Automated Wireless Monitoring of Water Distribution Systems

A Telog White Paper

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Introduction

"You can't manage what you don't monitor", an adage first attributed to Lord Kelvin applies to practically everything including water distribution systems.

Water utilities do a great job of producing good quality drinkable water in their processing plants. In-plant the water purification process is well monitored and scrutinized. Then the water is pushed out into the distribution system where far less is known. The primary reason for this lack of knowledge is that monitoring the water distribution infrastructure has been traditionally difficult and expensive.

Fortunately technology is coming to the rescue and making it possible to monitor remote water distribution systems assets economically and conveniently. The converging technologies of ubiquitous m2m cellular communications, low power robustly packaged RTUs (see Figure 4), Internet networking and powerful software analytics are emerging to provide utility operators the ability to visualize their system; 24/7. And this can be performed in all weather conditions with minimal manpower. If you can monitor your system; you can *better* manage it.

This paper provides an overview of a comprehensive, wireless, remote monitoring system for water distribution system operators including an economical application solution for every sensor, meter and instrument found throughout these systems.

Telogers

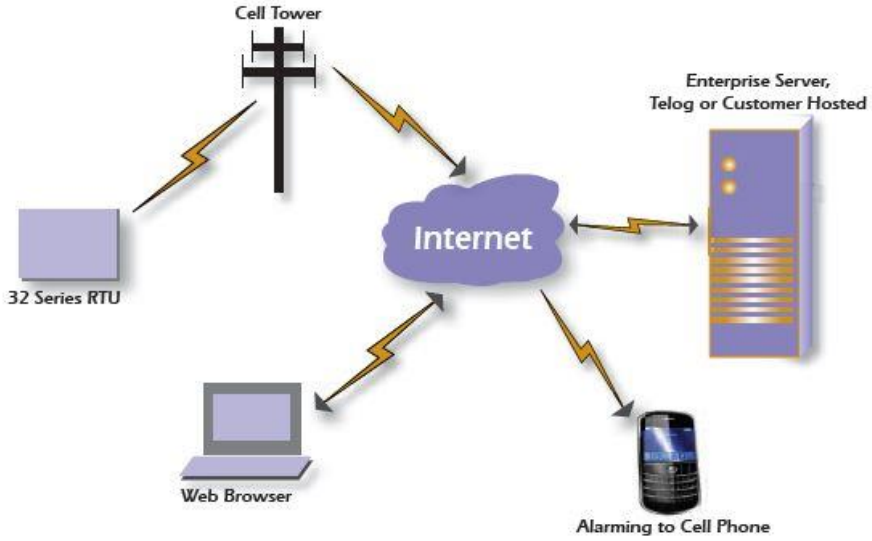


Figure 1: Wireless Water Distribution System Monitoring

Telog Instruments, Inc. offers a complete, mature remote monitoring system for water distribution system operators titled ***Telogers.*** *Telogers* provides an automated system for collecting, archiving, analyzing, viewing, reporting and sharing data from remote assets such as pressure sensors, flow meters, rain gauges, water quality sensors and analyzers, pump stations, water storage towers, pressure reducing valves, etc. This document describes the *Telogers* system and addresses specific application solutions for water distribution system operators. Key benefits of the *Telogers* system include:

- remote real time and historic data
- a common data platform for all distribution system parameters
- alarm notification and alarm forwarding management
- choice of communication technologies
- register encoder data from water meters for flow and billing
- battery, solar or line powered remote site RTUs
- system scalability
- automated operation
- open database for 3rd party sharing
- low procurement, installation and lifetime operating cost of ownership.

Remote Communication

Telogers remote communication options include:

- cellular
- telephone
- radio
- satellite
- Ethernet

Remote RTU data is automatically transferred to the user's host computer or Telog's DHS cloud application at a schedule defined by the user or in response to alarm conditions. Operational features include:

- call initiation by the RTU or server
- variable rate calls based on site conditions or alarms
- multi-level data integrity and security validation

Collected Data

All collected data is stored in an SQL database along with the RTUs configuration parameters. Stored data may be:

- displayed or printed in graphical or spreadsheet presentations
- exported in a variety of formats to 3rd party applications, e.g. SCADA, modeling, Asset Management, etc.
- processed by an analytics application to produce user alerts
- shared via website access over the user's intranet or the Internet.

User Hosted or Cloud Service

The *Telogers* host application, Telog ***Enterprise*** is available to users as a licensed, maintenance supported application that can run on the user's network. Or the user may choose to use Telog's DHS (Data Hosting Service) which is a cloud solution that operates Enterprise in a commercial data center.

Communications Technology

As stated above, Telog supports multiple communications technologies including cellular, radio, telephone, satellite and Ethernet. The vast majority of remote installations today are m2m data over cellular because:

- cellular network coverage is vast; estimated to blanket greater than 99% of water distribution networks.
- cellular m2m data costs are low and continue to drop
- reliability of data over cellular is excellent
- low power, low cost cellular data modems have emerged
- network security exists at multiple levels.

The cellular infrastructure is in place, is reliable and cost effective. It permits the deployment of low cost, small, low power RTUs that can remain networked or report on exception to any server location, anywhere.

An example of cellular data reliability occurred during the recent Super Storm Sandy where virtually all power was shut off in NYC because of tunnel flooding. Every metering and SCADA monitoring system became non-functional with the exception of the *Telogers* system which continued to monitor both water distribution and wastewater collection system assets throughout the storm.

The *Telogers* system continued to operate because all RTUs were battery powered, 97% of all cell towers were on backup generators and the utility operations center was on UPS backup. No data was lost through the storm and operators were able to continually asses the status of their water systems throughout and after the storm.

The "Internet of Things" defined by Wikipedia as *Equipping all objects in the world with minuscule identifying devices or machine-readable identifiers* will continue to drive wireless communications cost down and the number of potential monitoring sites up. It is estimated that by 2020, over 25 billion devices will be networked over the Internet. This will include every sensor, meter, valve or critical element of the water distribution infrastructure.

The *Telogers* system provides this capability today with the promise to continue the expansion of application solutions, lower cost monitors, improved analytics of data and improved user experience.

Battery Powered Recording Telemetry Units vs. SCADA RTUs

Telog RTUs are intended to be installed underground in harsh environments. These battery powered RTUs frequently operate for multiple years communicating over the cellular infrastructure on a single user replaceable battery. Data from these RTUs can easily be shared with a utility's SCADA system; making the *Telogers* system a robust, inexpensive remote frontend for that SCADA system.

SCADA RTUs are intended to be used in an environmentally controlled process plant connected to a high speed network and plugged into an AC outlet. Although SCADA RTUs have their place within a distribution system, they are not the right tool for remote, environmental monitoring scenarios. The following explains why:

Telog RTUs are data recorders which sample frequently, e.g. once per second, then reduce these samples to meaningful statistics at user defined intervals, e.g. the minimum, maximum and average pressure every 5 minutes or the total flow every 5 minutes, etc. Data is then pushed up to the user's server at a user defined schedule, e.g. hourly or daily, etc., or immediately on a measurement exceedance or site alarm condition. This allows the RTU to operate for years on a single user replaceable battery.

SCADA RTUs are polled by their host SCADA at a frequent rate when networked in a process plant but less frequently when deployed remotely communicating over a radio system. This requires the SCADA RTU to be continuously powered anticipating an incoming call; and if communicating via radio it needs a continuous AC power source.

Sampling infrequently, e.g. once/minute, also means that substantial data can be lost; pumps can turn on and off within a minute; water hammer events fly by in a few seconds. Sampling infrequently reduces data resolution and accuracy and notification of events.

Additionally, should the server shut down or the radio communications link be interrupted, the Telog recorder continues collecting and storing data for transfer to the host when the server connection reappears. The SCADA RTU however drops all measurements on the floor during these events; never to be uploaded to the server.

The biggest benefit of the Telog RTU is it can operate from battery power, typically for years. This dramatically reduces installation cost because it isn't necessary to plumb line power into an underground water vault, or wait months for the local electric utility to schedule the power drop.

A Telog battery powered, cellular enabled RTU can usually be installed underground in 30 minutes and with data up on the user's website before the installers can get back to the office. A typical Telog RTU cost of installation including equipment can range from $1,500 to $4,500.

A SCADA RTU with radio communications can take months to schedule an install at a cost ranging from $10,000 to $30,000 when power, antenna, repeaters, path studies, installation and equipment costs are considered.

Common Data Management Platform

A key benefit of the *Telogers* system is that **data from all distribution system monitored sites reside on a common data platform**. This adds efficiency and economy to the tasks of comparing and reporting.

Real-time Access

Immediate access to historical and real-time data from all key system-monitored parameters enable operators to make informed decisions when responding to alarm conditions. Sharing information with associates, consultants, and clients, throughout the utility organization is solid and understandable when all data is presented in a common format correlated with all parameters of interest.

Single Supplier Solution

Telogers provides a single supplier solution for the collection and integration of information throughout a water distribution system. It eliminates the need and inefficiencies of procuring and maintaining multiple vendor monitoring systems and data management application products.

Telogers Enterprise

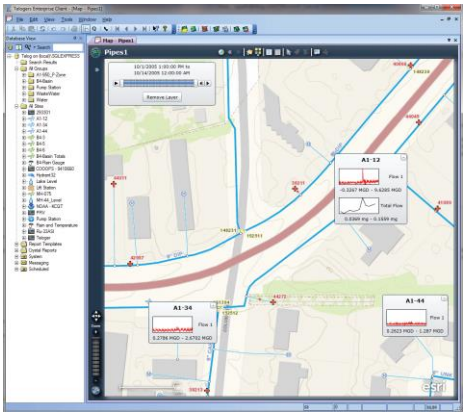


Figure 2: Flow on GIS Module

Telogers Enterprise is a comprehensive, scalable remote monitoring system created specifically for water and energy utility distribution and collection systems. It provides real-time information and alarms, as well as historical data, from remote sensors, instruments and analyzers. Using Enterprise, you can see exactly what's happening in the field within minutes of a change or an event— and you can make informed operational decisions, taking proactive steps to prevent problems.

This single-supplier solution allows you to gather, manage, archive and share information throughout your organization. Data from all remote sites reside on a common platform, setting a new standard for accessibility and usefulness of the information you collect. The comprehensive system brings your data together like never before, using the universal compatibility of Telog products:

Data Collection - Telog's field Recording Telemetry Units (RTUs) interface smoothly with any manufacturer's field sensors and instruments.

Data Transfer - Transferring data to the host computer takes place frequently and automatically.

Manage Data - Users can easily organize, view, generate reports and archive data.

Data Sharing - Share data over your intranet or the Internet; data recipients only need a web browser to view both tabular and graphical data.

SQL Database

Enterprise currently provides support for Microsoft's SQL Server and SQL Express as the relational database. Microsoft SQL Express is functionally a small version of Microsoft SQL Server with limited database size and is available from Microsoft license free.

For applications requiring larger databases, (e.g., collecting data from more than 25 remote recorders over many years), we recommend Microsoft SQL Server. The maximum database size for SQL is 524,272 Tbytes, effectively limiting the size of one's database to the amount of disk drive space available on the server.

A SQL relational database provides a number of advantages to *Enterprise* users including unlimited database size, increased operational speed producing graphical and numeric reports, and interoperability with third party applications such as HMI, GIS, billing, modeling and corporate ERP systems.

Data Analysis Module

Enterprise includes a Data Analysis Module to assist the operator in managing and analyzing data from remote sites. This application includes tools to permit the user to:

- create physical sites and measurements
- create statistical and/or pseudo (virtual) sites and measurements
- create custom reports and report templates
- edit data using manual or automated methods
- automatically produce scheduled reports
- rapidly review site measurements
- alarm on measurement anomalies or exceedance conditions.

The *Enterprise* Data Analysis Module enables the user to create as many measurement parameters as desired for any site. A site is a geographical location, for example a manhole or pipe. For each site, the user may create a few or dozens of measurements; some may be physical measurements obtained from remote RTU channel inputs, such as level, flow, rainfall, pressure, water quality, water hammer, temperature, etc. *Enterprise* permits measurements to be assigned to multiple sites and pseudo (virtual) sites.

Enterprise does not permit the user to edit any original data measurements provided from remote RTUs. All edited values are produced by direct user entries or automatically produced by defined calculations and therefore may be removed or changed by the user at a future date. Maintaining the original raw data provides data integrity and ensures no data is lost or corrupted by user action.

Website Data Access

Telogers Enterprise provides a web module that permits sharing the following information to authorized users, via a corporate intranet or the Internet using web browsers:

- access to historic data
- presentation of numerous parameters in one graphic presentation
- powerful graphic manipulation tools including active cursor, zoom and pan tools, and calendar selections (daily, weekly, monthly, quarterly, annually or custom times)
- numerical spreadsheet reports exportable in a variety of formats and time periods
- site status information, including recorder battery capacity, up-time report, sample rate, call schedule, calibration data, physical parameters, etc.

Data provided by the *Enterprise* web module is read only; the user has no access to modify the database or any operational system configurations. A client access control utility is included with *Enterprise* that permits the system administrator to control data content to authorized parties by user name and password. Client access control permits different permission levels. For example, utility customers gain access to final flow data from flowmeters servicing only their communities, while the utility's management and consultant engineer have higher level permission to view all measurements from all sites.

Telog Data Hosting Service

Telog provides a Data Hosting Service (***DHS***) for customers who prefer to outsource the data collection and data management functions. This also reduces the customer's cost and dependence on internal IT personnel and computer resources. See Figure 4.

When employing the Telog *DHS*, the customer's remote site recorders will communicate with a host computer at Telog's Data Management Center. Data will be collected and deposited into a client specific SQL database. This data may then be served up on a customer designed web page in reports defined by the customer.

For example, the remote RTU collects data from the flow meter (typically level, velocity and flow computations) at a user defined interval (e.g., 15 minutes) then forwards this data to the *Telogers* DMS host computer. The communication path begins wirelessly between the burial antenna and a local cell tower, then via the cellular carrier infrastructure and the Internet to the *Telogers* host. Internet Protocol (IP) addresses within each data packet instructs the network routers where to send each packet. Administrative controls on the *Enterprise* Server limit access to data to those web site visitors that log on with the appropriate user name and password. DMS customers may provide access rights to their clients to permit them access to information from specific sites, for example a single custody transfer flow meter.

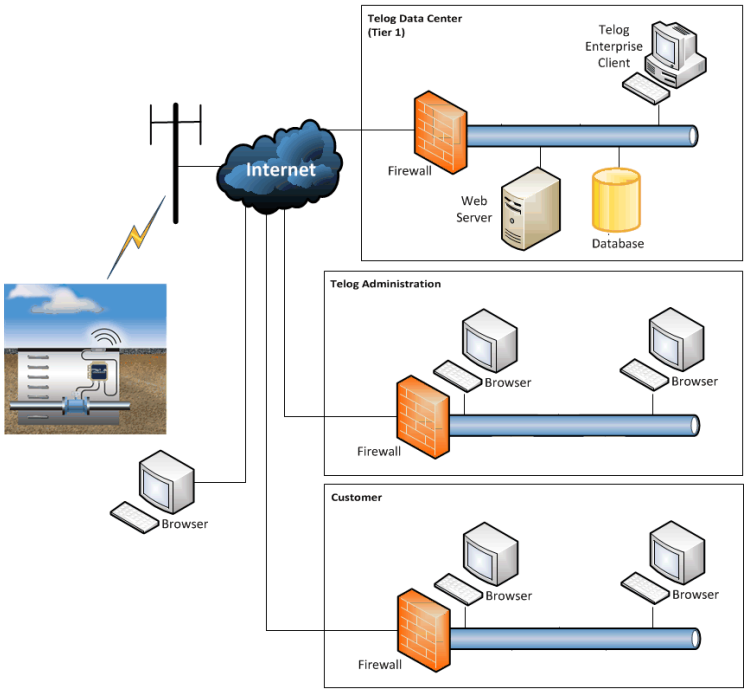
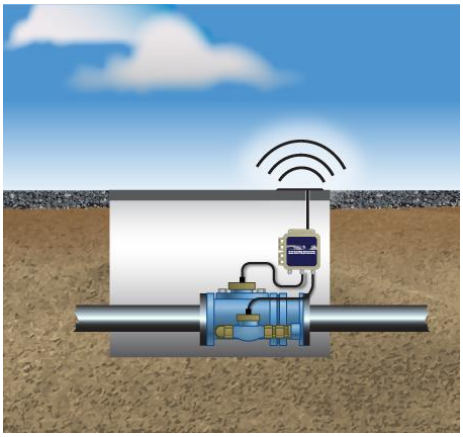


Figure 3: DHS Network Diagram

Figure 4: 32 Series Product Family for Water Distribution System Monitoring

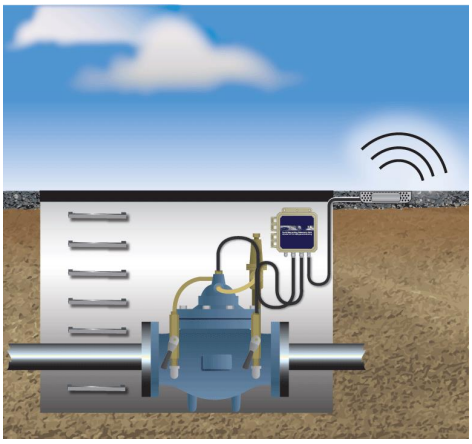
Application Descriptions

Flow Meter Monitoring



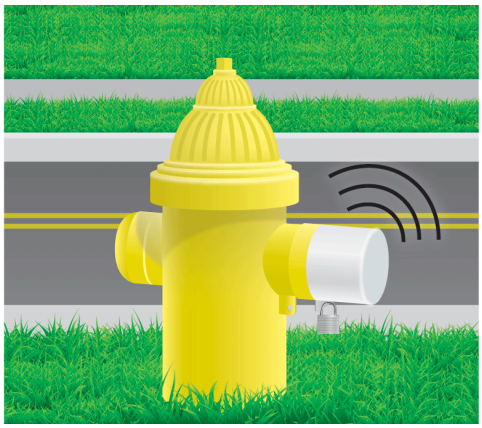
Telog's Ru-32m can directly monitor the encoder register of single or compound water meters providing both interval flow data and meter register data for billing. Telog supports industry standard Sensus and similar AMI protocols. And, since the Ru-32m is rated IP-67, it can be located in underground meter vaults. Telog also offers an optional burial antenna that can be installed below road or sidewalk surfaces.

Pressure Reducing Valve Monitoring



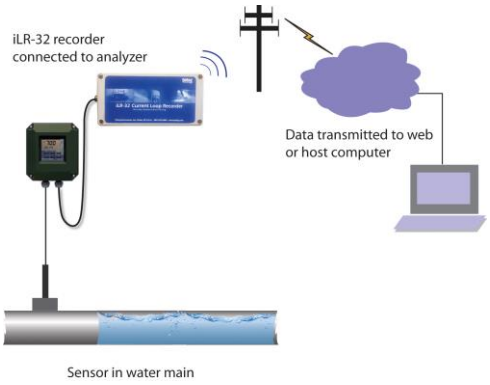
Telog's Ru-32 can be provided with two pressure sensors to monitor the input and output of your pressure reducing valves. Additionally, the Ru-32 can monitor the valve open position if the valve is configured with a valve position potentiometer (e.g. the CLA-VAL x117D). Knowing the differential pressure, the valve position and the valve flow characteristics (provided by the PRV manufacturer) the Ru-32 computes the flow through the valve. This produces a low cost, battery powered, wireless recording and real-time alarm system for PRV vault pressure and flow.

Water Hammer Monitoring



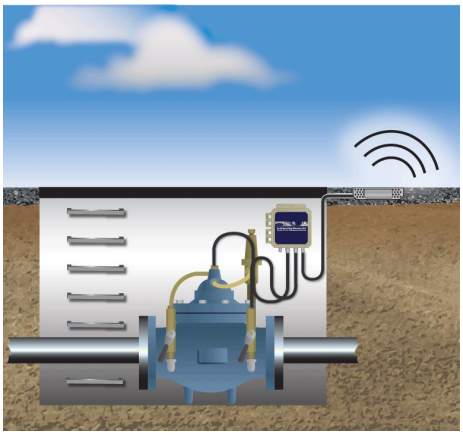
In addition to performing all the functions of the HPR-32, the HPR-32i Pressure Impulse Recorder captures water hammer and negative pressure event waveforms in a separate memory and wirelessly downloads them to Telog's host computer application. This recorder samples water pressure up to 20 samples/second, storing the waveform of impulse events that are detected by a user defined rate-of-change detector. The recorder only stores the real-time waveform during impulse events so over 200 events lasting from a few seconds to many minutes can be stored. Battery life of the HPR-32i in Impulse Recording mode can exceed 18 months.

Water Quality Monitoring



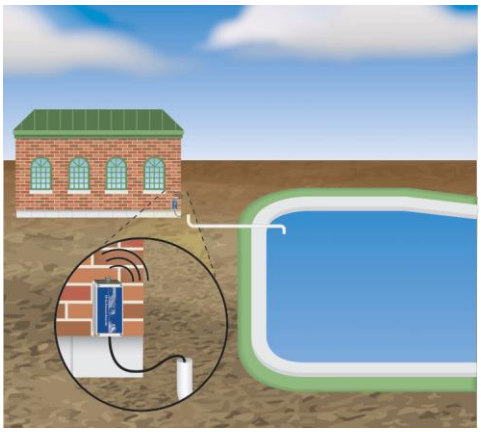
Telog's iLR-32 Current Loop Recorder can typically be attached to the output of any water quality analyzer used throughout water distribution systems including chlorine residual, pH, turbidity etc. The iLR-32 samples the current loop output frequently (e.g. every second) and reduces this data to meaningful interval data; e.g. 5 minute min/average/max or totals for transfer to your host computer on a schedule or in response to site real-time alarm conditions. Being battery powered, it can be deployed virtually anywhere the analyzer is located.

Pressure Relief Valve Monitoring



Telog's Ru-32 monitors the event switch on a pressure relief valve and also the pressure at the valve providing event history (time stamped to one second resolution) of when, for how long and at what pressure a Pressure Relief Valve operates. You can upload this information infrequently (e.g. daily) to your host computer or in response to alarm conditions; e.g. pressure trips or valve open duration. The included external antenna can be mounted to the underside of a non-metallic meter box or attached to the top of a metallic meter vault door. Our optional burial antenna can be installed below road or sidewalk surfaces.

Reservoir Level Monitoring

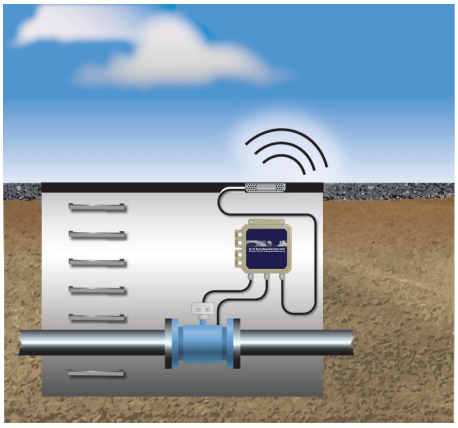


The PR-32 is ideally suited to monitor and report the level of reservoirs or other surface water bodies. Being battery powered and wireless, you can install the recorder virtually anywhere. In most applications it is only necessary to install a PVC or equivalent pipe to protect the level sensor from debris or surface ice damage.

Rainfall Monitoring

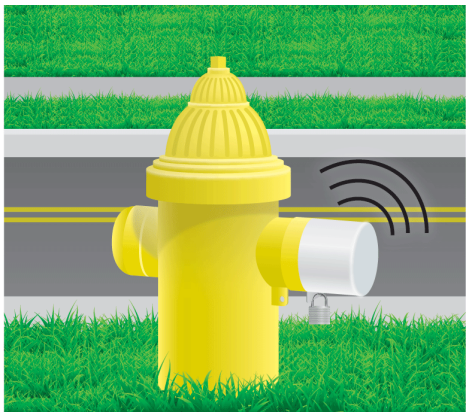
The Telog RG-32 Rain Gauge Recorder monitors the output of any tipping bucket style rain gauge to provide a record of interval rain totals of any user defined length, e.g. 5 minutes, 15 minutes etc. The RG-32 can be configured to call the host computer on a fixed schedule, e.g. daily, or it can call more frequently when it is raining, for example whenever 0.1 inch of rainfall has been accumulated. This would ensure that the user always knows what total rainfall has occurred up to the most recent 0.1 inch.

Mag Meter Monitoring



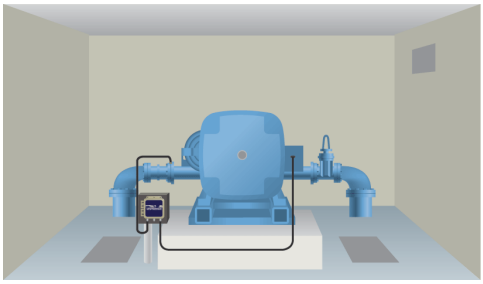
Telog's Ru-32 attaches directly to the pulse output of magnetic flowmeters (mag meters) to trend flow at user defined intervals, e.g. 5, 15, 30 minutes. Choose the pressure sensor option for a battery powered (up to 5 years), wireless flow/pressure monitoring system. You can program the recorder with hi and low alarm levels for both pressure and flow for immediate notification of out-of-range site conditions. The included external antenna can be mounted to the underside of a non-metallic meter box or attached to the top of a metallic meter vault door. Our optional burial antenna can be installed below road or sidewalk surfaces.

Hydrant Pressure Monitoring



Intended for attachment to common fire hydrants, the HPR-32 monitors system pressures and trends, min, max and average pressure history at any user interval. Data is internally recorded for many months and wirelessly transferred to the user's host computer on a schedule or in response to pressure faults or transients. The ideal product for fire flow testing, customer complaints and hydraulic model calibration.

Pump Station Monitoring

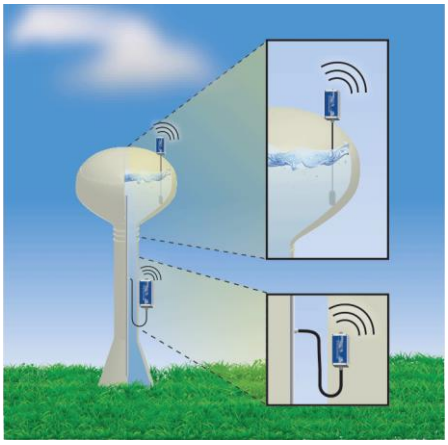


Telog's Ru-32 monitors one or two pumps for on/off duration, recording the time stamps of each pump cycle along with sensors for pump input and/or output pressure. The Ru-32 is battery powered and wireless so it can be located virtually anywhere the pumps are located. Telog host software rolls up pump run time over any time period; e.g. daily, weekly, monthly, etc. You can choose one of our external antenna options best suited to the size and type of building where the pumps are located.

Aquifer Level Monitoring

The PR-32 Pressure Recording System is supplied with a submersible level sensor that can monitor the level of underground aquifers to accuracies of 0.1%. You can choose a cable length from 6 feet to 600 feet and depth measurement ranges from 1 foot to 500 feet. Battery life exceeds five years when calling into the host server once per day which significantly minimizes site visit requirements. The PR-32 is small enough to install into a 4" x 7" diameter well-head. The sensor and cable can fit into a 1.5" diameter pipe.

Tank Level Monitoring



Telog's PR-32 Pressure Recorder provides a monitoring system for water tower level offering two installation approaches. You can drop a submersible level sensor into the tank from above or attach a pressure sensor to a fitting below the tank. Both methods provide an accurate means of determining tank level and Telog software can convert this level to volume if the geometry of the tanks is known. Because this system is both wireless and battery powered, installation is quick and inexpensive.