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Texas Cities Increase Efficiency in Distribution Systems

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Much of the water produced at municipal treatment plants never reaches its intended final destination.

Water leaks, unmetered uses, and inaccurate meters all contribute to unaccounted-for water, which is the difference between the amount of water produced by the utilities and the amount purchased by consumers. Nationally, unaccounted-for water losses range from 10 to 40 percent of the water produced.

It's not just water that's lost however. Every gallon that disappears represents lost revenues and increased costs. Obviously, water that doesn't get to the customer can't be used and sold. On the other hand, unaccounted-for water losses ma. create the impression that additional water supplies and/or distribution systems are needed when all that's really required is reducing waste in the system. Unaccounted-for water losses may increase the infiltration of outside water into wastewater treatment plants, resulting in greater volumes to process and therefore increased costs to pay.

Many Texas cities, however, are working hard to round up this lost resource. Supply management strategies to increase efficiency of water distribution systems are being incorporated into the water management plans of many areas. New technologies, particularly computerized "leak correlators," can pinpoint leaks with surprising accuracy, reducing unnecessary excavations and preventing minor leaks from developing into major headaches.

It's fairly straightforward to calculate unaccounted-for water losses. Most cities know the amount of Water produced and the amount of consumption purchased. Things get a little trickier when calculating losses, however. Nonvisible leaks that don't surface are difficult to locate without sophisticated technology. It's almost impossible to determine how long, how much, and at what rate a pipe has been leaking. Many utilities simply look at the amount of water leaking per minute to estimate the amount lost for one year. This technique is convenient, but may not be accurate.

There are other problems. What cost should be assigned to the amount of water lost: the cost to produce raw water or the much higher cost to deliver treated water? Most Texas cities use the raw water price, although some rely on the treated water cost. Other cost-related issues concern "what-if" scenarios.

One well-publicized advantage of leak correlation systems is that they pinpoint the locations of leaks and sizeably reduce the need for unnecessary road excavations. The premise is that an accurate leak locator will find the leak after digging just one small hole, instead of randomly searching for the leak by turning a thoroughfare into something resembling Swiss cheese. Although the principle is sound and probably valid, it is difficult to assess the potential for street repairs.

Almost every utility surveyed for this article has different procedures to track nonrevenue-producing sources of water. Typically, street cleaning, fire fighting, system flushing, and water used at construction sites are not metered. The biggest discrepancy is irrigation for parks and highway medians. In some cases, the amount used for these purposes is unmetered. In other cases, city utilities sell metered amounts of irrigation to other city departments.

Finally, information on the accuracy of water meters (master and individual-customer types) was scarce. Even without leaks, unaccounted-for losses can occur if customers receive or use more water than their meters record.

WATER AUDITS

Water audits are comprehensive approaches to supply management and involve much more than just looking for leaks. A water audit includes many of the same features of any other audit. This involves measuring assets (in this case, the water supply) and liabilities (the amount of water used by the utility and consumers). The difference between the amount produced and the amount paid by metered sales is the unaccounted-for water loss. Analyzing the results of a water audit may lead to the development of programs that increase the accuracy of water meters, locate visible and nonvisible leaks, and track previously unmetered uses.

Two examples of results generated through comprehensive water audits involve studies recently completed in the Houston area for the City of West University Place and Municipal Utility District (MUD) 24.

Consultants hired by West University Place compared production against metered sales and other uses. They found, for example, that only 71 percent of production actually resulted in metered sales. The remainder was identified as under registration of residential meters (4.7 percent), underground leakage (13.9 percent), public uses such as fire fighting and street cleaning (2.0 percent), unavoidable leakage (6.7 percent), and miscellaneous losses (1.6 percent).

The audit revealed that 12 leaks totaling 300,000 gallons per day (more than 109 million gallons per year) were located in a leak detection program. Those losses would have represented $27,375 if the leaks had continued for a year. Another important finding was that 84,000 gallons per day could be accounted for if the accuracy of residential meters were increased from its present level of 93 percent to 99 percent.

Elements in the West University Place water audit included testing master meters (meters that supply water to the distribution system), comparing production and consumption, measuring night-time flow rates, evaluating the accuracy of residential meters, and checking for leaks. Recommendations to improve the efficiency of the water distribution system included more record-keeping to account for sources of water use that don't produce revenue for the city, development of a computer-aided meter reading system, testing and replacement of small meters, and development of a systemwide map showing leaks and mains. Many recommendations in this report could benefit other Texas cities.

Consultants working with MUD 24 compiled a database consisting of water consumption; discharges to wastewater plants; the number of commercial and residential meters; operations and maintenance costs; costs of water production and wastewater treatment; and the number, type, and amount of water mains and lines. From this database, unaccounted-for water losses were estimated at 7.6 percent.

Among other things, MUD 24's report suggested that leaks in the water distribution system may be contributing to the infiltration entering the wastewater system. In 198586, the metered amount of wastewater discharged by the treatment plant exceeded the volume of water produced by the utility by more than 30,000 gallons. A leak detection program to eliminate infiltration could save the utility $21,040.

For many municipalities, a "do-it-yourself" water audit developed by the Water Resources Center at Texas Tech University may be an easy-to-use, low-cost way to identify and reduce unaccounted-for water losses. This audit asks questions that help a community evaluate the efficiency of its water system. Illustrative examples accompany all questions, and explanations are provided for terms used in the audit.

The components of the water audit are water supply (including the distribution system and leakage data), wastewater collection, treatment and disposal, and stormwater management and conservation.

TEXAS EXPERIENCES AT LOCATING LEAKS

Many Texas utilities that had experienced significant losses from their water distribution systems are now reducing those losses through leak correlation and other programs.

Officials with the City of Houston say that their unaccounted-for water losses averaged 21 percent from July 1986 to June 1987. One major source of these losses is breaks in water mains and lines that are caused by unstable clay soils.

Houston initiated a leak detection program in September 1986. The program involves surveying the distribution system, then following with leak correlators to pinpoint breaks. The surveys have been successful at locating 22 nonvisible leaks totaling more than 862,000 gallons per day of lost water, including three undetected leaks of more than 100,000 gallons per day. City officials estimate that those leaks resulted in "possible" daily costs of $129,384 (assuming the leaks had continued for one full day). The leak correlators have also been useful in pinpointing 66 visible leaks that were reported to the city. City officials estimate that these leaks deprived the utility of $405,400 per day (over $19.5 million annually).

The City of Fort Worth has been conducting an extensive leak detection program since 1984. From April 1985 to April 1986, 25 nonvisible leaks were detected at an estimated loss of 2.17 million gallons per day (MGD). In its survey, the city also found that 152 fire hydrants, 21 valves, 13 meters, and 57 meter boxes were leaking. Surprisingly, one of the 12 surveyed sectors accounted for 71 percent of water losses in the entire system. Another 46 reported visible leaks were pinpointed that accounted for a loss of 3.94 MGD.

Fort Worth officials calculate cost savings based on the wholesale cost of water, in this case $0.63 per 1,000 gallons. City officials estimated water losses at more than 6.15 MGD, which resulted in a projected cost savings of $1.41 million annually. Expenses associated with the leak correlation program were calculated at $48,000 per year or about $97 per mile of the surveyed system.

Unaccounted-for water losses in the City of Austin average only 8 to 10 percent. The City of Austin has been using leak correlators for the past four years, regularly surveying about 1,000 miles of water lines annually, in addition to pinpointing reported leaks. In 1985-1986, the surveys identified 5.5 million gallons per day of leaks.

The LCRA began a leak detection "demonstration program" in December 1986 when it offered leak surveys to water suppliers with water losses greater than 10 percent. County judges recommended which water suppliers would take part in the program. (Once the demonstration program ends, LCRA may begin scheduling surveys for a nominal charge.

LCRA sent personnel to 10 water districts in its service area to conduct leak detection surveys as part of the demonstration program.

The team surveyed all service connections, valves, and hydrants within the system and tested a sample of the service meters. An estimated 147,000 gallons per day of unaccounted-for water at a savings of $61,700 has been identified in this program. One water district in Travis County slashed its unaccounted-for water losses from 38 percent to 9 percent after taking part in the program.

The San Antonio City Water Board reports that unaccounted-for water losses averaged 15 percent (914 million gallons) during 19831985. The board began a leak survey and correlation program in 1986. Results are not available.

Unaccounted-for water losses in the City of Dallas averaged 13.4 percent in 1985-1986. Dallas meters all of its water users, including irrigation water delivered to city parks and highway medians. Dallas is using acoustical sounding equipment to locate reported visible leaks. No estimates on the efficiency of this program in locating leaks were available.

LEAK DETECTION PROGRAMS

Leak detection programs can be excellent ways to cut unaccounted-for water losses. These programs identify areas where water is escaping from the system and repairs are needed.

Leak location programs have traditionally consisted of visual inspections (where customers were requested to report visible leaks), acoustical surveys, miniprobe sensors, tracer gases, and infrared photography.

Acoustical surveys usually involve the use of microphones to amplify the sound of leaks. Water makes noise as it escapes from pipe and impacts on surrounding soils. The intensity of the noise depends on pipe material, water table conditions, size of the leak, depth of the pipe, soil material, and background traffic noises.

Escaping fluids create sound frequencies different from those produced by fluids in pipes that are not leaking. (The sound is often compared to "popping popcorn.") Three distinct sounds are important: 1) a high-intensity sound originating from where the water first escapes; 2) a quieter sound generated by the water's impact on surrounding soils, and 3) a sound (like a fountain) of water circulating around the hole formed by the leak.

Acoustical surveys sometimes produce misleading results. Along busy urban streets, leaks from water lines and mains are hard to distinguish from traffic noise and other sounds. As a result, acoustical surveys are most effective during early morning hours.

Miniprobe sensors are small probes with radio transmitters that are inserted directly into the main of a distribution system. A surface sensor monitors the movement of the probe, which flows to the location of a major leak. Although expensive and labor-intensive, this technique can be useful in locating large leaks, particularly in plastic piping.

Tracer gas methods, also expensive and complicated, can be used to pinpoint major breaks when acoustical surveys are not practical. Nitrous oxide, helium, and methane-nitrogen are the most frequently used gases for locating leaks.

Infrared photography can be useful when ground temperature is lower than that of potable water. In this method, large leaks may put enough heat into the surrounding soil to raise its temperature. Subject to interference from other heat sources (such as steam lines), this method requires sophisticated equipment and trained personnel.

Another system, proposed but not widely implemented, involves installing pressure sensors at test nodes along the distribution system. Sensors measure flow and pressure, then continually relay this information to a computerized database. If a rupture occurs, the large drop in flow and wide variations in pressure signal the location of the leak.

IMPROVING THE ACCURACY OF WATER METERS

Meters of various sizes measure the amount of water entering a distribution system as well as the amount consumed by individual consumers. If meters are inaccurate, customers receive free water_ water that ends up costing the utility money. Factors contributing to inaccurate meter readings can include water chemistry (too much sediment can clog a meter, for example), water use habits of consumers, and the composition of connecting service lines and distribution mains.

Residential meters in some parts of Texas under-register consistently by more than 6 percent. In a system that produces 1.5 million gallons per day, that could lead to an under registration of more than 100,000 gallons per day, leading to $75,000 annually in lost revenues.

Experts recommend that master meters, large industrial meters, and residential meters be tested regularly. To test residential meters, usually water flows through the meter at various rates. Many Texas cities have regular programs to test and repair larger meters. (Fort Worth regularly tests and repairs meters larger than three inches, and removes and replaces small meters that have become obsolete.) The amount of water registered by the meter is then compared to the amount of water discharged through the meter. The most important flow rate is 2 to 7 gallons per minute (GPM), because that's the range where residential customers consume 70 percent of their water.

A relatively new development is the use of computer-aided meter reading systems. This may increase efficiency because some models automatically compare an individual's monthly usage with the amount of water consumed in previous months. If the figures vary greatly, the computerized unit automatically takes a second reading.

SOURCES OF WATER LEAKS

Unstable and corrosive soils, the improper installation of pipes and mains, damaged pipes, corrosive pipe material, the age of the system, and the volume of water and wastewater flowing through the system all contribute to leakage.

Poor construction techniques can actually encourage leakage. Placement of damaged pipe, poor sealing of joints, and improper placement of bedding materials can create major leaks. Many Texas cities require that officials from their utilities be present when new lines are installed to ensure that standards are met.

Proper construction techniques are even more important when lines are placed in clay soils that shrink or swell. Bedding and backfill materials provide extra protection for pipes that are vulnerable to corrosion, shrinking, and swelling. It's important to select pipe materials that are compatible with soil types. High levels of sulfate create soils that will corrode pipes made of concrete or asbestos cement. These "hot" soils are common in much of east Texas. Sudden surges in water pressure (called "water hammers") can also increase leakage, particularly in soils that are already stressed.

Surprisingly, the age of pipes or mains was not regularly cited as a major cause of leaks. Many utilities reported that certain sections of older pipes were losing less water than similar segments that were decades newer.

BRYAN: INCREASING EFFICIENCY

The City of Bryan is a dramatic example of benefits gained through programs that reduce unaccounted-for water losses.

In 1984, the city had estimated its unaccounted-for water losses at 42.2 percent. In just four years, Bryan's unaccounted-for losses had shrunk to just 3.7 percent.

Unexpectedly, leaks in the system were not the major problem area. Instead, most losses were in administrative areas: 1) computer programs that performed customer billing required readjustment, 2) customer meters were often misread (usually due to incorrect multipliers), and 3) master meters were inaccurate and required recalibration.

Steps to increase efficiency included: 1) instituting a program to test and repair master meters regularly; 2) measuring usage in gallons to eliminate the use of multipliers; 3) random sampling, calculating water bills, and comparing calculations with computerized billings; and 4) replacing more than 75 percent of the meters in the city.

City utility workers helped to look for and report water waste. Water production personnel watched for sudden drops in distribution line pressures and unusual declines of water levels in elevated storage tanks. Other workers inventoried areas where streets crossed streams and drainage areas, looking for indications of nearby leaks such as unusual flows of water (a broken three-inch line flowing directly into a creek was discovered this way). Shortly after the first freeze, storm sewer inlet boxes were checked for escaping steam, which might indicate that water was flowing directly from a main into a storm sewer.

LEAK CORRELATORS

Leak correlators combine enhanced acoustical monitoring with computer technology. Leak correlation systems are success fully used in many Texas cities including Fort Worth, Austin, Houston, and San Antonio and in the counties serviced by the Lower Colorado River Authority (LCRA).

Most utilities use leak correlation equipment in a two-phase process. First, acoustical surveys identify areas where leaks are suspected.

After the survey, the detection crew returns to the targeted areas with the leak correlator. Listening devices are attached at two locations, on opposite sides of the suspected leak. Soundwaves from the devices are then transmitted to a nearby microcomputer, where operators enter data about the distance between the two listening devices, the pipe material (asbestos cement or ductile iron, for example), the diameter of the pipe, and the rate at which water should be flowing through the pipe.

The computer measures sound waves by "time of flight" to determine the location of the leak, then displays an irregular line or graph depicting the location at which soundwaves are greatest. By aligning a cursor with the peak of the graph, the computer identifies the location of the leak as a certain distance from one of the two listening posts.

In most instances, correlators are accurate to within a few feet of the actual leak. For correlators to correctly pinpoint leaks, up-to-date maps of the distribution system that list pipe location and composition are necessary. The cost of a leak control system can easily exceed $40,000. Leak correlators are not as effective in some larger pipes because the contact points are farther apart. Leak correlators also have not been as accurate at detecting leaks from some plastic pipes in which the sound is muted and is harder to detect. The equipment works better in flat terrain than it does in hilly or mountainous areas.

The advantages of leak correlators are numerous. Leaking water that could not be seen at the surface can be identified. When large leaks do surface, it is easier to precisely locate them. Because of this precision, costs of digging for potential leaks are reduced. One utility reported that now, because of correlators, it digs only one or two percent of the holes dug before this technology was available. Finally, the system is easy to use and requires only limited training.

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