Odor and Corrosion Mitigation Strategies for a Complex Large-Diameter Interceptor System

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Many municipalities in Florida utilize liquid-phase chemical treatment for collection system odor and corrosion control. These strategies aim to addresses odor, corrosion, and potential health and safety issues associated with hydrogen sulfide (H_2S) by seeking to either prevent H_2S from forming or from being released into the vapor phase. Many municipalities also contract with a vendor to provide turnkey services for the liquid-phase dosing, including providing and maintaining equipment, managing chemical inventories, and monitoring treatment performance.

While these turnkey dosing services can be advantageous for municipalities, there can often be room for liquid-phase treatment optimization. Taking a comprehensive and holistic view of the collection system can result in: 1) identifying key "hot-spot" target areas, 2) identifying the most desirable (cost-effective) chemical to be used for each specific location, and 3) selecting the appropriate dose for varying seasonal conditions.

The North Texas Municipal Water District (NTMWD) Upper East Fork Interceptor System (UEFIS) is a complex network of gravity sewers, force mains, and lift stations collecting wastewater from connection points with the cities of Allen, Frisco, McKinney, Plano, Princeton, Prosper, Richardson, Anna, Fairview, Lucas, Melisa, and Parker, as shown in Figure 1. The majority of UEFIS pipes are owned by NTMWD, with some owned by customer and member cities. Wastewater from UEFIS is treated by the Wilson Creek and Rowlett Creek Regional Wastewater Treatment Plants (RWWTPs), both operated by NTMWD.

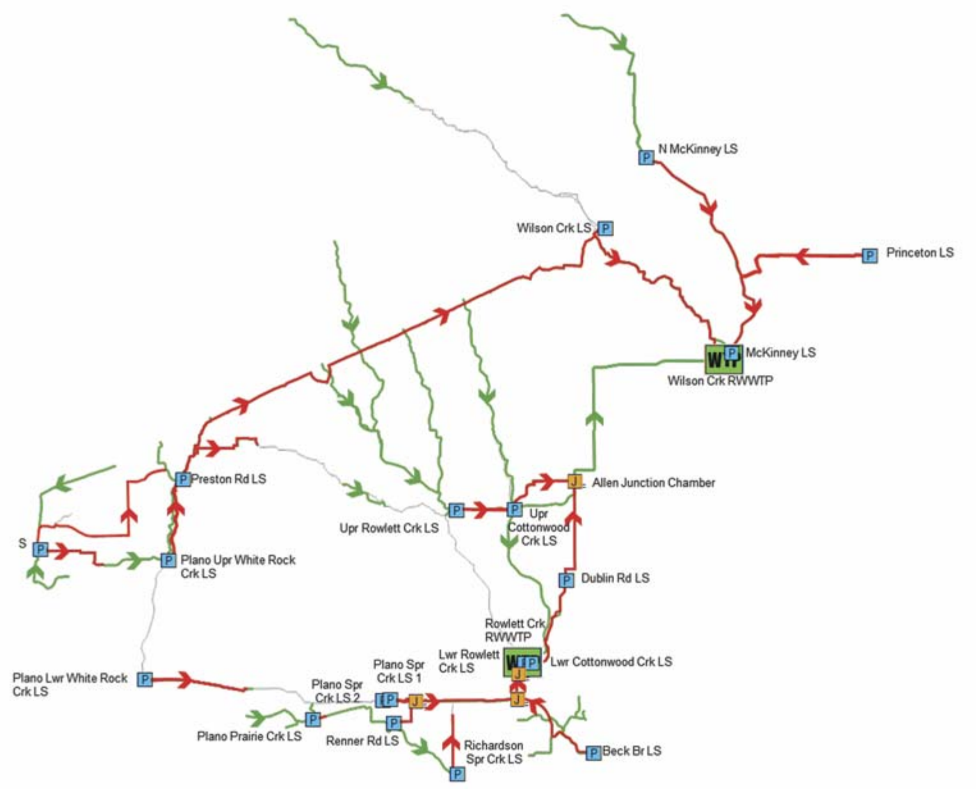

Figure 1. North Texas Municipal Water District Upper East Fork Interceptor System

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Like many municipalities in Florida, NTMWD currently implements a combination of vapor- and liquid-phase (ferrous salts, hydrogen peroxide, calcium hydroxide, and calcium nitrate) odor control in its collection system. The NTMWD is experiencing rapid growth in infrastructure and community encroachment, which necessitated a review of odor control strategies to determine if they were efficiently addressing current needs and what changes were required to proactively address emerging needs.

As a part of this process, Hazen and Sawyer developed an odor control road map that included the following tasks:

1. Existing-system data collection and evaluation
2. Field sampling of odor parameters
3. Development of a liquid H_2S model
4. Odor control alternatives development and evaluation
5. Potential odor control recommendations

Existing System Data Collection and Evaluation

Data Collection

The following existing system data were collected and evaluated:

- Existing and future collection system information, including pipe attributes and junction structure locations, from NTMWD's geographic information system (GIS) database.
- Hydraulic conditions according to NTMWD's InfoSWMM (stormwater model-

ing and management) hydraulic collection system model for UEFIS: The 2020 scenario in the NTMWD hydraulic model was used for development of a sulfide model.

- Historical odor complaints received by NTMWD from 2012 to 2017. A total of 60 complaints were received for the UEFIS area during this period and were geocoded on a map showing their location.
- Information on existing vapor- and liquid-phase odor control systems and strategies. The NTMWD operates 83 vapor-phase odor control units throughout UEFIS that include active and passive carbon cans, biological trickling filters, chemical scrubbers, and ionization systems. For liquid-phase treatment, chemicals are dosed at 10 lift stations, including the use of calcium nitrate and calcium hydroxide, as well as a combination strategy of ferrous chloride and hydrogen peroxide.
- Odor sampling data collected by NTMWD, odor control vendors, and data collected as part of the 2013 odor control master plan.

Odor Complaint Analysis

A total of 60 odor complaints were received for UEFIS from 2012-2017, as shown in Figure 2. Concerted odor control efforts helped NTMWD decrease the number of odor complaints received on an annual basis in 2016 and 2017. The NTMWD looks to maintain the recent low number of nuisance odor complaints and continues to be a "good neighbor."

Identification of Hot Spots and Sampling Locations

Several data sources were utilized to identify hot spots in the system and develop a field sampling plan. The following existing system data were evaluated:

- Odor complaint spatial data
- Current vapor- and liquid-phase odor control
- Pipe characteristics: materials of construction, diameter (criticality), slope, and type (force main versus gravity)
- Hydraulic conditions: manhole drops, force main discharges, hydraulic jumps, average dry weather flows, average flow depths, and dry weather flow velocities

As an example, Figure 3 shows the evaluation of odor complaints and force main discharge locations.

Field Sampling of Odor Parameters

Field Sampling Plan

The results of the existing system evaluation were used to develop a field sampling plan.

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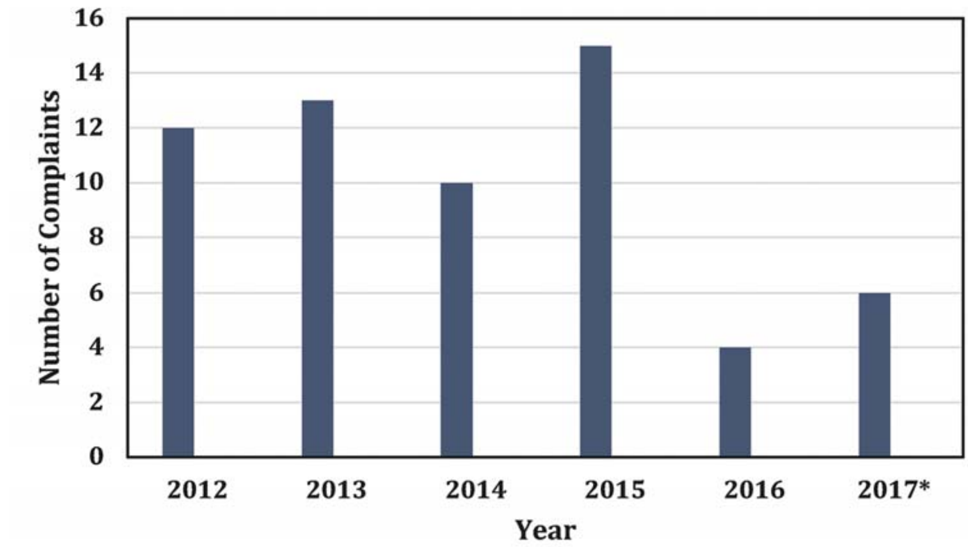

Figure 2. North Texas Municipal Water District Odor Complaints from 2012 to 2017

Figure 3. North Texas Municipal Water District Odor Complaints and Force Main Discharge Locations

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Sampling locations were selected to capture critical points for odor generation and control, determine the effectiveness and/or optimization of current odor control strategies, and allow for calibration and validation of the odor and corrosion model. Site selection was also based on accessibility for field sampling activities.

Field sampling parameters included pH (liquid and surface), nitrates, total and dissolved sulfides, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), soluble biochemical oxygen demand (BOD), vapor-phase H_2S, reduced sulfur speciation (evaluation of up to 20 reduced sulfur compounds common to wastewater conditions, at limited sites), and differential pressure. Figure 4 shows the field sampling locations.

Differential pressure and H_2S were recorded with continuous data logging monitors. The diurnal H_2S results were reviewed to identify the time of day when the peak concentrations occurred.

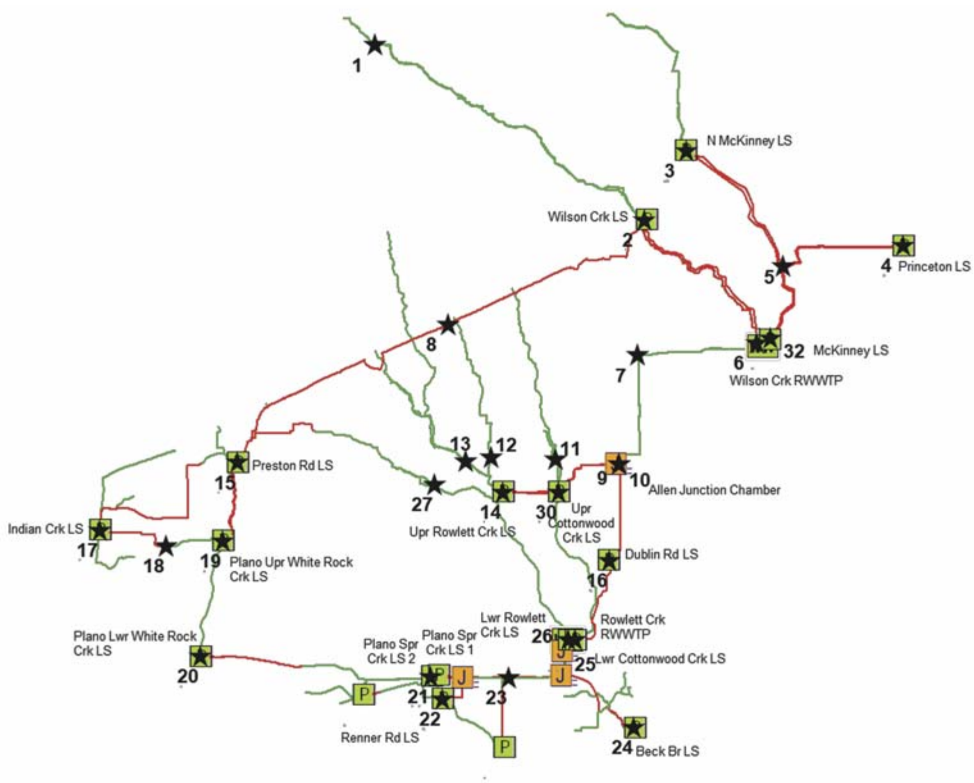

Figure 4. North Texas Municipal Water District Field Sampling Locations

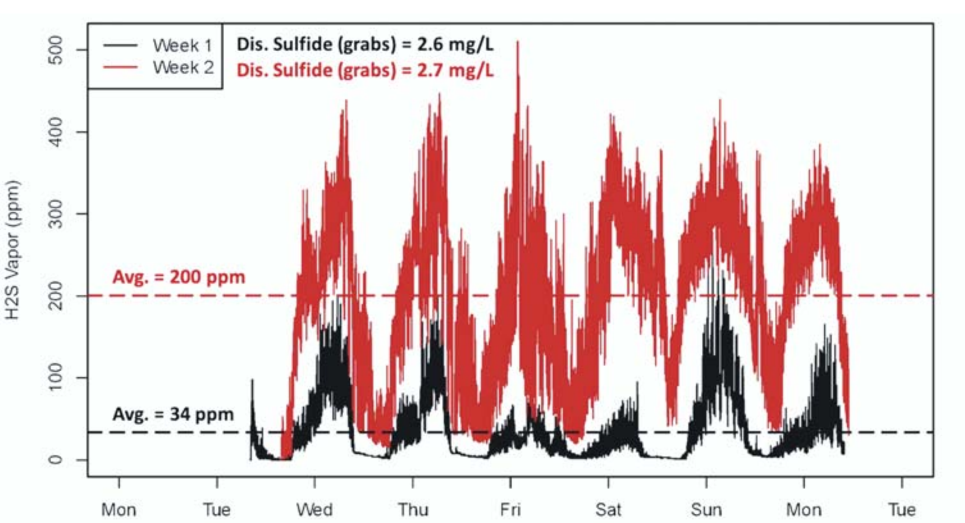

Figure 5. Vapor Hydrogen Sulfide and Liquid Dissolved Sulfides

Field Sampling Results

Recognizing the seasonal variability of collection system odors, the field sampling was broken down into two phases: early spring and summer. The first two weeks of sample collection occurred during early spring 2018, and additional sampling occurred during summer 2018. Both spring and summer sampling consisted of two weeks. Week 1 sampling represented normal baseline chemical feed conditions; chemical feed rates were then reduced by approximately 50 percent for Week 2 sampling during each phase (elimination of chemical feed was not feasible due to the potential for offsite nuisance odor impacts). Field sampling included the following:

- Two liquid grab samples were collected at each site for each week of sampling.
- Odalogs were deployed at each site to measure vapor-phase H_2S concentration continuously during the week of sampling.
- Differential pressure loggers were also deployed at selected sites for several days during both weeks of sampling. The data represent the tendency of the collection system to push odors out (positive air pressure) or pull outside air in (negative air pressure) the sewer pipes through any air passageway, such as manhole cover pick holes, laterals, vents, etc.

Since it's typical for odor and corrosion potential to increase with an increase in ambient temperature, sampling results for the summer were used to calibrate the sulfide model for the collection system and to understand the worst-case scenario for UEFIS. The collected sampling data were used to calibrate the H_2S model and to develop and evaluate alternatives for odor and corrosion mitigation within UEFIS. As an example, Figure 5 shows the H_2S vapor and dissolved sulfides for one of the sampling sites (and the differences between full- and half-chemical feed).

Bench-Scale Test Results

At certain critical hot-spot locations that were identified from a review of the field sampling results, wastewater samples were collected at predetermined times to coincide with the elevated sulfide/H_2S period of the day and brought back to a WWTP site, where bench-scale tests were performed. This effort was undertaken to determine an initial chemical dose that could reduce the wastewater sulfide concentrations to the target (less than 0.5 mg/l in this case), or the amount of chemical needed to raise the pH of the wastewater to above 8 (the level where ~92 percent of sulfide species are in ionic form and are not able to escape the liquid phase as H_2S).

The chemicals that were evaluated included ferrous chloride, sodium hypochlorite, hydrogen peroxide, magnesium hydroxide, and a proprietary chemical blend of calcium hydroxide and calcium nitrate (AE25). The doses determined by the bench testing were used to assess initial costs for chemical application comparisons.

Development of Liquid Hydrogen Sulfide Model

A UEFIS sulfide model was developed using NTMWD's existing InfoSWMM hydraulic model, in conjunction with a sulfide water quality model module that simulates dissolved sulfide generation and transport in the collection system. Prior to incorporating the sulfide module, the 2015 dry weather flow scenario in NTMWD's existing hydraulic model was updated to match flows and lift station operations during the field sampling events.

The sulfide module was then added and calibrated to match field sampling results. After calibration, the sulfide model was run with 2020 flows and planned capital improvement projects (CIPs) to predict future sulfide generation in UEFIS. Vapor-phase H_2S concentrations were estimated from the liquid-phase sulfide concentrations predicted by the model and the liquid-to-vapor sulfide ratios observed at each site during field sampling.

Figure 6 shows the comparison of model and supervisory control and data acquisition (SCADA) flows at various lift stations in UEFIS for Week 1 of the summer sampling. The modeling results were used to develop and evaluate alternatives for odor and corrosion mitigation within UEFIS.

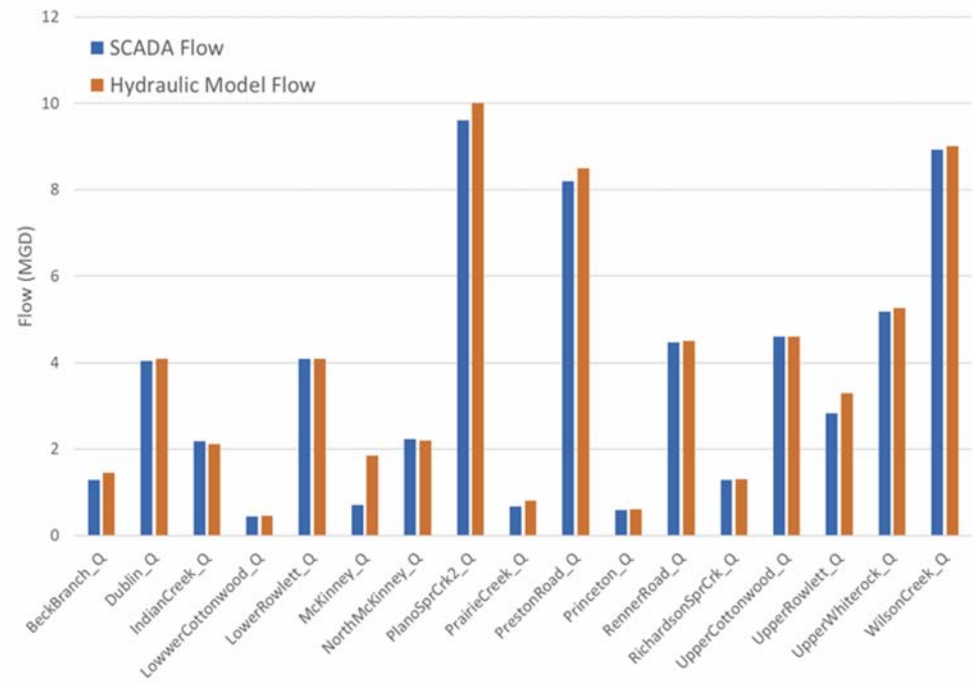

Figure 6. Comparison of Model and Supervisory Control and Data Acquisition Lift Station Flows

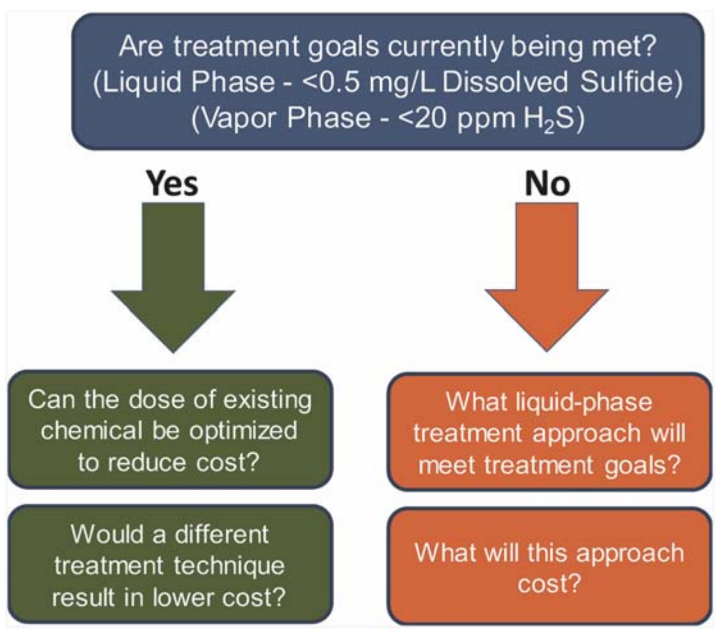

Figure 7. Alternatives Analysis Approach

Odor Control Alternatives Development and Evaluation

Alternatives Evaluation

The hot spots identified in Tasks 1 and 2 and the calibrated H_2S model developed in Task 3 were used to evaluate alternatives for UEFIS. The existing treatment and potential alternatives were analyzed by breaking UEFIS into subsystems so that treatment approaches could be developed for the unique characteristics of each subsystem, rather than applying a generic approach for the entire UEFIS. Once the subsystems were identified and calibrated, various strategies were evaluated to determine the optimal liquid-phase treatment.

The 2020 dry weather flow scenario in NTMWD's existing hydraulic model was used to develop alternatives. The approach for each subsystem depended on whether the existing treatment meets the desired odor and corrosion control goals of < 0.5 mg/L dissolved sulfide in the liquid phase and < 20 ppm H_2S in the vapor phase. If the subsystem met the treatment goals (Figure 7), analysis for that subsystem consisted of evaluating whether an existing chemical dose or treatment technique could be optimized to continue to meet treatment goals, but at a lower cost. If the subsystem did not meet the treatment goals (Figure 7), then multiple liquid-phase treatment techniques were considered and an approach was developed to meet the treatment goals.

Odor Control Strategies/Options

For individual subsystems, both vapor- and liquid-phase treatment options were considered.

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The liquid-phase treatment options evaluated are shown in Figure 8.

The chemicals evaluated under these categories included:

- Ferrous chloride
- Ferrous chloride and hydrogen peroxide
- Calcium nitrate
- Magnesium hydroxide
- Dissolved oxygen

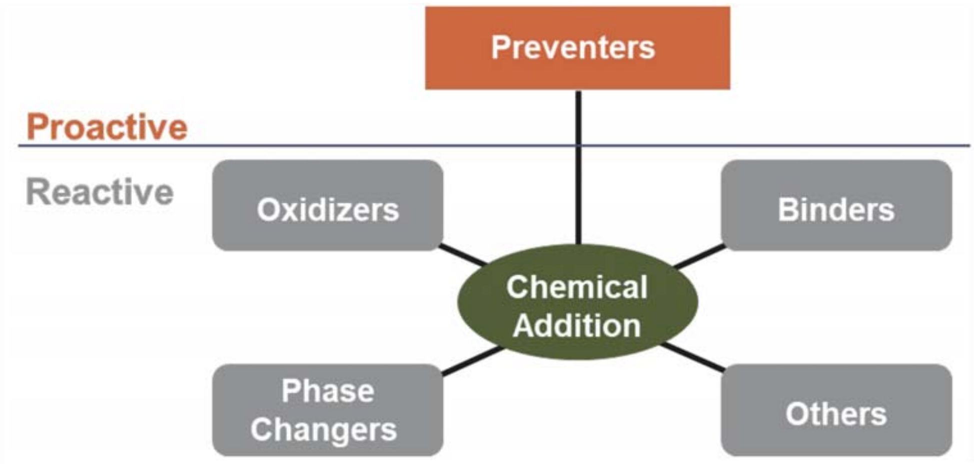

Figure 8: Liquid Phase Treatment Options

The vapor-phase treatment alternatives included:

- Activated carbon adsorbers (existing practice)
- Biological trickling filters (existing practice)
- *Ex situ* electro-ionization systems (existing practice)
- In-site hydroxyl radical ionization (potential supplemental treatment)

Potential Odor Control Recommendations

A final long-term plan for each of the subsystems is in the process of being completed as ongoing and planned modifications to the collection system are considered. When complete, estimated costs will be developed for each alternative for each subsystem. Based on the estimated costs, the treatment effectiveness, and the criticality of the location, recommendations will be implemented for each subsystem.

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