**Data Loggers Provide Cost Effective System Monitoring,
Alarming and SCADA Backup**

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Abstract

In an era of sophisticated and powerful control systems, the simple data logger continues to play an important role in the operation of water utilities. The Massachusetts Water Resources Authority uses a Supervisory Control and Data Acquisition system but still recognizes the value and versatility of data loggers.

Monitoring and Control System Development

The Massachusetts Water Resources Authority (MWRA) provides wholesale water service to 2.2 million people in 47 communities over an area 80 miles wide. In order to provide monitoring and/or control of 76 facilities and 161 revenue meters, the MWRA has developed a comprehensive system using Supervisory Control and Data Acquisition (SCADA) and data loggers.

Fifteen years ago the monitoring and control system tracked tank levels with mechanical floats and recorded meter flows with underground windup chart recorders. At that time maintenance staff made weekly meter visits to wind the chart recorders and replace the circular chart paper. In 1989 the MWRA began its shift to digital devices by selecting a single channel data logger produced by Telog Instruments to replace the chart recorders. This change reduced the level of meter maintenance and improved the ability to accurately bill water usage. The new data loggers only required monthly visits for installing fresh batteries and downloading the data that was stored as 15-minute average values.

In the mid 1990s a meter modernization program brought power and phone service to the meter chambers. Along with the utilities came an upgraded data logger that stored 4 channels of data and was accessible by modem. Maintenance labor hours dipped again as the recorder now had an AC power source and its data could be downloaded remotely.

A new era had begun. Operators could call meter sites with a PC and see real time or historical pressure and flow data. The data loggers in turn could call the operators to notify them of alarm conditions that might indicate a water system failure. The initial success brought acceptance and more success as the data loggers were used to monitor and record information at tanks, reservoirs, pressure reducing valves and water quality monitoring sites. At the same time the data loggers were becoming ubiquitous the MWRA was installing the beginnings of a SCADA system. The operators' experience with the data loggers and the associated PCs was excellent preparation for a transition to the remote control and monitoring of the new SCADA system.

In the late 1990s and early 2000s the use of data loggers continued to mature and grow along with the SCADA system. The data loggers were upgraded again, this time to a 14-channel model. Locations with multiple units could be consolidated into one. Additional information and alarming on conditions such as AC power failure and chamber flooding became standard. With this upgrade came a marriage of the data loggers and the SCADA system. This was accomplished with a new driver for the SCADA system and by

installing data circuits. Many data loggers now have both a dial-up connection for intermittent use and a data circuit connection for continuous communication. The data circuit allows polling by the SCADA system. Once the data is on the SCADA system, it is passed to historian software and is then made available to managers at home and in the office.

Advantages and Disadvantages of Data Loggers

Assuming the alternative to a remote data logger is a SCADA system then the data logger presents a number of advantages and a few disadvantages. On the top of the list of data logger advantages is the ease of installation and configuration. Where a SCADA system requires custom programming of the operator interface and the controller, a data logger only needs to be configured through simple database entries and option selections. This can save significant time and money.   Savings can also be found in the capital and operating costs of data loggers. Depending on the features selected, data loggers with modems costs on the order of $1,100 to $1,800. Programmable Logic Controllers (PLCs) and associated communications devices that can be used to fill the same role in a SCADA system cost on the order of $1,400 to $4,600. Assuming data communications occur over a wired phone system, respective monthly phone bills are approximately $24 for a data logger's voice grade line and $80 for a PLC's data circuit.

Other non-monetary advantages of data loggers include their low power consumption. The intermittent nature of data logger communications and the modest current draw of its electronics allow for battery powered operations that can be independent for half a year at a time.   Another apparent advantage of the data loggers communicating over voice phone lines versus PLCs communicating over data circuits is that the voice lines in the MWRA system area seem to be more reliable. Over the past two years the MWRA's water system has experienced data circuit failures at three times the rate of voice line failures. This may not be a fair comparison since the data circuits are constantly being monitored and the voice lines are not. So it is possible that voice line failures occur at the same rate as data circuit failures but are temporary and go unnoticed.

Of course the main disadvantage of a data logger compared to a SCADA system is the lack of process control and remote control. Data loggers generally do not provide output signals that can be used to drive equipment or relays. Another disadvantage of data loggers relates to the last stated advantage. Because the data logger's voice line is not constantly in use, there is always a small degree of uncertainty whether an alarm condition will be properly reported. The MWRA's partial solution to this problem is to test all phone lines daily and to automatically issue an hourly test alarm to make sure that the incoming phone line, the computer server and its software are not experiencing problems. If an hour goes by without any alarms including the test alarm, the operators know something is amiss and report the failure.

Data Loggers Roles

Given the versatility and advantages of data loggers the MWRA continues to make valuable use of them. The following list illustrates the variety of roles that data loggers play:

Revenue Data
One principle use of data loggers at the MWRA is the recording of meter flow data for revenue collection. High and low range differential pressure transmitters and fire flow bypass annubars are sampled every second and recorded as 15 minute averages. On a monthly basis this data is compiled and distributed to the service communities in a one page summary that compares their current month's use to that from a year ago and notes their percent change compared to other communities.

Water System Monitoring
Every day operators periodically check the health of the water system. Data loggers and the SCADA system are used to monitor tank and reservoir levels, pressure reducing valve (PRV) performance, water quality parameters and other facility functions. Secondary water system facilities such as some standby reservoirs and flood control reservoir are primarily monitored with data loggers. Data loggers and the SCADA system monitor vital system parameters for abnormal events. High and low alarms are transmitted to the Operation Control Centers where operators can react to the problem at hand.

Troubleshooting and Post-Mortems
When a pressure drop to a community occurs, one of the first reactions is to check the data loggers or their data feed on the SCADA system to see if other services are experiencing the same problem. If that is the case, the data is reviewed for signs of a water line break or a low tank level. If the problem is isolated to a single community service the relative location of the break can be determined by checking the pressure and flow at the meter. Increases in flow and near normal pressure indicate a community pipe break. A distinct drop in pressure and flow indicate a MWRA pipe break. Problems with pressure spikes generated by pumping stations and discolored water from high water velocities can also be analyzed using the data loggers. The power of the data logger as an emergency response tool is matched by its value in performing post-mortems of system failures. A review of historical data can lead to the identification of the failure causes.

SCADA Backup
Occasionally tank level data or other critical process control feedback communications are lost and the real time display of data logger values becomes essential for the continued running of the water system. In these cases operators can use the data logger values for remote manual control via the SCADA system.

Valve Operations
In order to accommodate pipeline or valve construction projects, MWRA staff plan and execute major rerouting of water. A vital part of these operations is the real time monitoring of community pressures to make sure everything happens as expected. Valve crews also monitor for system impact during their normal valve exercising maintenance.

SCADA Supplement
At many locations the data loggers are tied into the SCADA system with data circuits. This union of systems provides a quantum jump in the monitoring reach of the SCADA system. Large numbers of metering sites can be displayed in real time simultaneously. Through the SCADA historian, metering data is made available to manager's desktops and over the Internet. During this upgrade the data logger system also benefited by the inclusion of trickle charged batteries that power the units during utility failures.

Compliance Data
Data loggers are still a data source for regulatory compliance reporting. Monthly reports to the Massachusetts Department of Environmental Protection include information collected by the SCADA historian and data loggers. If there is a problem with the SCADA data collection the data loggers also provide a secondary source to turn to.

Engineering Data and Hydraulic Modeling
Data logger flow and pressure data is readily available back to 1992 for engineering design. This historical data is used for meter sizing and pipeline projects. In some instances it is used on its own. In other cases the data is used as input for the MWRA's hydraulic model. Engineers and planners also use the data loggers for collecting system parameters during trial configurations that become the basis for future capital project design.

Mobile Units
In addition to the normal fixed data logger installations, the MWRA regularly uses portable data loggers to collect information on a temporary basis. Flows are recorded with data loggers connected to pitot tubes that are used to make quality control checks on adjacent venturi meters or to measure flows at sites without meters. Portable data loggers are also occasionally connected to community fire hydrants to monitor local pressures during special MWRA operations. The portable loggers are either read in the field with handheld data terminal units or are brought back to the office for downloading.

Equipment Maintenance
Data loggers play a role in equipment maintenance. In the past, PRVs experienced problems with pilot needle valve clogging. This was corrected by installing filters. In order to monitor the condition of the filters, data loggers record the differential pressure across the filters. High differential values trigger a maintenance visit for filter cleaning or replacement. A second data logger maintenance task is monitoring the automatic exercising of fire flow by-pass valves. Once a week PLCs exercise fire flow by-passes to make sure they are functioning properly and are ready to react to high flows from fire fighting. Data loggers are used to record these actions and provide information on failures

before they become critical. Other data logger maintenance tasks including monitoring their own battery condition and checking for flooding in meter chambers.

<u>Community Assistance</u>
One step in the monthly compilation of meter revenue data is the graphing of individual meter flows. Visual clues from the graphs often highlight the start of a community pipe leak. These leads are passed on to community water managers. Occasionally multiple meter flow changes indicate a valving issue within a community as water moves to different pressure districts in a new pattern.

Future Data Logger Uses

The use of data loggers continues to evolve. On a test basis the MWRA has begun deploying battery powered data loggers with wireless cellular phone communications. Currently CDPD protocol is used. In the future the MWRA will switch to 1XRTT communications. While the capital cost for this configuration is approximately $600 more than using a landline, the monthly phone bill will drop to $10 per month.

Another anticipated future use of the data logger is for remote transmitter maintenance. The addition of a single output on the data logger will enable the retrofitting of meter sites so that a maintenance technician will be able to remotely perform a flush and bleed of the meter transmitters. This would eleveate the need for all but transmitter calibration and flooded chamber pumping visits.

On the software side of things, the MWRA is expecting the future inclusion of embedded statistical tools in the data loggers' PC server. This will help automate the identification of abnormal flow conditions that signal pipe leaks. Finally the server software is expected to move to a web browser interface that is linked with a more powerful SQL database.

Conclusions

In many ways data loggers are like the fat multi-function pocket tools that have come to replace the Swiss army knife. Data loggers are convenient, versatile, simple to use, reasonably priced and adaptable to many jobs. There are times when they are not appropriate and a more complete tool kit, like a SCADA system, is needed, but often a data logger is all that it takes to get the job done.