Taming The Missouri River With Wireless Flood Control

Eric P. Marske
Customer Service Engineer
Electronic Systems Technology, Inc.

William J. Higgins, P.E.
Electrical Engineer
Delich, Roth & Goodwillie, P.A.

Kansas City was one of the hard hit areas during the floods of 1993 that devastated the Midwestern United States. The Fairfax Levee in eastern Kansas City, Kansas probably would have failed during the high Missouri River levels without an intricate network of pumps, pressure relief wells, and wetwells all operating together to maintain the ground water level. During the flood, all pump stations were constantly manned and operated by hand. This complex network of pumps and valves is now being controlled by a wireless distributive control network using Square-D Programmable Logic Controllers (PLC) and ESTeem Wireless Modems. This new control system is designed to provide a major reduction in labor during times of high river conditions and prevents a disaster to the businesses that operate in the drainage district. The Fairfax Levee is part of the Fairfax Drainage District in Wyandotte County, Kansas (Figure 1).

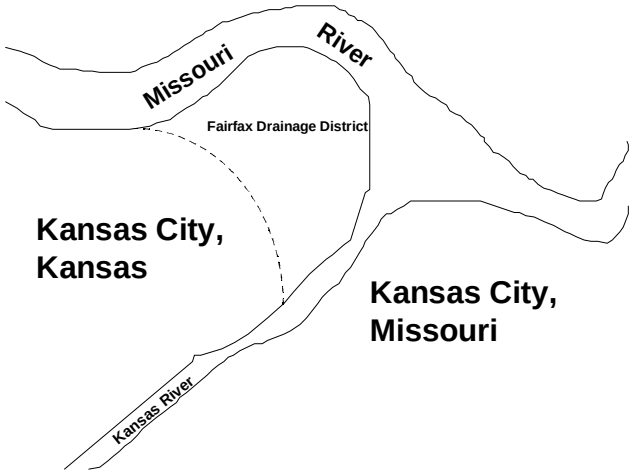

Figure 1 - Fairfax Site Layout Diagram

The levee runs along a turn in the Missouri River that flows through Kansas City and converges with the Kansas River. This historical water transportation area is still a major supply route for the area. The system protects all businesses that operate in the district boundaries including, a major General Motors assembly plant. The control system is designed to monitor and control a total of forty-three pumps in eleven pump stations. The pump stations receive water from storm drainage and pressure relief wells located on the land side of the Fairfax Levee. During high river levels, the pressure relief wells discharge into a system of collection headers which transport the flow to the pump station wetwells. The pumps operate to empty the wetwell. Without the pressure relief wells and pump stations, the levee could fail during high river levels. The radio frequency (RF) network consists of eleven remote pump stations sending information to the district office (Figure 2).

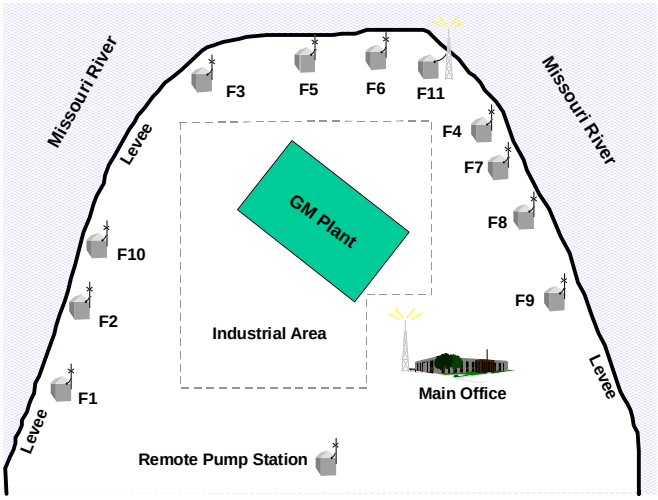

Figure 2 - Fairfax Drainage District

Each of the eleven remote pump stations has a Square D PLC and an ESTeem Model 96C, UHF wireless modem (Figure 3). The furthest distance from the main office to the most remote pump station is six miles. Omni-directional antennas are mounted atop the roof of each pump station. All pump control for each station is performed by the PLC at the station. Each PLC provides the following control and monitoring functions:

- Starts and stops pumps based upon wetwell levels
- Monitors motor current
- Monitors wetwell level

- Lead/Lag Rotation of pumps
- Monitors station entry
- Monitors sluice gate positions

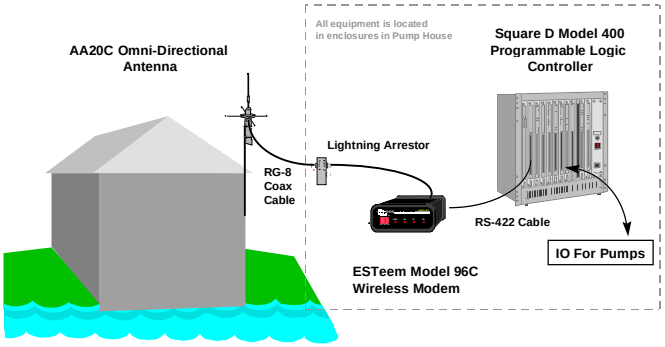

Figure 3 - Typical Remote Pump Station Diagram

The district office communicates with all remote stations through an ESTeem Model 96 Wireless Modem and an omni-directional antenna mounted on a fifty-foot antenna tower (Figure 4).

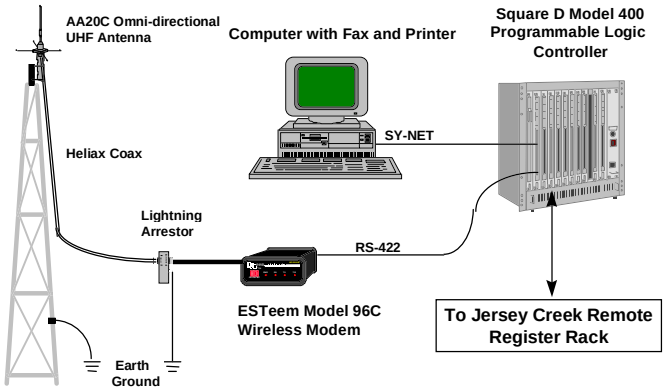

Figure 4 - District Office Diagram

The district office PLC acts as a data concentrator for the entire system and also controls the Jersey Creek Pump Station. Each remote PLC reports by exception to the district office PLC. Wonderware, a user interface software, uses Windows DDE link to access the data table of the district office PLC. This table contains all current information and status for each pump station. This operator interface is a network connection and responds very quickly. The Wonderware software provides a graphical representation of the operating status of the remote pump stations. Communication is initiated by the pump stations to the district office, unless the operator wishes to change start and stop levels for the pumps or put stations into an override mode. In override mode, the operator takes direct control of pump starting and stopping. While in this mode of operation the operator's screen shows whether the processors are operating and their key switch position. Because the ESTeem modems act as Network Interface Modules, the status registers can be accessed to check the PLC's operational status. Each station PLC has an internal timer. If the station PLC has not initiated a communication to the district office PLC within any thirty minute period, it will automatically initiate a communication and upload its data table. This assures the most up-to-date information to the operator.
The ladder logic, written by William Higgins, of Delich, Roth & Goodwillie, P.A. Engineers, is used to program multiple communication routes for each pump station (Figure 5).

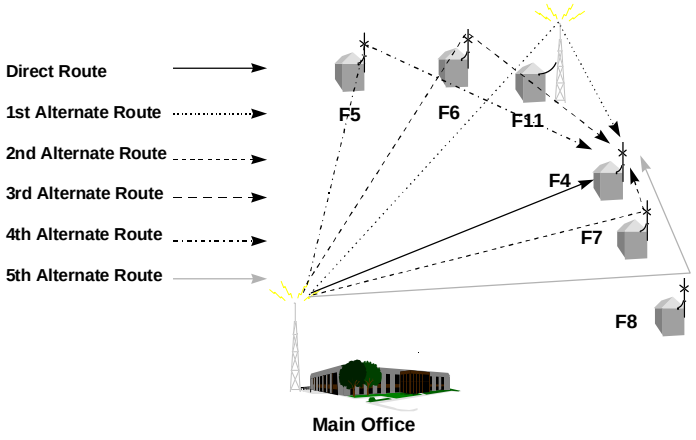

Figure 5 - Alternate Route Diagram

The initial communication is direct between each pump station's ESTeem Model 96C and the district office. When communication is initiated the PLC's internal timer is activated. The sending station then waits for a valid response from the receiving PLC. If a valid response is not received before the timer times out, the ladder logic changes the communication route to go through a repeater. An antenna mounted on a forty-foot wooden pole located at Pump Station F11 can receive signals from any station along the Levee and is an excellent relay site for all pump stations. The ESTeem modem can act as an independent node, a repeater or both concurrently. If the first repeater route is not successful, another repeater route is tried. Each PLC has at least five alternate routes. Following a successful transmission, the PLC will stay in the alternate route for twenty transmissions. The direct route is tried again on the twenty-first transmission. On subsequent communication failures, the modem starts at the last successful alternate route. Using this method, the PLC always seeks out the most reliable communication route.

Each successful alternate and direct communication are counted and transmitted to the district office PLC for display on the operator's screen. If an alternate route is being used, the repeater station is also displayed. This allows the operator to monitor each station and detect any communication problems.

A wireless network was found to be an economical solution for the Fairfax Drainage District control system. No residual costs were associated with the wireless system, except for maintaining the FCC license. The following were some of the reasons why radio communication was selected:

- Buried cable could be destroyed during excavation work for levee construction projects.
- Overhead twinax or fiber optic cable would be susceptible to damage from vehicles using the levee.
- The construction and leased line costs associated with a telecommunication system made this option cost prohibitive.

Some of the advantages of using a wireless control network consisting of the ESTeem radio modems and Square D PLC's at the Fairfax Drainage District were:

- Each PLC is independent of every other PLC in the network.
- Additional nodes can be easily added to the network without changing the entire system.
- ESTeem radio modems have an integral Square-D driver to directly interface to the processor and act as a network interface module on the Square D network.
- The ability to change the communication route in the ladder logic of the PLC.
- Proven reliability of the hardware in this and similar applications.

The wireless network controlling all aspects of the Fairfax Levee operation has proven to be a reliable solution for the Fairfax Drainage District. When asked what lessons he had learned about working with radio communication, the system integrator wrote "Don't be afraid to use radio communication. Since the system has been operational, the communication links have been the most reliable part of the system."