

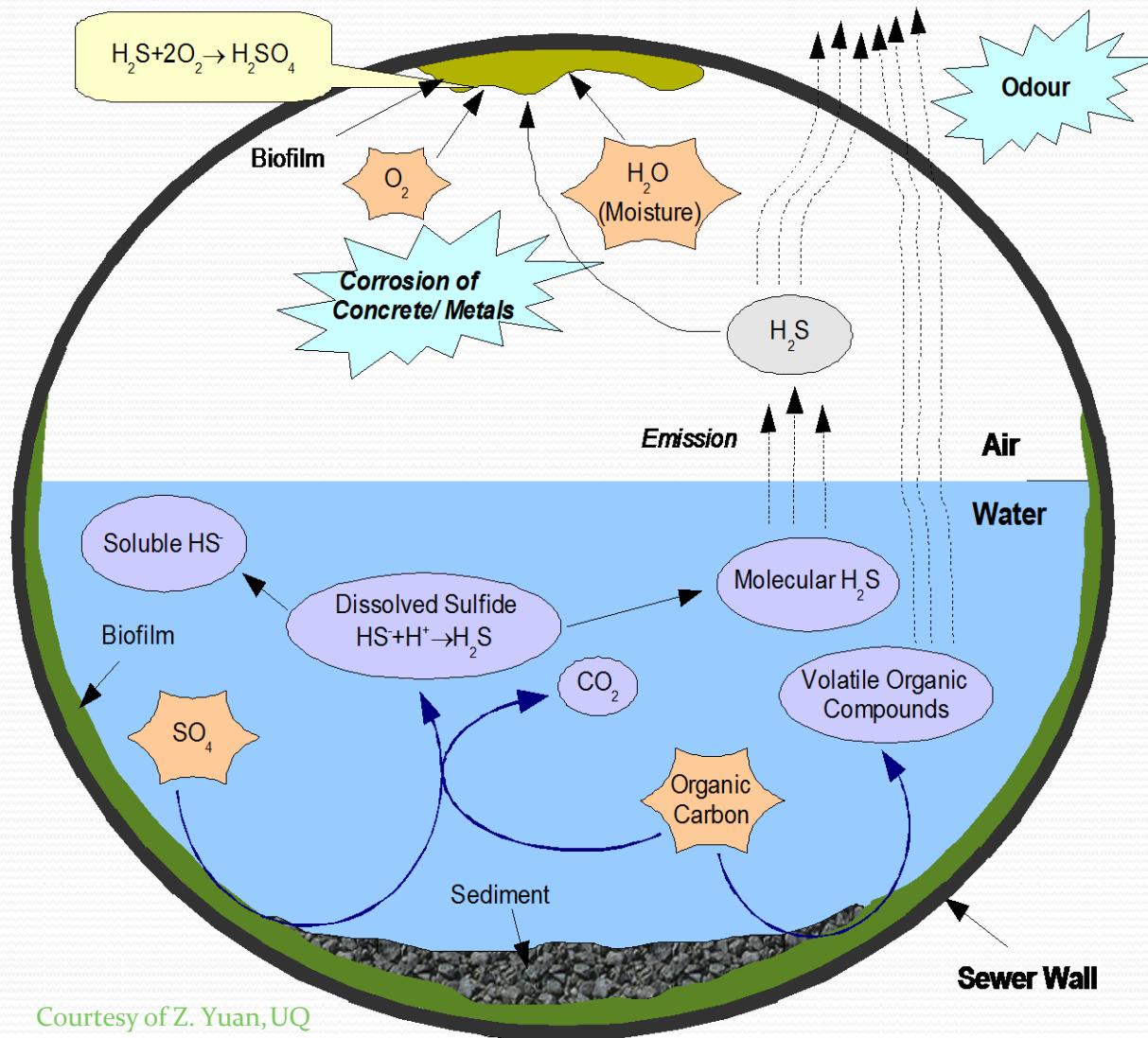
BioAugmentation in Force Mains, Gravity Sewers and Pumping Stations



Presentation Outline

- Who, What, When, How of BioAugmentation
- Collection Systems Basic Chemistry/Biology
- Industry Studies, Videos and Tests
- DC Water Main Pumping Station Project
- WERF CAPS Study
- Path Forward

How does it happen?



Courtesy of Z. Yuan, UQ

What is BioAugmentation

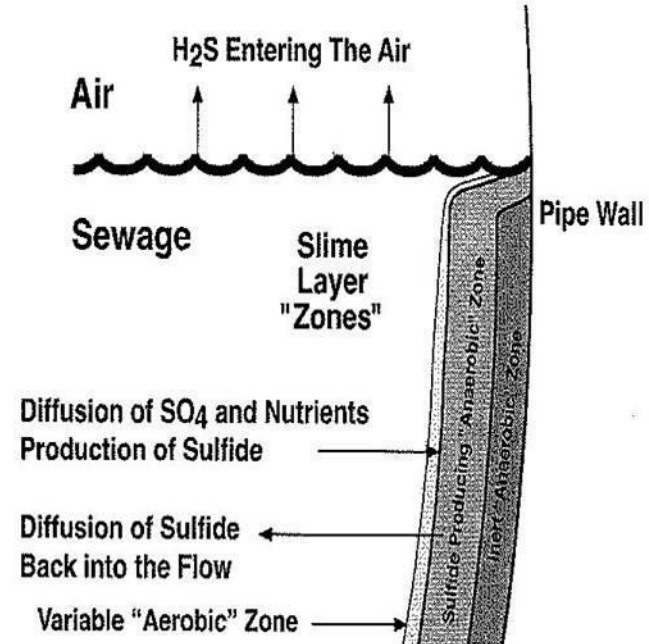
The addition of:

- Micro organisms
- Oxygen, Hydroxyl Radicals (Ozone)
- Surfactants

In to the flowing sewage to eliminate bio-slime on sewer walls, FOG above the water in particular and the formation of toxic gases

How They Work - Microbes

- Micro Organisms Eat Organic Matter
- Tiny – Trillion Can sit on the Head of a Pin
- Are Cultured by Manufacturer to Destroy Typical Organic Matter
- Safe to Humans, Effective Against FOG and BioSlime



How They Work – Microbes Cont'd

Aerobic Organisms

- Require Oxygen
- Bi-products are
 - Water
 - Carbon Dioxide
 - Ammonia

Anaerobic Organisms

- Environment Free of Oxygen
- Bi-Products
 - Hydrogen Sulfide
 - Methane
 - Water
 - Carbon Dioxide

How They Work – Oxygen, Hydroxyl Radicals Addition

Increasing Dissolved Oxygen Provides Life Sustaining Oxygen to normally Oxygen Depleted Sewage.

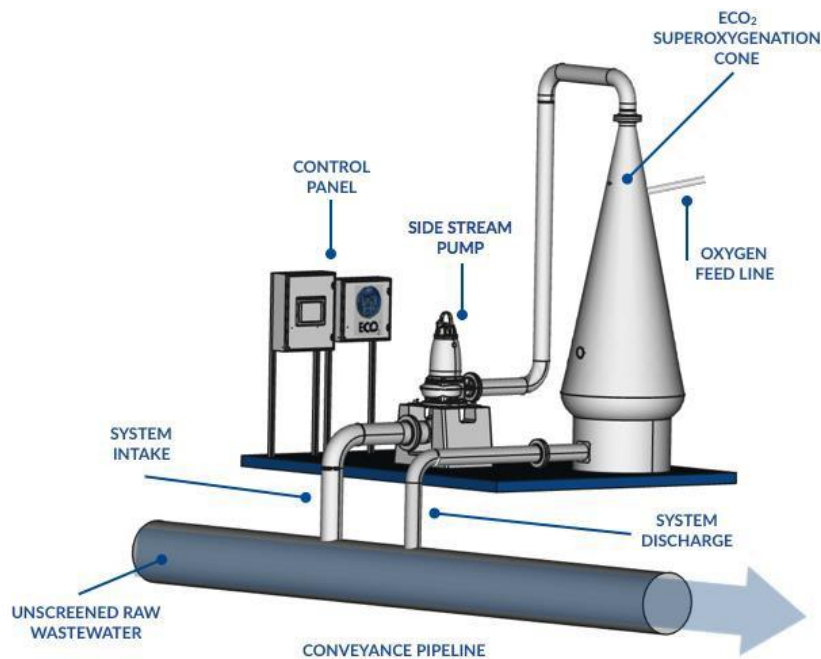
- Aerobic Organisms Multiply
- Convert Organic Matter to Water, Carbon Dioxide

Adding Ozone Oxidizes Organic Matter

How They Work – Oxygen cont'd

ECO₂ Technology

Nano Air Bubbles Aeration System (NABAS)



SYSTEM OPERATION



Before starting BGS systems



After starting BGS systems
(Nano Bubble Aeration Image)

How They Work – Hydroxyl Radical

Parkson-OHxy Phogg



NABAS Bubble System



STX Catalytic – Source Technologies delivers Hydroxyl Radicals
Not Shown

How They Work – Hydroxyl Radical

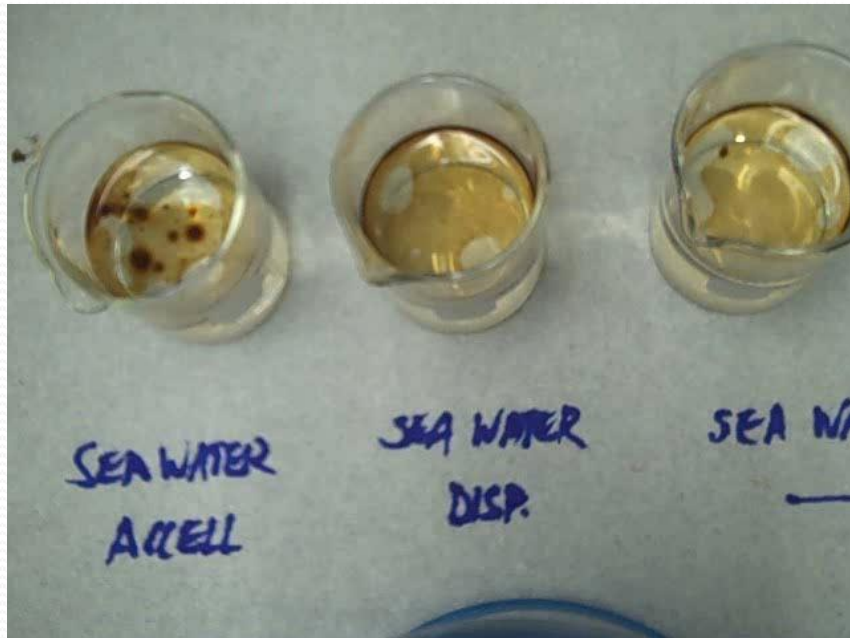
- Free Radicals oxidize organic matter by removing electrons from the compound to achieve stoichiometric balance, therefore, reduction/oxidation is the result
- This method can be mixed directly into the water or introduced as a 'fog' on top of the water.

How They Work - Surfactants

- Surfactants make water wetter and break up dirt, grease , grime, etc.
- Generally are chemically based such as soaps, dishwashing liquids, etc.
- In early 70's generally banned from use in sewers when the contained phosphorous.

How They Work – Surfactants - Accell

Gulf Oil Spill Demo



Sao Paulo Brazil – River Test



How Is Chemical Addition Different From BioAugmentation

- Chemicals maybe toxic – Ozone is only Biological product that can be hazardous if inhaled
- Chemicals are not easily portable
- Require Frequent Tanker Truck Deliveries
- Difficult to Locate in Cities



Key Collection Systems Terms

- pH – if pH is above 8.5 H_2S will not be generated
- Interfacial Tension (IFT) measures the spreading effect between water and anything floating on the top
- O.R.P. – Oxidation Reduction Potential measures the effectiveness of water to oxidize or “clean” itself or in case of treated wastewater assist in cleaning the body of water it has entered.

Leading Industry Studies

- WERF Nov 8, 2007
Minimization of Odors and Corrosion in Collection System, Phase 1
- Studied science of Bio Slime
- Reviewed 4000 papers on subject
- Defined ORP (oxidation reduction potential) as key element to overcoming hydrogen sulfide

Biological ORP Scale				
ORP (mV)	Process	Compound(s) Present	Zone	Products
+ 300	A	O ₂	Aerobic	Carbon Dioxide (CO ₂) + Water (H ₂ O)
+ 200				
+ 100	B	NO ₃ ⁻ /NO ₂ ⁻	Sulfide-Producing Anaerobic	Nitrogen Gas (N ₂) or Sulfide (S ²⁻)
0				
- 100	C	SO ₄	Inert-Anaerobic	Fermentation Products and Methane (CH ₄)
- 200				
- 300	D	Organic Carbon Compounds		

A = Organic Carbon Oxidation
 B = Denitrification if Nitrate/Nitrite Present
 C = Sulfate Reduction w/o Nitrate/Nitrite Present
 D = Fermentation and Methane Generation

Leading Industry Studies – cont'd

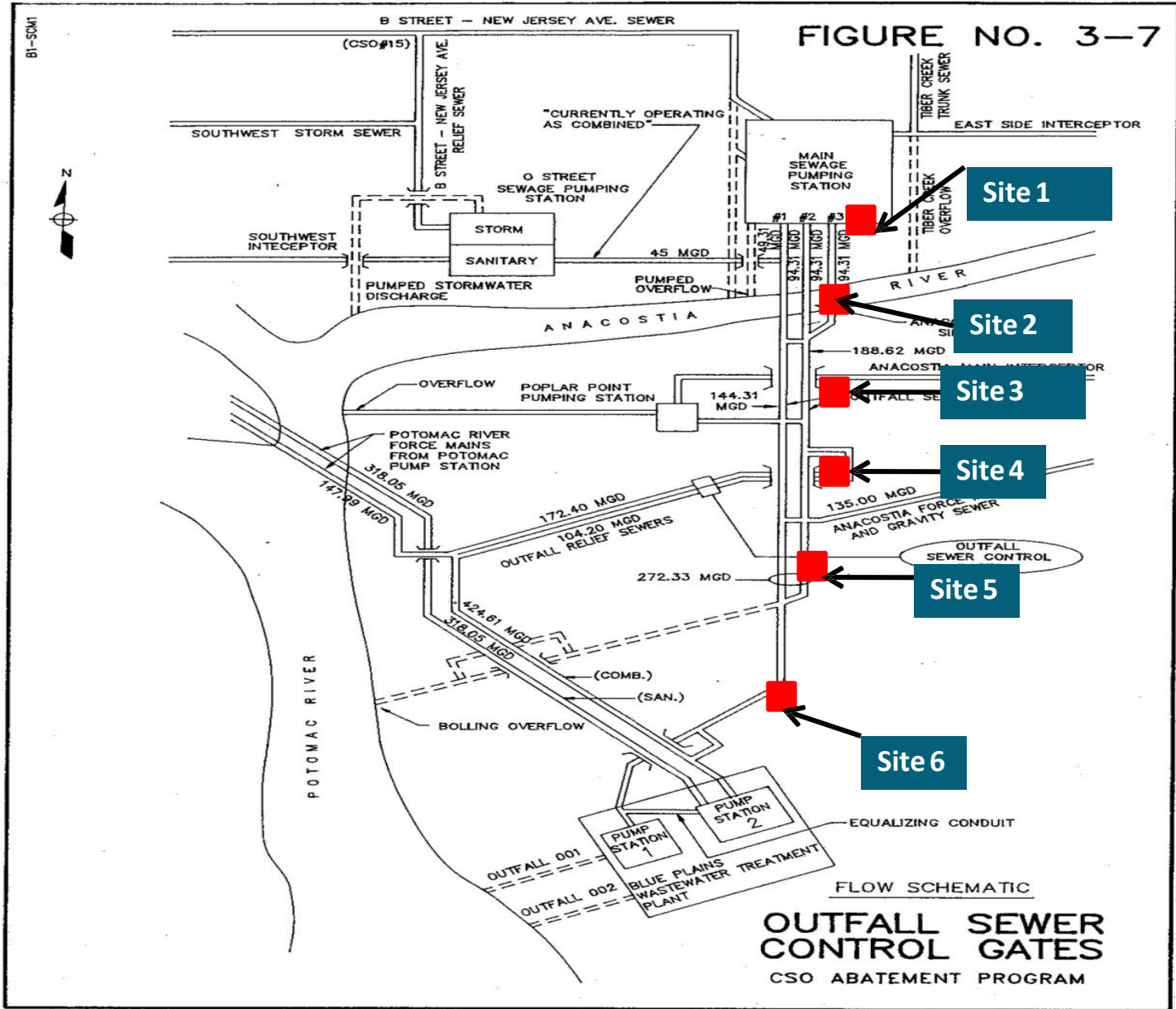
American Water Co WEFTEC 2010 – Sioux Falls Study

- Introduced Microbes in Collection System
- Reduced BioSolids by 15%
- Increased BOD
- Speculated BOD Easier to Treat

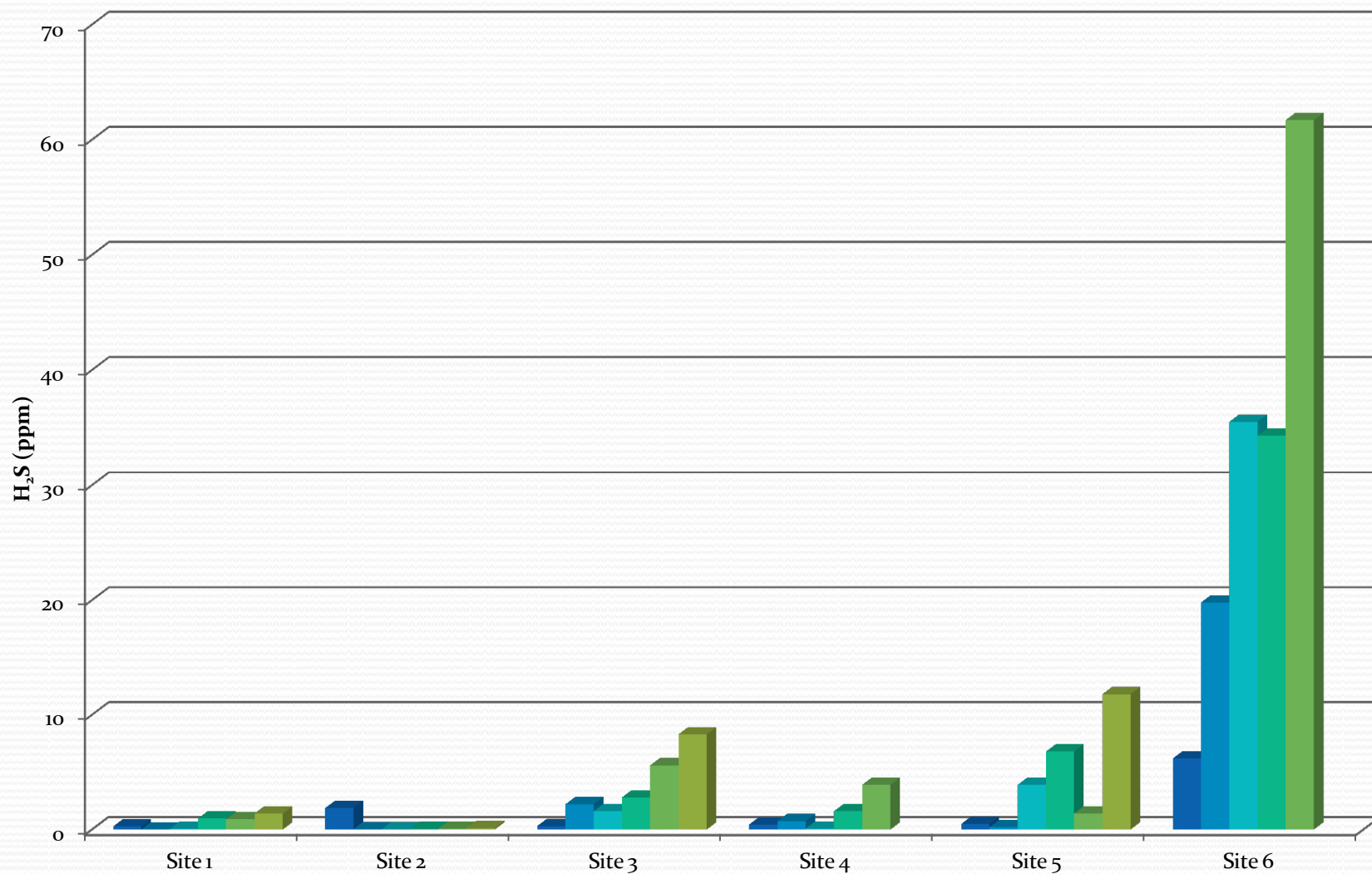
DC Water 2011 Summer Accell3 Research Project

- Thanks to Howard University's Charles Glass, PhD and his students
- Add Accell3 at a different rates at Main Pumping Station – 0.1, 0.2 and 1.9 ppm
- Track Performance at 6 Sites on the East Outfall Sewer
- Take Samples
- Measure ORP, DO, pH, TSS, VSS, H₂S, COD, NH₃, PO₄⁻³

Location of Sites

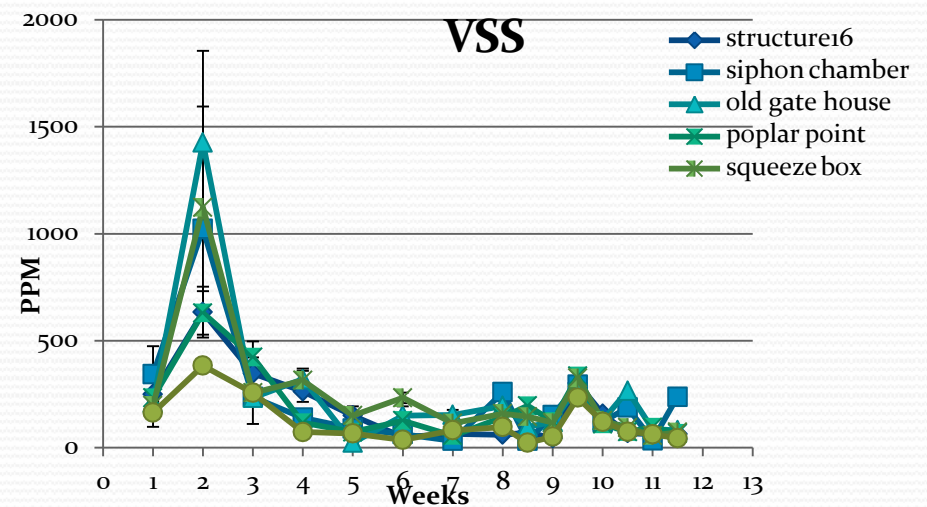
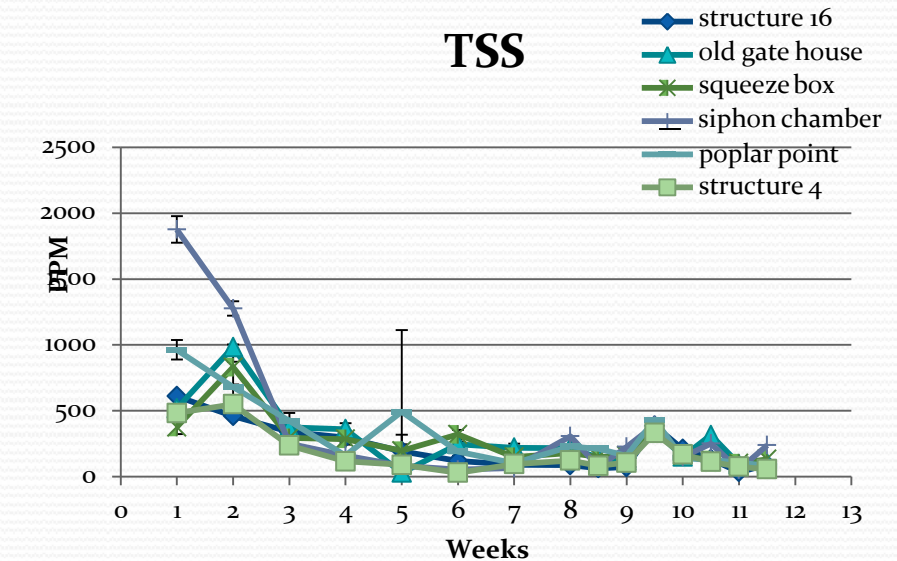


Average Hydrogen Sulfide Concentration at Six Sites



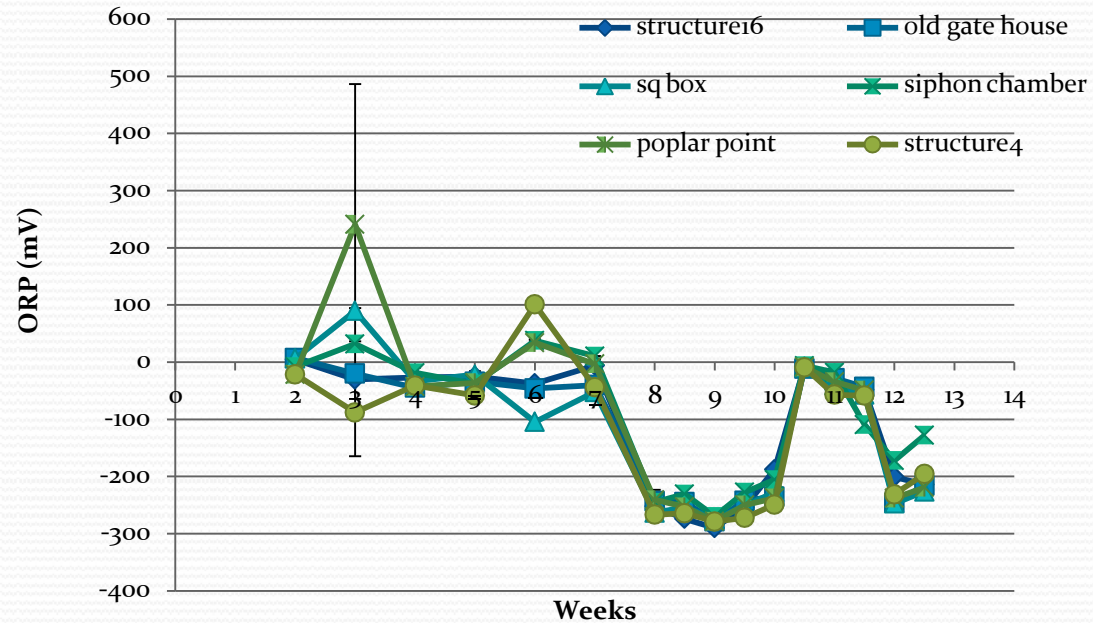
Data Analysis

- Reduction in TSS and VSS during the summer may have been due to the uncoupling of microorganism reproduction from energy use.



ORP Results: All Locations

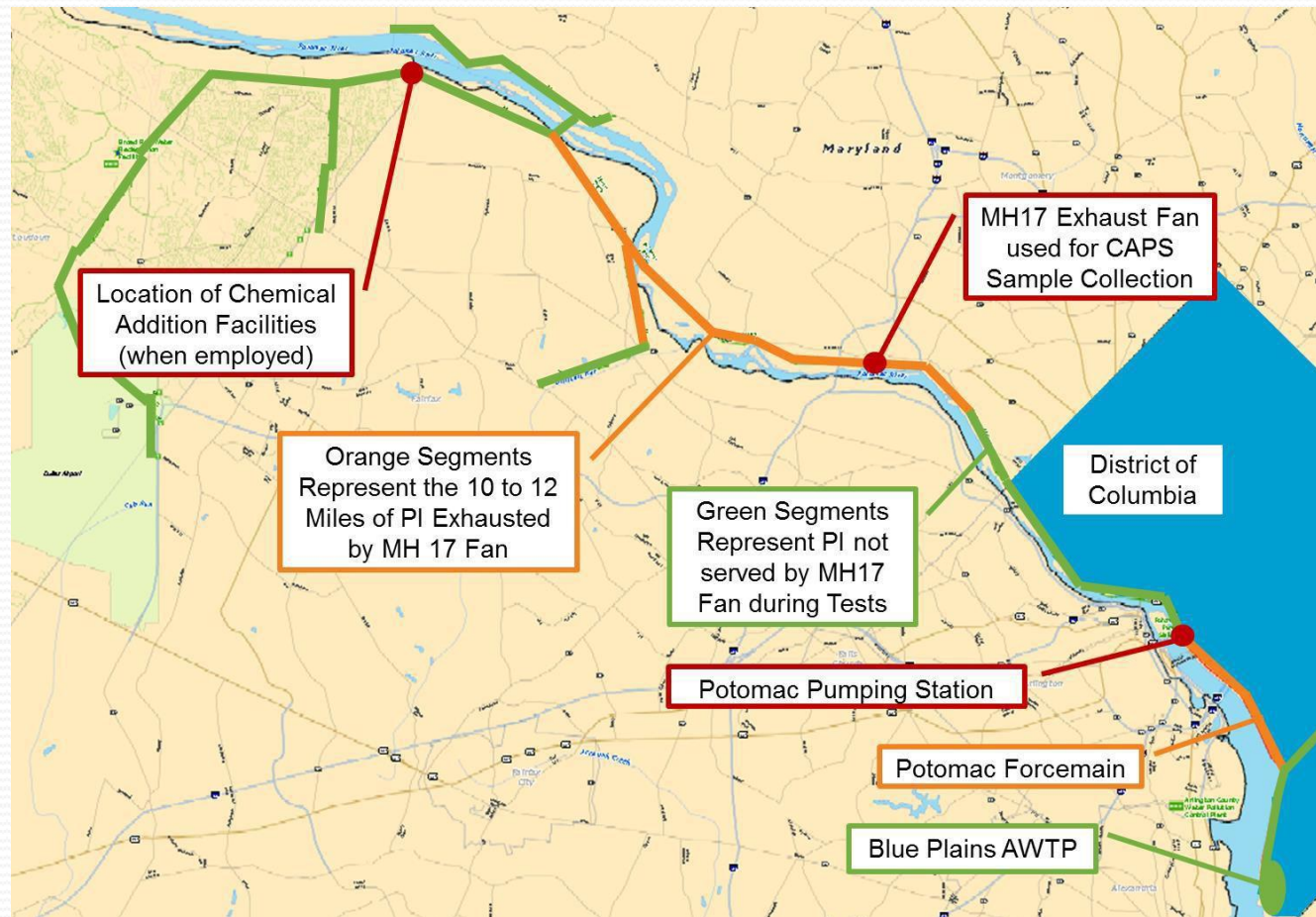
- H₂S gas is produced at -50 to -250 mV.
- ORP values reached -300mV during 100+ weather



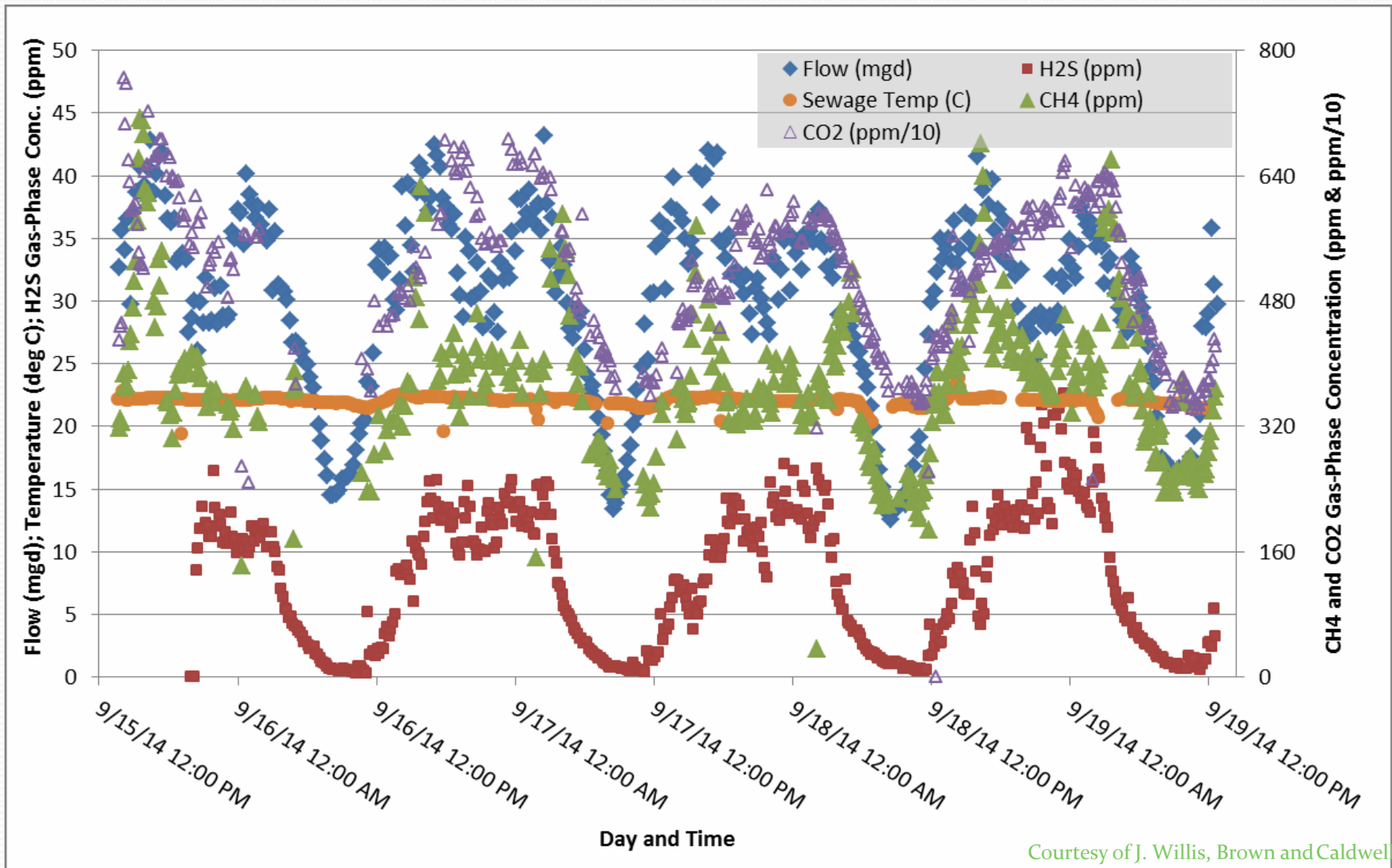
WERF Manuscript: DC Water's Sewer-Methane Carbon Footprint

- **John Willis^{1, 2*}, Haydee DeClippeleir³, Walter Graf⁴, Akshay Kumar⁵, Barry Lucas³, Sudhir Murthy³, Chris Peot³, Pusker Regmi¹, Abhiram Satyadev⁶, Charles Sweeney³, Keshab Sharma², Hiram Tanner³, and Zhiguo Yuan²**
- 2 The University of Queensland
- 3 DC Water
- 4 Water Environment Research Foundation (WERF)
- 5 RK&K Engineers
- 6 Arcadis
- * JWillis@BrwnCald.com

DC Water's Potomac Interceptor

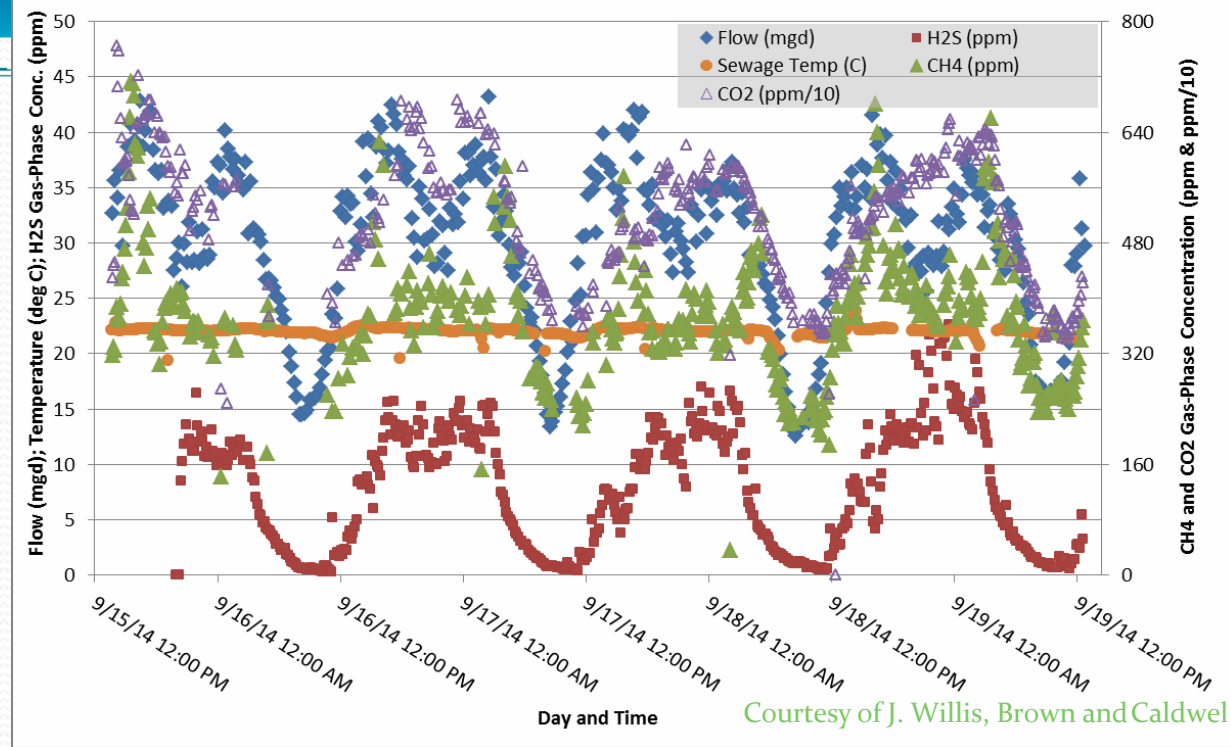


Results - Summer Baseline



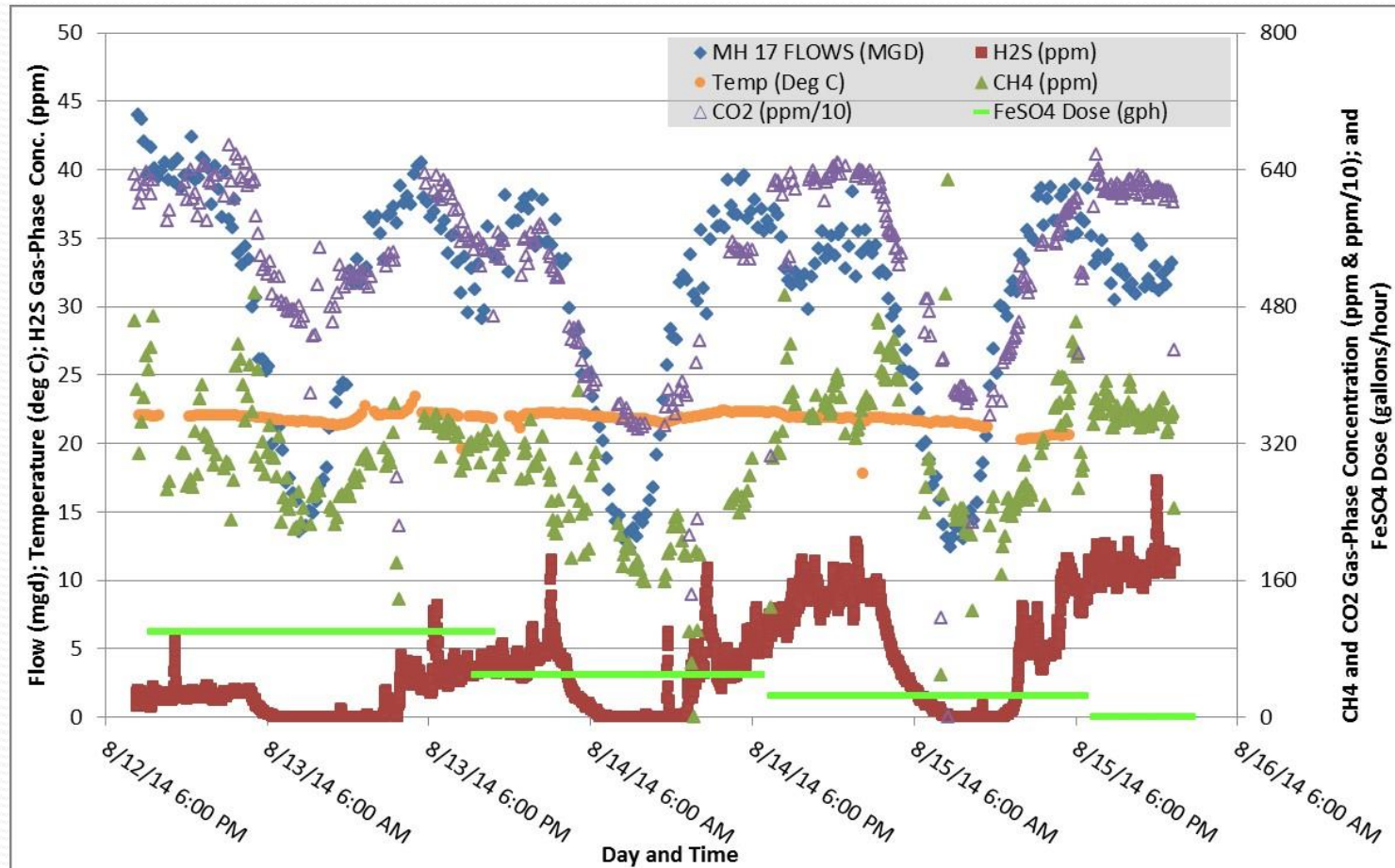
Courtesy of J. Willis, Brown and Caldwell

CO₂ Emissions suggest Significant Aerobic Activity in the PI



- Atmospheric CO₂ should be ~400ppmv
- Observed headspace CO₂ values averaged 5,200ppmv; for an increase of 4,800ppmv
- Would expect ~1-to-1 CO₂ to CH₄ ratio
- Suggests >20 times aerobic than anaerobic
- CO₂ is more soluble in water than CH₄

Chemical Addition of FeSO_4 Did Not Effectively Control H_2S



Path Forward

- Addition of Microbes to remediate FOG blockages
- BioAugmentation best used for Routine Maintenance of Mains & Pumping Stations to avoid FOG, Corrosion and Hydrogen Sulfide and to Protect Workers
- To Track Benefits/Need for BioAugmentation Test for O.R.P.
- Perform Additional Research to Enhance Collection Systems Natural Aerobic Activity.