New Technology for Biofilm Removal and Hydrogen Sulfide Control in Sewer Lines: Lake Nona Trial

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The wastewater division for the City of Orlando (city) was experiencing hydrogen sulfide (H_2S) odor and corrosion concerns near the Narcoossee Road area, specifically at a force main discharge manhole and in the downstream gravity system. In May 2015, Cloevis™, a biofilm removal technology, was introduced to the wastewater system at Lift Station (LS) #155 for the purposes of mitigating H_2S formation in the force main. As a result, the gaseous H_2S production was greatly reduced, as were the foul odor and corrosion.

Cloevis is an innovative process that removes the biofilm that harbors sulfate-reducing bacteria (SRBs). It does this by using free nitrous acid (formed in situ by adding sodium nitrite and an acidifying agent) to specifically target the ecology in force main sewer systems, resulting in sustained suppression of gaseous H_2S production. While control of H_2S has been achieved in wastewater collection systems with the utilization of many different technologies (primarily with oxidation, precipitation, pH adjustments, and vapor-phase systems), the process provides an alternative solution for unique situations, such as the lack of a suitable site to house conventional chemicals and equipment, or an effective dosing location. Future process benefits to the city would include the potential for minimal chemical storage onsite, no equipment downtime excursions that permanent equipment sites experience, no long-term chemical residual downstream, no impact by sulfide loading, and minimal labor and maintenance demand. The process has two main phases:

1. The "conditioning" phase, when the ecology of the force main is changed to support the suppression of sulfides in the slime layer.
2. The "maintenance" phase, when the force main is treated at intervals in the future to provide ongoing sulfide control within established parameters.

The process was developed at the University of Queensland in Australia and licensed to USP Technologies (USP) as the exclusive provider in North America. Queensland researchers conducted field tests in Australia prior to the licensing agreement and found that intermittent dosing of free nitrous acid (FNA) can achieve effective control of sulfide production in rising main sewers. One single dose for eight to 24 hours can provide lasting effectiveness up to 10 days, for an average reduction of sulfide by 80 percent. Testing also found that no biofilm adaptation to FNA was observed; instead, successive dosing may achieve better control efficiency due to repetitive weakening of the biofilms.

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The city's chosen sewer line originates at LS #155 and discharges into a manhole in the median of Narcoossee Road. This system was chosen due to the following characteristics:

- It has a definitive process feed point (LS #155).
- It receives minimal side flows.
- The force main detention time (DT) is within process parameters (although DT has not been found to be a limiting factor in most cases).
- Significant sulfides are generated in the force main.
- Minimal sulfides are originated from the line segment prior to the process feed point.

It was decided that a trial of the new process would be done at Lake Nona, a 7,000-acre mixed-use planned community within the city limits of Orlando, southeast of Orlando International Airport. The goals of the Lake Nona trial were as follows:

- Characterize the critical collection system aspects, including wastewater flow, force main diameters, chronic odor complaint areas. and visible corrosion of system appurtenances.
- Determine the detailed sulfide loadings in the LS #155 force main upon discharge onto the Narcoossee Road manhole.

- Determine the rate of sulfide reduction with the utilization of the process technology.
- Prove the concept of the technology (as outlined herein) as an effective strategy for control of H_2S odors and corrosion from LS #155 force main discharge up to and including LS #138, limiting average atmospheric H_2S to a mutually-agreed-upon level of 10 parts per million (ppm).
- Quantify the treatment performance, cost-effectiveness, and operational benefits of the program as a whole for the localized segment tested, and as an optimized strategy for additional H_2S corrosion and odor control in the city's wastewater collection system.
- Provide the city with a comprehensive report of all findings and recommendations.

Results

The city contracted with USP to conduct an odor control demonstration of its new technology with the specific goal to reduce H_2S in a selected segment in the city's wastewater collection system. For the purposes of this trial, the primary control point was the outfall (discharge) manhole for the flow emanating from LS #155; a secondary control point was at LS #138.

Although the process has been successful in other collection systems in Australia and the western United States, the Orlando project was the first in Florida and adds to the city's H_2S control program, which features multiple technologies, including chemical as well as vapor-phase treatments. This demonstration provided the basis for the fundamental proof of concept required for determination of the level of success of the process in the Narcoossee Road system.

Application Approach

The treatment requires an initial conditioning phase where the biofilm that harbors the SRBs is removed, and then an ongoing maintenance phase, where treatments are repeated for a few hours every one to four weeks, depending on the rate of regeneration of H_2S. It is used on force mains and can be employed either alone or in combination with other (continuous) treatments.

Mechanism of Control

The technology involves periodically adding an acid, such as hydrochloric acid (HCl) and sodium nitrite, into the wastewater (Figure 1) and utilization of the force main scouring velocity in order to remove SRBs within the conveyance system biofilm. Since the SRBs thrive deep within the biofilm, sufficient contact time (i.e., approximately four to 24 hours of contact at pH 5) is required during treatments for successful removal.

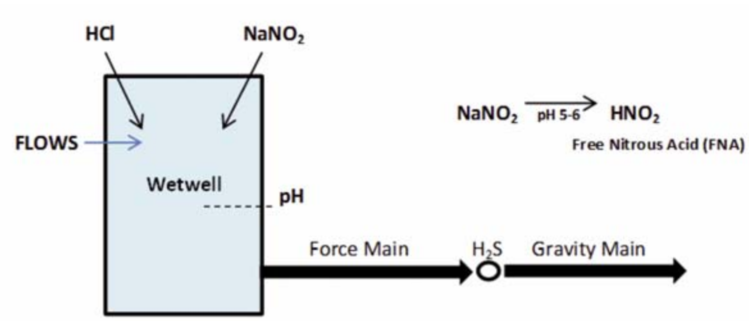

Figure 1. Biofilm Removal Technology: Chemical Dosing/ Monitoring Schematic

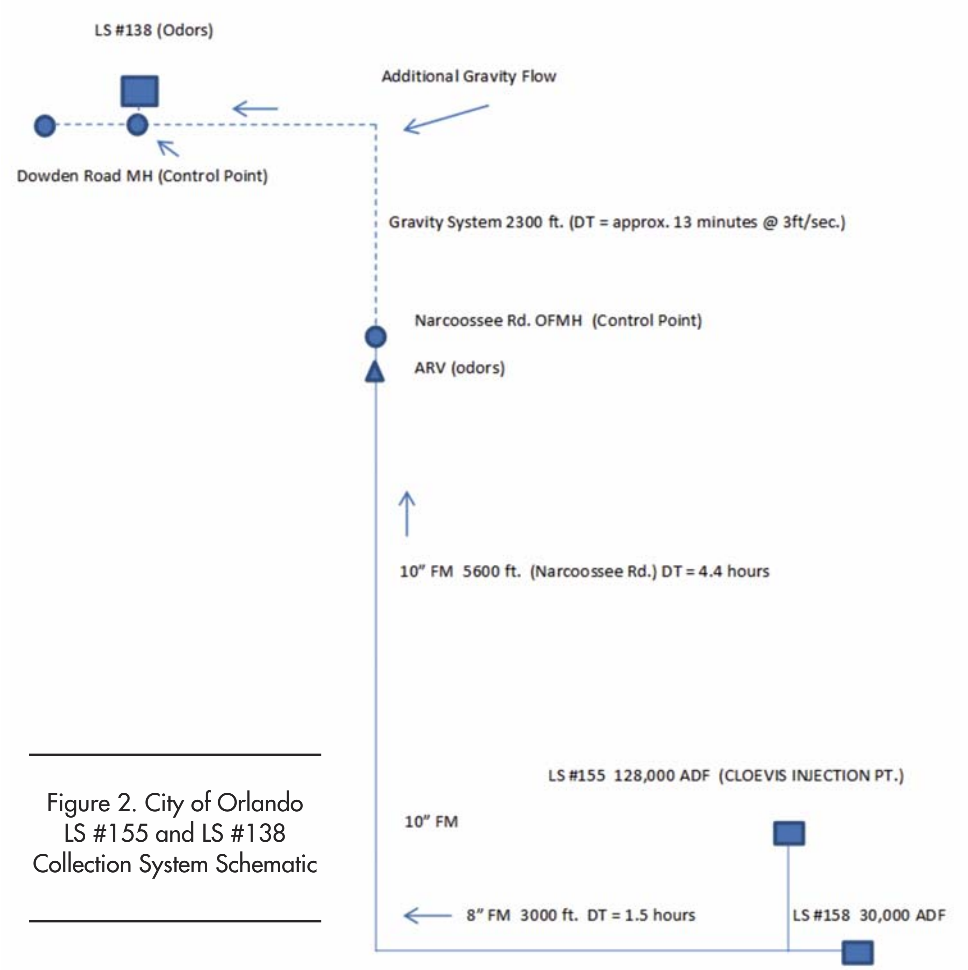

Figure 2. City of Orlando LS #155 and LS #138 Collection System Schematic

Chemical Demands

The two factors affecting chemical demand are:

1) The amount of acid required to lower the four to 24 hours of volume of wastewater flow to pH 5. The amount needed for pH depression can vary with the wastewater, but is typically in the range of 4-5 ml/L of 1 Molar HCl.
2) The frequency that treatments need to be reapplied to arrest the biofilm growth rate, which in turn depends on wastewater biochemical oxygen demand (BOD), temperature, pipe velocity, and sulfate levels. For most municipalities, frequencies range from once every two to three weeks in peak summer to once every two to five weeks in deep winter.

At LS #155, FNA was formed in the wet well by metering HCl (25 percent) into the station, continuously monitoring and controlling to approximately pH 5 and adding liquid sodium nitrite (40 percent) as the station wastewater level was rising. Both chemicals were fed below the water level in the wet well while continuously mixing using a wastewater recirculating pump.

As suggested in other previous trials, two 24-hour conditioning treatments were conducted at LS #155 on May 12-13, 2015, and again on May 15-16, 2015, to remove the biofilm in the

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Table 1. Cloevis Chemical Dose Rates

Test Condition	Treatment Duration (Hours)	Nitrite Rate, gph	HCl Rate, gph
Treatment	24	1.75	0.76
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Treatment	12	1.75	0.76
Treatment	8	1.75	0.76
Treatment	12	1.75	0.76

Wastewater flow = 128,000 gal per day (gpd)

Table 2. Description of Sampling Locations and Frequency

Sampling Location	Sampling	Frequency (# samples collected)
LS #155 Wet Well	pH monitoring	Continuous during treatments
Narcoossee Road Manhole	Liquid grab sampling	Weekly throughout demonstration
Dowden Road Manhole	Liquid grab sampling	Weekly throughout demonstration

Table 3. Testing and Analysis Methods

Test Performed	Method
Total Sulfide	*Standard Methods* 4500-S2-D, Methylene Blue (LaMotte drop)
Dissolved Sulfide	Same as total sulfide method using pre-flocculation to remove insoluble sulfides, Gastec 211LL tubes
pH/Temperature	Combination glass electrode
Residual Nitrite	Hach DR-900, Method 8153

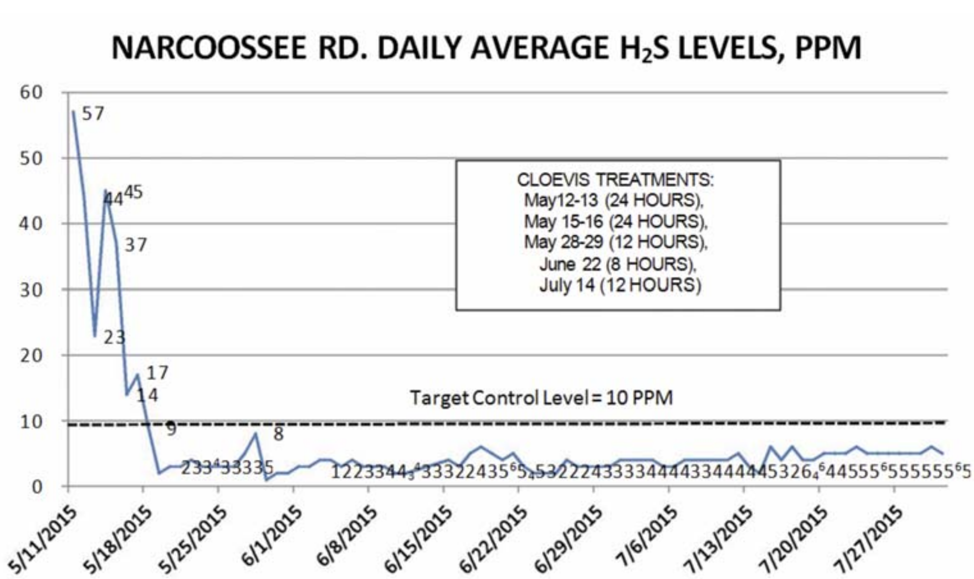

Figure 3. Compiled Vapor Hydrogen Sulfide Data Logged Measurements Throughout Cloevis Demonstration

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downstream force main. Maintenance (recurring/intermittent) treatments were administered on May 28-29, 2015 (12 hours), June 22, 2015 (8 hours), and July 14, 2015 (12 hours), to prevent the re-establishing of the biofilm and associated H_2S production.

Table 4 shows that the number of days between treatments increased from two to 20 days throughout the trial, signifying the effectiveness of the process in preventing biofilm reestablishment.

In order to measure the performance of the treatments at both control points, and to provide the basis for the intermittent treatment schedule, OdaLog® data loggers were placed at the Narcoossee Road and Dowden Road manholes, both before treatment began (in January and February 2015) and continuously during the trial from May 12, 2015, through July 30, 2015.

Additionally, wastewater samples were collected on a weekly basis and tested for dissolved sulfide (S-), temperature (Fahrenheit), pH value, and nitrite residual.

Collection System Schematic

Figure 2 illustrates the collection system characteristics.

Chemical Application and Durations

Various treatment scenarios were tested throughout the trial based on prior applications and ongoing evaluation of this trial at the control points at Narcoossee Road and Dowden Road. Table 1 shows the range of treatment conditions evaluated.

Sampling Locations

Table 2 describes the sampling locations (in detail) and the testing frequency at each of the manhole locations.

Data Collection and Analytical Methods

In order to monitor the effectiveness of each treatment, USP conducted continuous monitoring of gaseous H_2S (App-Tek OdaLog monitor/data logger) at the Narcoossee Road and Dowden Road manholes. Additionally, wastewater samples were analyzed on a weekly basis and tested for dissolved sulfide, temperature (Fahrenheit), pH value, and nitrite residual.

Treatment Results

Hydrogen Sulfide Data

Ultimately, H_2S atmospheric levels measured at the control points determine the success or failure of any sulfide control process. As the process is particularly dependent on proper treatment processes and sufficient contact time in the force main to be successful, ongoing analysis of current sulfide levels is paramount.

The numbers on the graph in Figure 3 signify the average gaseous H_2S level (ppm) for each day during the trial, including the day prior to the first treatment. Table 4 shows the gaseous H_2S levels (ppm) during each of the baseline and treatment stages of the trial. The graph clearly illustrates the effectiveness of the technology in the Lake Nona system. The H_2S levels were reduced from an average of 57 ppm to 5 ppm or less following the initial conditioning for the duration of the trial.

With the treatment, peaks greater than 30 ppm usually only occur once or twice per day, generally during high-flow periods, as a result of "pass through" sulfide (produced in upstream segments not receiving the treatments). These treatments thus eliminated sustained, lengthy periods of high H_2S that were routinely observed in the baseline readings, which resulted in odor complaints and system corrosion.

Downstream at the Dowden Road manhole, despite septic wastewater from the Lake Nona Country Club combining with the treated flow from Narcoossee Road, sulfide levels were reduced significantly, as the baseline (untreated) average of nearly 60 ppm and peaks approaching 150 ppm were reduced to an average of less than 30 ppm (and peaks of 50 ppm). Most of the measured sulfides in the Dowden Road manhole can be attributed to the Lake Nona Country Club flow. It must be noted that although the OdaLog sessions show significant reductions in H_2S levels throughout the trial, both control points also passed the qualitative "smell test" (as determined discrete subjective tests), i.e., there was a distinct difference in the odor level at each, both with and without the manhole cover in place.

Wastewater Analysis Data

Aqueous sulfide levels were measured prior to the introduction of the technology to the Lake Nona system, during treatment sessions and between intermittent maintenance treatments. The relationship between aqueous and atmospheric sulfide levels in the process-treated force mains is case-specific, but overall reductions were realized at both the Narcoossee Road and Dowden Road manholes, following the conditioning treatments and for the remainder of the trial.

Conclusions

Based on the data collected during the demonstration by USP, several important conclusions about the process demonstration can be reached.

The 24-hour sessions on May 12-13, 2015, and May 15-16, 2015, provided sufficient base treatment, and along with the three subsequent maintenance treatments, the process proved to be successful in the Lake Nona system and continuously maintained a level of <10 ppm of H_2S (average). The treatment removed 92 percent of the H_2S on an average daily basis at the Narcoossee Road manhole, which therefore will also reduce corrosion. As stated previously, the number of days between treatments increased on average throughout the trial, signifying the effectiveness of the process in preventing the reestablishment of biofilm, and ultimately, sulfide production.

The benefits of the process to the city include the potential for minimal chemical storage onsite, no equipment downtime excursions that permanent equipment sites experience, no long-term chemical residual downstream, and minimal labor and maintenance required.