GATE AUTOMATION AND CENTRALIZED CONTROL IN A SOUTH CENTRAL TEXAS IRRIGATION DISTRICT

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ABSTRACT

This paper presents an overview of a project to retrofit and automate 11 check gate structures within a selected section of the eastern canal system in LCRA's Gulf Coast Irrigation Division. LCRA owns and operates three irrigation systems in the lower Colorado River Basin. This project is funded by a combination of funds from the House Bill 1437 Agricultural Water Conservation Program, and a USBR grant. Each check gate structure will consist of two aluminum slide gates with actuators and instrumentation for automatic control, powered by solar panels. Other project features include 3 spill monitoring sites, a radio based data communication system (DCS), and a supervisory control and data acquisition (SCADA) system. Gate manufacturing, and telecom design and installation are being accomplished in-house, with gate design by a contracted engineering firm. The House Bill 1437 (HB 1437) Agriculture Water Conservation Program was developed to meet rising municipal demands in Williamson County (located in the Colorado River Basin of Texas), conserve river water used for irrigation, and maintain agriculture productivity. For more information on this program please visit http://www.hb1437.com. The HB1437 short-term plan established a goal of conserving 10,000 acre feet per year by 2014. This project to automate existing canal check structures is part of this plan. The USBR grant enabled LCRA to include the centralized SCADA component of the project.

The water savings from this project is estim ated to be 2,600 acre-feet per year or a 3.5% reduction in the eastern secti on of Gulf Coast's average annual water diversion (73,000 acre-feet per year). W ater management will be improved on the entire e astern section of the system as a result of automating the gates at the head of the system.

INTRODUCTION

The House Bill (HB) 1437 Agriculture Water Conservation Program is an innovative way to conserve agricultural water, meet rising municipal demands, and maintain agricultural productivity. A bill, HB1437, passed by the Texas Legislature in 1999, authorized the Lower Colorado River Authority (LCRA) to transfer up to 25,000 acre-feet of water annually to Williamson County, if the transfer results in "no net loss" of water to the lower Colorado River basin. No Net Loss" is generally defined as the hydrologic condition where the volume of water transferred is equivalent to the volume of water conserved within the LCRA irrigation divisions. The bill also established a conservation surcharge on the transferred water which funds on-farm and in-division agricultural

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conservation projects with the LCRA irrigation division. Additional details of the program history and legislation are available at www.hb1437.com

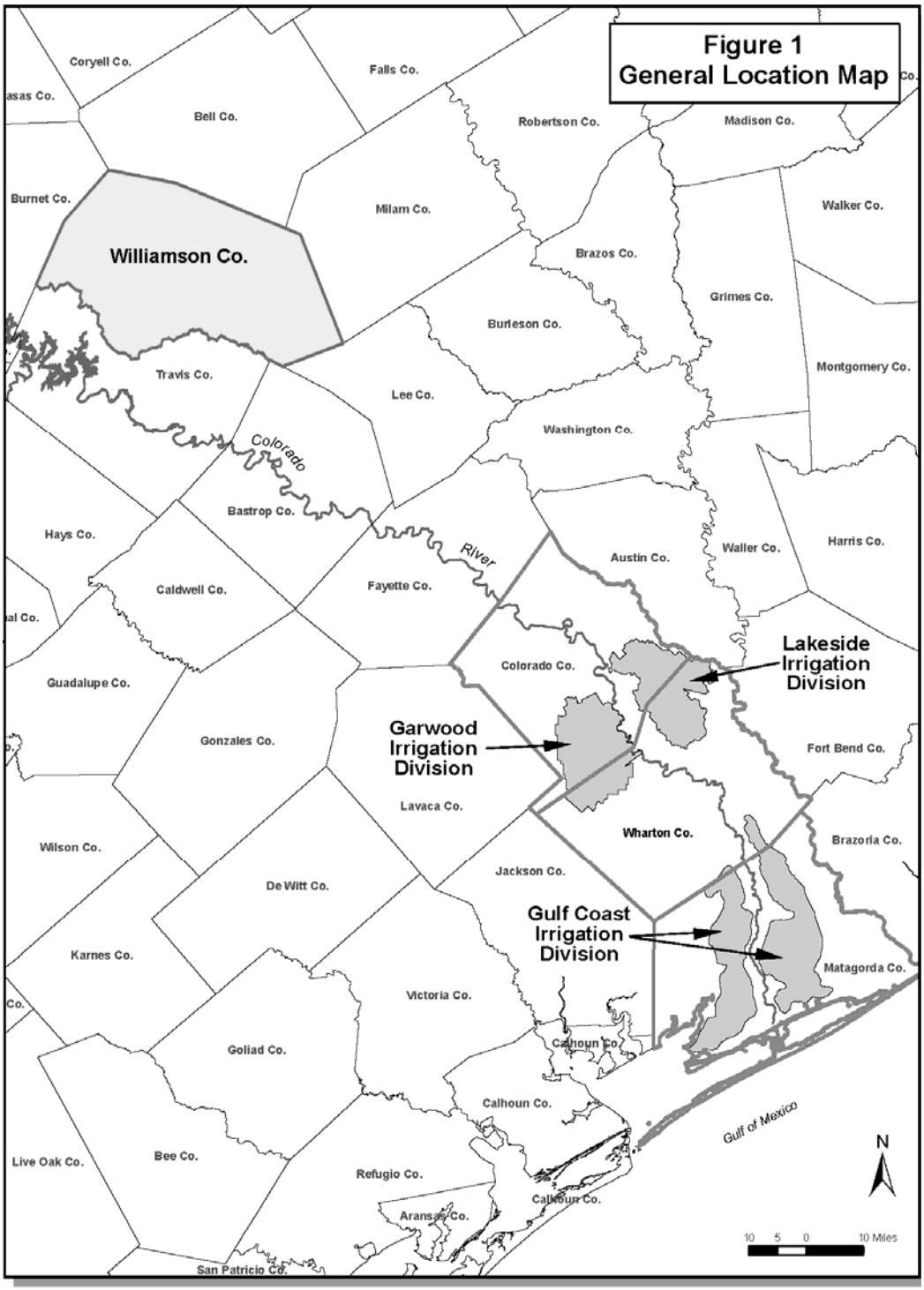
The LCRA is a conservation and reclamation district created by the Texas Legislature in 1934. LCRA supplies electricity for Central Texas, manages water supplies and floods in the lower Colorado River basin through the operation of six dams, manages three irrigation divisions, develops water and wastewater utilities, provides public parks, and supports community and economic development in 58 Texas counties.

Program Overview

The HB 1437 Agricultural Water Conservation Program began in 2006 with a cost-share grant program to fund precision land leveling on rice farms. This program and verifying the water savings from it will be discussed in another paper presented at this conference. In 2009, LCRA completed a short-term strategy report update to develop 10,000 acft of water supply that recommended two capital improvement projects to be completed by 2014, equipping the Garwood irrigation division to be able to measure water deliveries and bill based on volumetric use, and installing automated gate structures in the irrigation divisions. For more information on this plan please visit http://www.hb1437.com. The latter project evolved into a project to replace and automate gates within the eastern section of the Gulf Coast irrigation division (Figure 2). Following the award of a USBR grant in 2010, the scope of the project was expanded to include a centralized SCADA system, a radio based data communication system, and monitoring of three spill site locations. The estimated amount of water that will be conserved through this project is 2,560 acre-feet per year based on an estimated reduction of 3.5% of average gross diversions for the eastern canal section over the last decade. The purpose of this paper is to describe the system that is being installed and the process LCRA went through to develop this gate rehabilitation project.

This project is a key part of the LCRA's water conservation program for agricultural uses that could be expanded to other divisions and sections in the future. The overall goals of the HB 1437 program are to: 1) Reduce agricultural use of surface water; 2) Plan and implement conservation projects to fulfill obligations of the LCRA contract with the Brazos River Authority (BRA) for HB 1437 water; 3) Provide funds from the Agricultural Water Conservation Fund to implement water conservation projects; and 4) Provide program performance information to the LCRA Board, BRA water customers, and the public in accordance with LCRA Board Policy.

The program is funded through the income stream generated from the conservation surcharge applied to the water sales contract. The conservation surcharge is applied to both reserved water and transferred water. The reservation fee applies to contracted water reserved for future use and is used to help pay the cost of storing and managing reserved water supplies.



Overview of Gulf Coast Irrigation Division

The Gulf Coast Irrigation Division diverts water from the Colorado River for agricultural use through both a specific water rights permit LCRA holds with the Texas Commission on Environmental Quality for this irrigation operation (acquired in 1960), and the use of stored water from the Highland Lakes, which LCRA operates under more general water

rights permits. It has a serviceable area of 490 square miles, 350 miles of managed canals, and approximately 2,400 structures. Figure 2 presents an overview of the entire Gulf Coast Irrigation Division.

The control or "check" structures include bulkheads, water boxes, slide gates, flash board risers, pipes and valves, pipe headers, crossings, siphons, under-drains, bridges and foot bridges. The existing check structures are original and date to approximately the 1920s and 1930s. The picture to the right depicts a typical structure.

Typical Gate Structure

The major crop grown is rice (~85% in most years) with the remainder in turf grass and row crops. In 2010, about 22,300 acres of rice was planted, and 14,400 acres of that was watered for a second crop. In addition, about 7,350 acres was watered for turf, row crops or to create ponds for attracting wildlife. Total diversions for the Gulf Coast Irrigation Division have ranged from approximately 84,000 acre-feet per year to 198,000 acre-feet per year in the last ten years.

LCRA Capabilities

As a large organization with diverse lines of business, LCRA is uniquely positioned to complete most of the work for this gate rehabilitation project internally. The Smithville Rail Fleet Maintenance Facility (LCRA Smithville) maintains more than 2,000 aluminum railcars that transport western coal from Wyoming mines to the Fayette Power Plant. The highly respected metal fabrication team at Smithville supports projects for other LCRA energy and water operations as well, including fabrication of new floodgates for a recent modernization project on LCRA's Max Starke Dam. The slide gates proposed for this project will be fabricated by the Smithville facility.

LCRA also offers low-cost, reliable telecommunications services to employees and a limited number of communities throughout Central Texas. With more than 40 radio sites strategically scattered within LCRA's service territory, radio coverage reaches from counties around the Highland Lakes to Matagorda County along the Gulf Coast. LCRA also has the ability to offer collocation tower space. In the mid 1990's LCRA began investing in maintenance equipment for its three irrigation systems (track hoes, bull dozers etc.) and now is fully capable of all canal maintenance. Today, LCRA has a trained staff capable of installing the check structures proposed in this project with limited training assistance from staff engineers and a consulting engineering firm.

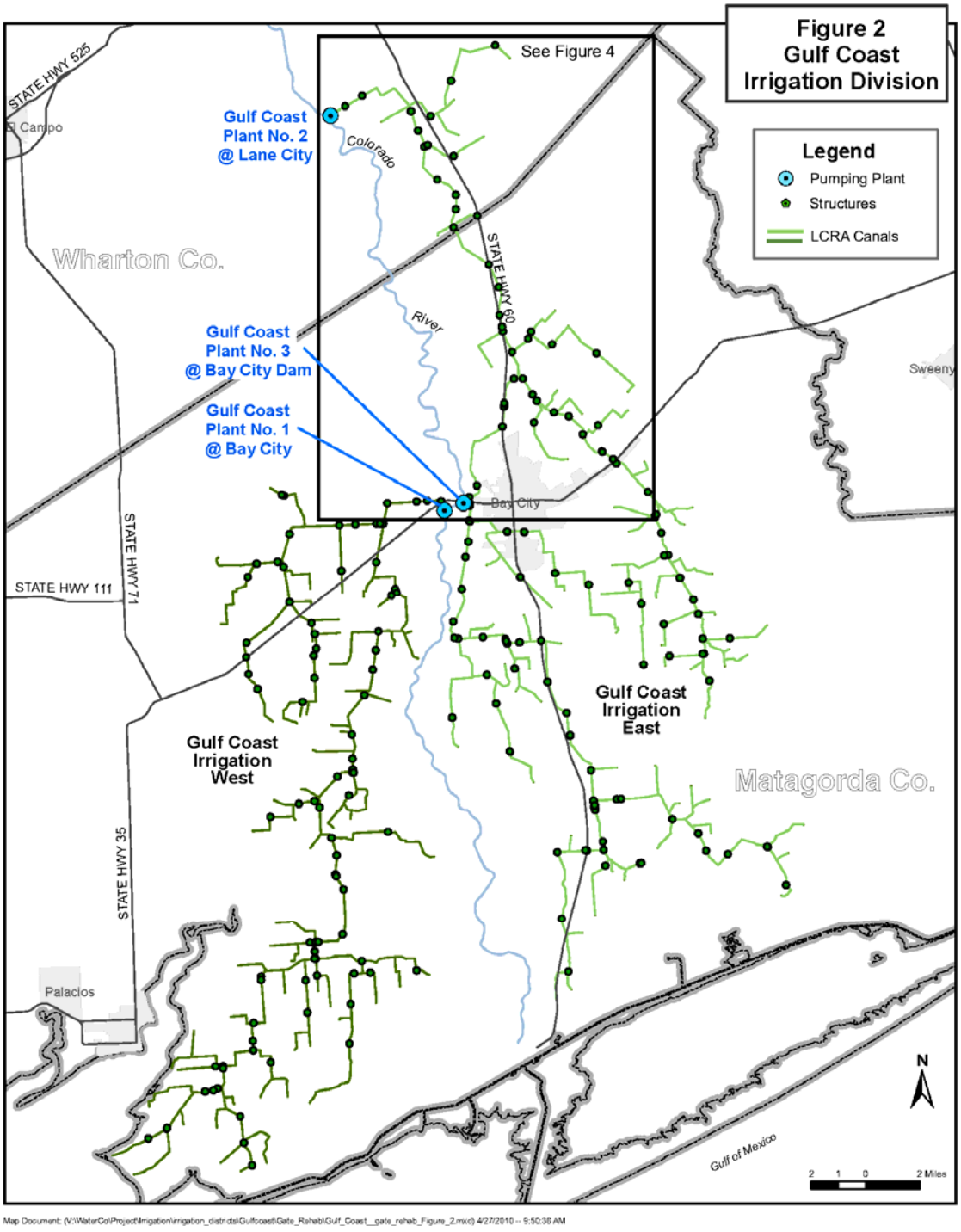


Figure 2. Gulf Coast Irrigation Division

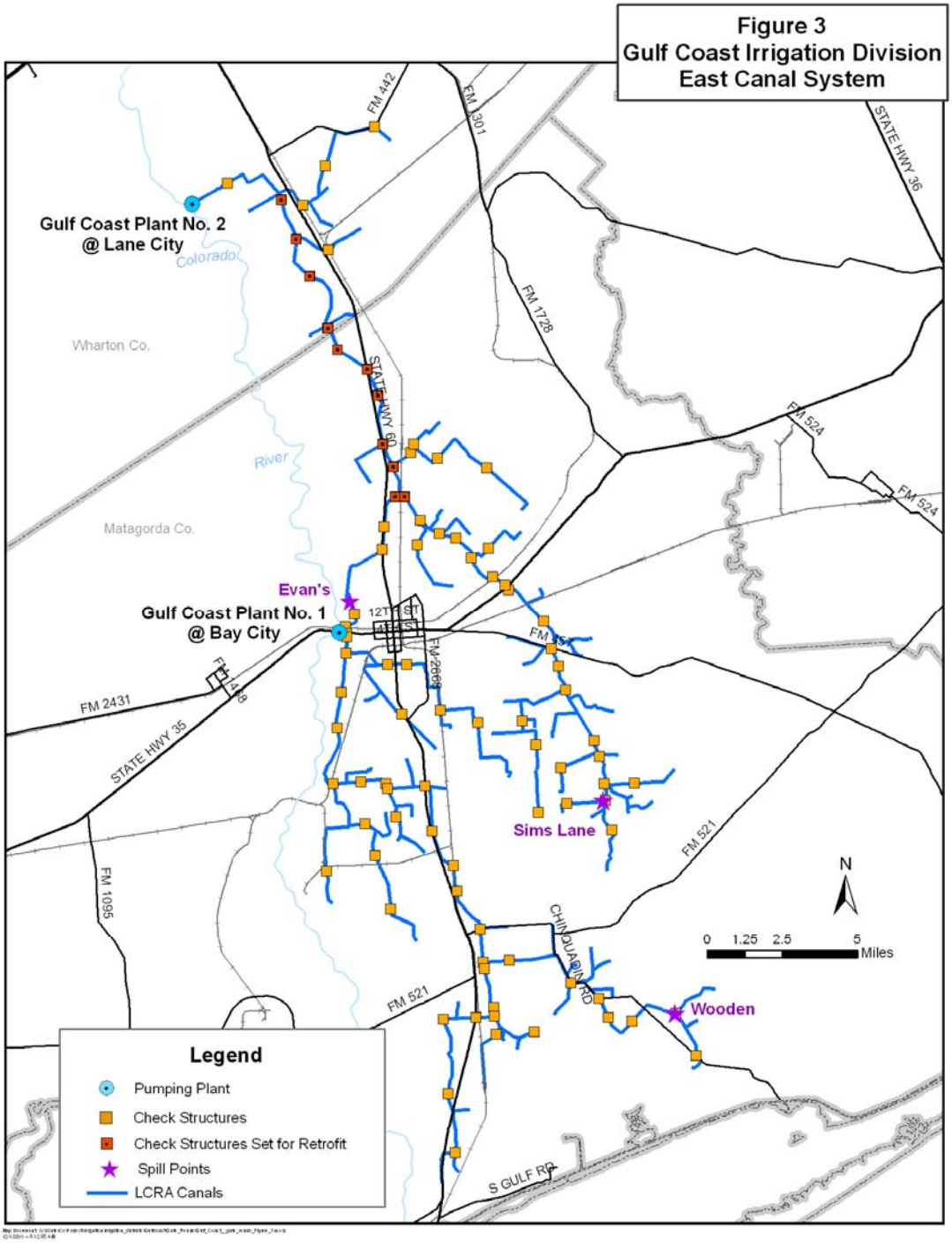


Figure 3. Gulf Coast Irrigation Division, East Canal System

TECHNICAL PROJECT DESCRIPTION

Project Overview and Approach

The objective of this project is to retrofit and automate 11 check gate structures within a selected section of the eastern canal system in LCRA's Gulf Coast Irrigation Division. Each check gate structure will consist of two (2) aluminum slide gates with actuators and instrumentation for automatic control. Other project features include 3 spill monitoring sites, a radio based data communication system (DCS), and a supervisory control and data acquisition (SCADA) system.

Figure 3 presents an overview of the eastern canal system with possible spill monitoring sites. The master radio and SCADA components will be located at the main office, which is adjacent to the Gulf Coast Pumping Plant No.1.

The project is organized into 3 basic areas as shown in Figure 3 and include:

Field Structures and Devices. These components are those elements in the canal system and include the check structures, and spill monitoring sites. The proposed field structures and devices include:

- A total of 22 slide gates, located at 11-check gate structure sites.
- 3 spill or overflow monitoring sites.
- Radio based data communication system necessary for communication and control.
- Solar powered electrical system.
- Remote Terminal Units "RTU" Controllers necessary for controlling the gates actuators.
- SCADA Data Base Application "ClearSCADA" necessary for monitoring and controlling the check gates.

Radio Data Communication System. This work includes the setup and integration of the new structures and devices into the LCRA's radio network. The design, equipment procurement, and installation will be by LCRA Telecom forces to provide a system fully integrated into LCRA's irrigation operations including the planned upgrades to the radio trunk system for LCRA's river diversion pumping stations.

SCADA Control System. This work includes development of the control algorithms, and data acquisition protocols necessary to control and monitor the new gate structures.

The work will be accomplished by a combination of internal LCRA forces and Axiom-Blair Consulting Engineers. Work responsibilities are summarized below:

- Engineering Design Plans – Axiom-Blair
- Gate Fabrication – LCRA Rail Car facility
- Construction – LCRA Irrigation Division Staff
- SCADA and Radio Data Communication System - LCRA Telecommunication (LCRA Telecom) and LCRA Engineering Services.

The SCADA component will add an important feature as it will provide LCRA operations the ability to better control water levels and flow rates within the canal and field delivery systems. This additional control will improve operating efficiency, reduce energy consumption, and conserve water.

Mechanisms by which the expected performance will be achieved include:
Reduce energy consumption by reducing the diving miles required to manually operate check gates.
Reduce pumping hours and motor run time by maintaining full canals and reducing the frequency and number of canal recharges.
Flow estimates by measuring the CFS through the gates using Bernoulli equation.
Conserve water by reducing the number of spills through spill measurement and monitoring.
Conserve water by remotely monitoring water levels.
Conserve water by controlling water levels to utilize the storage capacity of the canal system.

Project Plan and Status

Project execution is organized into the following 10 work tasks.

Task 1 Prepare Design Memorandum

A design memorandum was prepared to document and specify the conditions and design parameters to be used to prepare the construction plans and specifications, operation and control philosophy, and the protocols for integrating the various sub-systems (gate operation, radio telemetry, and instrumentation and control parameters) into a functioning system. Approval to proceed with construction was received from the Texas Historic Commission indicating that the gate structures are not historic monuments requiring special construction consideration, and from USBR, indicating that the project is in compliance with NEPA (National Environmental Policy Act).

Axiom Blair Engineering firm was responsible for the design of the Field Structures and Devices and prepared the design memorandum. It incorporated LCRA's requirements for the radio telemetry system, the SCADA system, and LCRA's Irrigation Division operational requirements.

Task 2 Prepare Plans and Specifications

Plans and specification necessary for the construction of the Field Structures and Devices, i.e. gates, gate operators, and spill monitoring structures have been prepared. A site reconnaissance was completed of each site in January-February 2011 to confirm dimensions for gate fabrication and installation, and any necessary site development work. The irrigation division is in off-season and the canals are empty from Nov-Feb, facilitating this task. This work was led by the design engineer Axiom-Blair, with support and information provided by LCRA.

Task 3 Equip Procurement

This task includes acquiring the necessary equipment and materials for the field devices, radio system, and the SCADA system. All of the major equipment identified for the project was acquired under existing LCRA contracts.

Task 4 Gate Fabrication

This task is to fabricate the 22 USBR type automated slide gates and will be lead by the Lead Engineer at the LCRA Rail Fleet Maintenance Facility in Smithville, TX, which specializes in aluminum fabrication. A test gate was fabricated to work out production details and provide the irrigation division staff a concept of how the gates will be installed.

Gate dimensions and material specifications were modified during the preparation of plans and specifications to a front bolt-on mount design instead of a slip-in design to allow the gate to open above the highest water level in the canal, allowing the manual gate to function as originally designed in the event of a malfunction. The following gate specifications were used:

- Gate Frame: 3-ft to 5-ft wide by 10-ft to 14-ft tall
- Gate Leaf: 3-ft to 5-ft wide by 6-ft tall
- Aluminum Plate: Grade 6061-T651, 0.378” thickness.
- Bolts and Fasteners: all stainless steel. Grade to be determined.
- Slide Strips: UHMW-Black 3M CVT Lam-N-Hard Pressure Sensitive
- Gate Actuator: Venture Actuators MA-8A4358653-64M

Task 5 Gate Installation and Field Construction

This is the construction part of the project and is being completed by LCRA forces. Activities include performing the necessary site preparation for installation of the fabricated gates, upgrading spill monitoring sites and their related support equipment, e.g. actuators, electrical supply, instrumentation etc.

Installation of tower foundations was completed in September 2011. Control cabinets were installed in October-November 2011.

The effort is being led by the LCRA’s Irrigation Division with support and inspection by LCRA Engineering Services. The majority of the work associated with this task must be completed during the non-irrigation season.

Task 6 DCS and SCADA System Integration

This task is related to the development and integration of a radio based data communication system to reliably communicate data from the field sites, (gates and spill sites) to the control room at the Gulf Coast division office. It will be led by the LCRA SCADA engineers with support from the LCRA Telecom group.

The radio systems being installed are GE iNet900 II radios for the 11 check structure and 3 spill monitoring sites. These radios will communicate back over LCRA's SONET Microwave network to Bay City Control Room ClearSCADA Server.

LCRA Telecommunications group has conducted a detailed signal survey to confirm that no repeaters are needed. All of the sites are within 20 miles of the Master radios.

General specifications of the radio system are:

- Location of Tower: Existing LCRA tower at the Bay City office and Lane City
- FCC and RF Band: Unlicensed 902-928 MHZ ISM
- Number data radios:
    - Check Structures – 11
    - Spill Structures – 3
- Antennas (for both types) – MAXRAD 12db Onm i and Yagi
- Minimum Antenna height: 30-ft
- Radio types
    - Check structure: GE iNet900 II
    - Spill Structures: GE iNet900 II
- Power Supply and Battery Backup: 12 VDC 3A minimum – 300AH battery capacity
- Surge and Lightening Protection: To be determ ined- as required by LCRA Telecom

Data from each site will be polled and received at two master radios located at the Bay City Office and the Lane City. Radio data will be fed into a the Irrigation SCADA network. The antennas are located on existing LCRA towers.

The radio towers ended up being re-designed from the design envisioned in the original grant proposal (based on a similar project in the Rio Grande Valley) to follow LCRA safety standards and allows maintenance to be done by climbing the tower instead of needing a bucket truck to perform maintenance. The original proposal from LCRA Telecom was for a much more expensive and larger tower with a larger concrete base. The final design was a compromise to take safety concerns as well as cost concerns into account.

Task 7 SCADA Programming

This task includes programming of two components: the first is the SCADAPack RTU controller programmed using Telepace software and data reporting necessary to operate and monitor the gate installations via the radio data communication system. All Communication will be done over TCP/DNP3 Protocal. This work will be led by Axiom Blair with support from LCRA. LCRA will provide to Axiom Blair control equipment and SCADA software including:

- SCADAPack 350 RTU's.
- Telepace Programming Software.

The second SCADA component is ClearSCADA advanced human machine interface (HMI). This work will integrate the new gate system into LCRA's radio data communication systems for the pumping plants and other internal systems required by LCRA. The canal gates will have the ability to be controlled remotely from the Bay City Office control room. An LCRA Irrigation Operator will be able to set the gates in auto upstream level control or (STO) "Set to Order" gate height. This advanced HMI programming work will be done by LCRA Engineering Services and will include:

- ClearSCADA Data Bace Software ViewX Run Time, Alarming, and Historian.
- The server will be a Dell R410 Class Server

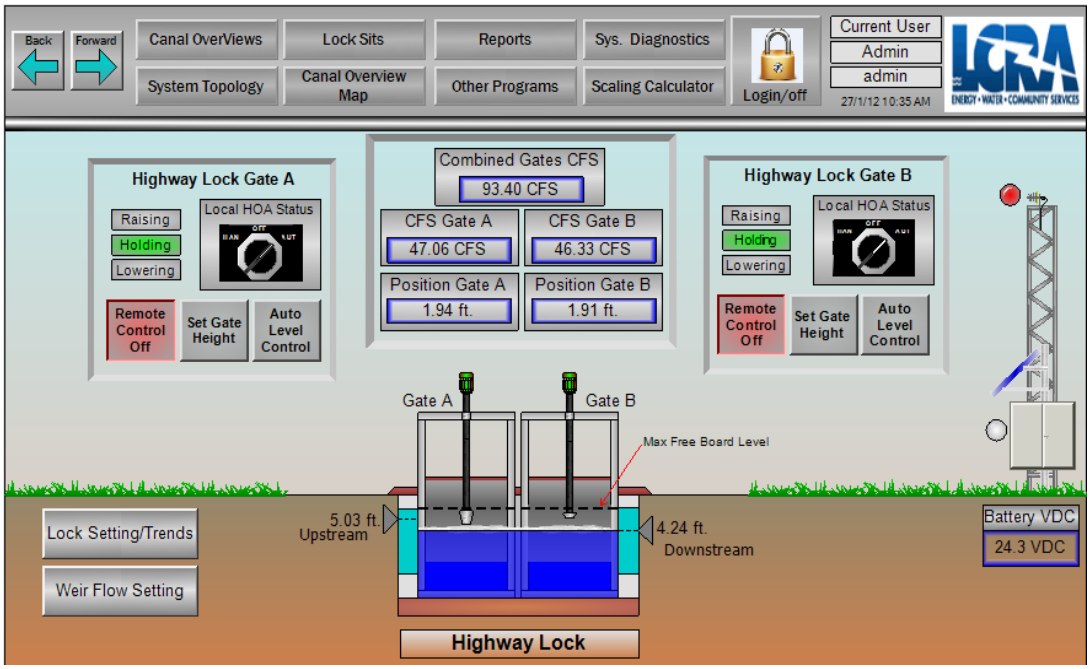


Figure 4. SCADA control user interface

Task 8 Startup and Acceptance Testing

This task includes the work required to integrate all of the various sub-systems; check structures, spill monitoring, and radio DCS into a functional check structure monitoring

and control system. Work will include performance and reliability testing, and acceptance testing required by Gulf Coast Irrigation Division operations. This effort will be led by LCRA Engineering Services.

Task 9 Regulatory and Conservation Reporting

This task includes the work required to comply with federal laws and regulations related to the project, and the project performance reports required by USBR. These efforts have been led by LCRA with assistance from USBR and LCRA's cultural resources team, which assisted with the assessment of state historical commission rules. Approval to proceed with construction was received from the Texas Historic Commission in the fall of 2010 and the USBR officially notified LCRA that the project meets all regulatory requirements in the fall of 2010. A final project report to USBR is due at the end of the project.

Task 10 Project Management

This task includes the work necessary to plan, execute, procure, control, and closeout the proposed project. These project management functions include but not limited to organizing and directing the project team, progress meetings with USBR, processing payment requests, updating project schedule, and preparation of progress reports.

CONCLUSION

To date, the successful collaboration of many LCRA departments has led to the development of quality gates and communication systems for the Gulf Coast Irrigation Division's gate rehabilitation and control project. The main challenge with this project has been managing cost over-runs. There was a philosophical difference of opinion between LCRA Telecom services and LCRA's irrigation division staff in the design requirements for the radio towers. Most of the work done by LCRA Telecom services is for much larger projects where 100% reliability is essential and the cost of a radio tower is a small percentage of the budget, such as Substation Yards and vital emergency radio systems for Fire, EMS and Police. Irrigation division operating and maintenance budget is picking up a substantial portion of the labor cost shortfall, and the LCRA Board recently authorized an additional $90,000 to be spent from the HB1437 fund to complete the project. The short project completion window of 24 months required by USBR has also been a challenge since re-design decisions had to be made quickly to adhere to the tight schedule. If all or a substantial proportion of LCRA's three irrigation divisions are to be retrofitted with these gates, the cost per site must decrease to become economically feasible on a large scale. If the same gate design is retained, design engineering costs will reduce substantially with future projects. Another remaining challenge with this project is to quantify the water savings achieved as a result of these gate improvements to verify the current water savings estimate. The main purpose of installing instrumentation at three spill points was to assist with this goal. Water delivery efficiency will also be assessed, taking weather fluctuations into account, but it could take five years or more to accumulate the data needed to verify savings estimates.