Advanced Sewer Process Modeling to Develop Odor and Corrosion Solutions for Managing Sewer Assets

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Presentation Outline

- Generation of sulfides/odors in collection systems
- Impact of sulfide generation on collection systems
- Collection system sewer process modeling
- Odor/corrosion mitigation
- Case studies

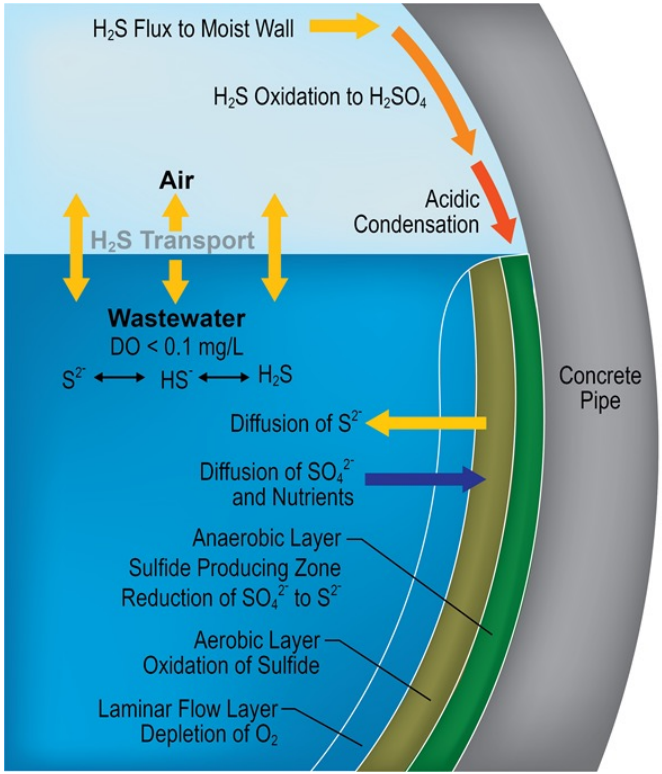
Generation of Odors

- Most wastewater odors caused by sulfides
- Generation of sulfides in sewers in ***simple*** terms:

  Sulfate (SO_4^{2-}) + Anaerobic Bacteria → Sulfides
- Sources of Sulfates
  - Potable water
  - Ground water infiltration into sewers
  - Sulfates from industrial, commercial and domestic sources

Sulfide Generation in Sewer Pipes (Simplified)

- Sewer system = complex bioreactor
- Wastewater rich in biomass, organic substrates, and SO_4^{2-}
- Sulfate reduction in anaerobic zone produces H_2S
- Sulfur oxidation in aerobic zone
- Gas-water transport
- When oxygen insufficient (<0.1 – 1.0 mg/L), sulfide diffuse into wastewater



Why are Sulfides in Sewers an Issue?

- Odors
  - Sewers are everywhere and near people
  - H_2S is a nuisance odor at low concentrations - pp*b*
- Corrosion
  - Relatively low concentrations can significantly decrease sewer life
  - Sewer collapse
  - Estimate sewer life for asset management planing

Why are Sulfides in Sewers an Issue?

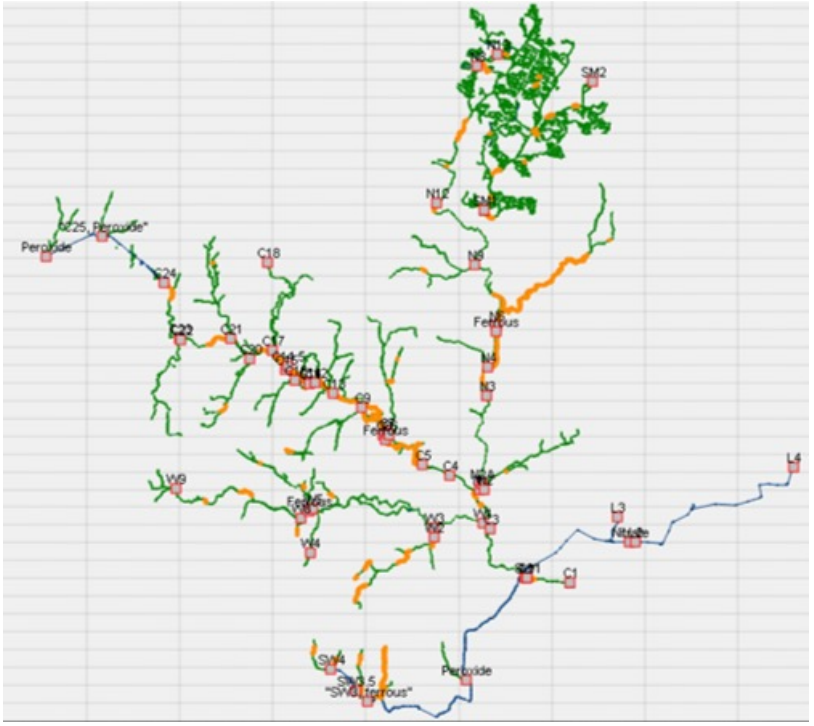
- Worker safety
  - Sewer H_2S concentrations can exceed deadly concentrations (>100 ppm)
  - Even with confined space entry procedure, deaths have occurred
- Impact on resource recovery plants

Sulfides in Sewer Have Increased Over Time

- Heavy metals largely removed from the sewage
- Water conservation increased BOD concentrations
- Urban growth/sprawl

Computer Modeling Addresses Challenges of Odors and Corrosion in Collection Systems

- Challenges in calculating impacts of complex pipe network
- Numerous variables that impact estimates
- Complexity of processes: sulfide generation, corrosion, stripping, and ventilation

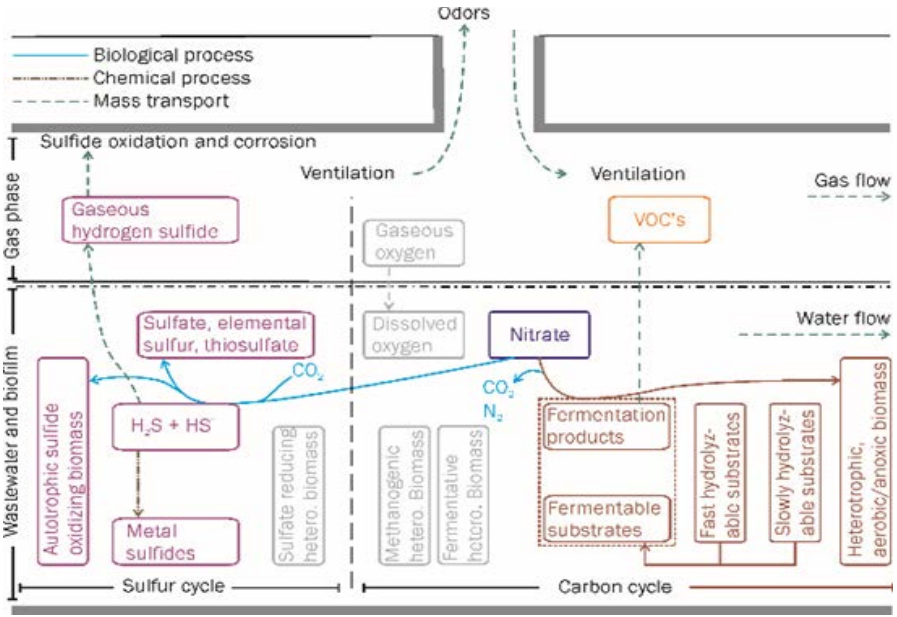


Benefits of Sewer Process Modeling

- Avoid costly sampling programs
- Identify optimum mitigation measures without full scale trial and error
- Perform what-if scenarios to determine impact of varying conditions (e.g., flow, BOD, temperature) on odors/corrosion
- Design sewers to minimize odor/corrosion
- Determine impacts of climate change: increasing temperatures, low dry weather flow

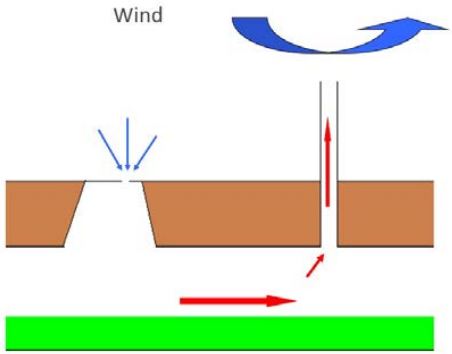
WATS Sewer Process Model

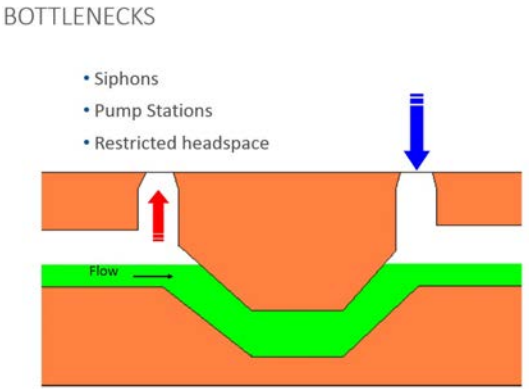
- Similar to wastewater treatment process models, WATS simulates, aerobic, anoxic, and anaerobic process and adds mass transfer/ventilation to the sewer headspace



Ventilation a Key Modeling Parameter

- WATS provides estimates of sewer ventilation
  - Determine H_2S concentrations
  - Determine odor “mass” = concentration x flow
  - Estimate corrosion rates
  - Determine out-gassing locations and magnitude
  - Size vapor phase systems without costly fan testing systems
  - Predict zone of influence





Many Viable Control Technologies

Vapor Phase

- Biotechnology (biofilter, biotowers)
- Carbon Adsorption
- Thermal Treatment
- Chemical Scrubbers
- Ozone and Ionization
- Containment
- Ventilation
- Collection and Treatment
- Multi-Stage Treatment

Liquid Phase

Oxidation
- Hydrogen Peroxide
- Chlorine (hypo)
- Permanganate
- Oxygen Injection
- Air
- Nitrate
- Microbial fuel cells
- Slow release solid phase oxygen

Change Equilibrium
- Magnesium hydroxide
- Lime

Sequestration
- Ferrous
- Ferric
- PRISC
- pH Control

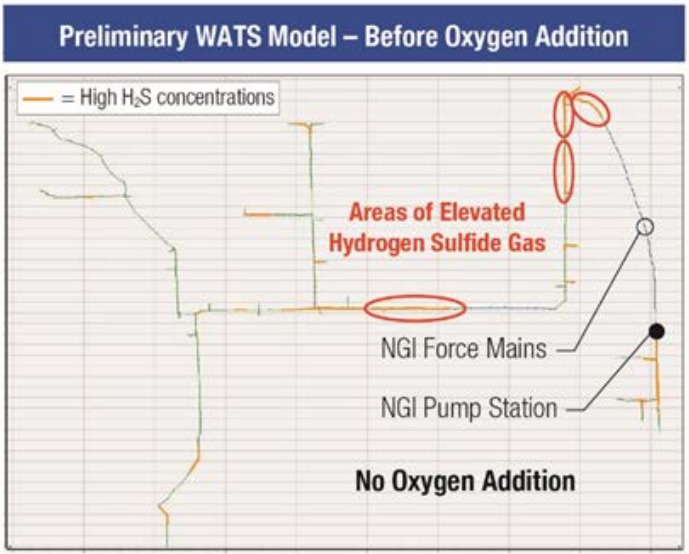
Inhibition
- Free Nitrous Acid
- FNA + H2O2
- Calcium Nitrate
- Anthraquinone
- Enzymes
- pH Shocking
- Molybdate

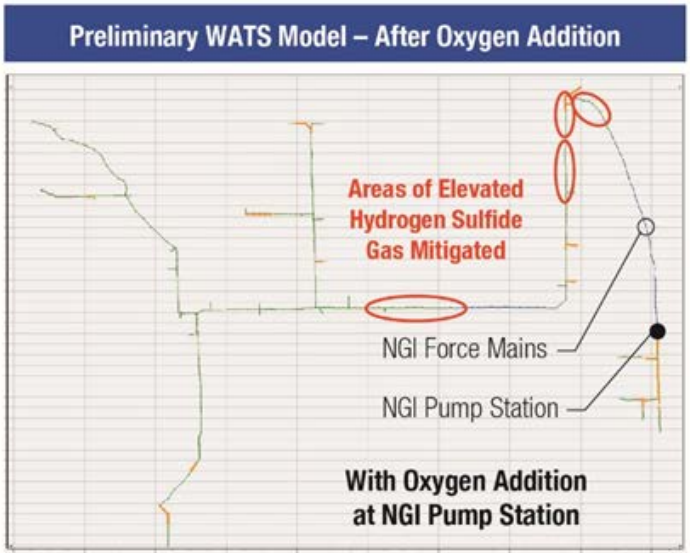
Prevention Through Design

- Maintain Velocities
- Reduce Points of Turbulence
- Control/Alter Ventilation
- Line Pipes
- Concrete Additives
- Air Jumpers

WATS and Control Technologies

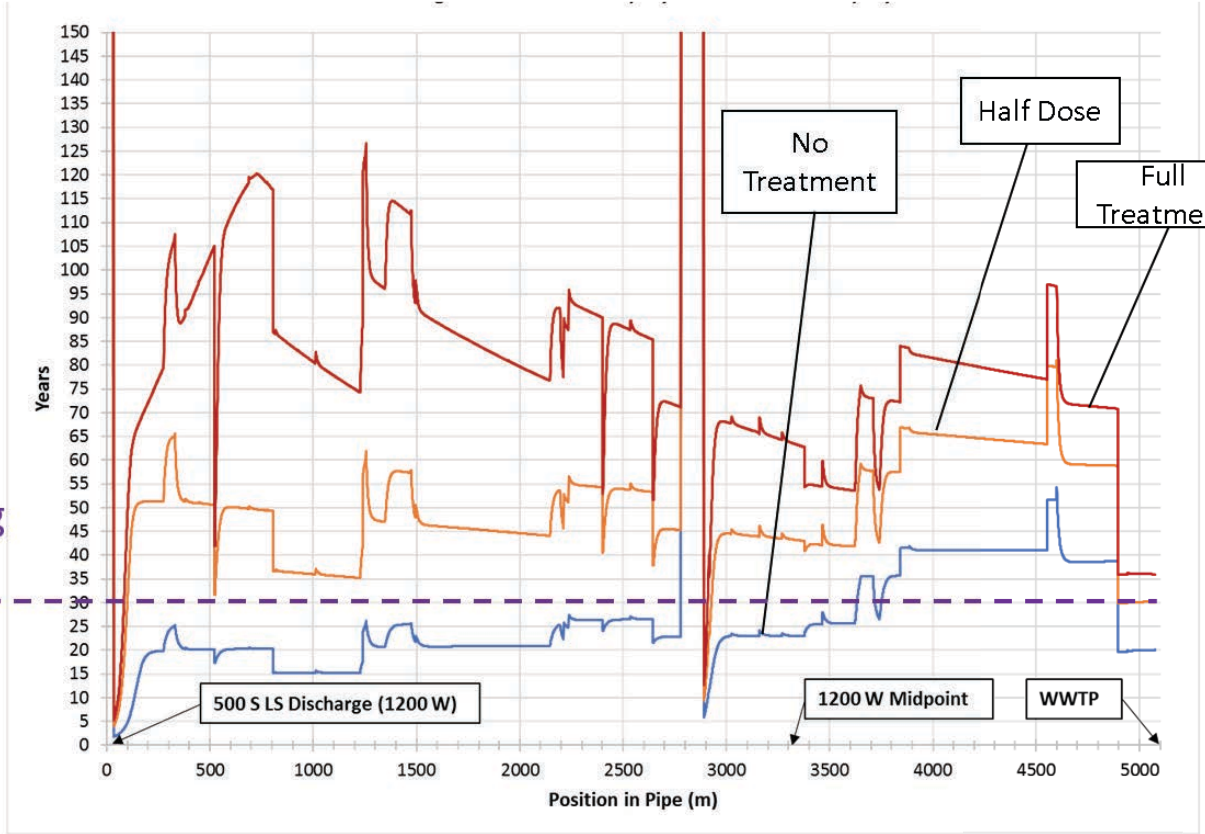
- Simulate odor/corrosion and evaluate mitigation methods (e.g., chemicals and vapor phase treatment)





WATS and Asset Management

30 Years Remaining Life



Integrate Collection System and Treatment Plant Models for Holistic Solutions

- Predict influent characteristics (e.g., ferment VFAs in sewer to drive bio-P)
- Air emissions (H_2S, VOCs) from liquid treatment
  - Needed for air permitting and odor impacts
- Fate of sulfides – digester gas/SOx emissions from engines/flares
  - Needed for engine design, catalyst, maintenance costs
- Additional biosolids generation (e.g., iron salt precipitants)

Case Study: Milwaukee MSD

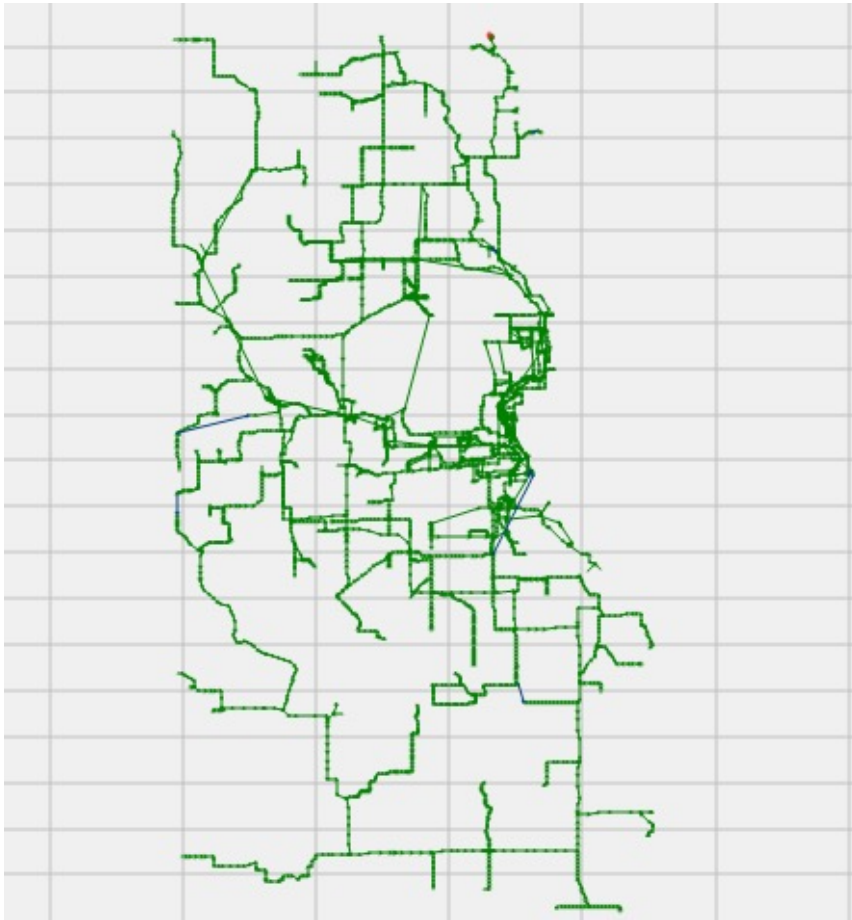
- Serves 1.2 million people
- 28 community customers
- ~ 200 square miles of collection system
- Own/operate larger interceptors and a deep CSO storage tunnel
- Two treatment plants: ~150 mgd average / 630 mgd peak capacity

Milwaukee MSD Overview

- History of conveyance system odor issues caused primarily by H_2S at multiple locations
- Project purpose: Develop an overall plan for controlling odors and corrosion in the entire conveyance system

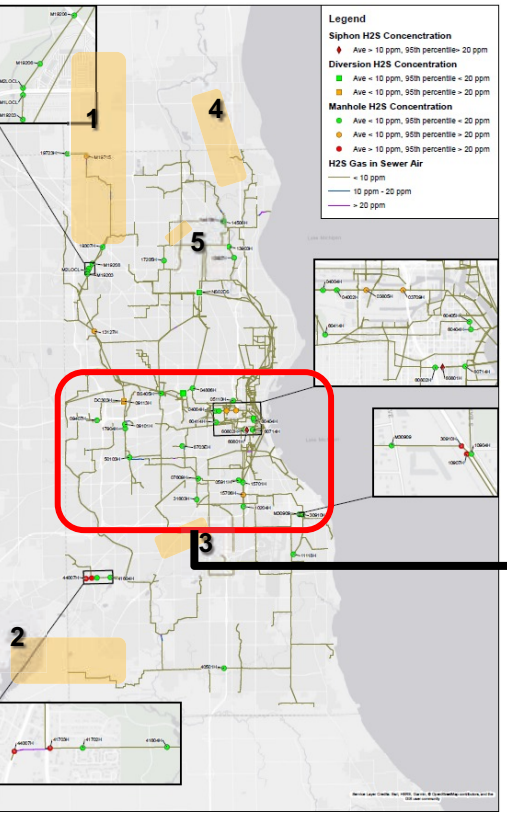
WATS Model Setup

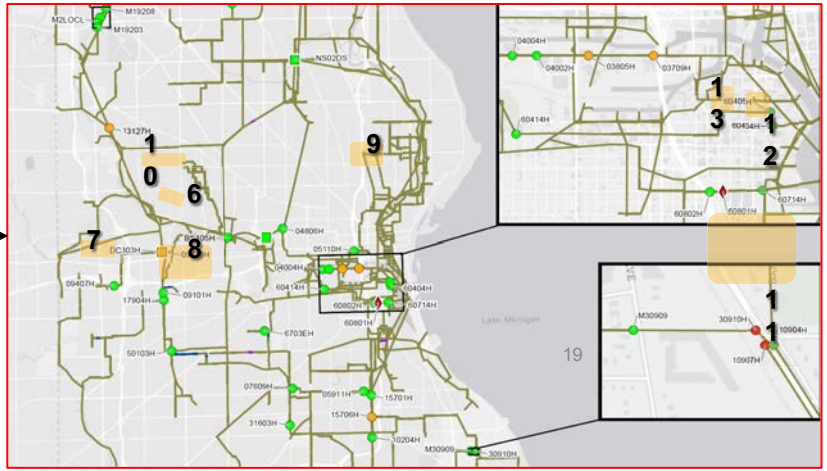
- Used MMSD's existing SWMM model inputs to avoid extensive data entry
- Utilized historical MMSD H_2S data
- Targeted sampling plan for model calibration



Break system into zones

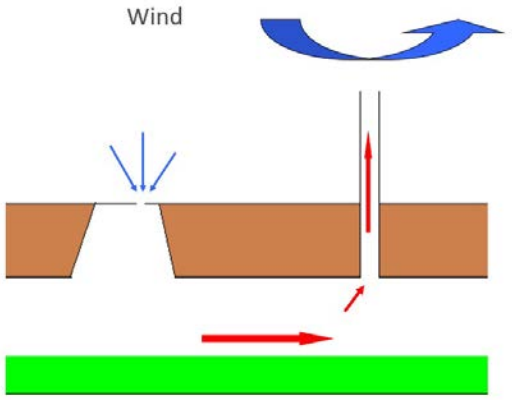
- 15 zones evaluated to determine if further evaluation justified
- 8 zones evaluated further
- Determined if mitigation necessary and most cost-effective mitigation measures
- Identified areas that could have corrosion



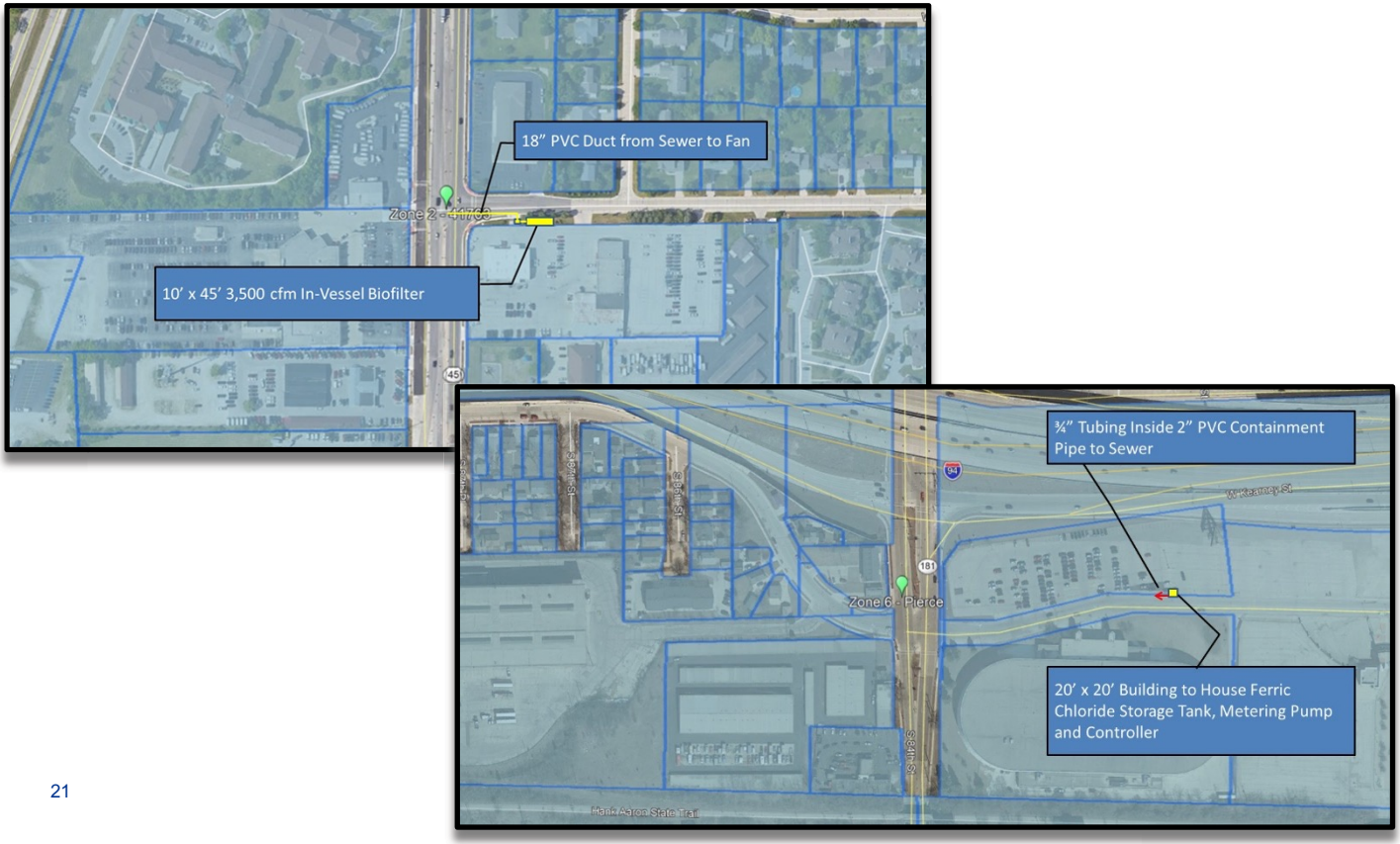


WATS Used to Size Ventilation Rate for Odor Control

- Avoided extensive fan testing
- Estimated H_2S concentrations
- Estimated corrosion rates
- Predicted zone of influence
- Provided reasonable estimates of odor control size that could be refined later with fan testing

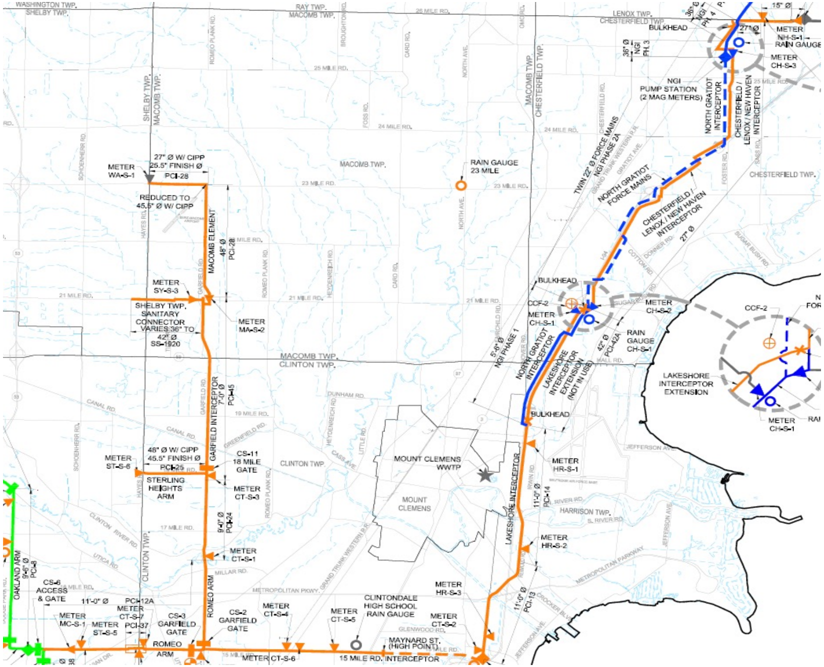


Conceptual Controls Developed for Each Zone

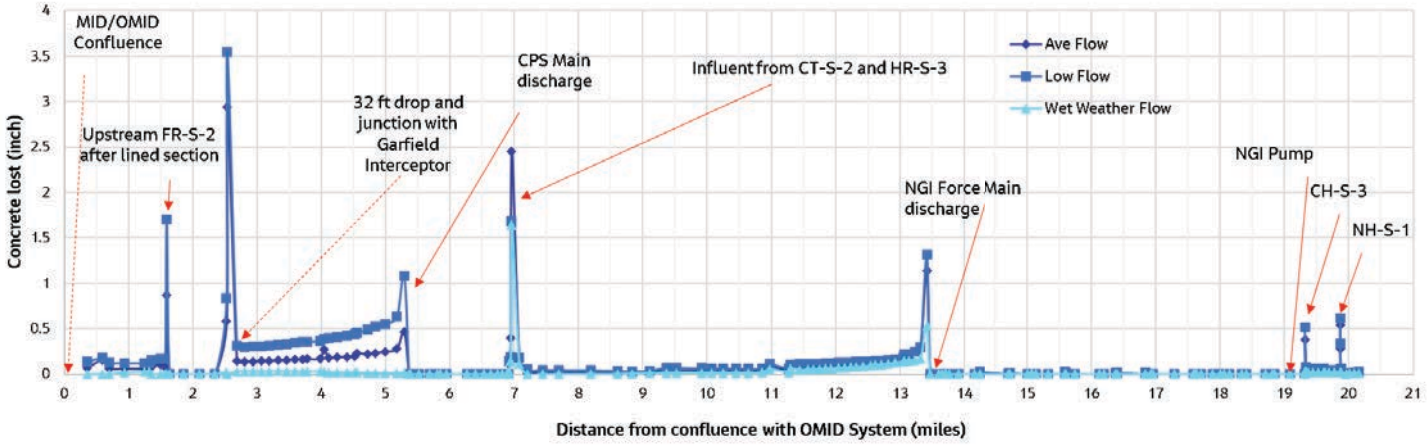


Case Study: Oakland/Macomb Counties (Detroit)

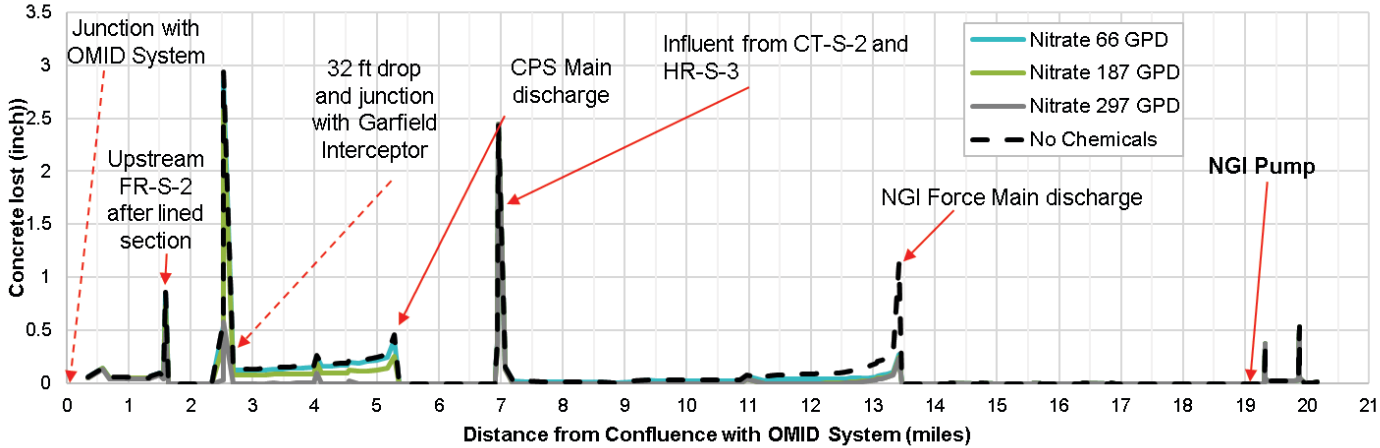
- Deep interceptor – 22 sewer connections followed by drops (1 to 32 feet)
- 800 square miles
- Two force mains with high H_2S
- Flow control structure frequently operated
- Issues:
  - Historical corrosion
  - Corrosion due to storage operation of flow control structure
  - Odors



Impact of I&I Reduction and Wet Weather



Chemical Doses and Types Compared



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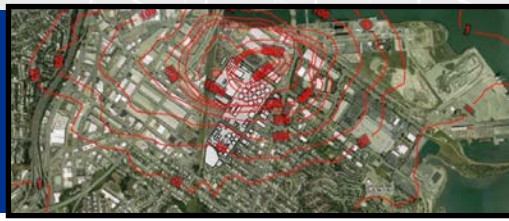

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