Water Utilities Using Space-Based Innovation to Manage Assets

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For decades, planetary scientists have been trying to find liquid water on Mars. In 2018, researchers detected a possible reservoir with the Mars Express Orbiter, orbiting Mars since 2003. While scanning the ice cap at Mars' South Pole, the probe's radar instrument, called MARSIS, detected a feature approximately a mile beneath the surface with a radar signature matching that of liquid water. MARSIS (Mars Advanced Radar for Subsurface and Ionosphere Sounding) is a low frequency, pulse-limited radar sounder and altimeter. It features ground-penetrating radar capabilities, which uses synthetic aperture techniques and a secondary receiving antenna to isolate subsurface reflections.

Utilis in San Diego, CA, uses the same satellite imaging technique from satellites orbiting the earth to survey large areas and collect and analyze backscattered radar signals. These signals can be interpreted using a proprietary algorithm to determine an indicator of potable water pipeline leaks. The algorithm identifies subsurface signals that are consistent with a specific dielectric constant that relates to potable water. These signals are overlaid with a distribution system map to identify points of interest (POI) that are then investigated by boots-on-the-ground (BOTG) field crews to pinpoint and verify leaks.

This technology can be successfully used on all types of pipe, e.g. metal or plastic, and on all sizes of pipe. Additionally, the service is completely remote and non-intrusive and is equally effective in rural or urban areas. New Braunfels Utilities (NBU) contracted with Utilis for to provide this imaging in the fall of 2018. The agreement included four services spread over a 12-month period, all having been delivered and fully investigated in the field.

The City of New Braunfels is in greater San Antonio, TX. NBU was established in 1942 when the City purchased the local electrical transmission and distribution systems. The water and wastewater functions were transferred to NBU from the City in 1959. NBU is a municipally-owned utility governed by a five-member board appointed by the city council. The system consists of 573 miles of water mains and has a service territory of 88 square miles located in Comal and Guadalupe counties.

In FY2018, NBU served a population of 84,200 through 39,060 service connections. An average of 13.3 million gallons-per-day (MGD) is supplied to the system with a net sales volume of 10.9 MGD. This equates to a non-revenue water (NRW) volume of 2.4 MGD, or 18%. NRW is defined as the total of real losses or system leakage, apparent losses such as meter inaccuracies and unauthorized consumption, and unbilled authorized consumption such as system flushing and firefighting flows. NBU has a goal to reduce NRW and has deployed various technologies in the past five years.

Four satellite images of the entire NBU service area have been collected and analyzed for leaks. These images were taken between 22 August 2018 and 1 May 2019. The BOTG field inspections occurred between August 2018 and July 2019. A total of 816 POIs were identified and a total of 229 leaks were found pursuant to the Utilis-directed field inspection work. This work occurred over 56 crew days and covered 176 miles of pipeline. A performance metric of 4.1 leaks per day and 1.3 leaks per mile was achieved.

Subsequent to collecting and analyzing each of the four satellite images, the Maintenance Planner directed the leak crew to inspect a certain area identified as likely leak locations. A total of 14 crew days were allocated to provide field inspection services for each of the four images. Crew days are defined as nominal eight-hour work days for the three Line Technicians. The total hours spent on the leak detection tasks were divided by eight to calculate a crew day. The primary value performance metric is leaks per crew day found. The more leaks found per-day in the field, the better the return on investment of physical and fiscal resources. A secondary metric is

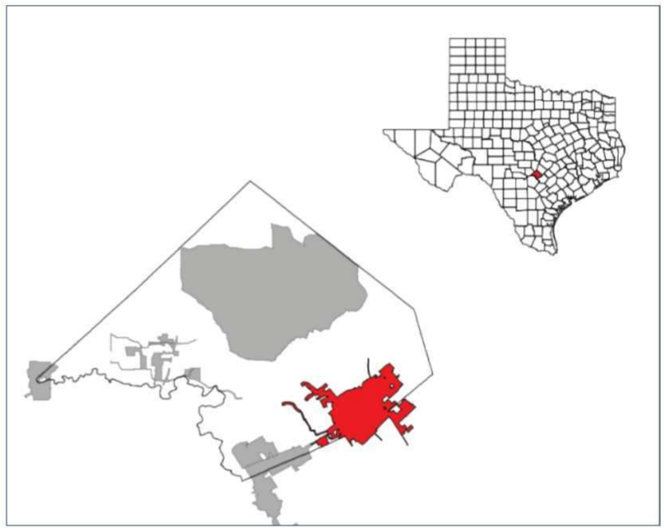

Figure 1. Location of New Braunfels, TX.

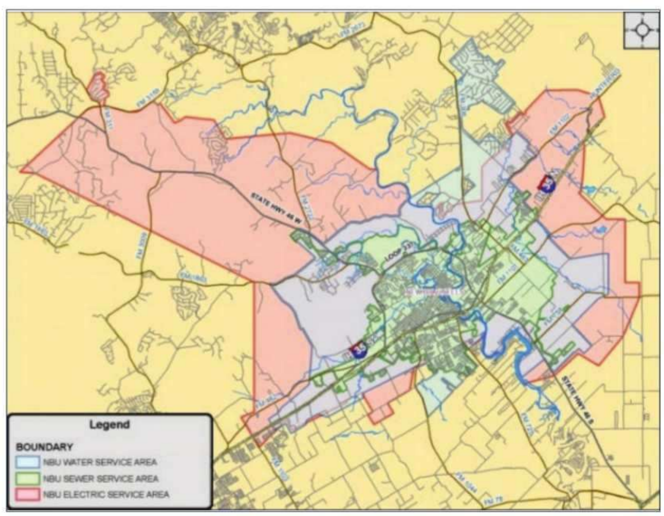

Figure 2. Map of New Braunfels.

leaks per mile physically inspected. This shows the technical ability of the satellite imagery to identify likely leak locations and the ability of the BOTG field crew to correlate the actual leak location.

Of the 229 leaks found, 46 were on main lines and 82 were on service lines. The remaining leaks were found on the customer side of the meter. These are the leaks that contribute to real water loss and non-revenue water. **(See Figure 3)**.

A return on Investment (ROI) calculation can be performed to determine the overall value proposition of finding and repairing leaks. The accuracy of this metric relies on the calculation of the cost to find a leak, the marginal cost of water purchase and production, and the estimation of the size and duration of the leak. NBU staff has provided information on the cost of water purchase and production which is estimated to be $4.52 per 1,000 gallons. This is the value of the NRW real losses. NBU calculated the size and duration of each leak found during the full Utilis service and this data is used to estimate the total water loss per leak over time and moving forward.

There are two main components in determining the value of lost water due to a leak; leak flow rate and leak duration. NBU calculated these by determining the leak type when it is uncovered and estimating the leak flow rate when it is repaired. The calculated leak volumes from NBU side leaks averaged 8.7 gpm. Some of the leaks were easily fixed during the field inspection by tightening fittings on meters or valves. These leaks were set at a zero-leak rate.

The NBU-side leaks are defined as either identifiable or unidentifiable. NBU created these definitions to localize Utilis' value-add to their particular system setting. Unidentifiable leaks are those that were determined impossible to find with traditional methods and only possible using the Utilis method. These leak types might be in rural areas with no connections that are not typically visited, or, leaks occurring in rocky soil where it is never expected to surface (e.g., Edwards Aquifer recharge zone). The leak duration for identifiable leaks was set at 45 days, or 1.5 months, based on the fact that the Utilis surveys and subsequent field inspections are performed quarterly. Therefore, the average duration of the leak, if evenly distributed over the three-month period is half that time. For the unidentifiable leaks the duration was pegged at 2.5 years, or 30 months. NBU historically could survey and inspect only 20% of the full system per year, thus taking 5 years to inspect the entire system. Therefore, the leak duration was set at half the 5 years, or 30 months.

In order to estimate the volume of water loss and thus the value of fixing the leak, the leak flow rate was multiplied by the duration defined by its designation. Of the 128 NBU side leaks 36 of those were deemed unidentifiable. Altogether it was calculated that total water loss due to these leaks was 48.7 million gallons. This equates to a lost value to NBU of $220,120. The simple payback period is 6 months as the cost of the full service (four images) was $100,000. Another way to analyze the value proposition is to calculate a return on investment (ROI). The total cost of the Utilis/NBU program was $155,500 in FY2019. The water value savings was calculated to be $220,100. The operating budget savings is calculated to be $146,400 based on the reduction in labor used to search for leaks during a one-year period. Therefore, total benefit is $366,500. This equates to a 135% ROI.

The Utilis service is proficient at locating leaks that can be repaired and thus reduce non-revenue water loss. In addition, many of the leaks identified by the Utilis satellite survey are non-surfacing leaks. These leaks are found even though they are not visible above ground. They have not been reported by customers and inspected through the work order process. They would have gone undetected for an extended period of time; months and possibly years. Another value proposition of the Utilis service is to support asset

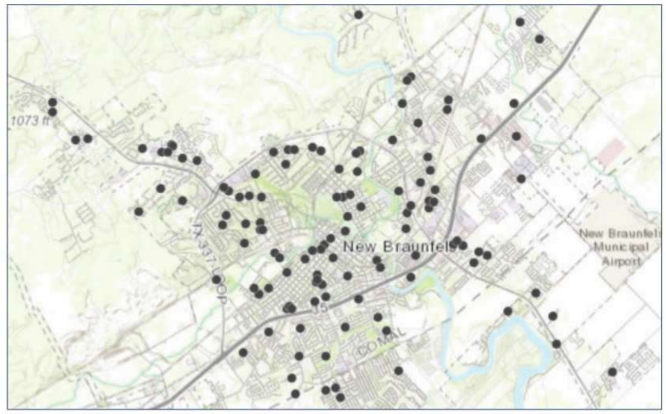

Figure 3. Map of utility-side leaks.

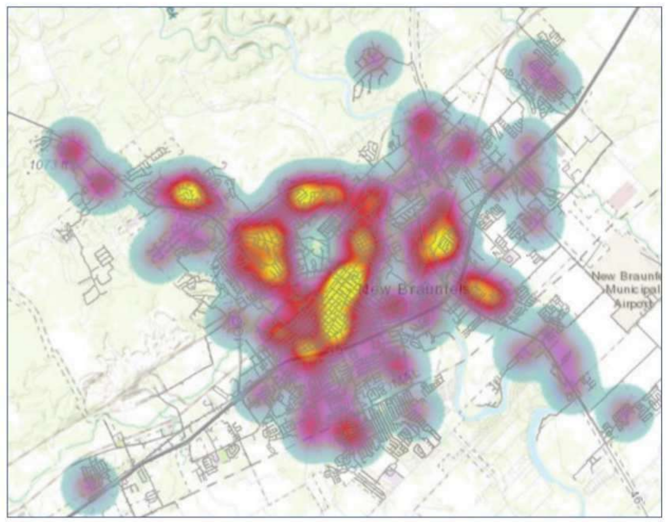

Figure 4. Heat map of utility-side leaks, identifying hotspots.

management and long-term planning functions. As can be seen in **Figure 4**, the map of utility-side leaks can be transformed into a hot spot map.

This map exhibits the underground signature of leaking potable water within the NBU system area. The yellow areas show the location of the highest leak concentration. Of the 128 utility-side leaks found by the Utilis program, 43% were non-surfacing. The heat map shows areas within the NBU service area that could be inspected further and considered for replacement. This information can be thought of as an acute issue effecting the system. It is a picture of the current, ongoing pipeline leakage. The heat map can also be overlain with NBU work orders to further define where acute problematic occur within the system. This data can be correlated with other asset information such as pipe type, pipe age, ground water levels, soil conditions, etc. to determine if the pipe section should be included in a capital replacement program. This information constitutes the chronic issues occurring in the system that will cause medium- and long-term damage. Additionally, a systemic view of the system can be analyzed to determine how, operationally, leakage can be reduced and long-term damage be prevented. Pressure zone areas can be superimposed on the heat map to visualize correlations and plan pressure reducing strategies to prevent ongoing and future issues.

As more satellite leak images are recorded and confirmed, the heat map can be refined to add asset planning value to NBU.