Modifications to Mitigate MICC in Septic Tanks

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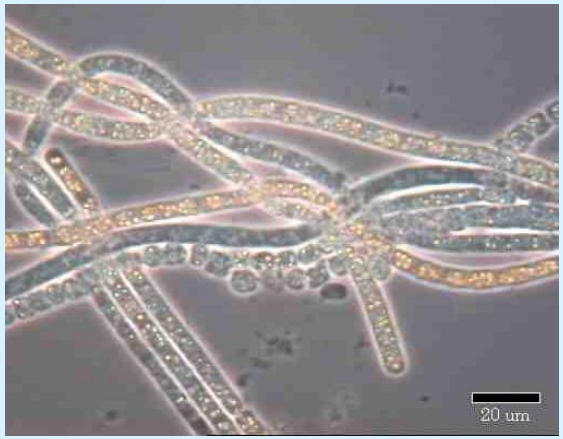
Septic Tank Inlet Riser

Septic Tank Outlet Riser

Sulfide oxidizing bacteria



$$H_2S + 2O_2 \rightarrow SO_4^{2-} + 2H^+$$

- Oxidize hydrogen sulfide to sulfuric acid
- Require oxygen for growth
- Obtain carbon from CO_2
- Prefer to grow on effluent surface where rising H_2S meets O_2

Thiobacillus

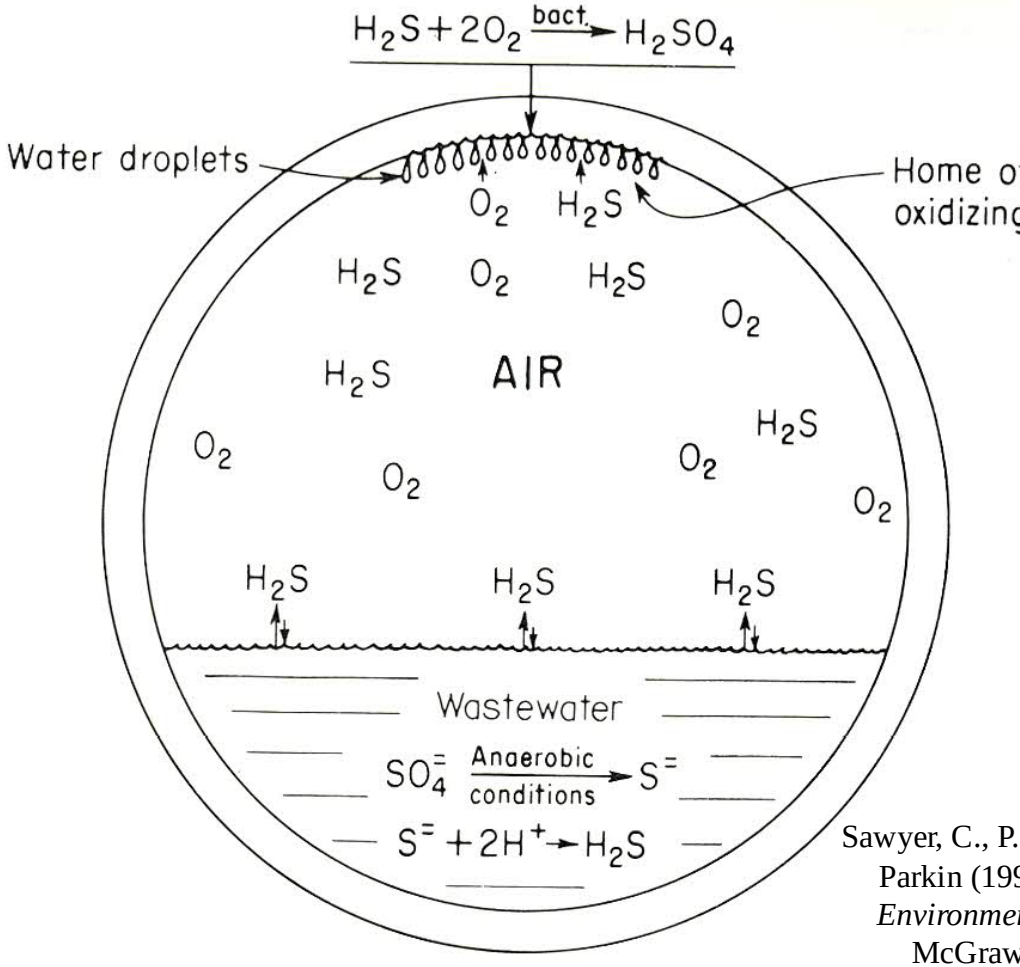
a genus of small rod-shaped bacteria that live in water, sewage, and soils, derive energy from oxidation of sulfides, thiosulfates, or elemental sulfur, and obtain carbon from carbon dioxide, bicarbonates, or carbonates in solution

Sulfate reducing bacteria

$$BOD + SO_4^{2-} + 3H^+ \rightarrow 2CO_2 + 2H_2O + H_2S$$

- Reduce sulfate to hydrogen sulfide
- Require absence of O_2 for growth (anaerobes)
- Must obtain organic carbon for growth from BOD
- Consume acidity

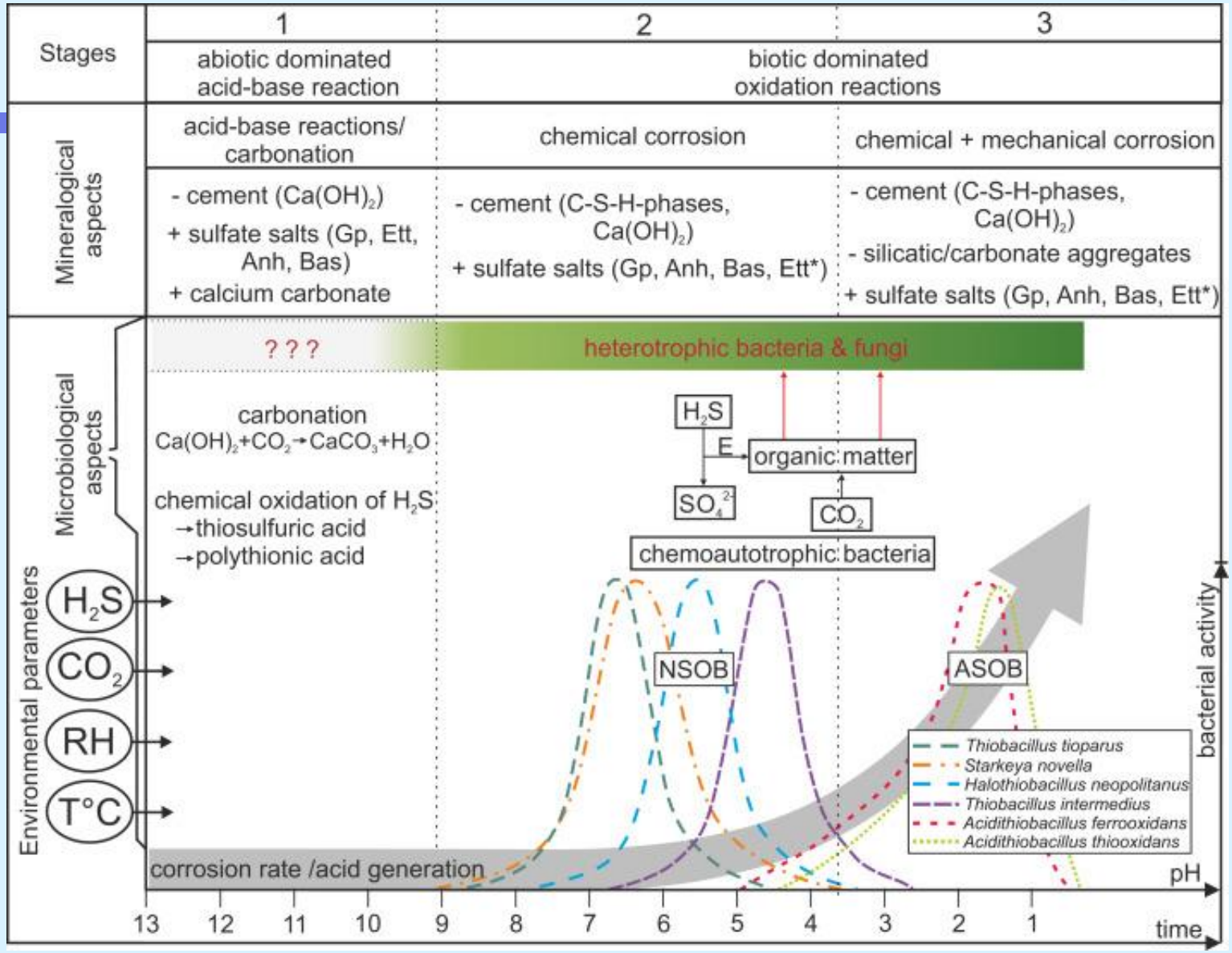
Crown corrosion in sanitary sewers



Sawyer, C., P. McCarty, and G. Parkin (1994) *Chemistry for Environmental Engineering.* McGraw-Hill: New York.

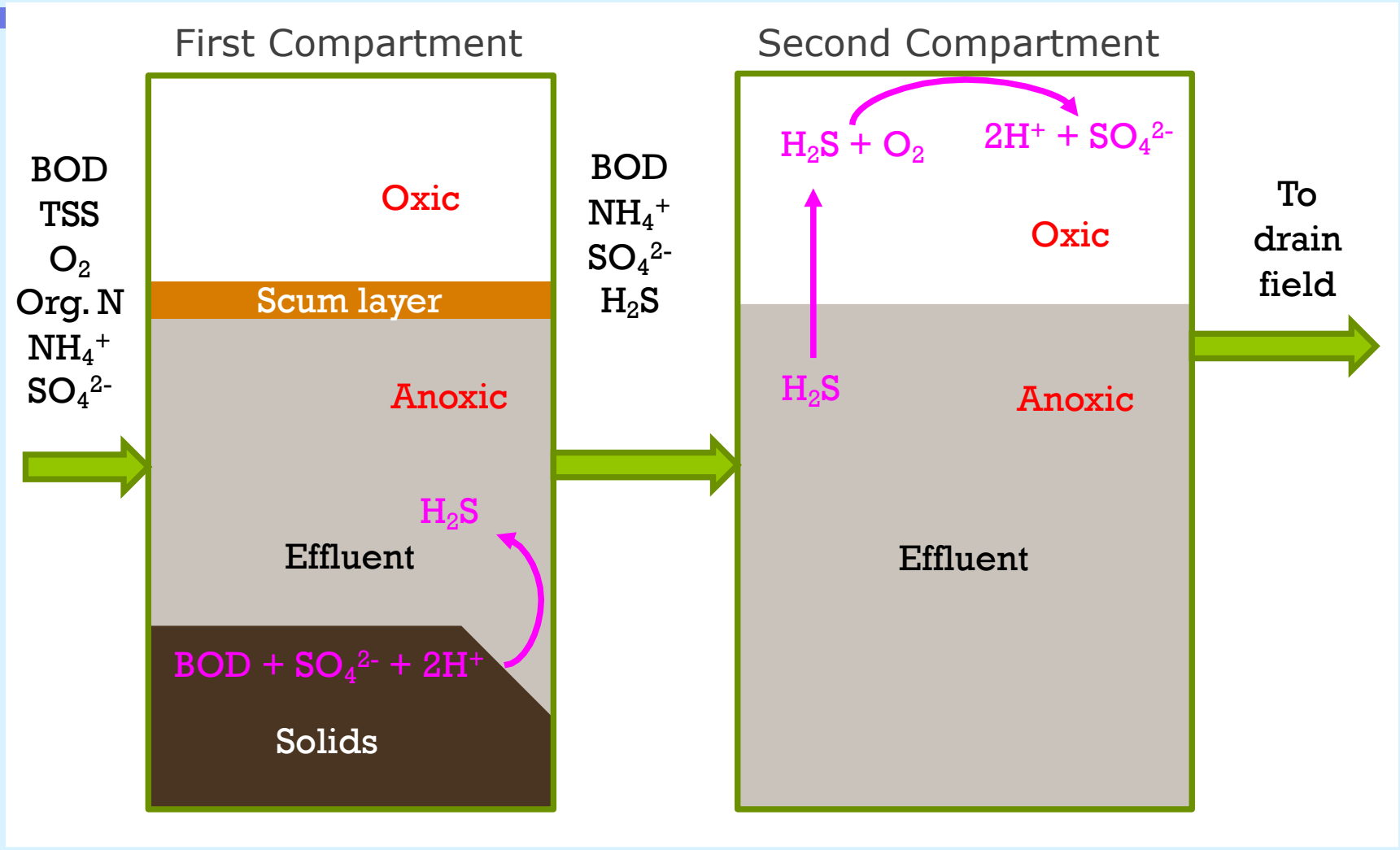
Cover corrosion in a septic tank

Succession of microbes with pH



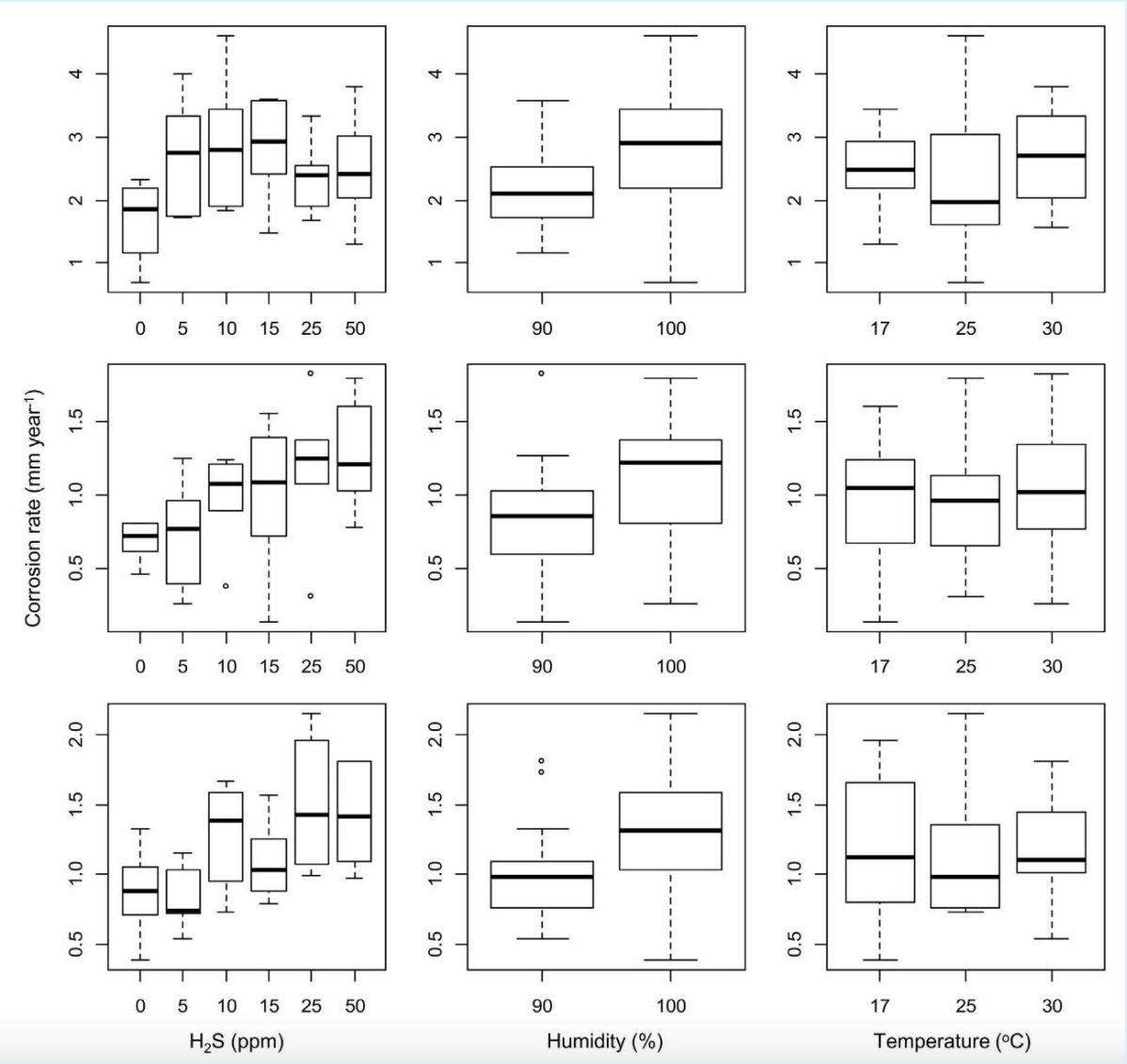
C. Grengg et al. (2018) Advances in concrete materials for sewer systems affected by microbial induced concrete corrosion: A review. *Water Research* **134**: 341-352.

Conceptual overview



Outlet side of pump chamber

H_2S gas concentration effect on MICC



G. Jiang et al. (2015) Identification of controlling factors for the initiation of corrosion of fresh concrete sewers. *Water Research* **80**: 30-40.

H_2S gas concentration effect on MICC

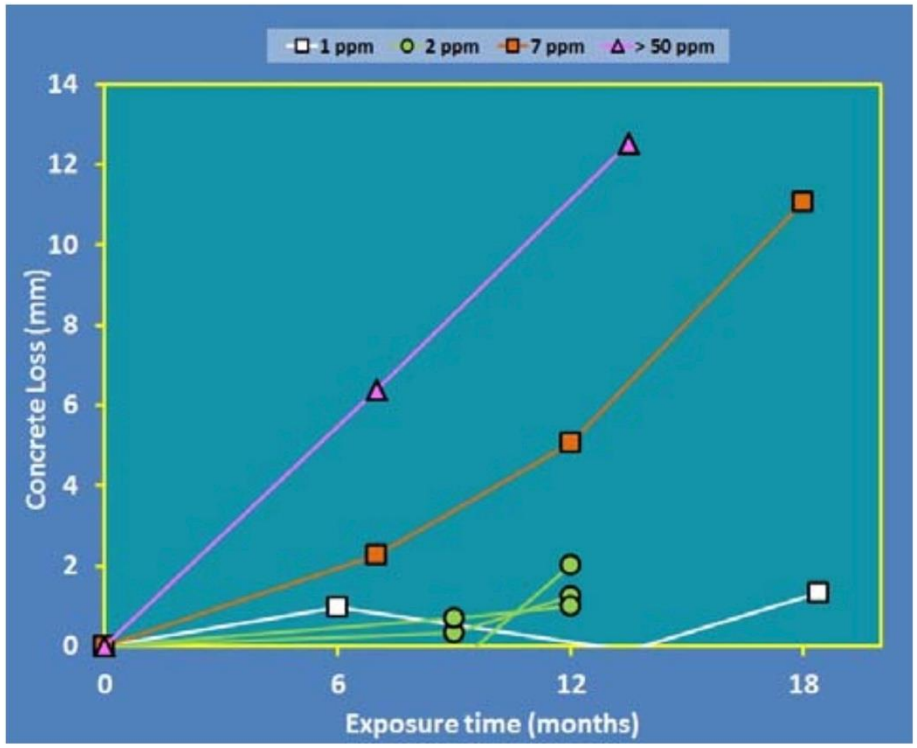


Figure 10. Loss of concrete experienced by old concrete coupons in the field trials.

T. Wells et al. (2012) A collaborative investigation of microbial corrosion of concrete sewer pipe in Australia.

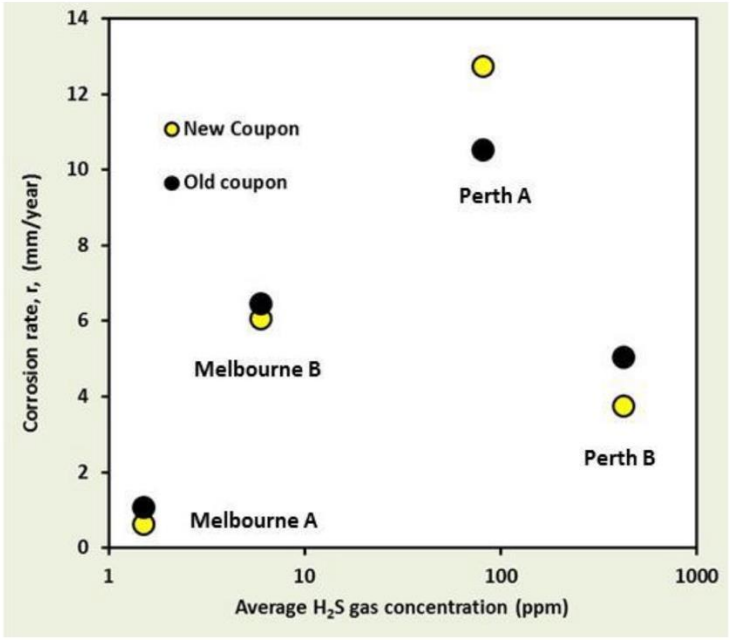
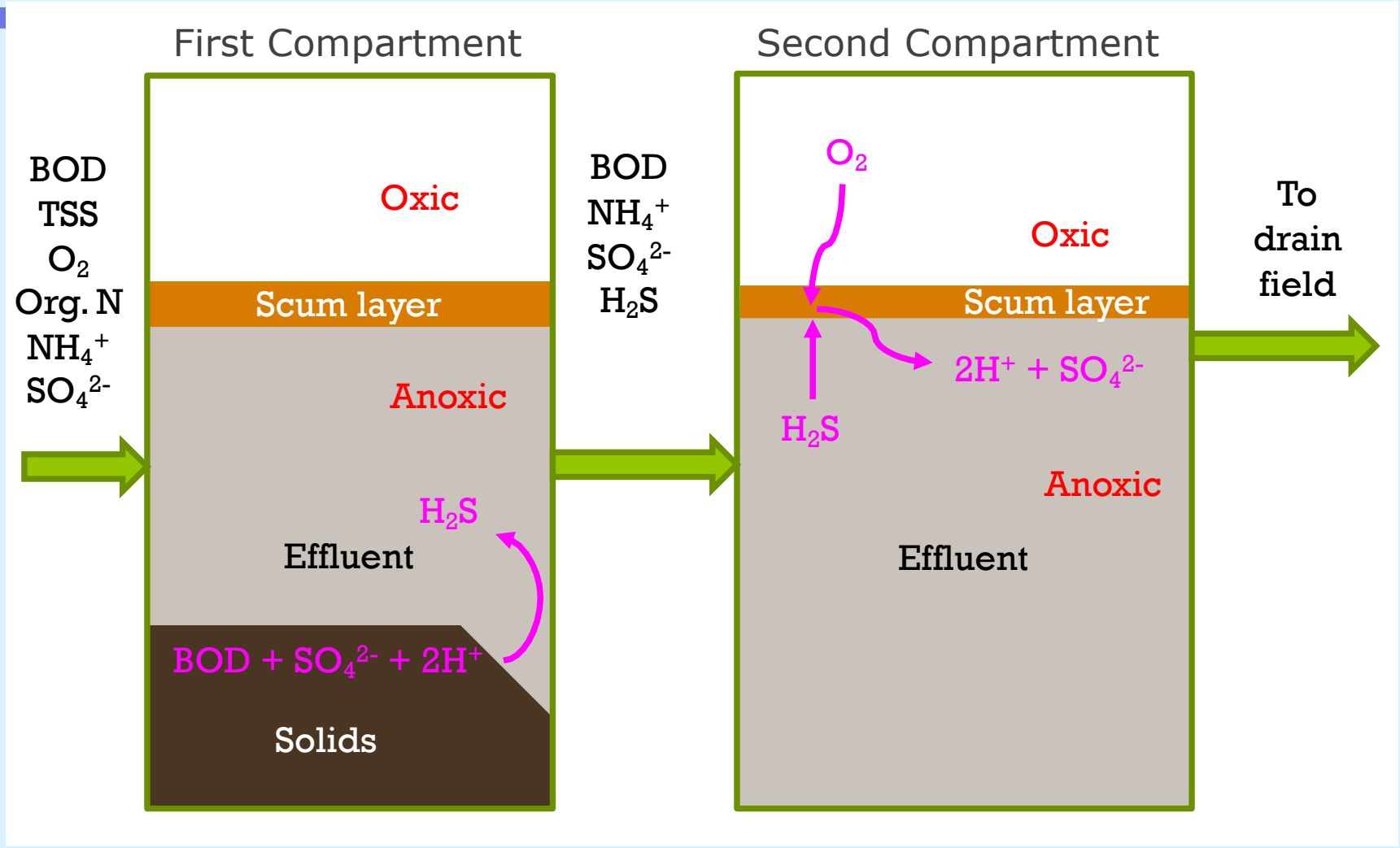


Figure 14. Corrosion rate, *r*, as a function of Average H_2S concentration.

T. Wells et al. (2014) Findings of a 4-year study of concrete sewer pipe corrosion.

Conceptual overview



Mature scum layer

Intact biofilm

Primary triggers in septic systems with gravity distribution

Effluent filters

Open outlet baffles

Objective 1

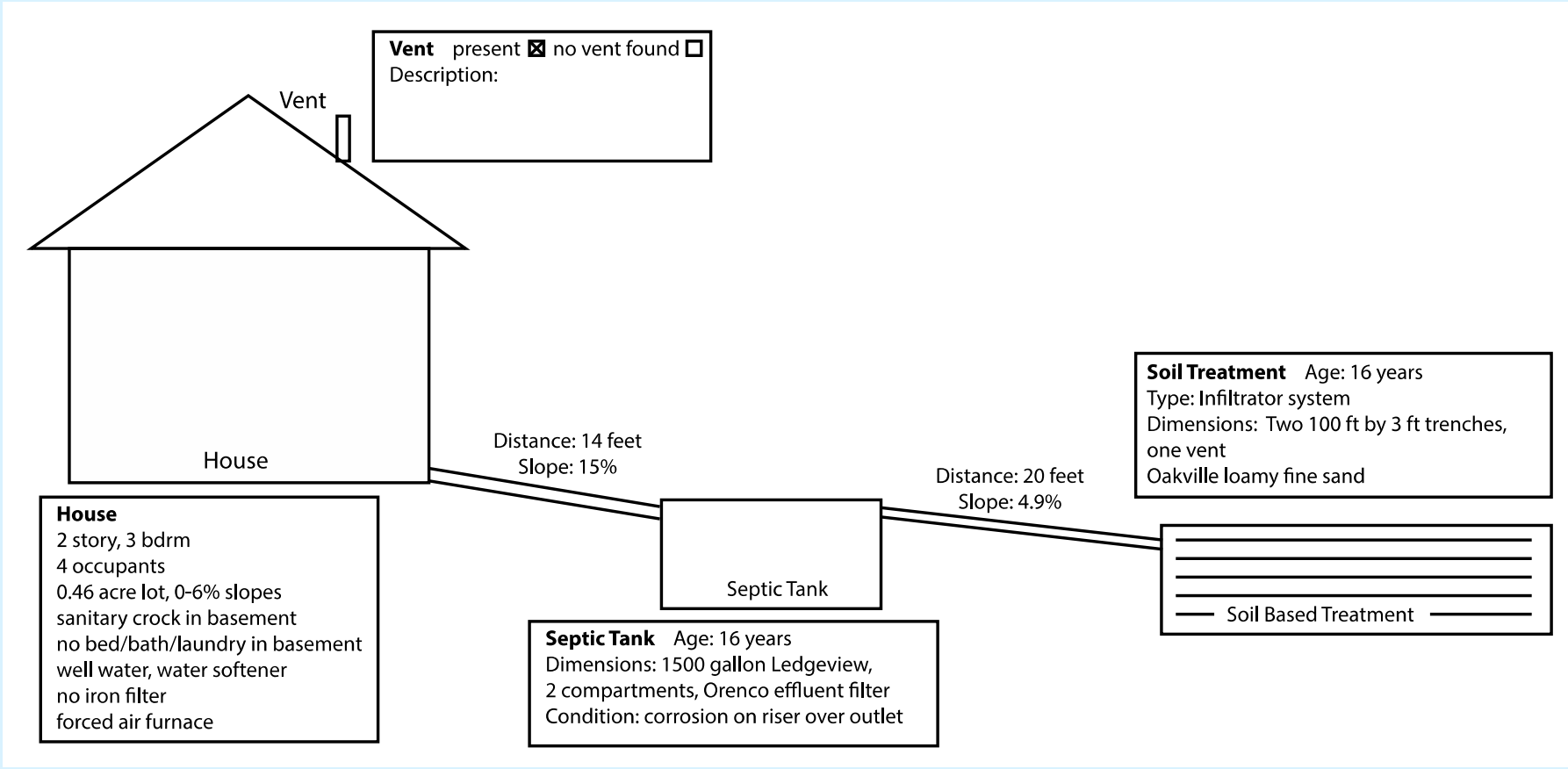
- Test how **capping top of effluent filter** affects H_2S gas magnitude and distribution

Field measurements

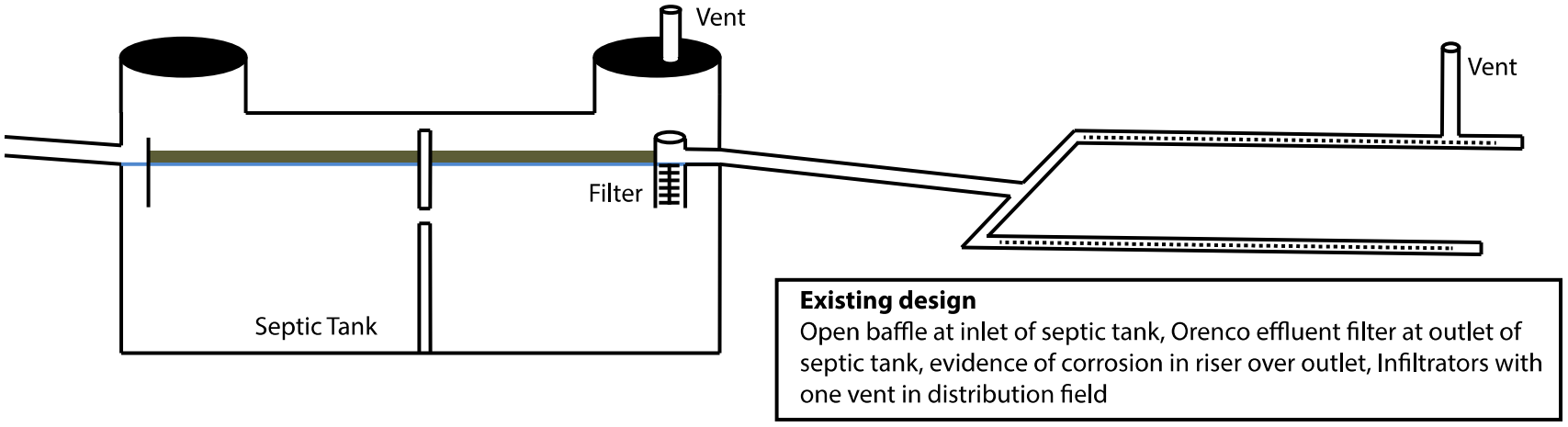
H_2S gas concentrations

Air velocities from vents

Site 3 system layout (Oostburg, WI)

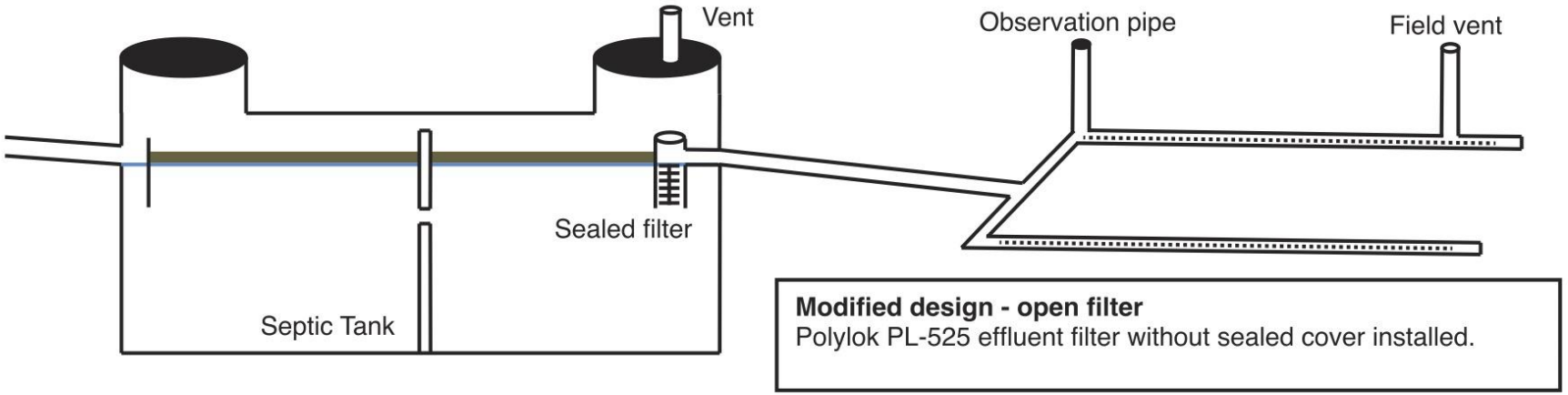


Site 3 pre-modification

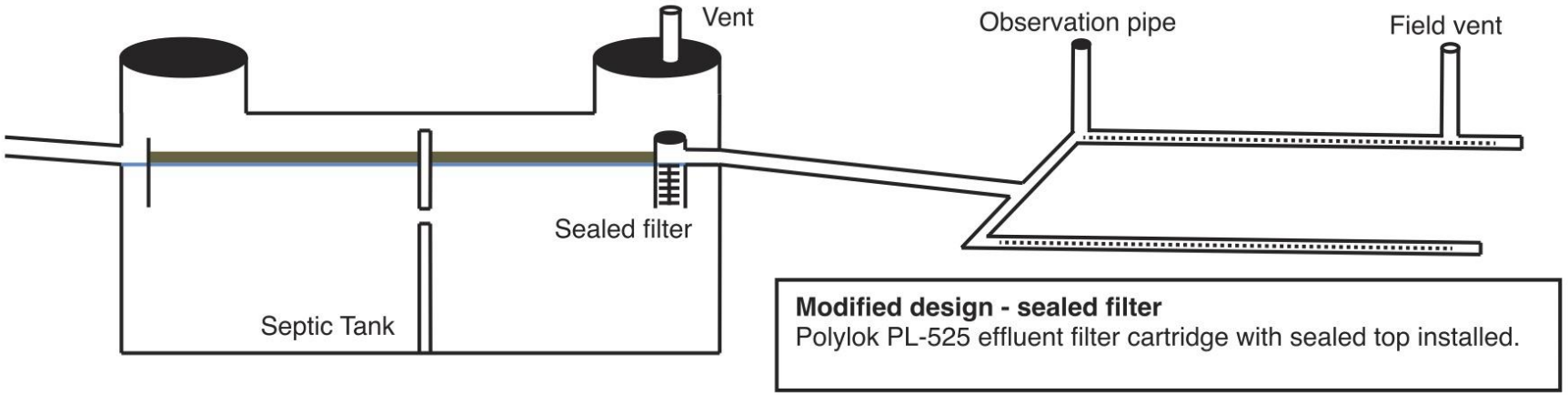


Existing design
Open baffle at inlet of septic tank, Orenco effluent filter at outlet of septic tank, evidence of corrosion in riser over outlet, Infiltrators with one vent in distribution field

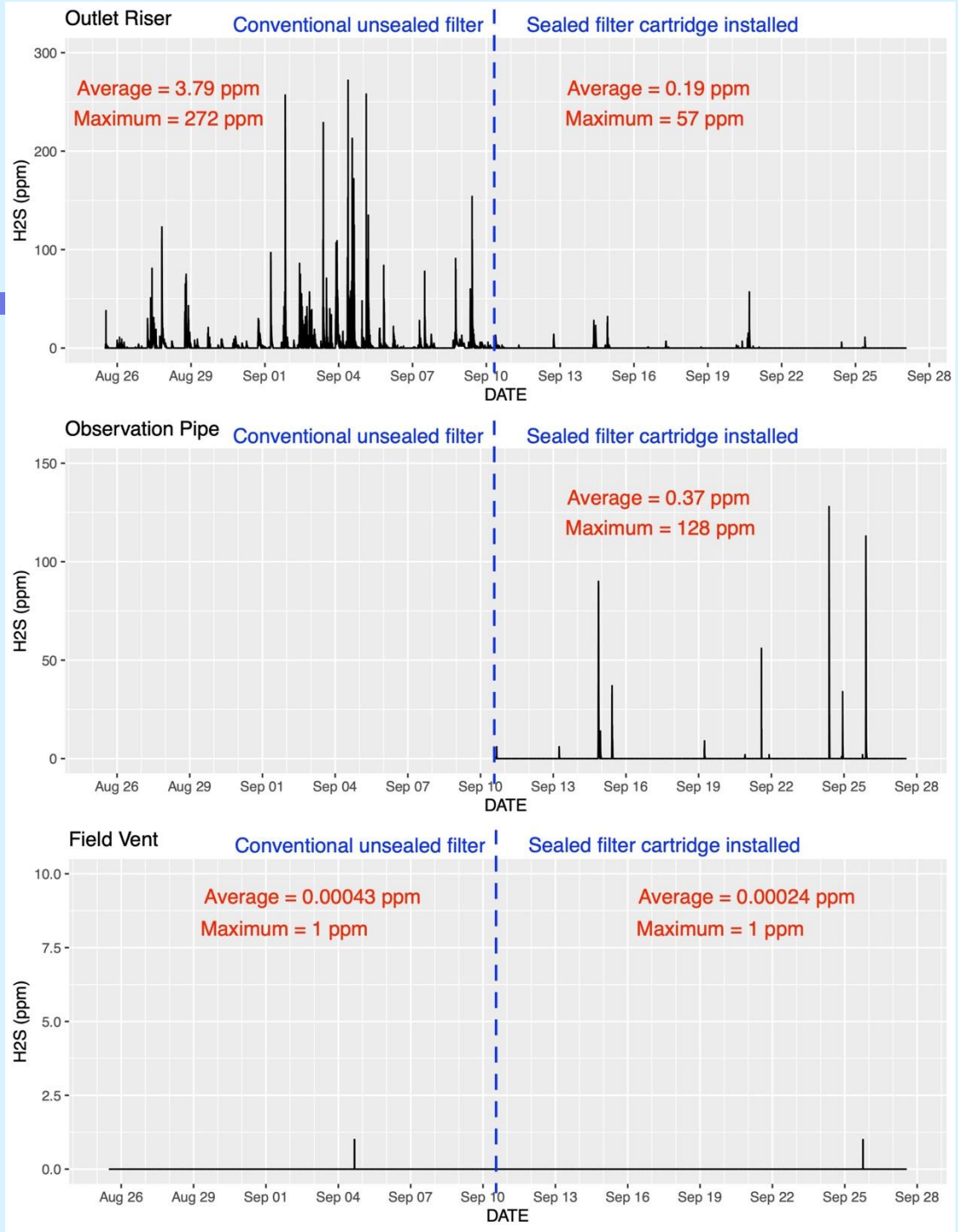
Site 3 – Objective 1

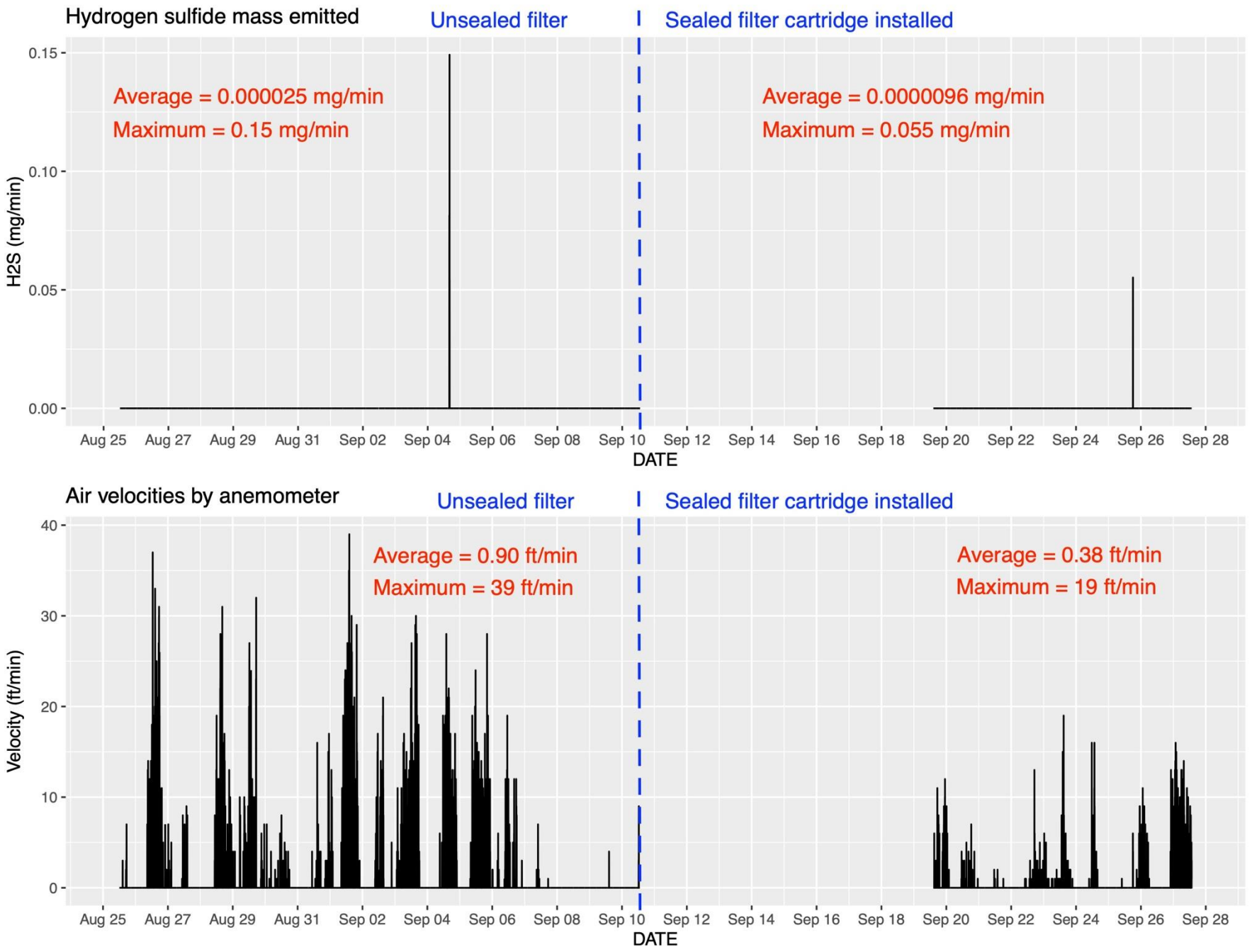


Modified design - open filter
Polylok PL-525 effluent filter without sealed cover installed.



Modified design - sealed filter
Polylok PL-525 effluent filter cartridge with sealed top installed.

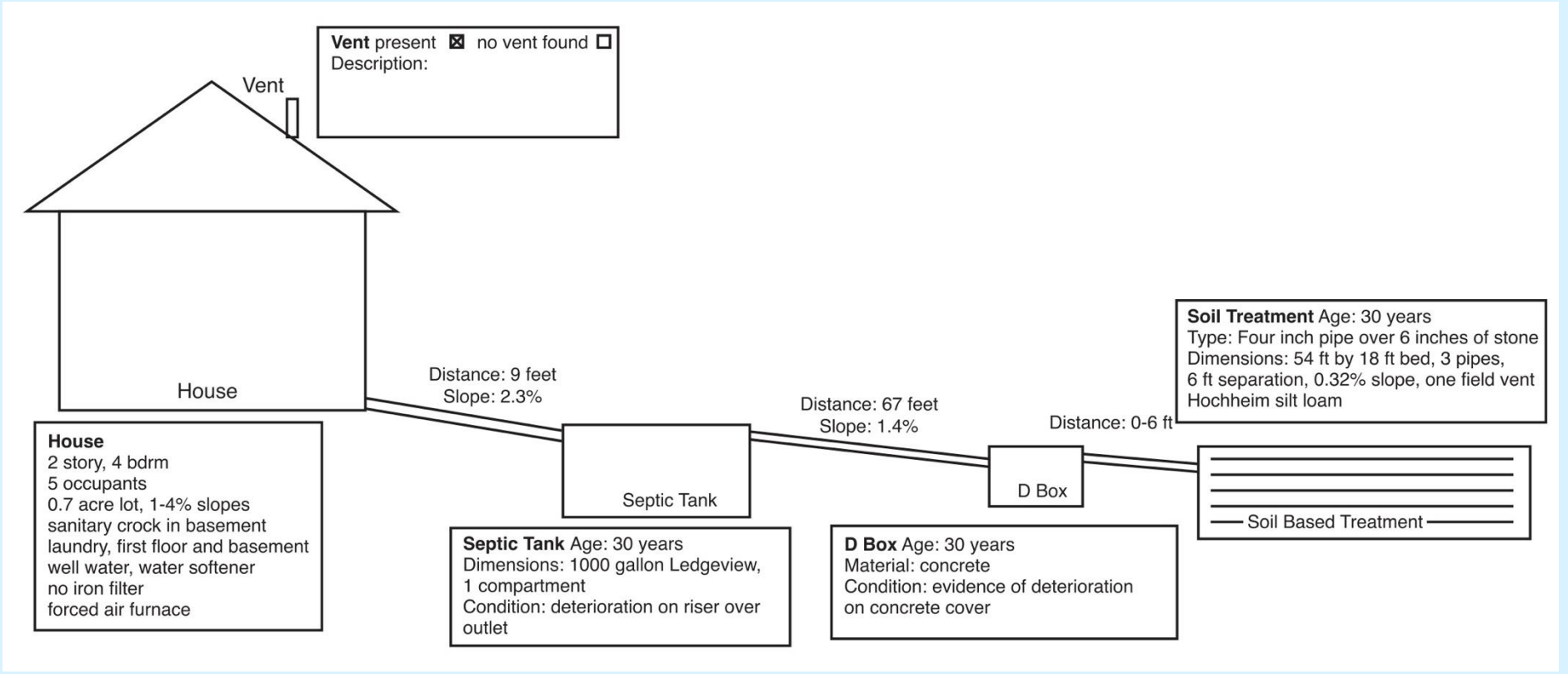

Outlet Riser
Conventional unsealed filter
Sealed filter cartridge installed
Average = 3.79 ppm
Maximum = 272 ppm
Average = 0.19 ppm
Maximum = 57 ppm
H2S (ppm)
300
200
100
0
Aug 26
Aug 29
Sep 01
Sep 04
Sep 07
Sep 10
Sep 13
Sep 16
Sep 19
Sep 22
Sep 25
Sep 28
DATE
Observation Pipe
Conventional unsealed filter
Sealed filter cartridge installed
Average = 0.37 ppm
Maximum = 128 ppm
H2S (ppm)
150
100
50
0
Aug 26
Aug 29
Sep 01
Sep 04
Sep 07
Sep 10
Sep 13
Sep 16
Sep 19
Sep 22
Sep 25
Sep 28
DATE
Field Vent
Conventional unsealed filter
Sealed filter cartridge installed
Average = 0.00043 ppm
Maximum = 1 ppm
Average = 0.00024 ppm
Maximum = 1 ppm
H2S (ppm)
10.0
7.5
5.0
2.5
0.0
Aug 26
Aug 29
Sep 01
Sep 04
Sep 07
Sep 10
Sep 13
Sep 16
Sep 19
Sep 22
Sep 25
Sep 28
DATE


Hydrogen sulfide mass emitted
Unsealed filter
Sealed filter cartridge installed
Average = 0.000025 mg/min
Maximum = 0.15 mg/min
Average = 0.0000096 mg/min
Maximum = 0.055 mg/min
H2S (mg/min)
0.15
0.10
0.05
0.00
Aug 25
Aug 27
Aug 29
Aug 31
Sep 02
Sep 04
Sep 06
Sep 08
Sep 10
Sep 12
Sep 14
Sep 16
Sep 18
Sep 20
Sep 22
Sep 24
Sep 26
Sep 28
DATE
Air velocities by anemometer
Unsealed filter
Sealed filter cartridge installed
Average = 0.90 ft/min
Maximum = 39 ft/min
Average = 0.38 ft/min
Maximum = 19 ft/min
Velocity (ft/min)
40
30
20
10
0
Aug 25
Aug 27
Aug 29
Aug 31
Sep 02
Sep 04
Sep 06
Sep 08
Sep 10
Sep 12
Sep 14
Sep 16
Sep 18
Sep 20
Sep 22
Sep 24
Sep 26
Sep 28
DATE

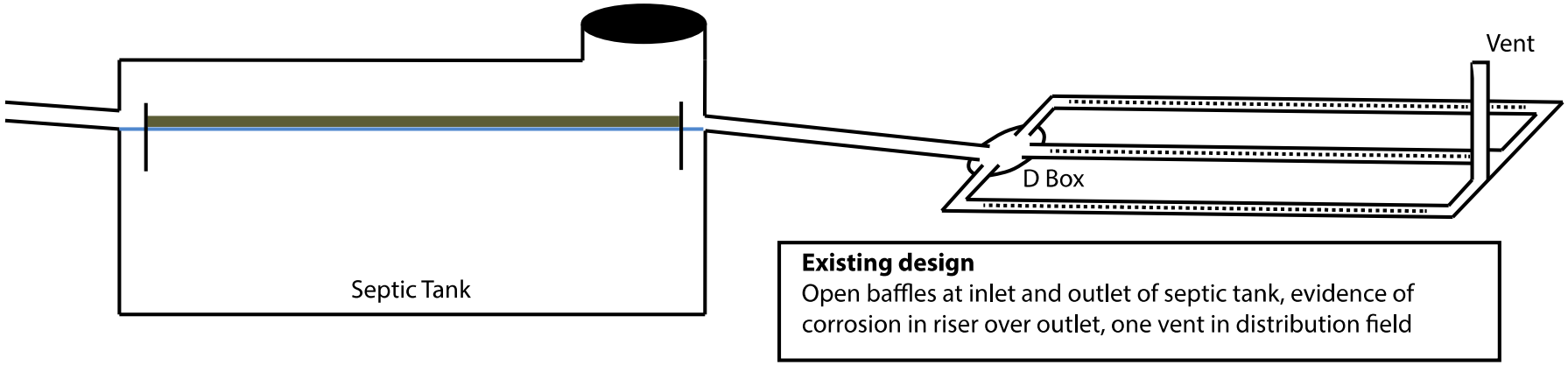
Objective 2

- Test how **capping outlet tee baffle** affects H_2S gas magnitude and distribution

Site 1 system layout (Random Lake, WI)



Site 1 pre-modification



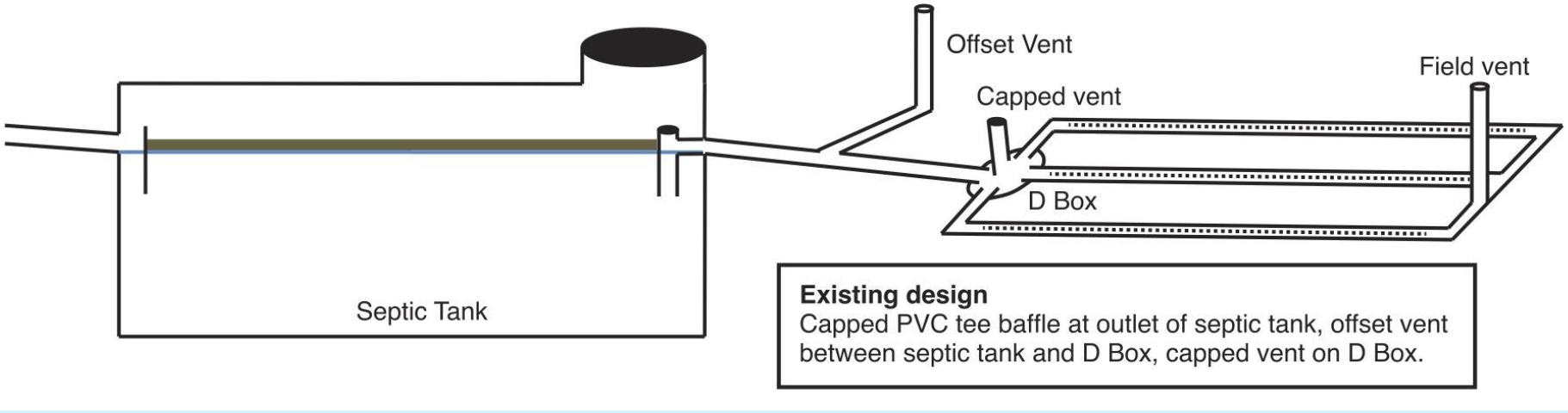
Bottom side of cover of tank

Existing open baffle at septic tank outlet

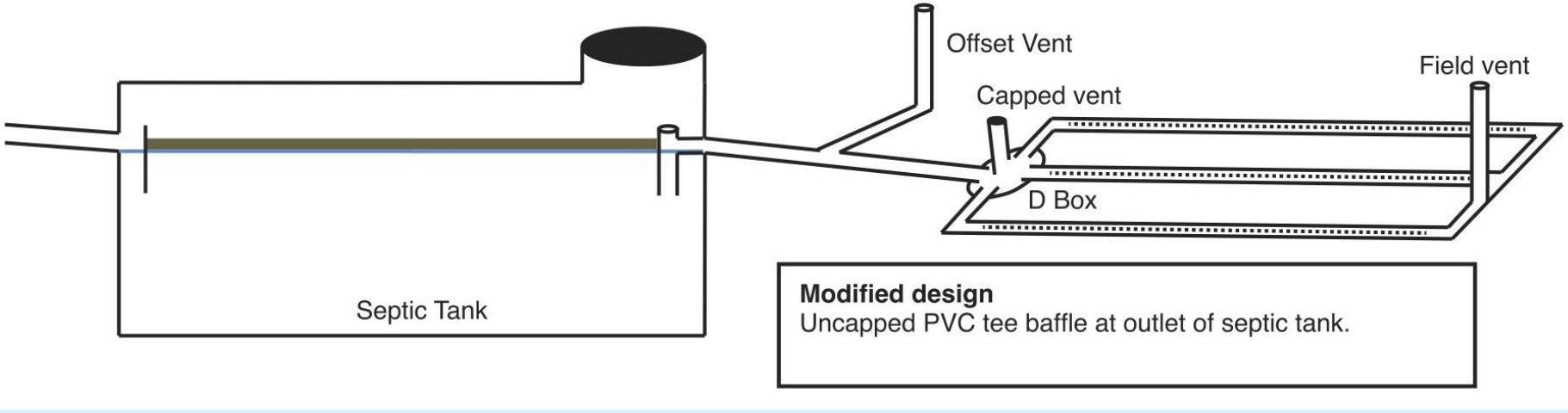
New modified outlet baffle

New offset vent added to existing effluent line

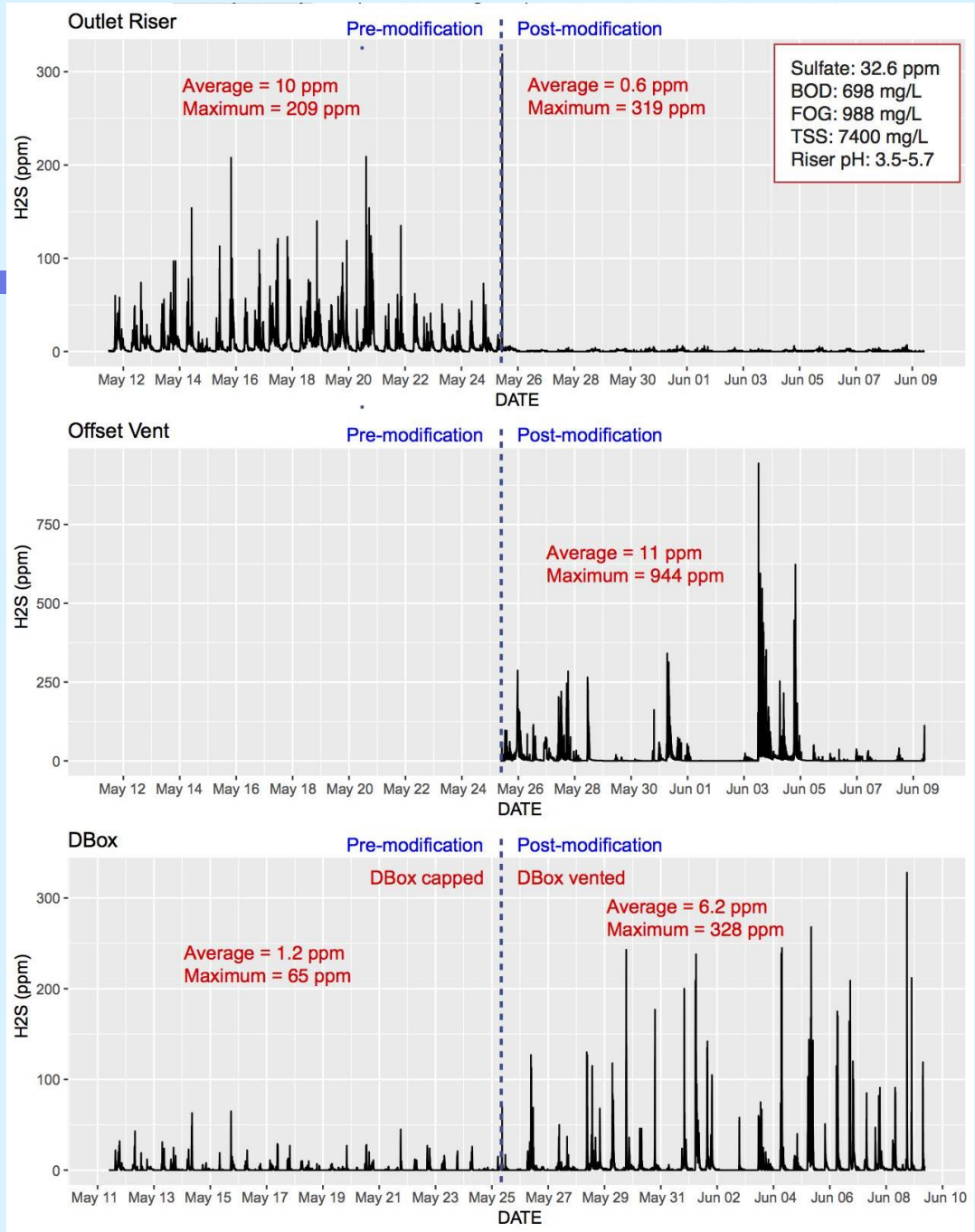
Site 1 - Objective 2



Existing design
Capped PVC tee baffle at outlet of septic tank, offset vent between septic tank and D Box, capped vent on D Box.



Modified design
Uncapped PVC tee baffle at outlet of septic tank.



Average Sulfide Conc.

Pre-Modification (2018)

- Outlet riser = 10 ppm

Post-Modification

- Outlet riser = 0.6 ppm

One year later (2019)

- Outlet riser = 0.06 ppm

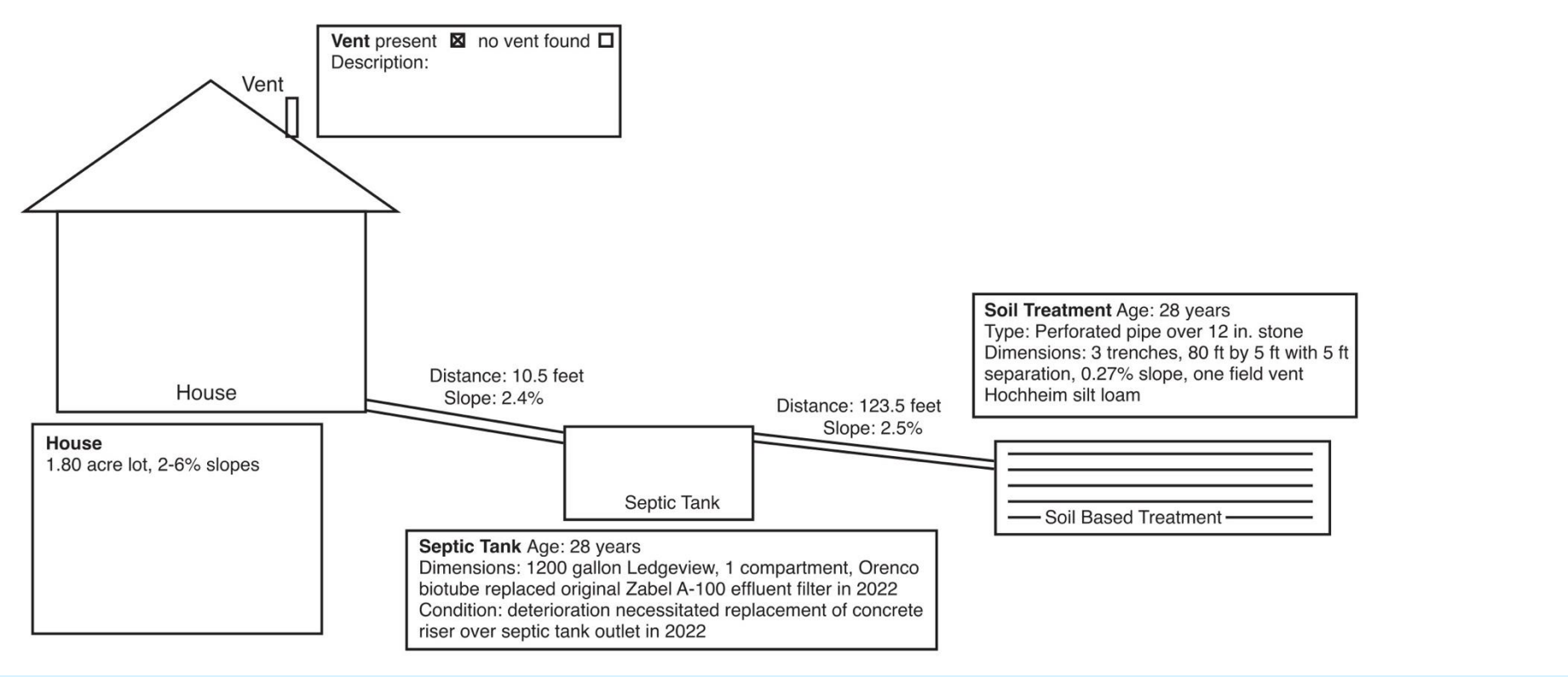
Outlet tee uncapped (2022)

- Outlet riser = 34.1 ppm

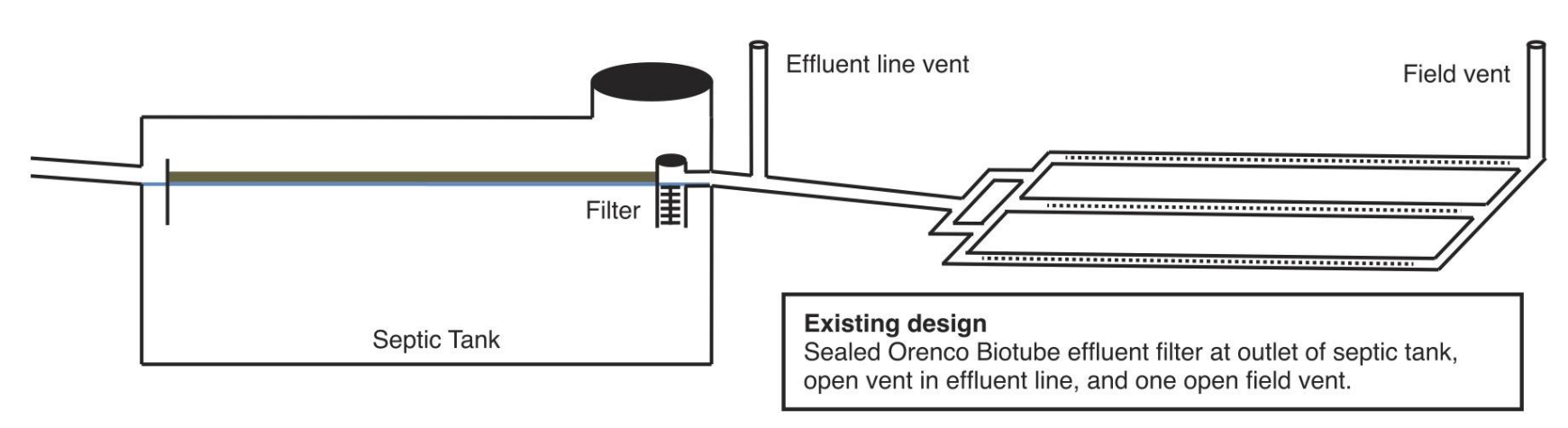
Objective 3

- Test how **adding odor filter to modified vents** affects H_2S gas magnitude and distribution

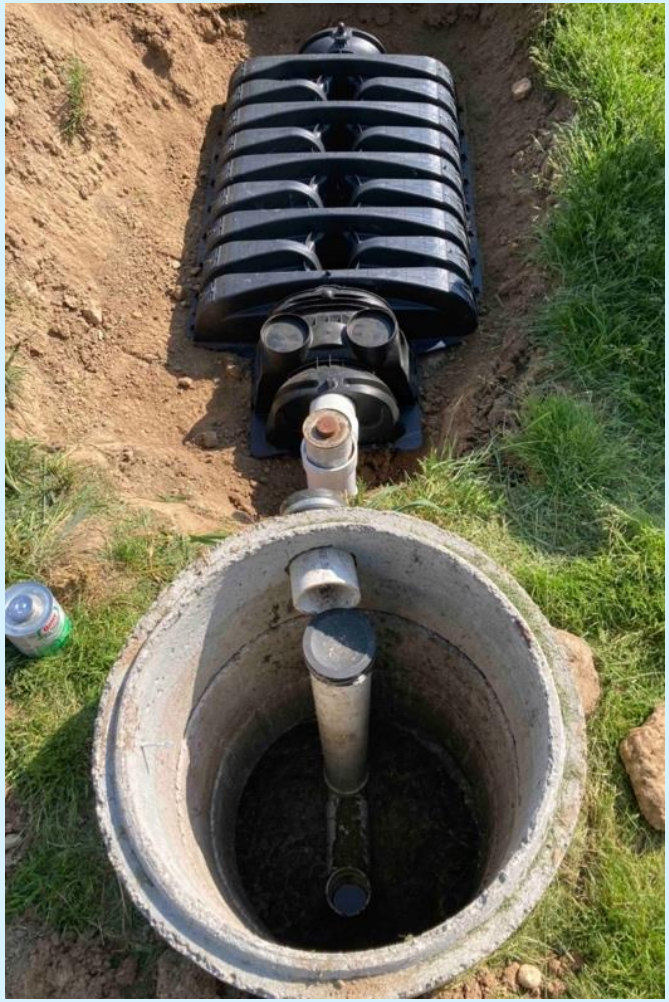
Site 5 system layout (Plymouth, WI)



Site 5 pre-modification

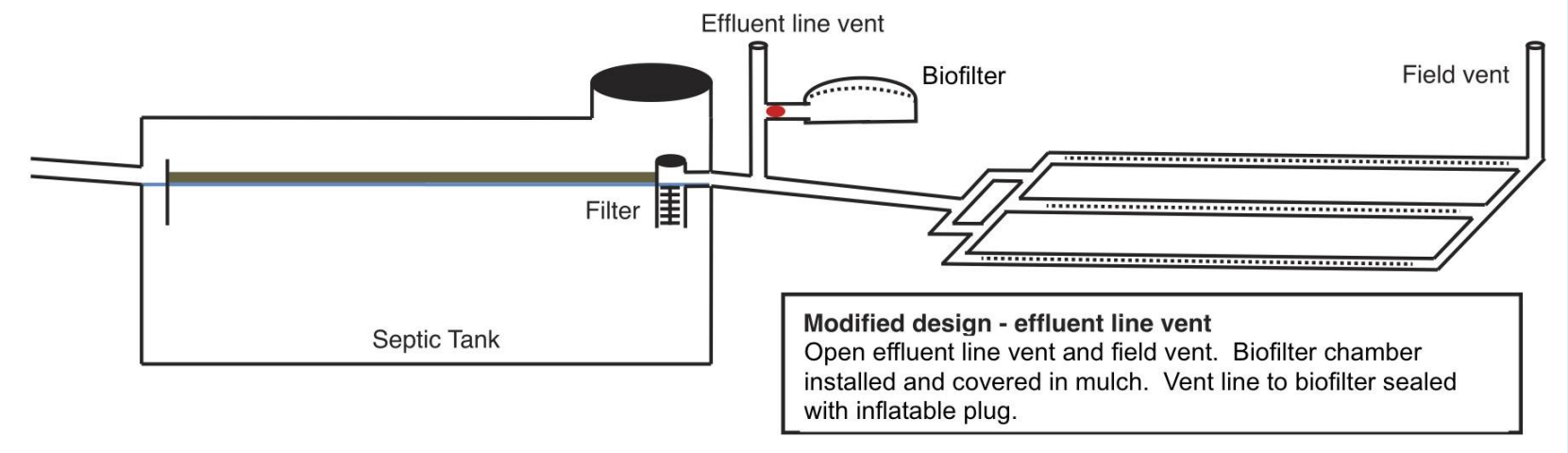


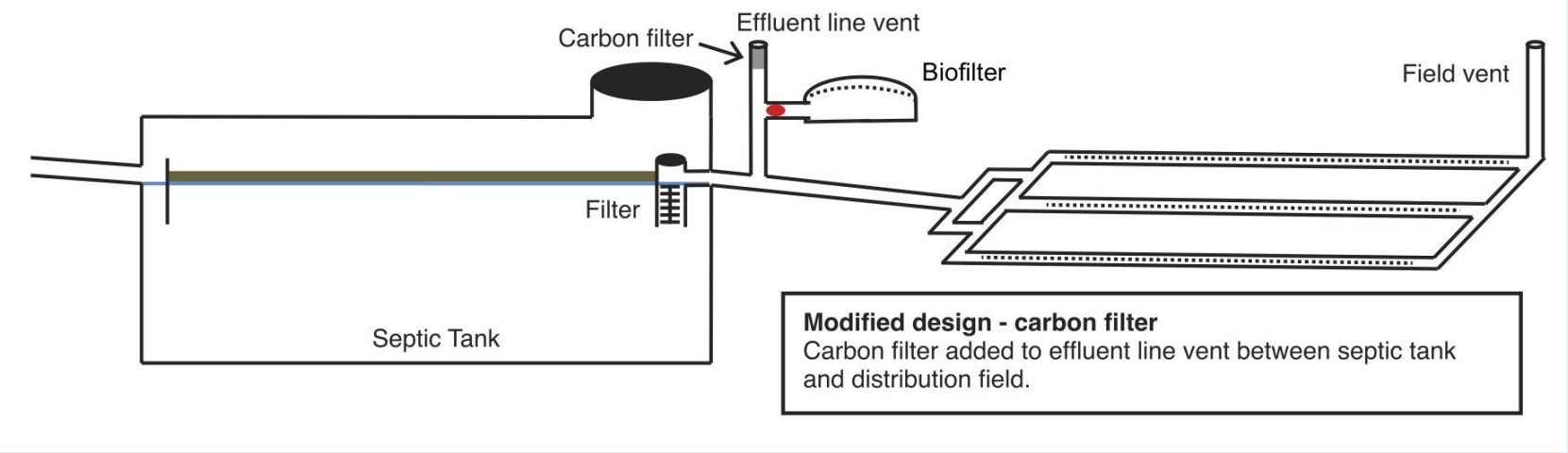
Biofilter installation



Biofilter installation

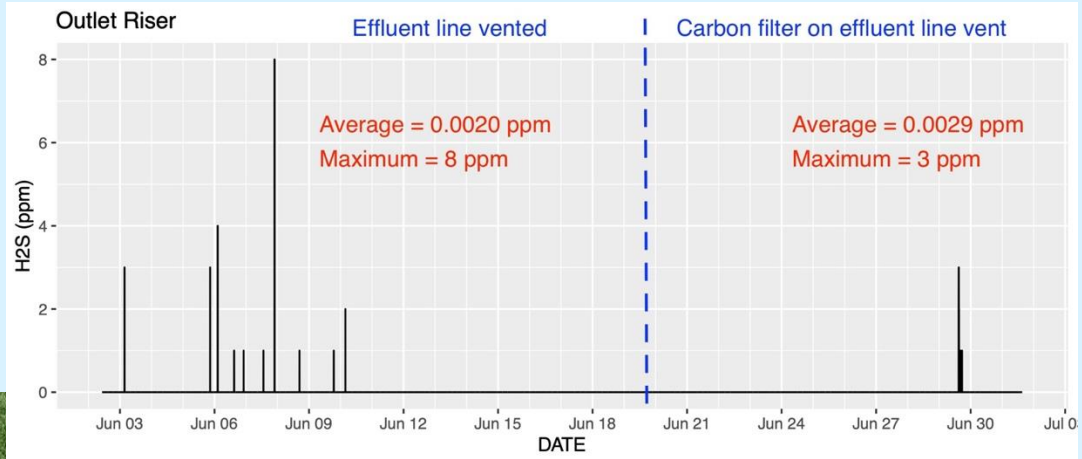
Site 5 – Objective 3

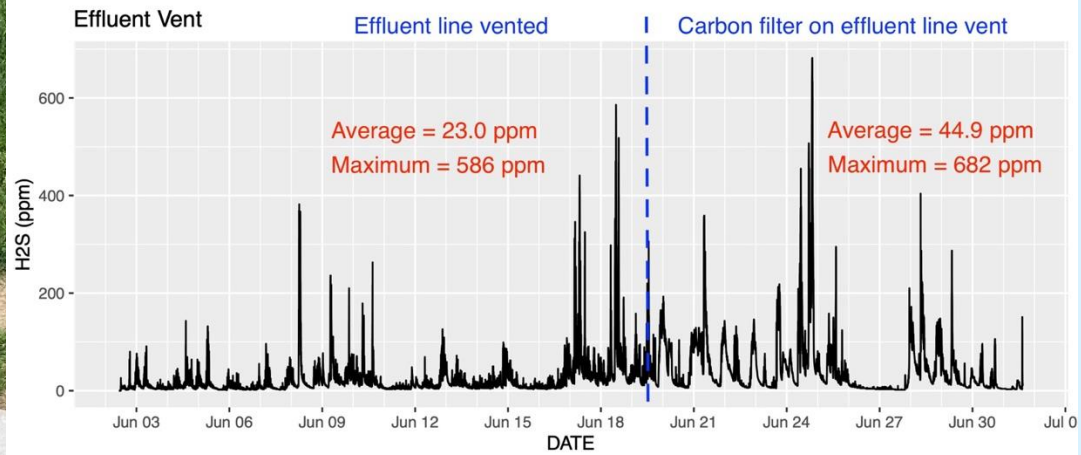


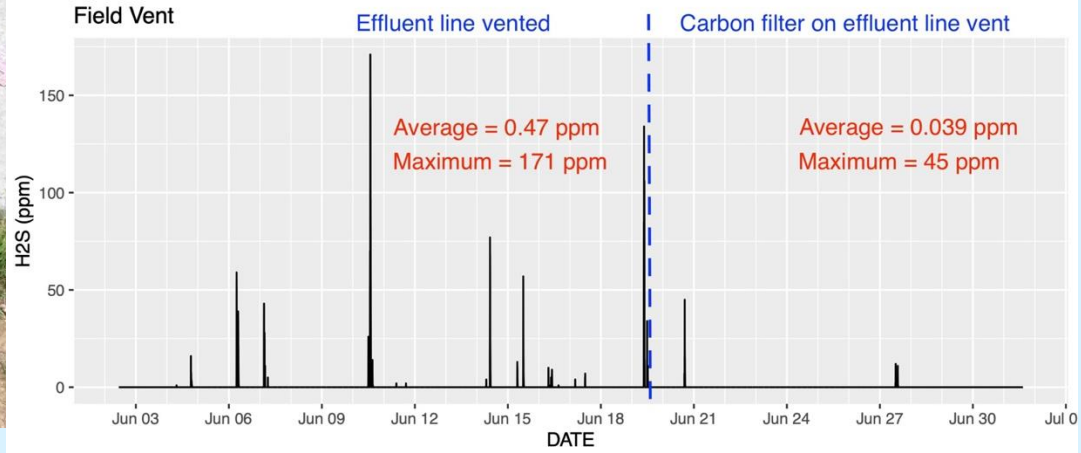


Carbon filter added to top of effluent line vent pipe

Objective 3 results



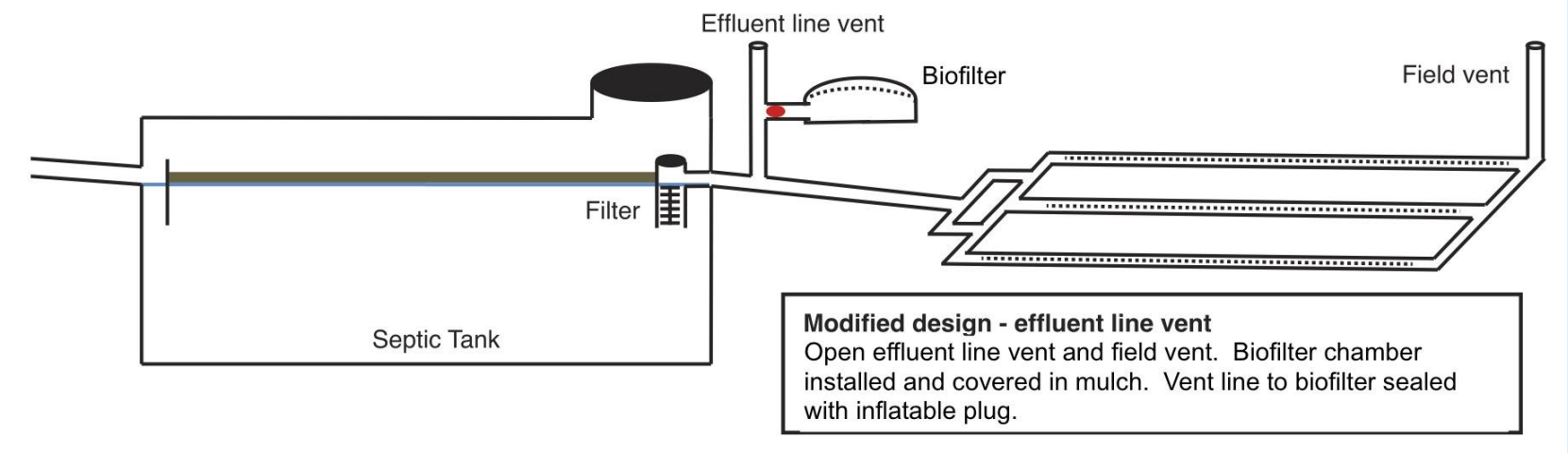


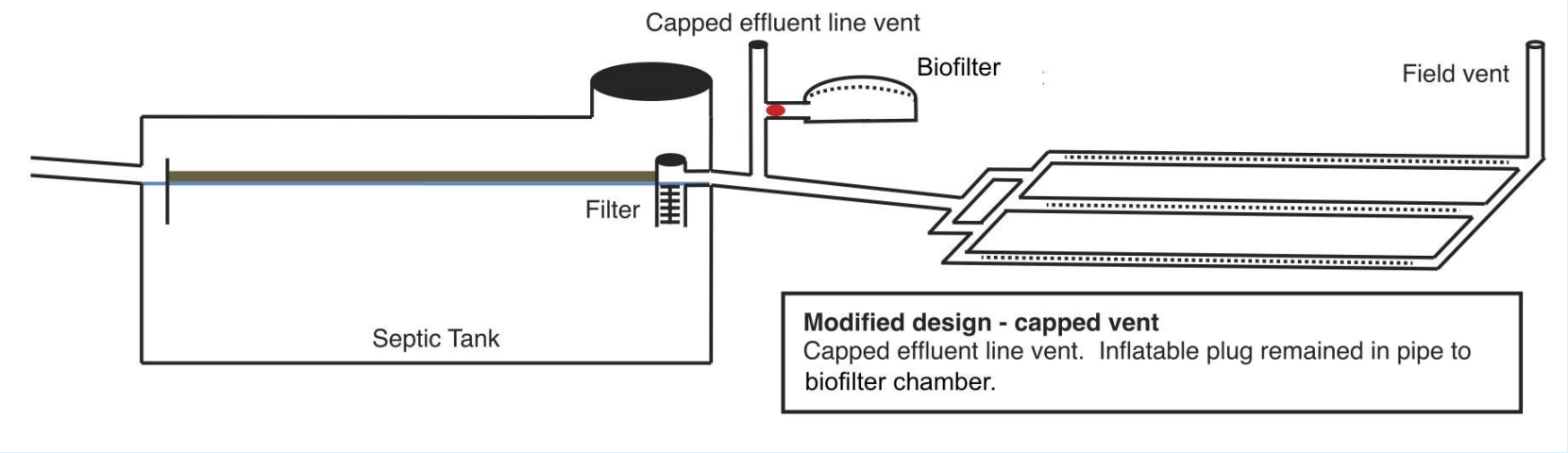


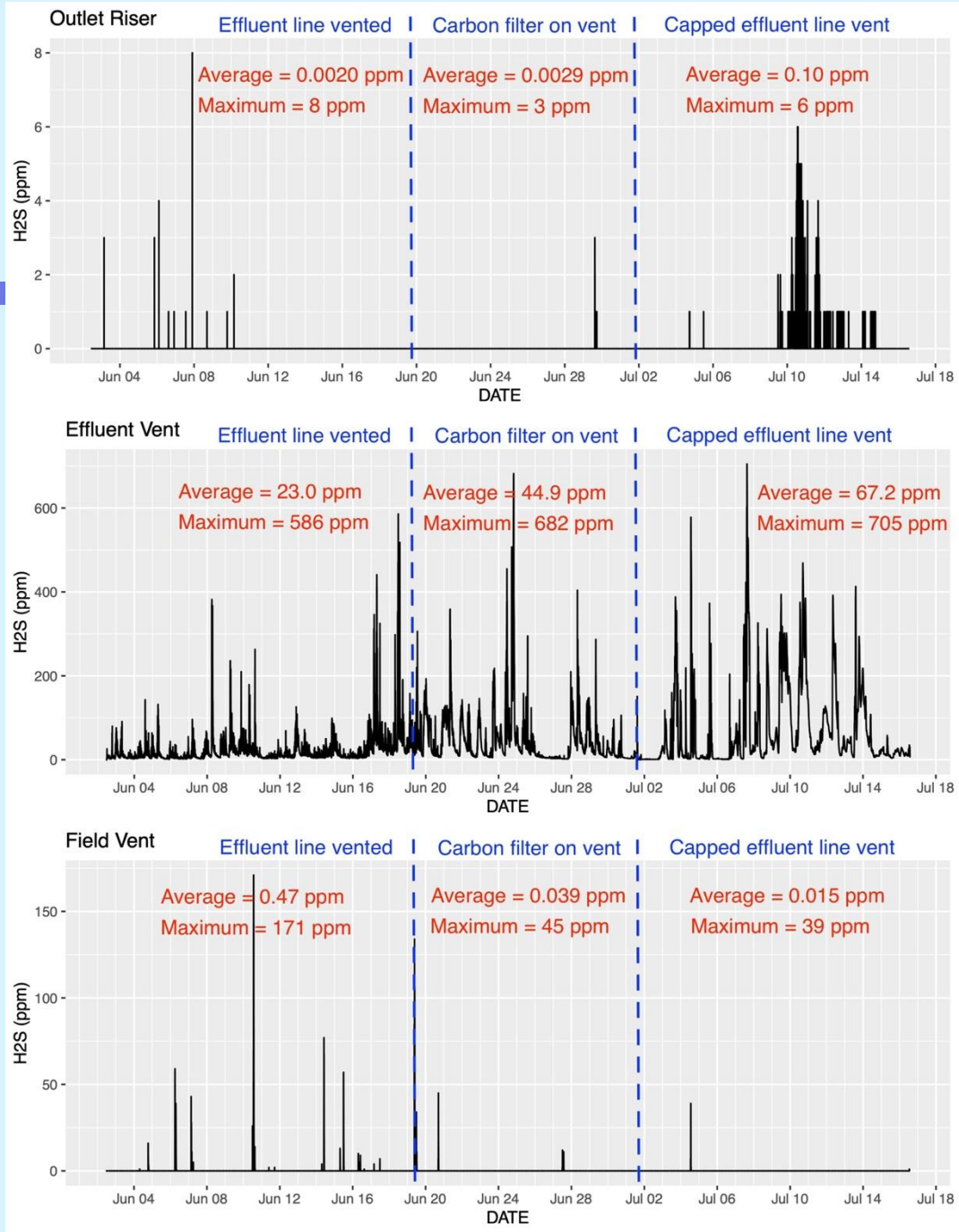
Objective 4

- Test how **capping modified vents** affects H_2S gas magnitude and distribution

Site 5 – Objective 4







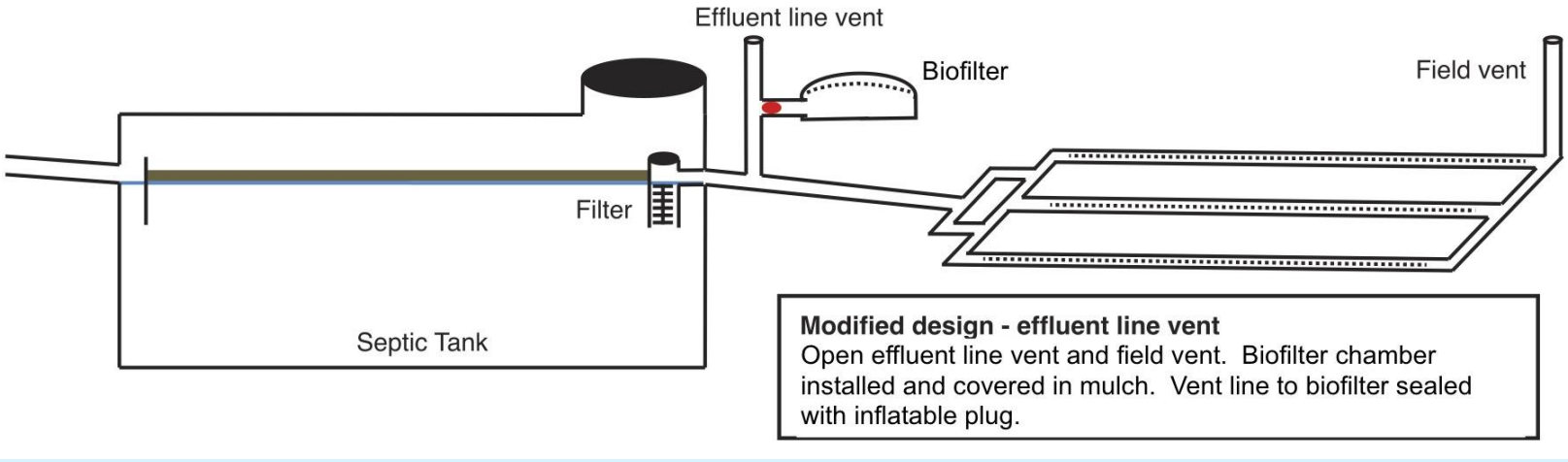
Objective 4 results

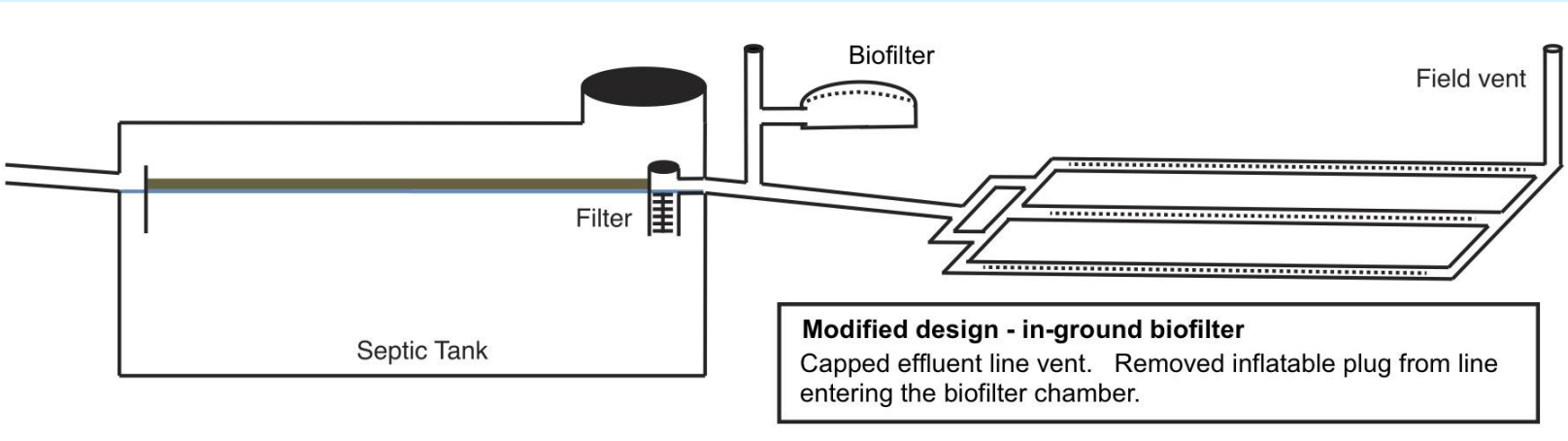
- Capping vent in effluent line reduced emissions from field vent but modestly increased H_2S gas in septic tank

Objective 5

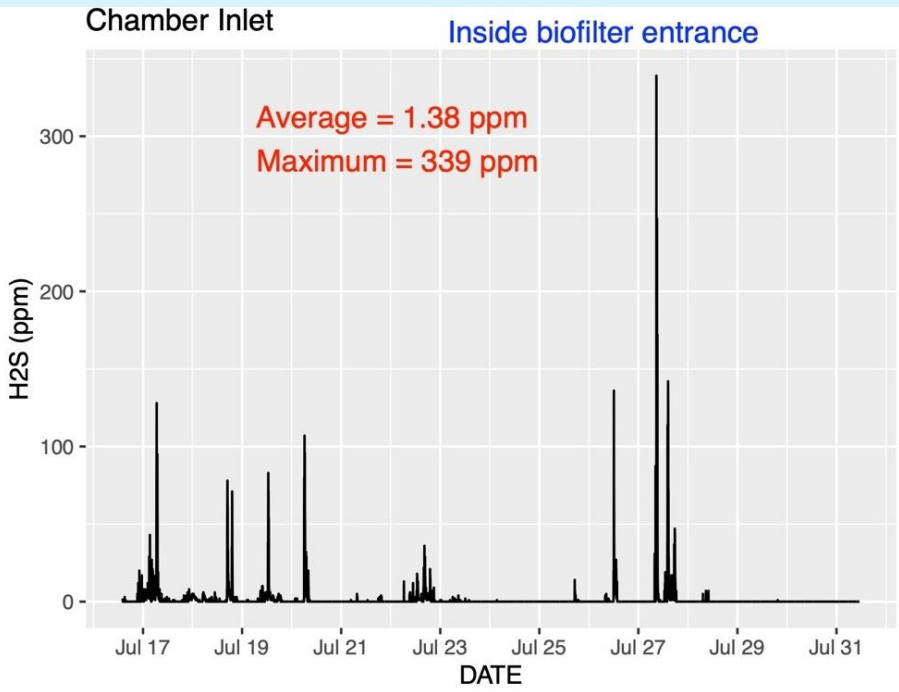
- Test how **in-ground biofilters** affect H_2S gas magnitude and distribution

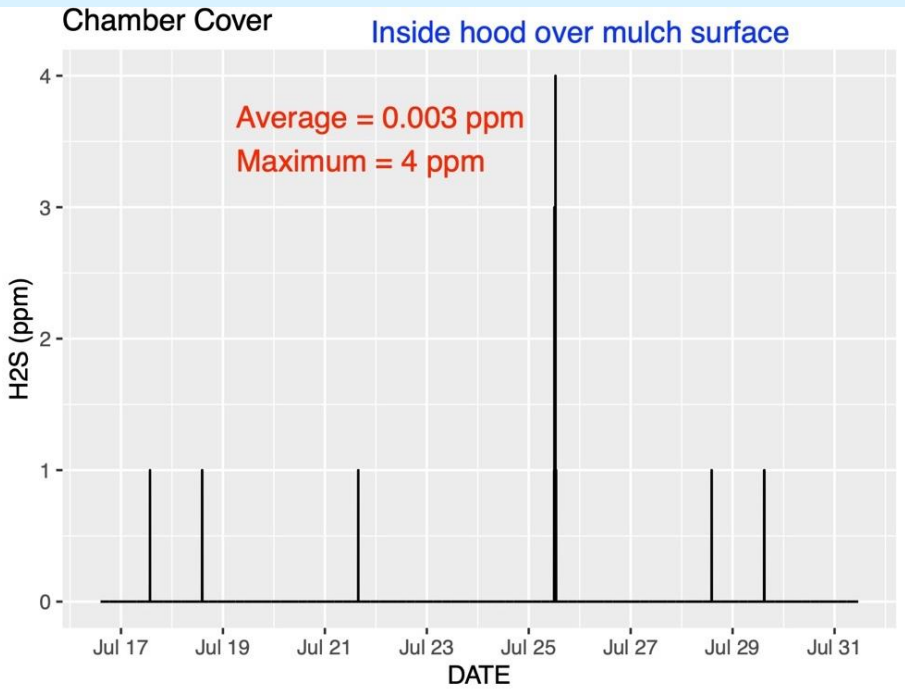
Site 5 – Objective 5

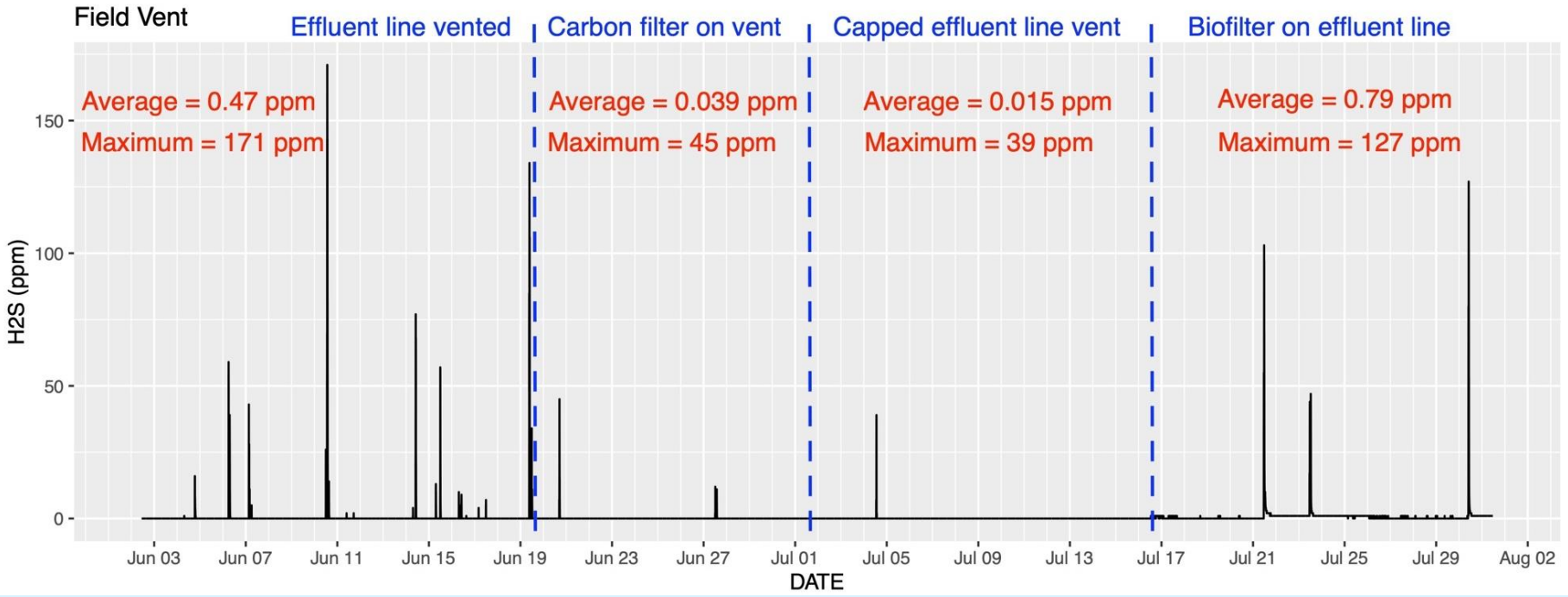


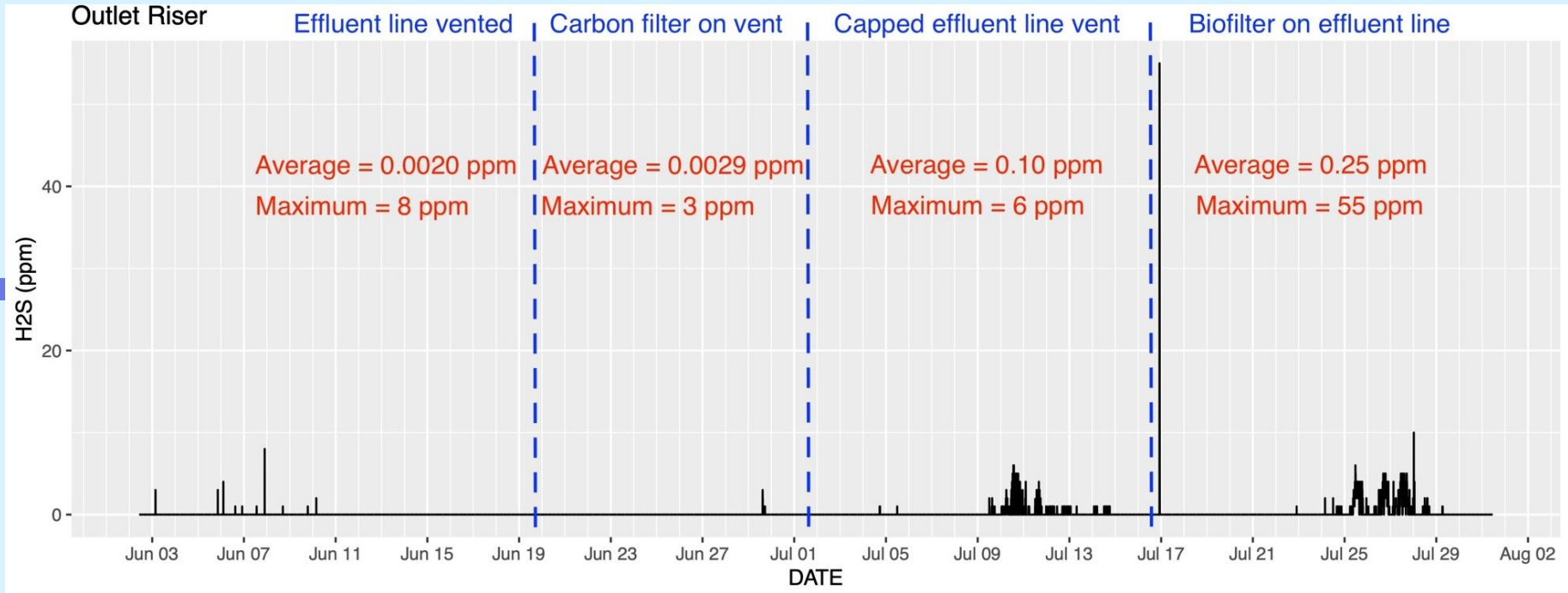


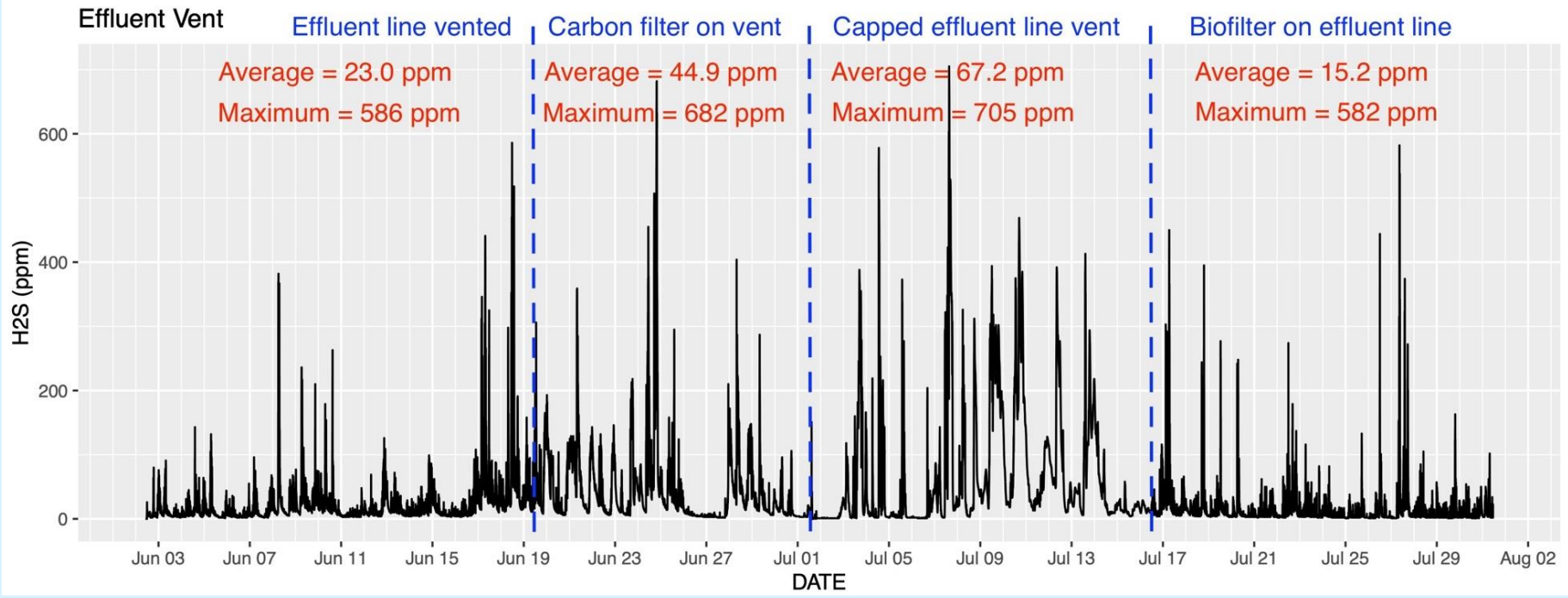
Biofilter emissions sampling


Chamber Inlet
Inside biofilter entrance
Average = 1.38 ppm
Maximum = 339 ppm
H2S (ppm)
0
100
200
300
Jul 17
Jul 19
Jul 21
Jul 23
Jul 25
Jul 27
Jul 29
Jul 31
DATE


Chamber Cover
Inside hood over mulch surface
Average = 0.003 ppm
Maximum = 4 ppm
H2S (ppm)
0
1
2
3
4
Jul 17
Jul 19
Jul 21
Jul 23
Jul 25
Jul 27
Jul 29
Jul 31
DATE


Field Vent
Effluent line vented
Carbon filter on vent
Capped effluent line vent
Biofilter on effluent line
Average = 0.47 ppm
Maximum = 171 ppm
Average = 0.039 ppm
Maximum = 45 ppm
Average = 0.015 ppm
Maximum = 39 ppm
Average = 0.79 ppm
Maximum = 127 ppm
H2S (ppm)
0
50
100
150
Jun 03
Jun 07
Jun 11
Jun 15
Jun 19
Jun 23
Jun 27
Jul 01
Jul 05
Jul 09
Jul 13
Jul 17
Jul 21
Jul 25
Jul 29
Aug 02
DATE


Outlet Riser
Effluent line vented
Carbon filter on vent
Capped effluent line vent
Biofilter on effluent line
Average = 0.0020 ppm
Maximum = 8 ppm
Average = 0.0029 ppm
Maximum = 3 ppm
Average = 0.10 ppm
Maximum = 6 ppm
Average = 0.25 ppm
Maximum = 55 ppm
H2S (ppm)
0
20
40
Jun 03
Jun 07
Jun 11
Jun 15
Jun 19
Jun 23
Jun 27
Jul 01
Jul 05
Jul 09
Jul 13
Jul 17
Jul 21
Jul 25
Jul 29
Aug 02
DATE


Effluent Vent
Effluent line vented
Carbon filter on vent
Capped effluent line vent
Biofilter on effluent line
Average = 23.0 ppm
Maximum = 586 ppm
Average = 44.9 ppm
Maximum = 682 ppm
Average = 67.2 ppm
Maximum = 705 ppm
Average = 15.2 ppm
Maximum = 582 ppm
H2S (ppm)
0
200
400
600
Jun 03
Jun 07
Jun 11
Jun 15
Jun 19
Jun 23
Jun 27
Jul 01
Jul 05
Jul 09
Jul 13
Jul 17
Jul 21
Jul 25
Jul 29
Aug 02
DATE

Primary conclusions

- Open baffles at septic tank outlet should be replaced by capped baffles
- Effluent filters should be covered to reduce H_2S gas release in septic tank
- Carbon filters are effective at reducing odors from vent pipes without exacerbating MICC

QUESTIONS