal and drained. After the rusty condition of the gate was determined as the problem, the district personnel cleaned and applied grease to the gate components.

The installation of the equipment for the RTU sites, which included the water level sensors, actuators, spread spectrum radios, and PLCs were successfully installed. The next decision was to decide on the programming language to be used for this project. The SCADAPack PLC can use several languages including ladder logic and C/C++.

We initially had limited programming experience, so we worked in close collaboration with other districts and their consulting engineering companies whom had similar SCADA systems. The consultants provided example programming codes using the C language and assisted us on understanding of the functions involved.

During the implementation of Phase II, we ran into problems with the calibration of the actuator at Walker Lake that controls a small radial gate. The gate feedback position signal of the actuator was giving false readings because the wrong potentiometer was installed. The AUMA sales representative made some initial miscalculations when during the specification process. We contacted AUMA for assistance. The company sent an engineer to work with us to solve the problem. The potentiometer was replaced and the actuator was properly calibrated.

The next problem was due to lightning events that occurred at the Walker Lake RTU site. One of the analog inputs on PLC board along with fuses and a water level sensor was damaged and the team replaced water level sensor and PLC.

The final problems were encountered at the District Lake RTU site during the installation of the radio system. We had a series of problems on gaining line-of-sight. The initial tests showed that signal strength was at -110 db, and not within the optimal signal range between -40 and -100 db, not allowing any communication to the master station. The antennae height was then raised from 30 feet to 40 feet, which increased the signal strength to an achievable range between -98 db to -100db. While this is still not a desired range, we have future plans to add a repeater station for signal strength improvement. But so far the district has not had any problems with radio communications.

A summary of the lessons learned from problems experienced during the process of the project:

- Need proper evaluation of existing equipment before proceeding to next task
- Understanding the use of the programming language

- Ordering proper equipment (i.e. lightening protection, actuator components)
- Proper planning out the installation of equipment
- Establishment of suitable line of sight for radio telemetry system
- Calibration of actuators and water level sensors

CONCLUSIONS

The money is the essence for the implementation of any kind of project whether it is SCADA or rehabilitation of canals and pipelines. But the Board of directors most of the time are unwilling to spending money for these small SCADA demonstration projects due to the cost, mistrustful of technology, fear of the cost for operation and maintenance of the system and etc.

We had been working with several districts in the region on design and implementation of SCADA projects for various applications. However, most of the districts are willing to work and they do understand importance of technology on improvement of water delivery efficiencies in the conveyance systems.

In addition, most of the districts are experiencing shortages on number of canal riders who perform daily operations of gates, turnouts and pumps. Most of the canal riders are about to retire but districts are having hard time on recruiting new canal riders. This seems to be one of the biggest problems in near future.

We learned many lessons throughout design and implementation phases of SCADA projects. But when working with irrigation districts other issues arise including:

- Districts not installing the equipment as provided in project plans
- Lack of understanding and seeing the overall project goal (slows down project implementation)
- Lack of education on the cost, time and efforts need for each project
- Not understanding the importance of being involved on all aspects of the project, including learning how to use to control systems

This was one of the successful projects that we have implemented so far. Another part of the success of this project was due to the district manager's willingness to spent money to combat the flooding problems in his reservoirs; the board members were also very supportive.

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