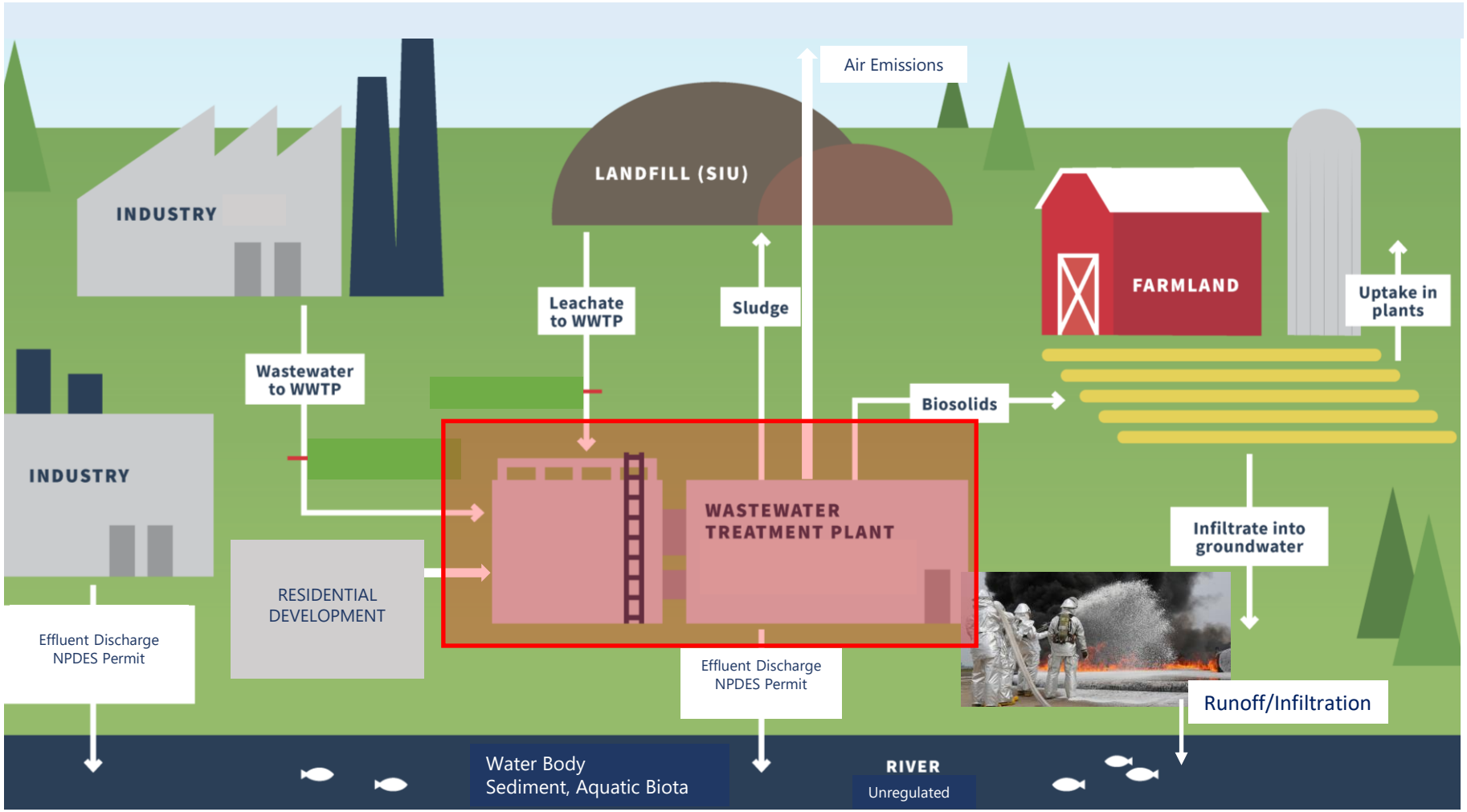
Characteristics of PFAS Source Signatures in Wastewater Systems

Dr. Paula J. Mouser and Sydney Adams, Presenters
Eamon Twohig, Coauthor

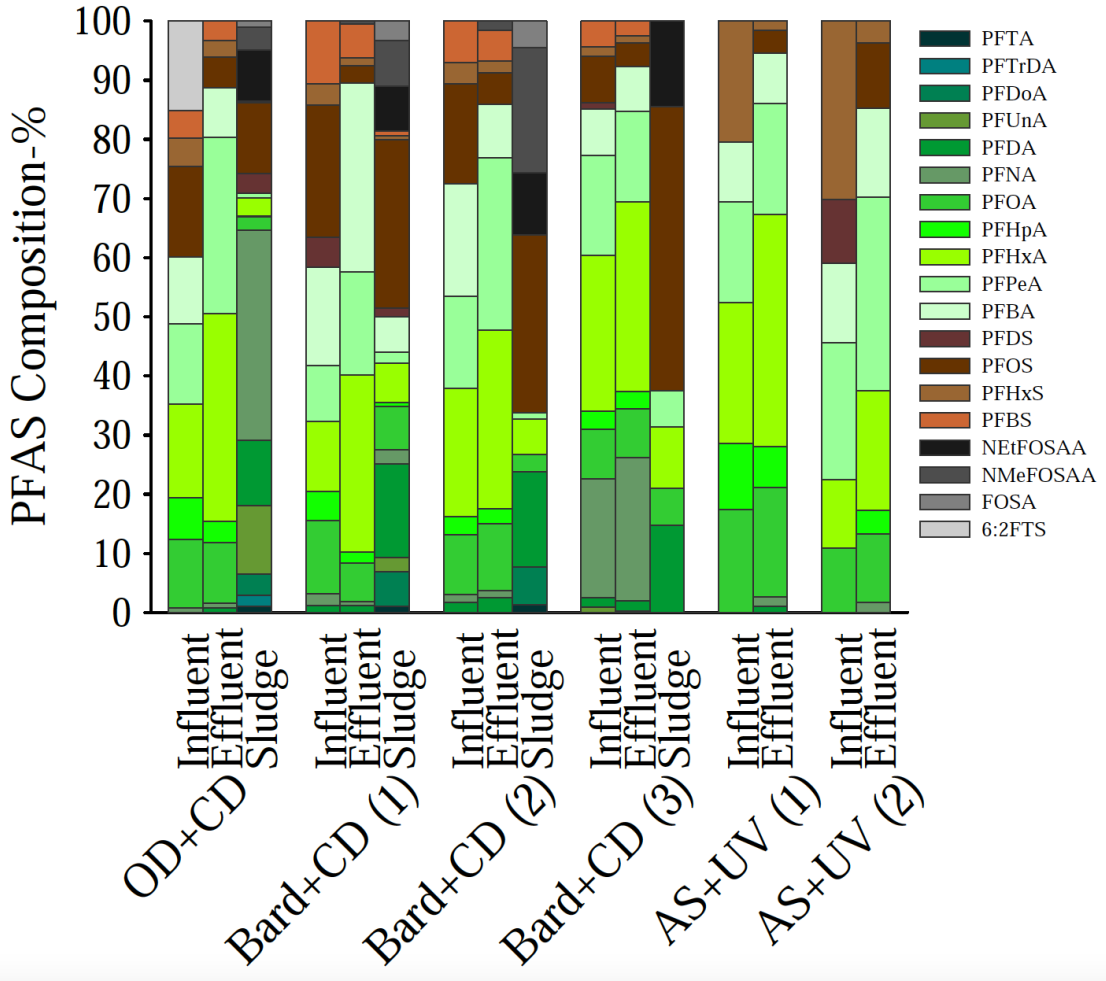
NEWMOA Conference - April 6th, 2022

Wastewater treatment facilities play a central role in concentrating and fractionating PFAS



Modified from Michigan Department of Environment, Great Lakes, and Energy
https://www.michigan.gov/pfasresponse/0,9038,7-365-86510_88079-476131--,00.html

PFAS signatures in WW effluent differ from sludge



Tavasoli et al. 2021, *ES:PI*

Mixture of PFAAs, percursors - influent

Shorter chain, PFCAs – effluent

Longer chain, PFSAs, percursors – sludge

Partitioning driven by $\log(K_d)$


Environmental Science Processes & Impacts

ROYAL SOCIETY OF CHEMISTRY

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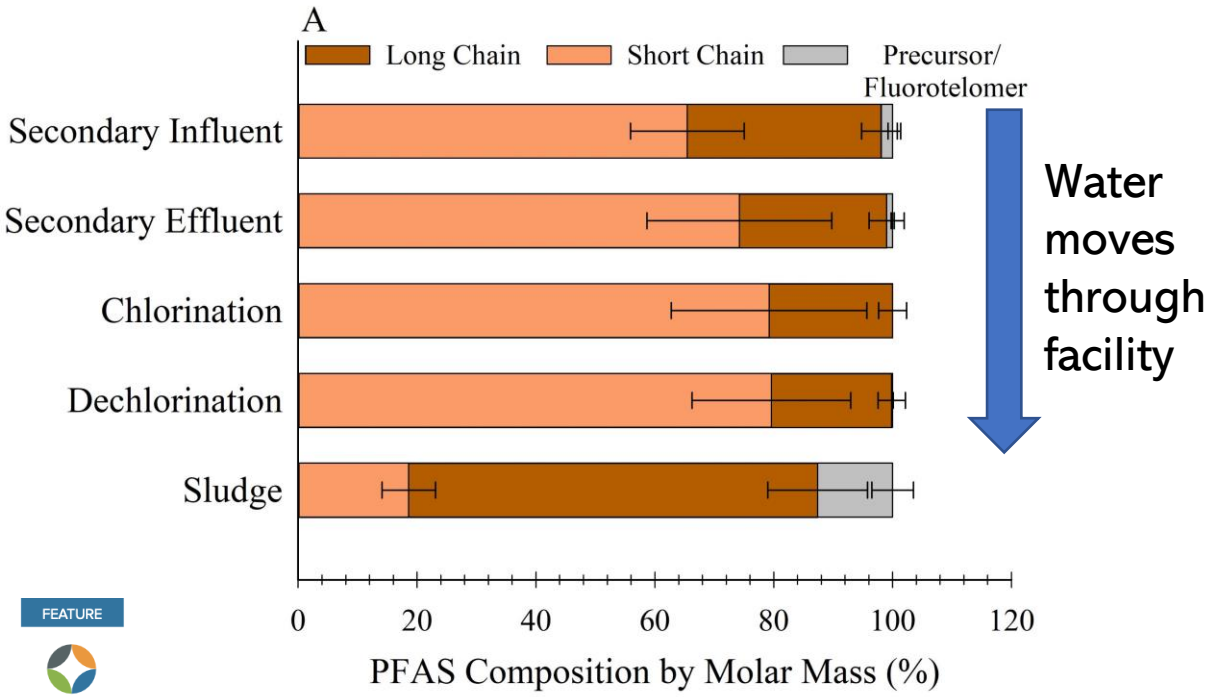
Cite this: DOI: 10.1039/d1em00032b

Distribution and fate of per- and polyfluoroalkyl substances (PFAS) in wastewater treatment facilities†

Elham Tavasoli,[ab] Jenna L. Luek,[a] James P. Malley Jr[a] and Paula J. Mouser[*a]

Fractionation occurs through facility



FEATURE

NEWEA

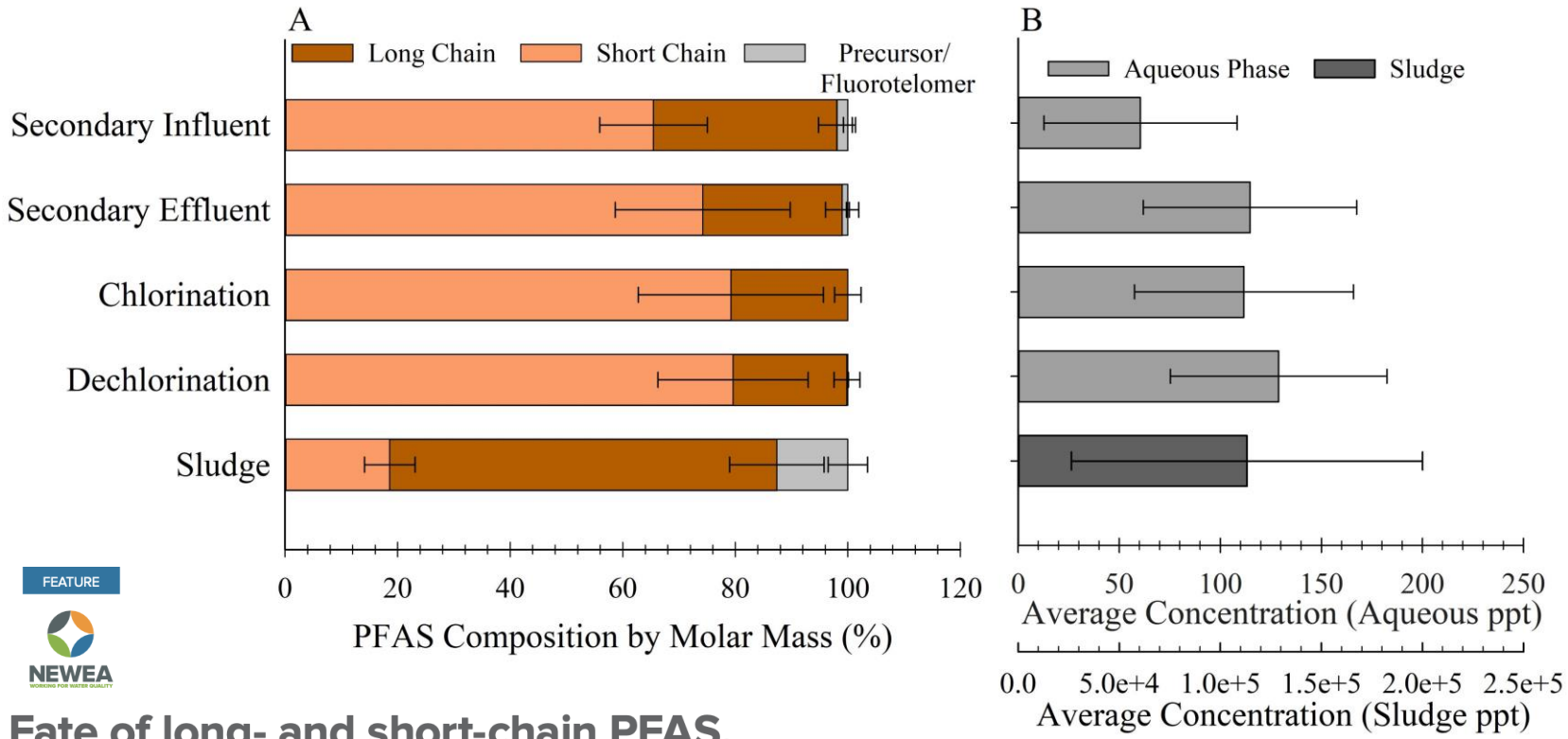
Fate of long- and short-chain PFAS, pharmaceuticals, and personal care products in wastewater biosolids

SYDNEY ADAMS, CASSIDY YATES, CARMELA ANTONELLIS, JENNA LUEK, PhD, JAMES P. MALLEY, JR., PhD, and PAULA MOUSER, PhD, PE (corresponding author)
Department of Civil and Environmental Engineering, University of New Hampshire, Durham, New Hampshire

Percent of short chain PFAAs increases in aqueous phase during treatment

Long chain PFAAs and precursors/FT sequestered in sludge

Fractionation occurs through facility



ΣPFAS concentrated 850 to 1850x higher in sludge

FEATURE

NEWEA

Fate of long- and short-chain PFAS, pharmaceuticals, and personal care products in wastewater biosolids

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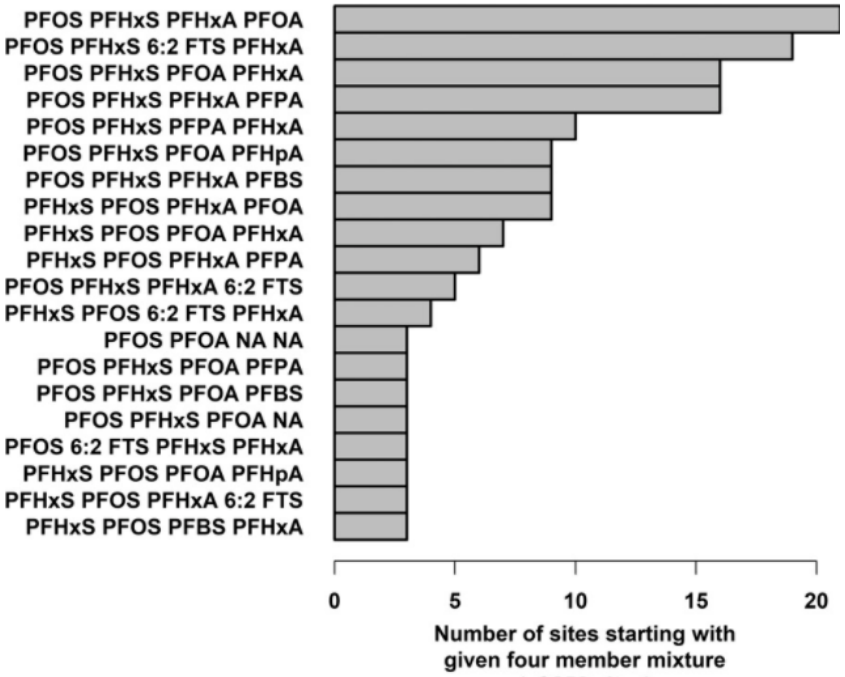
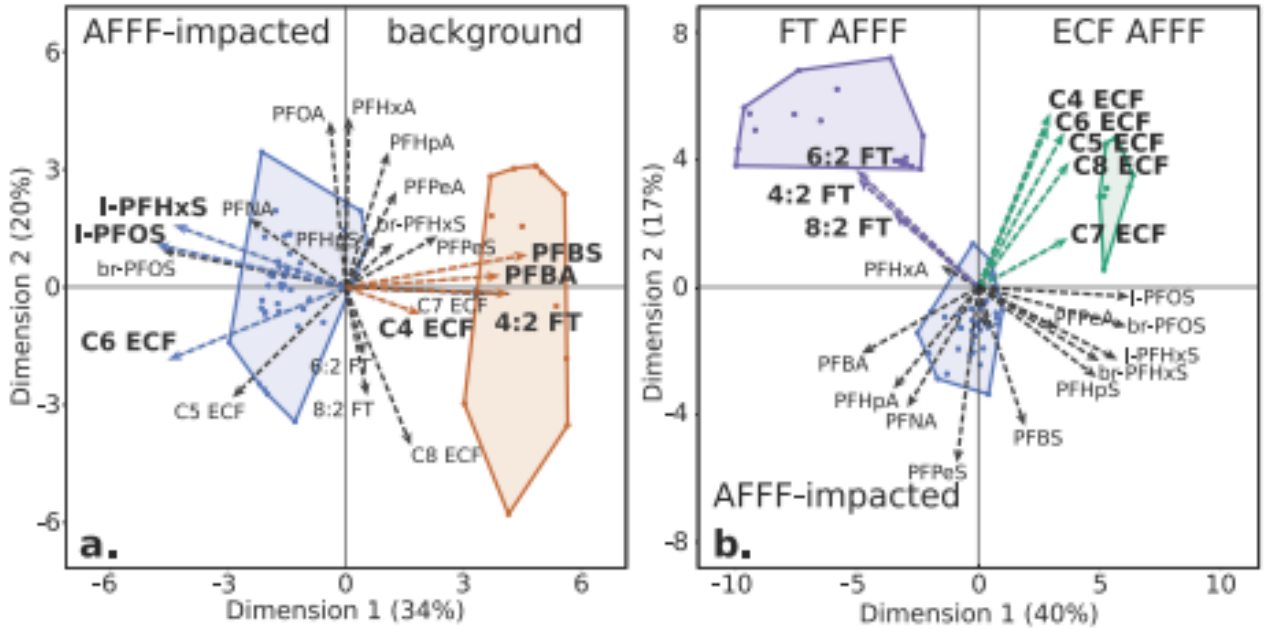
Department of Civil and Environmental Engineering, University of New Hampshire, Durham, New Hampshire

PFAS fingerprinting commonly applied to surface waters, but not wastewater





Environmental Toxicology and Chemistry

Hazard/Risk Assessment | Full Access

Per- and Polyfluoroalkyl Substances (PFAS) in Surface Water Near US Air Force Bases: Prioritizing Individual Chemicals and Mixtures for Toxicity Testing and Risk Assessment

Andrew East, Richard H. Anderson, Christopher J. Salice

First published: 07 October 2020 | https://doi-org.unh.idm.oclc.org/10.1002/etc.4893 | Citations: 11

Environmental Science & Technology

pubs.acs.org/est

Article

Isolating the AFFF Signature in Coastal Watersheds Using Oxidizable PFAS Precursors and Unexplained Organofluorine

Bridger J. Ruyle,* Heidi M. Pickard, Denis R. LeBlanc, Andrea K. Tokranov, Colin P. Thackray, Xindi C. Hu, Chad D. Vecitis, and Elsie M. Sunderland

Characterizing sources could help reduce PFAS from WWTF

LOCAL & STATE

Maine to investigate more than 500 sludge sites for contamination by 'forever chemicals'

With $30 million in state funding, officials plan an unprecedented effort to test sites statewide for chemicals known as PFAS and assist people affected by the pollution.

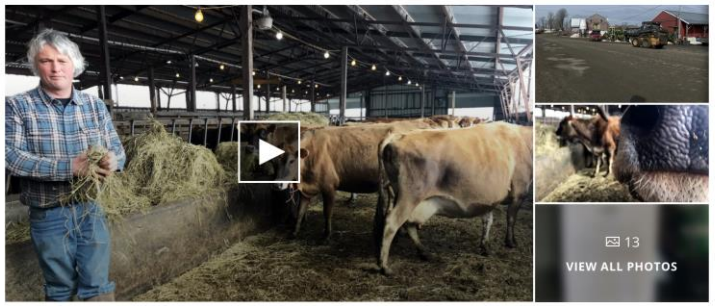
BY KEVIN MILLER STAFF WRITER

PFAS chemicals found in some garden fertilizers, according to study

According to an Ecology Center and Sierra Club study, all of the fertilizers investigated contain biosolids, leftover sludge from wastewater treatment plants

'Forever chemicals' contaminate milk on Maine dairy farm

by WGME | Thursday, February 17th 2022



A farm in Albion has discovered harmful forever chemicals in some of their products. (WGME)

ALBION (WGME) – A farm in Albion has discovered harmful forever chemicals in some of their products.

- **Also read:** Maine farmers could face financial ruin amid 'forever chemical' crisis

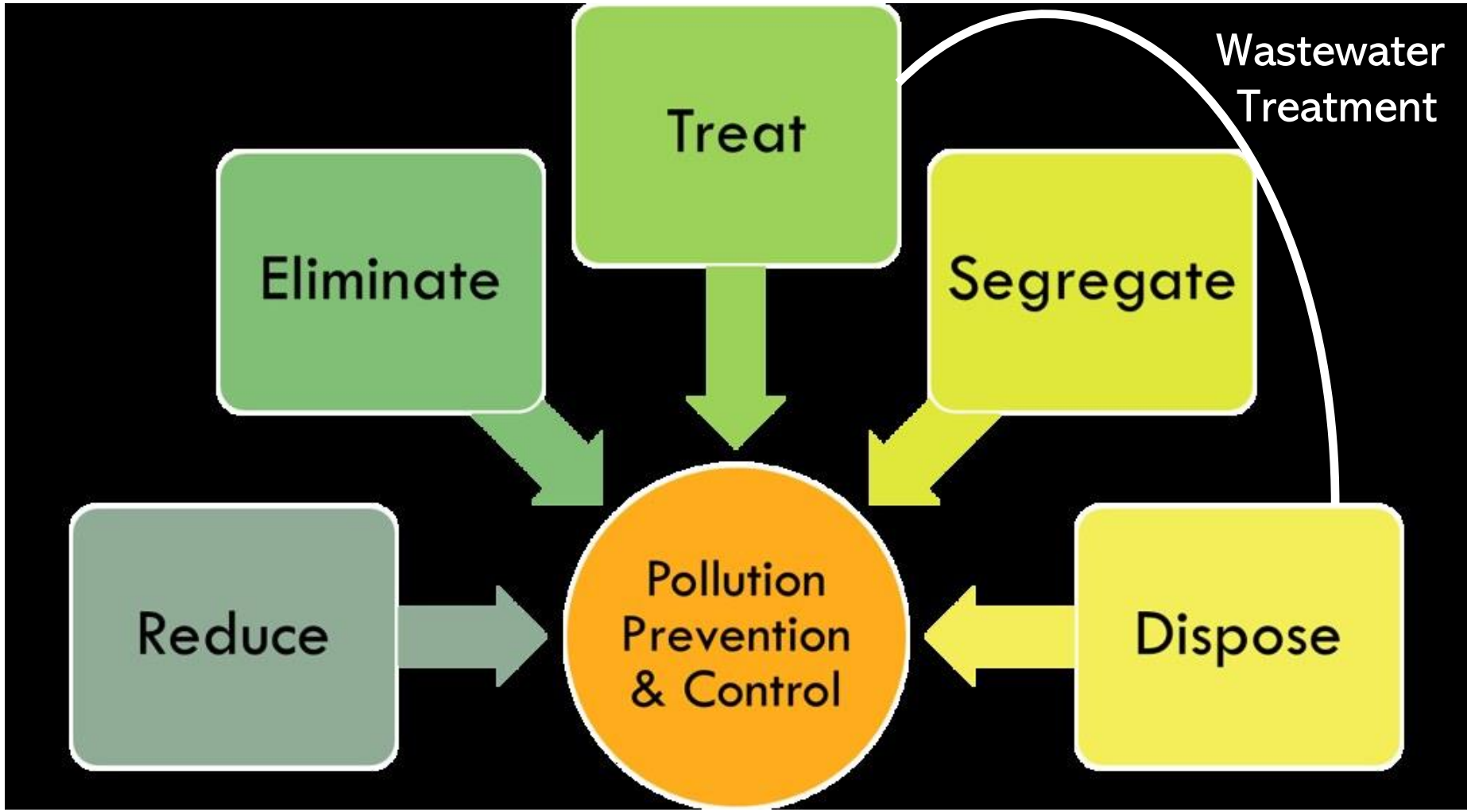
Late last week, the owners of Misty Brook Farm found out some of their cow milk was contaminated with PFAS.

Now they're waiting for test results from the state.

Rulemaking ongoing for:

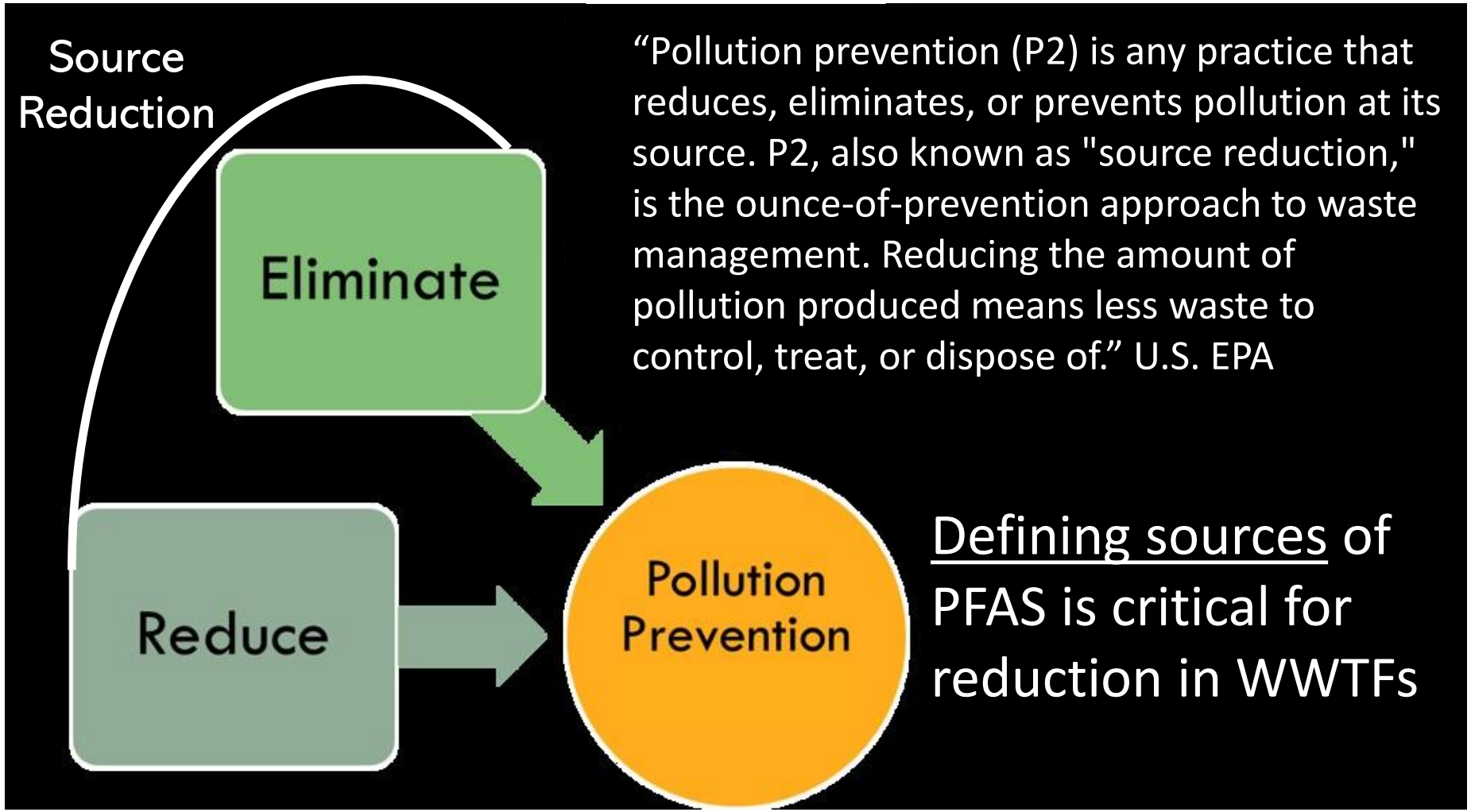
- -Biosolids
- -Surface Water
- -NPDES Permitholders

What tools target PFAS mass reduction in WW?



From: https://www.lanl.gov/environment/sustainability/pollution-prevention.php

What tools target PFAS mass reduction in WW? Pollution Prevention (P2)



"Pollution prevention (P2) is any practice that reduces, eliminates, or prevents pollution at its source. P2, also known as "source reduction," is the ounce-of-prevention approach to waste management. Reducing the amount of pollution produced means less waste to control, treat, or dispose of." U.S. EPA

<u>Defining sources</u> of PFAS is critical for reduction in WWTFs

From: https://www.lanl.gov/environment/sustainability/pollution-prevention.php

Our “Fingerprinting” Approach…

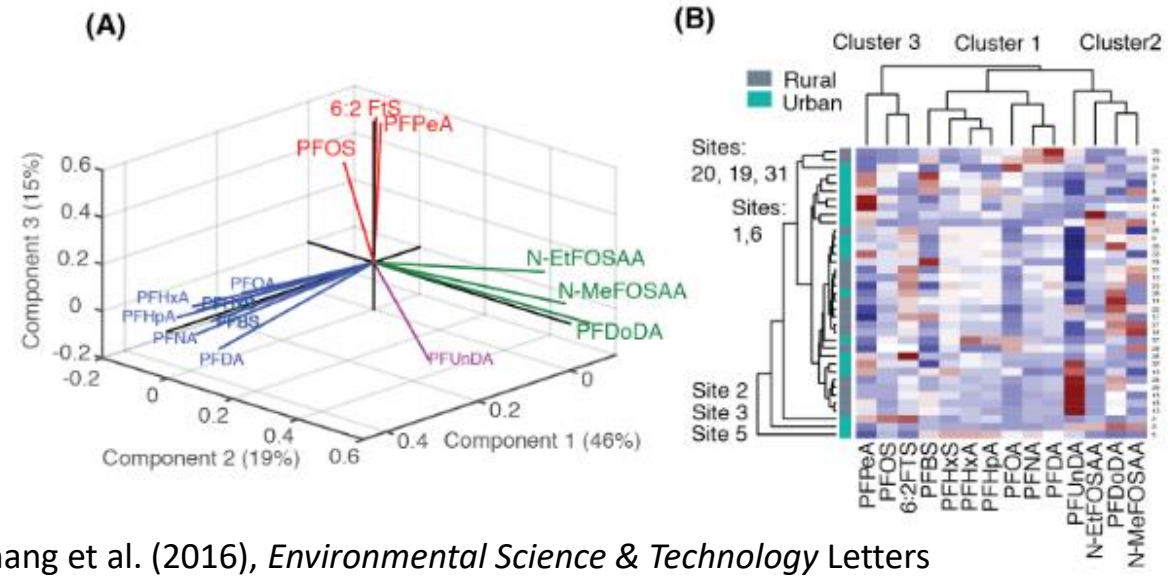
Overarching Objective:

Mine growing PFAS databases to evaluate sources and removal patterns in different wastewater media (with the ultimate goal of elimination)

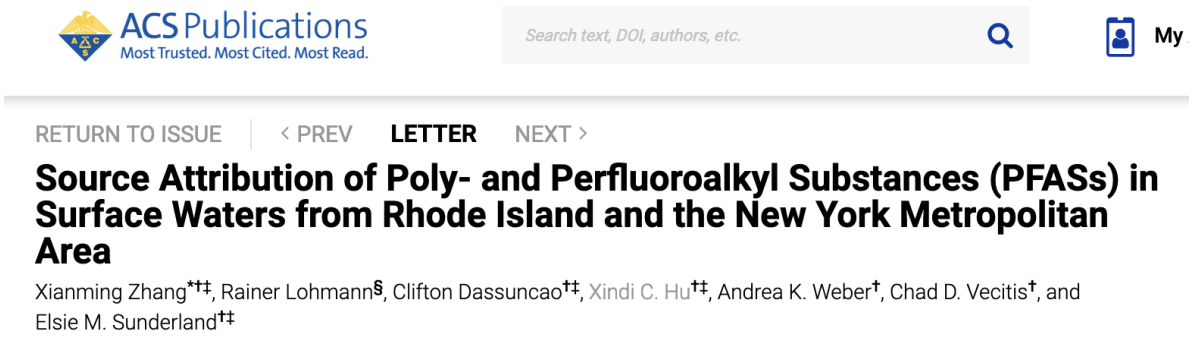
Research Questions:

1. Are there differences in influent, effluent, and sludge PFAS signatures?
2. Are known upstream sources associated with predictable PFAS compositions?
3. Does sludge handling influence PFAS signatures?

A word about methods…



Zhang et al. (2016), *Environmental Science & Technology* Letters



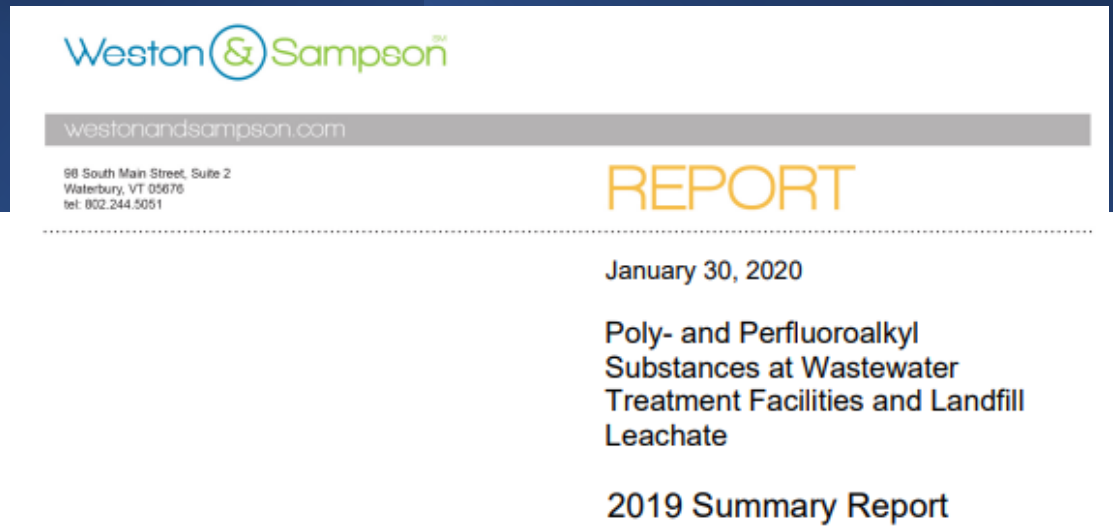
Multivariate statistics are a valuable tool to explore relationships between variables (PFAS) and samples

Examples include:

- Principle Component Analyses (PCA)
- Hierarchical Clustering
- Non-multidimensional scaling (NMDS)
- Analysis of Similarity (AOSIM)
- Indicator Species Analysis
- Artificial Neural Networks (ANNs) inc. SOMs

Data and databases used…

- "PFAS at Wastewater Treatment Facilities and Landfill Leachate", (2019) Weston & Sampson, available from VTDEC
- PFAS in WWTF influent, effluent, sludges, biosolids, available through NHDES "One-Stop" database (accessed 2020)
- Other growing databases (Michigan EGLE, Maine DEP, others)


Weston & Sampson

westonandsampson.com

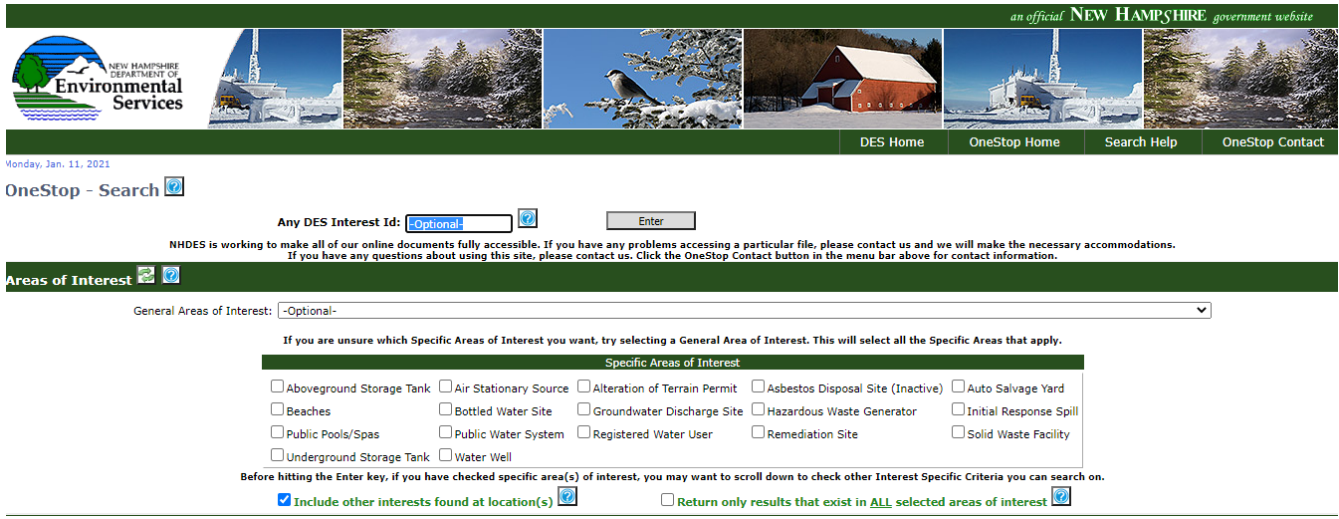
98 South Main Street, Suite 2
Waterbury, VT 05676
tel: 802.244.5051

REPORT

January 30, 2020

Poly- and Perfluoroalkyl Substances at Wastewater Treatment Facilities and Landfill Leachate

2019 Summary Report



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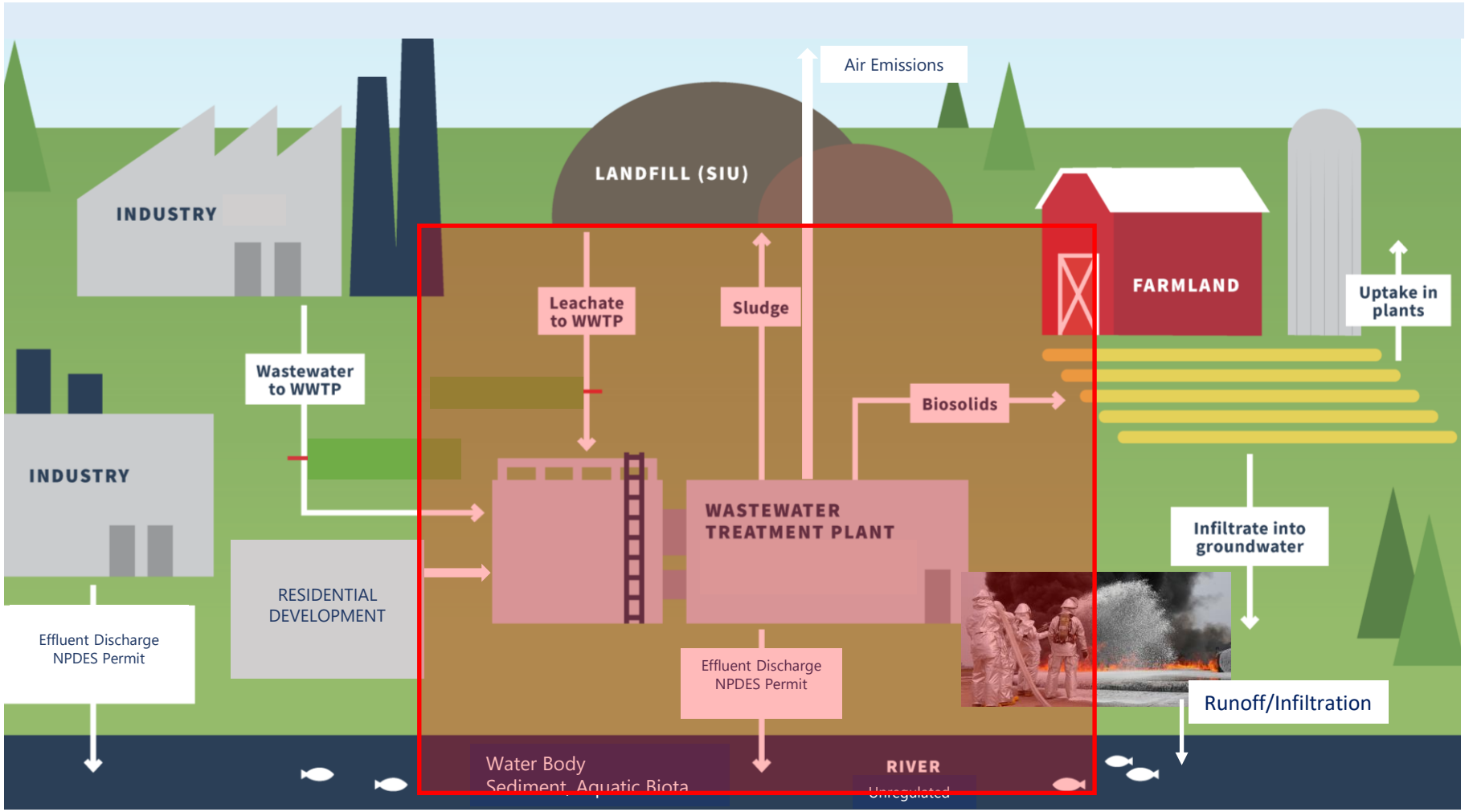

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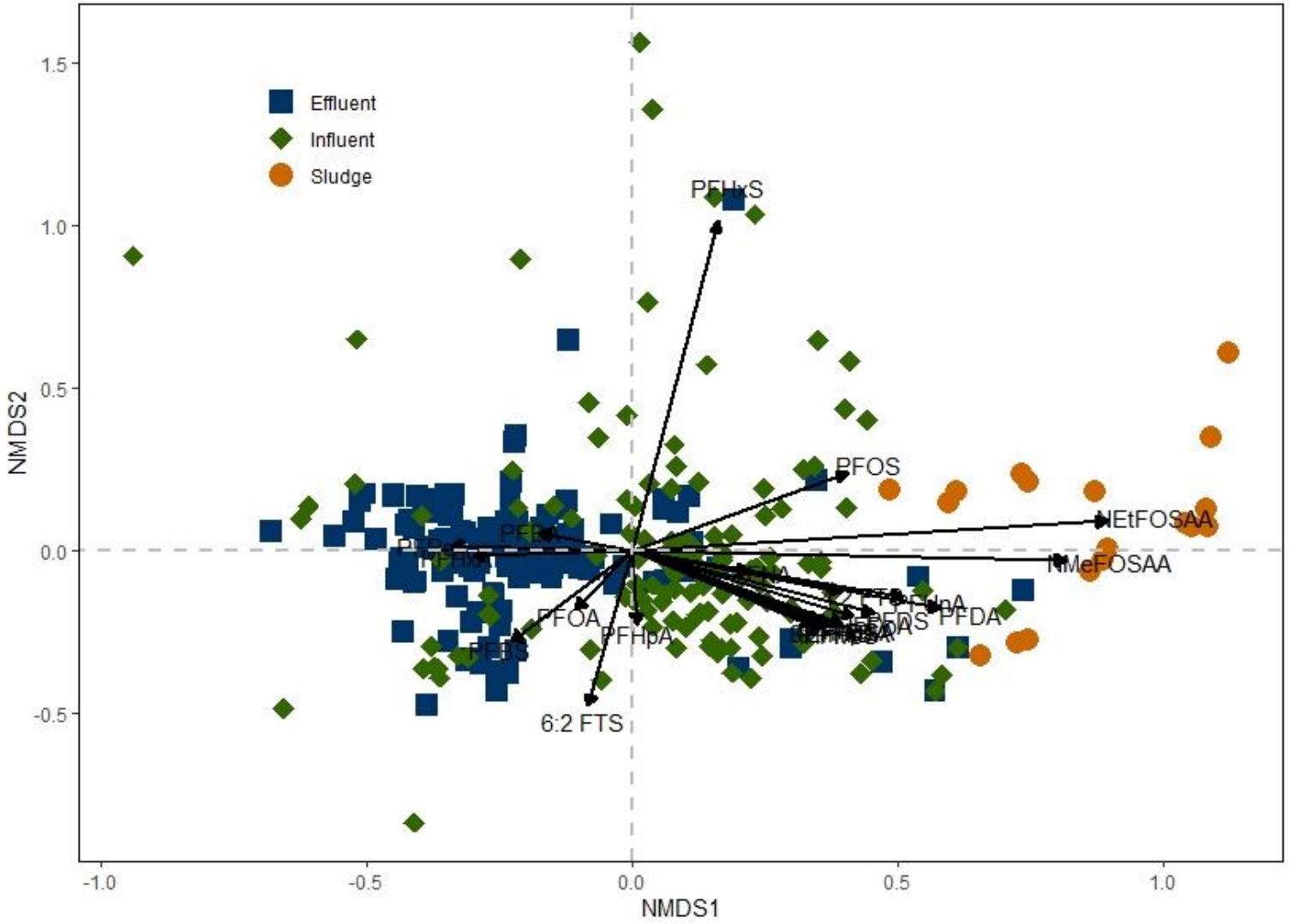
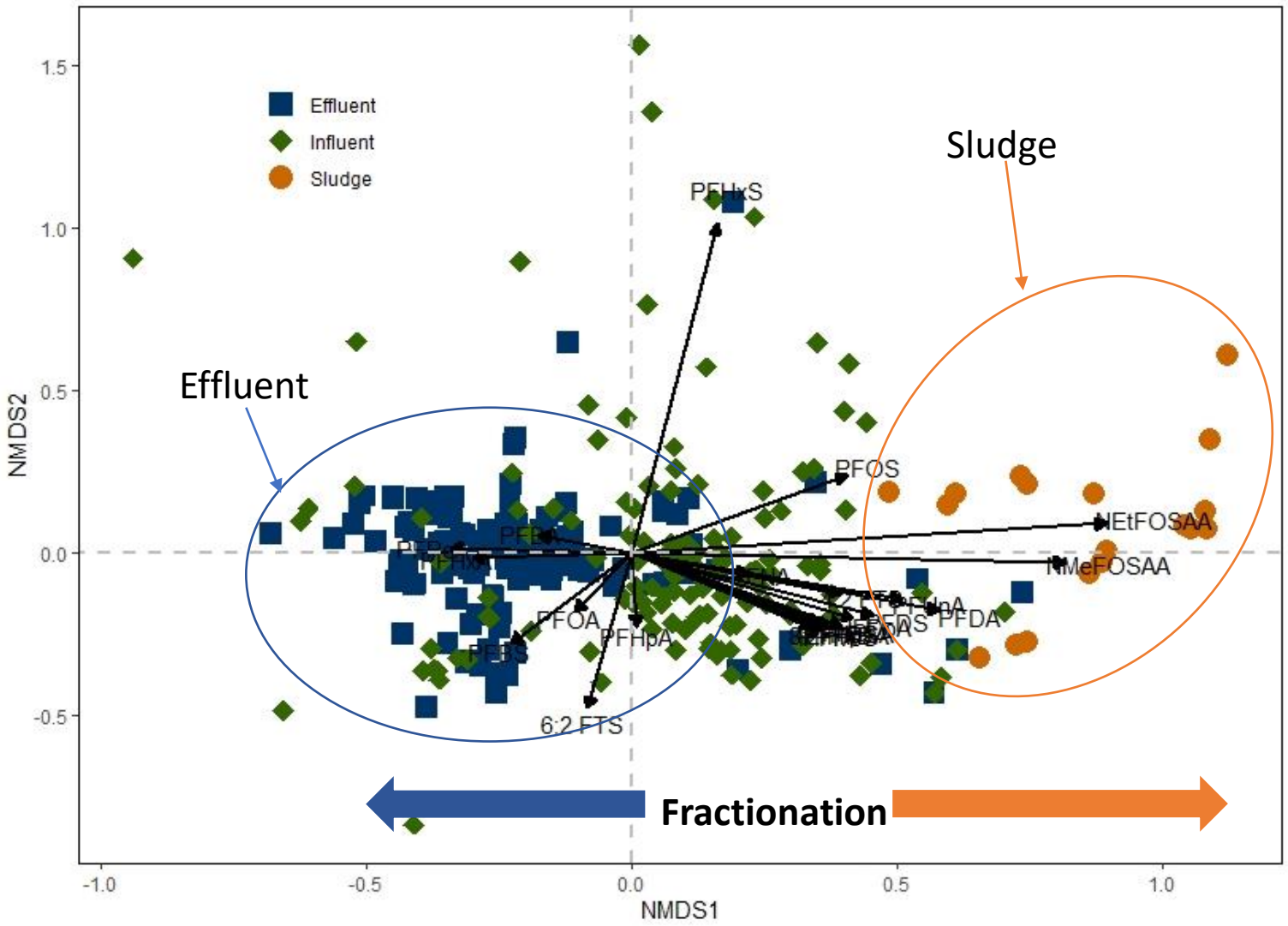
Applied NMDS with analysis of similarity (AOSIM) to W&S data



Adams et. al, in preparation. Non-multidimensional scaling of influent PFAS measurements for 18 Vermont WWTFs (AOSIM, Figure S1, $p<0.001$, $R=0.3234$; Pairwise ADONIS, INF & EFF $p<0.001$, INF & Sludge $p<0.001$, EFF & Sludge $p<0.001$).

Applied NMDS with analysis of similarity (AOSIM) to W&S data

PFAS composition was distinct between wastewater medium



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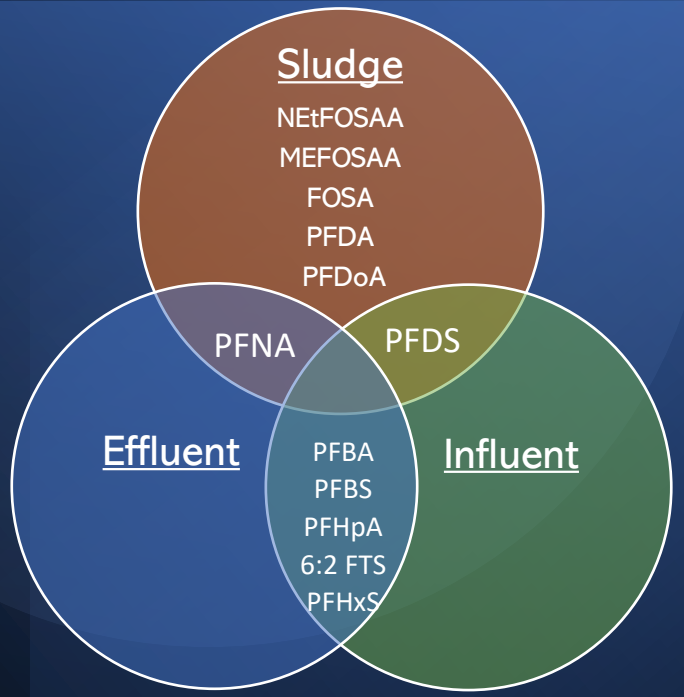
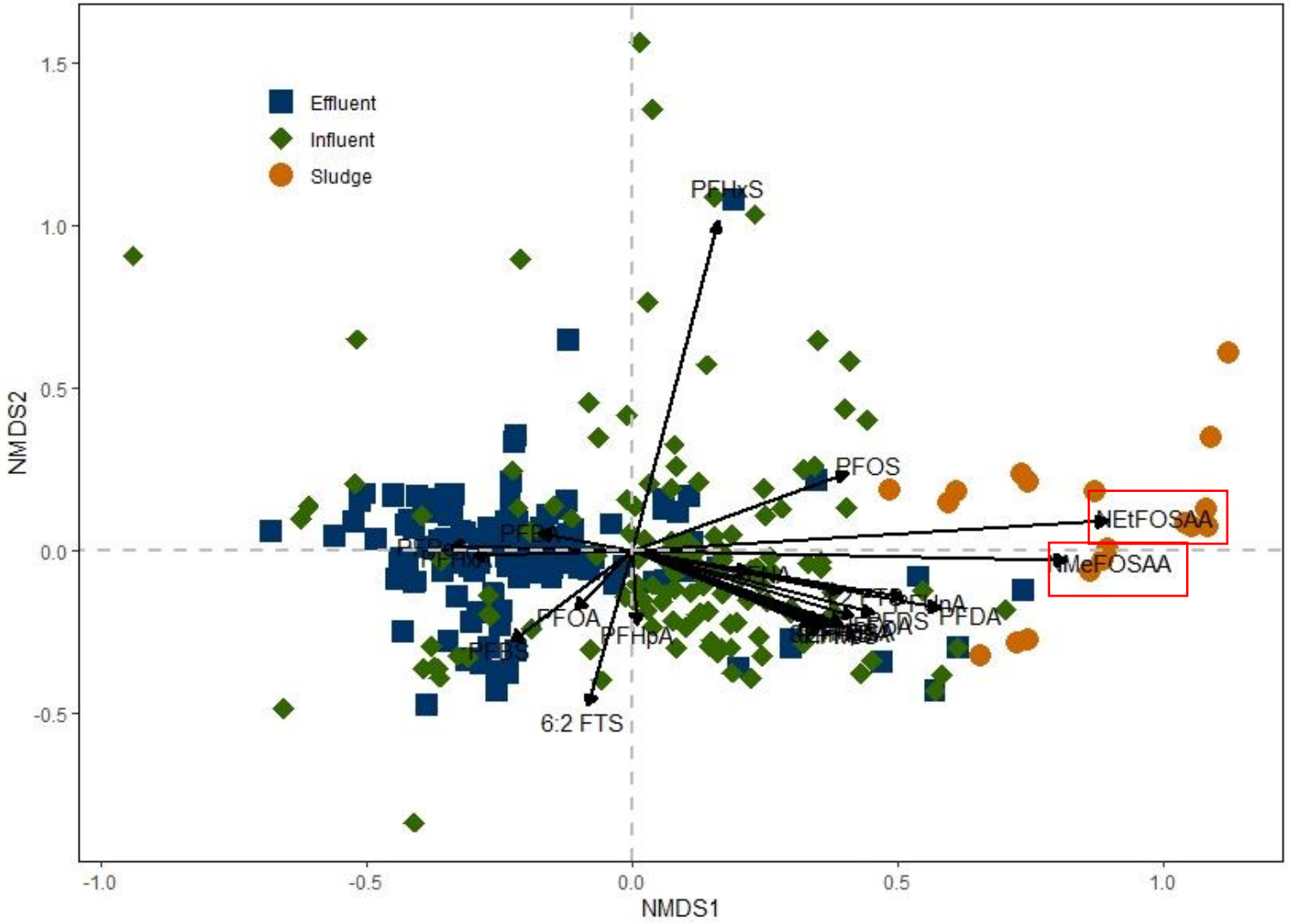
Indicator analysis revealed which congeners were driving group composition



Venn diagram illustrating indicator species analysis results



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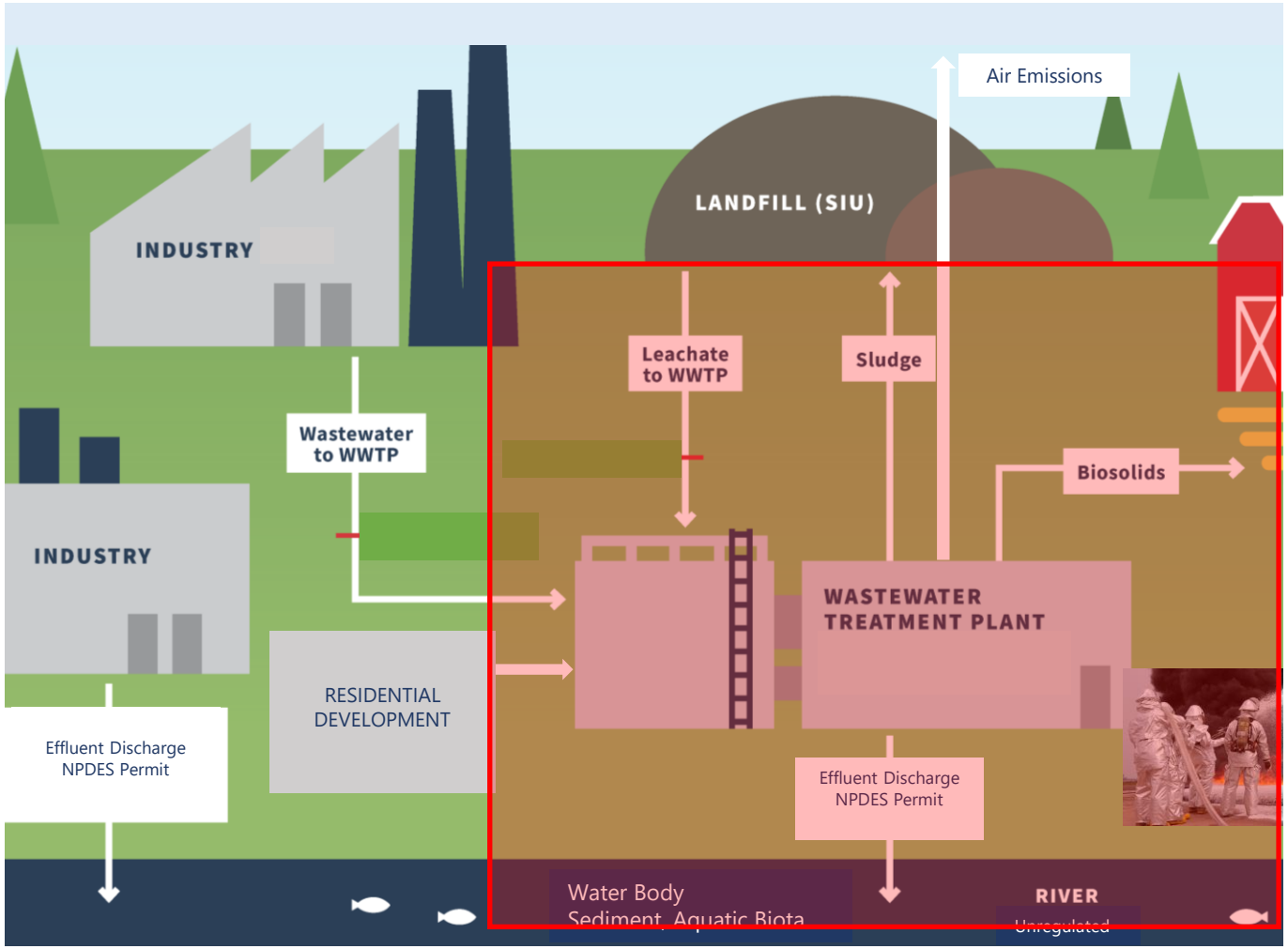
1. Are there differences in influent, effluent, and sludge PFAS signatures?



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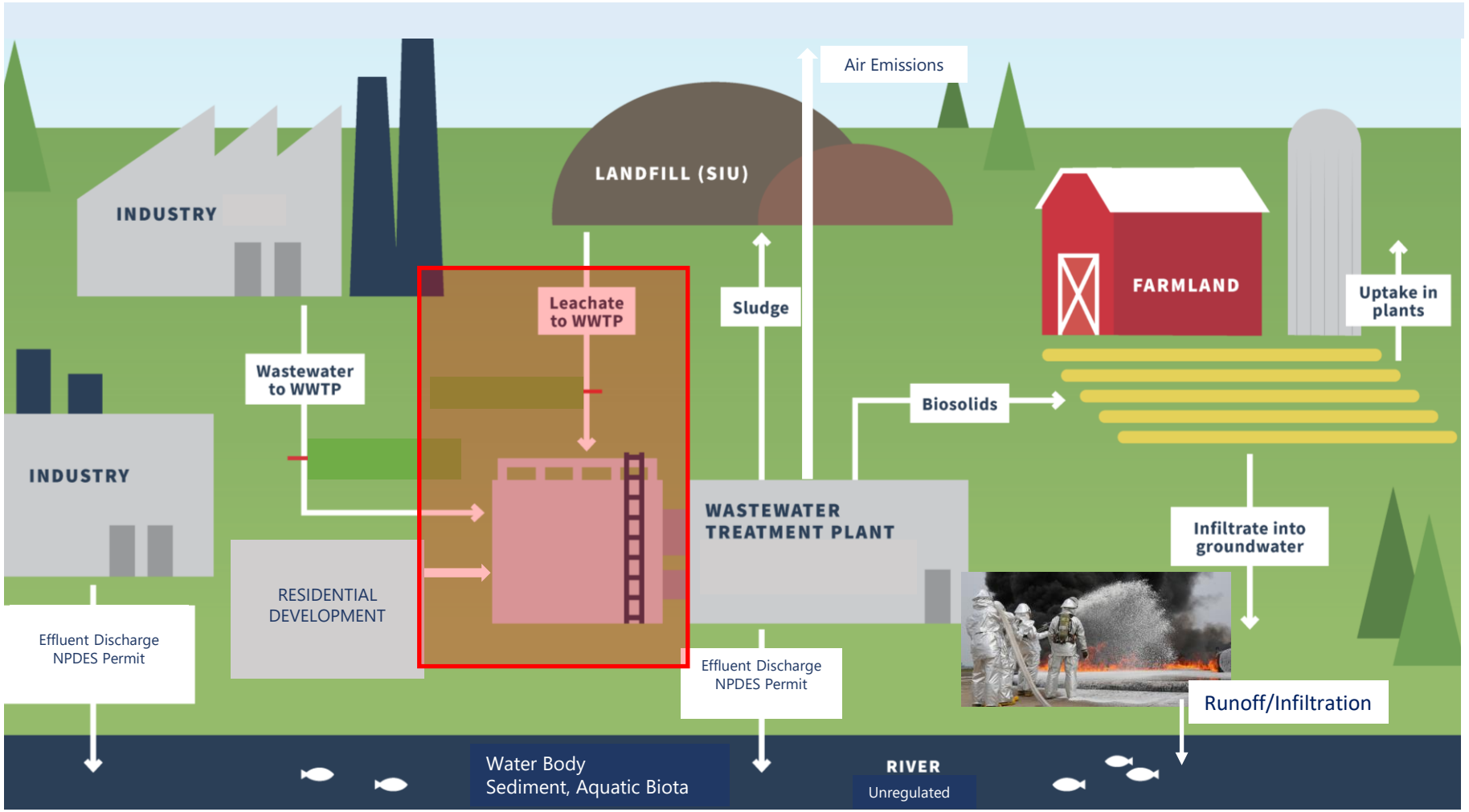
Summary/key points

- PFAS fractionate during treatment, dissimilar signatures in effluent and sludge
- Long chain, precursor, and sulfonates PFAS in primarily in biosolids

2. Are known upstream sources associated with certain PFAS compositions?



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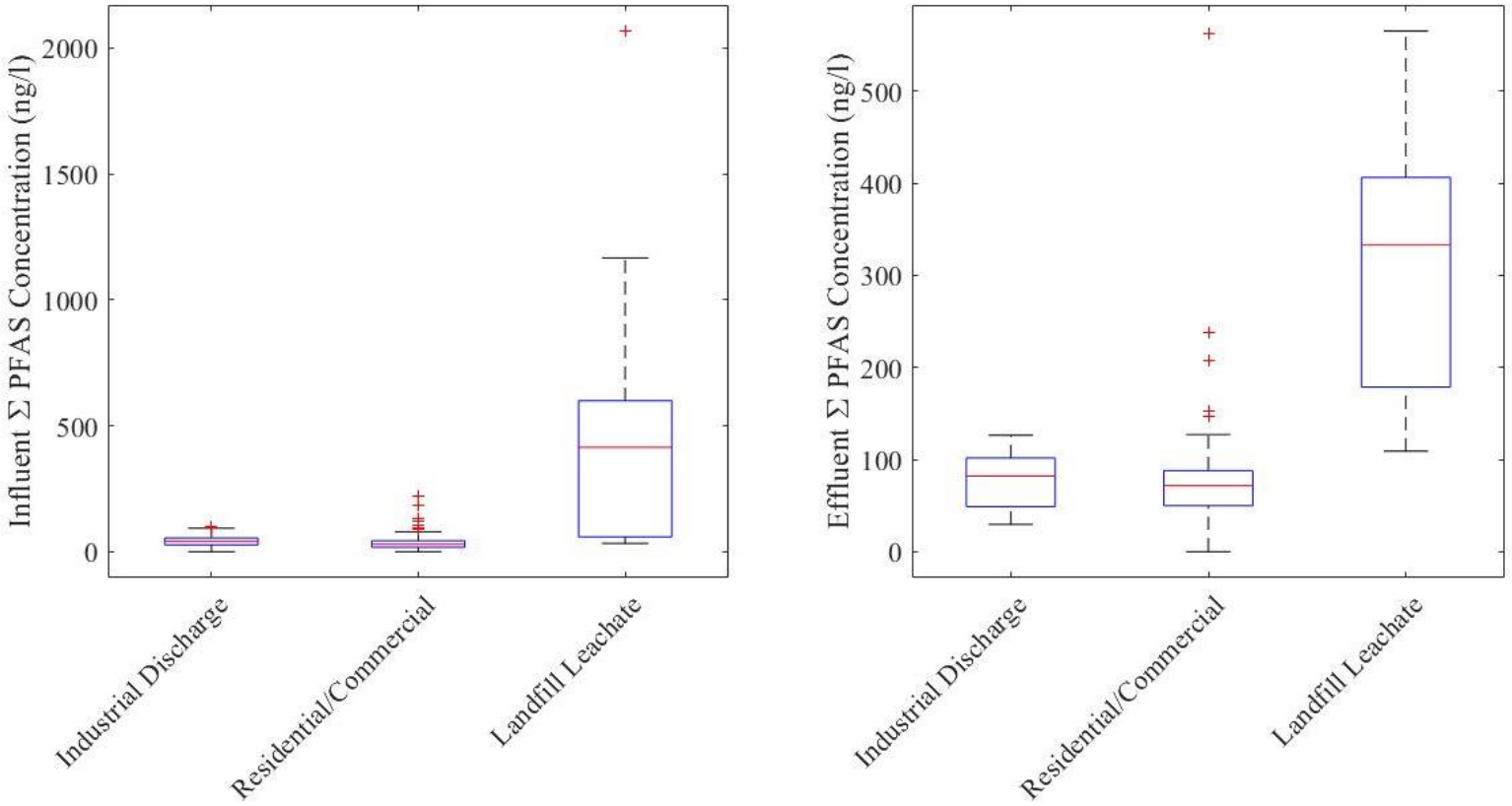
Same data, but classified by sources known to be discharging to WWTFs

Industrial Discharge (with IPP)	Landfill Leachate (>1%)	Residential/Commercial/ Food Prep Only
Barre	Montpelier	Burlington- North
Brattleboro	Newport	Shelburne
Burlington- Main		South Burlington- Bartlett Bay
Essex		St. Johnsbury
Milton		Williamstown
Randolph		Northfield
Rutland		
Saint Albans		
Springfield		
Swanton		

Sidenote: concentration differences observed by source



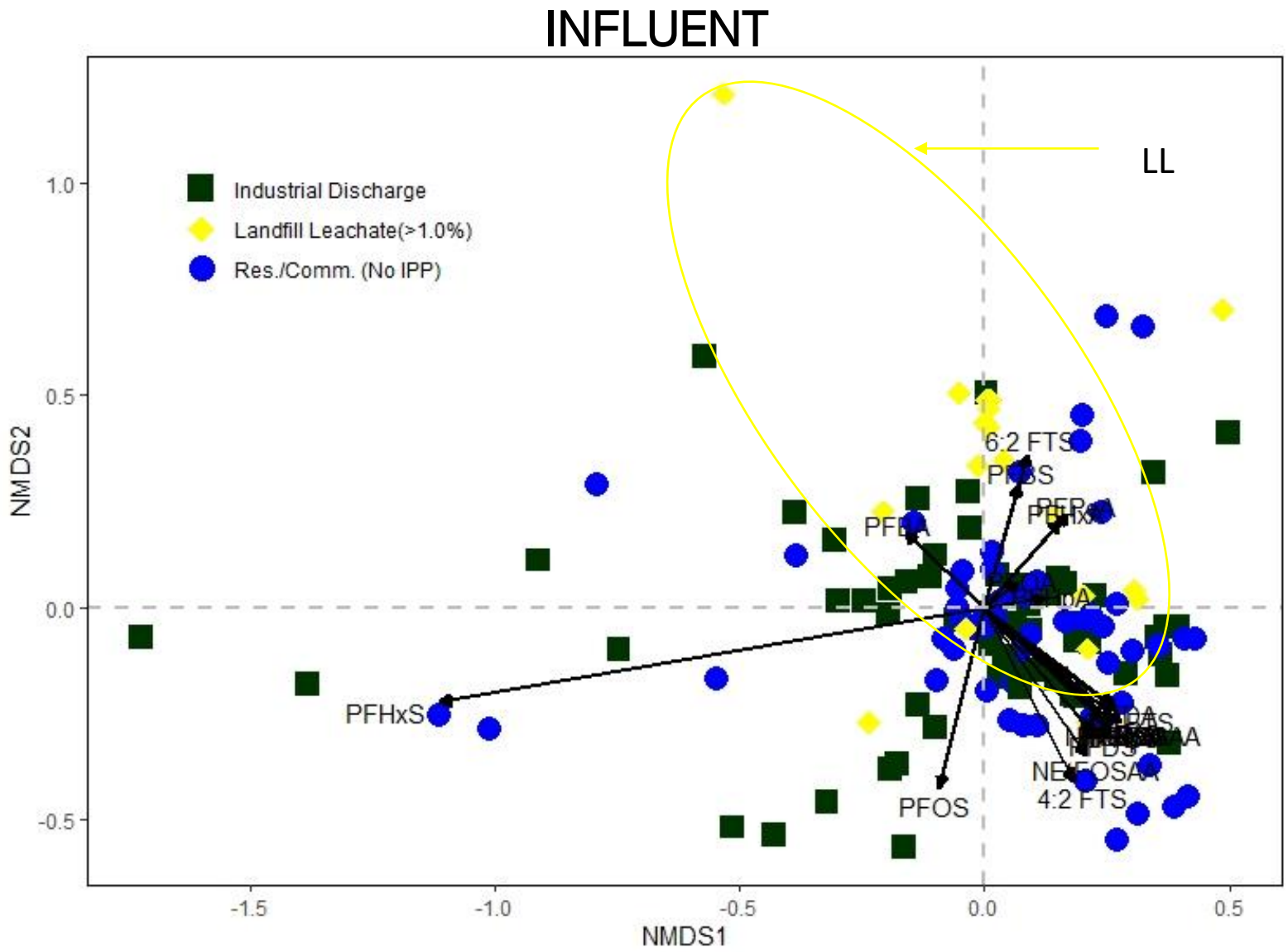
Mean total PFAS concentration categorized by influent characteristic (A) for influent and (B) for effluent (Kruskal-Wallis ANOVA and Tukey-Kramer Test; alpha=0.05)

ΣPFAS higher for WWTFs accepting >1% landfill leachate

Trend similar in both influent and effluent

Applied NMDS with analysis of similarity (AOSIM) to W&S data

Landfill leachate-accepting influent samples distinct in signature



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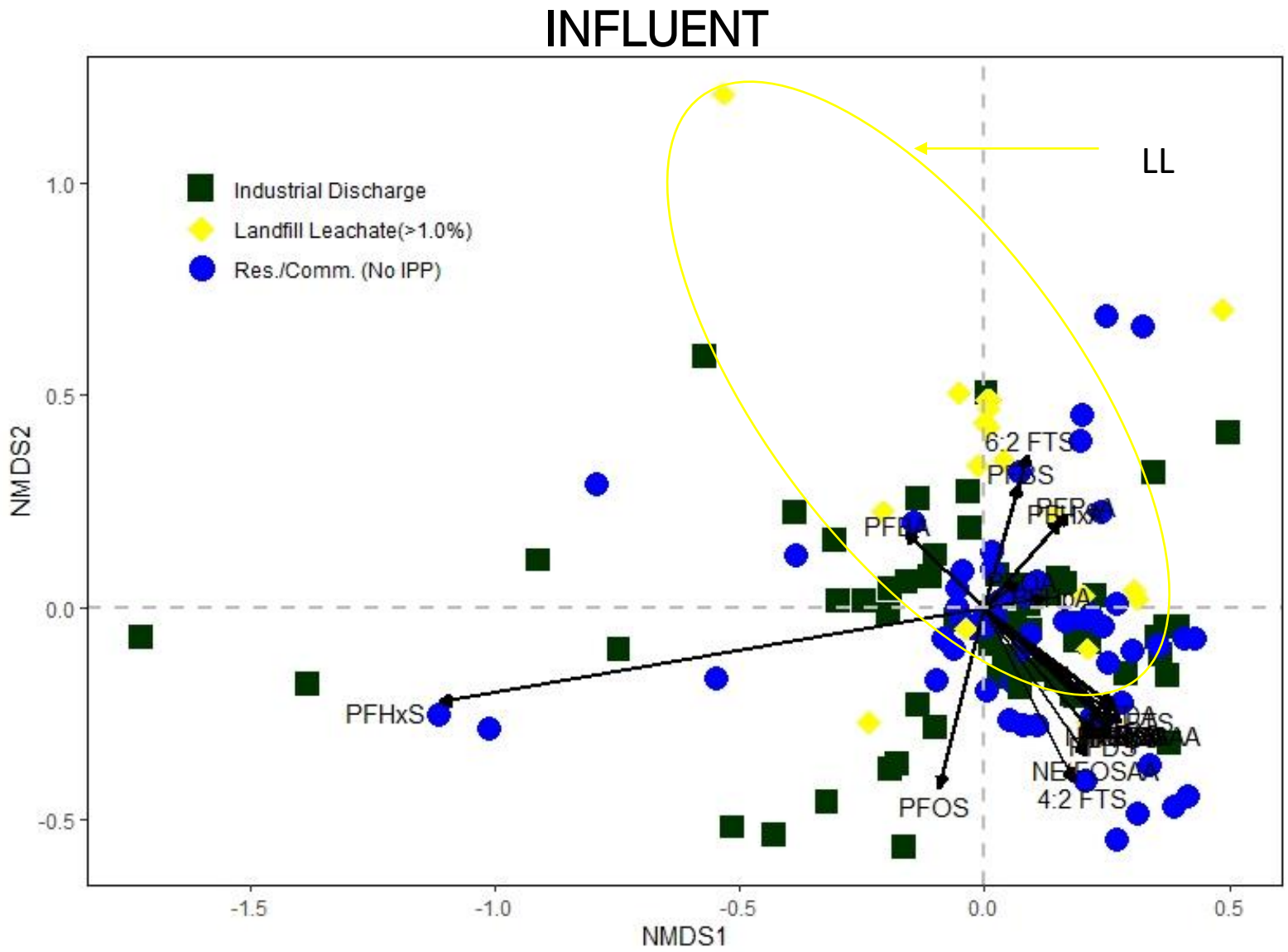
Applied NMDS with analysis of similarity (AOSIM) to W&S data

Landfill leachate-accepting influent samples distinct in signature

Industrial discharge (IPP) too broad to cluster from residential/commercial



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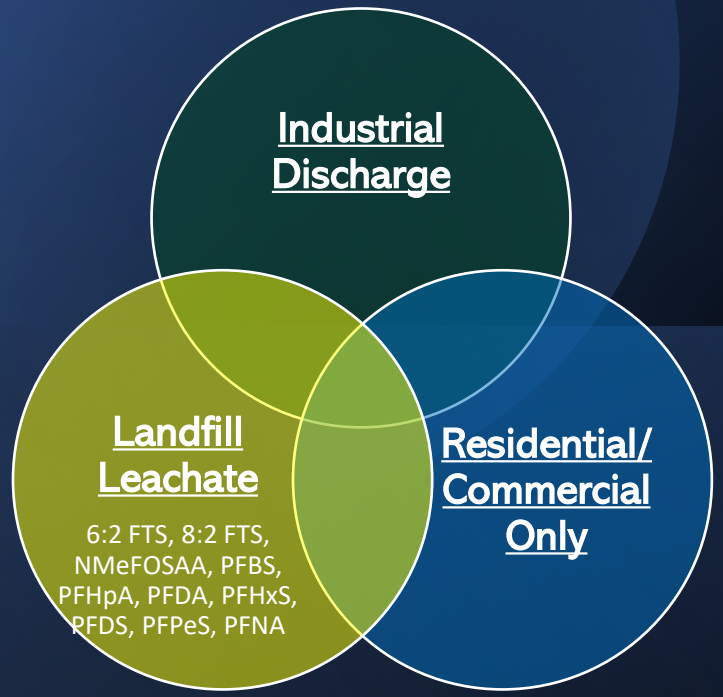
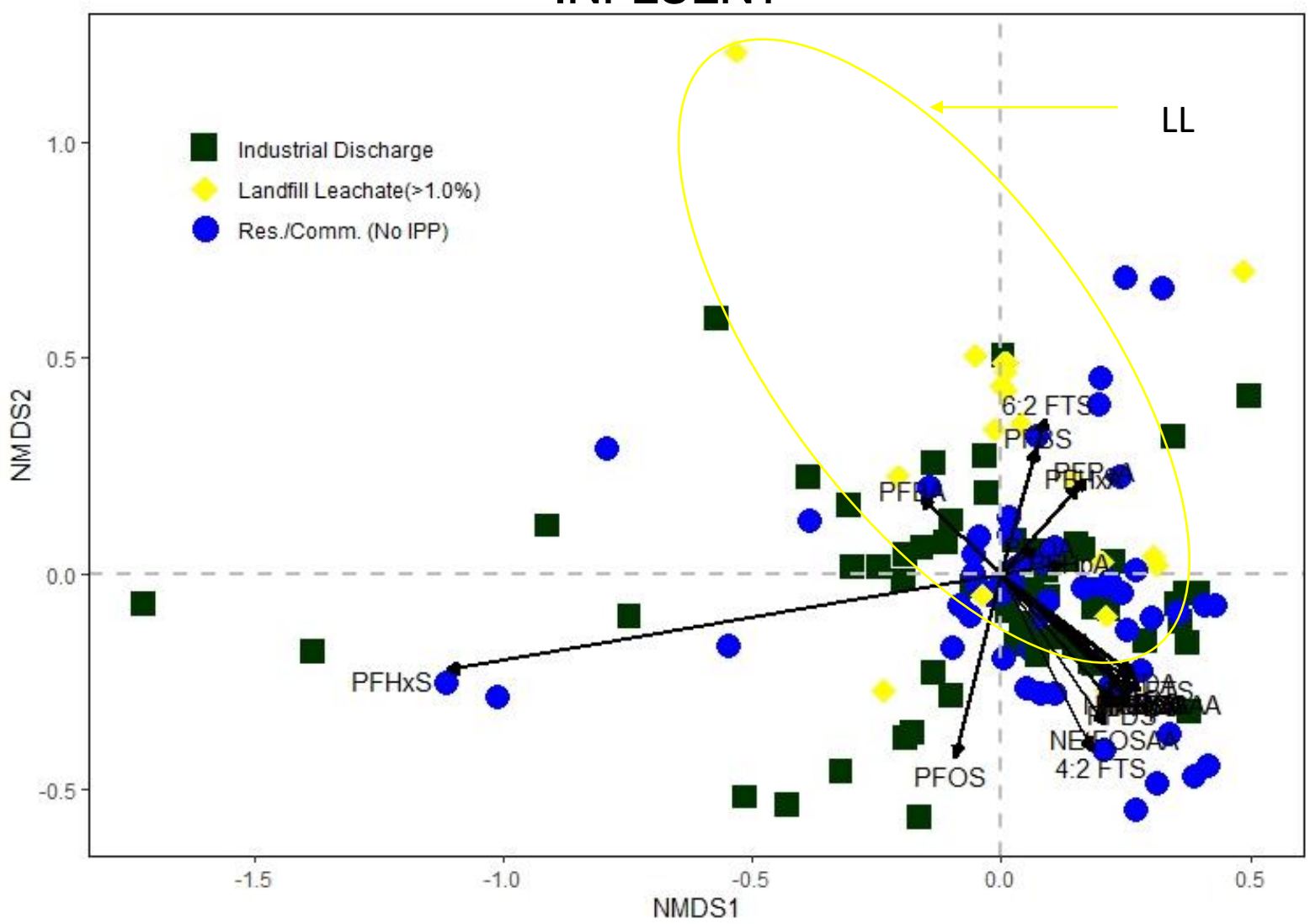
Indicator analysis revealed FT and short chain PFAS drive differences in samples containing landfill leachate



Venn diagram illustrating indicator species analysis results

INFLUENT



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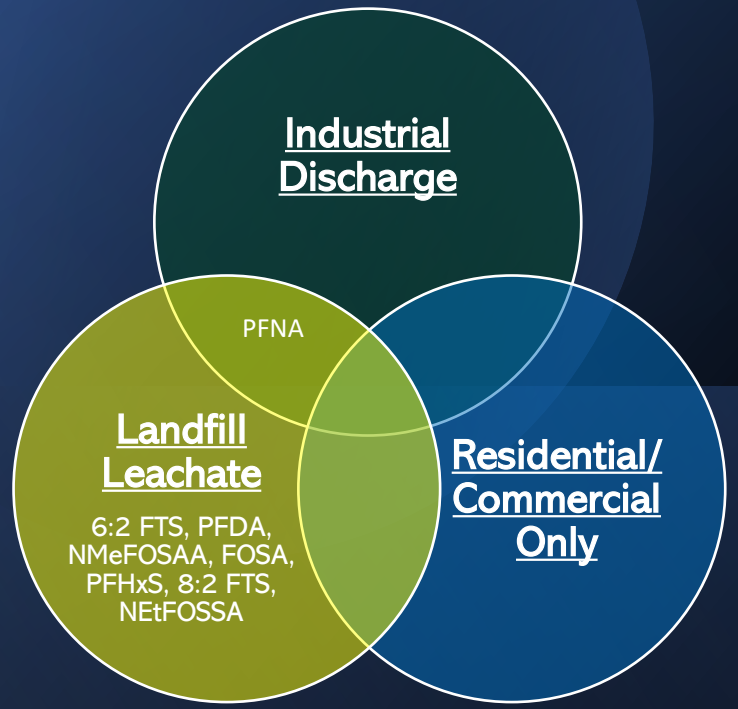
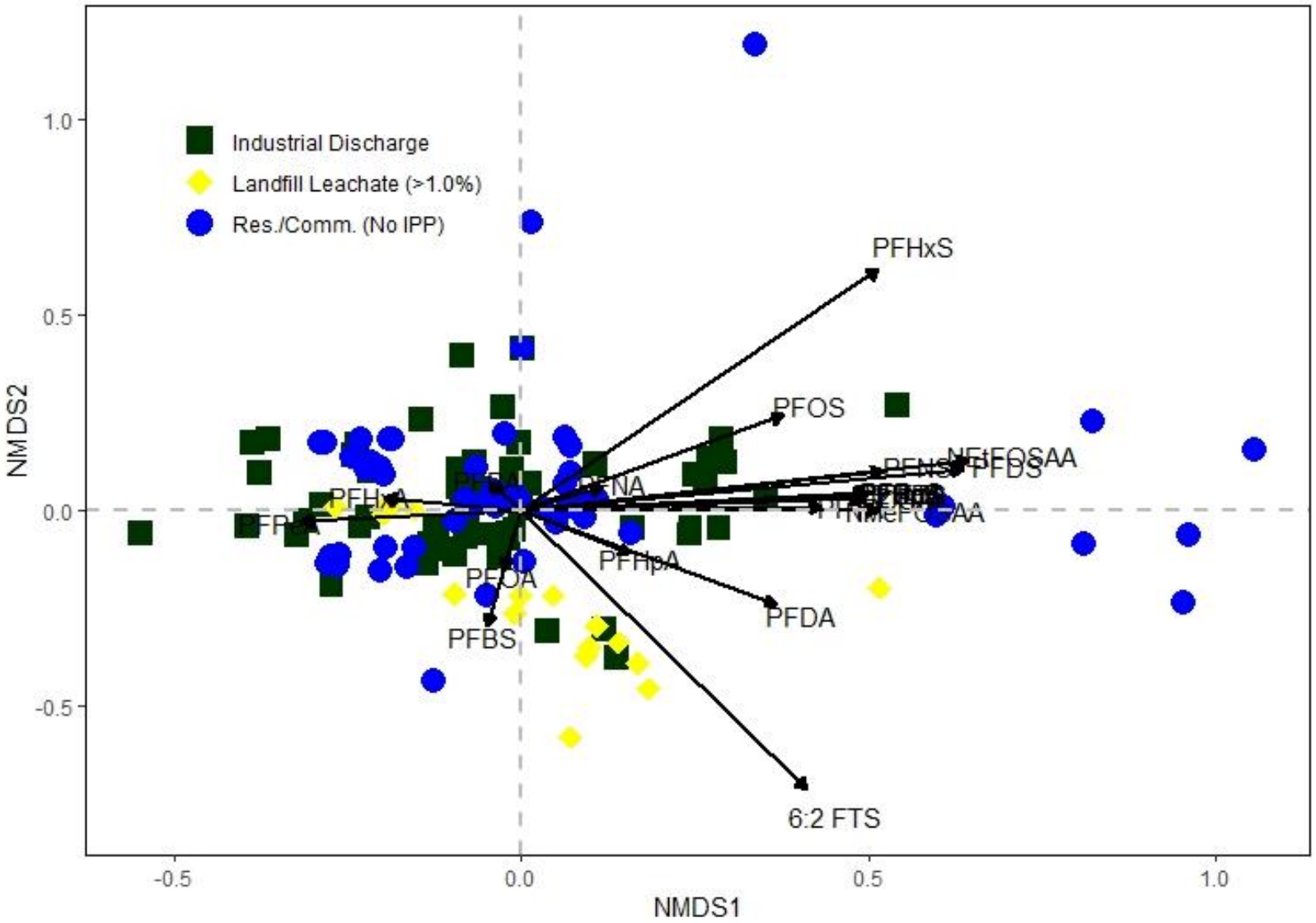
Differences in source composition are less pronounced after treatment



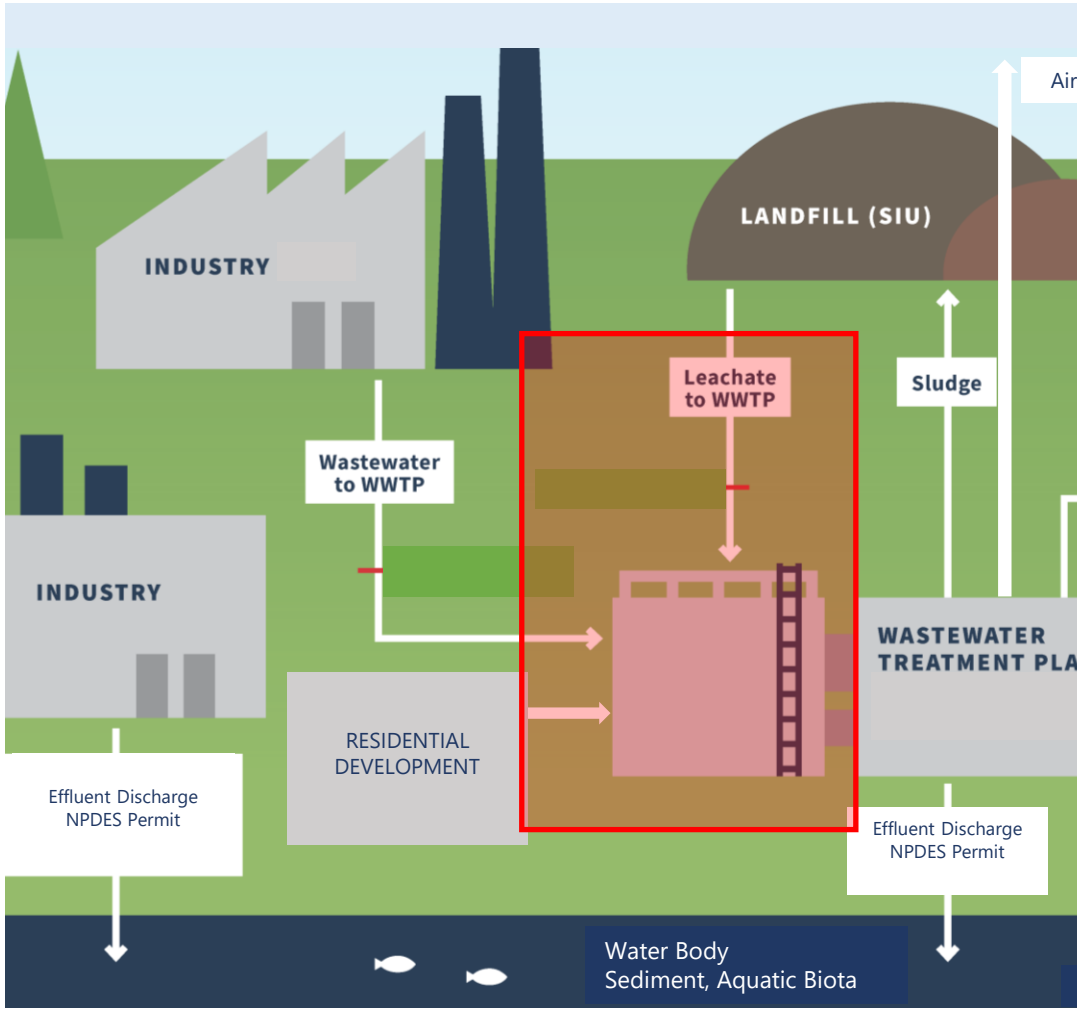
Venn diagram illustrating indicator species analysis results

EFFLUENT



Adams et. al, in preparation. Non-multidimensional scaling of effluent PFAS measurements for 18 Vermont WWTFs (AOSIM, Figure S1, $p<0.001$, $R=0.1396$, Pairwise ADONIS: ID & LL $p<0.001$, ID & RES $p=0.012$, LL & RES $p<0.001$).

2. Are known upstream sources associated with certain PFAS compositions?



Modified from Michigan Department of Environment, Great Lakes, and Energy
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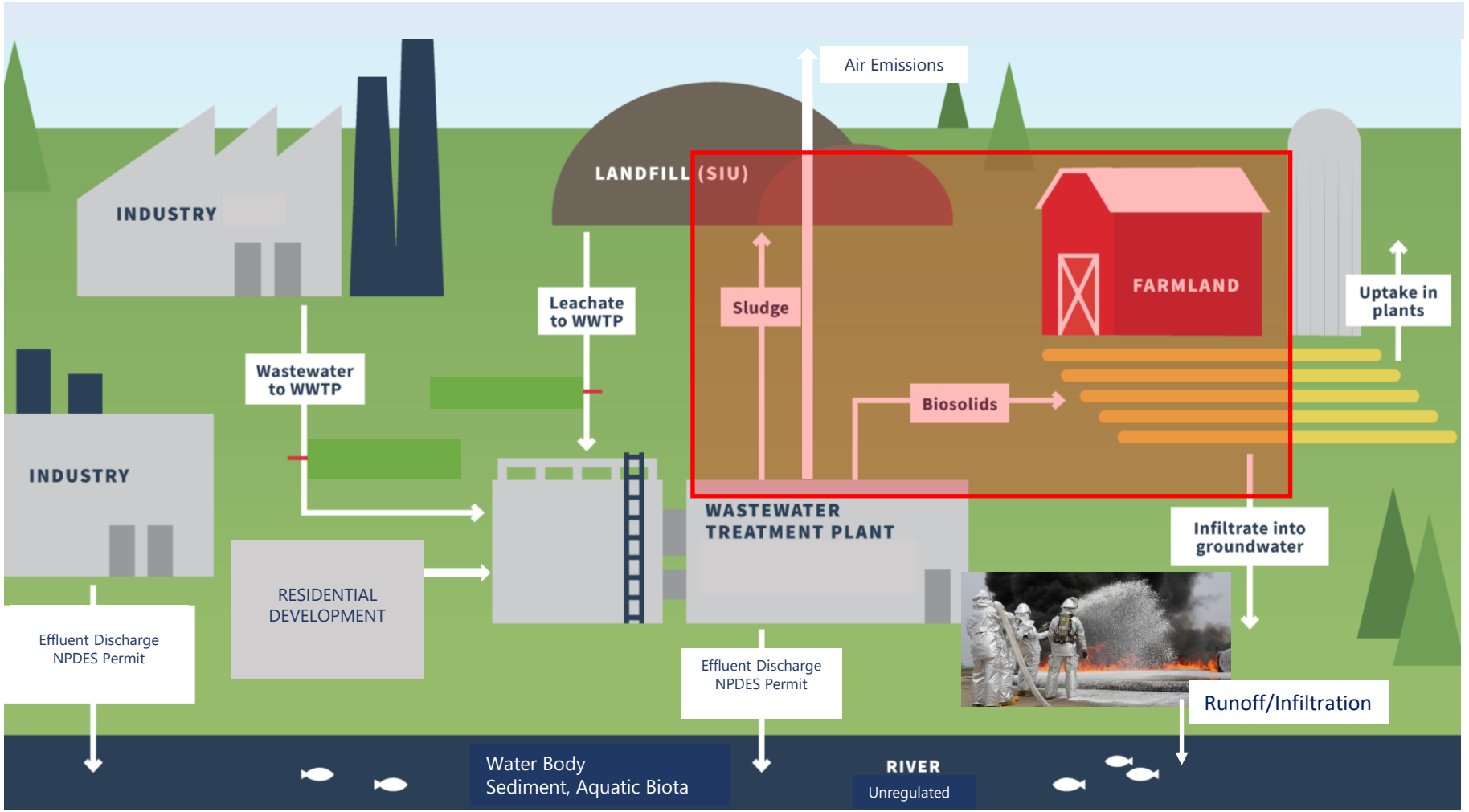
Summary/key points

- Leachate signatures evident in influent and effluent
- Further source characterization would improve clustering in influent and effluent

3. Does sludge handling influence PFAS signature?



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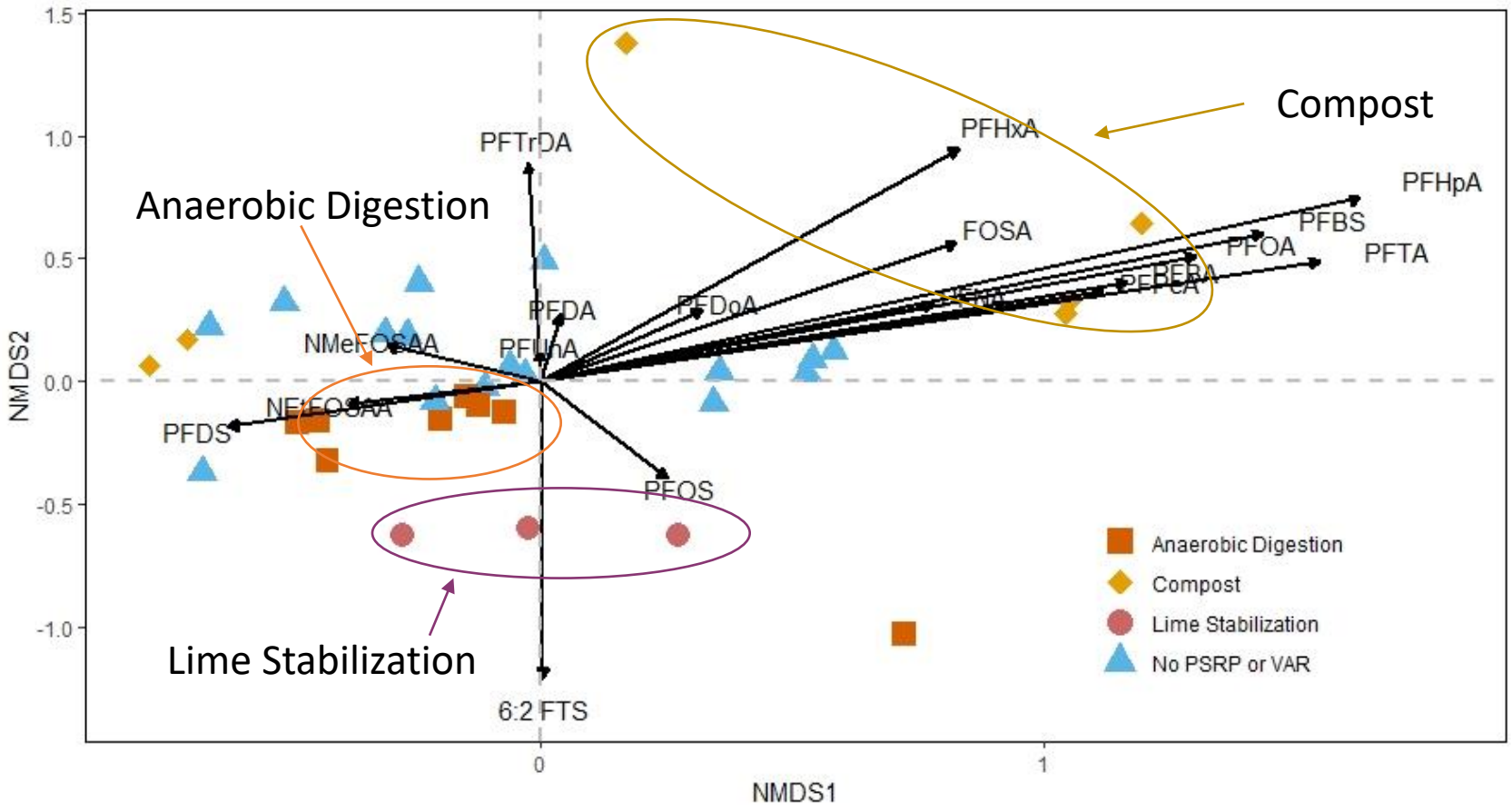
Applied NMDS with analysis of similarity (AOSIM) to NH and VT biosolids data



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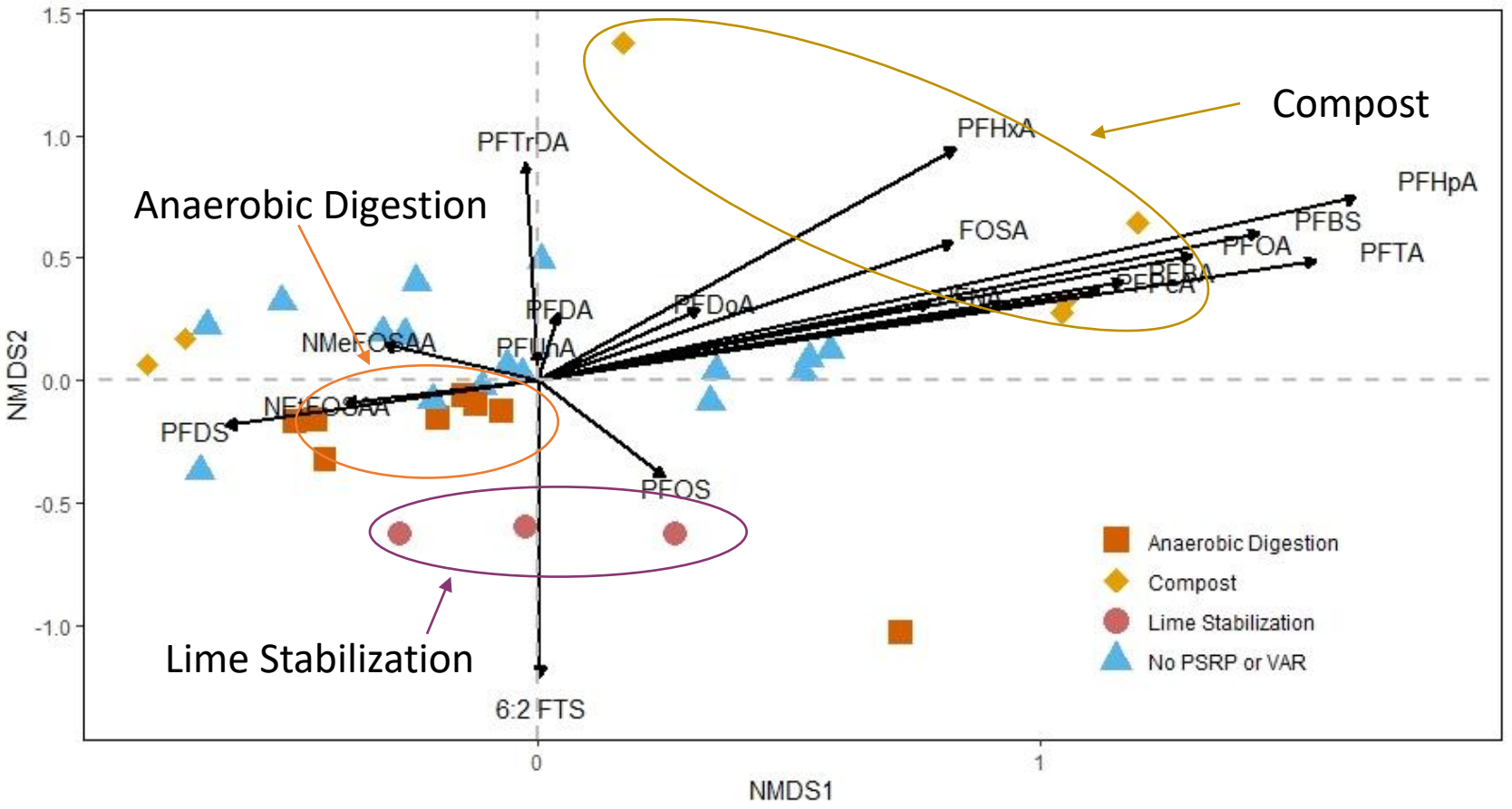
Applied NMDS with analysis of similarity (AOSIM) to NH and VT biosolids data

Stabilization treatment significantly alters PFAS signature



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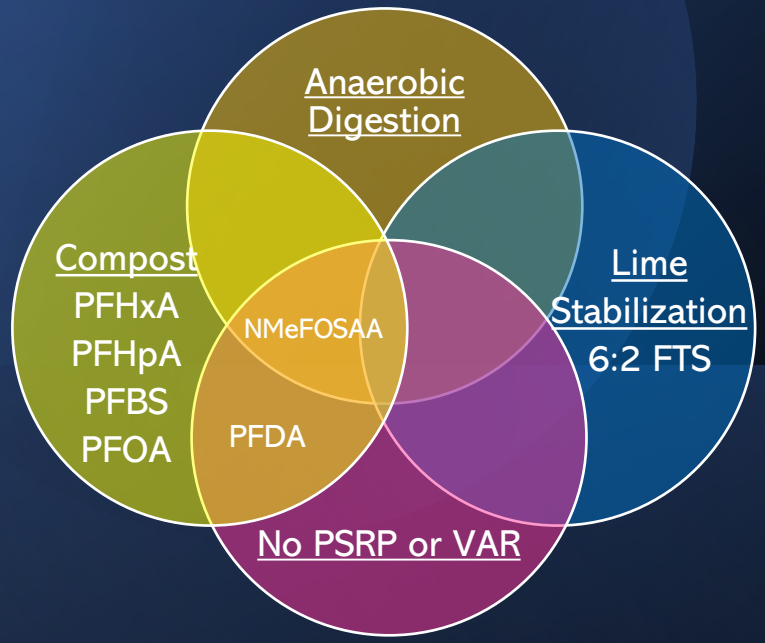
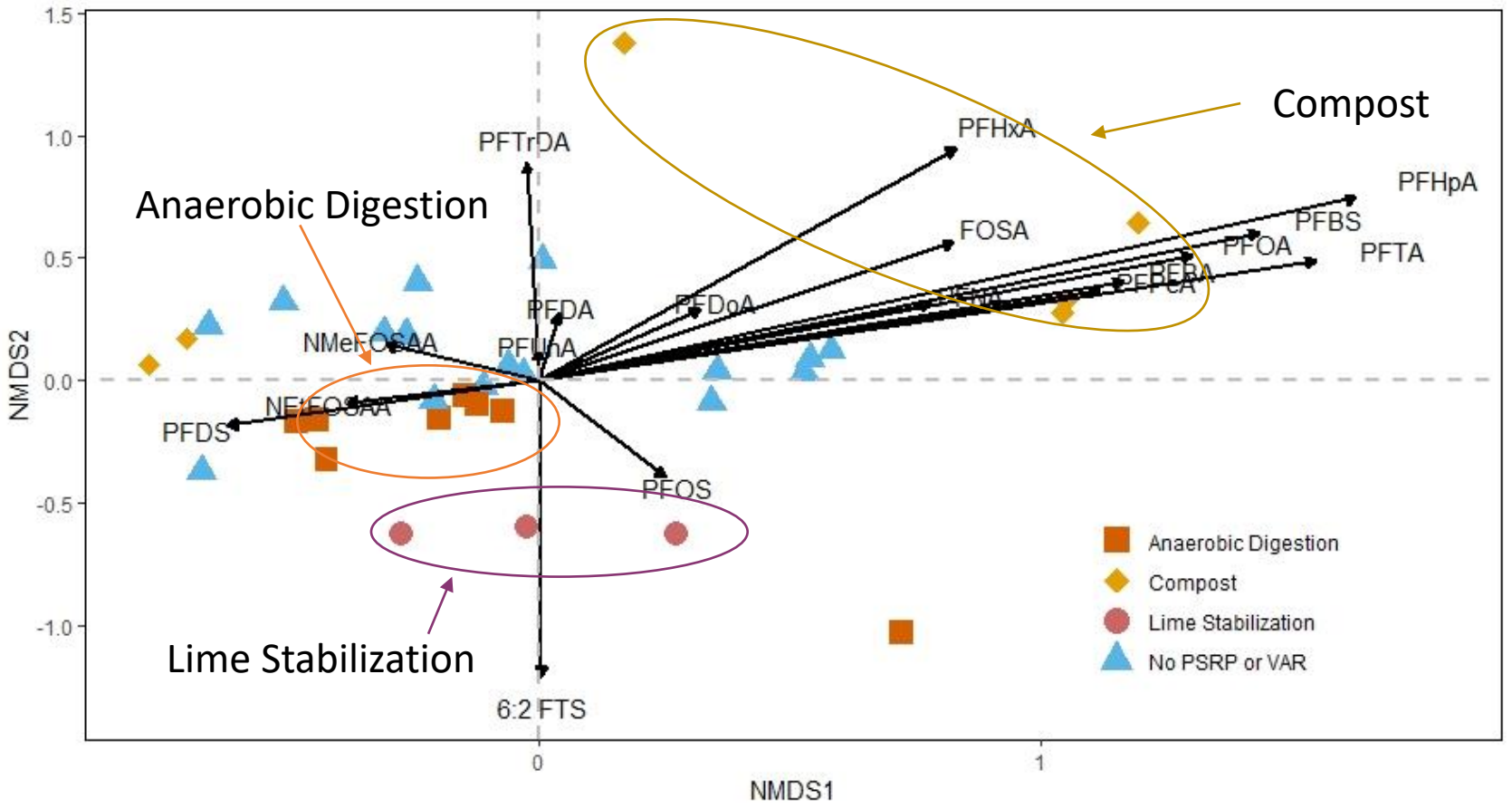
Compost handling had distinct signature of short chain and PFCA compounds



Venn diagram illustrating indicator species analysis results



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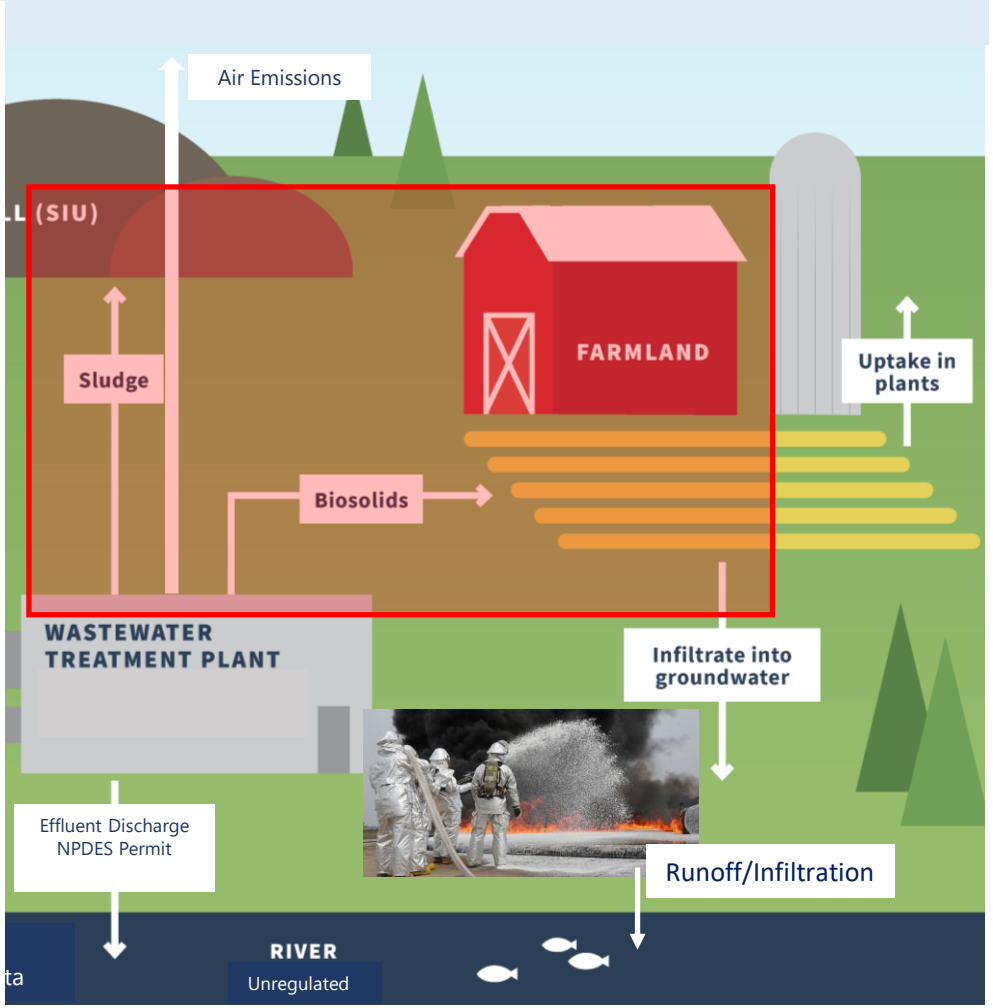
3. Does sludge handling influence PFAS signature?

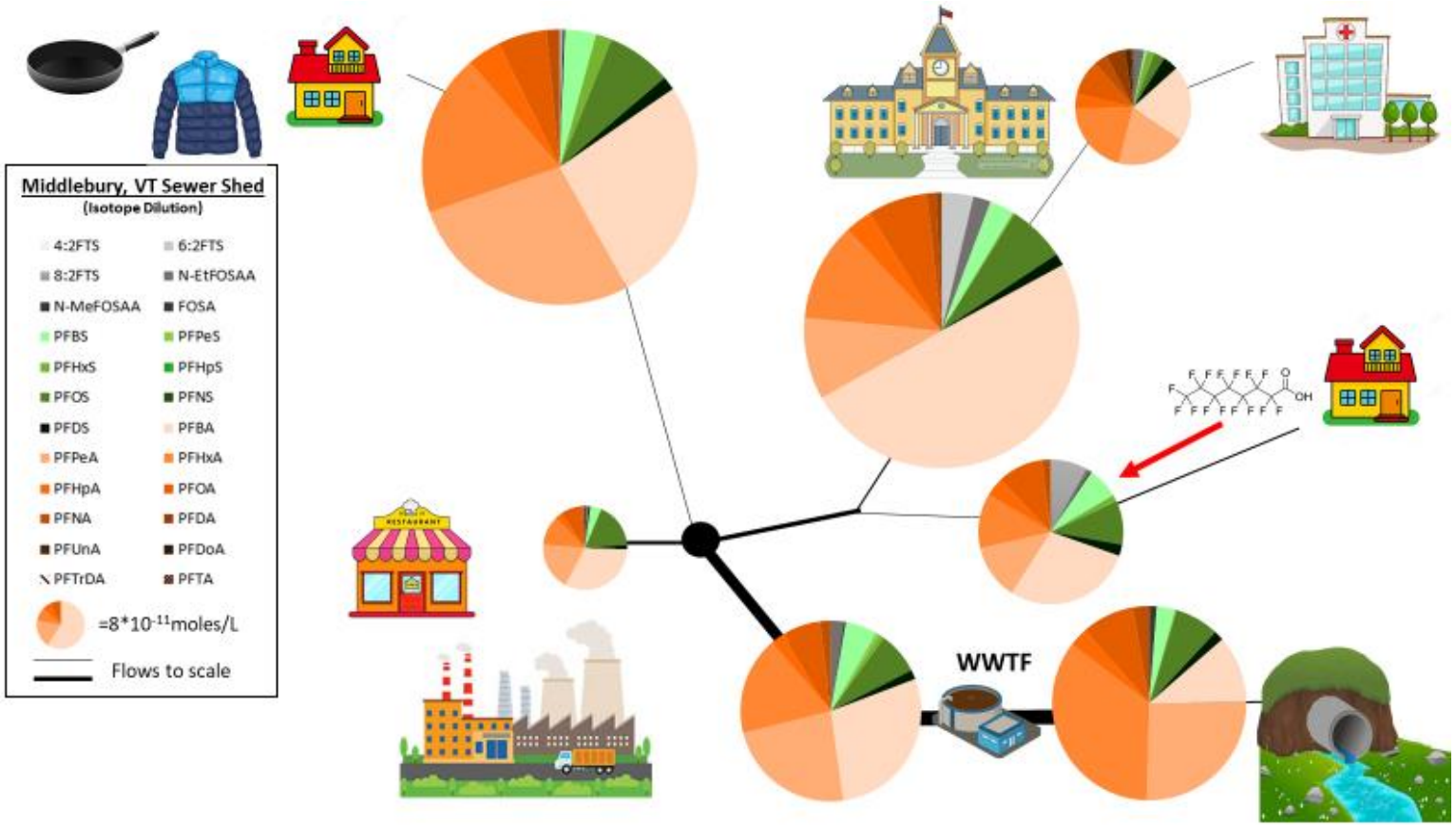
Summary/key points

- Stabilization processes alters PFAS signatures
- Composted sample signatures are distinct, dominated by shorter chain PFAS, possibly due to incorporated media or handling differences.



Modified from Michigan Department of Environment, Great Lakes, and Energy
https://www.michigan.gov/pfasresponse/0,9038,7-365-86510_88079-476131--,00.html

Looking upstream, applying P2 approach…



Characterizing municipal and industrial sources in upstream VT sewer sheds

Improved knowledge of signatures will help municipalities predict, reduce, eliminate upstream sources

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Thank you! Questions?

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