Drought to Flooding to System Failure:
How to Work with Information You Have to Manage Collection System Needs

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How to Work with Information You Have to Manage Collection System Needs

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The weather outside is frightening . . . especially for those of us who are charged with operation and maintenance of our wastewater collection systems. The extended drought followed by long periods of soaking rain punctuated by intense rainfall events and widespread flooding have resulted in increased numbers of reportable sanitary sewer overflow events, collapsed pipelines, and newspaper stories about the state of our collection systems.

Extreme drought will cause shrinking and cracking of the bedding material and natural ground around wastewater pipelines. This can result in horizontal and vertical displacement of pipeline joints and manhole connections, as soil cracking and shifting will occur at different rates along the length of a wastewater pipeline segment.

Drought followed by extreme rainfall results in higher than normal infiltration rates, since the rainfall has a clear path through the cracked earth to the pipe and manhole joints. As rainfall continues, swelling of the previously dry and cracked soil occurs as it returns to typical moisture level conditions. This weather pattern can also result in further displacement of wastewater pipe and manhole joints.

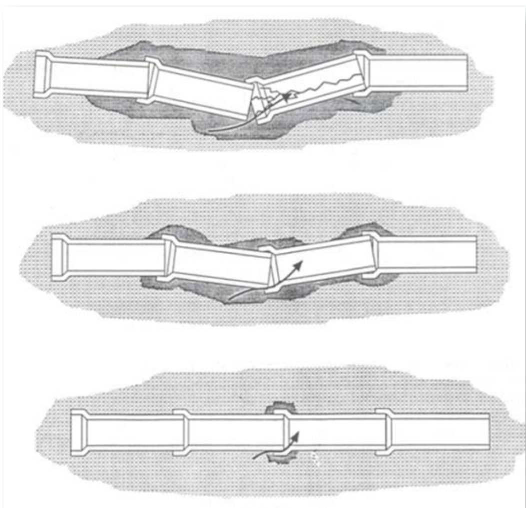


Figure 1.0 – Images of pipe joint failure due to soil movement.

As a result of the drought to flooding weather pattern, the wastewater collection system has experienced two events that can result in open pipe and manhole joints. The aging network of wastewater infrastructure, following these weather patterns, is now more susceptible to failure. Higher infiltration rates result in reduced available pipeline conveyance capacity for typical daily flows. Open pipe joints provide a clear path for root intrusion and bedding material/soil migration into the pipe. Follow the higher infiltration rate/reduced pipe capacity and open pipe joints with periods of extreme rainfall and flooding, the impact on the wastewater collection system results in system-wide sanitary sewer overflows and wastewater infrastructure failures.

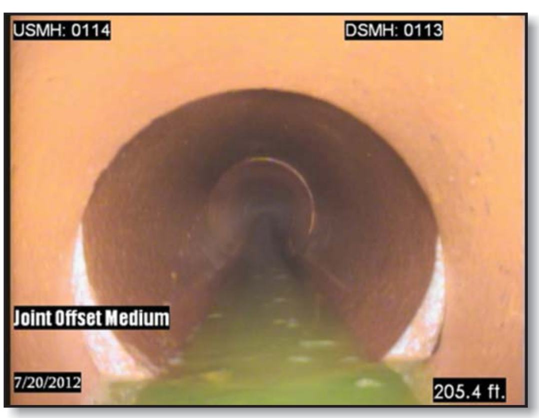


Figure 2.0 – Internal Pipe Image of Dye Test infiltrating through an open pipe joint.

Throughout the drought, many throughout the region enacted water conservation efforts, which resulted in lower water rate revenue for municipalities. During the drought period, existing preventative maintenance efforts for the wastewater collection system may have been reduced due to lack of available funding


Overflows caused by heavy rains

CITYCENTER – Massive rains forced 100,000 gallons of overflow into area creeks this week. Manhole covers lifted under the pressure of the rainswell that swept

Figure 3.0 – Newspaper article reporting rainfall induced overflows.

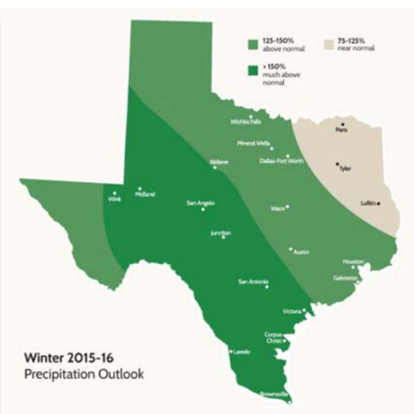


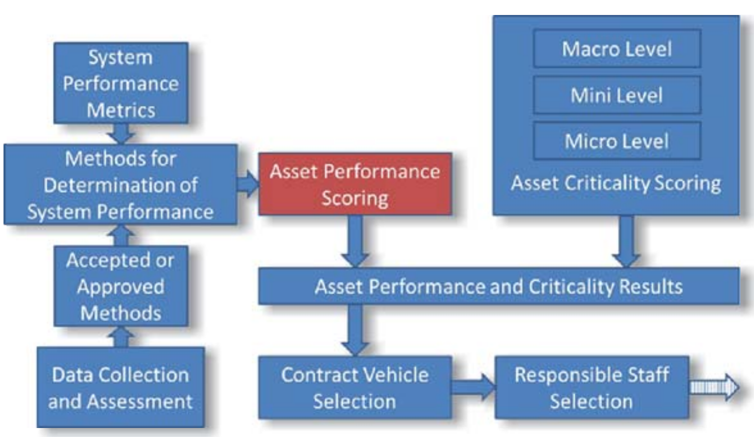
Figure 4.0 – Weather Forecast Map for Texas 2015-2016

or possibly are perceived lack of system need. During drought conditions, most municipalities are focused on providing potable drinking water to utility customers, and not on addressing potential problems with the wastewater collection system.

Some climate forecasts predict a wetter than normal winter 2015 and spring 2016 for Texas. Therefore more wet weather is probable, while many are experiencing critical and widespread collection system problems with no funding/budget to address system issues, and little time to resolve known issues before the next forecasted wet weather period. All of which is just a reminder that no one can control the weather, and thus a continuous proactive approach to collection system management is important whether it is raining or the sun is always shining.

In an ideal situation, everyone would have perfect/verifiable data and information that could be used to make accurate decisions regarding system needs at exactly the right point in time to avoid poor collection system performance. However, since everyone lives and works in an imperfect world, it is important to build on the existing data and information that we have and work with the tools we have available, while focusing on the areas of the collection system that are most likely to exhibit performance problems or failures during wet weather events. The alternative to working with data and information currently available is to embark on a possibly expensive and time consuming data collection effort. A targeted approach based upon existing available information can provide measureable results and reductions in recurring sanitary sewer overflows in less time, if we are able to identify where to expend meager resources such that the probability of sanitary sewer overflows will be reduced.

Figure 5.0 – Data Structure Process Flowchart



First things first.

Build on existing information by taking an inventory of available resources. We need to determine what we have to work with:

- What data is available regarding the physical wastewater collection system network?
- What information is available regarding wastewater system performance?
- What are the tools that we have available to examine and analyze the data?

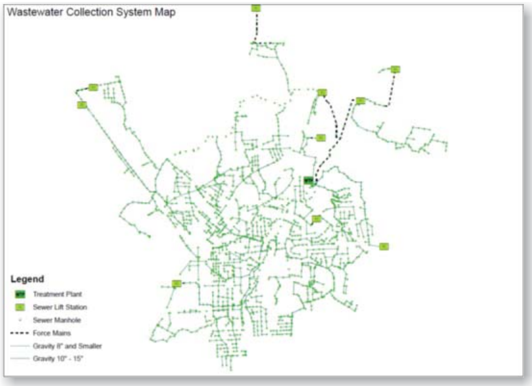


Figure 6.0 – Map of a wastewater collection system.

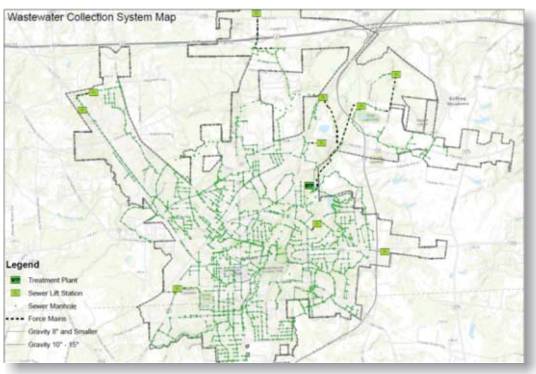


Figure 6.1 – Map of a wastewater collection system with aerial topography.

The answers to these questions will guide the process. At the most basic level, there is a map of the collection system. It may not be completely up-to-date, but it will typically contain enough information to get started – and it is better than nothing. From a rudimentary map of the wastewater collection system, we can determine the number of manholes, the length of pipe segments, pipe diameters, and the locations of aerial creek crossings and siphons.

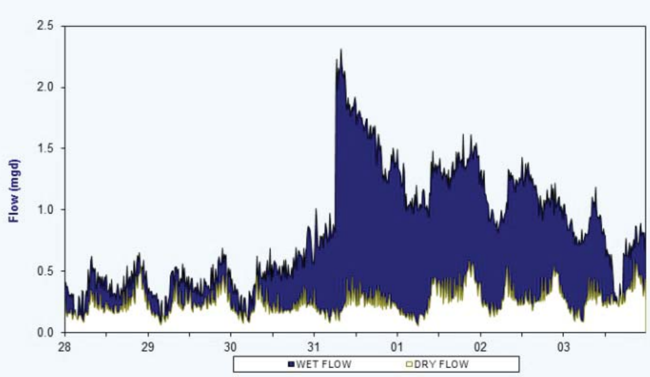
Add in other publicly available information and we can determine:

- Proximity of wastewater infrastructure to existing creeks and other waterways;
- Locations of wastewater pipes relative to critical infrastructure, such as hospitals and emergency services providers;
- Soil types;
- Tree growth patterns;
- Population distributions; and
- Locations of industrial and commercial users.

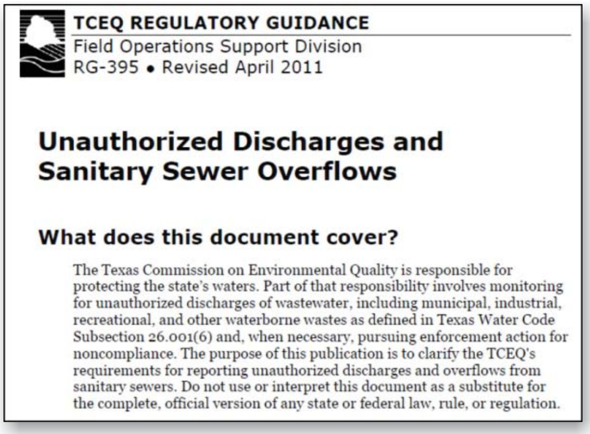
All is valuable information to begin working with that can be enhanced with wastewater collection system performance data and operations and maintenance records.

Owners and operators of collection systems will also have some type of system performance data (such as system flow information). This can range from system-wide flow and rainfall data networks to system flow rates entering the wastewater treatment plant or collection system discharge point (where a system discharges to and is treated as a part of a system owned and operated by others). This information can be used to roughly estimate available capacity in the wastewater collection system.

Figure 7.0 – Flow monitoring wet vs. dry weather data graph



Sanitary sewer overflow reports are also a useful source of information. These reports are required by the Texas Commission on Environmental Quality (TCEQ) anytime an overflow occurs. Overflow locations are indicators of areas where capacity is insufficient or where pipeline performance is restricted in some manner.



TCEQ REGULATORY GUIDANCE
Field Operations Support Division
RG-395 • Revised April 2011

Unauthorized Discharges and Sanitary Sewer Overflows

What does this document cover?

The Texas Commission on Environmental Quality is responsible for protecting the state's waters. Part of that responsibility involves monitoring for unauthorized discharges of wastewater, including municipal, industrial, recreational, and other waterborne wastes as defined in Texas Water Code Subsection 26.001(6) and, when necessary, pursuing enforcement action for noncompliance. The purpose of this publication is to clarify the TCEQ's requirements for reporting unauthorized discharges and overflows from sanitary sewers. Do not use or interpret this document as a substitute for the complete, official version of any state or federal law, rule, or regulation.

Figure 8.0 – TCEQ Sanitary Sewer Overflow Guidance Document

Operations and maintenance information is also extremely valuable in this exercise. Whether the data is stored in an advanced asset management system (AMS) or computerized maintenance management system (CMMS) or just rolling around in the minds of the operations staff or recorded on paper in metal file cabinets, it is useful information regarding the health of the wastewater collection system. This type of information can be used to determine the wastewater infrastructure that fails most frequently and to identify areas of the collection system that are maintenance "hot spots". This data can be applied to existing system information and prioritized by a set criteria such as pipe material, age, and number of reported issues (simple mathematical algorithm). Applying this data in a map format, a visual of the priority areas can be evaluated readily.

It is important to understand and qualify the condition of all of the available data and information as we continue with the process. Incomplete, invalid, or poor quality data will necessarily skew the results of any analysis. The old adage of "Garbage In – Garbage Out" applies here. We just have to limit the amount of garbage coming into the process and understand that the results that we obtain may not be perfect – but they are better than nothing at all. System data collection and verification is an expensive and time consuming process – one that tends to slow down or even halt the overall process of determining when, where, and how to proceed to address the immediate needs of the wastewater collection system. The information we have may not be flawless, but we must move forward and not get bogged down in the process of making everything perfect. We just need to understand the qualifications and limitations that must be placed on the existing data before moving forward. Judicious application of common sense and sound judgment to any analysis results is required.

Figure 9.0 – Map example of collection system priority pipeline segments.

Second Step . . . extend the information that we have using the tools that we have available. Gather and categorize the available data. This can be completed using spreadsheets, databases, a GIS, a CMMS, or even through the application of manual methods. Some types of information will fall into several categories. Determine what we are looking for in the data – most of the time the answer is available directly or through inference.

- Are we interested in determining areas for system inspections prior to rehabilitation?
- Are we are attempting to mitigate the cause of a recurring Sanitary Sewer Overflow?
- Are we looking for pipelines that are candidates for trenchless rehabilitation?
- Are we are looking for ways to help mitigate excessive infiltration and inflow caused by drought/rain/flood cycles?

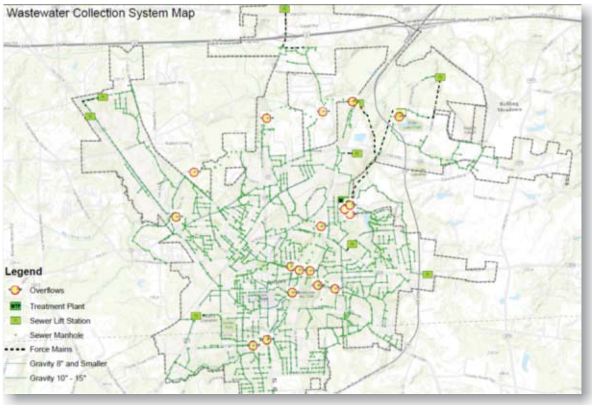


Figure 10.0 – GIS map showing repeat overflow locations.

Optimally, the available data is in a digital format and compatible with common Geographic Information Systems or database programs. This helps sort and analyze the data quickly, makes the data available for others to use, and expands the number and types of expertise that can be applied to the analysis process. Each of these programs form the basis for use in other applications, such as a Computerized Maintenance Management System (CMMS), spatial analysis programs, or Decision Support Systems.

Thus far, we have determined what we have to work with, the condition of our information, and the format of the data. The next steps are to evaluate our tolerance for risk and the consequences of a system failure.

Risk can be defined as the intentional interaction with uncertainty. Uncertainty is a potential, unpredictable, unmeasurable and uncontrollable outcome; risk is a consequence of action taken in spite of uncertainty. Since we are not 100% certain of the condition and performance of any particular portion of our wastewater collection system, there is some level of risk associated with the activities we perform (or don't perform) in order to maintain the system in a certain operating condition. It is generally accepted that an entity that does not engage in any kind of asset management activity for its collection system runs a greater risk of system failure than an entity that does engage in some level of asset management or preventative maintenance.

Risk Tolerance is the subjective judgment made about the severity or probability of a risk, and varies from municipality to municipality. There is a certain risk to the application of any method or combination of methods employed to operate and maintain a wastewater collection system. What risks are we willing to tolerate in order to repair one pipeline instead of another? Successful collection system owners and operators

Figure 11.0 – Picture of sinkhole.

Figure 12.0 – Picture of pipe collapse/failure with root intrusion.

strike a balance among acceptable risk, consequences, cost, and other factors such as public perception.

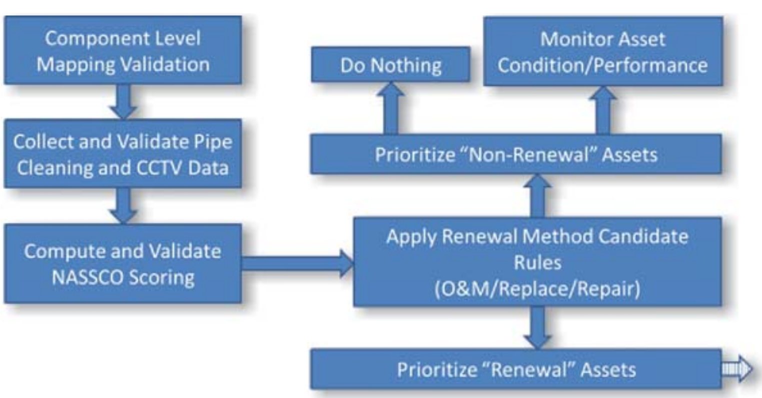
Consequence of failure is a more concrete subject. Consequences are the events that are caused by other, related events. A speeding ticket is a consequence of disobeying the posted speed limit. A sinkhole can be the consequence of a catastrophic pipeline collapse.

Open pipeline and manhole joints can be considered a consequence of the drought/rain/flood cycle. Some consequences are acceptable to a sequence of events. What consequences is a particular entity willing to accept in the event of a wastewater pipeline failure? The consequence of a small diameter pipeline failure in the upper reaches of the wastewater collection system may be acceptable when compared to the consequences of a large diameter interceptor failure under a major highway.

Once risk tolerance and the consequences of a system failure are determined, priorities can be set for actions to be conducted in support of wastewater collection system health. Portions of the system with the lowest risk tolerance, the worst consequence of failure, and are the most likely to be in the poorest condition are the areas that require the most immediate and thorough attention.

Third . . . we need to determine which portions of the collection system are most likely to be in the poorest condition. This is analysis of the data and information we have assembled regarding the collection system. A Decision Support System (DSS) can be used in this situation.

Figure 13.0 – Decision support system diagram/flowchart – data validation to pipe renewal prioritization.



A decision support system allows users to explore the outcomes of many different scenarios and combination of conditions before committing resources to a proposed problem solution. The outcomes are based on the application of sets of rules that are individually developed by the user to model the conditions in that particular collection system. The application here is that we can use a DSS to help determine what combination of conditions (both physical and performance) result in a pipe being determined to be in poor condition.

Figure 14.0 – Interior picture of wastewater pipe deteriorated by H2S

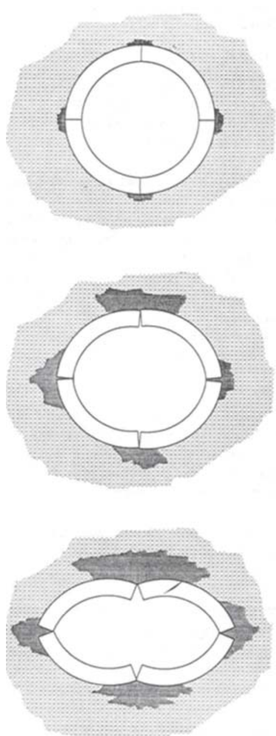


Figure 15.0 – Images of the impact of soil movement on buried pipes over time.

As an example, a common rule in wastewater decision support systems is associated with the condition of a manhole at or near the discharge of a force main. Although not every force main discharge in every wastewater collection system will experience deterioration due to gas generation from the wastewater flow splashing as it enters the manhole, it is a common condition in the industry. Application of this rule would isolate manholes and gravity pipelines within a certain distance (assuming they are connected) of a force main discharge point as being in potentially poor condition.

A few general points about the application of a DSS:

- DSS output can be quickly verified in the field and adjustments made in order to refine the DSS output.
- New rules can be created and applied to the data collected about the collection system to aid in the determination of probable pipe condition.
- DSS rules can be applied in combination or as a single rule.

Most decision support system software programs will accept data in a common spreadsheet or database formats, without any need for extensive data formatting prior to input. Advanced DSS software packages feature probability based tools to determine the most likely outcome of some event based on the outcome of various prior events. Rather than spend the time and effort to determine the set of conditions that result in a particular pipeline being in poor operational or structural condition, we can explore many different combinations – some traditional and some non-traditional – that cause pipeline structural deterioration and performance problems.

As a further example, if the purpose of the analysis is to discover which portions of the wastewater collection system have been adversely affected by the shrink/swell cycle of the soils surrounding a pipeline or manhole and are subject to increased infiltration rates, then an examination of the soils in the immediate vicinity of the sewer mains is a place to start. Soils that exhibit the capacity for significant shrinking and swelling are most likely to have damaged a buried pipeline.

The type of pipe material is a factor here. Older clay pipes, tended to have shorter segment lengths (thus more pipe joints) when compared to PVC pipelines. Overlaying a soils type map over the collection system map will highlight the portions of the collection system that are likely to fail due to this type of condition. Moving forward, we can overlay the boundaries of the 50 or 100-year floodplain on this map to identify pipelines that are likely to become inundated during a wet weather event.

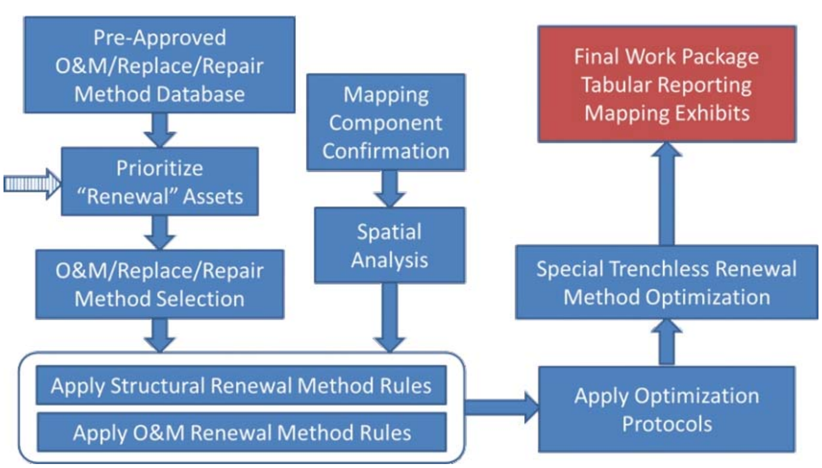
Figure 16.0 – Picture of Pipe in a drainage channel

We may have also identified older clay pipelines that are located in an area of active soils, but are located away from a creek or drainage way. These pipelines may have experienced the same open joint problems as those located in the floodplain, but they would be considered less likely to experience the levels of infiltration as infrastructure located in a creek, drainage channel or other waterway.

If we stop the analysis at this point, we have reduced the number of pipe segments that may be in need of inspection from all of the pipes in the collection system to a reduced percentage of the whole system. Combining the data pertaining to this subset of wastewater infrastructure with the risk tolerance and consequence of failure information specific to the system needs, we can develop a prioritized list of pipelines that require further attention.

This process of the prioritization of assessment efforts/needs is straightforward. We are attempting to knowledgeably reduce the number of wastewater infrastructure components that require immediate attention through the application of inspection methods and/or rehabilitation. If we begin our analysis with the entire wastewater collection system, and then eliminate wastewater infrastructure, based upon available data and the DSS analysis, determined to be in good condition, we can reduce the number of pipeline segments and associated infrastructure that require the additional expense and time consuming attention.

Figure 17.0 – Decision support system diagram/flowchart – through pipe renewal.



If we further analyze those pipeline segments and associated infrastructure with the purpose of eliminating even more wastewater infrastructure from the list of inspections by considering the risk of doing nothing and the consequences of a wastewater infrastructure failure, the list of pipeline segments that will most likely result in a failure will become more manageable. Once we have a manageable workload for inspection and/rehabilitation of the collection

Heavy rains lead to wastewater overflows

City Utilities today reported that recent heavy rainfall has caused sanitary sewer overflows at several locations, five of which exceeded 100,000 gallons. A utilities spokesperson stressed that none of the overflows of diluted wastewater have affected the City's

Figure 18.0 – Newspaper article example reporting rain induced overflows.

system, we can apply our resources to areas that will result in a reduction of the potential for system failure.

It should be noted that the outlined prioritization approach, the application of available system data with DSS analysis, should not be substituted for actual field inspection of the entire collection system over time or the continued collection and analysis of data and information regarding the collection system. The DSS analysis should be used in concert with prioritized and continuous field inspections as it can be a powerful tool that allows for the intelligent allocation of scarce resources that improves as more data and information is applied.

Common sense and experience with the collection system frequently outperforms even the most advanced computer programs. Don't be afraid to "go with your gut" when trying to determine how and where to focus investigative efforts and rehabilitation dollars in addressing wastewater collection system needs in providing one of the most important services to society – the successful conveyance of wastewater flows to treatment/reclamation facilities.

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For more than 100 years, Burgess & Niple has led the development of infrastructure in rural and urban regions. Our success is driven by a passion for advancing the built environment with exceptional concern for quality of life, safety and sustainability. Our work spans the world and ranges from complex urban renewal projects to finding potable water for arid, rural villages.