Recovering Lost Water

Innovative leak detection technology provides value to small rural water utility

By Paul Gagliardo

Small, rural communities are sometime left behind when it comes to technological innovations.Many rural areas still lack highspeed broadband internet access. This dilemma can be exacerbated by lack of resources and economies of scale that do not allow for new technologies to be deployed in a cost-effective manner. The City of Greenville is located in west central Mississippi (see Fig. 1) and is the county seat of Washington County. It has a population of approximately 35,000 people and encompasses 27.7 square miles of area. It sits on the eastern bank of Lake Ferguson, an oxbow lake left over from an old channel of the Mississippi River. During the Civil War, Greenville was burned to the ground by Union troops in actions related to the Siege of Vicksburg. After the war, the city was rebuilt three miles upriver at the highest point between Memphis and Vicksburg. Notwithstanding the move to higher ground, the Mississippi River Flood of 1927 inundated Greenville and a major portion of the Mississippi Delta region with flood waters for months. On a more positive note, Muppets Creator Jim Henson was born at King's Daughters Hospital in Greenville and grew up in nearby Leland. The Greenville water system contains 292 miles of pipe mains and delivers 6.6 million gallons per day (MGD) of water to customers. The system experiences approximately a 25 percent non-revenue water (NRW) level and does not have a proactive leak detection program. The NRW rate is higher than the United States average of 16 percent. In many instances, not just related to water utilities, small rural areas cannot realize the benefits of their larger urban neighbors.

Greenville alerted to leak on 16-inch water main through ASTERRA Recover program. Photo courtesy of David Hangar, Water Maintenance Division, City of Greenville.

Figure 1. Location of Greenville and a map of its service area.

Courtesy of Asterra.

Larger entities have economies of scale. They can deploy new technologies and spread the cost of the new service among many customers. Additionally, innovations can be tried and, even if they fail or do not achieve the returns anticipated, the cost can be absorbed with less overall impact to the customer, whereas smaller utilities do not have that luxury. Companies with new, innovative approaches may not want to market to small utilities due to the relatively low revenue and profit to be realized with a fixed cost of customer acquisition. Rural areas are also at a disadvantage in the case of pipeline leak detection, as lower population density makes pinpointing leaks more difficult. When there are fewer listening points, or they are further apart, leaks are less likely to be found. Conversely, rural areas can have less ambient noise, so using acoustic methods to pinpoint leaks can be more successful. Greenville is an exception to these norms. ASTERRA, a relatively new company offering innovative solutions for water savings through satellite-based leak detection, did market directly to them. The cost of service was deemed to be a reasonable, low-cost investment for the utility. The leak detection performance metrics were excellent even though it is a rural area. The return on investment was less than one year and the real water loss levels were reduced by almost 25 percent. Greenville hired ASTERRA to provide a unique service, called Recover, to locate likely pipe leaking locations using satellite-based synthetic aperture radar (SAR) images. These images can detect potable water leaking from water pipes underground. Water sources such as leaking pipes, lakes or swimming pools reflect electromagnetic (EM) waves. Every material has unique electric properties called dielectric constants. SAR sensors placed on an elevated platform such as a satellite or an aircraft send EM waves at a known frequency towards an area and read the EM backscatter from that area. The signals are compiled into an image of the area. This includes backscatter from water sources and other landmarks such as buildings, vegetation and topographical features of the area. Unwanted targets (e.g., swimming pools or saltwater) are filtered out or removed from the scan, thus leaving only the signal backscattered from pipeline water leakages (the signal from drinking water mixed with soil). The satellite images were collected and analyzed, and field boots on-the-ground (BOTG) crews were deployed in December 2021 to pinpoint the leak locations. Seventy leaks were found pursuant to this program. The real water loss identified was 0.39 MGD, which is 24 percent of the non-revenue water NRW) level of 1.65 MGD. Fixing these leaks will result in a substantial water and cost savings for the Greenville Water department. Greenville realized a 3-month simple payback based on the cost of service and the value of lost water that was recovered. The Recover leak detection program consists of two tasks: satellite survey of the entire system and leak pinpointing by BOTG field crews. The satellite survey can encompass up to 1,200 square miles of area and all the pipelines within that area. The survey unit cost per mile is lower for a large system than for a small system. The survey analysis identifies 5 to10 percent of the system length as likely leak locations (LLLs) where the BOTG field crew is deployed to pinpoint leaks. The BOTG costs are based on days in the field and are the same unit cost no matter the size of the project. It is reasonable to assume that the overall unit cost to find a leak would be lower for a larger system because the satellite survey cost per mile is lower. However, this is not the case as the BOTG cost per mile is much larger than the survey cost per mile. The value metric used to compare the value proposition is cost per leak found. The benchmark cost per leak found is $1,000. A lower unit cost shows a high value to the utility. At Greenville the cost per leak found was $692. This shows that even though Greenville is a small system, a very attractive value proposition was achieved. A large number of leaks were found on main pipelines. One of these leaks was found on a 16-inch water main and was not visible above the ground surface. The leak flow rate was estimated to be at least 20 gallons per minute. A pipeline burst from this pipe would have caused catastrophic negative results from property damage, lost water and extensive liability claims, not to mention having to perform an unplanned repair or replacement. Another method to calculate value is to compare the cost of water production to the value of the recovered water, or marginal new water supply. The cost of production at Greenville was reported to be $1.24 per 1,000 gallons. Based on the total cost of service and the volume of real water loss reduction, amortized over a one-year period, the cost of this recovered water supply was $0.34 per 1,000 gallons. The cost to find and fix leaks is one third the cost of production, showing great value to

Greenville crew repairs leak that would likely have gone undetected.
Photo courtesy of David Hangar, Water Maintenance Division, City of Greenville.

the utility. The ASTERRA best practices recommend that the BOTG field inspectors access all listening points available to try to acoustically pinpoint a leak. In rural areas there are fewer listening points per mile of pipe due to the low population density. When there are fewer listening points per mile of pipe, the BOTG crews can inspect more pipes per day. There is a direct inverse correlation between miles per day inspected by field crews and leaks found. Traditional leak detection program efforts cover almost 4 miles per day and find 1.3 leaks per day and 0.3 leaks per mile physically inspected. The ASTERRA Recover program was able to find 4.4 leaks per crew day and 2.7 leaks per mile while physically inspecting 1.6 miles of pipe per day. In this case, even in low population areas, the leak detection program was able to outperform the traditional methodologies. More than 65 percent of the leaks found were non-surfacing, meaning they would have not been identified at that time except for the satellite survey analysis. In addition, more than 40 percent of the leaks found in Greenville were on either main or service pipes, which typically have the largest leak flow rate according to AWWA Manual M36, Water Audits and Loss Control Programs. Finding and fixing these leaks reduces incalcitrant real water loss levels from potable water systems. The ASTERRA Recover program uses satellite images, which are completely remote and non-invasive. It does not require any utility resource to collect and analyze the image and provide a map of LLLs. For Greenville's project, the utility was able to provide accurate water system GIS shapefiles early in the project for ASTERRA to use in creating LLL maps for the field crews. ASTERRA then contracts BOTG field crews that can be deployed to pinpoint the leaks. This also does not require any resource allocation from the utility. Based on the pinpointing efforts, the utility can schedule work crews to repair the leaks and reduce their cost of production and real water losses from the system. This shows that even small rural utilities can benefit from new technologies. **RW**

Paul Gagliardo, MPH, P.E., has over 25 years of experience in the water utility business. Currently, he is an independent consultant providing advice to firms interested in the municipal water business. He is a registered engineer in California and has a master's degree in public health.