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Pressure-Transient Monitoring Supports Leak Detection

Since implementing a pressure-transient technology platform to monitor its 200-mile network, a Georgia water utility improved its asset management planning and ability to identify and respond to leaks.

BY THOMAS GINN AND BEN SMITHER

COBB County-Marietta Water Authority (CCMWA) is a water wholesaler that operates about 200 miles of transmission mains near Atlanta. The system's primary loop is 75 miles long, with pipe diameters of 36 to 54 inches, consisting of ductile-iron and prestressed concrete cylinder pipe materials. CCMWA's system, which is designed to provide a maximum of 150 mgd to its customers, currently provides an average of 82 mgd of potable water to 10 municipal customers who, in turn, serve 850,000 end users.

With three pump stations sited on a loop operating in a single pressure zone, the flow direction can change depending on demand and input balance around the loop. The loop (Figure 1) is designed to carry water long distances at low velocities (to minimize head loss) at pressures ranging between 20 and 230 psi because of ground elevation differences in the service area. The system has five elevated storage tanks sitting on ridgelines running southwest to northeast. Each tank has a single feed, and the tanks' presence stops many pressure-transient events from propagating across the network.

Following a series of tapping saddle failures of 6- to 12-inch-diameter outlets, CCMWA first began talking with Syrinix (www.syrinix.com), a pipeline monitoring technology company, in 2016. Each of these events created an orifice flow condition that limited the leak rate to flow within the capacity of the looped transmission pipe network. The head loss caused by the faults wasn't easily visible in the network's steady-state pressures.

Figure 1. Complete CCMWA Loop

The CCMWA system's primary loop is 75 miles long, with pipe diameters of 36 to 54 inches.

SPOTTING SYSTEM FAULTS

CCMWA's method of spotting large faults involved calculating the total system demand by looking at the high-service pumping rate into the system ± the tank drafting/filling rate and monitoring rainfall amounts to estimate what "normal" demand should be expected. For example, during summer months when it's raining, demand should drop toward a minimum, and demand should increase when it isn't raining.

Analysis of a 12-mgd fault, which occurred in 2014, showed an extra head

An 8-inch tapping saddle failure occurred on one of CCMWA's 42-inch mains. By collecting pressure-transient data in a high-sample rate mode (128 times per second), operators were able to quickly locate, isolate, and identify the leak.

PHOTOGRAPH: CCMWA

loss of only 2 psi in the 36-inch looped transmission main (design capacity 140 mgd). A look at leak hydraulics helps to understand why these leaks are difficult to spot, and analysis was undertaken to determine that the maximum expected head loss a 10-mgd fault would cause in the looped system is 12 feet if the fault is at the most distant point (0.37 bar/5.3 psi).

Some leaks are much closer to the pump station, making the steady-state head loss for these even harder to spot. The analysis also pointed to a solution that large faults could be spotted by monitoring for pressure-transient events, which are caused by large breaks as well as pump starts and stops, pump emergency stops, altitude valve closures, large customer feed valve operations, and manual valve operations (line isolation, flushing, etc.).

Acoustic monitoring wasn't a cost-effective approach given the system's spatial dimensions, with 200 miles of network and a device required every 2,500 feet. Having ruled out acoustic monitoring, CCMWA decided on pressure-transient monitoring as the best technology solution to align with its specific need.

In March 2016, CCMWA installed 10 Syrinix Pipeminder devices spaced 5–10 miles apart, covering the areas where most leaks had occurred. Since that time, CCMWA has been working closely with the company using the high-resolution data collected to gain the best possible information about the loop.

One Friday night, at 7:56 p.m., two abnormal events were spotted: first, an unexplained and significant change in the direction of the flow leaving the treatment plant and, second, an unexpected pressure drop detected at the treatment plant and one other monitoring site.

Operators immediately suspected a major leak or break on the 42-inch line leaving the treatment plant toward the east. The operations staff called for a crew to begin looking for the leak immediately. By 10 p.m., the leak was located, isolated, and identified as the failure of an 8-inch tapping saddle.

A comparison of the high-sample pressure data alongside the supervisory control and data acquisition (SCADA) data collected at the same time shows the advantage of having the pressure-transient data collected in a high-sample rate mode (128 times per minute). The additional data make it easy to interpret travel times for the transient waves and immediately spot any anomaly. The lower-resolution pressure recordings from the SCADA system at 1-minute intervals don't provide enough detailed data for significant events such as bursts to stand out against what could be normal operational behavior. Therefore, breaks can be missed.

In the past three years, CCMWA has worked to develop key analysis methods for pressure-transient events. This has allowed the utility to focus on meaningful events that are more easily highlighted and to avoid having to analyze a vast amount of data.

THE POWER OF TRIANGULATION

The term "triangulation" is used to identify the source location of major transient events, such as bursts, and is an automated feature within the Syrinix analysis platform. The resulting pressure wave from a burst event is detected at multiple monitoring sites, and using the high-resolution data collected by the system, software algorithms analyze the event and determine the burst's location.

In June 2019, coincidentally as CCMWA staff were attending AWWA's Annual Conference and Exposition in Denver, a burst alert was generated. The burst was so big that CCMWA operators were immediately aware of it through the SCADA system. However, via the transient monitoring system, operators were also able to identify the location of the break before any personnel arrived. This meant operations staff and local authorities could go directly to where they were required without wasting any time.

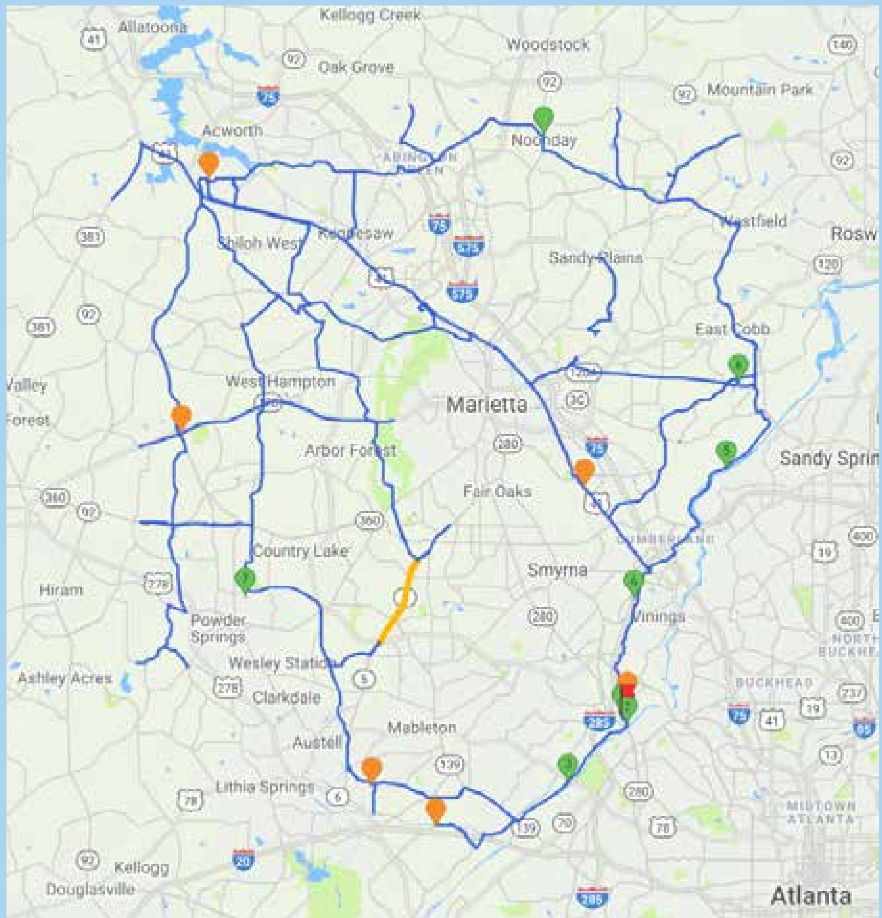
Three devices measured the pressure drop, and a call from operations was received with the message that one point had dropped to 0 psi. The estimated leak flow was 100 mgd, and significant pressure drops—including up to 188 psi at the nearest pressure-monitoring location—were observed across the network.

The green pointers on the map in Figure 2 show the devices that identified the break, and the red flag denotes the estimated break location—placed 150 meters from the exact location. Within the system is the capability for manual interaction and a rerun of the triangulation algorithm to improve the computed distance. However, delivering such a precise location estimate within a few minutes of the actual burst is an excellent automated result. Delivering the break's location via this automated triangulation procedure allows the field crews to deploy to the location of the break and begin work rather than spending time looking for a break across several miles of pipe.

CCMWA staff also value another system feature called event clustering, or shape classification, which is basically pattern recognition used to compare and classify transient waveforms against an exemplary set of reference transients derived from the network. By classifying similar shapes into actions, like a pump stop or pump start, the software can automatically differentiate daily events from unique occurrences. This advanced level of intelligence prevents investigative time and resources from being unnecessarily spent on known network behavior and allows users to see how operational adjustments to the network affect common transients.

Figure 2. Detection Points Identified Leak Locations

Green markers indicate the devices that picked up the break and were used to automatically triangulate its location.



A FASTER DETECTION METHOD

With the monitoring devices in place, the software platform continues to offer a simple yet powerful way to display pressure-transient data and is accessible from anywhere. Before the units were installed, CCMWA didn't have access to any real-time pressure transient data and was limited to pressure readings via its SCADA system, which couldn't provide the clarity of the new monitoring platform. Monitoring pressure transients in its network allows the utility's operators to detect the fast-developing large leaks that used to elude them, better troubleshoot immediate problems, and make better planning and asset repair and management decisions.