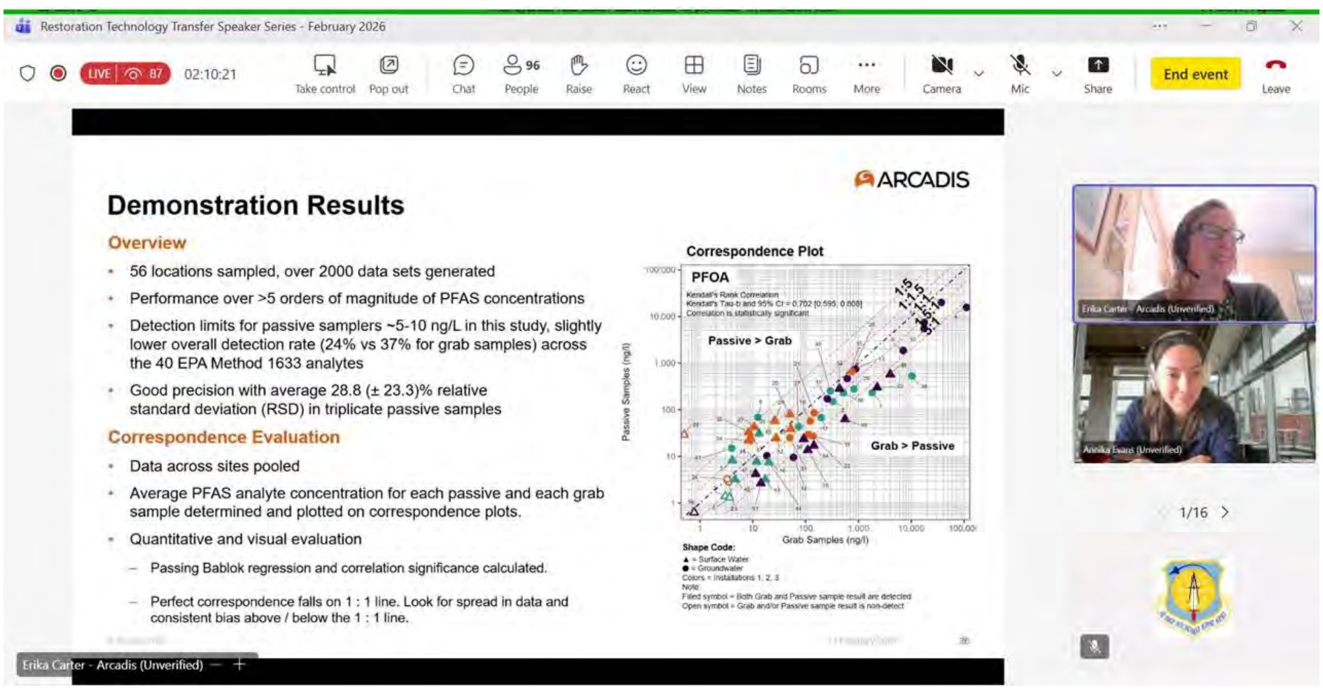
Restoration Technology Transfer Speakers Series
February 2026

Osorb® (PassiveX™) Passive Sampler for
Per- and Polyfluoroalkyl Substances (PFAS) in Groundwater and Surface Water

Presenters: Dr. Erika Carter & Annika Evans (Arcadis)

This webinar covered the AFCEC BAA 2215 field demonstration, which built upon the initial field testing utilizing the commercially manufactured sampler and expanded evaluation to six sites across three installations with varying environmental characteristics. The Osorb® (now commercially available as PassiveX™) passive sampler, is an integrative (time-averaging) device for PFAS sampling in environmental waters. Passive samples for PFAS were collected with paired grab samples of groundwater and surface water at 56 locations. Grab samples were analyzed for PFAS and several geochemical variables to measure correspondence with the passive results and evaluate for bias. Overall, the demonstration results indicate that at this stage of development the PassiveX™ passive sampler is appropriate for many applications, including site screening, general characterization and mapping of relative higher/lower concentrations across a site, and performance monitoring of a remedy.



Dr. Erika Carter & Annika Evans discuss demonstration results of the passive sampler.

This event and future events are updated and posted on the AFIT website at: https://www.afit.edu/CE/index.cfm.

POCs:
Joseph Dimisa, AFIT (joseph.dimisa@us.af.mil)
C.J. Garcia, CTR, Booz Allen Hamilton (carlos.garcia.56.ctr@us.af.mil)
Kurt Lee, AFCEC/CZPR (kurt.lee.3@us.af.mil)

Webinar Structure

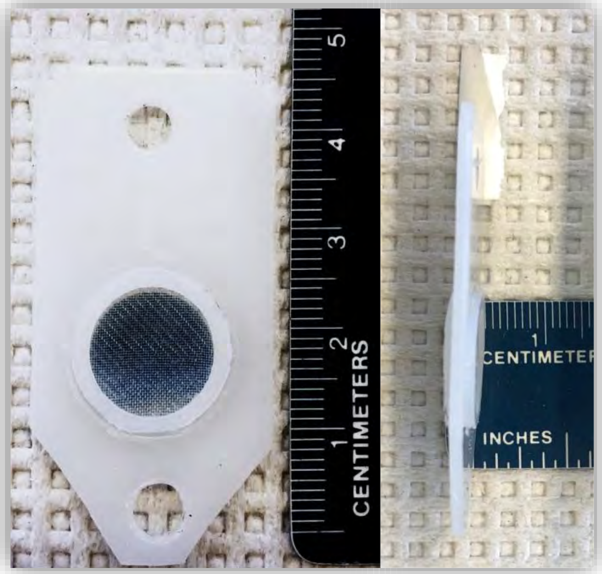
	[Restoration Technology Transfer Webinar Series – eDASH Archive]()
5 min	Welcome and Administrative Business
40 min	*Osorb® (PassiveX™) Passive Sampler for PFAS in Groundwater and Surface Water* – Arcadis: Erica Carter, Ph.D. & Annika Evans
10 min	Questions and Answers
5 min	Final Thoughts

Osorb® (PassiveX™) Passive Sampler for PFAS in Groundwater and Surface Water

AFCEC BAA 2215 Field Demonstration

CZTE Restoration Tech Transfer Webinar Series

February 11, 2026



Osorb® Passive Sampler Prototype

PassiveX™ PFAS Sampler

Outline

1 **Passive sampling introduction**

2 **PassiveX™ PFAS sampler development**

3 **BAA 2215 demonstration**
Scope, passive sampler use, results

4 **Conclusions and resources**

1. Passive Sampling Introduction

Passive sampling advantages

- PFAS sampling is resource-intensive
- Passive sampling offers potential* reductions in:
  - Onsite labor (health & safety advantage with reduced labor cost)
  - Equipment / power needs
  - Investigation-derived waste
  - Cross-contamination
  - Shipping costs
    - Large volume (500 mL) for EPA Method 1633, plus bottle for TSS. Some passive sampling methods produce lower weight/volume of samples for shipping.
  - Analytical costs (e.g., PassiveX™ sampler)

Passive sampling can provide efficiencies and cost savings while yielding reliable data.

***Specific advantages vary by sampling device.**

Passive Groundwater Sampling

- Can be used to collect a representative groundwater sample for most physical and chemical parameters without purging of a well.
- Collects a groundwater sample from a user-defined interval while limiting mixing fluid from other intervals.
- Can be activated and removed for sample collection within several hours to several months.
- 3 Categories
  - Grab sampler: A device that recovers a sample of the selected medium that represents the conditions at the sampling point, including any chemicals present, at the moment of sample collection.
  - Equilibrium sampler: A device that relies on diffusion of the analytes for the sampler to reach and maintain equilibrium with the sampled medium.
  - Accumulation (integrative) sampler: A device that relies on diffusion and adsorption to accumulate analytes in the sampler.

Hydrasleeves, Snap Sampler® → Grab sampler

Passive Diffusion Samplers Dual-Membrane PDB, PFASsive™ → Equilibrium sampler

PassiveX™ PFAS Sampler → Accumulation (integrative) sampler

Many Passive Sampling Options

Interstate Technology Regulatory Council (ITRC) 2024 Passive Sampling Technology Update
https://psu-1.itrcweb.org

Combines and updates 4 prior ITRC guidance documents from the early 2000s into comprehensive document

Evaluates **24 passive sampling technologies**

Covers passive sampling options for **groundwater, surface water, and soil**

Recent DoD Support for PFAS Passive Samplers

- Size/Dimensions
- Ease of use and analysis
  - Can it be analyzed by commercial lab?
- Integrative or equilibrium
- Sensitivity to environmental conditions
  - temp, pH, TDS, etc.
- Detection limit
- Deployment time
- Degree of field testing/application
- Commercial availability and cost

SW	Surface Water	$\int dx$	Integrative
GW	Groundwater	$\rightleftharpoons$	Equilibrium
SPW	Sediment or Pore Water		Commercially Available

ER20-1127

SW
GW
$\int dx$

ER20-1293

SW
$\int dx$

ER20-1156

SW
GW
$\int dx$

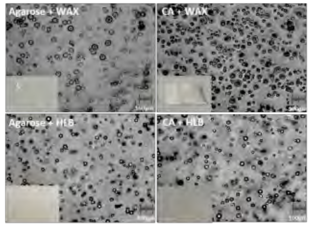
ER23-7741 PFASsive™

SW
SPW
$\rightleftharpoons$

ER23-7696

SPW
$\int dx$

ER20-1336



SW
GW
SPW
$\rightleftharpoons$

ER21-5104

SW GW SPW $\rightleftharpoons$

ER20-1363

SW*
GW*
$\int dx$

ER20-1073

SW
GW
SPW*
$\rightleftharpoons$

ER23-8494

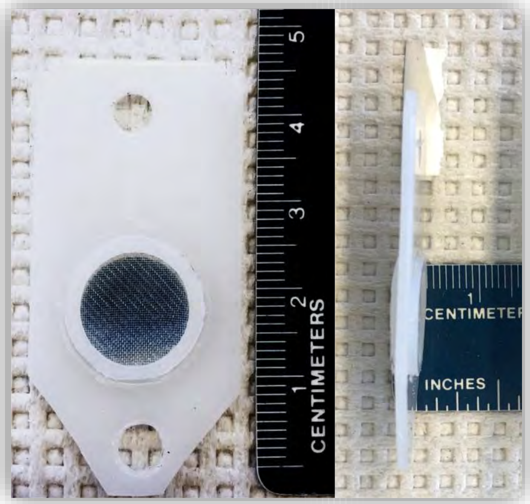
GW
$\int dx$
$\rightleftharpoons$

Method comparison

2. PassiveX™ PFAS Sampler Development

Introduction

- PassiveX™ is an accumulation sampler that sorbs PFAS over deployment period
- Prototype designed and field-tested in SERDP project ER20-1127 (Arcadis and College of Wooster)
- Commercial manufacture by Aquanex Technologies, LLC*
- Cu(II)-polyethyleneimine-Osorb® adsorbent
  – Mesoporous organosilica resin
  – Weak anion-exchange groups
  – Cu(II) for high affinity binding of short chain PFAS
- PFAS concentration in water is calculated based on lab-derived "sampling rate"
- Requires recording **deployment and retrieval date/time and water temperature**
- Shipped to lab in centrifuge tube on ice – small size, reduces shipping cost
- Several commercial labs perform analysis (modified EPA 1633)



Prototype - Polyethylene construction with 80-mesh granular Cu(II)-polyethyleneimine-Osorb® sorbent

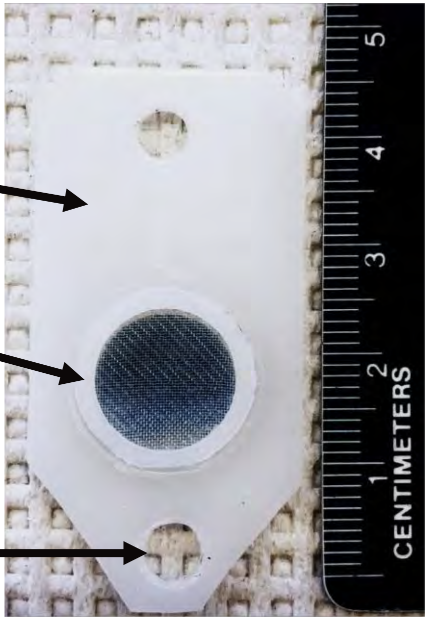
* PassiveX™ PFAS passive samplers for water and sediment are commercially available and discounts are offered for research applications https://aquanextech.com/collections/passive-samplers

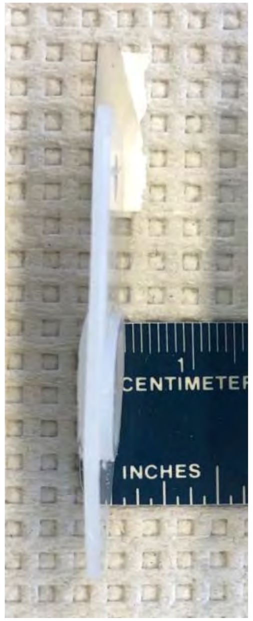
Passive Sampler Design

HDPE frame

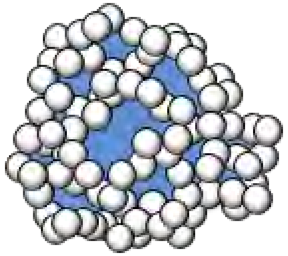
Adsorbent enclosed in PE mesh

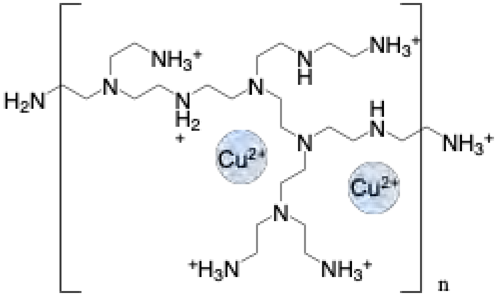
Attachment point





Adsorbent: 80 mesh granular Cu(II)-polyethylenimine-Osorb® (pre-wetted, ready for use)

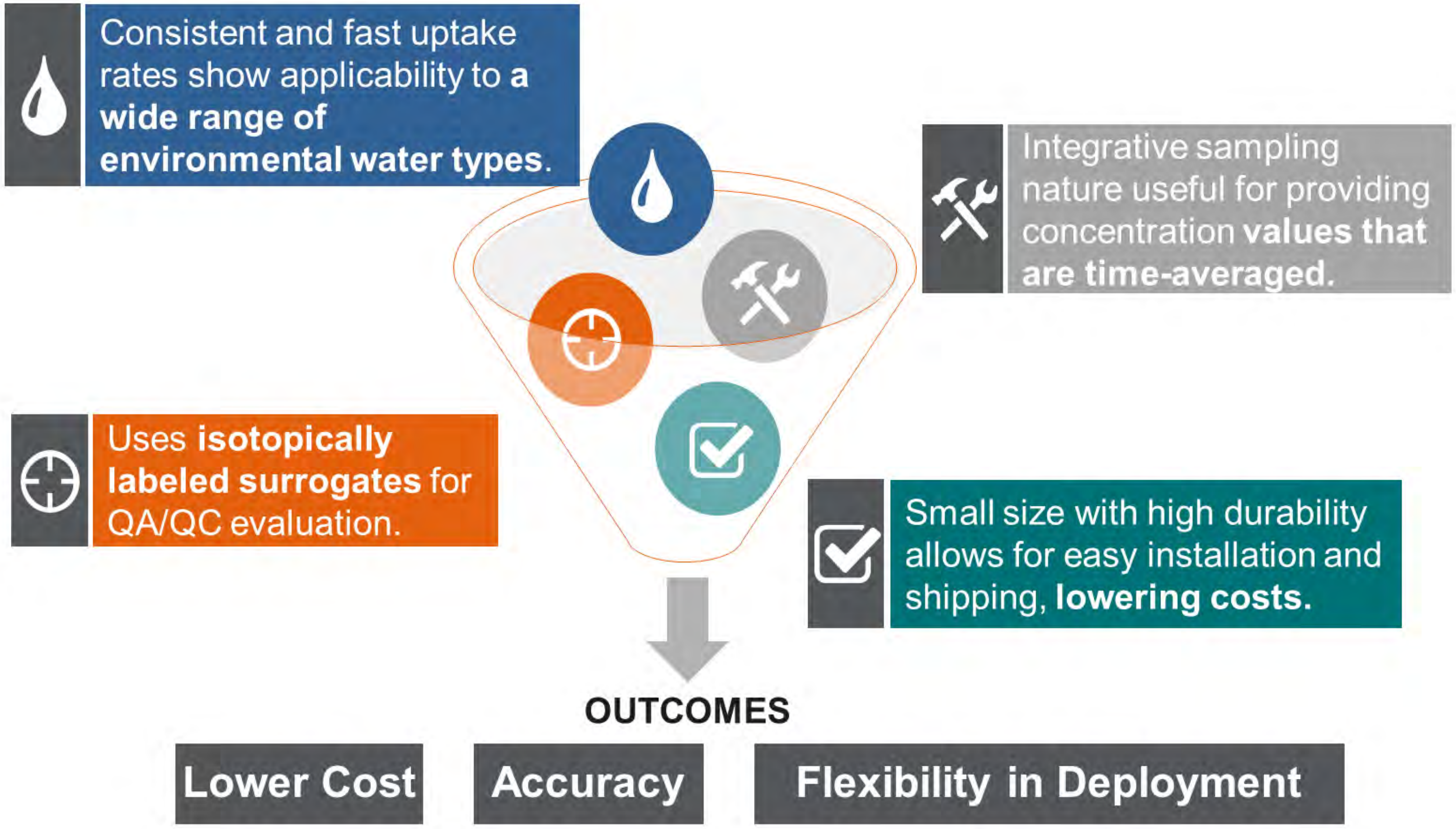




HDPE for surface water and groundwater

Stainless steel housing for sediment

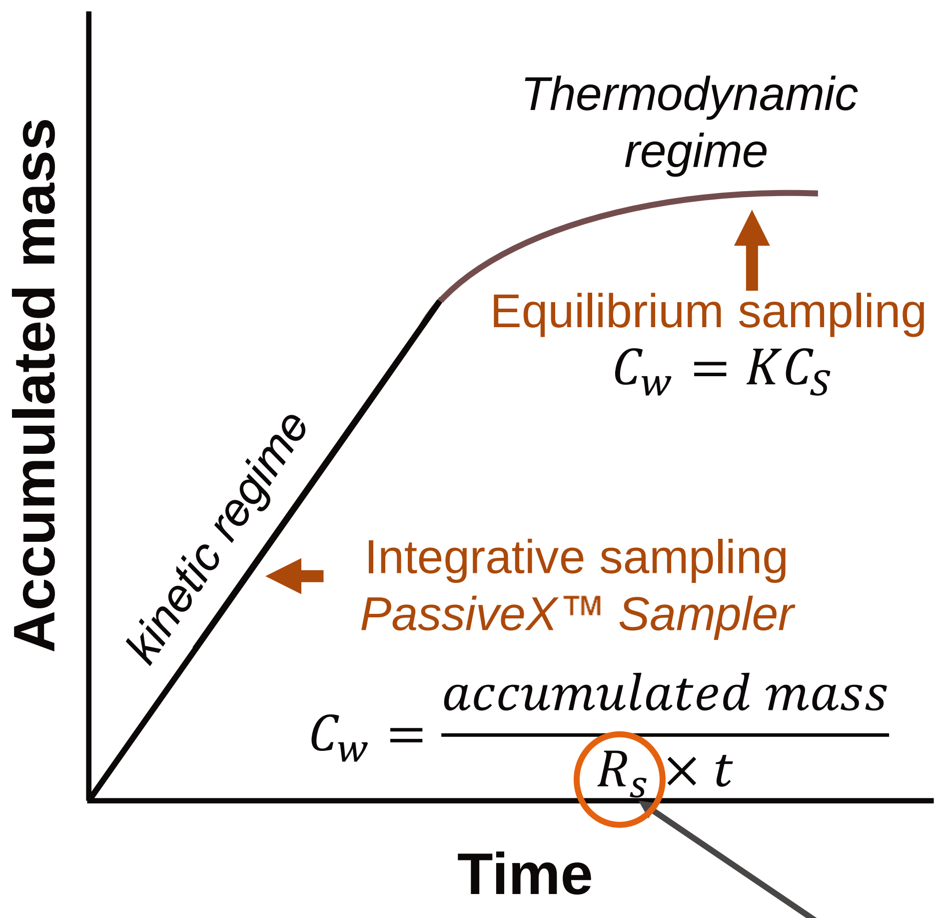
PassiveX™ Sampler Advantages

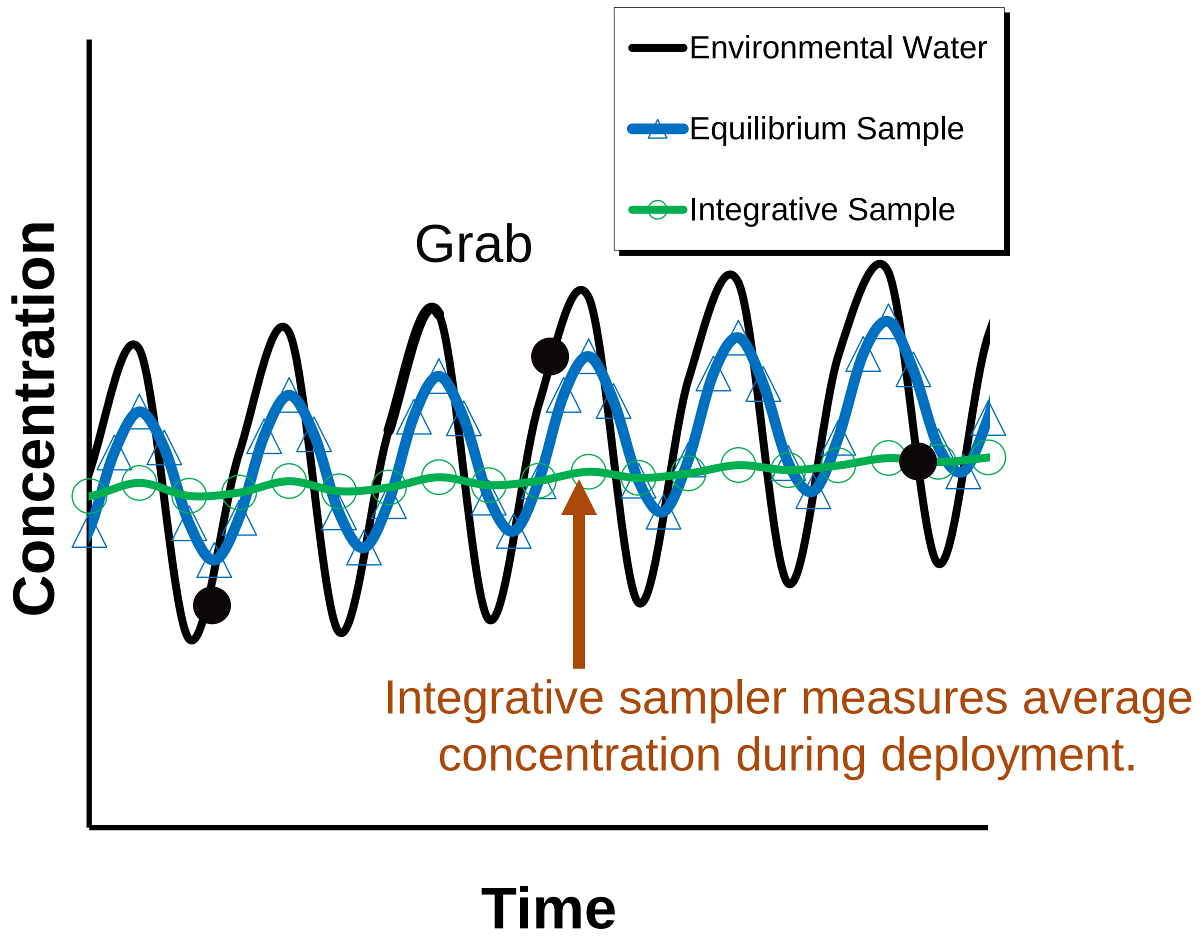


Deployment in groundwater

150 Field Samples

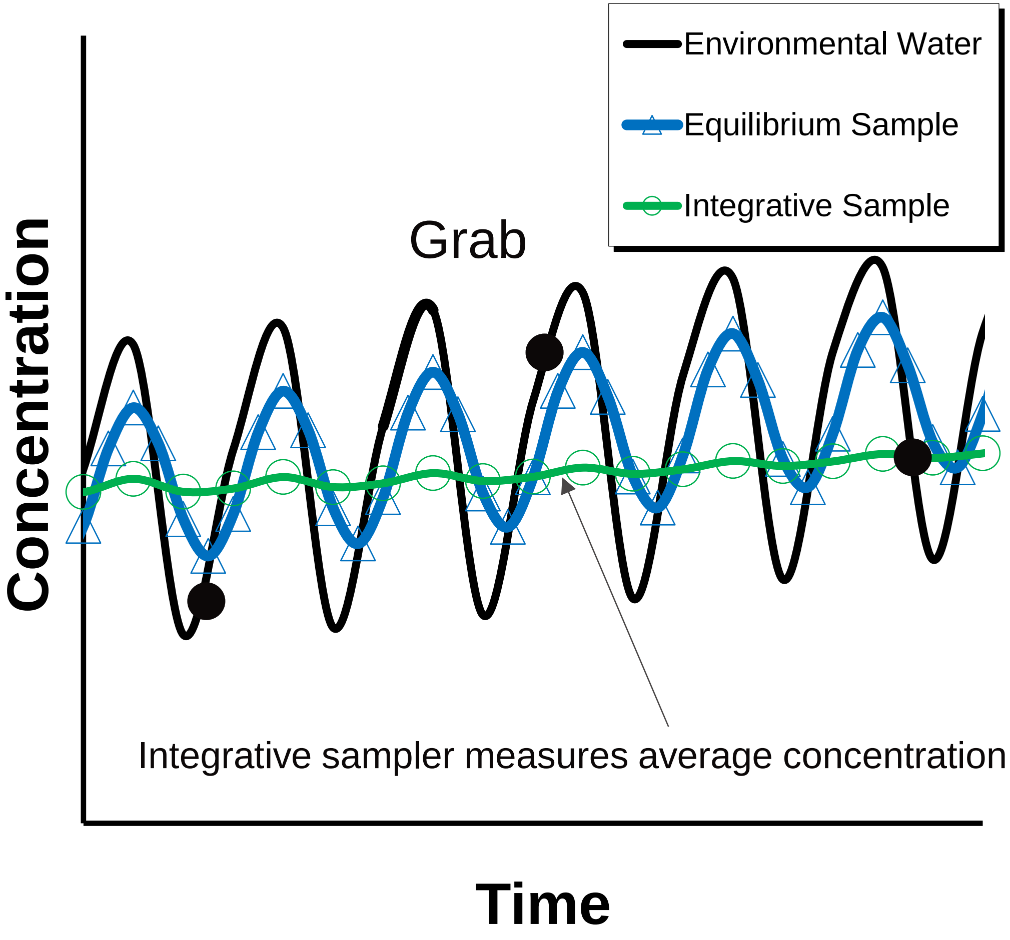
Modes of Passive Sampling



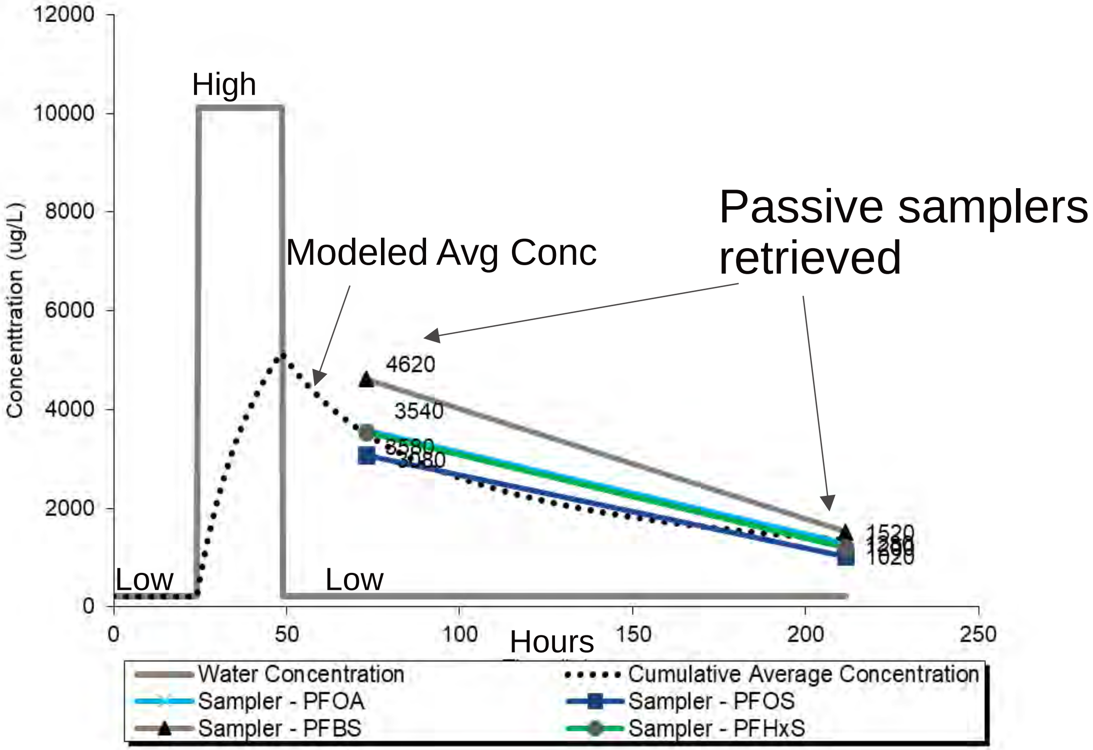


R_s value (Sampling Rate) empirically derived for each analyte

Lab Measurement of Integrative Behavior

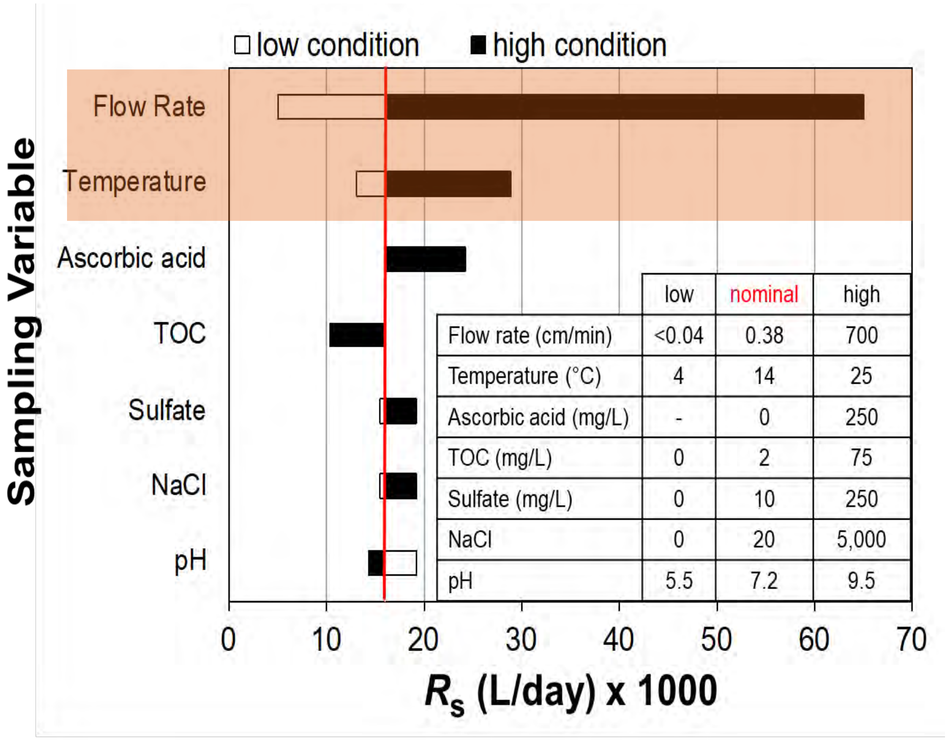


Variable Concentration Experiment



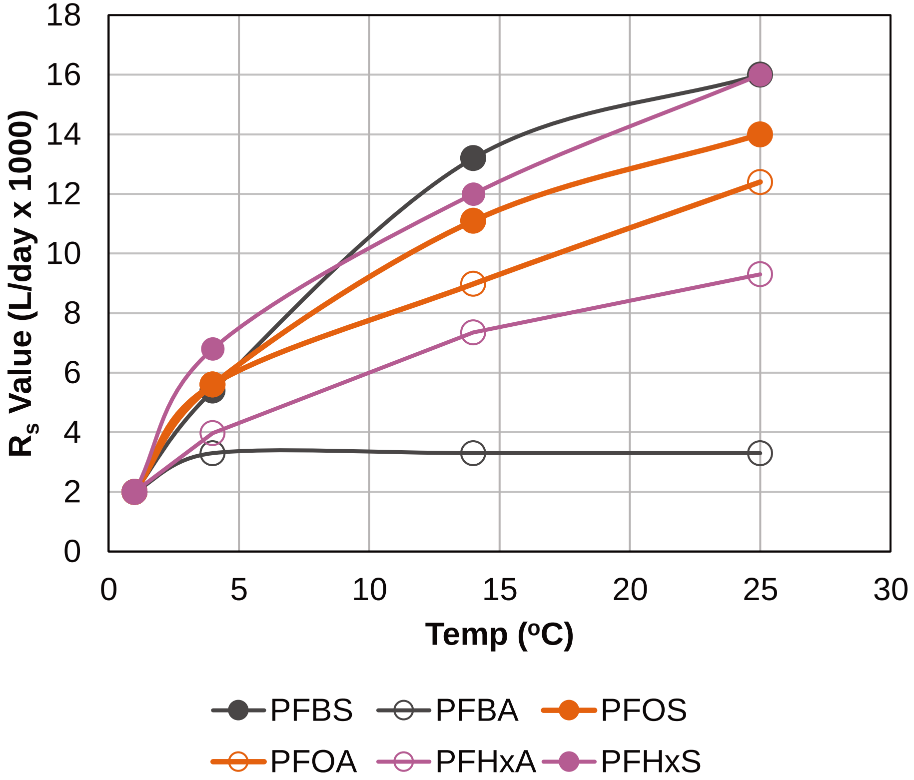
Measured passive sampler concentration matches modeled cumulative average water concentration. Binding to sampler is ~ unidirectional (on >>> off).

R_s Sensitivity to Environmental Conditions



	low	nominal	high
Flow rate (cm/min)	<0.04	0.38	700
Temperature (°C)	4	14	25
Ascorbic acid (mg/L)	-	0	250
TOC (mg/L)	0	2	75
Sulfate (mg/L)	0	10	250
NaCl	0	20	5,000
pH	5.5	7.2	9.5

R_s is most sensitive to flow rate and temperature



R_s is corrected for temperature with Langmuir-style curve fitting

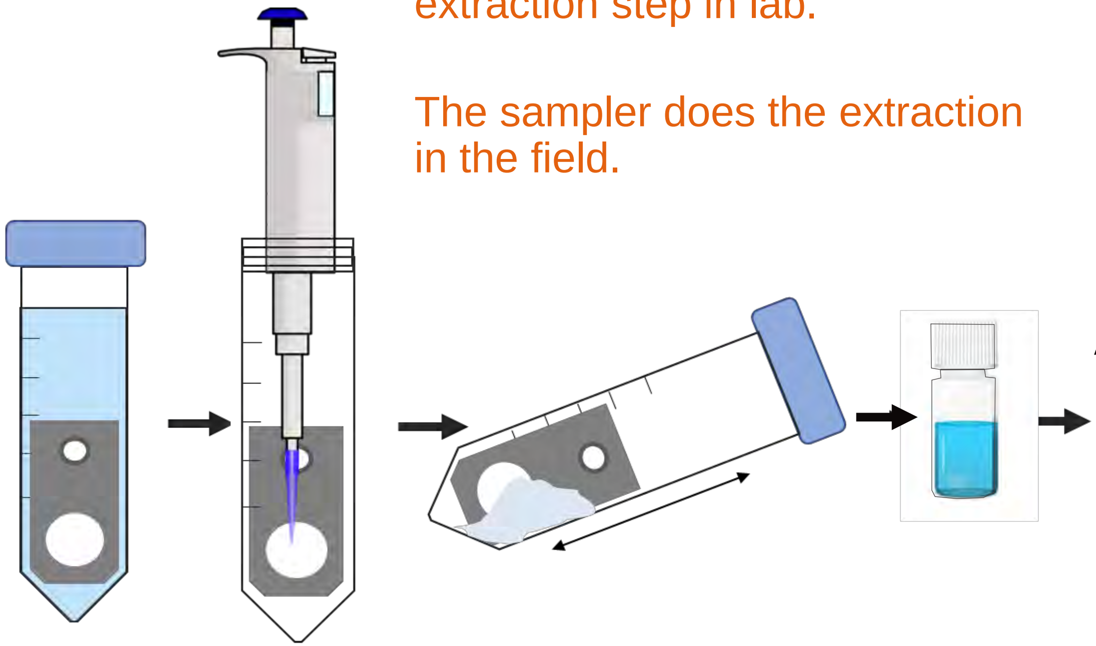
Passive Sampler Analysis

Current Labs – EPA Method 1633 Analytes (and more) – timing of 3rd party accreditation

- Enthalpy Labs – October 2025 (DoD ELAP)
- Pace Minneapolis – Fall 2025 (DoD ELAP)
- Eurofins (Lancaster, PA) – soon
- SGS-USA (Dayton, NJ) - soon
- International: SGS-Germany (Fellbach), ALS Global (Hawarden, UK), Pacific Rim Labs (Vancouver, Canada)

Method eliminates time-consuming solid phase extraction step in lab.

The sampler does the extraction in the field.



Analyze by LC-MS Modified Method

Steps 1-2: Rinse in DI water, centrifuge

Step 3: Apply 50 µL surrogate solution

Step 4: Extract with 2.0 mL of methanol, agitate on shaker.

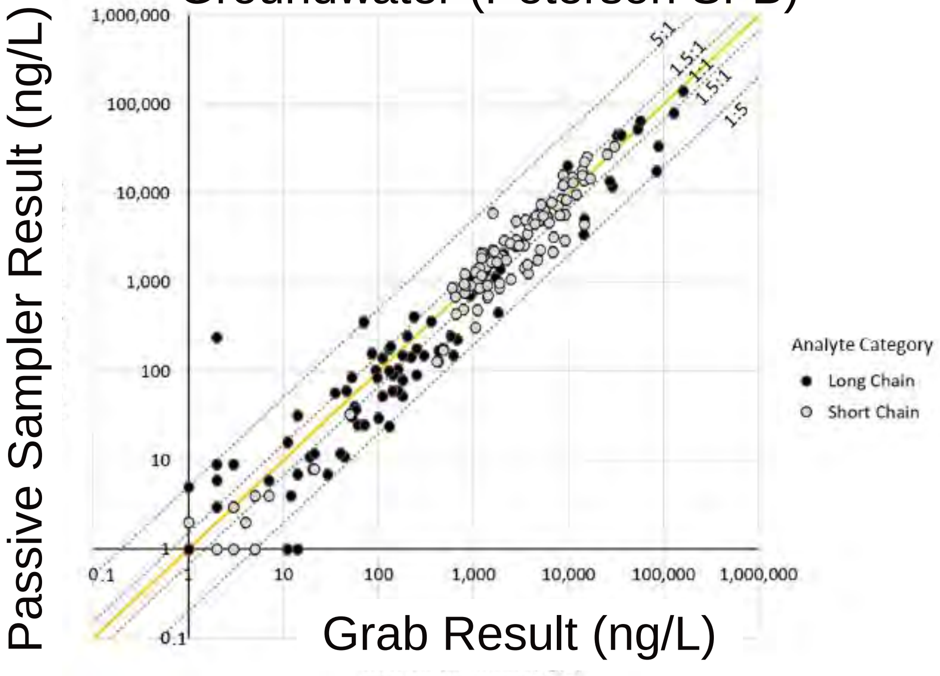
Steps 5-7: Decant methanol extract, add internal standards, run on LC-MS.

$$\textbf{PFAS Concentration (ng/L)} = \frac{\text{Mass (ng)}}{[\,\underbrace{R_s\ (\text{L/d})}\ \bullet\ \text{Days deployed (d)}]}$$

Empirical Sampling Rate, R_s depends on PFAS analyte, temperature, water flow

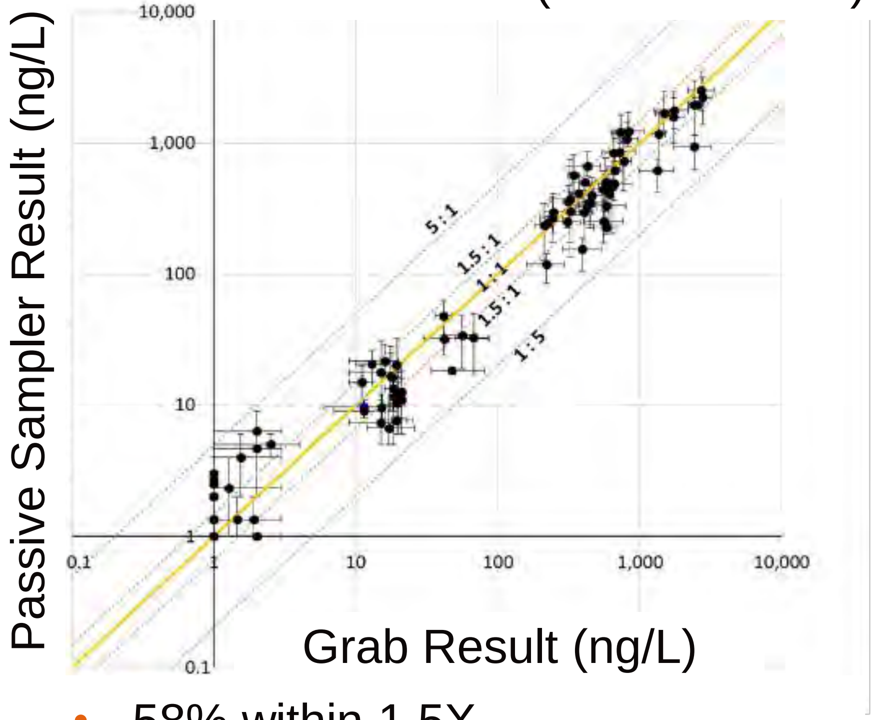
SERDP Demonstration Results in Groundwater and Surface Water

Groundwater (Peterson SFB)



- 56% within 1.5X
- 71% within 2X
- Short and long chain performed similarly
- 14% RSD passive sampler replicates

Surface Water (Ellsworth AFB)



Performance over 5 OoM PFAS concentration range

- 58% within 1.5X
- 80% within 2X
- 30% RSD passive sampler replicates

Edmiston et al. (2023) GWMR

SERDP Demonstration Results Ohio River

		PFOA (ng/L)		PFOS (ng/L)	
River	**River Mile**	**Passive sampler**	**EPA Composite**	**Passive sampler**	**EPA Composite**
Allegheny	8.2	1.1±0.1 (J)	<1.01 (U)	1.2±0.1	1.06-4.94 (J)
Monongahela	11.9	1.6±0.1	1.01-5.23 (J)	0.7±0.1 (J)	1.06-4.94 (J)
Ohio	60.8	1.9±0.4	<1.01 (U)	2.0±0.3	1.06-4.94 (J)
Ohio	109.6	2	<1.01 (U)	1.6	1.06-4.94 (J)
Ohio	159.2	1.8	<1.01 (U)	1.4	1.06-4.94 (J)
Ohio	207.9	5.5	1.01-5.23 (J)	4.2	1.06-4.94 (J)
Ohio	257.6	6.3	6.3±0.4(2)	3.5	1.06-4.94 (J)
Ohio	306.0	2.1	1.01-5.23 (J)	0.6 (J)	1.06-4.94 (J)
Ohio	355.1	4.1±1.1(2)	5.5	3.2±2.0(2)	1.06-4.94 (J)
Ohio	404.7	4.6	5.8	3.2	1.06-4.94 (J)
Ohio	453.3	2.3	6.6	0.8 (J)	1.06-4.94 (J)
Ohio	502.3	4.4	5	1.0 (J)	1.06-4.94 (J)
Ohio	698.4	3.2	1.01-5.23 (J)	1.2	1.06-4.94 (J)

Edmiston et al. (2023) GWMR

Passive sampler and composite results consistent at low (<10 ng/L) concentrations.

3. BAA 2215 Demonstration Scope and Results

Demonstration Scope

Demonstration Scope

- Deploy passive samplers at 3 Installations
- Collect groundwater and surface water samples
- 6-10 groundwater and 6-10 surface water locations at each base
- Goal to target wide PFAS concentration range
- Co-located passive and grab samples
- Passive samplers deployed for 14 days
- At 50% of locations, passive samplers collected in triplicate to calculate precision
- Multiple grab samples collected over 14-day deployment period
- Field parameters, temperature logging
- Laboratory analysis for PFAS, geochemical parameters
- Include one base with co-constituents (chlorinated volatile organic compounds)

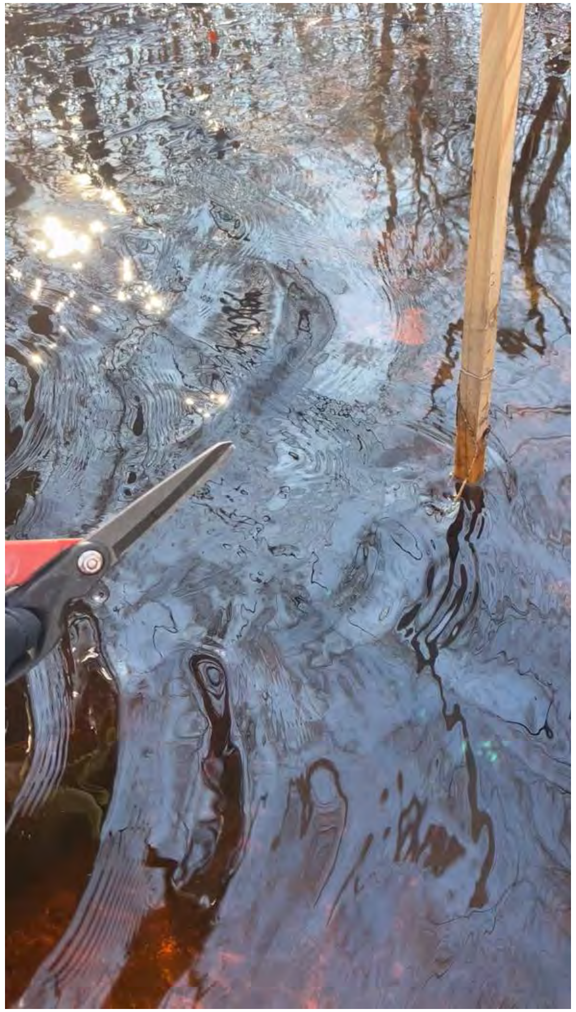
Using the Osorb® (Passivex™) Passive Sampler

Deployment Steps




- Sampler is shipped in a centrifuge tube that should be retained for shipment to the lab upon retrieval
- Securing the sampler to a deployment line
  - *Groundwater*
    - Attach to PFAS free twine or chain
    - Lower into well ensuring that sampler sits at the pre-selected depth in the water column
    - Secure twine or chain to well cover
  - *Surface Water*
    - Attach to PFAS free twine, chain, or zip ties
    - Place sampler into the water such that it sits at the pre-selected depth in the water column
    - Secure twine or chain to a sturdy object that will remain visible and accessible despite water fluctuations.
- Additional weights or floats may be required to ensure samplers sits at the appropriate depth
- Multiple samplers can be attached in series for replicates
- Sampler must remain submerged throughout deployment period
- Record sampler deployment date and time

Retrieval Steps



- Remove sampler from water and cut it free from the deployment line.
- If the sampler is covered with mud / debris, you can rinse it off with PFAS-free deionized water or wipe the external housing gently with a kimwipe. It will be rinsed again in the analytical laboratory.
    - Avoid touching the sorbent material during deployment and retrieval
- Place sampler into the centrifuge tube in which it was received
- Record water temperature and retrieval date/time
- Ship samplers in centrifuge tubes on wet ice to the lab

Deployment / Retrieval Lessons Learned

Groundwater

- Select PFAS free deployment line material prior to deployment event. Equipment blanks can be used to evaluate PFAS contribution of sampling equipment.

Surface Water

- Select PFAS free deployment line material prior to deployment event. Equipment blanks can be used to evaluate PFAS contribution of sampling equipment.
- Recon prior to sampler deployment
  - Where is the water level during dry periods, and where is it during wet periods/after rain events?
  - Is there wildlife in the area that could disturb the samplers (i.e. beavers, birds, etc.) ?
  - How strong is the current?

These variables will impact how and where one secures the samplers.

Demonstration results

Demonstration Results

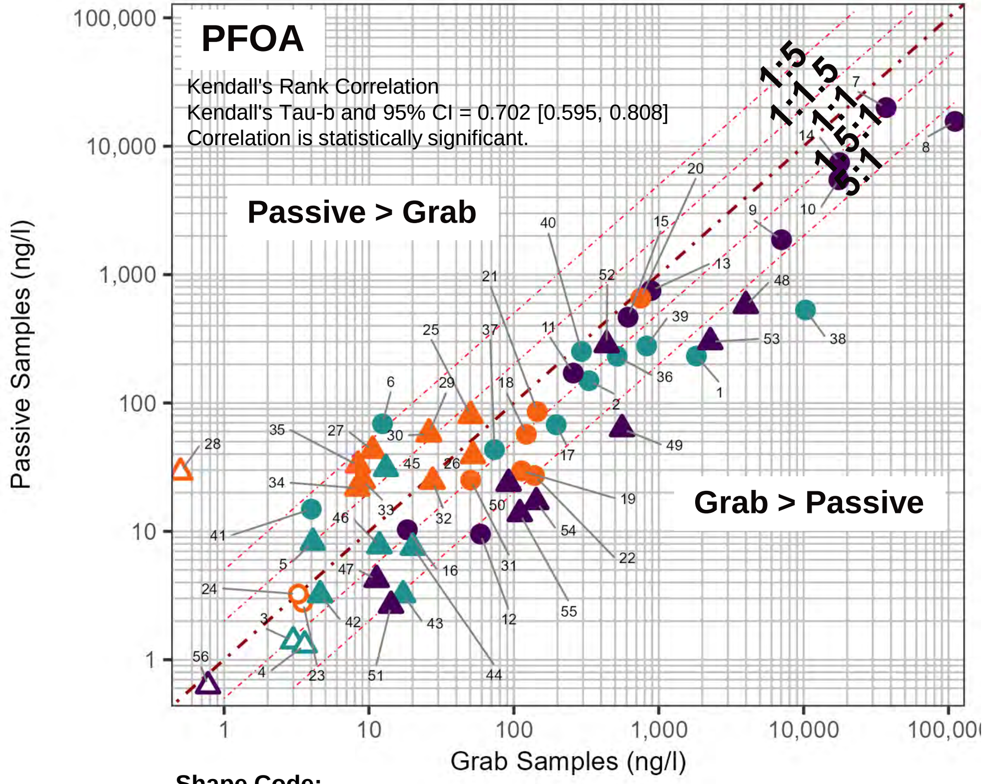
Overview

- 56 locations sampled, over 2000 data sets generated
- Performance over >5 orders of magnitude of PFAS concentrations
- Detection limits for passive samplers ~5-10 ng/L in this study, slightly lower overall detection rate (24% vs 37% for grab samples) across the 40 EPA Method 1633 analytes
- Good precision with average 28.8 (± 23.3)% relative standard deviation (RSD) in triplicate passive samples

Correspondence Evaluation

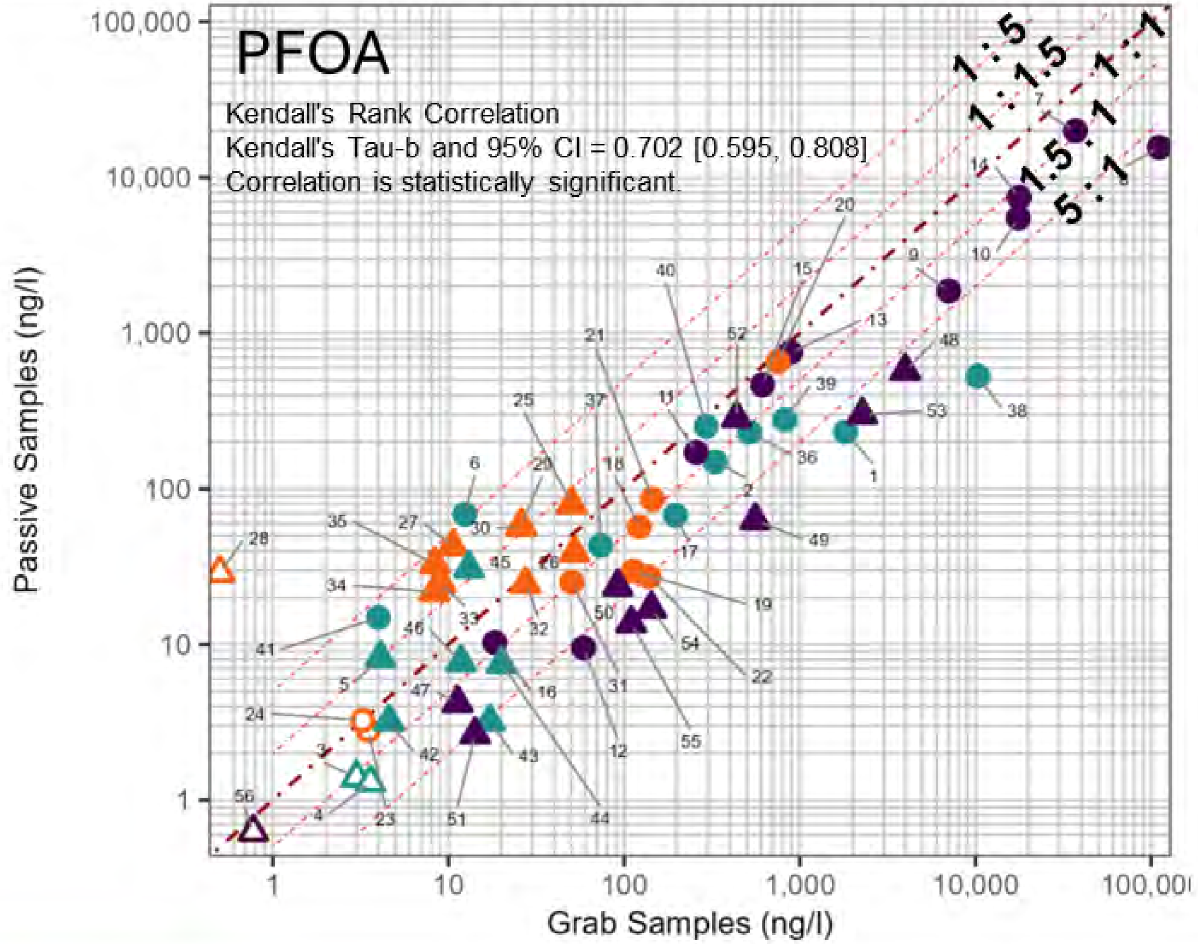
- Data across sites pooled
- Average PFAS analyte concentration for each passive and each grab sample determined and plotted on correspondence plots.
- Quantitative and visual evaluation
  - Passing Bablok regression and correlation significance calculated.
  - Perfect correspondence falls on 1 : 1 line. Look for spread in data and consistent bias above / below the 1 : 1 line.

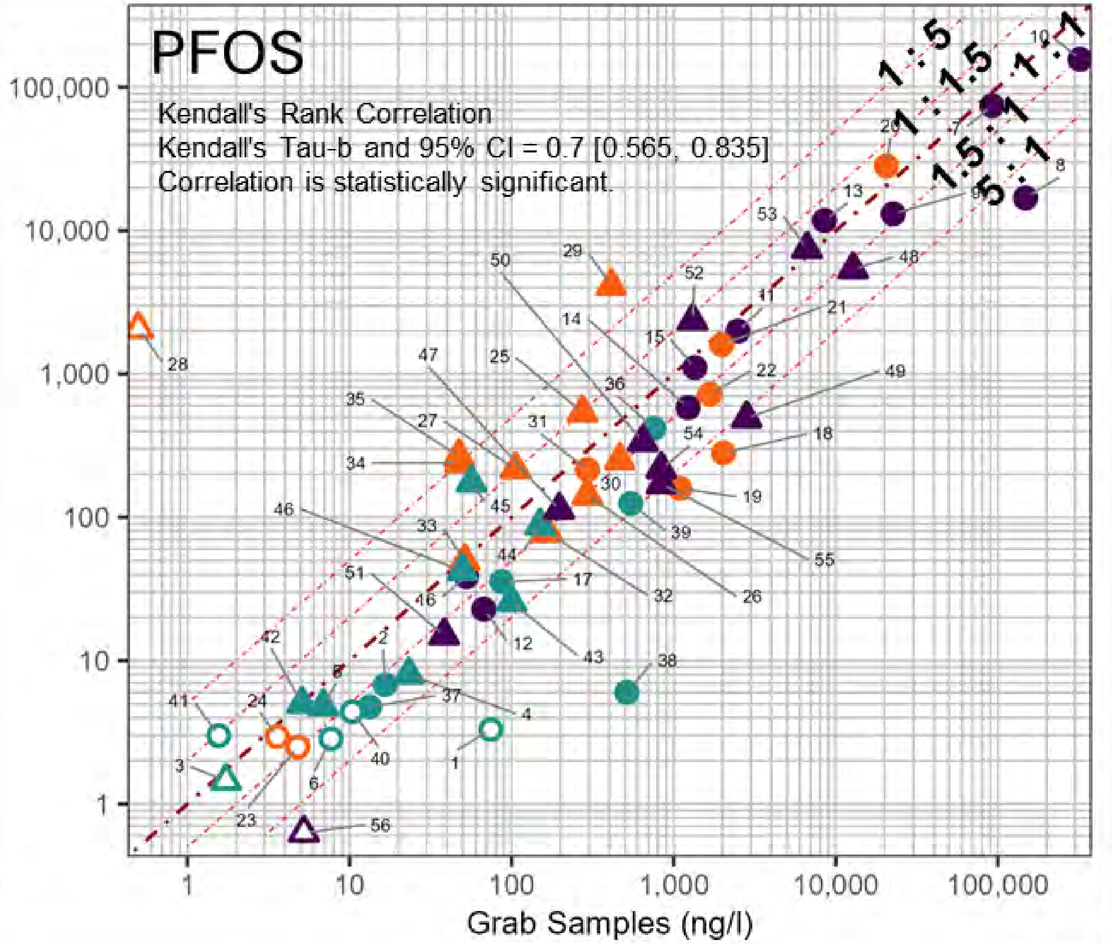
Correspondence Plot



Shape Code:
▲ = Surface Water
● = Groundwater
Colors = Installations 1, 2, 3
Note:
Filled symbol = Both Grab and Passive sample result are detected
Open symbol = Grab and/or Passive sample result is non-detect

Demonstration Results





Color Code:

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- Installation 2
- Installation 3

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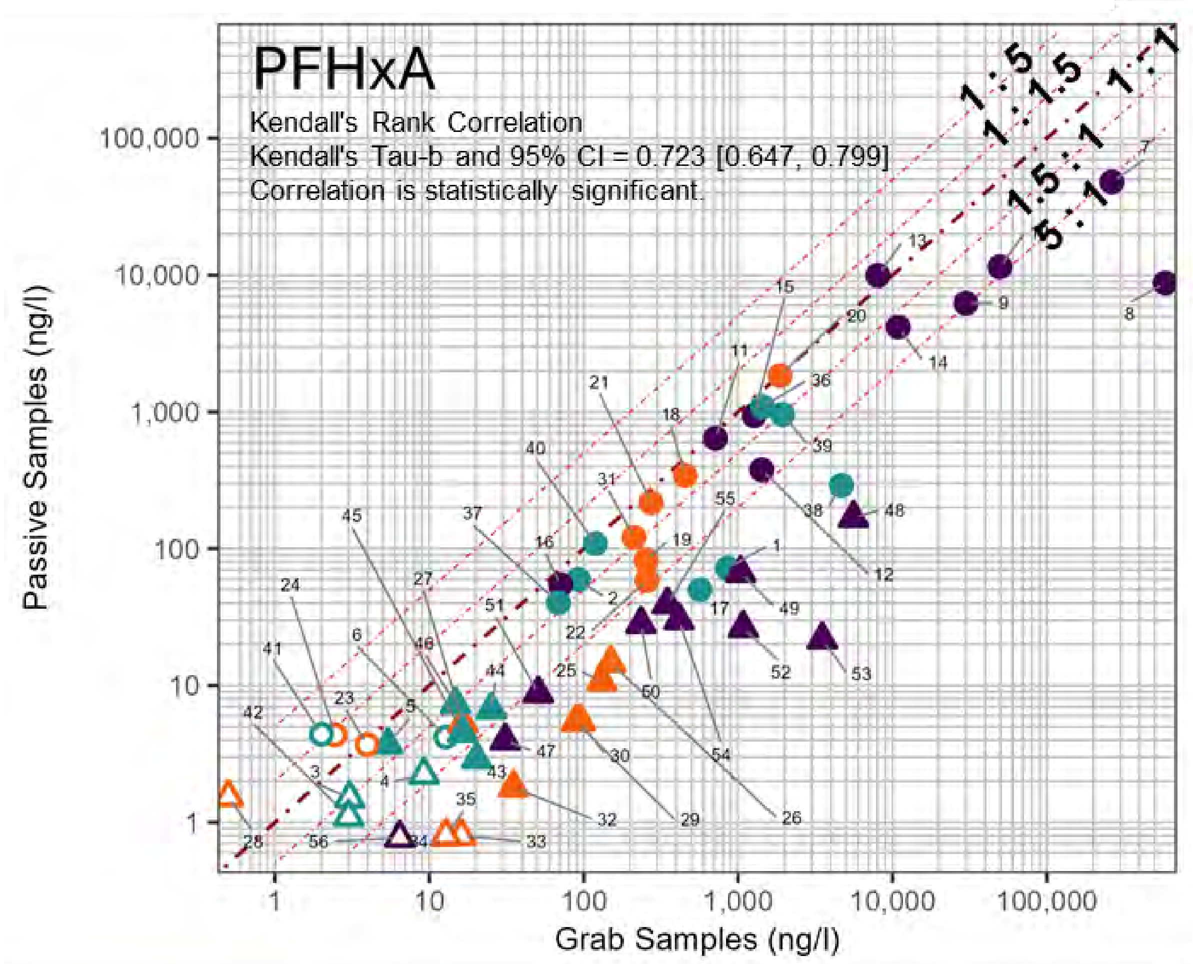
Acronym:

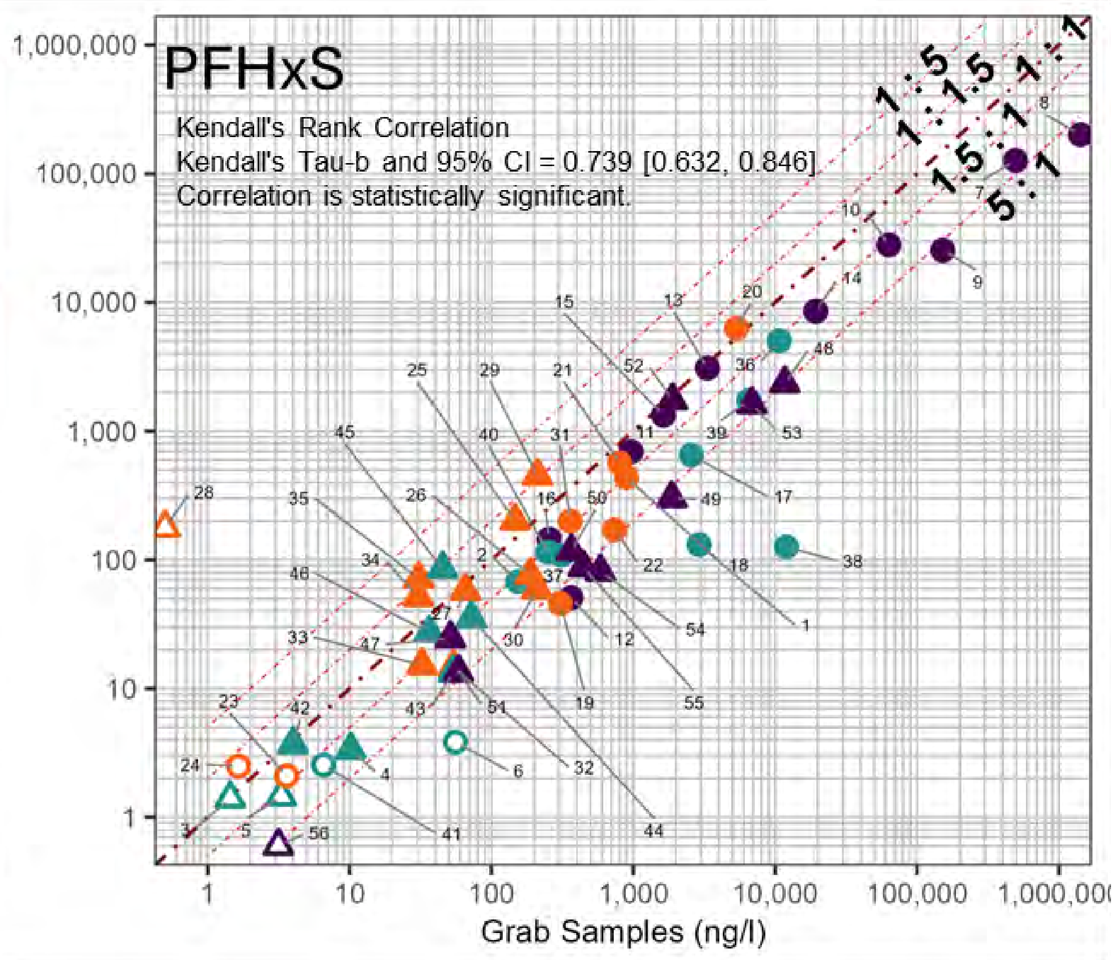
ng/L = nanogram per liter

Observations across analytes/sites:

- Significant correlation between passive and grab data
- 72% of passive & grab detects agreed within 5X each other
- 46% agreed within 2.5X each other
- Often more spread/scatter in surface water results

Demonstration Results





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Observations across analytes/sites:

- Regression slope was consistently less than 1
- Low bias, on average, grab was 2.5X passive

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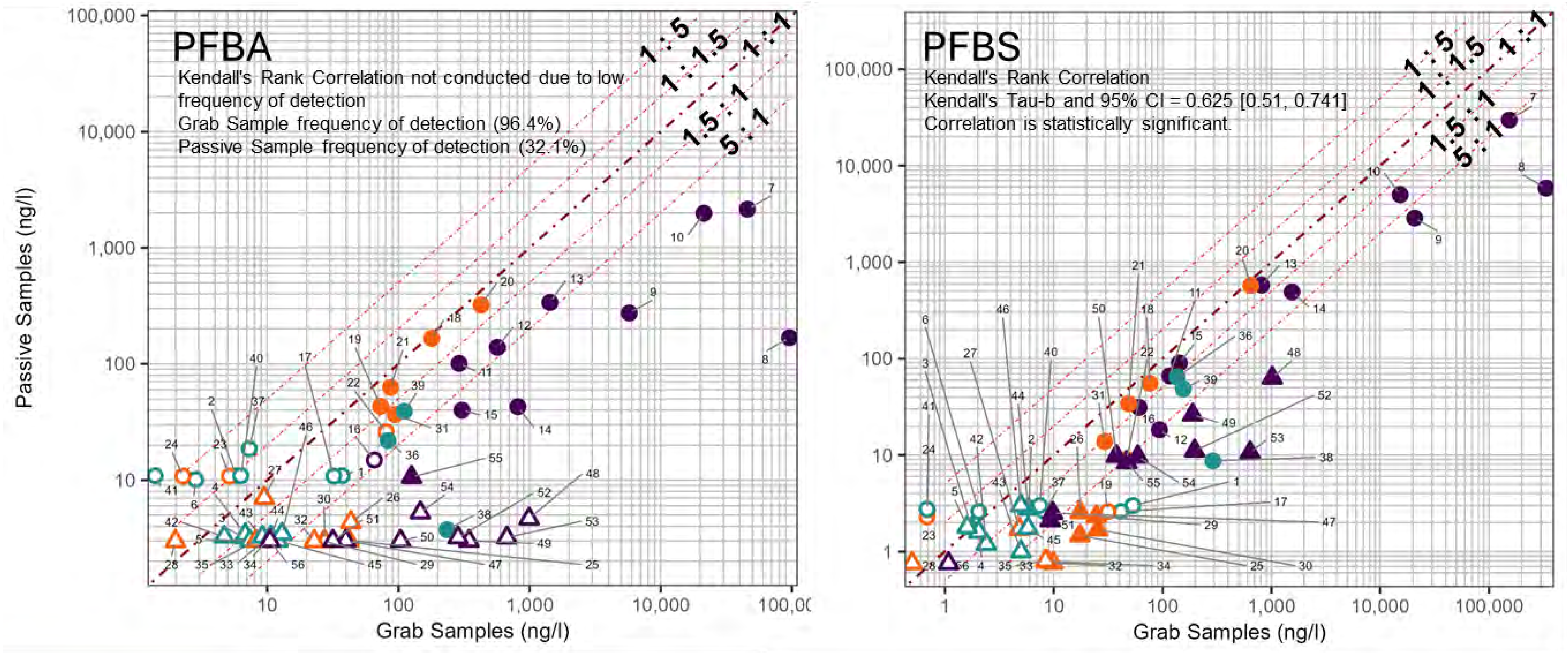
Demonstration Results



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Shape Code:

▲ = Surface Water
● = Groundwater

Note:
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Acronym:

ng/L = nanogram per liter

Observations across analytes/sites:

- More (low) bias observed for short chain PFAS
- Less detection of some short-chain PFAS (PFBA)

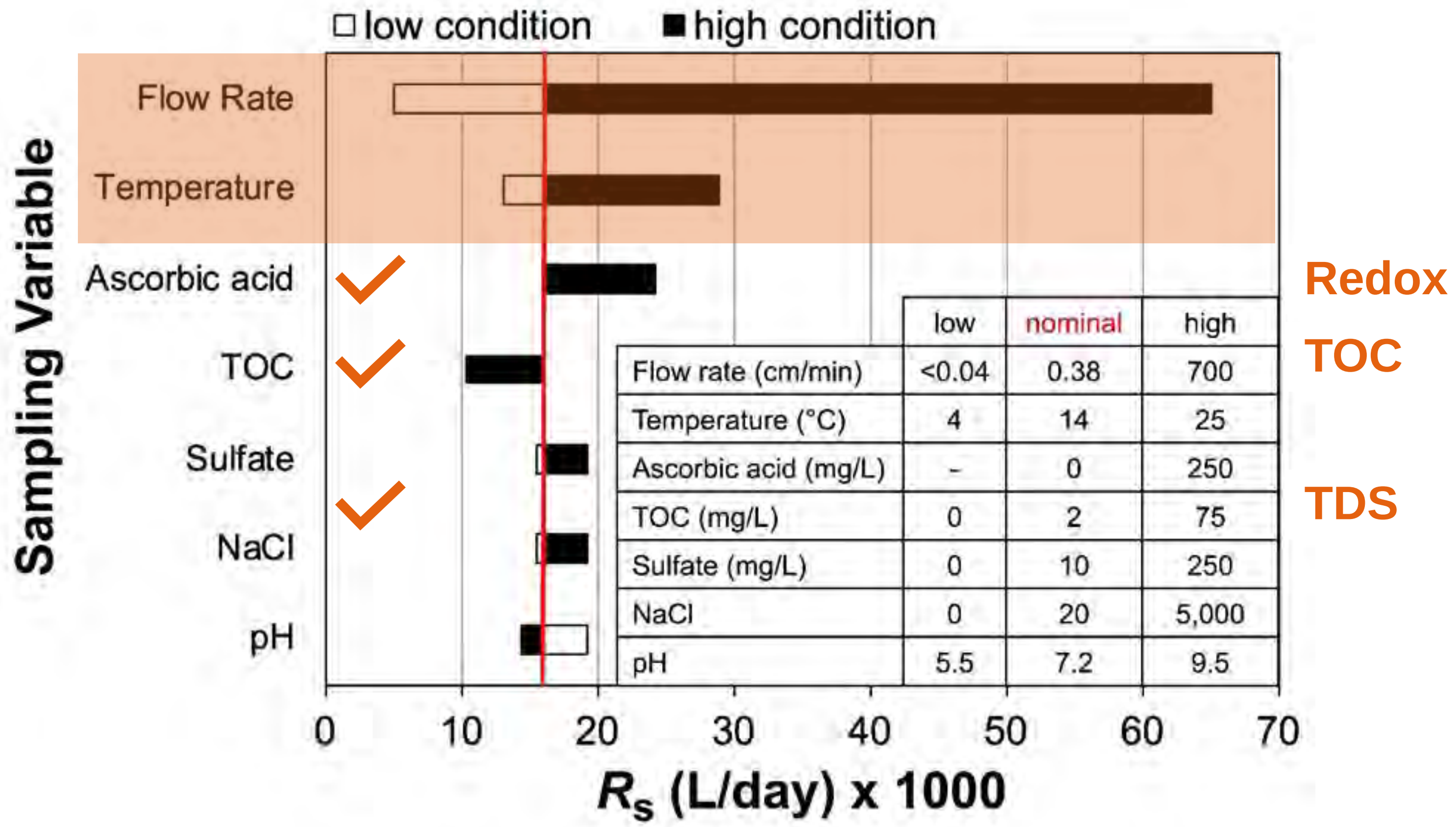
Exploring Bias

Initial investigations found the passive sampler to be relatively insensitive to environmental variables.

BAA demonstration further explored significance of temperature fluctuations during deployment and several geochemical variables (redox, TOC, TDS, turbidity)

One site contained co-constituent TCE

Tornado Plot of Sampling Rate Sensitivity to Environmental Variables



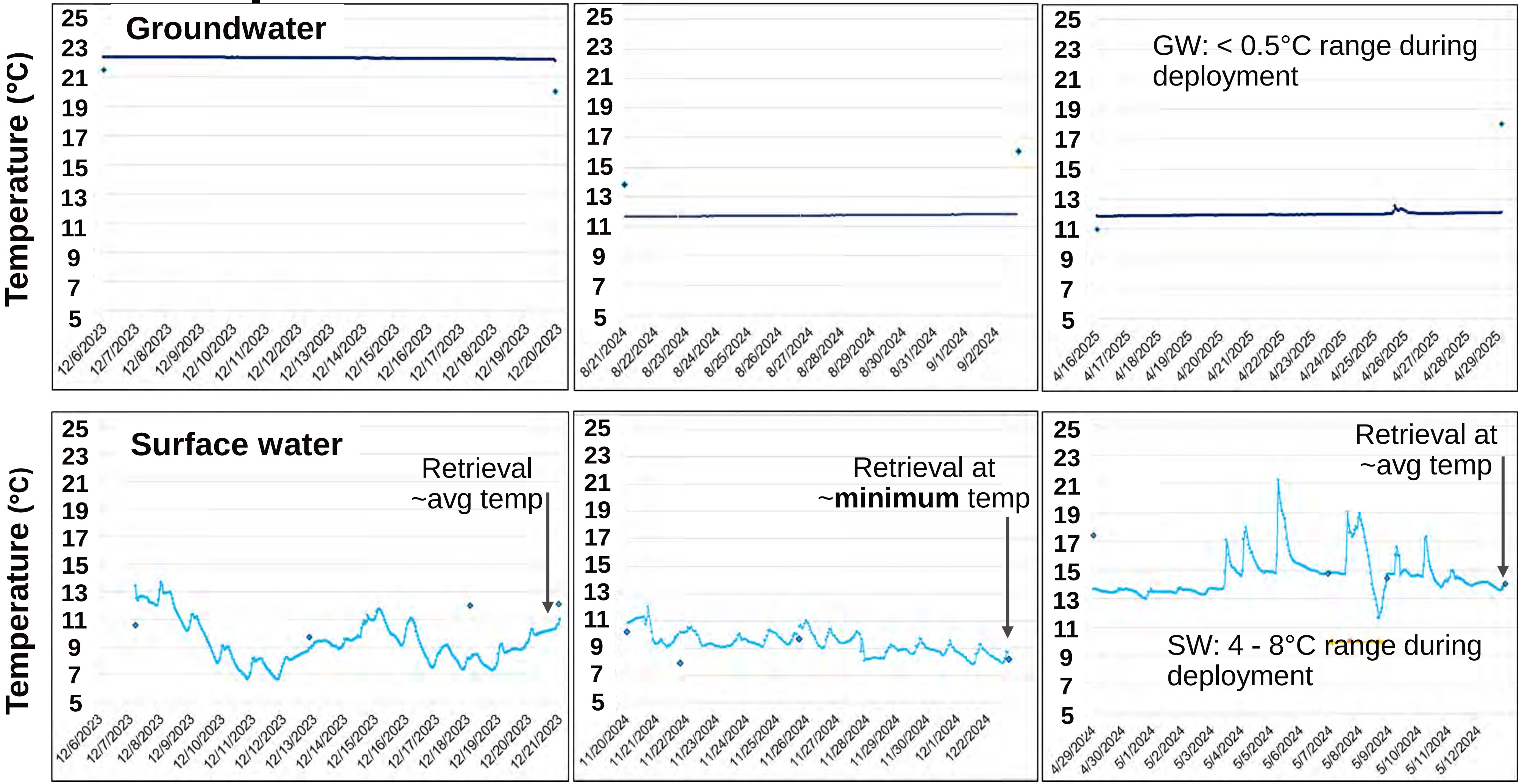
	low	nominal	high
Flow rate (cm/min)	<0.04	0.38	700
Temperature (°C)	4	14	25
Ascorbic acid (mg/L)	-	0	250
TOC (mg/L)	0	2	75
Sulfate (mg/L)	0	10	250
NaCl	0	20	5,000
pH	5.5	7.2	9.5

Exploring Bias – Temperature

Is temperature range during deployment an important factor to consider?

Concentration calculations are based on water temp at passive sampler retrieval.

At Installation 2 surface water site, passive samplers were retrieved at ~ the minimum temperature during deployment period with a 4° range. Sampling Rate (R_S) correction factor would adjust measured concentrations by a ~small factor of 1.1 to 1.2.



Installation 1 | Installation 2 | Installation 3

Conclusion: For temperature range <5° C, frequent temperature measurement & correction is not warranted.

Exploring Bias – Geochemical Variables

Measured correlation between Grab : Passive result ratio and geochemical variable concentration.
(Included paired detect results only, all sites pooled.)

Correlation for some PFAS analytes between Grab : Passive ratio and variables TOC, turbidity, and redox (ORP and iron)

Geochemical Variable
(# significant correlations per tested PFAS analytes)

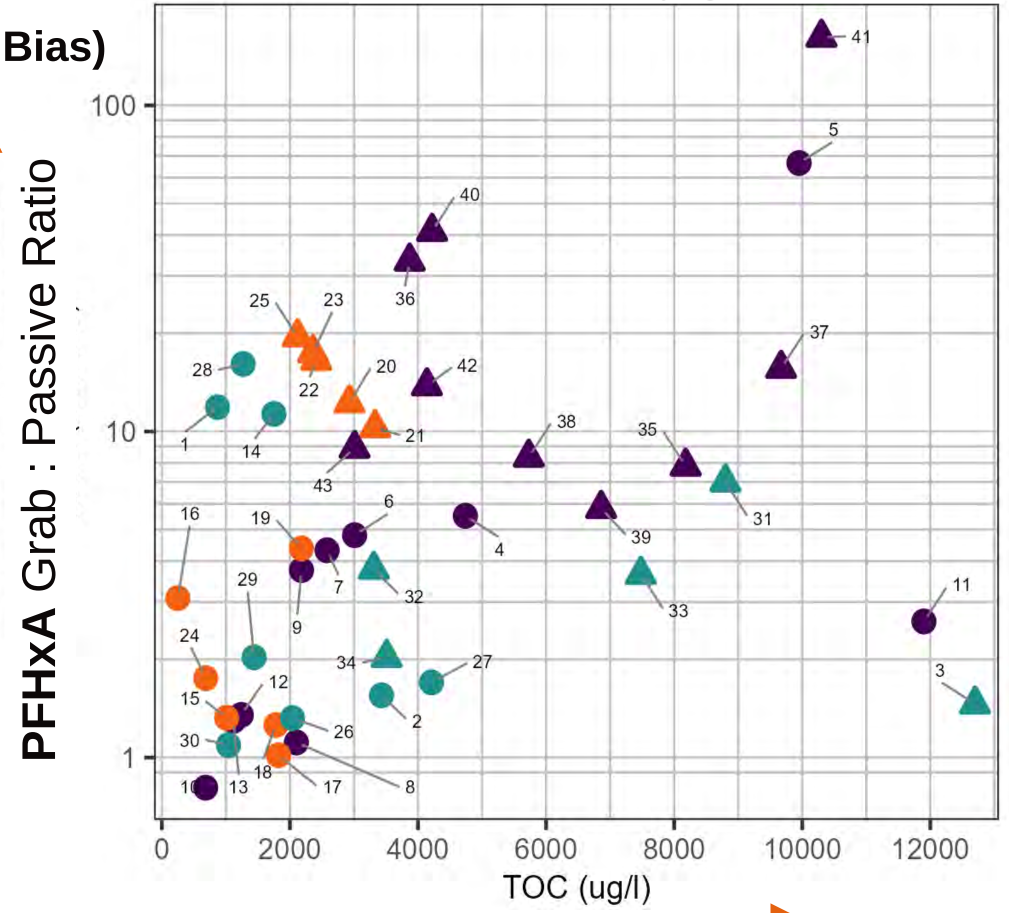
More (Low) Bias Positive Corr.	TOC (9 of 16)	Turbidity (5 of 16 - *long-chains*)		Lower Redox *High Iron* (1 of 16)	TDS (1 of 16)
Less (Low) Bias Negative Corr.		Turbidity (4 of 16 - *short-chains*)	Higher Redox *ORP* (6 of 16)	Lower Redox *High Iron* (4 of 16)	

No observed qualitative correspondence between Grab : Passive result ratio and co-constituent TCE.

Grab : Passive Ratio

(Low Bias)

Kendall's Rank Correlation
Kendall's Tau-b and 95% CI = 0.285 [0.0799, 0.49]
Correlation is statistically significant.



Geochem. Variable Conc.

Relatively insensitive to environmental variables.

Exploring Bias – Sorbent Media Production

- Passive samplers used for this project were among the first batches produced by the commercial manufacturer.
- Potential issues identified:
- Variability in mass of sorbent media per sampler (wet-packing vs. dry packing)
- Differences/variability in sampling rate (R_s) values in sorbent media batches prepared by original research laboratory vs. manufacturer – manifested in tint difference in sorbent
  - Potentially related to valence/binding capacity of copper ion
  - Original lab-prepared media had higher R_s values, especially for short-chains
- R_s difference in media prepared using original lab-prepared vs. early manufacturer process is enough to account for most of the low bias observed in this demonstration

PFAS	Relative R_s Early Mfr / Original Lab Media
PFBA	7.7
PFBS	1.9
PFPeA	3.4
PFHxA	2.0
PFHxS	1.8
PFHpA	1.8
PFOA	1.7
PFOS	0.8
PFOSA	1.4
PFNA	1.2
PFDA	1.2
Average	2.3
Range	0.8 - 7.7

Data from P. Edmiston, College of Wooster

Issues identified and addressed by the manufacturer, with improved process and quality controls implemented in the last 6 to 12 months.

4. Conclusions and Resources

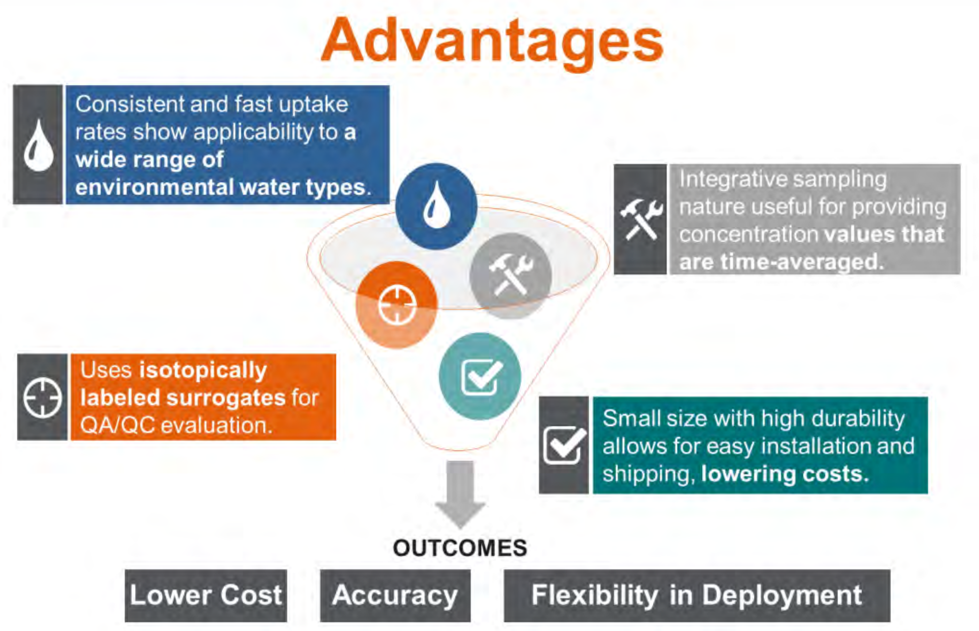
Conclusions

PassiveX™ sampler reporting limits: ~5-10 ng/L in this study

Good correspondence between the passive and grab result observed across over 5 orders of magnitude in concentrations:

- 46% of paired detect samples within 2.5X the grab result and 72% within 5X
- Some apparent low bias (passive less than grab) potentially due to early manufacturing issue. Manufacturer has subsequently modified production and verification procedures.
- Largely insensitive to geochemical variables

Repeatable results (average 28.8% RSD) in groundwater and surface water



Recommended uses at current technology development stage:

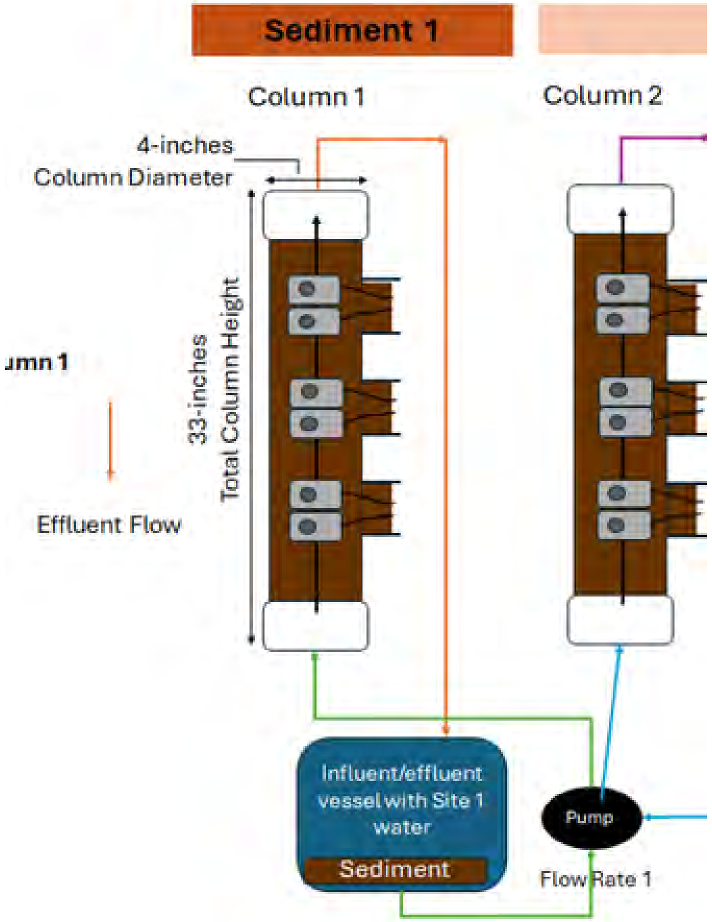
- Site screening
- General characterization / mapping of relative concentrations across a site
- Remedy performance monitoring

Not demonstrated for quantitative risk assessment or compliance monitoring

Additional Demonstration Projects

Sediment Porewater (ESTCP 23-7696, P.I. E. Carter)

- Completed static tank and packed column tests in site sediment
- Confirmed sampling rates within <5x expected values
- <40% RSD
- Demonstration at two field sites planned for 2026



PFAS Passive Sampling Method Comparison (ESTCP ER23-8494 P.I. J. McDonough)

- Recently initiated, will compare multiple styles of passive samplers and grab sampling

Resources

Edmiston, Carter, Toth, Hershberger, Hill, Divine, 2023. Field Evaluation the Sentinel™ Integrative Passive Sampler for the Measurement of Per- and Polyfluoroalkyl Substances in Water Using a Modified Organosilica Adsorbent. GWMR 43(4), https://doi.org/10.1111/gwmr.12574

Edmiston, Hill, Hershberger, Hartmann, Carter, Divine, 2023. Laboratory Validation of an Integrative Passive Sampler for Per- and Polyfluoroalkyl Substances in Water. Environmental Science: Water Research & Technology, 9, 1849 – 1861. https://doi.org/10.1039/d3ew00047h

Hartmann, Hefner, Carter, Liles, Divine, Edmiston, 2021. Passive Sampler Designed for PFAS Using Polymer-Modified Organosilica Adsorbent. AWWA Water Science, 3(4) https://doi.org/10.1002/aws2.1237

Interstate Technology Regulatory Council (ITRC) 2024 Passive Sampling Technology Update. https://psu-1.itrcweb.org

Two US Patents issued (11,650,138 B2; 11,703,426 B2)

Questions?

Contact us

Erika Carter

Principal Geoscientist

Erika.Carter@arcadis.com

Annika Evans

Staff Engineer

Annika.Evans@arcadis.com

Theresa Olechiw

Project Manager

Theresa.Olechiw@arcadis.com

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