**REAL-TIME FLOW MEASUREMENT IN**
**CACHE VALLEY IRRIGATION CANALS**

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## ABSTRACT

Increased stress on water resources in Cache Valley, Utah has caused a need for improved water management on the irrigation canals throughout the valley. Through a joint project with the Utah Division of Water Rights (UDWR), the Utah Water Research Laboratory (UWRL), various canal companies, and Utah State University (USU), a data acquisition and telemetry system was expanded to include several irrigation canals which take water from the Logan River. With the cooperation of the Logan River Commissioner and several canal companies, new stations were set up to monitor the flow rate on seven irrigation supply canals. Through the use of digital shaft encoders and a radio telemetry system, real-time flow data are now publicly available on the UDWR website. The installation of this system is expected to help improve water regulation throughout the valley. The readily available flow monitoring data has made water managers' jobs easier, as well as providing water users with a more efficient way of monitoring water levels in order to conserve water throughout the irrigation season.

## INTRODUCTION

### Background

Historically, due to water abundance, there has been no need to actively regulate water withdrawals from the Lower Bear River. However, recent years of drought have caused increased stress on the water resources of the lower Bear River in Cache Valley, Utah. As water grew scarce in a recent summer, some water users continued to pump more than their given allocation from the Bear River. It takes about five days for the river commissioner to physically visit each of the pump stations along the river, allowing water users to run their pumps for several days before being noticed, or simply stop pumping when they knew the river commissioner would be passing by.

In order to solve this problem, the UDWR implemented a data acquisition and telemetry system to provide better and more frequent information for the monitoring and documentation of withdrawals from the river. Since the spring of

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2005, some 120 stations have been set up at pump sites and open-channel measurement flumes along the lower Bear River in northern Utah. Each station transmits water depth or flow data to the UDWR base station in Logan via radio signal. The data are then sent to the UDWR server in Salt Lake City, are processed using calibration and other algorithms, and are made available to the public on the UDWR website.

In the spring of 2006, the Logan River Commissioner contacted the Biological and Irrigation Engineering Department at USU to request help with irrigation water management on the canals which take water from the Logan River, a tributary of the Bear River. The UWRL, through USU, provided funding for the design and implementation of a data acquisition system at sites in seven of the canals. The list of sites was provided by the Logan River Commissioner, Ms. Colleen Gnehm, after a review of the condition of extant mechanical water level recorders. Some of the required SCADA equipment was purchased by the UWRL, and the rest was supplied by the UDWR, but both collaborated on the installation at the various canal sites. Canal company personnel also assisted in the installations, providing some tools and labor to complete the process.

## METHODS AND DESIGN

### Project Overview

The design consisted of a data acquisition and telemetry system, along with a power supply, at seven existing Parshall flumes and broad-crested weirs, all of which operate exclusively under free-flow conditions. Thus, a single water level measurement was sufficient to determine the flow rate at each measurement structure. In locations where the radio signal was unavailable or too weak due to obstructions from trees or buildings, a data logger was used in place of the telemetry system to record, rather than transmit, flow measurement data. This was the case at two of the seven sites. A summary of the project components and their respective uses is given in Table 1.

A small shelter houses the data acquisition system at each site, protecting it from the weather and vandalism. The shelter rests over a stilling well, and the depth of water in the well corresponds to the depth of the water in the canal on the upstream side of a measurement flume or broad-crested weir. The stilling wells were connected to the measurement structures through a standard tap, according to their design. The digital shaft encoder was installed in the shelter on a wooden board over the stilling well. The new encoders and float assemblies replaced the existing and dilapidated Steven’s recorders, which were removed. The encoder was connected to a pulley with a float and counterweight which was placed inside the stilling well.

Table 1. Summary of Project Equipment.

| Equipment | Use |
|---|---|
| **Telemetry System** | |
| Repeater Antenna | Relay radio signal to base station at UDWR |
| Transmitter and Antenna | Send flow measurements to repeater antenna |
| Signal Converter | Convert SDI-12 from encoder to RS-232 for radio transmission |
| **Data Acquisition** | |
| Digital Shaft Encoder | Measure depth of flow in canal and transmits via SDI-12 signal |
| Data Logger* | Record depth from encoder and convert to flow rate |
| **Power Supply** | |
| Solar Panel | Collect sunlight and convert to power |
| Solar Controller | Prevent solar panel from overcharging the battery |
| Battery | Provide power to the system |

*only used on sites where radio reception was unavailable

In order to transmit flow data from various locations around Cache Valley to the UDWR base station, a network of repeater towers was necessary, providing line-of-sight coverage. One such repeater tower was placed on the roof of the Engineering Building at USU (Figure 1). To establish signal connection with the repeater antenna, a radio antenna and transmitter were mounted on a steel pole that was cemented into the ground next to each shelter (Figure 2). Water level data are then transferred from the UDWR base station in Logan to the server in Salt Lake City for display on their web page (http://waterrights.utah.gov/cgi-bin/dvrtview.exe?Modinfo=Collection_Sysview&COLLECTION_SYSTEM=LBEAR).

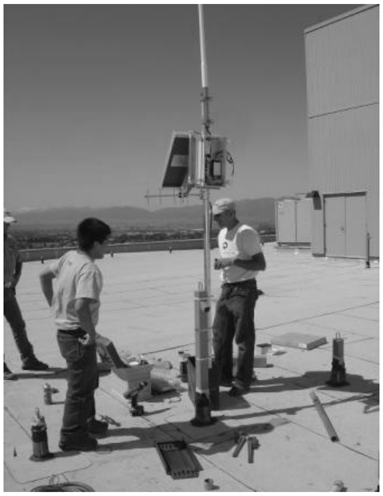

Figure 1. Installation of the Repeater Antenna on the USU Engineering

Figure 2. Installing a radio antenna and solar panel next to a shelter at a Parshall flume.

**Component Details**

The radio signal used in this project is a license-free, low power, 100-mW frequency. The antennas are 900 MHz, spread-spectrum, 9dBi Yagi antennas, manufactured by HyperLink Technologies. They were coupled with an XStream-PKG-R RS-232/485 RF modem manufactured by MaxStream. The modem, or transmitter, has a range of up to 20 miles with a high-gain antenna. The transmitter uses an RS-232 serial port to receive data from the encoder, thus it was used in conjunction with a RS-232 to SDI-12 host interface manufactured by Water Log Series to allow communication with the encoder (Clayton and Hunt 2007). The digital shaft encoders used were Enviro-Systems SDI-12, model SE105S. A Water Log Series model H-500XL data collection platform was used where adequate radio signal strength was unavailable. The data logger has an SDI-12 input and three RS-232 serial ports for interaction with a PC that allows data to be downloaded directly to a portable computer. This eliminated the need for installation of a SDI-12 to RS-232 signal converter. In addition, the logger has a built-in key pad and display for programming in the field. It also has a PC card slot that can be combined with a compact flash card for data download, eliminating the need to take a laptop computer to the field. The logger also has extra ports for additional data logging capabilities, which allows expansion for future water management developments.

Each station was powered by a 16 x 19 in., 20-watt solar panel connected to a 4.5-amp solar controller which prevents the batteries from being overcharged. Sealed, lead-acid 12-volt, 24 amp-hour batteries were used at each site.

## Installation

Installation procedures of the encoders and telemetry system varied at each location, as the conditions at each flume or weir were quite different. In many cases, overgrown vegetation had to be trimmed back in order to gain access to the stilling-well enclosure. In some cases, the board covering the stilling well had to be replaced, as shown in Figure 3. In other cases, existing base boards and cable holes from the old Steven's Recorders were used (Figure 4).

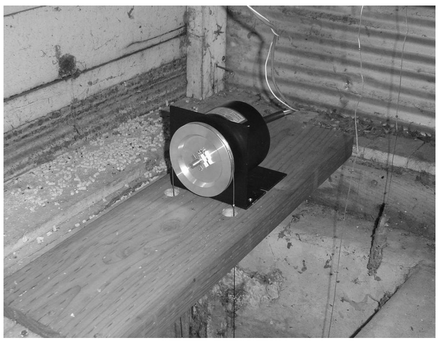

Figure 3. New Digital Shaft Encoder

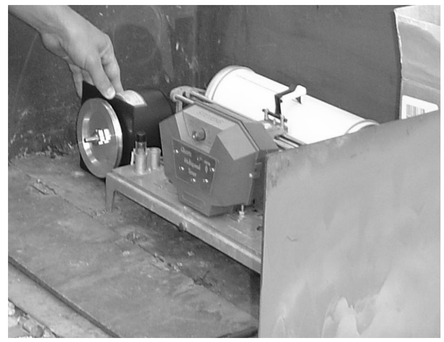

Figure 4. A New Encoder Next to an Old Steven's Recorder

The radio antenna and transmitter, along with the solar panel and controller were mounted on a steel pole that was cemented into the ground next to the shelter. In one case, the antenna and power supply was installed on the roof of a neighboring business building to provide adequate radio reception to the site.

Data loggers were programmed to record date, time, battery voltage, water depth, and flow rate. To determine the flow rate, the free-flow equation was programmed into the data logger using coefficients and exponents that were obtained from calibration measurements of the specific flume or weir of the site. Records and observations show that the flumes at these two locations have a downstream drop in canal bed elevation and never operate under submerged-flow conditions.

The five new stations with radio reception that were set up on the Logan River canals were assigned a unique address for identification in the existing system. Each station in the system is assigned a specific address, or numeric code, for identification by the UDWR server. To gather data, the system sends out each address sequentially. Each station responds by sending back its address, voltage, and flow rate. If the address is correct and the values look reasonable, then the data is recorded. If the station does not respond, the system goes through a certain number of "retries" in order to gather data before passing on to the next station on the system. This number is defined by the administrator and is partially based on the signal strength at each station (stations with weak signal strength tend to require more retries).

Once the system has called (or attempted to call) every station, it automatically starts over. If the system runs through a complete cycle of all stations in under five minutes, a sleep mode is invoked until the five-minute period is reached, at which point the call cycle begins again. However, the cycle has never been completed in less than five minutes in this system, especially with the recent addition of several new stations.

The two stations without radio reception are manually integrated into the system as the River Commissioner gathers the data during the normal weekly route of checking pumps, flumes, and measurement weirs. The data can either be downloaded by the use of a data card that inserts directly into the data logger or by hooking the data logger up to a PC for direct download. A manual was written for the River Commissioner on how to utilize the data loggers.

## RESULTS AND DISCUSSION

As this project was only recently completed, direct impacts of the system on water management have not yet been determined. However, as other projects of similar nature have shown, the beneficial effects will be felt by both water managers and users alike. Administrators of the lower Bear River project have stated that the publicly available data has solved a number of water disputes between farmers. Similar results were seen in the Sevier River Basin, where a large-scale SCADA system has improved water conservation and provided easier decision making for water managers (Berger et al. 2006). Dr. Mac McKee, director of the UWRL, commented on how the system has improved management during years of drought and reduced water disputes (McKee and Khalil 2006). It is expected that the addition of data from the Logan River to the system already in place on the lower Bear River will have similar effects.

This project has shown how major organizations can successfully cooperate to improve water management and conservation. The UDWR provided the technology and design of the telemetry system, and the UWRL provided funds to complete the project. The expertise and effort of USU faculty and students were a valuable resource for both labor and problem solving. Last, but not least, local canal companies provided labor and tools to assist with the equipment installation. As a result, all organizations involved have gained valuable experience in cooperating to improve circumstances for both water managers and water users.

## SUMMARY

Through the combined effort of the UDWR, UWRL, USU, and various canal companies, the lower Bear River SCADA system was expanded to include the canals of the Logan River, a major tributary of the Bear River. Digital shaft encoders, radio transmitters, and data loggers were installed to bring accurate and timely data to water managers and water users through the UDWR webpage. The implementation of this project is expected to improve water regulation throughout Cache Valley, which will help make a positive impact on the local water supply and water conservation in general. The cooperation of state and local organizations serves as an excellent example of how to use all available resources collaboratively in order to enhance water management.

## REFERENCES

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