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By Jared Raney

COVER PHOTO: Grand Prairie utility crew leader Rene Luna (left) instructs utility worker Emilio Davila on the maintenance and inspection of a SmartCover flow monitoring system. Grand Prairie has drastically reduced SSOs as well as inflow and infiltration by prioritizing projects based on extensive flow monitoring data.

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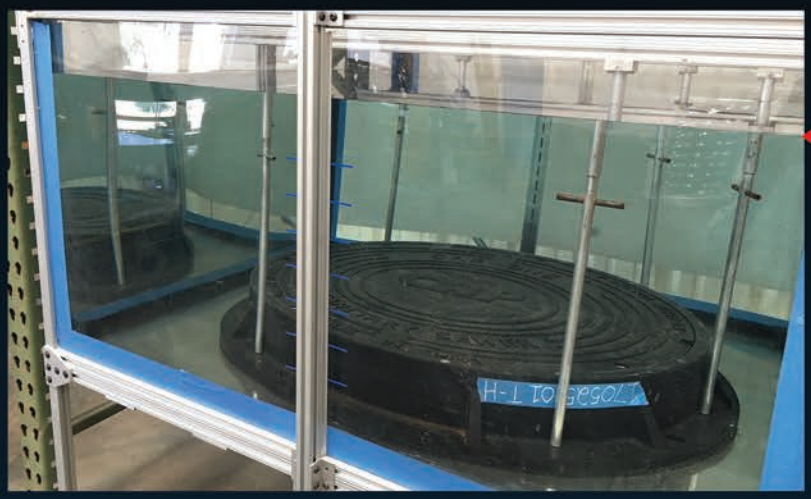

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A MODEL FOR MUNICIPALITIES

Kansas utility's in-house grouting program provides an efficient and cost-effective approach to reducing flow

By Deb Hammacher

Inflow and infiltration is a budget killer for utilities of all sizes. In addition to the bottom-line issue of treating extra water, I&I can create problems with capacity, potentially limiting community growth or necessitating additional facilities.

Staying on top of I&I is critical whether the work is in-house or outsourced. In-house programs can be cost-effective options. Hiring freezes or other budget constraints might dictate outsourcing.

The city of Olathe, Kansas, has an in-house program that is a model for other municipalities. For several years, Olathe has used a system of attacking leaks with the use of chemical grouts. These products are a permanent solution to stop both seeping and gushing leaks, as well as to fill voids caused by water erosion or settlement.

Leaks are identified through several channels, including CCTV inspection and reporting from construction crews, manhole crews, and others involved in the sanitary sewer system.

"As we come across leaks, we rate them based on severity, create work orders, and prioritize them in our asset management system. A follow-up visit is made to determine the method we are going to use, whether it's entering the manhole or probe grouting," says Olathe Public Works' I&I supervisor.

The I&I group equipped a cargo trailer with the tools, supplies and grout equipment they might need. This has also enhanced efficiency. The rig is ready to go whenever it is needed. The portability of the equipment means they have yet to find a manhole that they couldn't access. Leaks are sealed in minutes rather than hours and usually do not require full street closures.

The City of Olathe believes that chemical grout is a good business decision. "Using grout isn't a hard decision. It is very cost-effective. It is an easy tool to use and it works," the Olathe supervisor notes.

The city of Olathe, Kansas, has an in-house grouting program for correcting inflow and infiltration issues. The utility's I&I group has equipped a cargo trailer with all the tools, supplies and grout equipment they need to efficiently address problem manholes.

ANOTHER APPROACH

Other municipalities prefer to outsource this work. In some cases, they do not have the luxury of hiring permanent staff. In other cases, outsourcing solves problems with employee turnover and training. Whatever the reason, there are qualified contractors around the country who can meet the I&I control needs of public works or utility clients.

Foundation Professionals of Florida serves several municipalities across the state. A high water table coupled with heavy rain events from tropical storms and hurricanes are a recipe for significant I&I and sanitary sewer overflows. Curtain grouting manholes with polyurethane foam is one of the main ways they tackle I&I for their clients.

The math makes a compelling business case for tackling leaking manholes.

If one manhole leak adds 5 gpm, 300 additional gallons of water an hour need treatment. If a system can handle 50,000 gallons per hour and average daily sewer flow takes — very conservatively — 75 percent of that capacity, it takes only 50 leaking manholes to overburden the system. From a cost perspective, that 5 gpm leak means 2.6 million gallons of additional volume to be treated. If treatment cost is roughly $3 per 1,000 gallons, that is $7,800 per manhole in a year. This does not take into account the cost to run the system longer to keep up with the additional volume nor does it include costly Environmental Protection Agency fines for SSOs or failure of the structures while in service.

Foundation Professionals of Florida uses a two-step method. After pumping out the manhole, they seal leaks with a hydrophilic polyurethane (Hydro Gel SX from Prime Resins) that forms a tenacious bond to the concrete or brick manhole and can accommodate the movement or vibration that many manholes experience. The crew then encapsulates the manhole with a watertight, structural polyurethane foam that meets NSF/ANSI Standard 61 for contact with potable water (Prime Flex 920). Sometimes a manhole is lined after that if it is degraded and needs structural support.

The trenchless approach keeps cost and traffic disruption down versus an excavation repair.

"We help a municipality better serve its customers and we do that in partnership with them. Their workers are right there with us," says David Brown, Foundation Pros owner. "When we stop I&I, they can use taxpayer dollars for something other than treating extra wastewater." I&I

Comprehensive Planning

Grand Prairie's big-picture approach solves many problems, including inflow and infiltration

STORY Jared Raney | PHOTOS Olivia Ogren-Hrejsa

Suddenly, you find that flow is increasing drastically — the system is careening toward an overflow, and if inflow and infiltration is your problem, finding the source is no simple matter.

If your utility is like Grand Prairie, Texas, the solution to limiting I&I may not be finding that source at all — sometimes the best way to fix I&I is not to focus on it, but instead to take an all-encompassing systemic approach.

Grand Prairie struggled with a yearly average 65 sanitary sewer overflows throughout their 700-mile wastewater collections system in 2006.

Concerned by such a high number of overflows, the city embarked on a comprehensive assessment of the system, with an efficient inspection and monitoring approach using some innovative tools.

A combination of flow monitoring via SmartCover manhole monitoring and acoustic assessment using an InfoSense SL-RAT allow Grand Prairie to prioritize their replacement projects into a comprehensive master plan. Doing so limits emergency repairs and keeps them on the path to reducing I&I and eliminating overflows.

Today, the utility is down to single-digit overflows: eight per year for the last three years, and only three so far in 2018.

The cherry on top is that there have also been only three I&I-related events since 2012, compared to around five per year when the master plan started.

OLD AND NEW

Situated in the so-called Metroplex area between Dallas and Fort Worth, Grand Prairie is ripe for new residential development. On the other hand, it is also an old community with a lot of aging infrastructure.

Development sites often contribute inflow to the system through accidentals: a clean-out uncapped here, a loose manhole lid there.

Sites like this exemplify the importance of an ongoing monitoring program, which Grand Prairie has gone to great lengths to develop. Some of their greatest assets in this fight are monitoring and assessment solutions from SmartCover Systems and InfoSense.

Sewer repair and replacement projects in Grand Prairie (Texas) are prioritized in part by flow monitoring assessment using the SmartCover system. The green reflective box on top of the tilt cover hides the systems' antenna. Alerts are delivered to specified email addresses.

The management team at Grand Prairie Department of Environmental Quality includes, from left, Jim Siddall, water operations manager; Barry Walsh, utility operations superintendent; and David Clark, utilities projects coordinator.

PROJECT SHOWCASE

David Clark checks a manhole after receiving an alert from the SmartCover manhole monitoring system.

GRAND PRAIRIE (TEXAS) DEPARTMENT OF ENVIRONMENTAL QUALITY

INFRASTRUCTURE:
700-mile collections system

PROJECT:
Comprehensive wastewater system assessment

RESULTS:
Only three inflow and infiltration-related events since 2012

SmartCover provides a number of products for real-time condition assessment of manholes. Most of the systems tie into existing manholes and can be retrofitted for a number of purposes.

"We put them in areas where we know that we have to do periodic washing of the basins to make sure we don't have any overflows there," says Jim Siddall, water operations manager. "Instead of sending a crew out every 30 days to wash this particular line segment, we have a SmartCover on there and whenever it indicates that the flow in that manhole has reached a predetermined level, then we'll send a crew out and wash it."

As a result of this practice, utility workers have gone from cleaning a line every 30 days to an average of about every 120 days.

"We can spread the crews out a little more, and we wash the basins more on an as-needed basis, rather than on a just-in-case basis," Siddall says.

The InfoSense SL-RAT is also a valuable asset in this regard.

"We put that down in the manhole, and it transmits an acoustic signal to the next manhole. Depending on the strength of that acoustic signal, it tells us if there are any obstructions or high flows in there," Siddall says.

Using the SL-RAT, they score each line on a scale of 1 to 10, with 10 being completely clear. This saves on inspection costs, as using the SL-RAT takes much less time than a full video inspection.

"We're doing that to get a snapshot of the condition of the lines," Siddall says. "It helps us detect overflow points that we've had problems with in the past, but additionally, we use them for lines that we are washing on a periodic basis, and it has lessened the number of times we have to go out to those lines."

LESSONS FROM THE LAKE

In 2015, during heavy rains, a utility supervisor noticed high flow through one of the lift stations.

They thought that it could be due to a nearby housing development. Upon investigation, they found some inflow, but it didn't account for the volume passing through the lift station.

"What we found was there was a low depression, and our manhole was down in there," Siddall says. "The force of the initial inflow had forced the manhole lid off, and now that thing was underwater because the lake was

The Grand Prairie crew includes, from left, Emilo Davila, utilities main worker; Rene Luna, utility crew leader; Barry Walsh, utility operations superintendent; Jim Siddall, water operations manager; and David Clark, utilities projects coordinator.

David Clark looks over components of a SmartCover monitoring system.

"I would say that at least 80 percent of the I&I problems are coming from the private side. You have to imagine that the services on the private side are just about the same age, and we've found some of the old Orangeburg pipe down in that area. I'd say most of our I&I is coming from the private side."

The utility relies on building inspectors to ensure that new developments aren't contributing I&I, and uses mainly smoke testing to identify existing illegal tie-ins like roof drains and French drains.

"Some customers have actually dug around their clean-out next to the house and then pulled the clean-out off to drain their yards," Siddall says. "That's just getting out there and surveying the area, and doing an assessment of each neighborhood, and that's just a long and continuous process."

"Our lift station was draining the lake. I hesitate to think of how many millions of gallons. That was our biggest challenge right there."

Jim Siddall

coming underneath the road through a culvert into that depression area."

The crew had to build a cofferdam separating the depression and manhole from the lake overflow and pump out the water covering the manhole.

"Our lift station was draining the lake. I hesitate to think of how many millions of gallons," Siddall says. "That was our biggest challenge right there."

It's incidents like this that prove the value of flow monitoring.

"It has given us warnings on several occasions. On stormy nights, we'll get several calls on SmartCovers — we have about 50 of them now — and they're located all over town. Rather than having crews sitting here waiting for the overflow, we'll get an indication.

"We can mitigate and have the crews ready to standby for pumping, so it doesn't get outside of the manhole," Siddall says. "I'd say it has saved us a lot of time and money over the years."

There are two important aspects to the flow monitoring: data collection to assess pipe condition over time, and ongoing observation to identify spikes in flow that may indicate an impending overflow.

"It gives real-time data. They instantly tell us after a rain event how much calculated flow we got, and that has saved us a bunch of money also because those flow studies are usually pretty expensive," Siddall says. "That has helped us make decisions on which lines we want to replace."

MAKING THE PLAN

"Our plan was to get an assessment of the entire system, to determine what is causing these overflows, and what we could do to mechanically and operationally fix those," Siddall says.

The current master plan was created in 2016 after the original from 2006 was completed.

"Replacement of several lines, which included just ordinary replacement due to type of material, clay pipe and that type of thing, and to increase capacity in certain areas," Siddall says. "In that older area of town, we're having problems with the age of the lines and the condition; almost every year we're replacing lines down there."

Because there is so much new development in the area, many of the older sections of town with aging lines had to be upsized anyway due to nearby housing projects, equaling a double-whammy for the city.

Some aspects of the plan, such as the flow monitoring, don't address overflows or I&I directly. Instead, they are aimed at increasing operational efficiency to allow more resources for capital improvement and emergency replacements.

Jasmine Alvarez, utility dispatcher, monitors the SmartCover system and alerts a supervisor if an alarm is sent.

Now that they have a firm grasp of what's going on in the system, Grand Prairie is focused on increasing operational efficiencies day to day with flow monitoring, then channeling that extra time and money toward keeping their replacement schedule on track.

"Our plan is to continue to keep our lines clean and clear and in good mechanical shape, so that we can mitigate any type of overflows and mitigate the amount of money that we're spending on controlling those overflows." I&I

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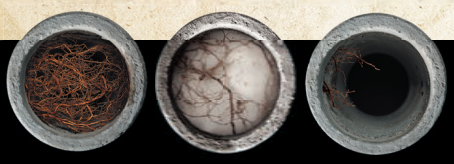

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FLOW MONITORING DATA REVIEW

Maximizing data uptime by applying a scattergraph review process

By Patrick Stevens, P.E., and Matthew Brown

We started this series of articles to provide guidance based upon over 40 years of flow monitoring experience. It is also an aid to rainfall-dependent inflow and infiltration study practitioners so that they may avoid project stumbling blocks that have been observed over time.

In the last article, we discussed the importance of focusing basin sizes to provide maximum granularity in identifying problem areas in the collections system. By reducing basin footages, a targeted approach can be applied that has benefits in cost and remediation effectiveness. This article is focused on data quality and maximizing data uptime by applying a scattergraph review process throughout the project progression.

It is a common approach to evaluate flow data by reviewing its hydrograph. A regular diurnal pattern suggests the meter is working OK. But it must be recognized that no flowmeter on the face of the earth actually measures flow; they all measure something else and calculate or derive a rate of flow. For the open-channel flowmeters used in I&I studies, water depth and water velocity are measured and flow is calculated by knowing the cross-sectional area of the flow. So the proper way to assess the quality of the meter data is to evaluate its measurements — depth and velocity — and the scattergraph is the tool for this evaluation.

There is a concept in the business community that key performance indicators can be used to guide the business. KPIs help organizations achieve organizational goals through the definition and measurement of progress. The key indicators must be measurable and must be key to the success of the task. KPIs can apply to any endeavor, and for driving a car, the speedometer and gas gauge are examples. For measuring before-and-after RDII reduction, the two KPIs are the depth-velocity scattergraph of open-channel flowmeter data and the Q vs. i (RDII vs. rainfall) plot.

Analyzing a scattergraph is a mandatory first step in evaluating a flow monitor's performance whenever flow monitors are utilized, and the user can apply two tests in sequence to evaluate data in a scattergraph: looking for a repeatable pattern and comparing data to manual readings. When this method is applied, you can count on reliable data forming the foundation of a successful I&I program.

REPEATABLE PATTERNS

The Manning curve is the classic curve used in sewer hydraulics to define the depth-velocity relationship. If the flow monitor data lines up with the pipe curve, the user knows that the sewer is experiencing uniform flow conditions; as depth increases, the velocity increases. If the flow monitor data does not line up with a pipe curve, one of only two things is occurring:

A) The sewer is not experiencing uniform flow conditions.

B) The flow monitor is failing to make valid measurements.

It is critical that the observer attempts to make this distinction before moving on to any other accuracy issues.

It is important to recognize that under nonuniform flow conditions the data may still be valid even though the data and the Manning pipe curve do not coincide. If the patterns indicate that valid hydraulic conditions exist, then the user should move on to manual confirmation of monitor readings.

The precision of a flowmeter can be assessed by the repeatability of the data pattern. Precision is determined by how tightly the data conform to a pipe curve. This concept is illustrated in Figure 1. Precise meters will produce a data pattern that adheres to the pipe curve much better than a low precision meter.

MANUAL CONFIRMATION

If the flow monitor's depth and velocity readings are coincident or very close to the manual readings, the user knows that the measurable components are correct or bias-free. It is important that only those data points immediately before and after the manual confirmation be used in this comparison. Apparent bias can occur in sewers with rapidly changing hydraulics such as an upstream pump station. Common sources of depth bias include pressure sensor drift, unstable hydraulics, large waves, noisy sites and fouled sensors.

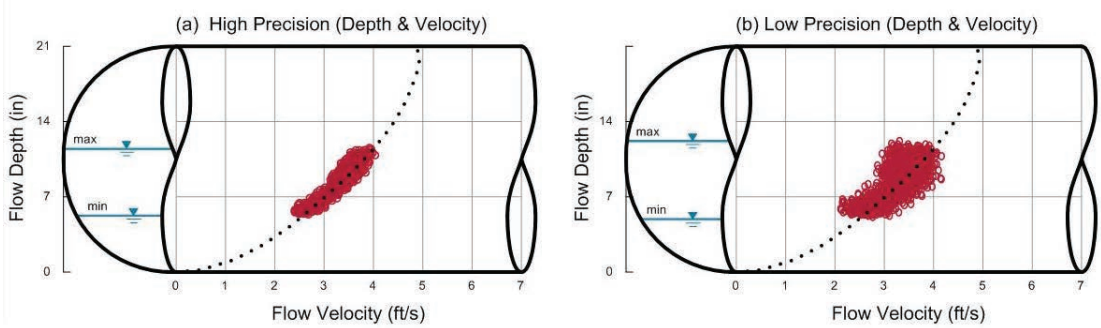

FIGURE 1: The precision of a flowmeter can be assessed by the repeatability of the data pattern. Precise meters will produce a data pattern that adheres to the pipe curve much better than a low precision meter.

To assess the quality of flow monitor data, three sets of data are plotted together on a scattergraph: (1) flow depth and velocity readings from the flow monitor, (2) manual depth and velocity confirmations collected with a ruler and a portable velocity meter, and (3) a pipe curve described by the Manning Equation. Figure 2 shows how these data should appear in a site under uniform flow conditions with a properly functioning flow monitor. All three data sets should be aligned with each other.

It can be easily seen if the data points align well with the Manning pipe curve, but it is not clear how closely the manual measurements coincide with the flow monitor data. This is especially true if there are many data points. It is often instructive to look more closely at individual data points and the corresponding manual confirmations. Taking a manual confirmation at exactly the same moment as a monitor reading could distort sewer hydraulics and the monitor reading.

USING THIS TECHNIQUE

If the flow monitor data lines up with the pipe curve and can be confirmed manually, only then can the user consider the flow rates reported by the flow

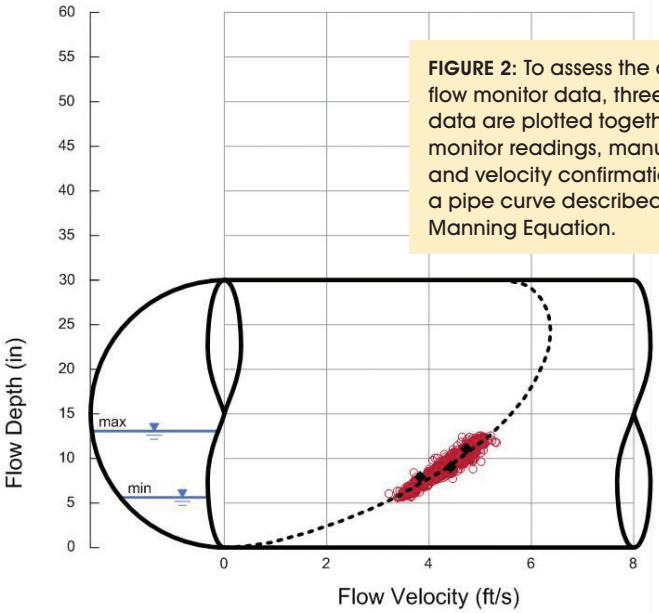

FIGURE 2: To assess the quality of flow monitor data, three sets of data are plotted together: flow monitor readings, manual depth and velocity confirmations, and a pipe curve described by the Manning Equation.

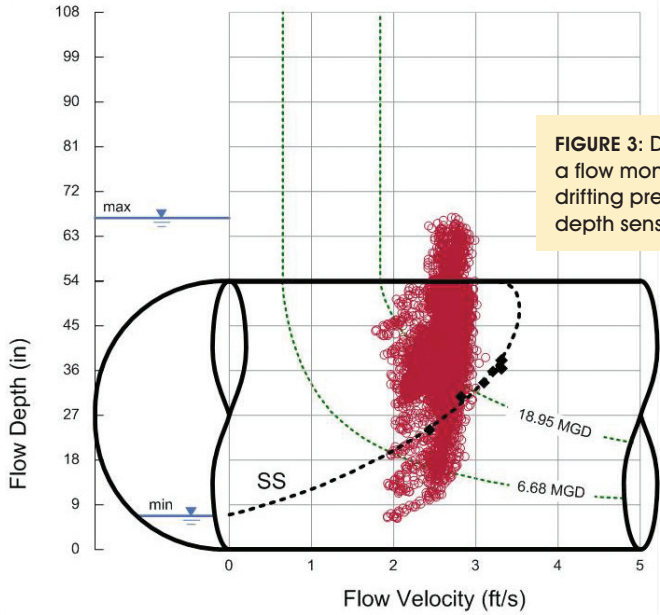

FIGURE 3: Data from a flow monitor with a drifting pressure depth sensor.

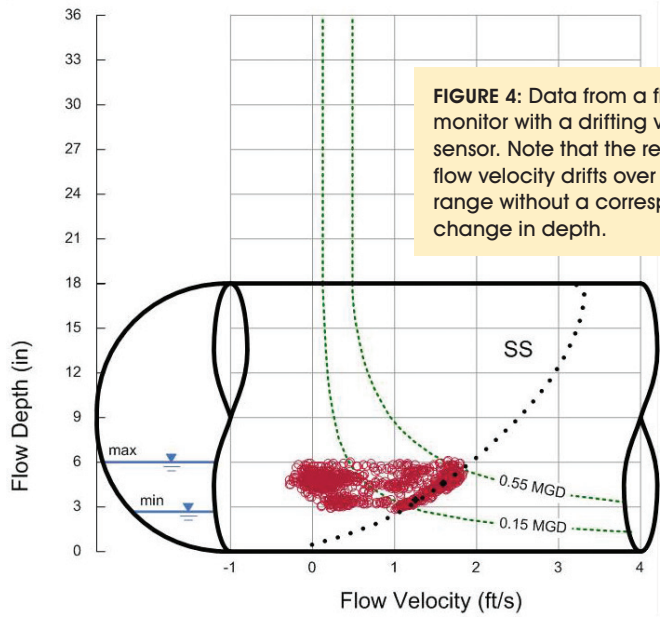

FIGURE 4: Data from a flow monitor with a drifting velocity sensor. Note that the reported flow velocity drifts over a wide range without a corresponding change in depth.

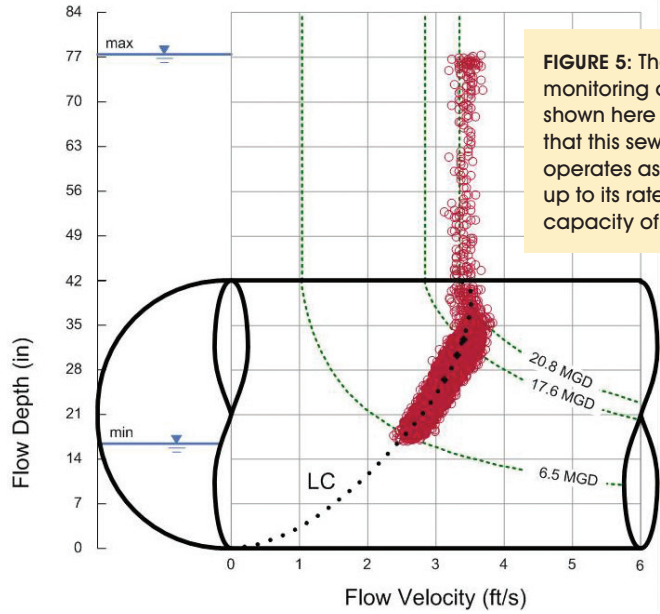

FIGURE 5: The flow monitoring data shown here indicates that this sewer operates as expected up to its rated capacity of 20 mgd.

monitor. Several things, including the use of an inappropriate equation or an incorrect pipe diameter can affect the accuracy of the subsequent flow calculations. A very common source of error is using the nominal pipe diameter shown on the drawings instead of using a field measurement. This frequently occurs in small-diameter sewers where the actual diameter often does not equal the nominal diameter.

Iso-Q lines are another useful tool when evaluating flow during an I&I project. Iso-Q lines are lines indicating depth-velocity points that result in a constant flow rate. They are made up of all depth and velocity combinations that generate a given flow rate. They are interpreted similarly to contour lines on a map.

When dealing with I&I, capacity is a high priority. Overflows occur when capacity is maximized during a wet-weather event. One way to prevent this from happening is to determine if all lines are operating at maximum capacity or if there is a blockage in the line that may be inhibiting the pipe from conveying its maximum potential. Iso-Q lines are an effective way to visualize the capacity at which the monitored line is operating.

Flow monitor data that do not lie on a pipe curve indicate either that the hydraulics are different or that the flow monitor is not working correctly. The scattergraph shown in Figure 3 displays data from a flow monitor with a drifting pressure depth sensor.

Note that the reported flow depth drifts over a wide range without a corresponding change in flow velocity. In this case, a series of pipe curves are observed at multiple depths and deviate significantly above and below the manual confirmations. The data from this flow monitor is invalid and should be disregarded.

The scattergraph shown in Figure 4 displays data from a flow monitor with a drifting velocity sensor. Note that the reported flow velocity drifts over a wide range without a corresponding change in depth.

In this case, an electromagnetic velocity sensor was fouled by grease, and sensor performance deteriorated over time, eventually causing the flow monitor to record negative velocities. The data from a flow monitor exhibiting this behavior is invalid and should be disregarded.

COMMON SCATTERGRAPH PATTERNS

The above examples indicated how scattergraphs can be used to identify equipment maintenance requirements. Scattergraphs also provide insight into site hydraulics and can describe relevant information pertaining to wet-weather performance.

Surcharge conditions are common in sewer systems, especially during wet-weather events. The flow monitoring data shown in Figure 5 indicates that this sewer operates as expected up to its rated capacity of 910 L/s (20 mgd). This value is shown using an Iso-Q line. *(continued)*

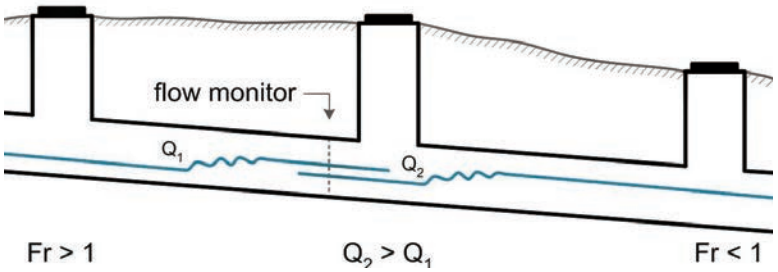

FIGURE 6: A hydraulic jump occurs when flow transitions from supercritical to subcritical flow. Supercritical conditions are observed on the upstream side of the jump, and subcritical conditions are observed on the downstream side of the jump.

Although surcharge conditions are common, it is uncommon to find a surcharged sewer that actually accommodates its rated capacity, as shown here. The minimum and maximum dry-weather flow rates are also shown using Iso-Q lines. The maximum dry-weather flow rate occurs at a depth-to-diameter (d/D) ratio of 0.77, a depth in excess of generally accepted design guidelines.

Most surcharge conditions result from downstream restrictions that reduce sewer capacity. The sewer will operate as expected up to a certain depth, but backwater conditions will be observed above this point and result in surcharge conditions at a lower capacity than expected. The impact on sewer capacity is readily identified using Iso-Q lines.

A hydraulic jump occurs when flow transitions from supercritical to subcritical flow. Supercritical conditions are observed on the upstream side of the jump, and subcritical conditions are observed on the downstream side of the jump, as shown in Figure 6.

This condition causes a wave to travel up and down the pipe. While the sensor can read well in either condition, the constant fluctuation causes two distinct flow patterns to be observed, which can create difficulty when evaluating an average flow rate. In the case of a hydraulic jump, the data takes a distinct shape and the relationship to Froude numbers can easily be observed.

As a data reviewer, this would indicate that the sensor position needs to be adjusted or an alternative site should be considered.

The signature of a sanitary sewer overflow in the scattergraph of flowmeter data depends on its position relative to a flow monitor. A SSO that occurs upstream from a flow monitor will be identified on a scattergraph by a cluster of surcharge data points at a constant flow depth and a constant velocity, as shown in Figure 7. The depth reported by the flow monitor during the SSO is controlled by the overflow elevation, and the velocity is controlled by the capacity of the downstream restriction.

This SSO lasted for almost eight hours. However, since the SSO occurred upstream from the flow monitor, the overflow volume cannot be estimated.

The scattergraph signature of a downstream SSO can also be identified.

Both upstream and downstream SSOs are characterized by a constant flow depth during an overflow. However, the additional flow escaping the system during a downstream SSO is detected by the flow monitor as an increase in velocity during the event, as shown in Figure 8.

The maximum overflow rate is determined using the Iso-Q lines and is approximately 2.8 mgd (13.3 mgd minus 10.5 mgd). This SSO lasted for about six hours and discharged 331,000 gallons of untreated wastewater to the environment.

Data review performed while flow monitoring for an RDII study is absolutely critical to the success of the study. The scattergraph is the ideal tool for performing this analysis through its ability to visually represent flow monitoring equipment concerns, as well as offering added information on hydraulic conditions present at a monitoring location. I&I

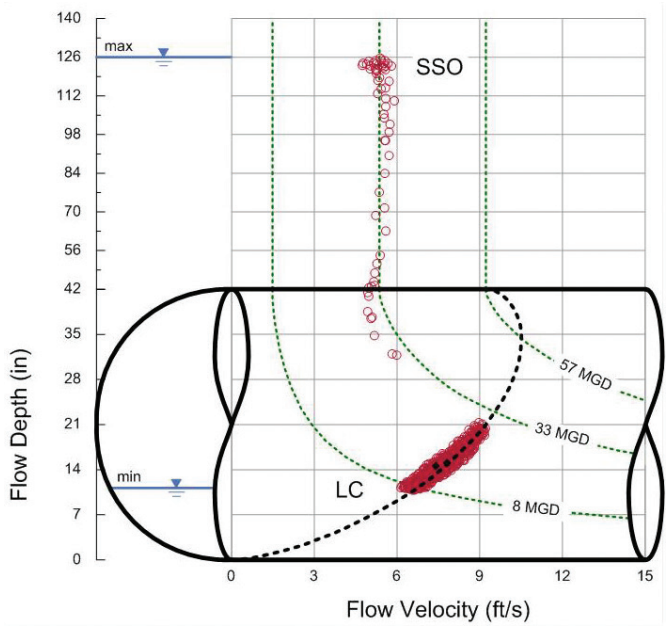

FIGURE 7: An SSO that occurs upstream from a flow monitor will be identified on a scattergraph by a cluster of surcharge data points at a constant flow depth and a constant velocity.

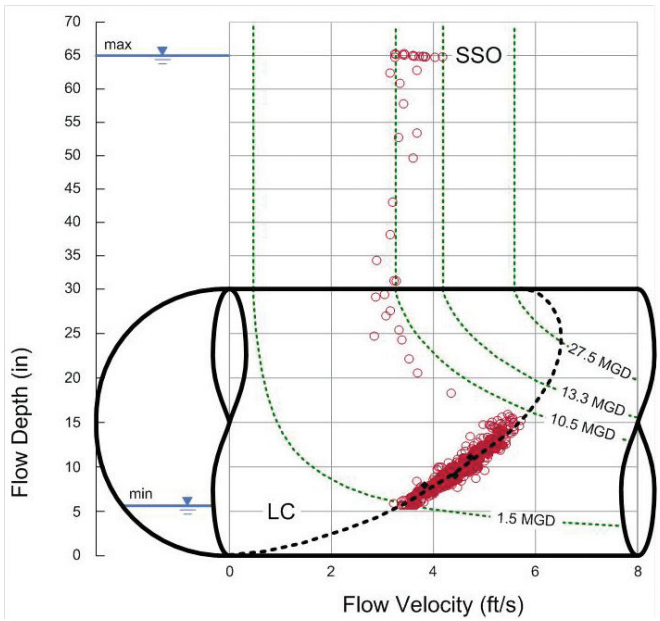

FIGURE 8: The additional flow escaping the system during a downstream SSO is detected by the flow monitor as an increase in velocity during the event.

More information can be found on these scattergraphs and others by visiting www.adsenv.com/scattergraphs

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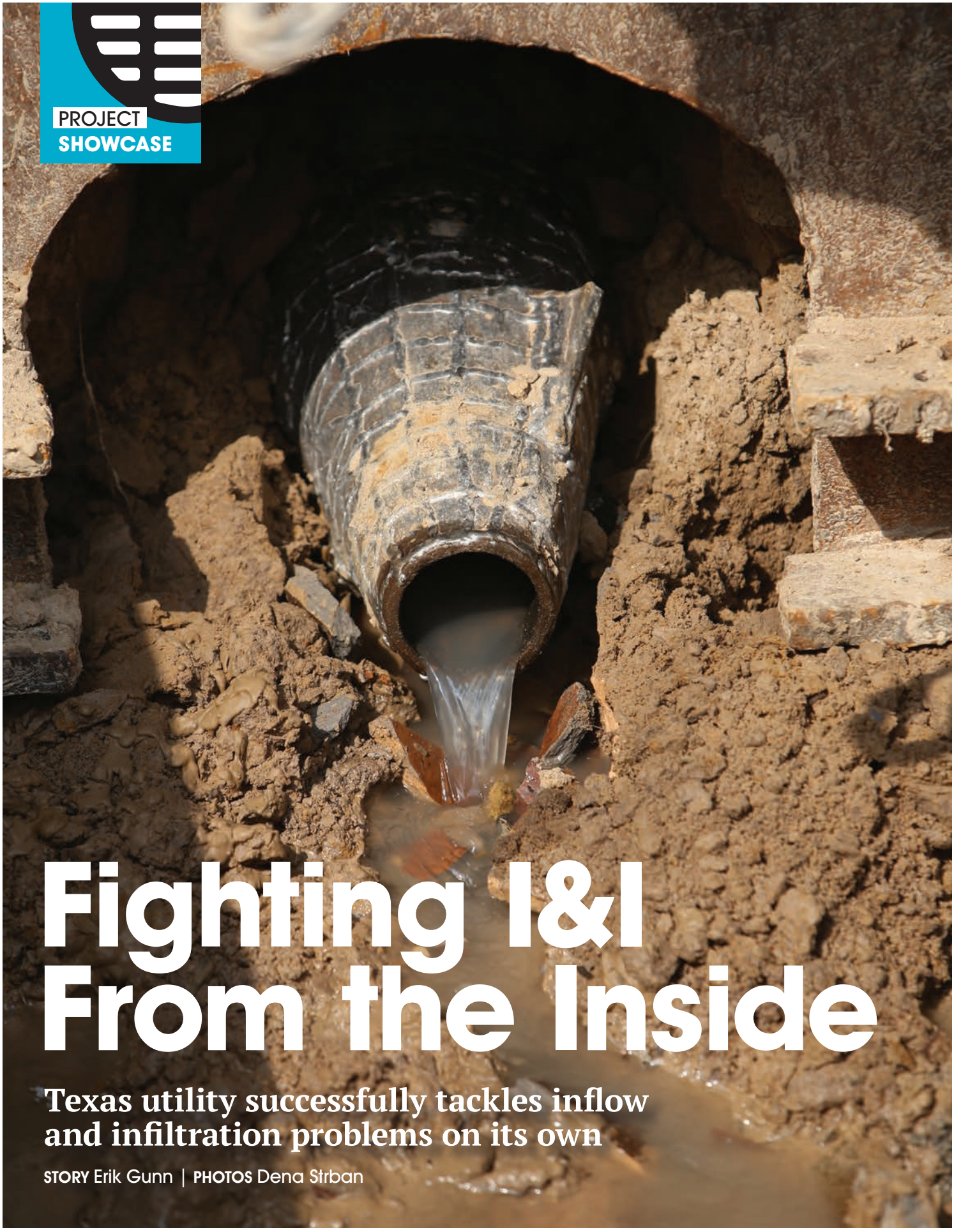

PROJECT SHOWCASE

Fighting I&I From the Inside

Texas utility successfully tackles inflow and infiltration problems on its own

STORY Erik Gunn | **PHOTOS** Dena Strban

FACING PAGE: Water flows from a 6-inch pipe bursting head (Vermeer) with bits of broken clay pipe in the surrounding soil. The Lufkin (Texas) Water and Sewer Utilities Department chooses pipe bursting over open trench replacement whenever possible. RIGHT: Technicians work on a connection to a new sewer main.

Sometimes you just need to do things yourself.

The Lufkin (Texas) Water and Sewer Utilities Department management culture emphasizes doing things in-house whenever possible. And while adhering to that ethic, the city has been pressing ahead with a comprehensive sewer rehab program that is targeting a long-standing stormwater inflow and infiltration problem.

The I&I reduction effort has been underway for more than a decade and won't be finished until 2023. But the results are already apparent.

"We're seeing next to zero stoppages," says Jason Arnold, assistant to the city manager and former utilities director. "When we're seeing major rain events, those neighborhoods just aren't having issues anymore."

Located about 120 miles northeast of Houston in eastern Texas, Lufkin sees its population triple every working day.

"We're a town with a population of a little over 35,000," Arnold says. "But our daily population is well over 100,000. The number goes up during the day because we are surrounded by several small communities. People come here to work, shop, dine and do business. We're also a major medical hub."

TAKING CONTROL

Lufkin's I&I problems go back decades. Nearly 75 percent of the collections system is made up of clay tile pipe, which is notorious for its vulnerability to cracks and root penetration that contribute to I&I. Before the I&I abatement program really took hold, a couple of inches of rain is all it would take to overload the city's sewer treatment plant.

"The lines just couldn't handle the flow. We'd have overflows in low-lying areas," says Patrick Lynch, a water and sewer utilities department foreman for 27 years who has the day-to-day task of helping to carry out the subsequent rehab programs. "Pretty much the whole system was overloaded — manhole covers were floating off."

In the year 2000, Lufkin undertook an in-depth study tracking the impact of I&I-related overflows. With extensive smoke testing, the study also identified hot spots.

Many of the leaks showed up in the private portion of sewer laterals, and the city wrote to homeowners, informing them of their obligation under city codes to have repairs made. But the study also identified plenty of work needed on city-owned lines.

SETTING PRIORITIES

In 2003, the city launched its sweeping 20-year repair and replacement program. The city was divided into five separate sectors that were ranked by priority. Work has finished on the two highest-priority sectors. Work on the third sector is underway now, and the lowest-priority fourth and fifth sectors will follow.

The team at the Lufkin Water and Sewer Utilities Department includes, from left, Sammy Stevenson, Dallas Stephenson, Hunter Willis, Amado Rosales and Patrick Lynch.

LUFKIN (TEXAS) WATER AND SEWER UTILITIES DEPARTMENT

POPULATION SERVED:
35,067

PROJECT:
20-year repair and replacement program

EMPLOYEES:
36 full time (all are cross-functional, water and sewer)

WASTEWATER INFRASTRUCTURE:
266 miles of sewer mains; 3,529 manholes, 12,313 service connections, 21 lift stations

ANNUAL OPERATING BUDGET (SEWER ONLY):
$500,000

WEBSITE:
www.cityoflufkin.com

Projects have ranged from point repairs for localized leaks to complete replacement of sewer lines.

For full replacement, Lufkin has opted for pipe bursting where possible rather than open-trench replacement. "A lot of our lines are under roadways, so it's more economical to do it by pipe bursting," Lynch says.

For some bigger projects, such as a recent trunk line main replacement using 24-inch pipe, the city will turn to outside help. But for most of the work, "We try to do as much as we can in-house," Lynch adds. "It's easier for us to get material and to service our equipment."

Lufkin uses Vermeer pipe bursting equipment — chosen because the company has a regional office less than 100 miles away, as well as for the quality of its machinery. The new pipe going in is all PVC.

"We've become experts in the whole pipe bursting process," Arnold says.

In more than a dozen years since the work started, Lynch has seen the equipment evolve. Where Lufkin once used an 8-ton winch to pull new pipe through the old, the city has upgraded to a 12-ton winch that allows for longer pulls — especially through the region's unforgiving clay soil that hampered the smaller tool's pulling capacity.

PERFECTING THE SYSTEM

More recently, the city has begun using Perma-Liner Industries cured-in-place products when that approach is feasible. In keeping with its do-it-yourself ethic, the city has been training its own crews and acquiring the lining equipment rather than contracting out for that work. But it remains in the early stages. "We're still perfecting the system," Arnold says.

In choosing where to use pipe bursting and where to use lining, Lynch says it depends on the situation. Pipe bursting requires some localized excavation, such as where laterals connect to the mains. Since CIPP lining is

"The lines just couldn't handle the flow. We'd have overflows in low-lying areas. Pretty much the whole system was overloaded — manhole covers were floating off."

Patrick Lynch

Patrick Lynch operates a HammerHead HydroGuide winch on a pipe bursting project.

ABOVE: Crew members glue a fitting on a residential lateral connection after installing a new main. RIGHT: The main winch with the bursting head emerging below.

an entirely no-dig system, it's especially useful where lots of other utilities — waterlines and electrical conduits, for example — are close to each other.

For lining projects, the city is now aided by a TRY TEK Machine Works robotic cutter that it sends through the lines to trim up the material where there are pipe transitions. Arnold says the city also developed its own winch system to help pull the liner material through. The vehicle used for lining work has been supplied with modified refrigeration units to store the liner material.

"Where we're still having to pipe burst are in those areas where we're

Pipe bursting helps Lufkin limit excavation to entry and exit pits and connection points.

Patrick Lynch, Water and Sewer Utilities Department foreman

"We have a good engineering department. We have extremely qualified operators — guys who can really do just about everything, and looking at the whole scope of a job, can do it the best and the safest."

Jason Arnold

not comfortable putting that cutter in the ground," Arnold says. "And then there are areas that are so long it's difficult to store (lining) stock that long or blow it in." Longer stretches require precision that can be challenging, he notes. "The biggest we've done so far is 575 feet."

But Lufkin is sold on the trenchless approach wherever it's practical. "The benefits are pretty obvious," Arnold says. "You're saving a lot of time; you're saving a lot of money. But most important, you're not risking a trench accident.

"We want to get people out of those trenches every chance we get, and that's what we're working toward."

MOVING FORWARD

The city has been happy with the outcome. "We can definitely see that we're making progress on the problems," Lynch says. "If you go through a spot where previously the sewer system was overflowing and where we have gone in and redone a section of it, you can see the system is able to handle it. Just knowing you're making a dent in the problem gives us the motivation to keep moving forward."

Training employees to do the work and acquiring the necessary equipment has given the city greater flexibility, Arnold says. "Because we have the expertise, we do everything that we can ourselves."

Doing the work in-house just makes problems easier to solve, the director explains. There are a lot fewer worries about who the city will have to call in an emergency or where the money is going to come from to hire a contractor to fix it.

"Rare is the construction project that we don't do," Arnold says. "We have a good engineering department. We have extremely qualified operators — guys who can really do just about everything, and looking at the whole scope of a job, can do it the best and the safest."

Keeping the work in-house also builds morale. "It changes the whole attitude," Arnold says. "Our whole attitude is that there's nothing we can't take care of. Our guys take a lot of pride in not needing to call in contractors to do what we're doing. They enjoy the fact that they're given the tools and the people to do what they need to do." I&I

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Eric Sisson (left) and Stephen Moore of Pennsylvania-based Pipe-Eye Sewer Services place a Cherne smoke machine over a manhole at the start of a smoke test.

"Let's be honest: We can't keep sewer lines completely water-free. Water finds a way to get in, no matter what. But we can limit it. The main idea is to drastically reduce the amount of water getting treated."

Kerry Roslinski

PROJECT SHOWCASE

Sealing the Deal

Contractor gives municipalities more options in the fight against unwanted storm flow

STORY Ken Wysocky | **PHOTOS** Mike Bradley

When Kerry Roslinski founded Pipe-Eye Sewer Services in 2003, acrylamide chemical grouting was not yet a widely accepted method for rehabilitating manholes and sewer lines. Nonetheless, offering that service came as naturally to him as tree roots growing in a sewer lateral — and proved instrumental to his company's success.

"When I started my business, I knew chemical grouting would work hand in hand with cleaning and inspecting sewers," he says. "Grouting is a very cost-effective way to rehabilitate pipes as opposed to replacing pipes, and it lasts a long time."

Roslinski wasn't afraid to embrace chemical-grouting technology because he'd had experience with it at jobs he held before he founded his Pennsylvania-based company. And being among the first in the Bradford area to offer the service gave him a big advantage because the technology is expensive, which makes it harder for competitors to enter the market.

Chemical grouting and an ancillary service, smoke and dye testing, make up nearly half of Pipe-Eye Sewer Services' business. Municipal sewer cleaning and inspection accounts for the balance. Roslinski estimates the company has grouted about 4,000 manholes and other structures within the company's service territory, which includes northwestern Pennsylvania and western New York.

Roslinski literally was born into the sewer-cleaning and rehab industry. His late father, Joseph, was Bradford's public works director for 35 years. Even the company name stretches back to Roslinski's childhood. When he was about 11 years old, he fell and landed on a pipe, which left a half-moon scar under one eye. "So kids at school nicknamed me 'Pipe Eye,'" Roslinski explains. "It's very ironic … and that's why in our logo, we use an eye for the dash in 'Pipe-Eye.'"

Jarrod Vobornik monitors the air pressure for a pipe pig while setting up to smoke test a section of sewer with Stephen Moore (left) and Eric Sisson.

"Under NASSCO's four definitions of infiltration, this one would've been rated as a 'gusher' times three. It wasn't the biggest job we've ever done, but the volume and pressure of the water flow made it very challenging."

Kerry Roslinski

CHEMICAL GROUTING 101

First developed about 50 years ago, chemical grouting is the oldest trenchless method for stopping groundwater infiltration into structurally sound sewer systems. Studies conducted by the U.S. Department of Energy indicate that the half-life of properly applied acrylamide grout is more than 300 years.

For those unfamiliar with chemical grouting, here's how it works: Technicians mechanically pull a remotely controlled device called a packer — essentially an inflatable plug made of heavy-duty rubber — to the location of a leak in a sewer line. The packer is attached to hoses that supply both grout and compressed air.

When the packer is in place, it injects the grout under high pressure. The grout then passes through the leaking spot, perhaps a failed joint or a crack in the pipe, and into the surrounding soil outside the pipe. After it cures, it creates a durable seal, or collar, that adheres to the pipe's exterior. As the packer is removed, it scrapes off any excess grout that's still inside the line.

The grout does more than just seal cracks or gaps in sewer lines; it also seals, stabilizes, and gels with the soil around it, even filling voids that often occur after backfilling during initial sewer installations. Some consider grouting superior to pipe lining because it doesn't rely on a bond between a liner and the pipe.

More and more often, grouting is used in conjunction with pipe lining, he points out. "We usually go through first and grout the joints, then they line it, then we come back and grout the (reinstated) laterals," he explains.

While it's not 100 percent foolproof, Roslinski says grouting is a very effective way to resolve inflow and infiltration. "Let's be honest: We can't keep sewer lines completely water-free," he says. "Water finds a way to get in, no matter what. But we can limit it. The main idea is to drastically reduce the amount of water getting treated."

TOOLS FOR SUCCESS

Pipe-Eye Sewer Services handles the work with three camera/grout trucks built by CUES, equipped with Graco grout pumps and Logiball grouting systems. The company uses

grout made by Avanti International. Two of the trucks feature lateral inspection and lateral and mainline grouting capabilities. For inspections, crews use CUES Ultra Shorty tracked cameras.

The company relies on a smoke-testing machine made by Cherne; a manhole rehabilitation machine made by Strong Mfg. Co.; Strong-Seal cementitious spray for manhole rehab work made by The Strong Co.; and epros spot-repair lining technology from Trelleborg Pipe Seals.

PIPE-EYE SEWER SERVICES
Bradford, Pennsylvania

FOUNDED:
2003

OWNER:
Kerry Roslinski

EMPLOYEES:
8

SPECIALTIES:
Trenchless chemical grouting of municipal sewers, laterals, and manholes; municipal pipeline inspections and cleaning; spot repair of sewer lines; smoke and dye testing

SERVICE AREA:
Western New York and northwestern Pennsylvania

WEBSITE:
www.pipeeyesewer.com

AFFILIATIONS:
NASSCO

Pipe-Eye owner Kerry Roslinski replaces a manhole cover.

Pipe-Eye Sewer Services also owns three Hi-Vac Aquatech jet/vac trucks and sewer cleaning and inspection tools from RIDGID, CST/berger, StoneAge and KEG Technologies.

"One of my big things is that I stick with the same equipment all the time," Roslinski says, explaining his philosophy about investing in new equipment. "Because we stick with the same equipment, our guys know it inside and out.

"Customers demand the most updated technology, so we're constantly striving to keep up with it. Companies that fail to do so run the risk of losing customers to competitors who do keep up with the latest technology."

HIGH-PRESSURE FIX

One of the company's toughest jobs wasn't necessarily the biggest in scope, as it centered on a roughly 2-inch-wide gap around about half of a 12-inch influent sewer line as it entered about a 10-foot-deep manhole in Wellsville. But the water rushing through the gap at about 60 to 80 gpm is what made the job extremely difficult, Roslinski says.

"Under NASSCO's four definitions of infiltration, this one would've been rated as a 'gusher' times three," he notes. "It wasn't the biggest job we've ever done, but the volume and pressure of the water flow made it very challenging. There was a lot of hydraulic pressure, which made it imperative to use a pneumatic grout pump."

To stop the leak, technicians first filled the void with oakum, rope impregnated with tar or a tar derivative. That reduced the flow by about 50 percent, as well as provided a barrier to hold in the grout. After drilling holes in the manhole around the area that was leaking, technicians used a Graco pneumatic pump (rated at about 60 psi) to inject the grout, Roslinski explains.

"We did what's called curtain grouting, in which we layer the grout in there," he says. "We inject an appropriate amount of grout, let it set up for 20 to 25 seconds, then continuously repeat that process over and over and over again until the water stops leaking through. Then we used hydraulic cement to bring the repaired area flush with the manhole wall."

> **"Many don't understand that as long as pipes are structurally sound, you can get three times more work done with grouting compared to the same amount spent on pipe lining."**
>
> Kerry Roslinski

The repair saved the municipality a significant amount of money related to unnecessary stormwater treatment. A sewer leak of 60 gallons of water per minute allows 86,400 gpd to infiltrate the storm sewer in question. Using the average per-gallon cost of stormwater treatment back in 2012, the year the repair was made, the municipality was easily spending in excess of $3,000 a day on treating water that shouldn't even be in the system, Roslinski points out.

Eric Sisson and Stephen Moore remove a smoke machine from a manhole during a smoke testing project.

MANHOLES AND LATERALS

Grouting projects have steadily increased again during the last three years in Pipe-Eye Sewer Services' service area. One primary contributor: More and more smaller communities and municipalities are receiving consent orders from state officials to stop inflow and infiltration that's causing sewer overflows, which in turn create potential environmental hazards for creeks, streams, rivers and the like, Roslinski says.

Pipe-Eye Sewer Services typically starts with smoke and dye testing to determine sources of inflow from illegal drain hookups, as well as sewer line leaks, followed by camera inspections where needed. Then the company grouts either sewer lines or laterals or a combination of both, depending on the municipality's needs and budget.

Roslinski says he often urges municipal officials focused more on sewer lines for inflow and infiltration to not overlook manholes and laterals. "We can drill and grout structurally sound manholes that might be leaking 25 to 60 gallons of water per minute and get instantaneous results with chemical grouting," he says. "We can do at least three manholes a day, depending on the volume of the leaks."

"And if that same manhole is a precast or brick manhole with poor structural integrity, then we come in with our Strong (manhole machine) trailer and apply a cementitious coating up to an inch thick, and you end up with a new manhole," he continues. "We have many, many communities in my neck of the woods in northwest Pennsylvania where we do as many manholes in a year that we can do for 'x' amount of dollars. So maybe we do 50 or 60 manholes year. That helps them fulfill their consent order from the state — shows they're making a good faith effort toward eliminating I&I."

CRITICAL FACTORS

Roslinski says educating municipal officials who aren't familiar with grouting, or have erroneous perceptions of it, is one key to success. "Many don't understand that as long as pipes are structurally sound, you can get three times more work done with grouting compared to the same amount spent on pipe lining."

Proper training is critical, too. Along with staying current on technological advances by attending trade shows, such as the Water & Wastewater Equipment, Treatment & Transport (WWETT) Show, Roslinski recommends Municipal Sewer Grout Schools held in various cities around the country and co-sponsored by industry manufacturers such as Avanti International, Logiball, CUES and Aries Industries. (For details, visit www.avantigrout.com/onsite-training.)

"You can't just jump into it," he cautions. "You need experienced workers and training. Grouting is not like running a sewer camera or a water jetter. Every year, the equipment gets more technologically advanced and computer-oriented."

Looking ahead, Roslinski plans to continue investing in new equipment, which he says is imperative to remaining competitive, despite the financial risks involved.

"I also see the grouting market getting bigger, at least in my neck of the woods," he adds. "Grouting is making a resurgence. ... We're banking on grouting and manhole rehab work."

Equipment and people are both critical, Roslinski says. No mater how nice the equipment is, it takes great employees to operate it. "Our guys make things happen out in the field every day," he notes. "They do an excellent job." I&I

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BEST PRACTICES

PHOTOS COURTESY OF DISTRICT OF NORTH VANCOUVER

Over the past five years, the District of North Vancouver has combatted I&I within the Lynn Valley Sewer Catchment by targeting public infrastructure, but efforts have now turned to private-side infrastructure.

PRIVATE I

Leveraging public infrastructure to identify sources of private-side inflow and infiltration

By Joanne Slazyk

Newly rehabilitated mains surcharging during off-peak hours. Lift stations running two pumps in the middle of the night. CCTV operators pumping down mainlines to complete inspections.

We all know what private-side inflow and infiltration looks like. The problem is that it is difficult to find. Costs can be prohibitive and associated with reports and data that are impractical in an operations setting.

The District of North Vancouver is committed to I&I reduction. The district is a municipality of 85,935 people situated on the side of the North Shore Mountains in the Lower Mainland area of British Columbia. Winters are wet, and summers are dry. Seventy percent of the district's sanitary sewer pipes were installed between 1943 and 1970. A number of factors including steep terrain, high volume of annual rainfall, and the age of the system make I&I an important issue for district operations.

One area in particular, the Lynn Valley Sewer Catchment, has received recent attention due to restricted flow capacity at the downstream outlet where heavy winter rainfall events can lead to sanitary sewer overflows. The Lynn Valley Sewer Catchment encompasses an area of approximately 3.1 square miles and services approximately 5,625 private properties. The primary land use within the area is single-family residential. The district owns all infrastructure up to the private property lines. Sanitary laterals within private property are the responsibility of individual property owners.

We all know what private-side I&I looks like. The problem is that it is difficult to find. Costs can be prohibitive and associated with reports and data that are impractical in an operations setting.

Over the past five years, the district has combatted I&I within the Lynn Valley Sewer Catchment by targeting public infrastructure. Efforts have been moderately successful but the district has not been able to replicate the flow reduction results observed from a previous project that targeted private-side I&I.

The district's I&I team inspected 495 inspection chambers to identify properties with high potential for private-side I&I.

TAKING ACTION

In March 2017, the district created a Reduction in Inflow and Infiltration Team. The team consists of a project engineer, foreman and laborer. The project engineer coordinates repair contracts and oversees the program. The foreman provides inspection and contract administration services for contracts executed as part of the program and also completes field investigations to identify sources of I&I. The laborer completes field inspections and assists the foreman with daily tasks.

The district collects an array of sanitary infrastructure data. Included in this data is a 15-year-old sanitary CCTV program, a SCADA system that logs historical information, and a user-friendly GIS mapping system that displays attributes of district infrastructure. Since I&I eventually appears in public infrastructure, the district hoped to use the existing sanitary system and its associated data to identify potential sources of private-side I&I.

CCTV INSPECTION

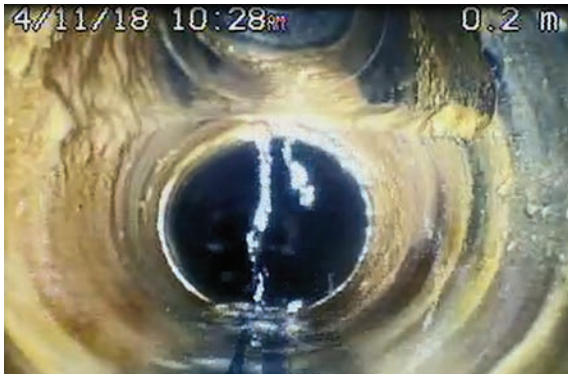
Inspection data within the Lynn Valley Sewer Catchment has been integrated with the district's internal GIS mapping system. Since the district began its CCTV program in 2003, approximately 78 percent of the sanitary gravity mains within the Lynn Valley Sewer Catchment have been inspected. Approximately 30 percent of those mains have been inspected multiple times in different years. The majority of inspections were completed in winter months when the ground was saturated and it was raining.

With the aid of the GIS mapping system, the I&I team looked through CCTV reports and videos to identify live connections and junctions.

If multiple CCTV videos were available, videos were cross-referenced to confirm the presence of live flow in each video. Laterals that were not live in each video were removed from the list and assumed to have been active due to regular sanitary operation. In general, the team noticed more recent videos showed increased volumes and flow rates from laterals.

The investigation identified 377 laterals with significant flow into the main. These laterals represent properties with high potential for private-side I&I. Since the district owns all laterals from the main to the property line, it is possible some I&I assumed to be private could originate from the public side of the pipe. The average length of public laterals in the Lynn Valley Sewer Catchment is 31.5 feet. The next steps of the program include mechanisms that allow the district to separate public from private-side I&I.

When the team began the exercise, all wet laterals were flagged regardless of volume and flow rate. The team realized early in the process that this method would identify too many laterals to investigate. The 377 flagged laterals represent those with moderate to significant observed flow. The GIS mapping system allowed the team to easily identify the residential address associated with each lateral for future use and documentation.



North Vancouver's push camera inspections of private-side laterals revealed cross connections (left) and infiltration (right) in many instances.

A push camera moves through a broken lateral line.

The I&I team analyzed early morning pump cycles at four small lift stations in an attempt to capture only pump cycles from private-side I&I.

PUMP CYCLE DATA

Four small lift stations are located within the Lynn Valley Sewer Catchment. The team analyzed pump cycles observed between 2 a.m. and 4 a.m. when sanitary flow is typically at a minimum. In an attempt to capture only pump cycles from private-side I&I, the team looked at data from rain events preceded by several days of dry weather.

The flow response from private-side I&I in the district is typically instantaneous where the response from groundwater entering public infrastructure often takes longer to appear in the system. The difference between dry- and wet-weather pump cycles was assumed to be attributed to I&I from private properties.

In the team's analysis of four subcatchments, two showed strong evidence of private-side I&I. The combined 107 properties within those two subcatchments became a priority for further investigation.

INSPECTION CHAMBERS

Approximately 20 percent of the properties in the Lynn Valley Sewer Catchment have sanitary inspection chambers (clean-outs). The I&I team inspected 495 inspection chambers to identify properties with high potential for private-side I&I.

The team used the district's GIS mapping system to create simple inspection maps. If team members observed a steady stream of clear water in the lateral at the inspection chamber in wet weather, the property was flagged for further investigation. Flagged laterals include all flow from a steady trickle to a full pipe. Once inspected, the team entered the results back into the GIS mapping system to track the locations of each inspection chamber inspected, cleared, and flagged.

Of the 495 laterals inspected, 372 were cleared and 115 were flagged. Another eight were undetermined because the team was not able to access those laterals.

NEXT STEPS

The next step in the program is to further investigate the properties flagged in the three methods described above. If not already present, a sanitary inspection chamber is installed at the property line. Preference is given to properties where significant flow was observed in the mainline CCTV video.

Sanitary inspection chambers allow for easy access to the lateral with a push camera. The push camera can then be used to identify source(s) of I&I. Cross connections are often observed as a Y connection in the private-side lateral. Infiltration is viewed as active gushers, runners, drippers, or seepers from broken pipe segments or open joints. The push camera has the added benefit of video capture, which allows the team to bring what they see in the field into the office for analysis and documentation. Once sources of I&I are confirmed, the team creates a remediation plan.

Leveraging public infrastructure is a cost-effective and efficient method to identify sources of I&I on private property. The district was able to take the findings from the program and turn it into specific repair works.

The success of the program depended heavily on dedicated field staff. Without their expertise and specialized skill set, much of the private-side I&I would not be identified and corrected. I&I

CURED-IN-PLACE CONDUIT CUTS INFILTRATION

PROBLEM:

Grand Central Station, one of New York City's most famous landmarks, has periodically launched repair programs and expansions since its origins in 1871. Expansions in the 21st century include the East Side Access project, connecting Long Island Rail Road to Grand Central Station. It was during this production that water infiltration was discovered in newly constructed conduits. The leaking conduit was located approximately 3/4 of a mile into the utility tunnel and 100 feet underground. It ran from the utility tunnel to a vault room and was encased in 6 feet of concrete.

SOLUTION:

Using **Flow-Liner Systems cured-in-place conduit,** a trenchless technology solution, a Flow-Liner Systems certified installer prepared and installed the lining system in the 4-inch electrical conduit, navigating several bends with ease.

Result: The leaking electrical conduit was successfully lined without excavation or disruption to the progress of the project and effectively ceasing the water infiltration.

800-348-0020; www.flow-liner.com

REHABILITATION SYSTEM SEALS OUT LIFT STATION INFILTRATION

PROBLEM:

Located in Albert Lea, Minnesota, about 90 miles south of the Twin Cities, three lift stations needed rehabilitation for a variety of reasons. Water was penetrating through the mortar joints and concrete blocks, causing their coatings to delaminate. It was also seeping into the structures and contaminating electrical equipment. The infiltration was an unnecessary and ultimately costly problem for any city's utility department.

These dry side-access hatchway lift stations built of concrete blocks required a system that would plug the leaks, as well as reseal and protect the surface from future damage.

SOLUTION:

The utility contacted Richard Hanson of Floorcoat Midwest. He recommended the **CLADLINER System,** which uses CLADSTOP 3 to address leaks and CLADLINER for sealing and resurfacing.

Fieldstone Services, the contractor for this project, began with proper surface preparation, using a 4-inch Metabo right-angle grinder fitted with a Joe Due shroud and vacuum attachment in order to remove all oil, dust, grease, dirt, loose rust and other foreign material to ensure adequate adhesion of the coatings.

After the surface preparation was complete, CLADSTOP 3 was mixed in small amounts and applied to the actively leaking areas. The remaining surfaces were sprayed with water from a small hand-held pump sprayer to provide a surface-saturated dry substrate. Lastly, CLADLINER was mixed and hand-troweled at a 1/4-inch thickness.

Result: Two weeks after the application, a follow-up inspection was conducted. It confirmed the success of CLADSTOP 3 in plugging the leaks and ultimately stopping the inflow and infiltration. The city's proactive rehabilitation measures will ultimately improve the efficiency of the lift stations and prevent any further cracking or deterioration from taking place.

877-708-2523; www.cladliner.com

MONITORING SYSTEM PROVIDES COST-EFFECTIVE SOLUTION

PROBLEM:

The Klamath Falls (Oregon) South Suburban Sanitary District encompasses roughly 10 square miles and includes more than 100 miles of sewer pipe and 1,000 manholes.

One of the key focus areas for South Suburban Sanitary District is management of I&I. "Monitoring of remote locations is an important part of our ongoing efforts to identify and combat I&I," says Mike Fritschi, district manager. "We started monitoring in 2012 by installing four initial flow monitoring units for a cost of $50,000 but, when the need arose for expanding our efforts to more locations, we required a more flexible, easy-to-install, and cost-effective solution."

SOLUTION:

To address the I&I monitoring expansion plan, the South Suburban Sanitary District turned to the use of the **SmartCover Systems sewer monitoring system** for several reasons. First, the cost per unit was significantly lower than previous solutions and the deployment flexibility was less invasive because SmartCover Systems does not require any confined-space entry for installation.

Also, based on calibration against the installed flow systems, the SmartCover Systems units proved to be as accurate as needed. In addition, the integrated SmartTrend software supported in-depth trend analysis and modeling to hone in on specific I&I issues.

Results: The SmartCover Systems units helped relatively small South Suburban Sanitary District staff target available resources to address real issues of concern regarding I&I.

"Using SmartCover Systems allowed us to quickly expand and improve our I&I monitoring processes at a much lower cost than the alternatives," Fritschi says. "Deployment was quick and easy because no confined entry was required, which allowed us to get up and running fast without a lot of wasted staff time. Also, we get the side-benefit of real-time monitoring and alerts in more locations. In addition, the SmartCover tech support staff even tailored special software that allows us to aggregate flow information from multiple locations, thereby enabling more flexibility to analyze relationships between sites and to better understand the dynamics within the sub-basin."

760-291-1980; www.smartcoversystems.com I&I

TAKING TURBULENCE IN STRIDE

Ultrasonic level detectors overcome obstacles and improve wastewater flow studies

By Donald P. Massa

Ultrasonic noncontact distance measurement technology is the most accurate and cost-effective method for measuring the water level within pipes because the ranges of the distance to be measured are very short due to the small diameters of the pipes. Most ultrasonic sensors, however, have two major problems performing the measurements in the operating environment of a sewer.

The first problem is that the sensors typically have a minimum measuring range of 4 inches or longer, and they are also usually several inches thick. Therefore, if they are installed at the top of a pipe, they can't measure the water level if it is less than 6 or 7 inches from the top of the pipe. Since many of the pipes in a typical system are 8 inches in diameter or less, these sensors cannot obtain readings if the water level is above the lowest 10 percent of the pipe.

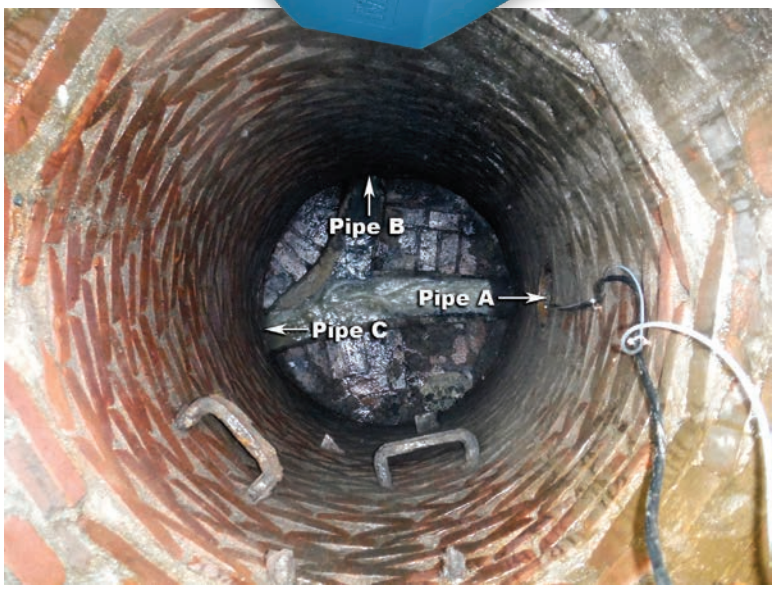
The second problem is that most ultrasonic sensors utilize transducers with very narrow radiation patterns that are typically around 10 degrees. This means that the sound radiates from the sensor in a very narrow conical 10-degree beam. This type of design allows the sensor to obtain longer detection ranges when the target is flat and perpendicular to the beam, but it does not work well when the reflecting surface is very uneven, which is the case with the turbulent surface of water rapidly flowing in a pipe. This uneven surface causes the reflection of the sound pulse to scatter in many directions so that the echo is outside the detection angle of a very narrow beam transducer.

Ultrasonic sensors can be properly designed to overcome these problems and provide the accurate liquid level measurements required in sewer applications. To accomplish this, the mechanical design of the sensor must be very thin so that when mounted in a pipe, the transducers will be as close to the top as possible. In addition, using two transducers allows one to transmit the ultrasonic sound pulse when it is driven by a large voltage and the other to receive the echo reflected from the surface of the water.

Most ultrasonic sensors contain only one transducer that both transmits and receives the sound pulse. Because the transducer is a resonant device, the excitation voltage pulse causes it to ring like a bell that's been hit with a hammer. It takes time for the ringing voltage to dissipate until it's less than the levels produced by the reflecting echo when it returns to the transducer. That's why most ultrasonic sensors have a minimum detection range, or lockout, of 4 inches or more. If the sensor is designed with two transducers, the receiving transducer does not have a large transmit voltage placed across it when the sound pulse is being generated. Therefore, the sensor can detect the low-voltage pulse produced by the receiving transducer from the echo very quickly after the transmitting transducer emits the sound pulse.

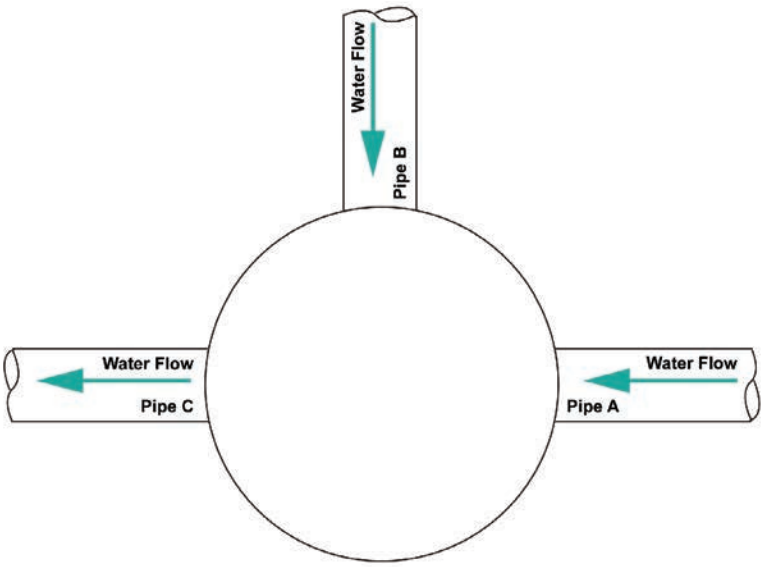
If the transducers used in the sensors have beam angles that are approximately 20 degrees, the echo caused by the turbulent surface of rapidly flowing water will be detectable. In addition, an IP68 rating will ensure sensors can handle being submerged when the pipe is totally full during an unusually large water influx.

The IP68-rated MassaSonic FlatPack Ultrasonic Sensor is only 1 inch thick and contains two transducers, which allows it to measure the distance to the water surface when it is as close as 1 inch.

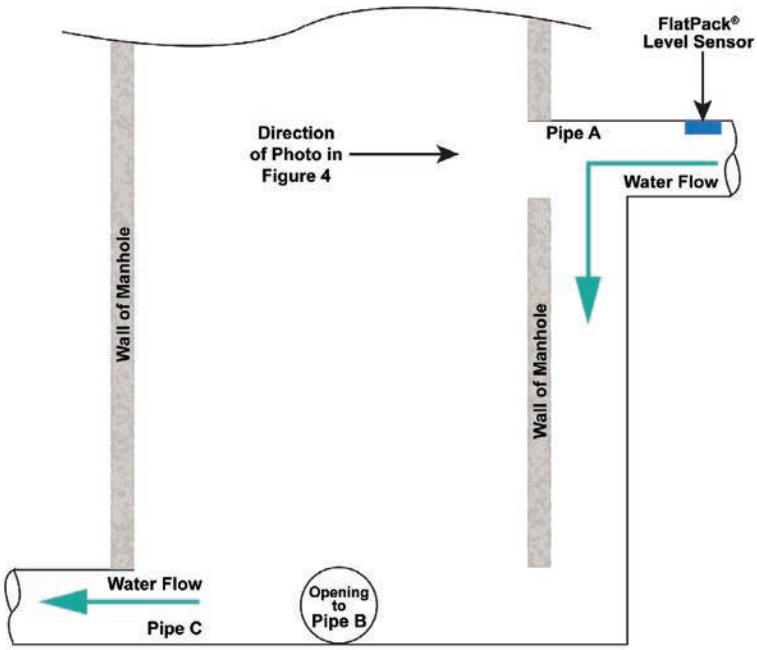


The view down this manhole shows pipes A and B flowing in separately and out through pipe C. The FlatPack sensor is mounted at the top of pipe A just before it enters the manhole.

The IP68-rated MassaSonic FlatPack Ultrasonic Sensor is only 1 inch thick, so it can be shallowly mounted at the top of a pipe. It contains two transducers, one for transmitting and the other for receiving, which allows it to measure the distance to the water surface when it is as close as 1 inch. The transducer radiation patterns are also 20 degrees, which enables detection of the echo pulse when the reflection is scattered by the turbulent surface.



This illustration shows the direction of water flow in the 8-inch-diameter pipes where they tie in to the manhole.



This cross-sectional Illustration shows three 8-inch pipes intersecting at one of the manholes in the Boston Flow Study and the location of a FlatPack Level Sensor in pipe A.

A GOOD EXAMPLE

A recent, very successful water flow study conducted in the MetroWest suburbs of Boston showed how a thin ultrasonic sensor with dual broad-beam transducers, such as the MassaSonic FlatPack, can effectively provide the required level detection in the pipes of a sewer system to enable reliable and accurate flow measurements.

This college town was about to have an increase of flows into the sanitary sewer system. The college was planning on erecting a new building on its campus and therefore petitioned the town conduct a study of the flows within the sewers so that the proper sanitary accommodations could be taken. Because the college effluent is directed into two separate systems, an impact assessment was carried out by an independent engineering firm to

A view inside pipe A from the manhole, showing the FlatPack mounted at the top of the pipe.

support construction permitting. The flow study was replicated three times between January and June 2017 to ensure the accuracy of the range of flow rates measured.

Within the sewer shed, peak flow rates were measured at different manholes. FlatPack Sensors (Massa) were mounted at the top of pipes just before they entered the manholes.

The recorded measurements revealed that the sewer pipes' flow levels were ranging between 14 and 22 percent of full pipe capacity. This information is being used to help the college and town quantify the actual inflow and infiltration.

The campus building project is projected to increase the sanitary sewer flows by 750 gpd, which will likely need mitigation within the sewer shed. The Massachusetts Department of Environmental Protection's Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Surveys recommends assuming a 50 percent peak infiltration removal (measured as 50 percent of dry-weather baseflows) as a preliminary estimate of sanitary sewer flow reduction after implementation of rehabilitation measures.

During all three of these studies, the MassaSonic FlatPack Sensors were able to accurately measure the level of water in the pipes, which allowed for precise and repeatable measurements of the water flow during the entire flow study program.

ABOUT THE AUTHOR

Donald P. Massa is president and CTO of Massa. I&I

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