The H2S Challenge : From Detection to Decision Making

A Data-Driven Approach to H2S Management

05/11/2024

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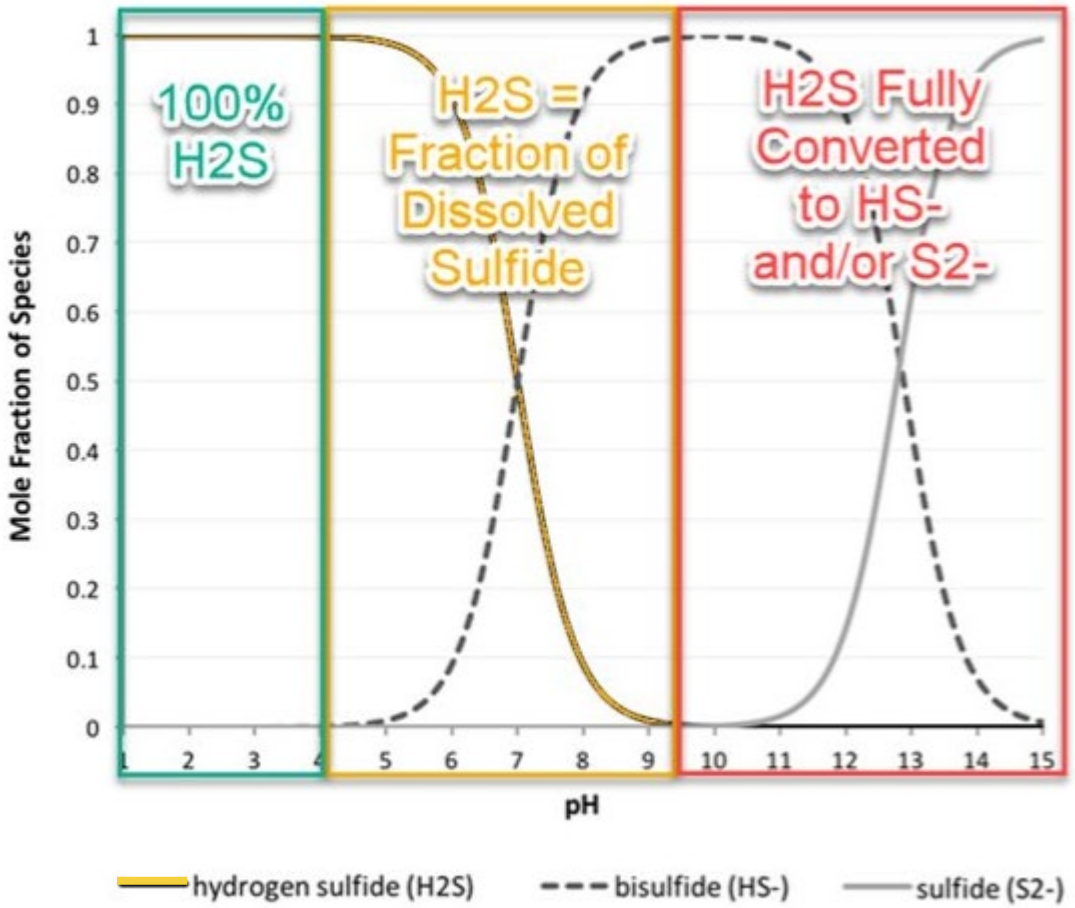
Agenda:

1. The H2S Problem in a Nutshell
2. Product information
3. Application
4. Case Studies

What is Hydrogen Sulfide (H_2S) ?

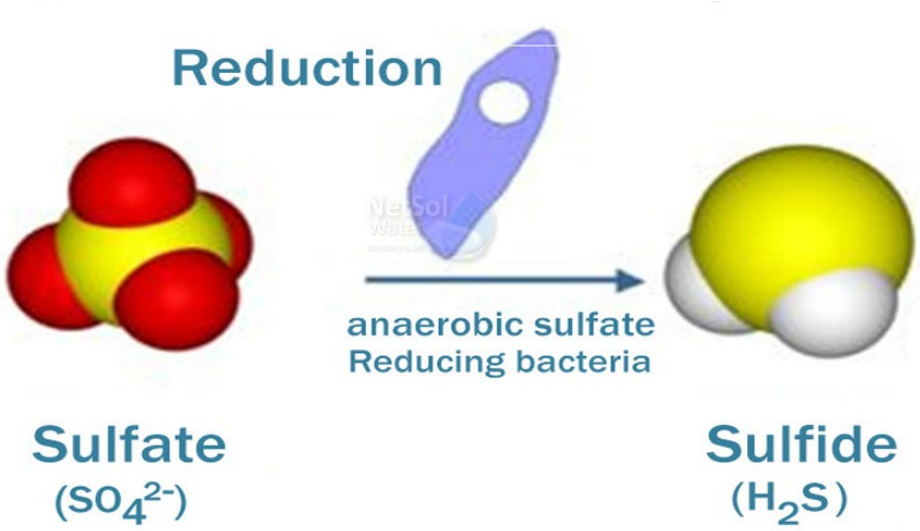
- Colorless gas
- "Rotten egg" odor at low concentrations
- Soluble in water & oil; acts as weak acid
- Fraction is pH dependent; at pH 7, 50% of dissolved sulfide is H_2S
- ***Total sulfide*** calculation possible with pH sensor
- Dissolved H_2S easily stripped from liquid phase to gas phase
- Highly flammable and toxic
- Heavier than air

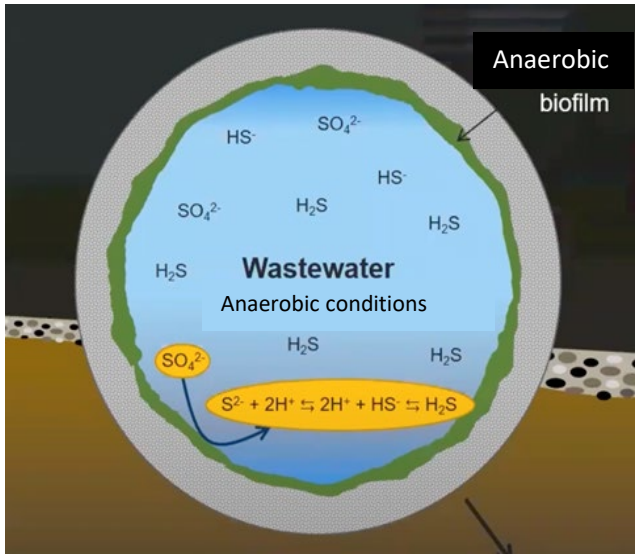


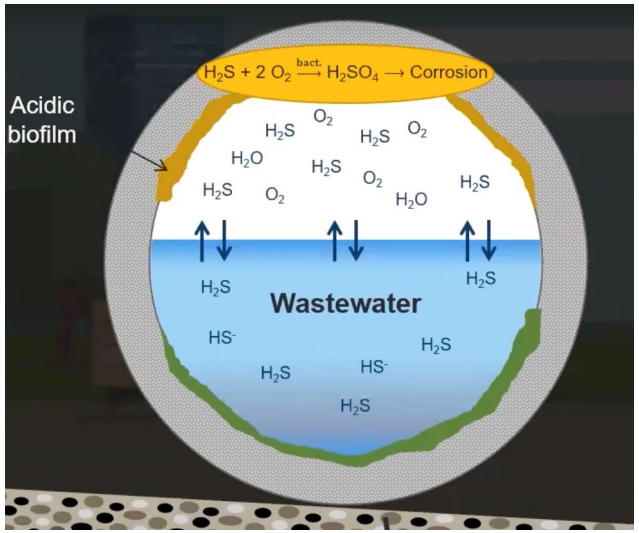
$$S^{2-}+2H^{+} \leftrightharpoons 2H^{+}+HS^{-} \leftrightharpoons H_2S$$

H_2S Formation in Wastewater Environments

- Anaerobic bacteria convert sulfate to dissolved H_2S
- H_2S is stripped downstream causing phase change from liquid to gas
- Oxygenation of H_2S forms **sulfuric acid**





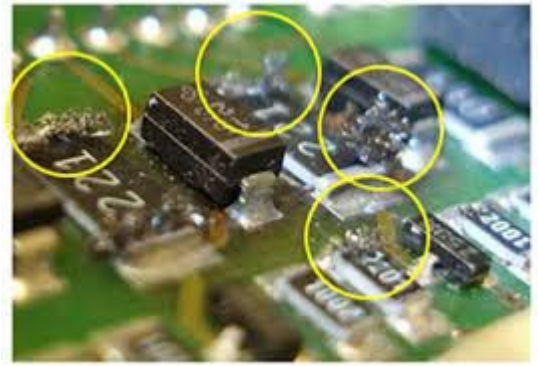


What are the Risks of H_2S?

Safety

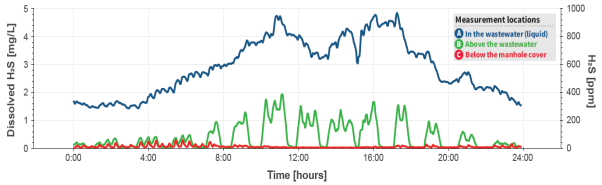
Odor Nuisances

Asset Corrosion



The Importance of Measuring H_2S in Wastewater

Pinpoint Hazards



- *Identify risks* in areas prone to H_2S accumulation

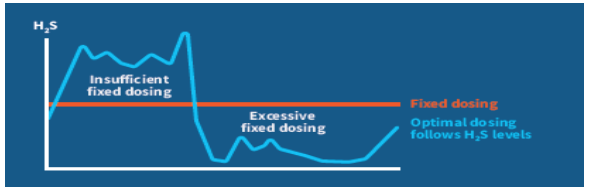
Prevent Complaints

- *Neutralize odors before they cause complaints*

Protect Assets

- *Prevent damage, failures, and operational upsets*

Optimize Chemical Use



- *Minimize excess chemical treatment upsetting critical downstream biological treatment processes and wasting $$*

H_2S Measurement Alternatives

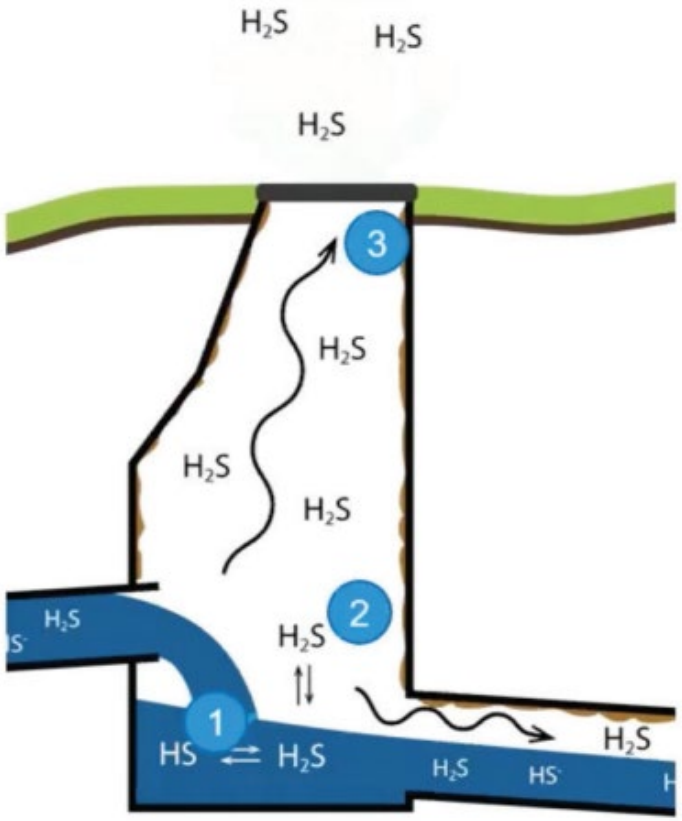
- Don't Measure; Rely on customer complaints – Reactive only

- Grab Sampling – Only a snap-shot in time

- Vapor-phase Monitoring – Limitations

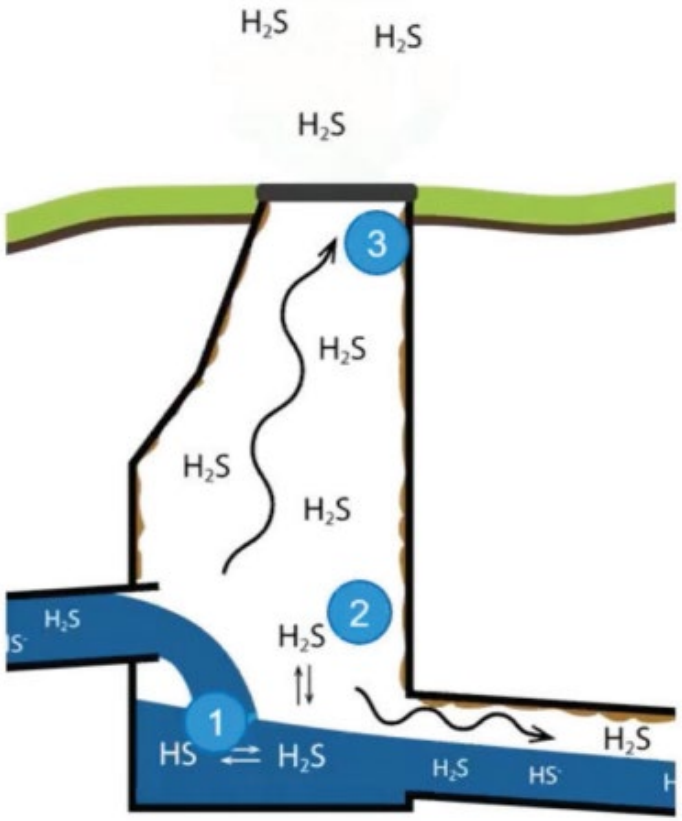
- Liquid-phase Monitoring – Preferred

Limitations of H_2S *Vapor-Phase* Measurements



- H_2S gas sensors monitor only H_2S fraction stripped from solution
- H_2S gas highly influenced by ventilation & accumulation; difficulty with representative samples
- Many gas phase sensors are prone to fail under high exposure applications and moist locations

Benefits of H_2S *Liquid-Phase* Measurements



- More consistent and comprehensive readings
- Complete H_2S fraction; measured at its source
- Probes need to be designed for wet and aggressive conditions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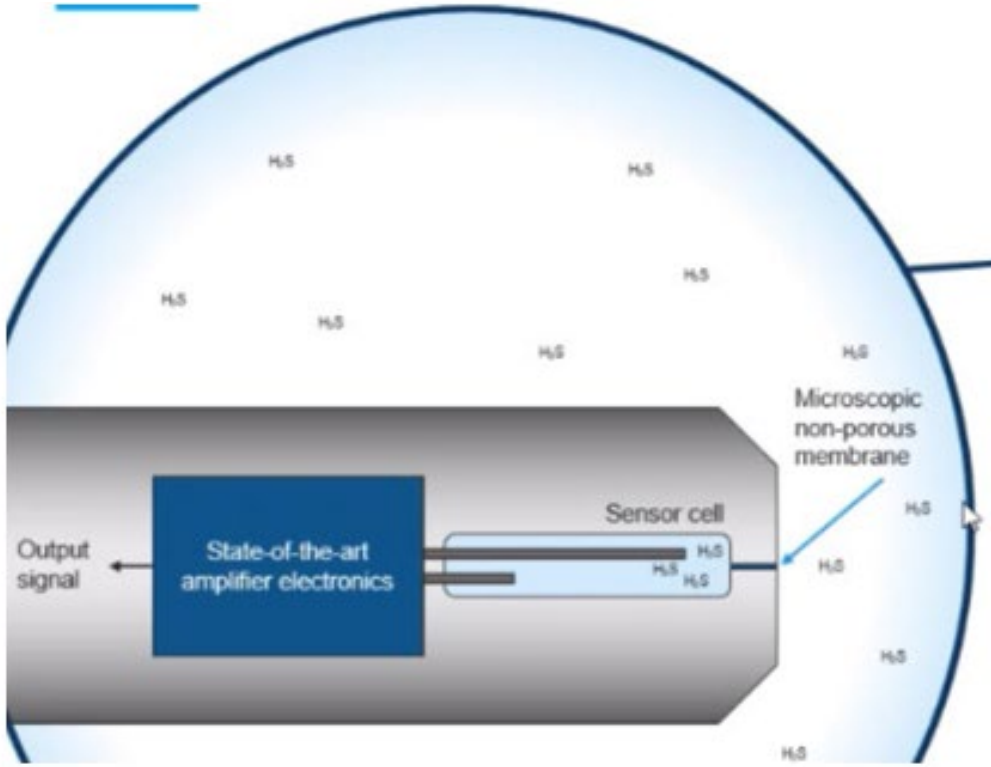
Product information

The H_2S sensor GS1440 / GS2440

Principle of Measurement



<u>Micro</u>electrochemical sensor

- ✓ Insensitive to flow
- ✓ Measures in gas or liquids
- ✓ Tolerates changing environments

The H_2S sensor GS1440 / GS2440

Robust, anti-fouling membrane

Corrosion-resistant stainless-steel

GS1440/GS2440EX Sensor H_2S Specifications

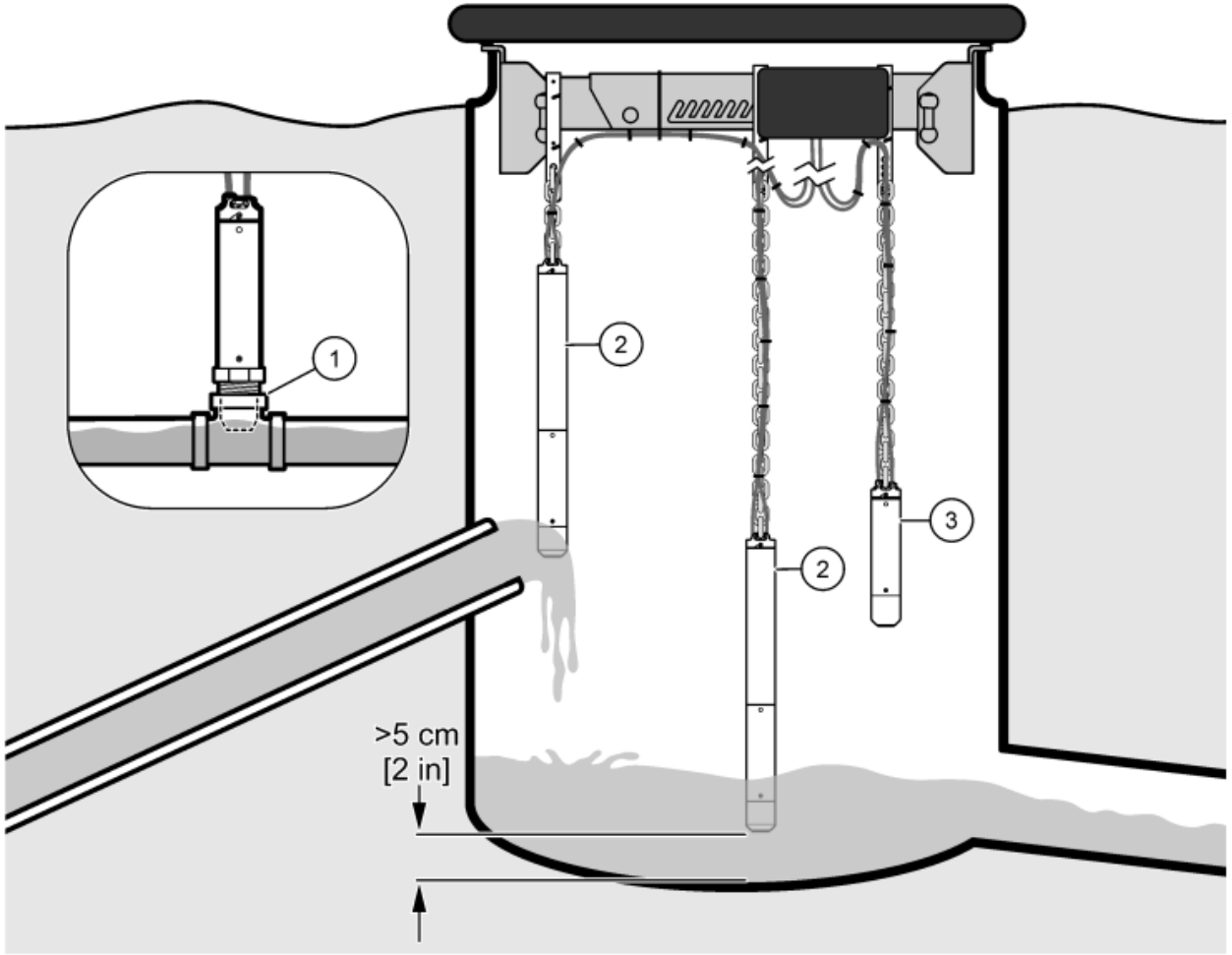
Measurement Method	Electrochemical
Sample Medium	Water or Air
Range	0-5 mg/L (in water); 0-1000 ppm (in air)
Response Time (t90)	<30 seconds
Ingress protection	Max water depth 10 m (IP68)
Operating temperature	0 °C to +40 °C (32 °F to +104 °F)
Relative humidity	0 - 100%
Calibration/Secondary standard	1000 ppm (+/-) 2% gas standard
Calibration frequency	1-6 months depending on use
Cleaning	Mechanical cleaning (wipe) of sensor face for in-water installations
Mounting options	Chain mount (in-situ), in-pipe, flow cell (bypass)
Sensor Diameter	48.3 mm (1.9 in)
Sensor Length	240 mm (9.4 in)

Hazardous Certification(s)	ATEX and UKEX: II 1G Ex ia IIC T4 Ga IECEx: Ex ia IIC T4 Ga Class I Zone 0 AEx ia IIC T4 Ga Class I Division 1 Groups A-D T4 Ex ia IIC T4 Ga (-20°C ≤ Ta ≤ +60°C) (only for GS2440EX)
Weight	1.36 kg (3.00 lb)
Materials	Stainless Steel (316 L)
Power Options	4-20mA loop power DC power (12-28 V) Battery powered**
Battery Life	3 months average (Field Transmitter H2S EX)
Communication Options	4-20 mA RS-232 Cellular (3G/4G) to Cloud data platform**
Warranty	12 months
Consumables	Calibration gas bottle; Batteries**

*** with Field Transmitter*

Note: If the sensor is set up to measure mg/L in liquid and the liquid level drops, the sensor, then in air, it will continue to read correctly the air H_2S concentration; however, it will still display in mg/L.

The H_2S sensor GS1440 / GS2440: : Mounting Options



Caution: Hach H_2S Sensors Not Primary Safety Devices

- The GS1440 and GS2440EX sensors are designed to monitor H_2S concentrations in gas or liquid, they serve as process instrumentation only
- These sensors are not designed or certified to protect humans from exposure to unsafe levels of H_2S
- Manuals for the sensors and field transmitters contain the following warning:

⚠ DANGER	
	Do not use the GS1440 or GS2440EX sensor as a safety device to identify the hydrogen sulfide concentration in an area. Obey all applicable regulations and occupational health and safety precautions before entry into confined spaces and toxic hazard environments. Get advice from the occupational health and safety department at the workplace or the government regulatory body to identify the possible hazards and safety standards.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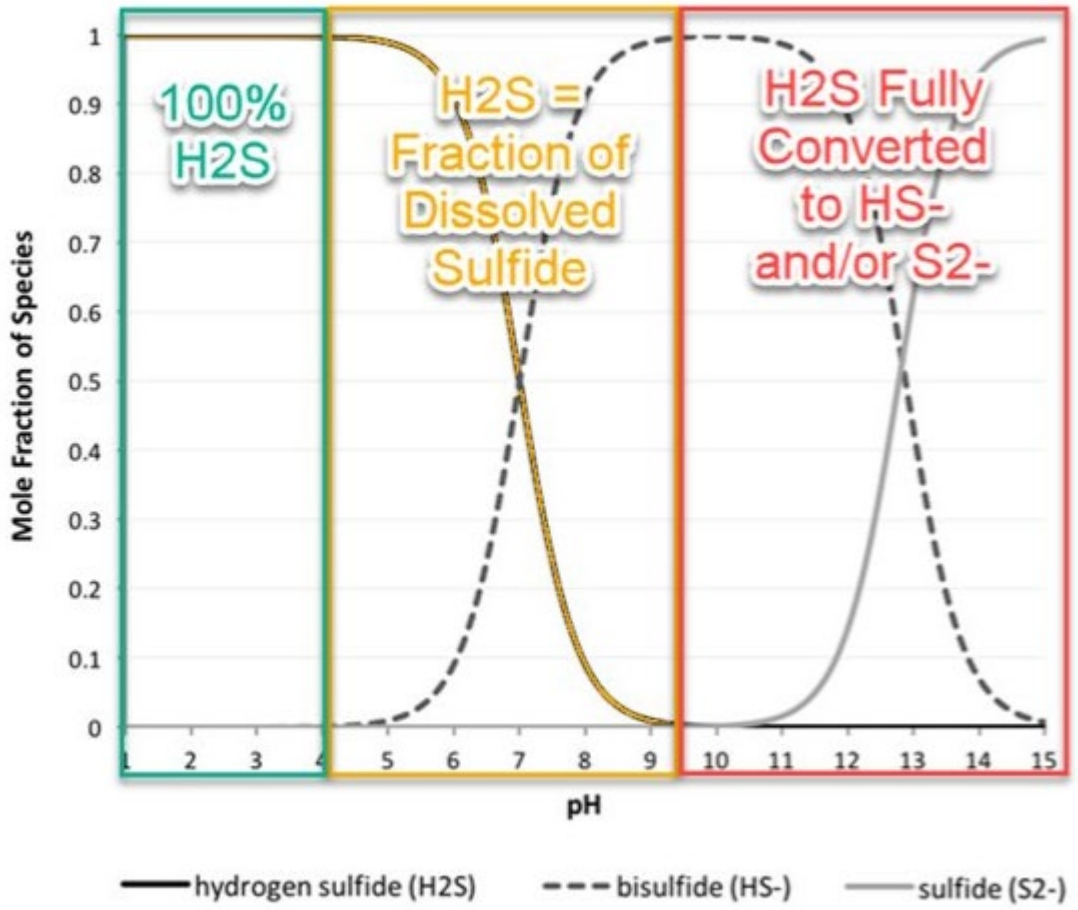
Applications

Hydrogen Sulfide (H_2S) vs total sulfide measurement?

- H_2S is soluble in water and oil and acts as a weak acid ($H_2S/HS^-/S^{2-}$)
- At pH 7, 50% of dissolved sulfide is H_2S
- Simplified formula when pH is around 7 (so when we neglect the S^{2-} content):

Total Dissolved Sulfide in mg/L = $[H_2S] + [H_2S] \cdot 10^{pH-7}$

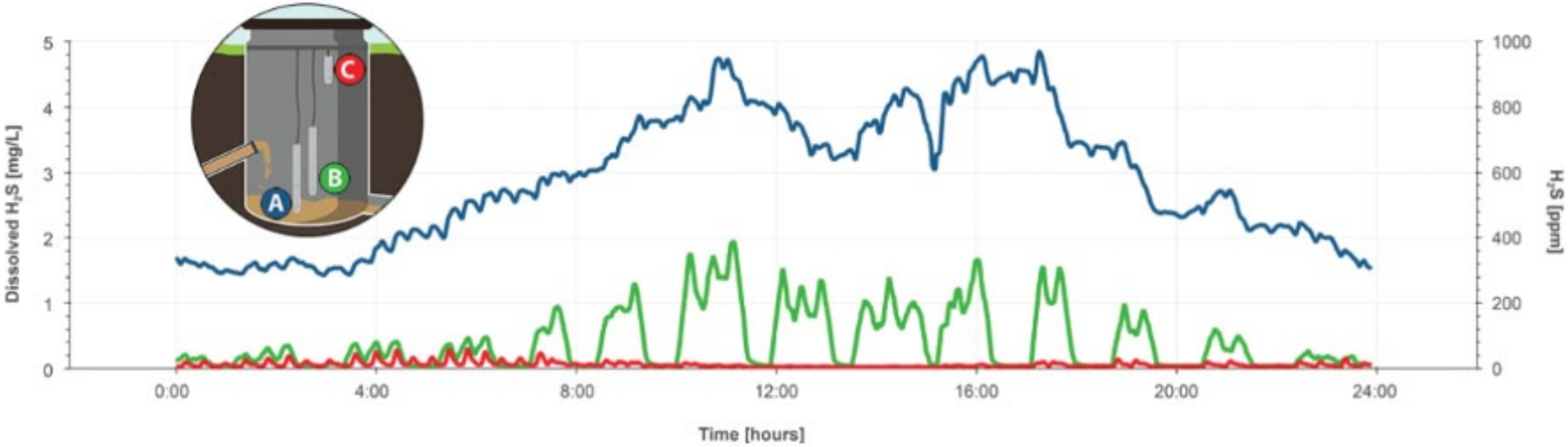
- A total sulfide calculation is possible if the sensor is paired with a pH sensor.



pK_1=6.97 and pK_2=12.90

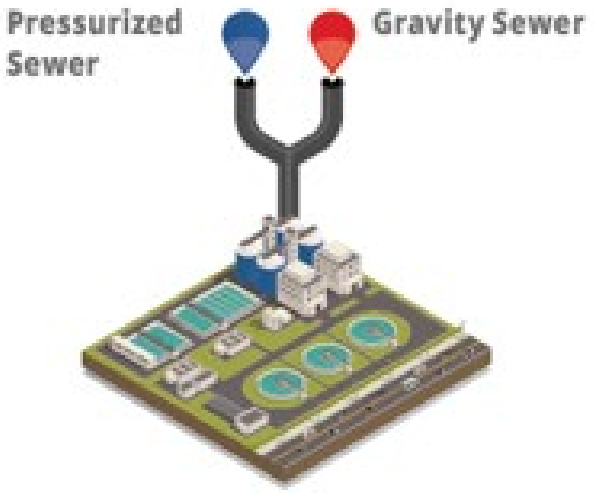
$$S^{2-} + 2H^+ \leftrightharpoons H^+ + HS^- \leftrightharpoons H_2S$$

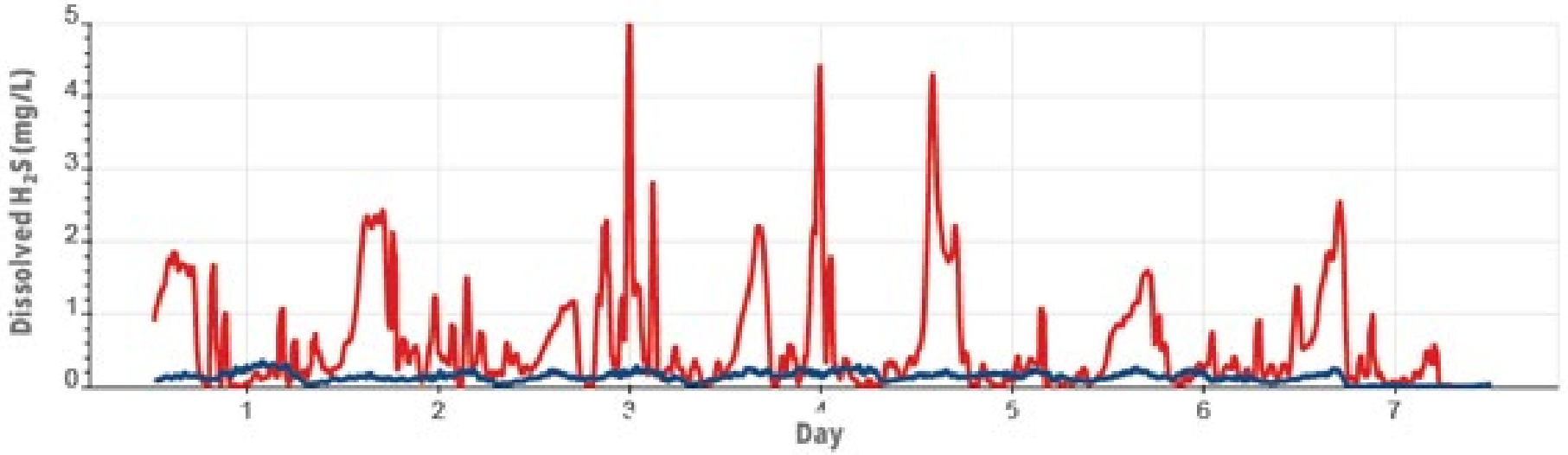
Application Examples



- A: Liquid-phase; B: Vapor-phase just above liquid level; C: Vapor-phase at top of manhole
- Liquid-phase: Demonstrated higher sensitivity, captured peak H_2S concentration events
- Gas-phase: Struggled to capture peaks unless influenced by turbulence from pumping activity

Application Examples

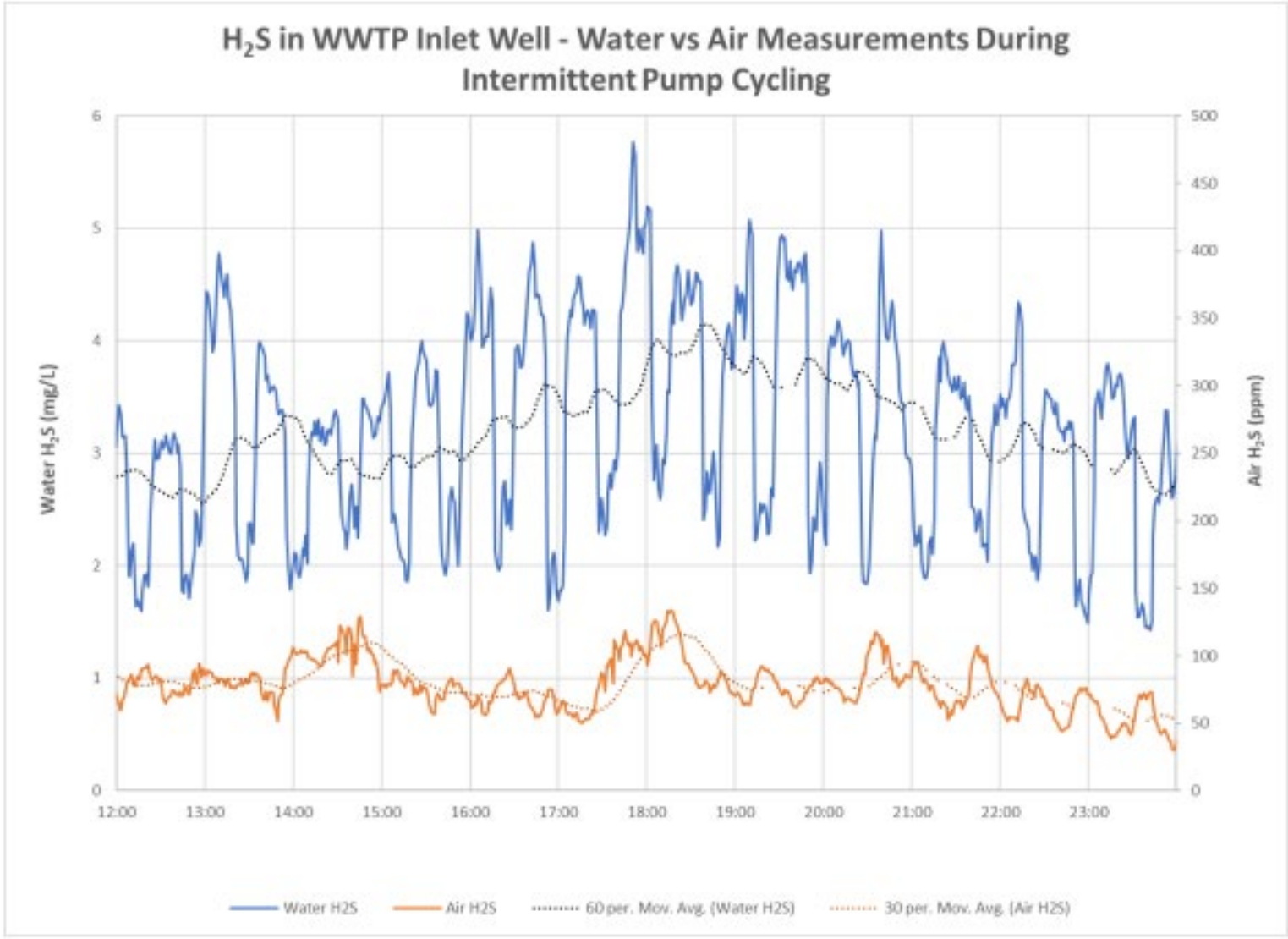




- Sensors showed impact that different types of collection systems have on H_2S concentration
- Both graphs reflect liquid measurements

Benefit of Liquid Phase H_2S Measurement

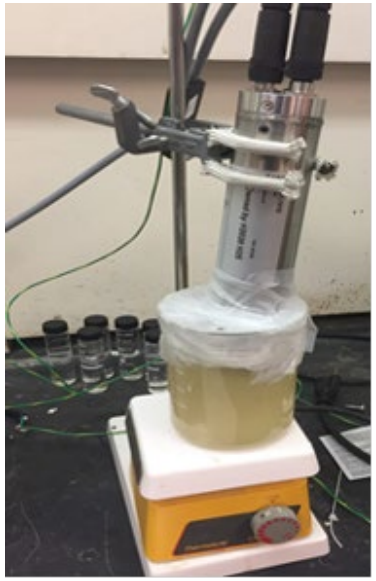
- Liquid-phase: demonstrated greater sensitivity to H_2S in influent source contributions
- Gas-phase: heavily affected by external factors like turbulence and pumping cycles



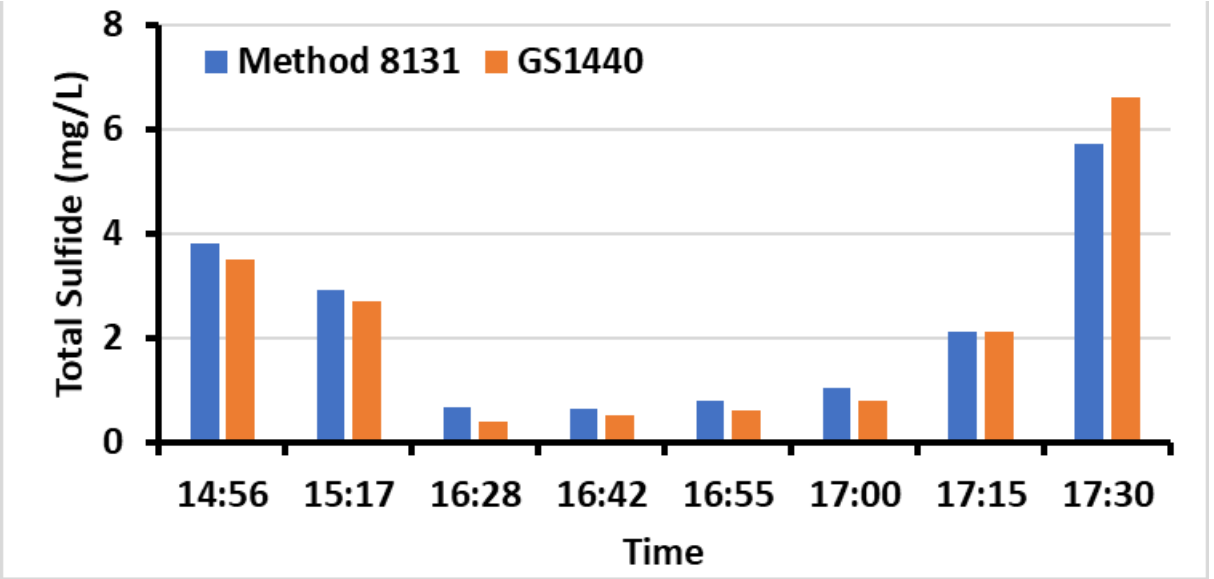
H_2S Measurement Comparisons – Sulfide (Method 8131, 10254)

- Buffered with 50 mM phthalate (high buffer capacity), pH 4.01
- Parafilm over sample beaker, reducing loss of H_2S
- Converts all dissolved sulfide to H_2S -> detectable by GS1440/GS2440EX

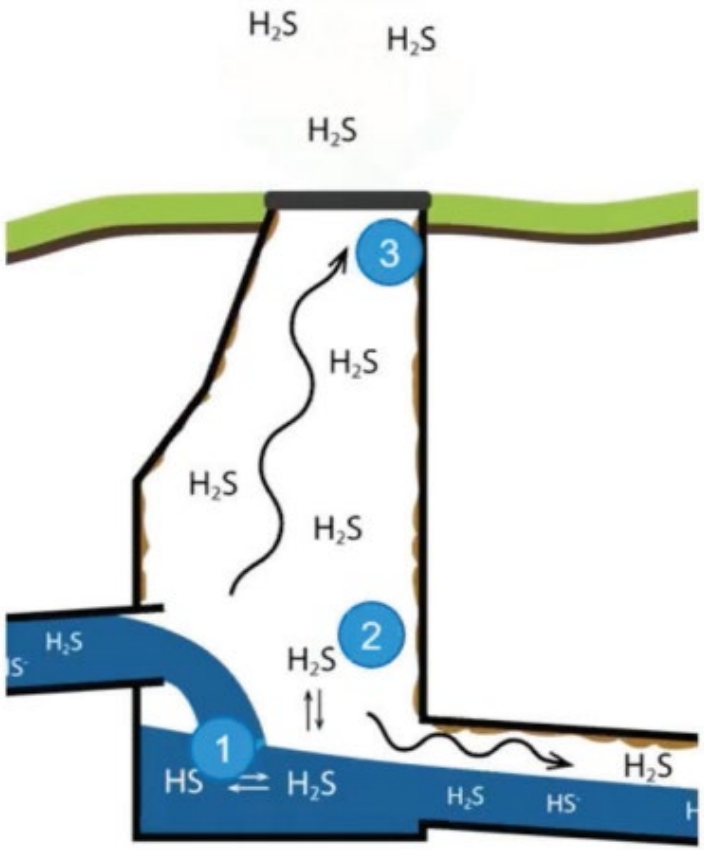
Sensor calibration with sulfide standard



Sample measurement



H_2S sensor : the liquid phase measurement vs the gas phase measurement



- A gas phase sensor is the go-to technology since years
- But gas phase measurements could provide incomplete / inaccurate measurements:
  - Sensor location, sewer ventilation and turbulence are key factors influencing H_2S air concentrations
- A liquid phase measurement provides :
  - Reduced maintenance compared to gas phase measurements
  - A reliable indicator of H_2S content

H_2S sensor : the liquid phase measurement vs the gas phase measurement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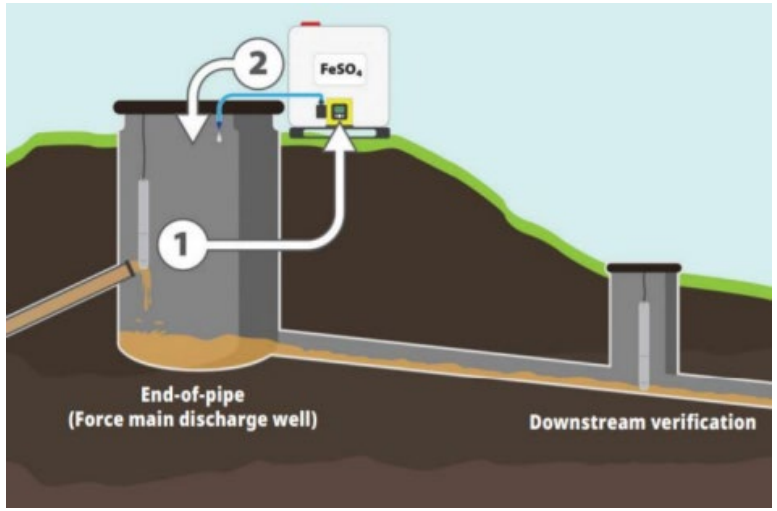
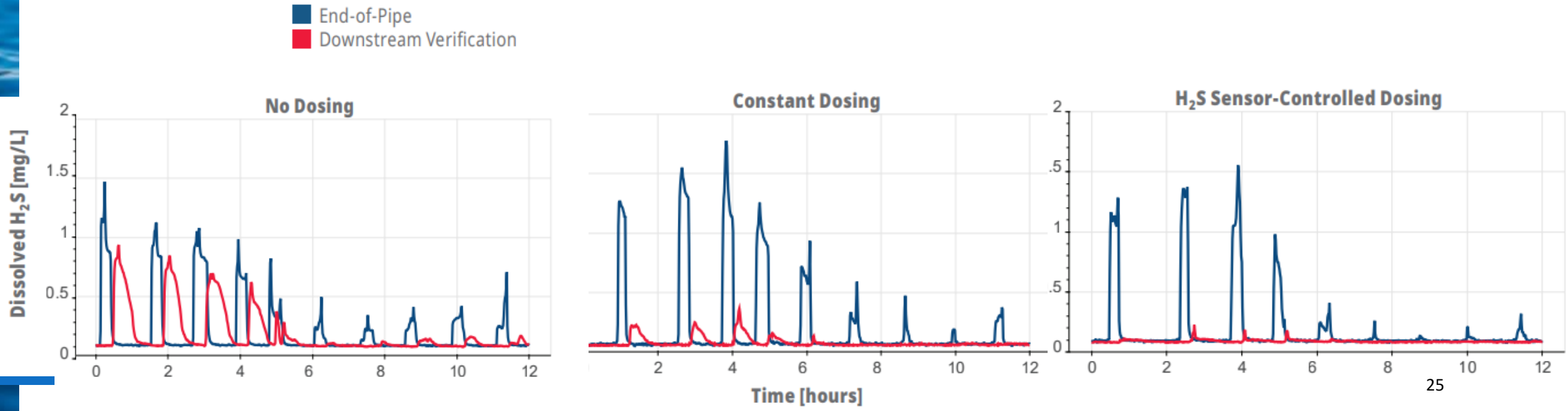
Case Studies

Benefits of Liquid-Phase H_2S Measurement in Dosing Strategy



- An H_2S measurement to pace ferrous sulfate chemical dosage improves system efficiency compared to a constant dosing strategy – 1.2 km pipeline.
- Use feed-forward or feed-back

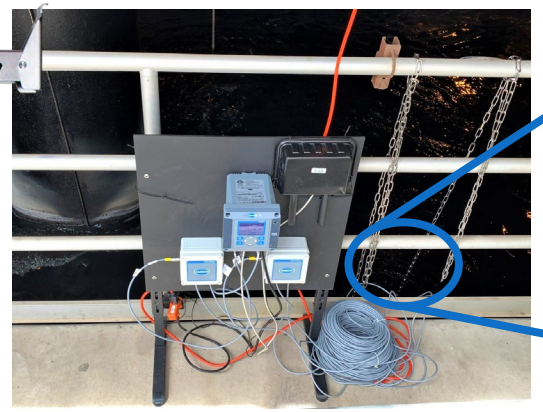


Applications

The Collection System

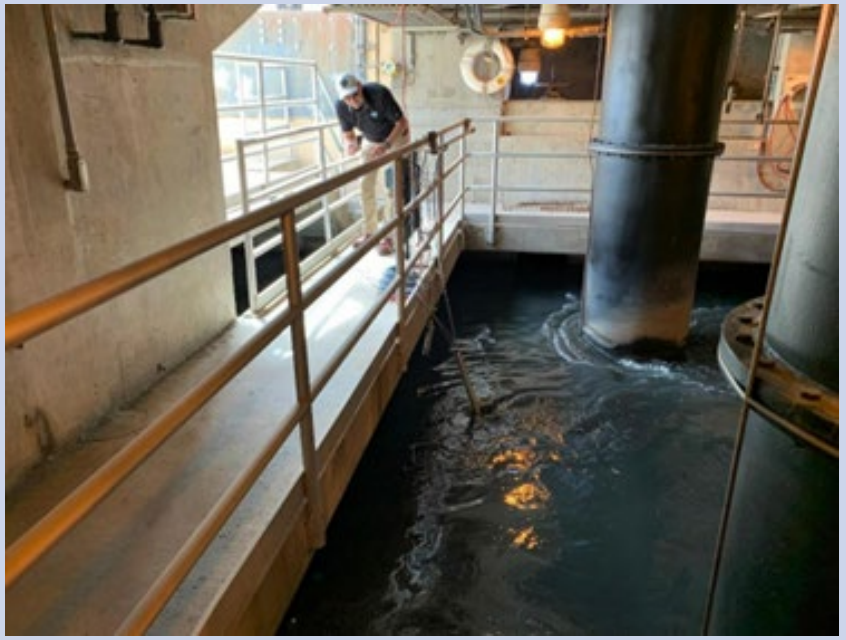
- Mapping of risk areas
- Optimisation of existing mitigation strategies
- Monitoring for warranty of concrete resistance

The WWTP

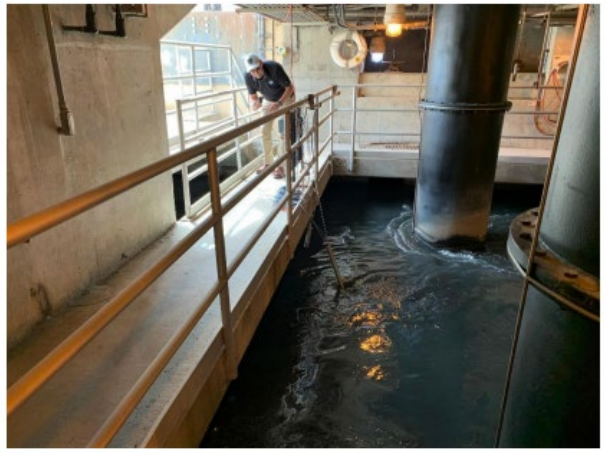


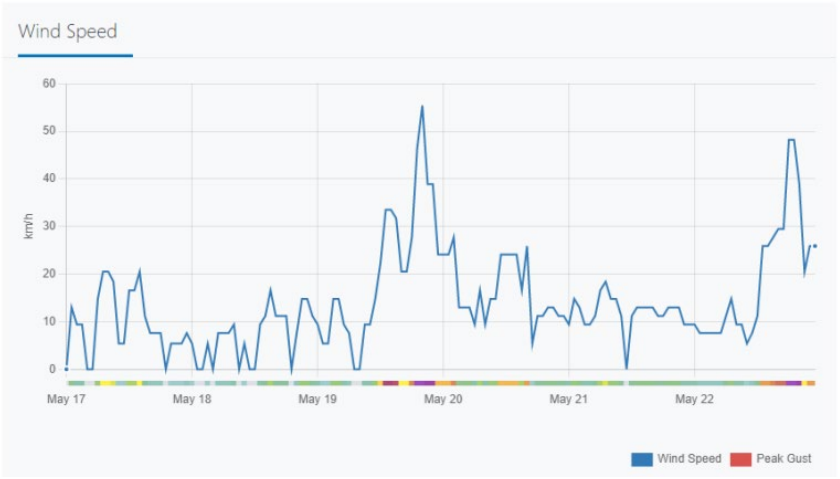
- Headworks influent
- Primary Clarifiers
- Buffer tanks
- Odor scrubber
- Sludge thickening
- Digestion (liquid phase)

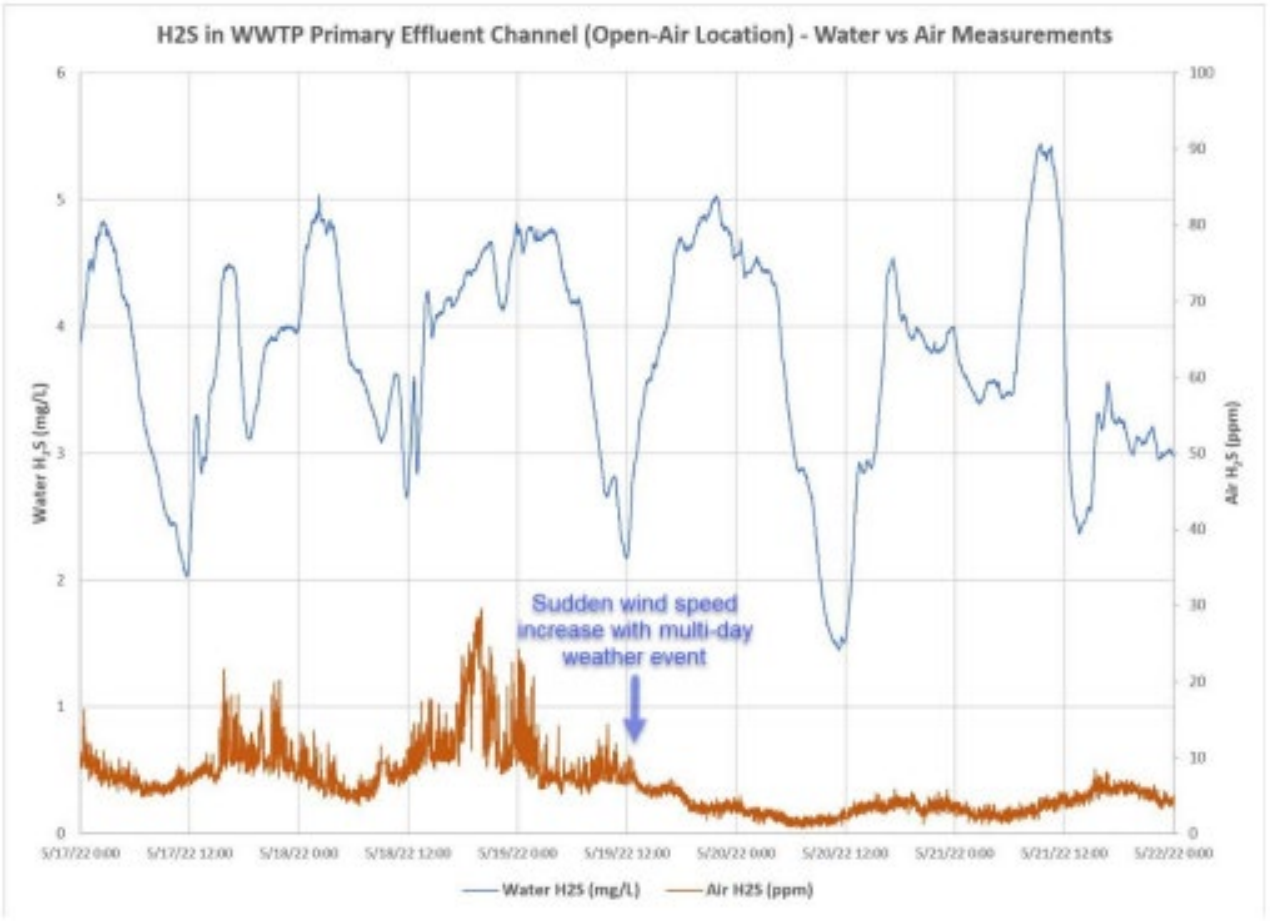
The H_2S measurement : Application Case A

Site A

Location : A tank in the effluent of a primary treatment stage
Objective : Illustrate the benefits of a liquid phase measurement / the limitations of a gas phase measurement

The H_2S measurement : Application Case A



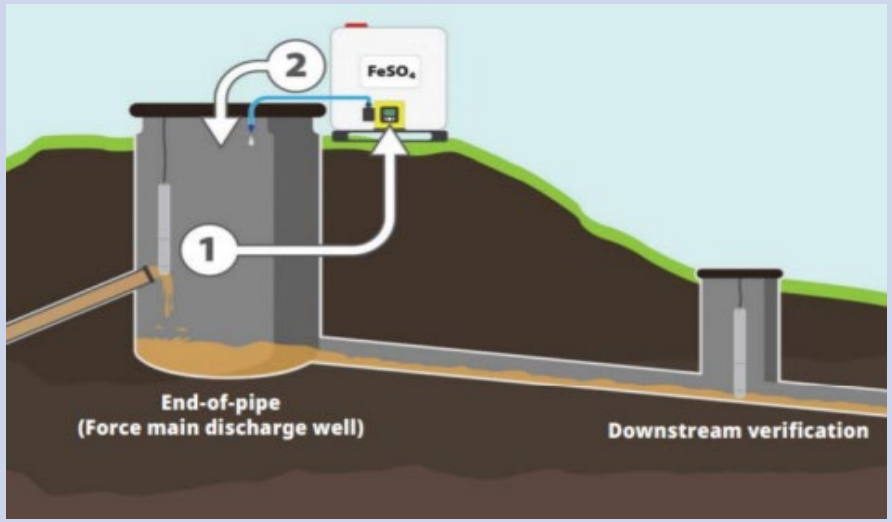




⇒ **Gas phase measurements can under-represent the scope of an H_2S problem**

The H_2S measurement : Application Case B

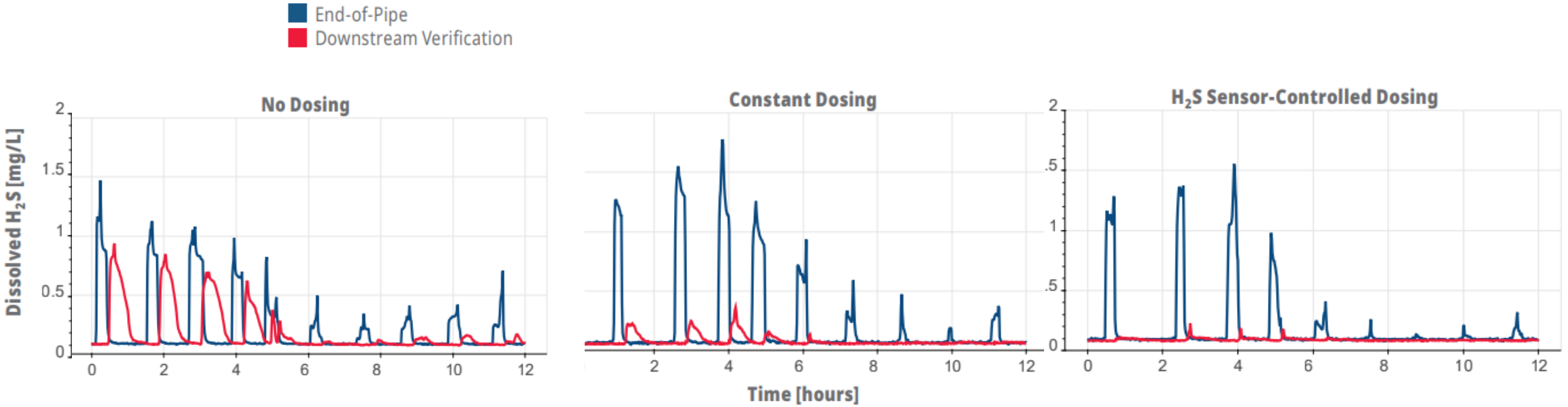
Site B



A discharge well after force main before a curative treatment of H_2S with ferrous sulfate

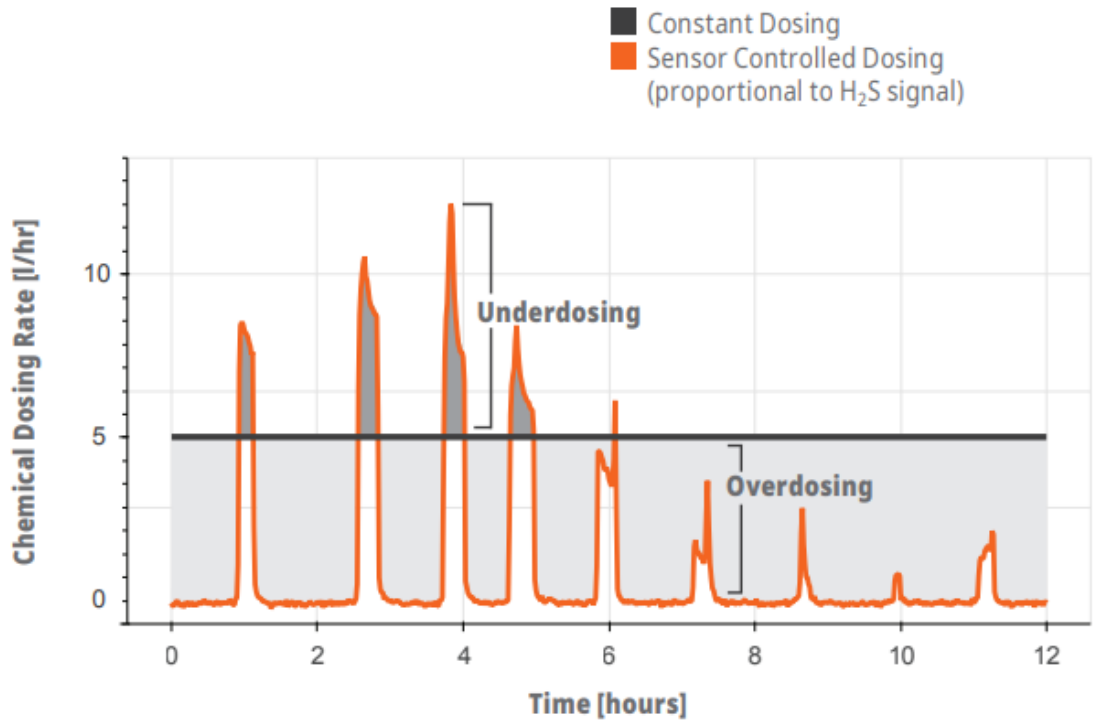
A site to illustrate the benefit of a dosing strategy in relation to the H_2S concentration in the liquid phase

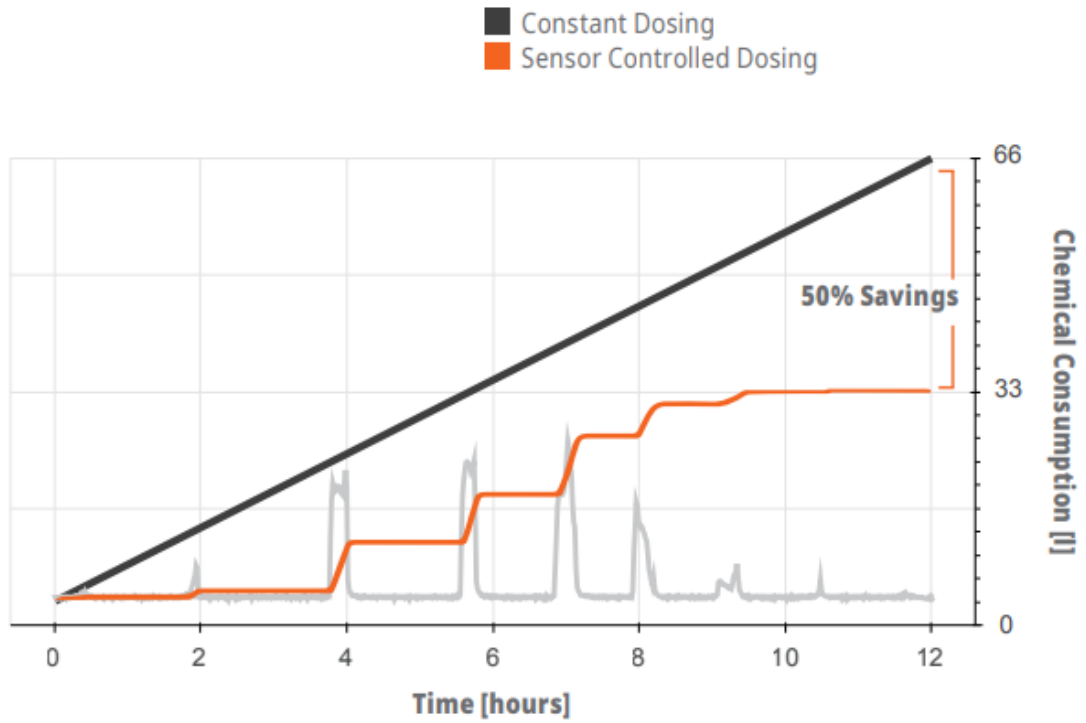
Application Case B : The use of H_2S liquid phase measurement for reagent dosing



⇒ H_2S is a dynamic variable (dependent on pump operating parameters, seasons, temperatures, flow rate and precipitation...) and as the composition of the effluent changes, a constant reagent dosing cannot completely neutralize the effect of H_2S peaks

Results Site B : The use of H_2S liquid phase measurement for reagent dosing





⇒ **A dosing strategy based on an H_2S measurement improves system efficiency while using 50% less chemical compared to a constant dosing strategy.**

Conclusion

- Liquid-phase H2S monitoring improves the operator's ability to:
  - ✓ Locate H2S hotspots
  - ✓ Continuously monitor H2S concentrations in networks and wastewater treatment plants
  - ✓ Optimize and automatically control H2S mitigation strategies
- Limited Maintenance:
  - ✓ No consumables
  - ✓ On-site calibration
  - ✓ Several years of service life

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Thank You

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