From Coast To Coast, What Florida's Largest Utilities are Doing About Inflow and Infiltration

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From the east to the west coasts, Florida's largest utilities have the challenge of developing adequate plans for assessing the impacts from inflow and infiltration (I/I) and then designing appropriate rehabilitation and replacement (R&R) programs to manage the identified I/I. Hillsborough County Public Utilities Department (HCPUD) and JEA are two utilities that are implementing I/I programs.

This article will discuss the similarities and differences between the two I/I programs, identify challenges and solutions experienced during the field investigations, and present the results and outcomes as each utility moves forward with the next phases of its program.

An Unseen Issue Exposed

Often overlooked, I/I is an issue for utilities, in both a figurative and a literal way. Figuratively, because the sewer collection systems that serve to collect and transport wastewater are buried and can't be easily seen or inspected by those operating them or the public at large; literally, because over the decades since installation of sewer collection systems, utilities have invested very little in maintaining these buried assets, which have a finite life. The I/I in these aging systems have been accepted as a normal operating condition that utilities must work around—that is until the wet and hurricane seasons of 2015 and 2016.

The Tampa Bay area endured torrential rainfall during the summer of 2015, experiencing over 28 in. of rainfall in July and August of 2015, which was over 13 in. above normal. In 2016, Hurricanes Hermine and Matthew hit the state, while it also felt the impacts of Hurricane Irma in 2017. It's estimated that between 200 and 500 mil gal (MG) of sewage was spilled into Tampa Bay over this time period. While numerous reasons can be identified as having an impact on the spills, I/I is a leading cause. Similar impacts, but to a lesser degree, were felt in northeast Florida following Hurricanes Matthew and Irma. Estimates indicate that approximately 13 MG of wastewater were spilled into northeast Florida waterways pursuant to those two hurricane events.

Response from the State

On Sept. 26, 2016, in response to recent spills associated with both sanitary sewer overflows and other sources, Florida Gov. Rick Scott issued an emergency rule enacting revised spill reporting requirements. The new rule required notification to both the Florida Department of Environmental Protection (FDEP) and the general public within 24 hours of a wastewater spill. Furthermore, during subsequent hurricanes, such as Matthew and Irma, FDEP did not suspend the rule for maintaining compliance with the revised wastewater spill reporting requirements, ensuring that it would be made aware of spills caused by these "Acts of God." Subsequently, FDEP issued many consent orders following these storms for sanitary sewer overflows (SSOs).

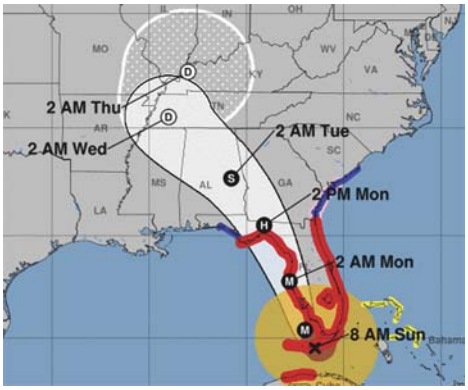
The Magnitude of the Issue

Managing large utilities with many miles of sanitary sewer collection systems is a challenge, which is all too familiar for many of Florida's major utility providers, such as JEA and HCPUD. Although each utility initially went about managing the challenges differently, their outcomes were ultimately similar.

The eighth largest community-owned utility company in the United States, JEA is the largest in Florida. It serves approximately 455,000 electric, 337,000 water, 261,000 sewer, and 8,000 reclaimed water customers, and is responsible for the planning, operation, and maintenance of extensive wastewater collection, transport, and treatment facilities. The infrastructure includes over 3,900 mi of sanitary sewers and force mains, more than 69,000 manholes, more than 1,400 pumping stations, and 11 wastewater treatment plants.

Six of the JEA wastewater treatment plants, including the Southwest Water Reclamation Facility (WRF) and the Arlington East WRF, maintain and utilize outfalls to the St. Johns River to dispose treated wastewater that is not distributed to JEA customers. These surface water discharges

The City of Jacksonville was severely affected by Hurricane Matthew.



Hurricane Irma brought heavy rainfall to the Tampa Bay area.

are regulated by FDEP permits, and the total nitrogen (TN) component of the wastewater flows is limited by total maximum daily loads (TMDL) in those permits. The TMDL 12-month average limit for the St. Johns River in Jacksonville is 683 tons. Between Oct. 1, 2017, and Sept. 30, 2018 (fiscal year [FY] 2018), the total amount of TN discharged to the St. Johns River from JEA's six WRFs and the St. Johns River Power Park (SJRPP) was 550 tons. The total TN discharge for FY 2019 is forecast to be 512 tons.

Through several corporate initiatives, JEA is committed to further reducing its TN TMDL. One of JEA's goals for realizing this reduction of TN is to implement and execute I/I studies of its wastewater service areas. The objectives of these studies are to identify and repair sewer system defects to reduce the entrance of extraneous flows into the wastewater collection system, which will result in lower wastewater flows, reduced pumping costs, less chemical usage, and lower wastewater treatment costs.

The presence of significant I/I issues in the Southwest Service Area (SWSA) has been documented in previous studies conducted in the early 2000s. More recently (in 2015 and 2016), JEA operations staff identified specific pump station basins in the SWSA, in which pumps were experiencing extremely high run times, and sewer overflows occurred during significant rain events. In November 2017, these conditions prompted JEA to solicit professional services through a request for proposal (RFP) process and select a firm to conduct an I/I study in specific pump station basins in the SWSA. Following Hurricane Matthew, JEA added several pump station basins located in the Arlington East Service Area (AESA), in which high flows were encountered in response to the hurricane, to the RFP. Pursuant to the RFP, the Southwest/Arlington East Infiltration and Inflow Study and Remediation Plan commenced in March 2018 to specifically identify, quantify, and eliminate sources of I/I.

The SWSA encompasses over 100 sq mi and is comprised of approximately 600 mi of 4- to 54-in. diameter pipes. The pipe materials of construction include approximately 420 mi of polyvinyl chloride (PVC) and high-density polyethylene (HDPE) pipe, approximately 120 mi of vitrified clay pipe (VCP), and 60 mi being a mix of cast iron, ductile iron, and concrete pipe.

The AESA encompasses over 100 sq mi and is comprised of approximately 650 mi of 4- to 42-in. diameter pipes, including gravity sewers and force mains. The pipe materials of construction include approximately 540 mi of PVC and HDPE pipe, approximately 106 mi of vitrified clay pipe (VCP), and 4 mi being a mix of cast iron, ductile iron, and concrete pipe.

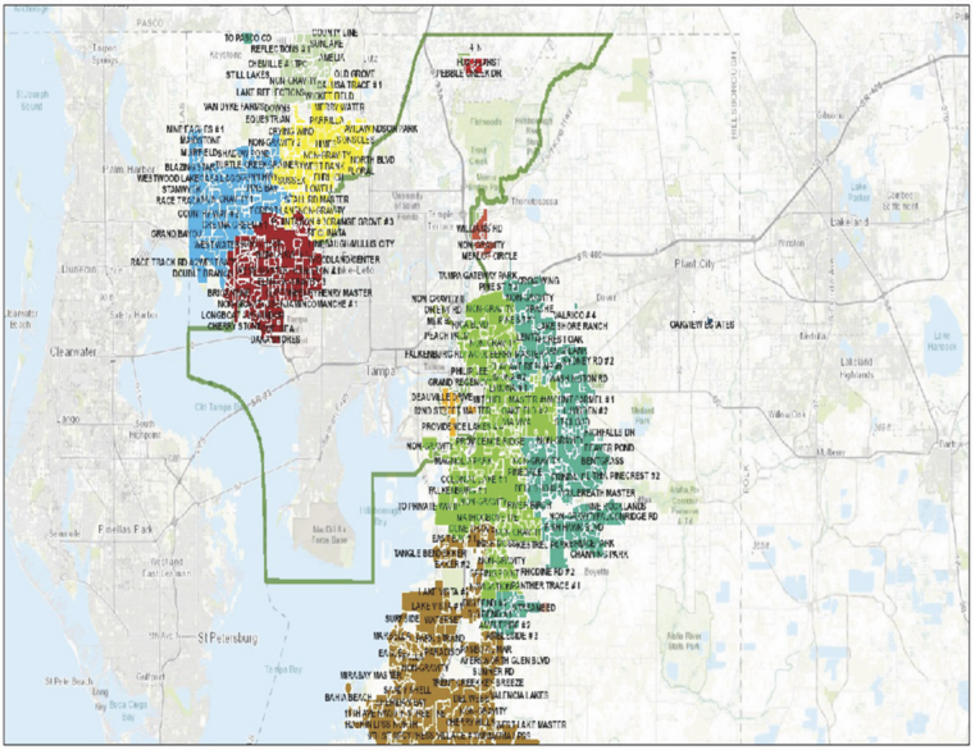


Figure 1. Hillsborough County Public Utilities Department Sewer Basins

As one of the largest utilities in Florida, HCPUD is similarly responsible for a large wastewater collection, transport, and treatment system. Infrastructure for HCPUD includes over 2,565 mi of gravity sanitary sewer and force mains, 809 pumping stations, 1,342 low-pressure sanitary sewer (LPSS) pump stations and 36,259 manholes, all flowing to six regional wastewater treatment facilities. In the past several years, each of the wastewater treatment plant facilities have experienced a wide range of I/I flows associated with these events, and HCPUD decided to start an I/I investigation with the River Oaks Advanced Wastewater Treatment Facility (RO-AWTF) basin.

The RO-AWTF basin has 90 pump stations. The basin was chosen as a beginning point due to four main factors:

- Physical location near Tampa Bay, which is affected by weather and tidal forces.
- Physical age of the plant, being the oldest of all in Hillsborough County.
- Pre-existing knowledge that the plant was scheduled to be demolished and a super station was to be built in its place to transfer the flows to the Northwest Regional Advanced Treatment Facility (NWRATF) in late 2019.
- Expansion of NWRATF to accommodate all of the River Oaks and Dale Mabry sewer basin flows.

The RO-AWTF has experienced swings of daily average flows from 8.6 mil gal per day (mgd) to peaks of 19.4 mgd during significant wet weather events (some named and others not). A recent comparison of the River Oaks pre- and post-I/I rates indicate an increase of 33 percent greater rainfall from 2017 to 2018, yet with the changes incorporated due to the study, the I/I rate remained the same. There were approximately 2,500 defects identified via the I/I contract and in-house staff as a result of this study.

As the I/I study in the RO-AWTF service area was concluding, HCPUD initiated a similar study for the Dale Mabry AWTF service area. This was recently demolished and a new super station built in its place, with flows being transferred in 2018 to the NWRATF. Since that occurred, there have been two unnamed events that caused a spike in flow rate to nearly 12 mgd, up from a normal 3 to 5 mgd average daily flow.

The Dale Mabry AWTF service area includes approximately 198 mi of 6- to 21-in. gravity sewer pipes consisting of various pipe materials and 111 pumping stations. The study is moving into its second phase soon, which is anticipated to be completed in early 2020. Figure 1 provides the locations of the HCPUD sewer basins.

The HCPUD is continuing its I/I work with the Falkenburg ATF sewer basin scheduled in 2019-2020 and the remaining sewer basins to fol-

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low in due course. The HCPUD is committed to reducing rainwater-derived I/I and diminishing overall SSO rates as well. Since 2010, HCPUD has lowered the SSO rate each year, with an approximate 26 percent reduction from 2017 to 2018, while at the same time experiencing unparalleled growth during this same period.

Both JEA and HCPUD identified the need to thoroughly investigate these major service areas to identify the sources of I/I and to develop an R&R plan to address issues found as part of the I/I investigations. The plans included flow monitoring and field investigative techniques to locate significant sources and quantities of I/I and develop an R&R plan to reduce I/I, delay treatment plant expansions due to excessive I/I, and incorporate cost-saving measures to magnify overall benefits.

Elements of a Standard Infiltration/Inflow Control Plan

When it comes to developing an effective I/I control plan, it's important to understand each community's issues and goals. Contrary to some opinions, they are often not the same from area to area (i.e., city to city, basin to basin), and therefore require a tailored approach to studying the problem and mapping out solutions.

In general, the first step in a comprehensive I/I project includes capturing and analyzing system flow data. This can be done using existing pump station data (if available) or through a flow monitoring program (flow meters, rain gauges, and groundwater gauges included) to "narrow the playing field." Flow monitors are typically placed every 20,000 lin ft, or in smaller sewer networks (often referred to as basins or subsewersheds) for best results. In basins with less than 5,000 lin ft, a series of instantaneous flow measurements (dry, wet) can be used in lieu of a permanent flow meter. Flow metering periods generally range from 12 weeks and up to a year. Either way, it's advantageous to consider performing an interim evaluation of the flow data to discover where there are opportunities to potentially relocate a flow meter, maximizing the use of any one flow meter, and further closing in on the real problem areas.

Once data are analyzed to understand which basins are impacted by high I/I, an area-specific and cost-effective field investigation plan can be defined. It's not necessary to perform closed-circuit television (CCTV) inspections, manhole inspections, smoke testing, and flow isolations systemwide if an effective flow monitoring plan is completed. The data will help reduce these quantities.

For high-infiltration basins, a good first step may include performing night flow isolations in small (~2,000 lin ft) sections to again narrow the portions of the larger metered basin that would be identified for CCTV pipe inspections and comprehensive manhole inspections (top down). For high-inflow basins, performing smoke testing first will help identify areas for additional manhole inspections (focused from chimney up) and any dye testing needed to locate direct sources.

After completion of these field activities, all data are compiled and analyzed to specifically identify each potential source of I/I. Identified sources are assigned an estimated rate of I/I and compared to calculated I/I from the flow meters. The I/I reduction plan is then developed based on cost-effective removal methods (repair, replace, rehabilitate) as compared to the current cost to continue to treat and transport the extraneous flows. It's always important to prepare a rehabilitation plan tied directly to affordability within the community's and owner's goals.

Site-Specific Inflow and Infiltration Control Plan

The flow monitoring study for JEA was begun to identify potential sources of I/I and remediation methods within the Southwest and Arlington service areas of Jacksonville as previously described. There are 25 sub-basins within these service areas, totaling approximately 91 mi of sewer pipe. Phase I, completed in 2018, consisted of performing a hydraulic condition assessment that included eight months of flow monitoring and the following estimated quantities of fieldwork:

- 190,000 lin ft of smoke testing
- 100,000 lin ft of CCTV inspections
- 900 manhole inspections plus preparation of a comprehensive I/I reduction plan report

Flow monitoring consisted of installing 28 flow meters, eight rain gauges, and 18 groundwater piezometers. The comprehensive I/I reduction report consisted of analyzing the data, identify high I/I areas, and outlining alternatives and costs to reduce I/I and recommendations that will bring the project into the second phase. The Phase II source investigation commenced in March 2019 and consists of CCTV inspections, manhole inspections, smoke testing, and night flow isolations.

Due to the high peak flows described earlier, HCPUD also chose to conduct an I/I study within the Dale Mabry AWTF service area to monitor flow and identify I/I sources. Phase I, completed in 2018, consists of quantifying I/I through flow, rainfall, and groundwater monitoring and assessment. Flow monitoring consisted of installing 55 flow meters, 25 groundwater piezometers, and nine rain gauges in 55 sub-basin areas of the service area.

Field results and data analysis were included in the Phase I flow monitoring report. This report documents the I/I rate in each drainage area, with recommendations for conducting the Phase II I/I source investigation study, which consists of dye testing, CCTV inspections, manhole inspections, and other tools or assessments, as necessary to identify I/I sources. Phase II source investigations commenced in June 2019.

Implementation

The JEA I/I investigation portion was conducted in two phases. Phase I consisted of performing a hydraulic condition assessment that anticipated flow monitoring, smoke testing, CCTV inspections, manhole inspections, and preparation of a comprehensive I/I reduction plan report. The flow monitoring network was deployed ahead of the 2018 wet season (June to August). Meter locations for JEA were scattered throughout the southeast area of Jacksonville in pump station basins previously determined to have I/I issues and consequently named as priority areas for I/I reduction.

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Wright-Pierce employs best safety practices when conducting field work.

Brian Pavao, field service manager, enters a manhole to install a flow meter.

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Flow meters were maintained and a preliminary I/I analysis was performed in July 2018 that provided the backing needed to recommend five meters that could be relocated, and an early, area-specific "Round 1" field investigation start. Round 1 fieldwork began in October 2018 with CCTV inspections, manhole inspections, and smoke testing. Based on the preliminary I/I analysis, weekly data review, and data quality collected through October 2018, flow meters were recommended for removal in December 2018, ahead of schedule, allowing for the final I/I analysis to take place in January 2019. While the final I/I analysis confirmed work previously recommended for the Round 1 field investigative plan, it also revealed some additional basins that warranted field investigations due to high infiltration, high inflow, or both. As a cost savings measure for this project, flow isolations were performed at night and during wet weather to supplement the flow monitoring program in areas where flow meters were not warranted due to basin size, and ultimately, to reduce the amount of CCTV inspection work needed.

The comprehensive I/I reduction plan report for JEA will be prepared following Phase II field investigative work and will include identified sources of I/I, estimated I/I rates, and a cost-effective analysis for rehabilitating compared to a continued treat-and-transport approach. Phase II source investigation work will include two rounds of daytime and nighttime instantaneous flow measurements, 100,000 lin ft smoke testing, and 600 manhole inspections. Phase III will consist of the design and construction of the selected recommended I/I reduction projects.

Similar to JEA, the HCPUD I/I study is being conducted in two phases. Phase I consisted of quantifying I/I through three months of flow, rainfall, and groundwater monitoring and assessment during June to September 2018. The flow monitoring program consisted of installing 55 flow meters, 24 in-manhole groundwater piezometers, and nine rain gauges in the service area. Flow meter locations for the HCPUD project were deployed in one contiguous sewershed in the Dale Mabry area. The driver for reducing I/I in this case was to reduce peaking factors to a new pump station before flows are transported to a new regional wastewater treatment facility.

Phase I also included performing two rounds of daytime and nighttime instantaneous flow measurements within specific subareas that supplemented the flow meter data and identified I/I quantities. Field results and data analysis were included in the Phase I flow monitoring report. This report documented the I/I rate in each metered sewer basin with recommendations for conducting the Phase II I/I source investigation study. Phase II will consist of additional night flow isolations (specifically to reduce the required amount of CCTV footage needed), pipe and manhole inspections, smoke testing, and other tools typically used to identify I/I sources.

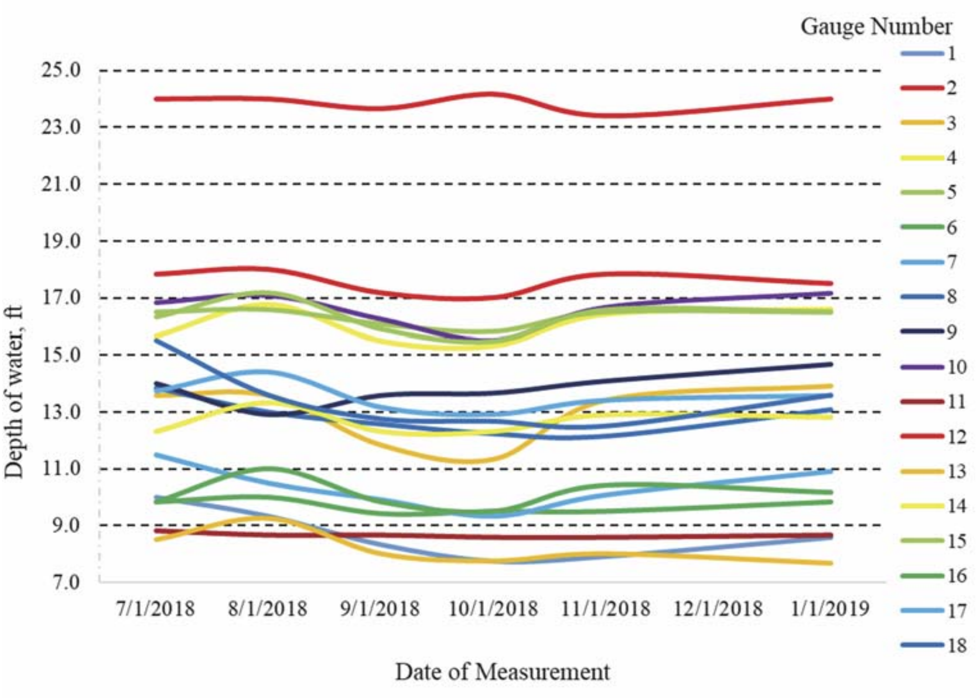

Figure 2. JEA-Measured Groundwater (Water Depth in Piezometers)

Results

For both projects, flow monitoring data were exported from the flow meters, uploaded to a flow data portal for review of trends and anomalies and compared to periodic manual depth/velocity measurements, and then imported into Sliicer, an online data analysis tool developed by ADS Environmental Services, to perform the I/I analysis. Raw data were used to summarize the following flow parameters at all meter basin sites: hourly average, hourly peak, hourly minimum, daily average, daily peak, daily minimum, and monthly volumes. Using Sliicer, a comprehensive analysis of rainfall, dry weather, and wet weather was performed.

Rainfall and Groundwater Results

Seventy-four rain events were captured during the JEA flow monitoring period. The largest storm was 3.82 in. of total rainfall on Dec. 3, 2018, which equates to a 1.6-year storm. In comparison, a typical one-year, six-hour storm for Jacksonville, as predicted by the National Oceanic and Atmospheric Administration (NOAA), is 2.99 in.

Of course, groundwater conditions can impact resulting levels of I/I, and for the JEA project, groundwater monitoring results indicate that levels were the highest in August 2018 and lowest during September to October 2018. Figure 2 provides an overview of the groundwater measurements recorded during the monitoring period.

Fifty-one rain events were captured during the HCPUD flow monitoring period. The largest storm was 3.81 in. of total rainfall on July 5, 2018. This equates to a five-year storm. In comparison, a typical one-year, six-hour storm for Tampa, as predicted by NOAA, is 2.94 in. For the HCPUD project, in-manhole groundwater gauge measurements were compared to data obtained from three United States Geological Survey (USGS) spring discharge data monitoring sites in Hillsborough County. Review of the USGS data during the flow monitoring period indicates that groundwater levels were highest in June 2018 and decreased in October 2018. Figure 3 provides an overview of the groundwater measurements recorded during the flow monitoring period.

Based on information observed on the United States Drought Monitor (https://droughtmonitor.unl.edu), drought was not present within the months of June to mid-October 2018, leading to the assumption that groundwater levels were at their highest in June 2018 and generally decreased throughout the summer months into October 2018, which is the typical pattern for Florida.

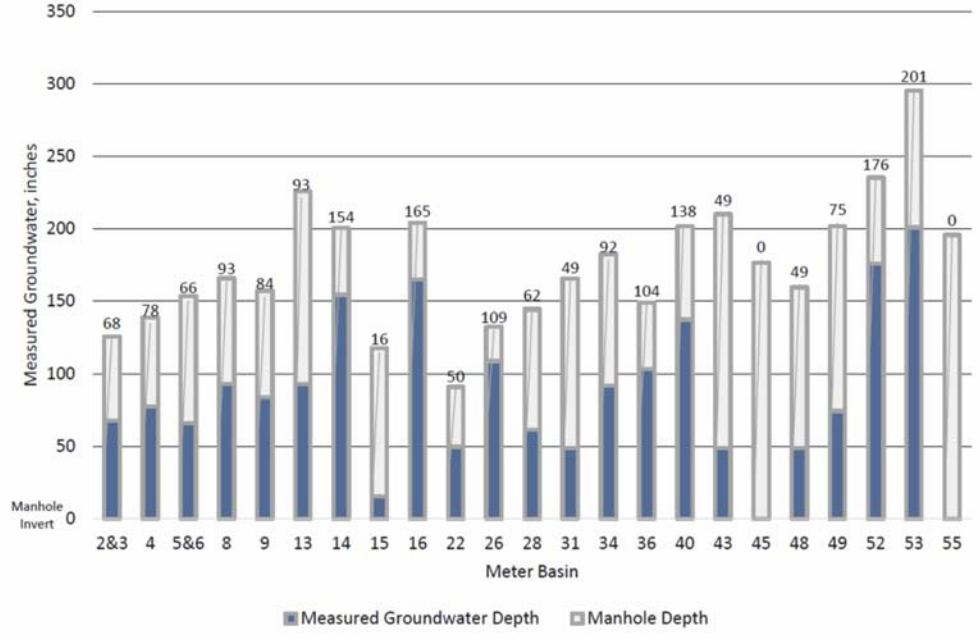

Figure 3. Hillsborough County Public Utilities Department-Measured In-Manhole Groundwater Levels

Base Infiltration Results

Dry weather flow is defined as base sanitary flow (BSF) and base infiltration (BI). The BSF includes domestic, commercial, institutional, and industrial wastewater, whereas BI is permanent infiltration that always occurs in the system, regardless of groundwater conditions. Dry weather flow does not include peak infiltration or wet weather flow.

For these analyses, dry weather days for the I/I evaluation were selected using Sliicer default settings. These default settings automatically chose daily flow data that met the following criteria:

1. Days that do not have rainfall.
2. Days that do not have preceding rainfall up to five days prior based on:
   - o Cumulative rainfall is not equal to or greater than 0.10 in. up to one day prior.
   - o Cumulative rainfall is not equal to or greater than 0.40 in. up to three days prior.
   - o Cumulative rainfall is not equal to or greater than 1 in. up to five days prior.
3. Average daily flows are within 85 percent and 115 percent of the cumulative dry day average flow for the entire flow monitoring period.

The BI enters the sewer collection system through pipe joints, pipe defects (including main sewer lines and service laterals), and defective manhole walls, benches, and pipe seals, typically from groundwater conditions. Rain-induced infiltration enters similarly to BI, but during rain events. The BI for the project area was based on analysis of the flow meter data and calculated using the Stevens-Schutzbach method, which uses the average dry day flows and minimum night flows to estimate BI.

During the flow monitoring period for each of the JEA meter basins, 1.69 mgd of BSF was calculated and 3.60 mgd of BI was identified in the project area based on analysis of the flow monitoring data. For the HCPUD flow monitoring period, 3.89 mgd of BSF was calculated and 4.43 mgd of BI was identified in the project area.

Following this analysis, infiltration rates were normalized based on sewer collection system size (sewer pipe length and diameter) for a comparison across each project area. The relative size of each meter basin was calculated by multiplying the diameter of each pipe size by its relative length and converting to in.-diameter-mi (IDM). The pipe lengths and diameters were obtained from each agency's geographic information system (GIS) data. It's an industry standard that further investigation and/or rehabilitation may be cost-effective if BI flows equal or exceed 4,000 gal per day (gpd)/IDM. Therefore, any meter basin with a net BI unit rate equal to or greater than 4,000 gpd/IDM was recommended as a priority basin for infiltration removal. Table 1 summarizes the BI results for each project area.

From Table 1, nearly 75 percent of the total BI identified as priority for further investigations exists in one-third of the total footage studied in the JEA project area, while nearly 60 percent of the total BI for the HCPUD project was found in a quarter of the system studied. The benefit of performing flow metering in the manner described allows these agencies to narrow the playing field and target the most significant problems first, as opposed to performing fieldwork, such as CCTV inspections, in all basins.

Rain-Derived Inflow and Infiltration

Inflow is expected to occur during wet weather and is reported as the peak inflow rate and the total inflow volume for the duration of a rain event; inflow can further be separated into direct and delayed inflow. Direct inflow occurs immediately at the start of rainfall and finishes after the rainfall ends. Delayed inflow occurs after the rainfall ends and finishes after the system has stopped responding to the rainfall entirely. Direct inflow can be referred to as rain-derived I/I and delayed inflow can be referred to as rainfall-induced infiltration. Direct inflow can also be described as the period in which there is a rapid response to rainfall; therefore, delayed inflow is the more gradual response to rainfall.

For the JEA and HCPUD projects, only direct inflow results are reported. This is due to the short duration of the rain events common to Florida, as well as the events overlapping throughout the metering period. Inflow volumes calculated in both cases were also based on the one-year, six-hour design storm, specific to each geographic location.

Inflow in a wastewater collection system is defined as water other than sanitary flow that enters a sewer system. Inflow is a direct result of stormwater runoff and can enter the wastewater collection system through numerous sources, such as downspouts, area drains, and service lateral cleanouts. In the public sector, inflow enters the wastewater collection system through sources, such as cross connections between sanitary and storm sewers, catch basins, and storm ditches, and sources, such as manhole defects at the cover, frame, frame seal, and chimney area. Large breaks or collapses in pipes may also become sources of inflow into the system.

For the JEA project area, a total of 5.54 MG of inflow were estimated based on the analysis of the flow monitoring data, and for HCPUD, the total inflow was 5.97 MG. Like the process used for infiltration, inflow per metered basin was normalized based on its size (sewer pipe length and diameter) for a comparison with other meter basins. Although there is not a de-

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finitive industry standard for addressing inflow, it's often agreed that most inflow from direct sources would be cost-effective to remove and should not enter the sanitary sewer system for treatment at a wastewater treatment facility.

For these projects, overall inflow rates were reviewed relative to each project area, and a natural division between the most excessive meter basins was determined. For JEA, meter basins resulting in more than 5,000 gal/IDM were recommended for additional inflow field investigative work, whereas meter basins with more than 7,500 gal/IDM were recommended in the HCPUD project area. This results in performing inflow related fieldwork, such as smoke testing, in 14 basins for JEA and eight basins for HCPUD.

Table 2 summarizes the results of the direct inflow volumes for each project area. For the JEA project, more than 80 percent of the inflow was identified in 44 percent of the basin footage, while more than 60 percent was identified in less than one quarter of the basin footage for the HCPUD project.

Next Steps

The typical next steps that result from a flow monitoring program include area-specific field investigations in basins with high infiltration, high inflow, or both. The goal of this follow-up fieldwork is to identify defects or locations associated with the high I/I numbers reported by the flow meters. Common techniques used to identify infiltration defects include pipeline inspection, such as CCTV or other screening technologies that identify leaks, and manhole inspections (top down). It's also common to perform night flow isolations to break up a larger meter basin into smaller subbasins to reduce the quantities of CCTV inspections. For inflow, the most common field techniques include smoke and dye testing to locate direct connections or defective laterals, in addition to performing manhole inspections focused on the top portion of the structure, such as the cover, frame, frame seal, and chimney.

For JEA, follow-up fieldwork began immediately following a preliminary review of the flow monitoring data and interim I/I analysis using Sliicer in fall 2018. The preliminary round of fieldwork consisted of 190,000 lin ft of smoke testing, 95,000 lin ft of CCTV inspections, and nearly 700 manhole inspections. Data have been reviewed for quality, but analysis of the results will be performed following the final round of fieldwork that began in April 2019.

The final round of fieldwork in the JEA project area will include 37 night flow isolations to reduce CCTV quantities, an estimated 100,000 lin ft (or less pending night flow isolations) of CCTV inspections, 591 manhole inspections, and 103,000 lin ft of smoke testing.

Table 1. Summary of Base Infiltration Results

Project	Net BI (MGD)	Pipe Length (LIN FT)	IDM	Net BI Unit Rate (GPD/IDM)
JEA - All Basins	3.60	430,427	765.2	164,197
JEA - Priority Basins	2.68	161,407	256.3	131,174
% of Total	*74%*	*37%*	*33%*	*80%*
HCPUD - All Basins	4.43	844,662	1379	234,473
HCPUD Priority Basins	2.54	222,472	339	152,814
% of Total	*57%*	*26%*	*25%*	*65%*

Table 2. Summary of Inflow Results

Project	Net Direct Inflow Volume (MG)	Pipe Length (LIN FT)	IDM	Net Inflow Rate (GAL/IDM)
JEA - All Basins	5.54	430427	765.2	392,768
JEA - Priority Basins	4.46	214,081	337.6	347,021
% of Total	*81%*	*50%*	*44%*	*88%*
HCPUD - All Basins	5.97	844,661	1,379	223,914
HCPUD Priority Basins	3.63	159,080	300	114,567
% of Total	*61%*	*19%*	*22%*	*51%*

The flow monitoring program for HCPUD was only three months in duration; therefore, an interim I/I analysis was not performed. The I/I analysis for HCPUD also used Sliicer, but was only performed once following the removal of all equipment. Area-specific fieldwork for the HCPUD Phase II source investigation program was recommended in 27 out of the 55 basins metered due to high infiltration, high inflow, or in some cases, both. Phase II work includes 106 night flow isolations, up to 130,000 lin ft of pipe inspections/leak detection testing, 1,800 manhole inspections, review of previously performed HCPUD smoke testing results, and potential dye testing.

Upon completion of the fieldwork in both project areas, estimated I/I quantities will be calculated and a cost-effective analysis will be performed to determine if rehabilitation is warranted over continuing to treat and transport I/I. An I/I reduction implementation plan for any rehabilitation and repair recommendations will be developed for future planning and design purposes.

Conclusion

A comprehensive and strategic flow monitoring program is essential to pinpointing I/I issues, and more importantly, narrowing the (I/I source) playing field. There are many strategies available for implementing a flow monitoring program that can be customized to meet any Florida community's goals for I/I reduction, while being affordable and getting to the root (locations) of the extraneous water problems.

The methods described for JEA and HCPUD did just that. Each program varied in approach, but ultimately led to finding, on average, two-thirds of the I/I reported by flow meters in just one-third of the pipe network in the study areas. In actual numbers, this equates to identifying 5 mgd of base infiltration that warrants additional field investigative work across 72 mi of pipe and 8 MG of inflow across just 70 mi of pipe, rather than all 241 mi of pipe in the combined (JEA and HCPUD) study areas.

This critical phase provides the basis for establishing a methodical approach to identifying actual I/I sources and a cost-effective R&R program focused on getting the most significant sources out first. The key to examining the success of this approach will be a postrehabilitation monitoring program to compare with prerehabilitation conditions.