Metropolitan Water Reclamation District of Greater Chicago

Welcome to the July Edition of the 2024 M&R Seminar Series

NOTES FOR SEMINAR ATTENDEES

- Remote attendees' audio lines have been muted to minimize background noise.
  For attendees in the auditorium, please silence your phones.
- A question and answer (Q/A) session will follow the presentation.
- For remote attendees, please use "**Chat**" only to type questions for the presenter. For other issues, please email Pam to SlabyP@mwrd.org.
  For attendees in the auditorium, please raise your hand and wait for the microphone to ask a verbal question.
- The presentation slides will be posted on the MWRD website after the seminar.
- This seminar has been approved by the ISPE for one PDH and approved by the IEPA for one TCH. Certificates will be issued only to participants who attend the entire presentation.

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LOS ANGELES COUNTY SANITATION DISTRICTS

100 YEARS

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A Pilot Study on Biotrickling Filters Using Synthetic Media for Design of Full-Scale Odor Control Facilities

MWRD Monitoring and Research Seminar

Warner Song

July 2024

Los Angeles County Sanitation Districts (LACSD)

- Wastewater Management:
  - 11 wastewater treatment plants
  - 1,400 miles of sewers
  - Serving ~5.5 million people
  - 850 square miles of service area
- Solid Waste Management
  - Landfills
  - Recycling centers
- Converting Waste Into Resources
  - 100 mgd of recycled water
  - 67 megawatts of electricity

Los Coyotes Water Reclamation Plant (LCWRP)

- ❑ 38 mgd capacity plant
- ❑ Odor complaints from neighbors and nearby commuters
- ❑ Planning is underway for an odor control facility

Current Odor Control System at LCWRP

- Activated Sludge Diffusion
  - Collects odorous air, directs it to the suction side of aeration blowers, and diffuses it into aeration tanks
  - Poorly designed ducting layout
  - Corrosive air incompatible with new tech aeration blowers
- Mobile Carbon Scrubbers
  - 8 ft diameter 3 feet deep carbon bed
  - Lasts 3 to 5 days to maintain outlet H_2S concentration less than 1 ppm

LACSD's Odor Control Facilities

- ❑ Stand-alone biotrickling filter (BTF)

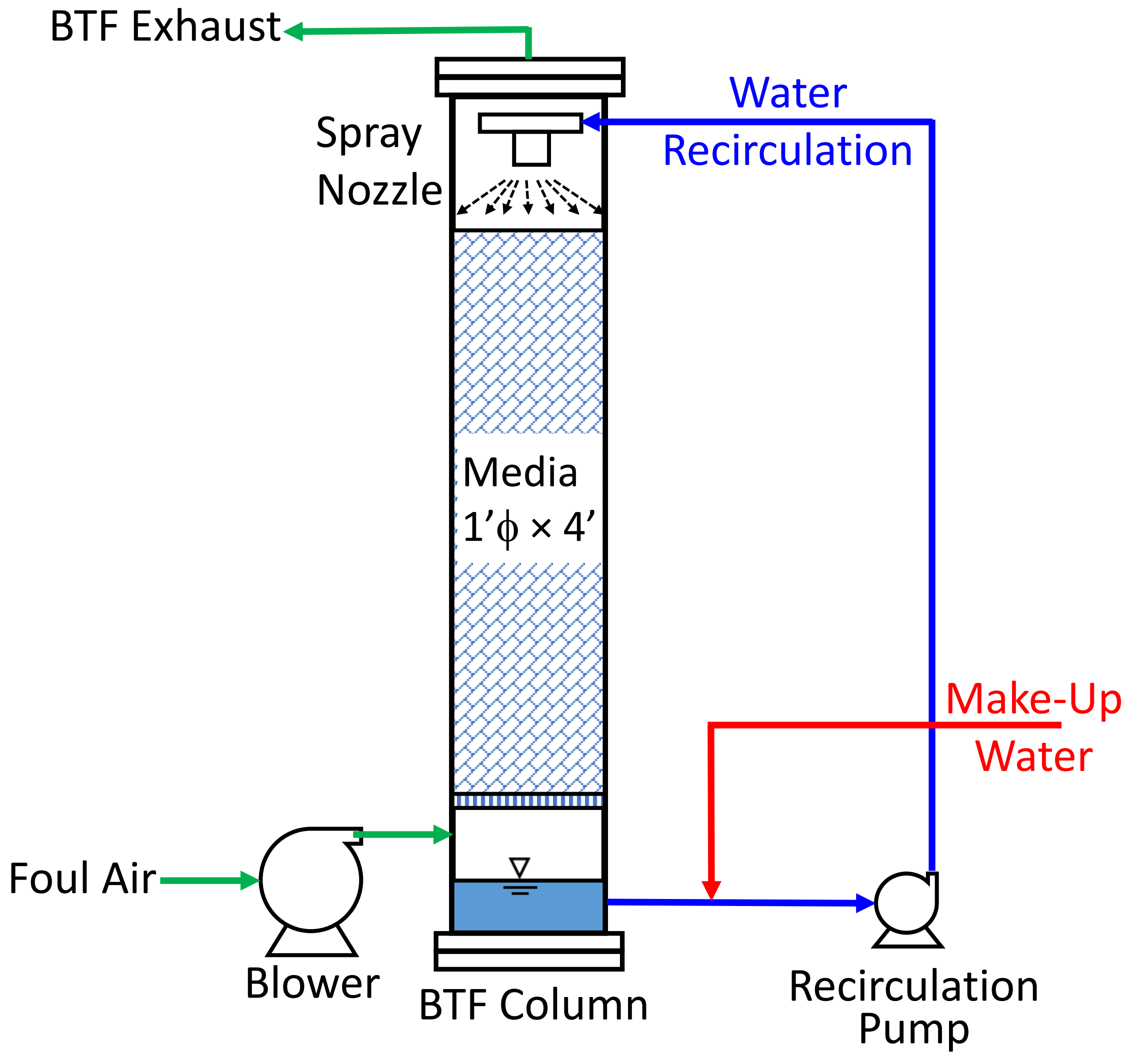
- ❑ Combined BTF & carbon scrubber

  → BTF removes most H_2S, and carbon scrubber removes residual H_2S and other odorous compounds.

LACSD's BTF Media

- Lava rock
  - Performance initially good but declined
  - Heavy (stress on media support)
- Synthetic media
  - Installed different types at several plants
  - Need side-by-side testing to compare performance → **Pilot testing**

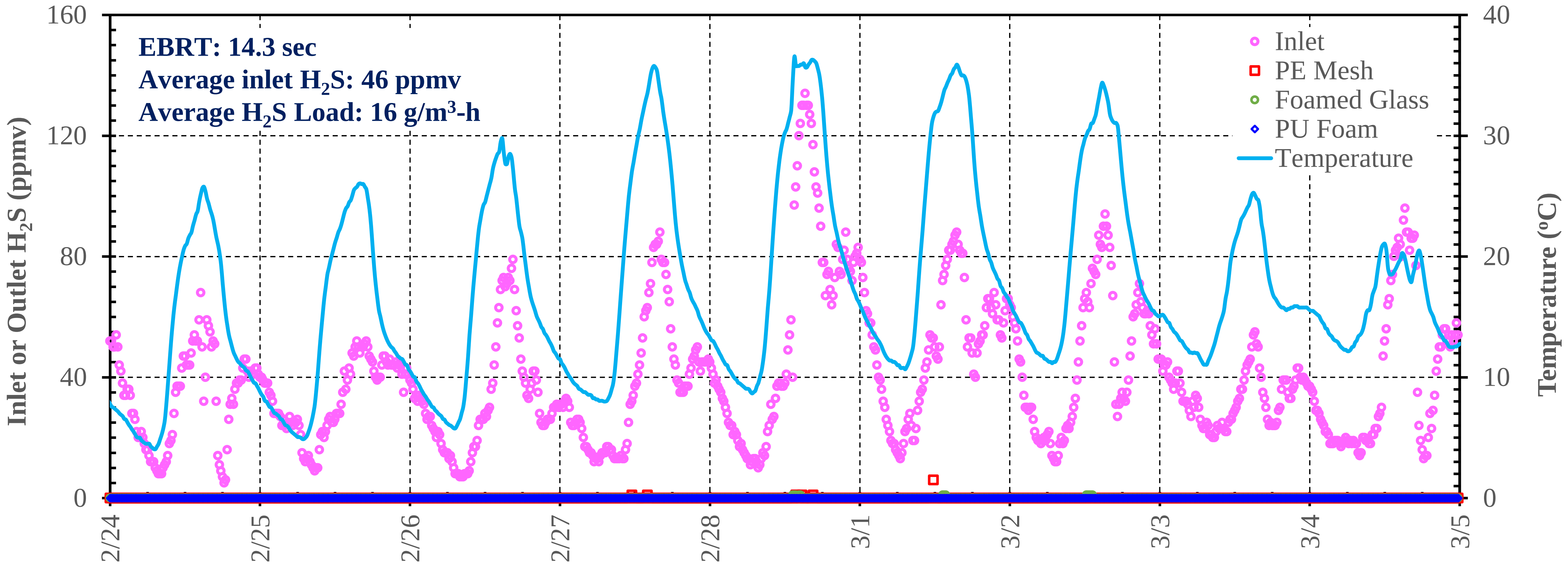
Schematic of Pilot-Scale BTF



- Foul Air
  - Upflow
  - H_2S is oxidized to S° and SO_4 → pH drops
- Recirculation Water
  - Downflow
  - Provide moisture & nutrients
  - Add make-up water to maintain pH ~2 (1.5–2.5)

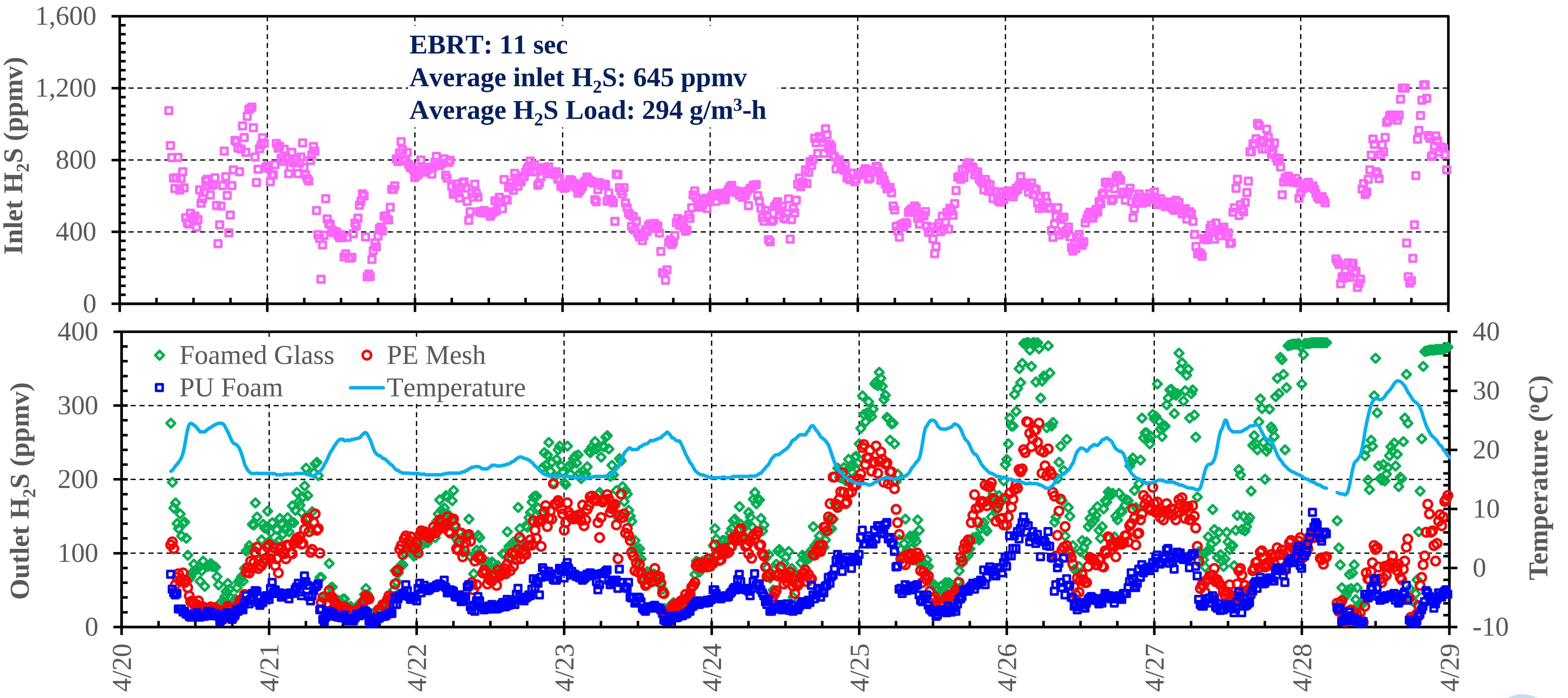
Pilot-Scale BTFs at LCWRP

Diurnal Pattern at Low H_2S Loading

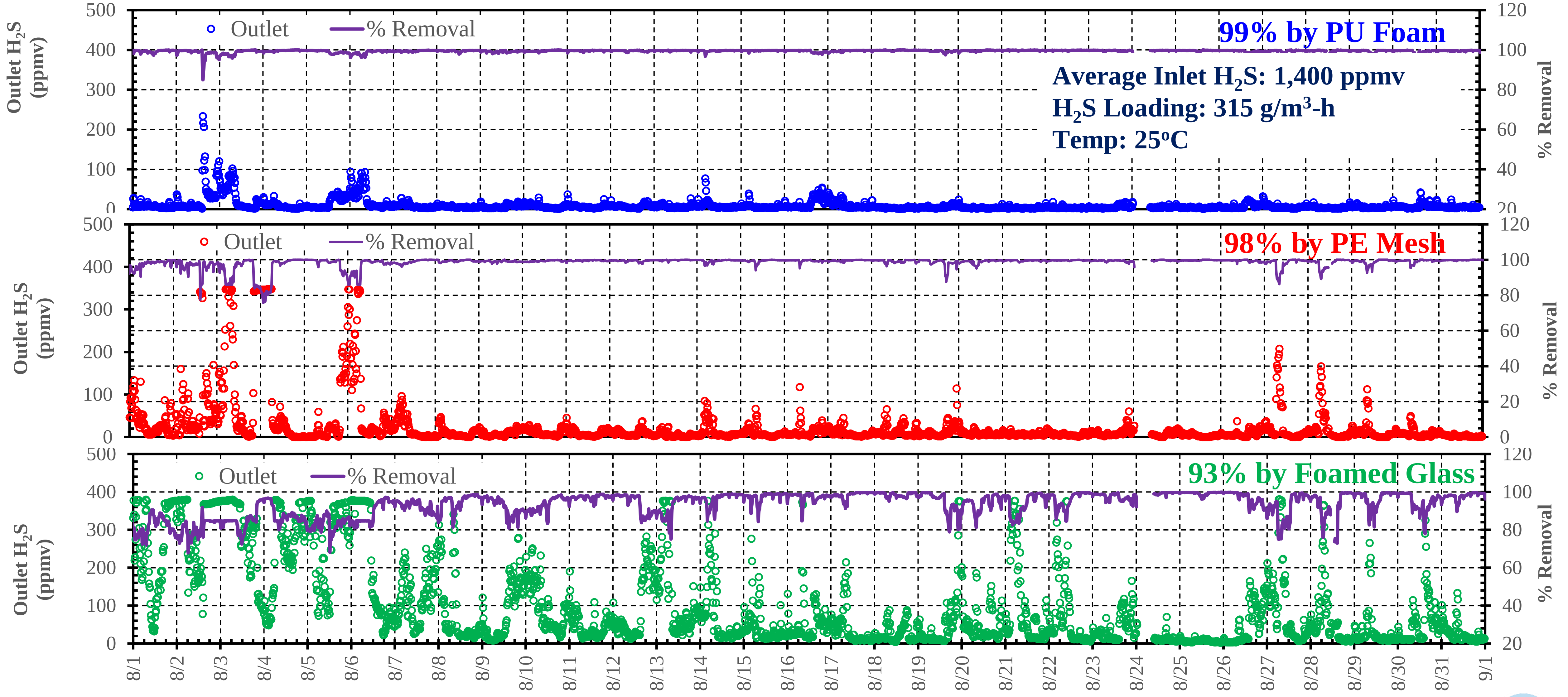


- All media achieve **nearly complete H_2S removal**
- Daily peaks in **H_2S load** and **temperature**

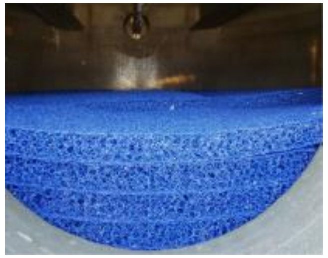
Diurnal Pattern at High H_2S Loading



Representative BTF Performance Data



Synthetic Media Properties

Media	Foamed Glass	PU Foam	PE Mesh (Low Density)	PE Mesh (High Density)
Image				
Material	Calcium Silicate	Polyurethane	Polyethylene	Polyethylene
Specific Surface Area	**600 sf/cf**	140-160 sf/cf	61 sf/cf	114 sf/cf
Porosity	**80-90%** **(51%)**	96-97% **(96%)**	92%	94%
Unit Cost	$10/cf	$25/cf	$48/cf	$50/cf

← Biological growth

← Contact time

- ❑ Poor performance of foamed glass is unexpected
- ❑ Porosity: spec of **80-90%** vs **51%** measured

Virgin vs Used Foamed Glass

- Biofilm on external surface only
  → Internal pores are inaccessible
- Actual residence time (51% of porosity)
  → e.g., 51% × 14 s of EBRT = 7.1 s

Permeability Assessment of Foamed Glass using Dye

After 1 Day

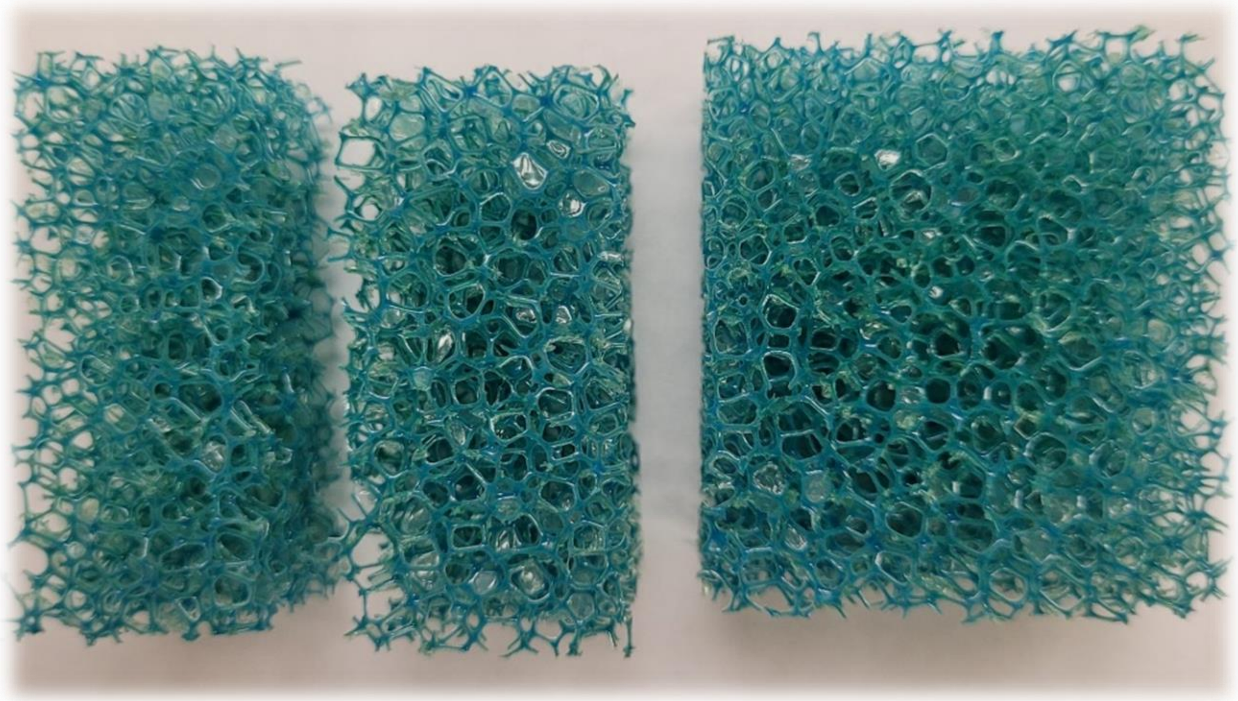
After 1 Week

After 2 Weeks

After 4 Weeks

- ❑ Dye gradually penetrated over time but didn’t reach internal pores
- ❑ **Internal pores**, along with their **associated surface area**, are **inaccessible** to water

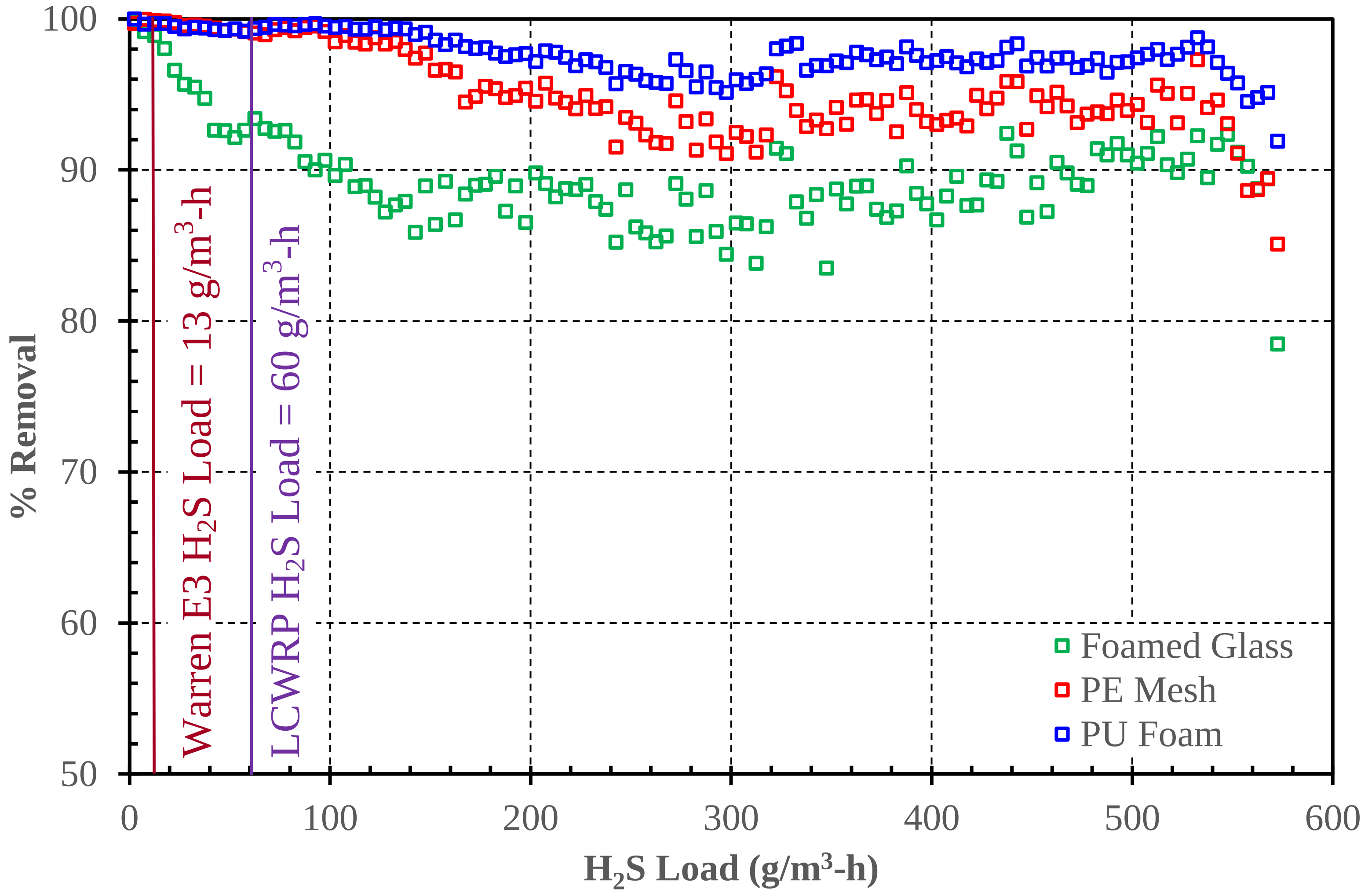
Cut Faces of Virgin and Used PU Foam



- ❑ Biofilms on both (i) External surface and (ii) Internal pore surface
- ❑ 96% of porosity allows effective residence time close to EBRT

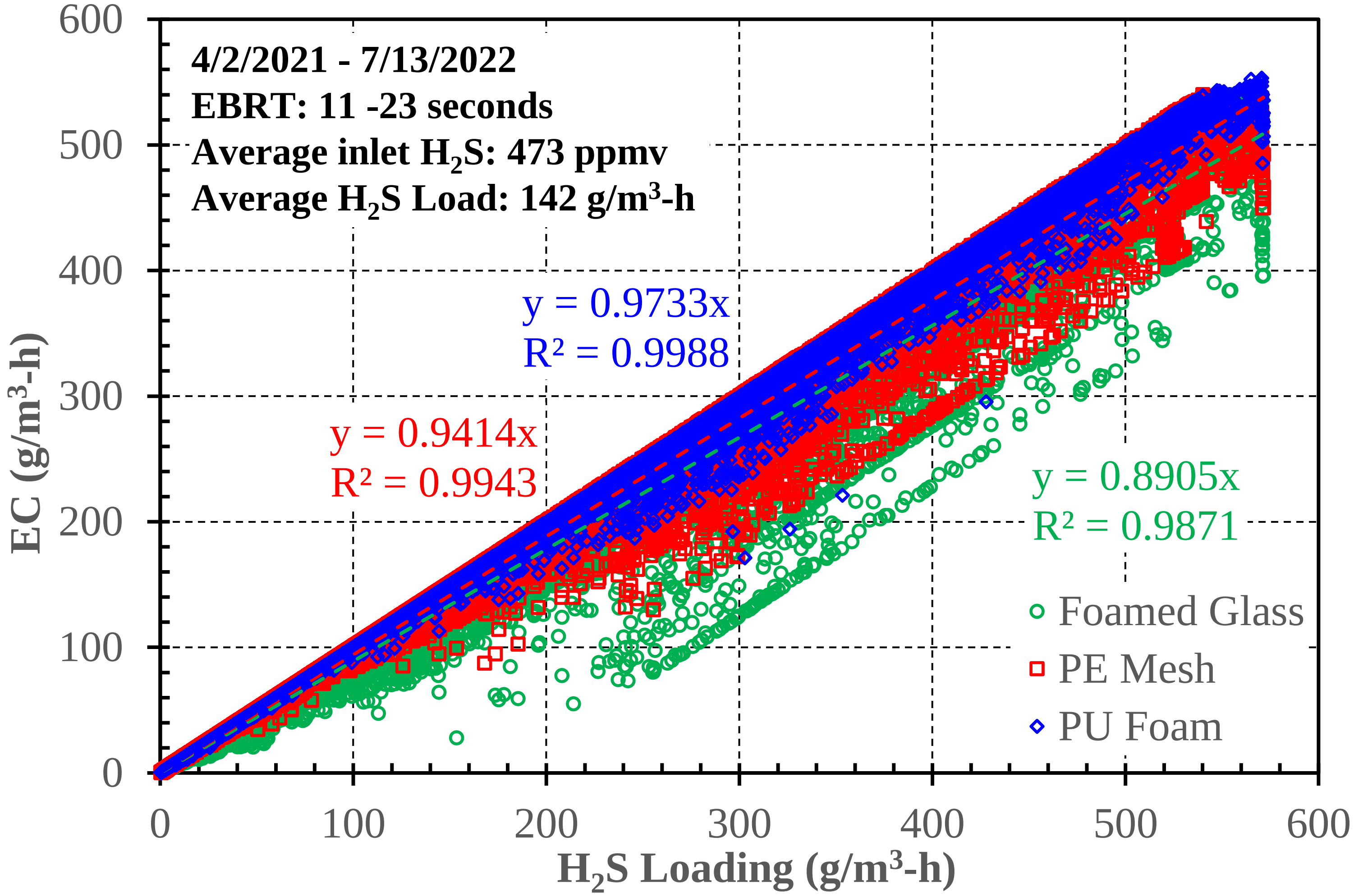
  e.g., Actual residence time = 96% × 14 s of EBRT = 13.4 s

H_2S Removal vs H_2S Loading



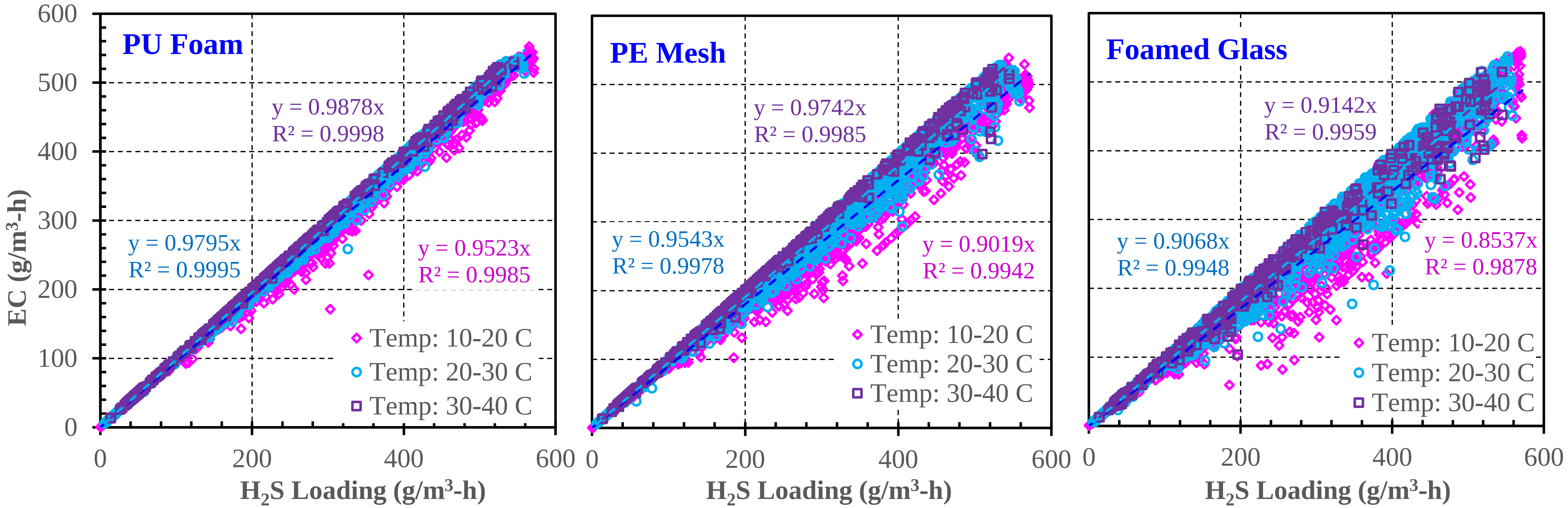
- H_2S removal declines at high H_2S loadings
- Foamed-glass showed the biggest drop in removal efficiency
- Can predict the BTF performance with the selected media

Elimination Capacity (EC) versus H_2S Loading



- PU foam provides the highest EC, followed by PE mesh, then foamed-glass
- EC increased linearly with H_2S loading due to more biomass and higher removal rate

Temperature Influence on H_2S EC



- Higher and less variable EC at higher temperatures
- PU foam most consistent, then PE mesh, then foamed glass at various **H_2S loading** and **ambient temperature** (diurnal and seasonal variations)

Visual Inspection of Used Media

Media	PU Foam	PE Mesh	Foamed Glass
Top			
Middle			
Bottom			

- ❑ No signs of media compression, deformation, or deterioration
- ❑ More biofilm and elemental sulfur on the bottom

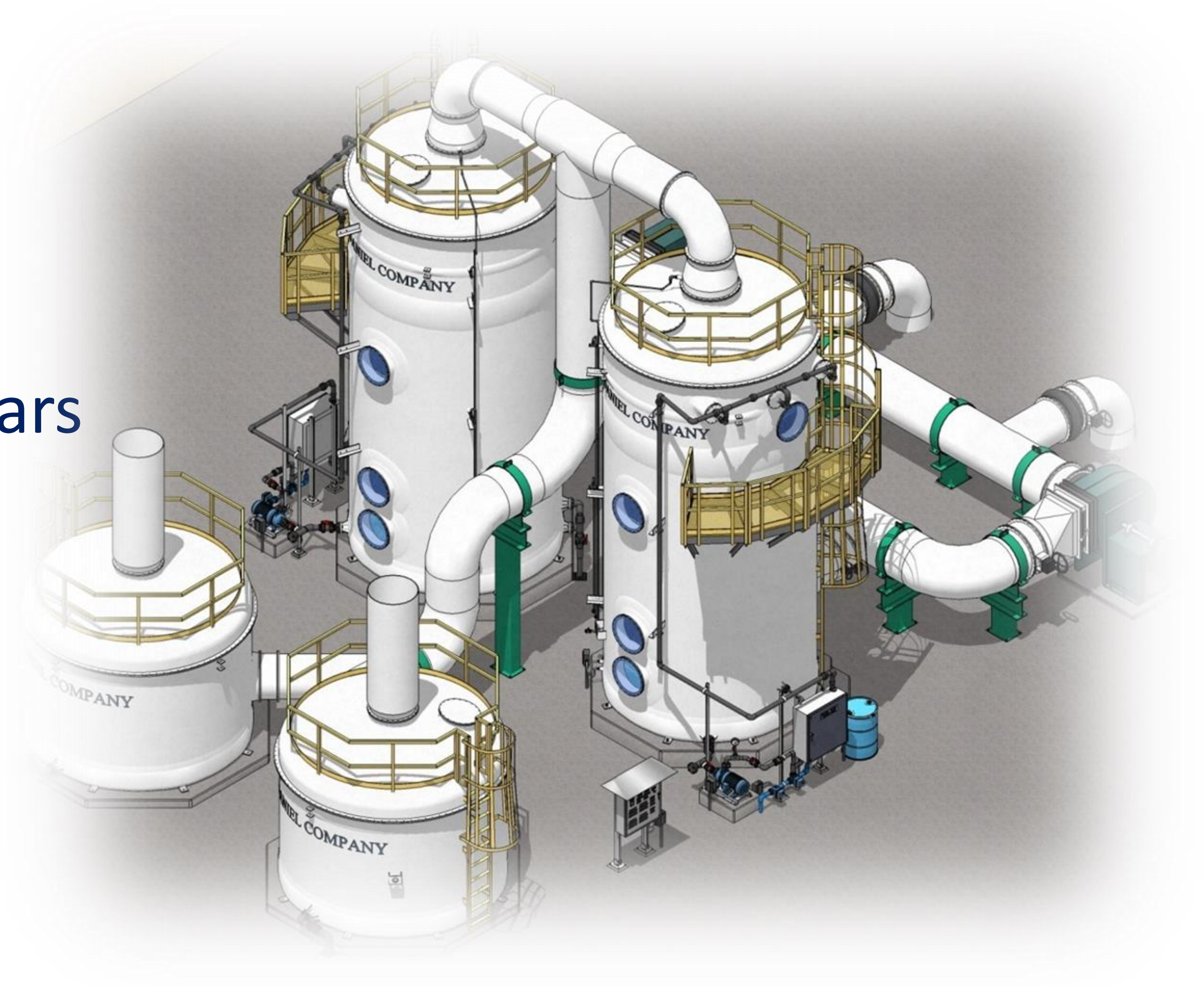
Cost-Effective Media Selection

❑ Warren Facility E3 Odor Control Facility

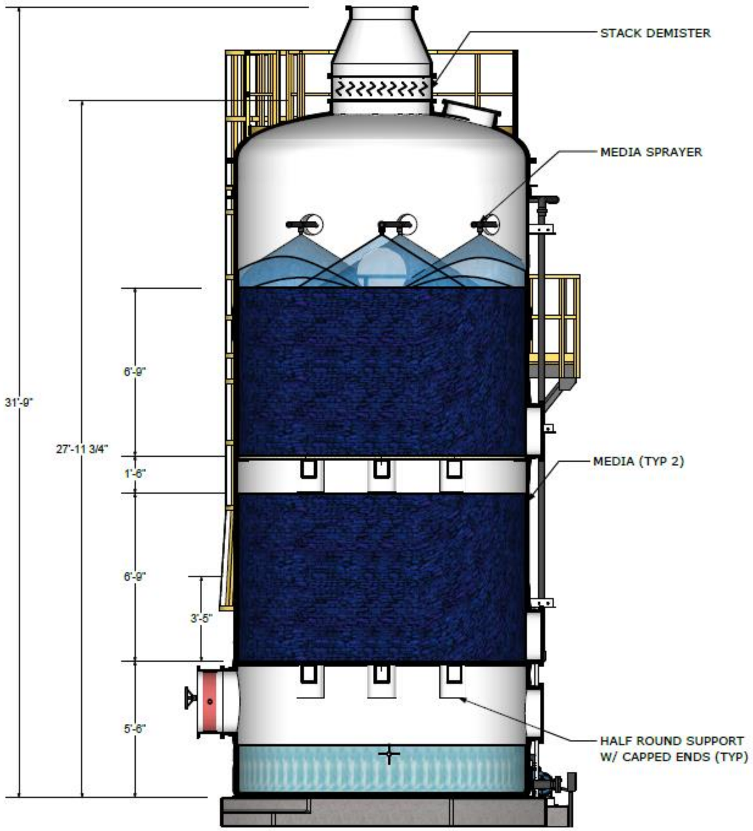
- H_2S loading: ~13 g/m^3-h
- Media bed depth: 12.5 ft
- Installed **foamed glass**
- Achieved > 98% removal over last 4 years
  - ✓ Inlet H_2S = 50–300 ppmv
  - ✓ Outlet $H_2S \leq 1$ ppmv

❑ LCWRP Odor Control Facility

- H_2S loading: ~60 g/m^3-h
- Recommend **PU foam** or **PE mesh**, to enable longer carbon service life



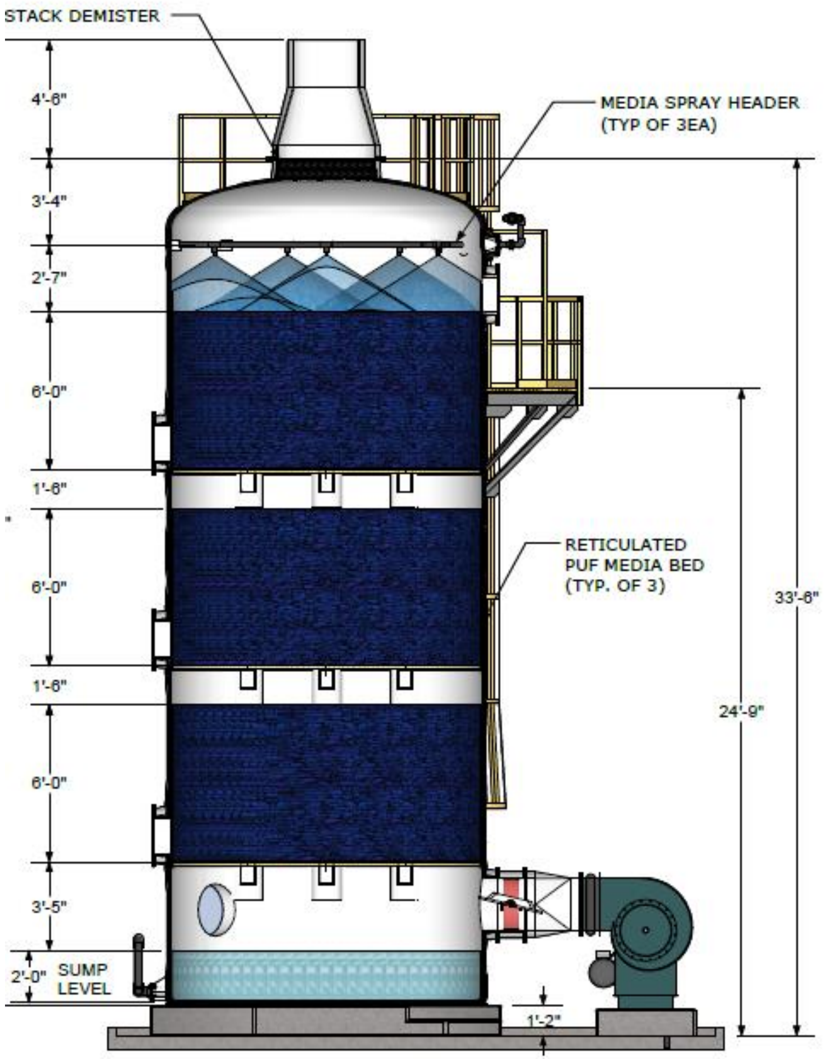
2 Dual-Bed BTFs vs 1 Triple-Bed BTF



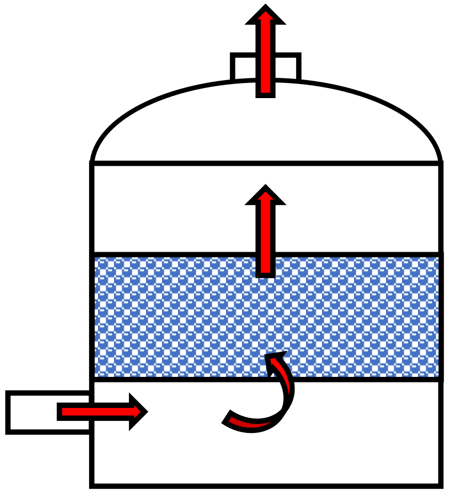
	Two BTFs (Dual-Bed)	One BTF (Triple-Bed)
Footprint	2×	1×
Airflow per Vessel	1×	2×
Superficial Velocity [a]	1×	2×
H_2S Load Per Vessel [b]	1×	2×

[a] **Velocity ∝ Headloss**

[b] **Load ∝ Fouling potential**

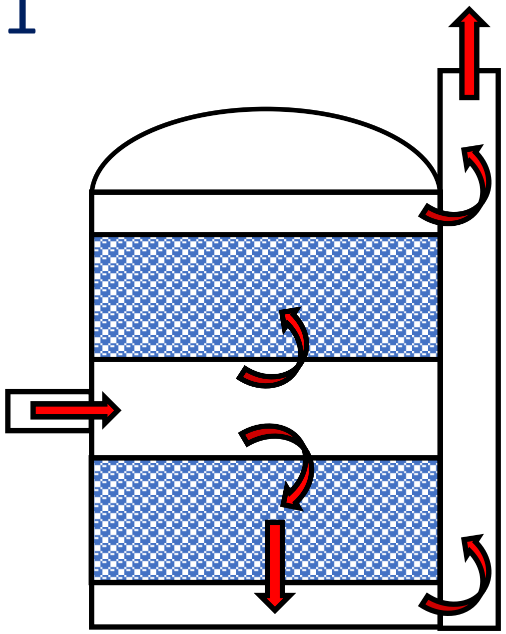


Carbon Scrubbers



Single-Bed
Carbon Scrubber

- **Necessity**
  - Always meet the AQMD H_2S limit of 0.5 – 1 ppmv H_2S?
  - Daily H_2S breakthrough in BTF outlet?
- **Redundancy**
  - Frequency of carbon changeout
- **Single-Bed vs Dual-Bed**
  - Dual-bed may lower capital cost and footprint required, but it is difficult to replace carbon media in the bottom bed



Dual-Bed
Carbon Scrubber

Breakthrough Time for Activated Carbon

GAC	Unit Cost ($/lb)	Adsorption Capacity (g-H_2S/mL)	Breakthrough Time (days)
Regular Coconut Shell	$1.95	0.03	**3 – 5**
Caustic Impregnated	$2.62	0.3	**49 – 62**
Extruded Cylindrical Pellet	$2.15	0.2	**77 – 96**

Notes:

- Mean particle diameter: 4 mm
- Regeneration cost: $0.55/lb

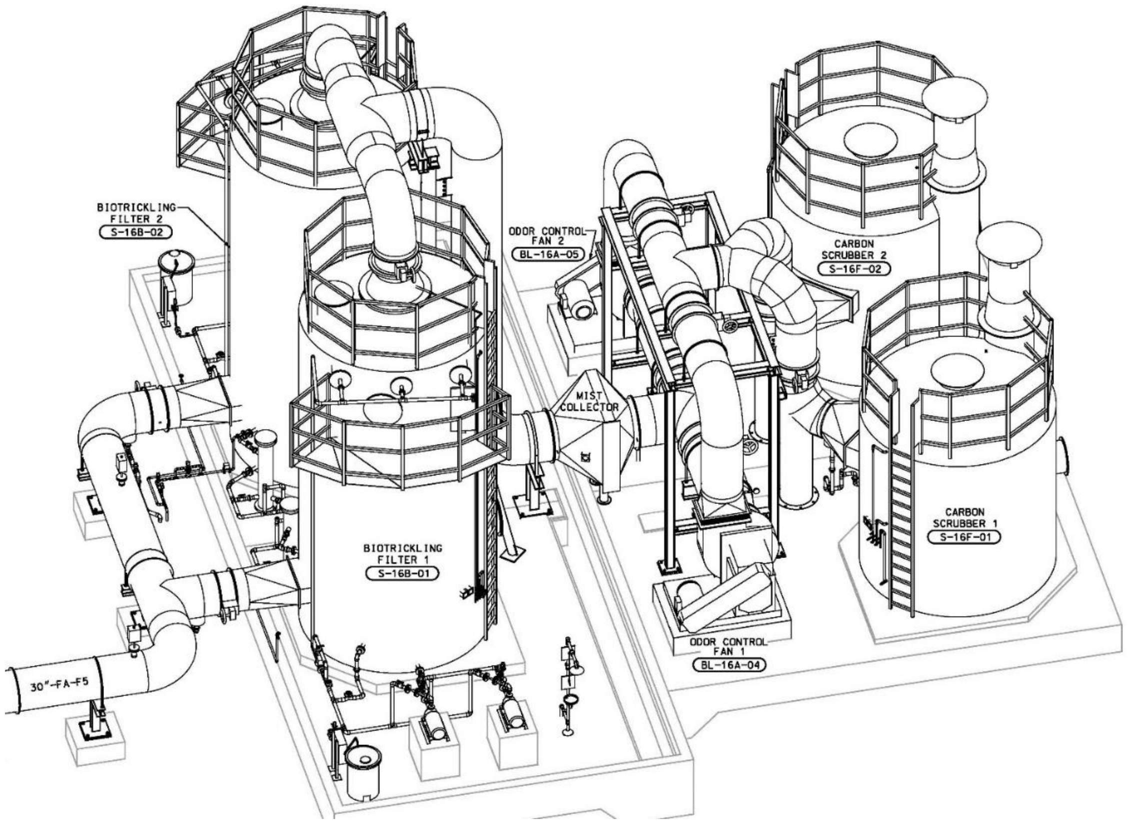
- ❑ Worth considering alternative carbons even without carbon regeneration

Proposed Design

Unit	Description	Value
BTF (2 duty)	Media bed diameter (feet)	12
	Media bed depth (feet)	12.4 (Typ. <7)
	EBRT (sec)	**14**
	Superficial velocity (ft/min)	53 (Typ. 50-100)
Carbon Scrubber (2 duty)	Bed diameter (feet)	12
	Carbon bed depth (feet)	**3**
	EBRT (sec)	3.4 (Typ. >3)
	Superficial velocity (ft/min)	53 (Typ. 50-60)

Notes:

- Design based on air flow rate of 12,000 cfm
- Maximum bed diameter for truck delivery = 12 ft



Cost Analysis for BTF Media and Activated Carbon

BTF media	Unit	PU Foam ($25/ft^3)	PE Mesh ($50/ft^3)	Foamed Glass ($10/ft^3)
Annual Cost for BTF Media	$/year	**7,000**	**14,000**	**2,800**
Annual Cost for BTF Media & Regular Carbon ($1.95/lb)	$/year	**14,700**	**23,900**	**83,100**
Annual Cost for BTF Media & Extruded Pellet Carbon ($2.15/lb)	$/year	**10,700**	**18,700**	**41,300**

- ❑ **PU Foam** and **Extruded Pellet Carbon** is best combination
- ❑ Higher cost of PU foam or PE Mesh would be **offset by lower annual cost for carbon**

Conclusions

- Under **low H_2S loading**, similar performance by all three media with nearly complete removal
- Under varying **H_2S loading** and **temperature** conditions, **most consistent and highest H_2S removal** by PU foam, then PE mesh, then foamed glass
- Differences in performance appear related to media properties: better performance with higher **accessible specific surface area** and **porosity**
- **Selecting the appropriate BTF media** based on the **estimated H_2S loading** ensures **reliable and cost-effective odor control**

100 YEARS

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Questions?

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