A Novel Test Method for Measurement of MIC in a Wastewater Collection System

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Odors and Air Pollutants

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Outline

- Background
- Objectives
- Methods
- Data
- Results

Background – Corrosion Impacts

Texas

Background – Corrosion Impacts

Kentucky

Impacts:

1. System Outage
2. Pollution Release
3. Danger to Public
4. Expensive and Disruptive to Fix
5. Headline News

Ohio

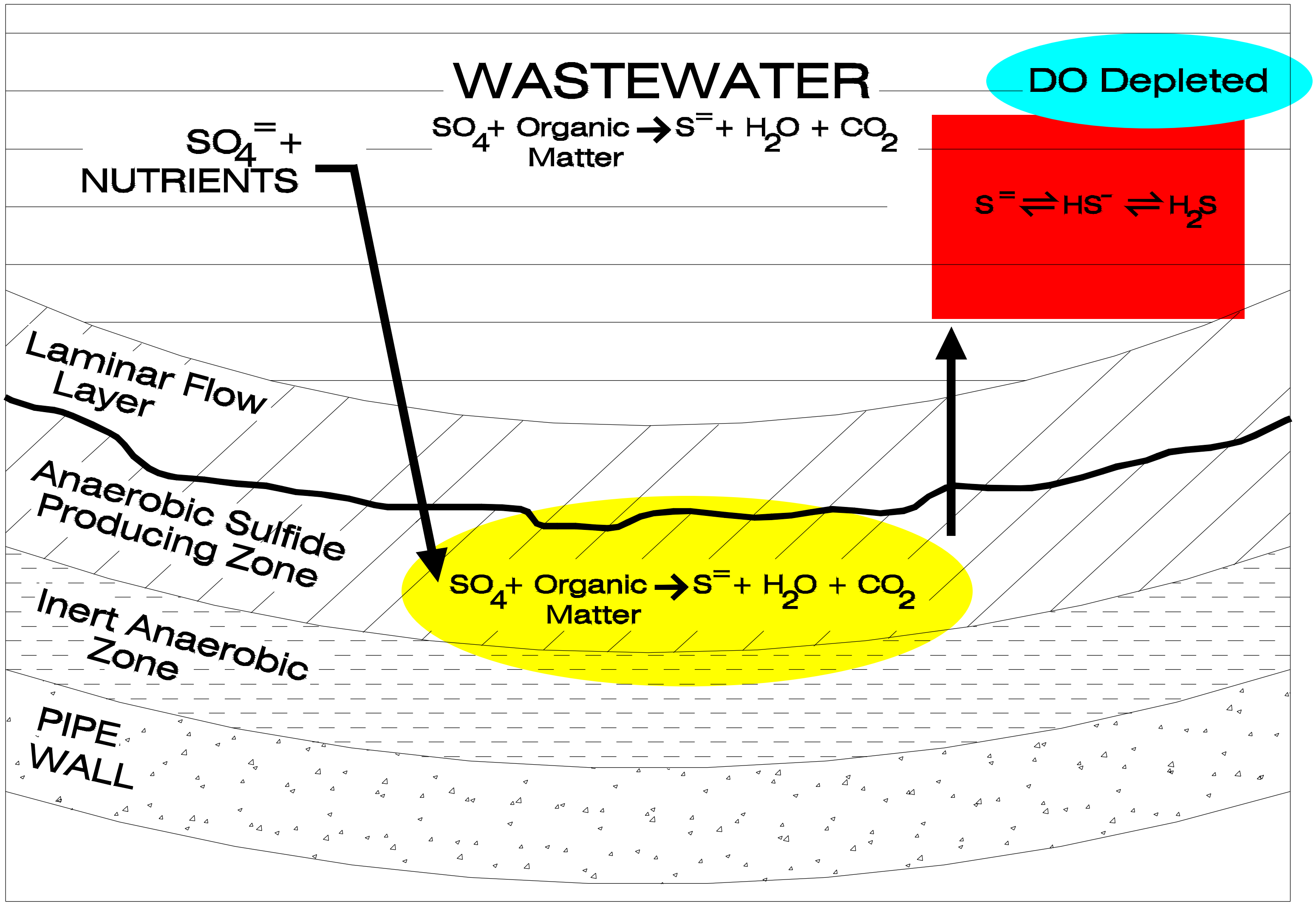
Is failure acceptable?
Do we have to wait for failure?
Can failure at key points be eliminated?

Background – Corrosion Impacts

1991 USEPA report to congress

- 89 cities participating in the survey
- $6 billion spent on sewer rehabilitation
- 32 cities reported sewer collapses
- 81% were believed to be due to hydrogen sulfide corrosion.
- 70% of the respondents reported hydrogen sulfide corrosion at the treatment plant.

Source of Hydrogen Sulfide



Mechanism of Concrete Corrosion

Step 1 – Aerobic bacteria deplete available oxygen

Step 2 – Anaerobic bacteria convert sulfate to sulfide

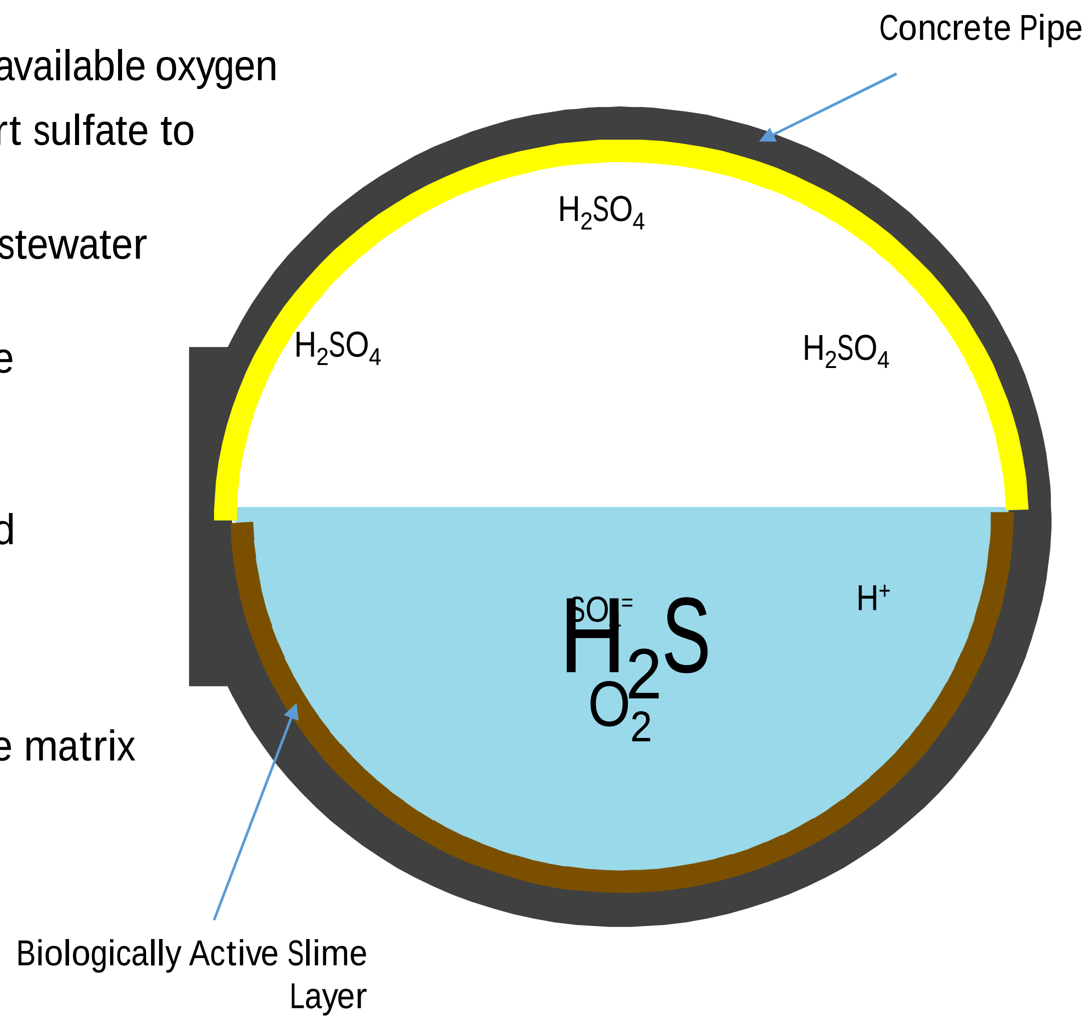
Step 3 – Sulfide combines with wastewater acidity to form hydrogen sulfide

Step 4 – Insoluble hydrogen sulfide escapes to headspace

Step 5 – Hydrogen sulfide is biologically oxidized to sulfuric acid

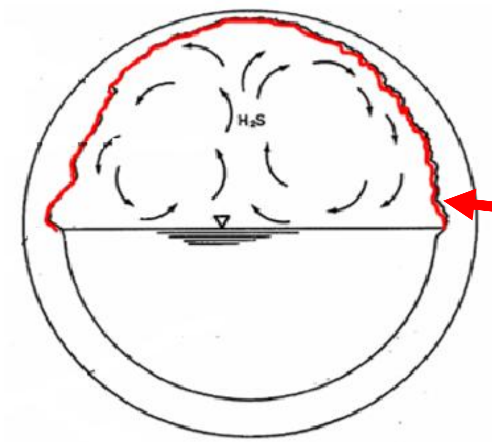
Step 6 – Sulfuric acid weakens the concrete structure

Acid reacts with calcium carbonate matrix



Background – Corrosion Impacts

Microbial Induced Corrosion



$$H_2S + 2O_2 \xrightarrow{\text{Sulfur Oxidizing Bacteria}} H_2SO_4 \text{ (sulfuric acid)}$$

Genus: Acidithiobacillius

Autotrophs – use inorganic substances to fulfill their energy needs

Obligate - Need Sulfur, Oxygen and Carbon to survive

Acidithiobacillus Intermedius pH ~ 4

Acidithiobacillus Thiooxidans pH ~ 2

Study Objectives

- **Quantify concrete corrosion – loss of mass over time**
- **Measure compressibility before and after exposure**
- **Compare samples at two similar locations in the wastewater collection system**
  - **Allow H_2S exposure in one sample - Untreated**
  - **Remove H_2S in second sample - Treated**
- **Try Destructive Test with Multiple Concrete Test Specimens**
- **Expose samples in an operating collection system for 2 years**
- **Measure exposure conditions in both samples**
  - **Long Term Hydrogen Sulfide Monitoring**
- **Test the Test….**

Summary of Test Sites

Two Sites Selected –

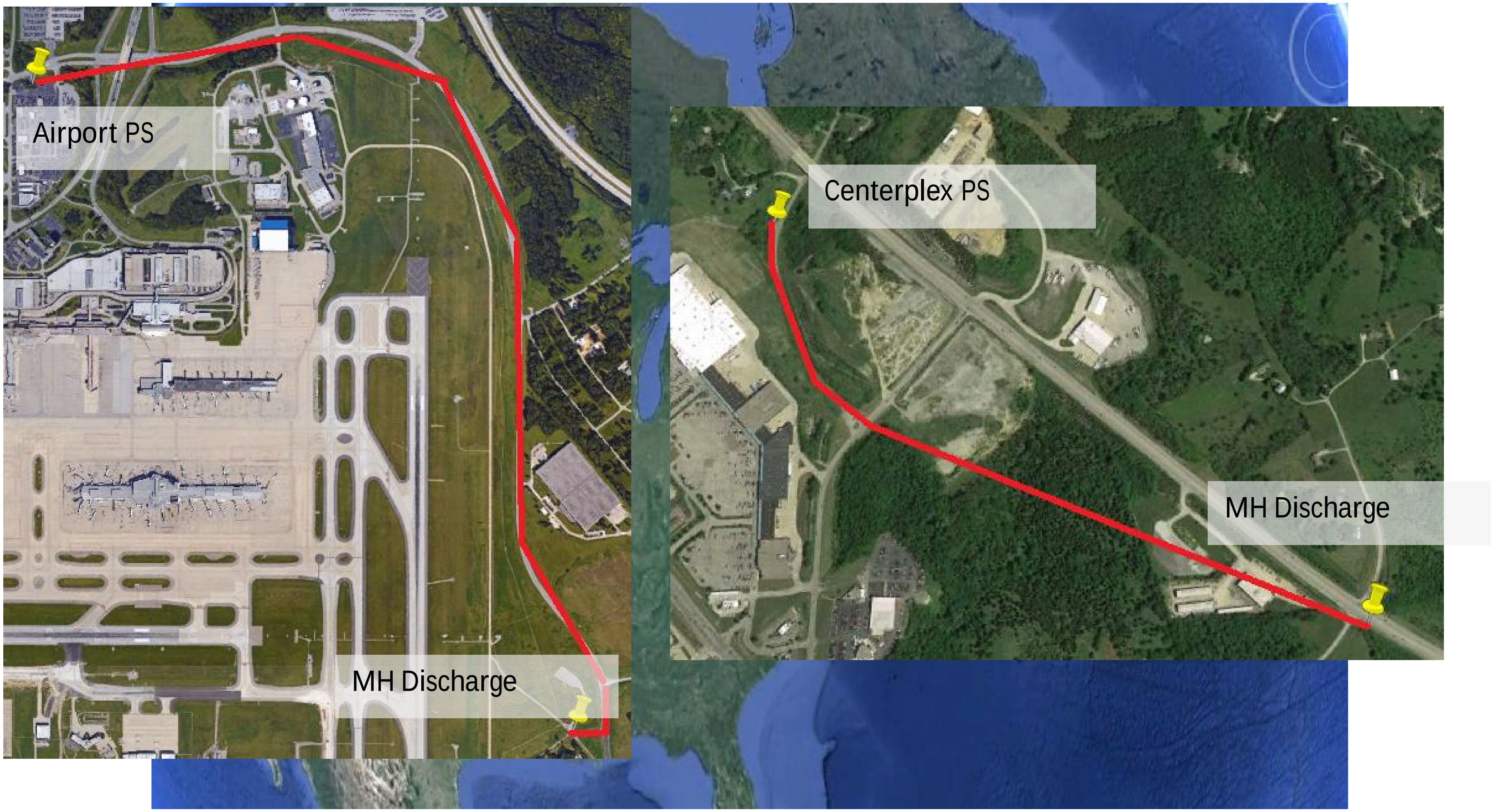
- Exposure to High and Low H_2S Concs

Similar Force Mains:

- Same Collections Basin / Water Quality
- Similar Retention Time
- Similar Atmospheric Conditions (Rain, Temp, Humidity etc)

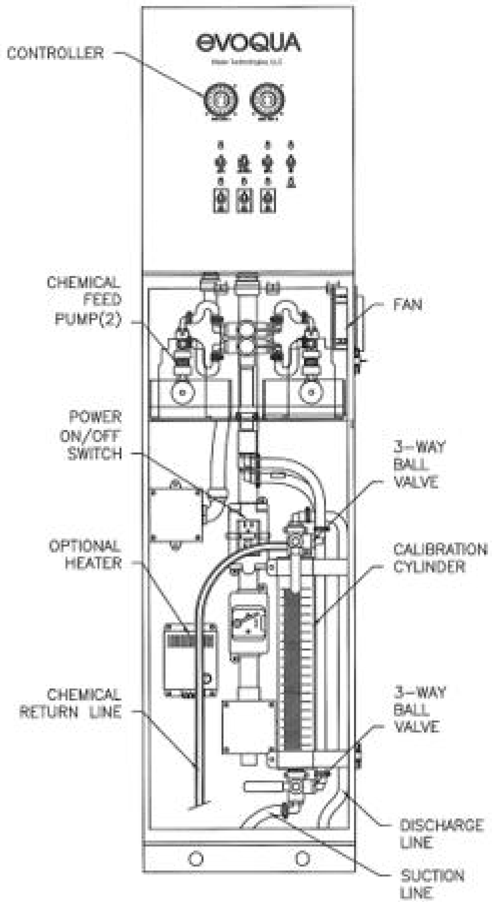
Parameter	Airport PS - Untreated	Centerplex PS - Treated
Average Daily Flow (MGD)	0.191	0.11
Forcemain Length (feet)	9,820	4,400
Forcemain Diameter (inches)	6	8
Average Retention Time (hr)	1.8	2.5

Study Area



Methods – "Treated"

- Centerplex Station "Treated"
- Hydrogen Sulfide Eliminated with the use of a Nitrate Salt
- Nitrate Salt is 60% active solution of a combination of calcium nitrate salts
- Nitrate harmlessly converted to Nitrogen
- Prevents sulfide formation
- Used for Odor Control



Methods – Test Specimens

Concrete test specimens

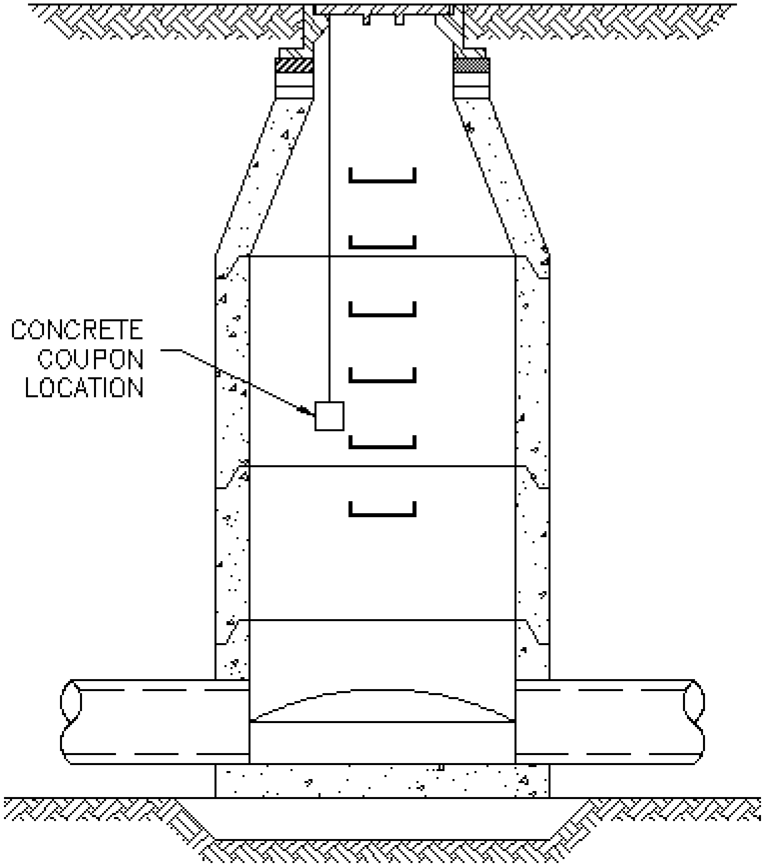
- Fabricated by third party contractor.
- Type II Portland cement
  - Performed in accordance with ASTM C150
- Testing and curing
  - Performed in accordance with ASTM C192

Concrete Coupons Curing

Methods – Concrete Test Specimens

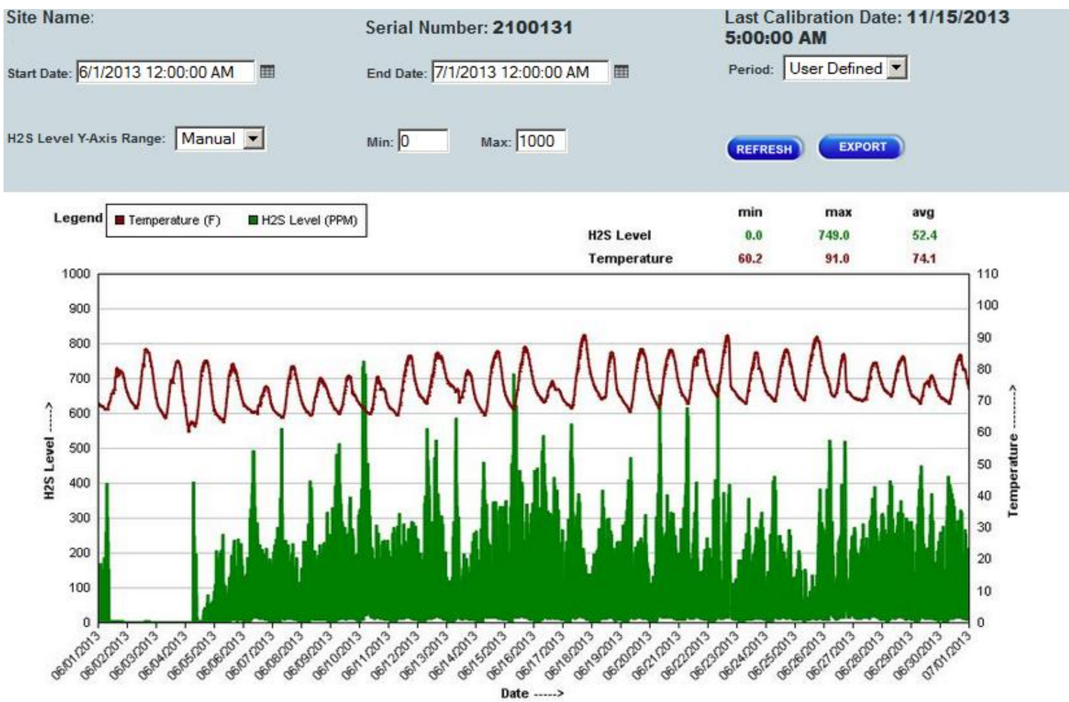
Concrete coupons

- 8 coupons exposed per site
- Treated
- Untreated



Methods – Sulfide Monitoring

- **Hydrogen Sulfide Vapor Concentration**
    - (5 min intervals)
- **Dissolved Sulfide**
    - (monthly)



Methods – Sample Weighing

Prior to each weight measurement:

- Samples were washed to remove attached growth
- The scale was calibrated with a 1.000KG standard

Sample weighing was performed on samples at 6 month intervals

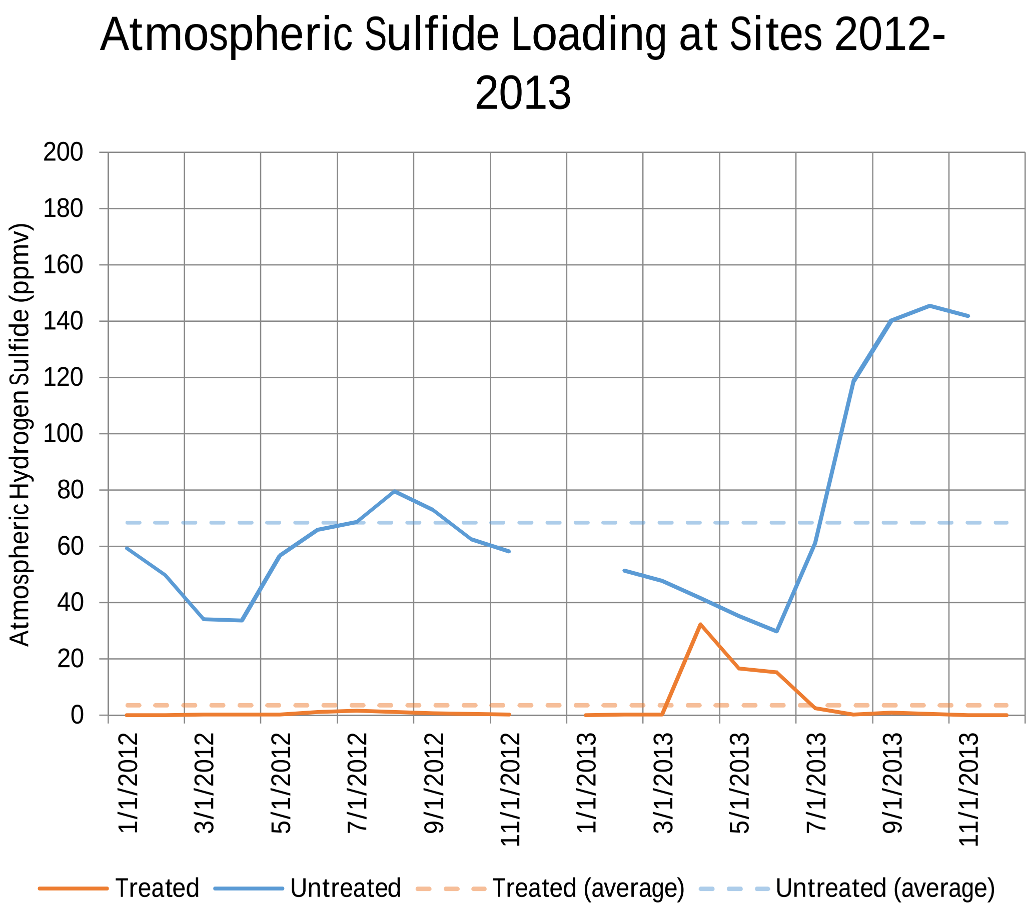
Methods – Compression Testing

Compression Testing

- performed by a certified 3rd party contractor
- performed as outlined in ASTM C39
- Forney FHS Series Premium Compression Tester

Data – Atmospheric Sulfide

- Airport PS – Untreated
  - 69 ppmv average H_2S
  - 146 ppmv peak
- Centerplex PS – Treated
  - 4 ppmv average
  - 32 ppmv peak



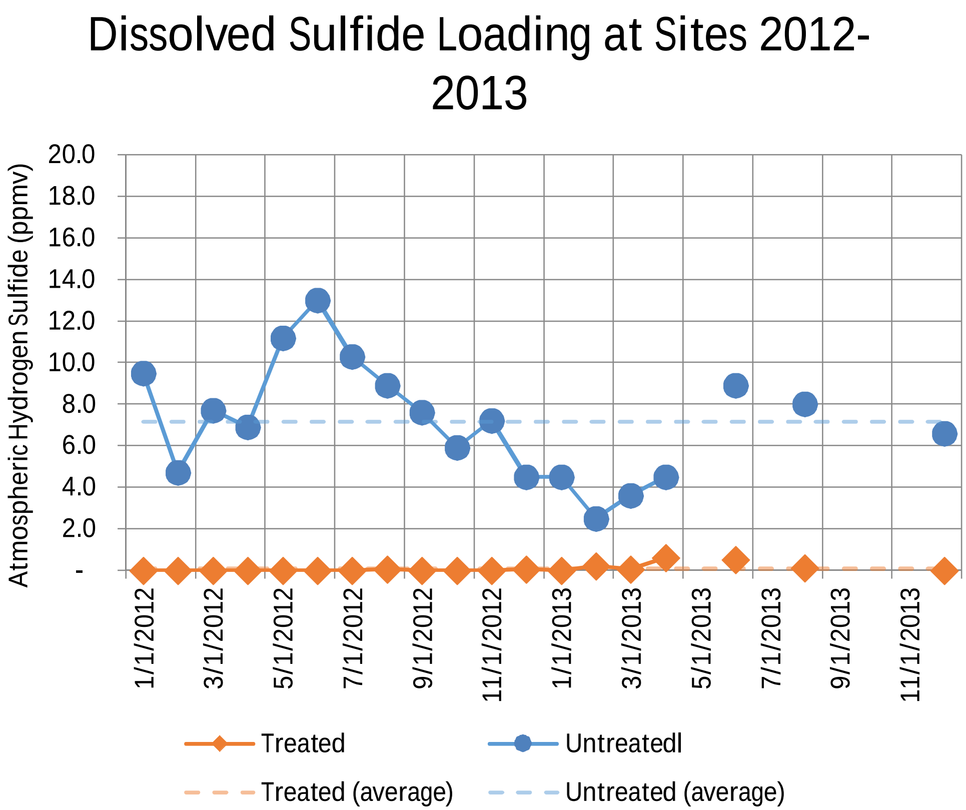
Data – Dissolved Sulfide

Airport PS - Untreated

- 7.2 mg/l avg DS
- 8.9 mg/l peak DS

Centerplex PS – Treated

- 0.08 mg/l avg DS
- 0.6 mg/l peak DS



Data – Calcium Nitrate Dosing

Calcium nitrate was dosed to obtain a slight residual at the control point

	Feed Rate (GPD)		Nitrate Residual (mg/l)	
	2012	2013	2012	2013
January	34.1	32.4	2	4
February	29.9	16.5	4	0
March	28.5	16.9	4	0
April	30	16.2*	4	0
May	28.5	17.5*	3	
June	30.8	35.8	1	0
July	41.7	36.2	2	
August	45.7	33.3	2	4
September	36.2	32.7	3	
October	34.9	47	4	
November	34.7	47.1	2	
December	34.1	27.2	4	3
AVERAGE	32.0		2.4	

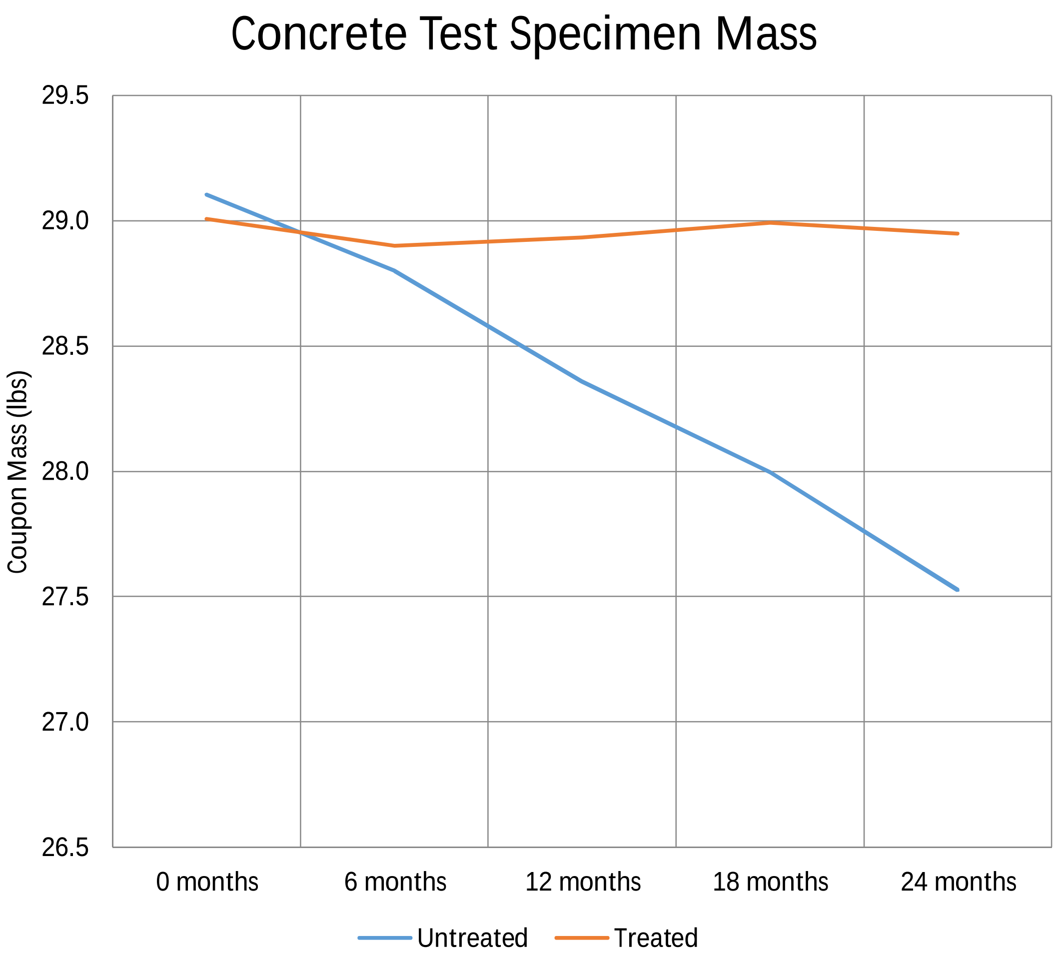
Data – Specimen Mass Summary

Airport PS - Untreated

- Avg wt
  29.1lbs to 27.5 lbs
- 5.4% loss of mass

Centerplex PS -Treated

- Avg wt
  29.0 lbs to 28.9 lbs
- 0.2% loss of mass



Data – Specimen Strength

Untreated for H_2S

- Compressive strength reduced 13%

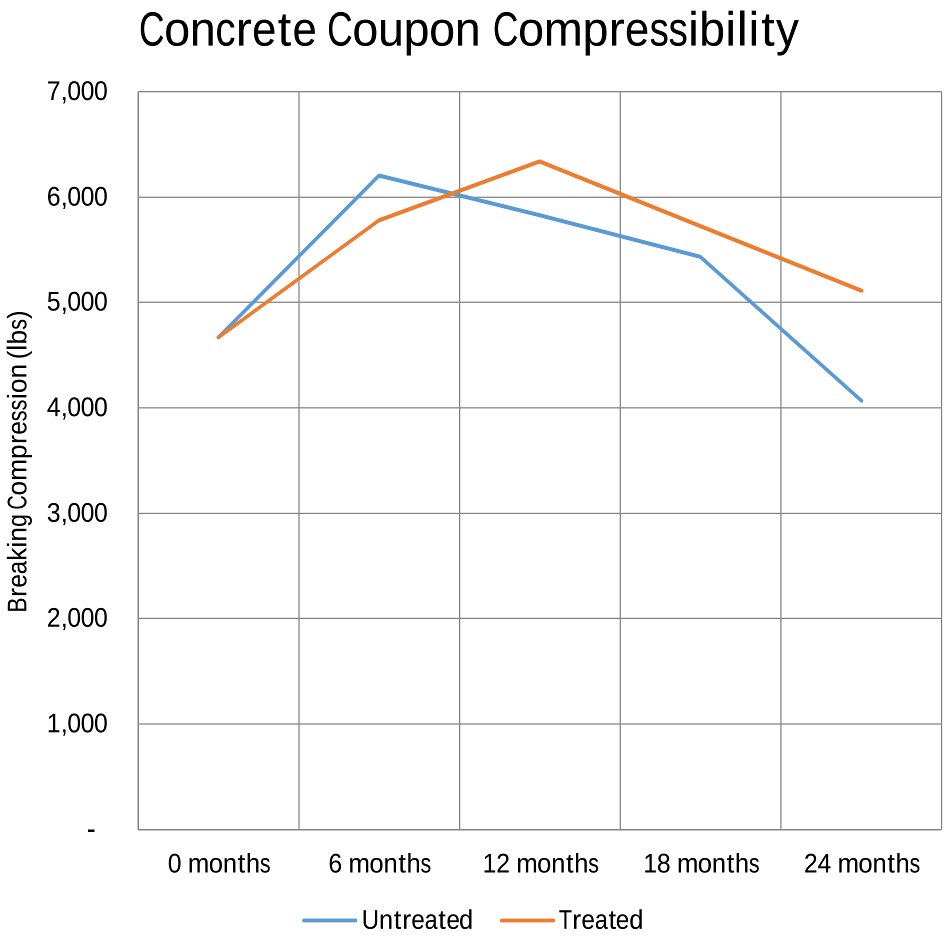
Treated for H_2S

- Compressive strength higher

Initial breaks on samples 4,667 PSI

Continued hydration accounts for increase in compressive strength

- Strengthening peaked at 6 months for untreated coupons.
- Strengthening peaked at 12 months for control coupons



Results – Treated Samples

Exposure to an average of 3.5 ppmv (two year period)

- **No loss in compressive strength During 2 year test duration**
- **0.2% reduction in weight**

Results - Untreated Samples

Exposure to an average of 69 ppmv
(two year period)

- **13% loss of compressive strength**

- **5.4% reduction in weight of samples**

Conclusions

1. Presence of > 60 ppmv H_2S impacted specimens
2. Presence of H_2S resulted in mass loss of concrete (5% Less)
3. Presence of H_2S resulted in loss of compressive strength (13% lost)
4. Treatment to eliminate H_2S resulted in improved concrete condition

Further Study

1. Add to the data set – study ongoing
2. Comparison of different H_2S exposure levels
3. Measure pH of Specimens
4. Better define H_2S neutralization cost benefits
5. Better define infrastructure life benefits
6. Better define the test…..Further Considerations
   - Shape of specimen
   - Cement composition
   - Timespan
   - Comparison with a new installation

Forward

Can we proact infrastructure failure…..

1. Infrastructure protection planning
   - Identify weak points….roadways
2. Monitor weak points
3. Look at cost benefits for protections
4. Implement Protections:
   - Operational Changes
   - Materials – Linings
   - H_2S - Capture or Neutralization

Questions?