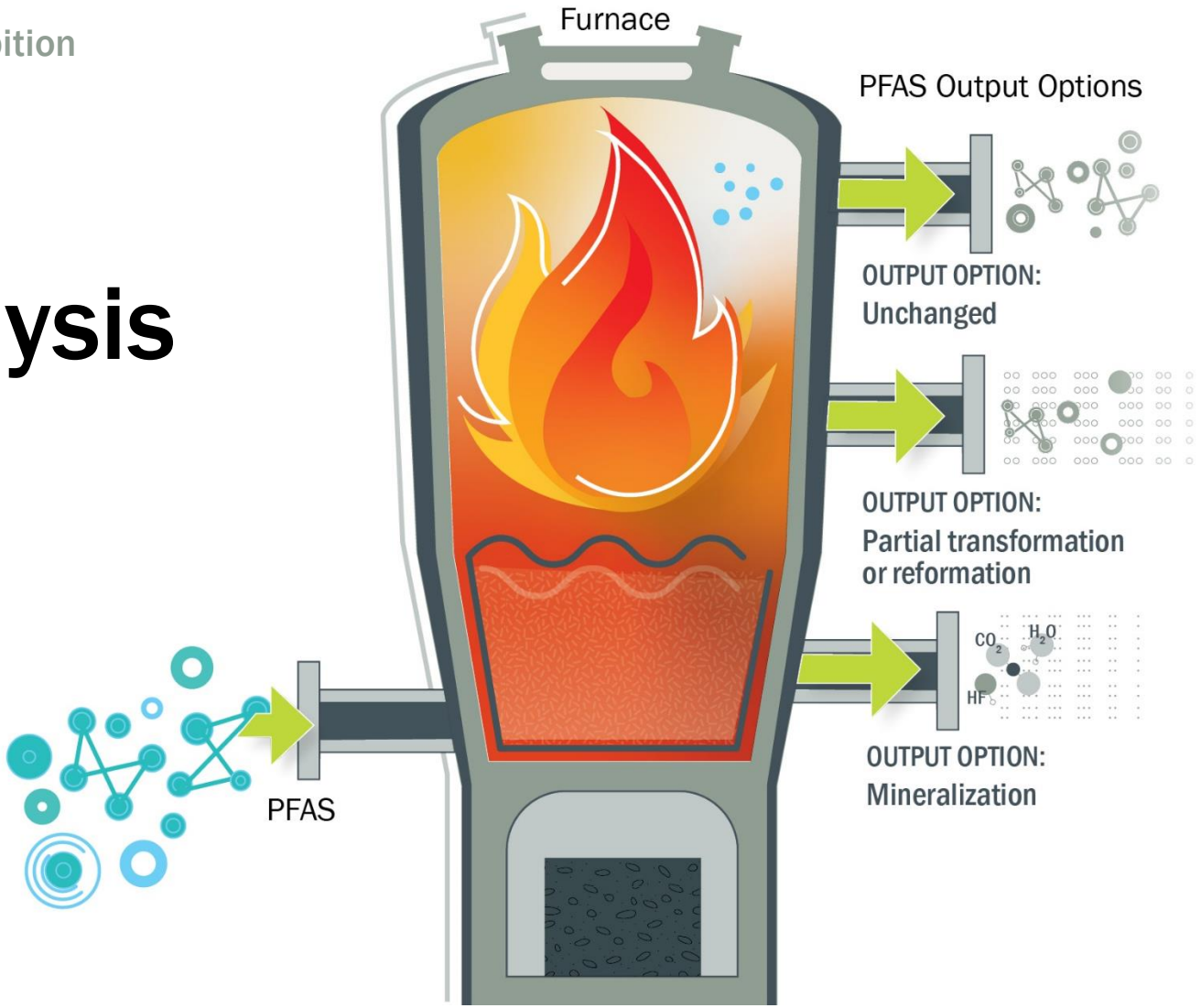
Brown AND Caldwell
Lloyd Winchell
651.468.2051
LWinchell@BrwnCald.com

NYWEA-NEWEA Joint Spring Technical Conference and Exhibition

PFAS Fate through Incineration and Pyrolysis

June 9, 2023



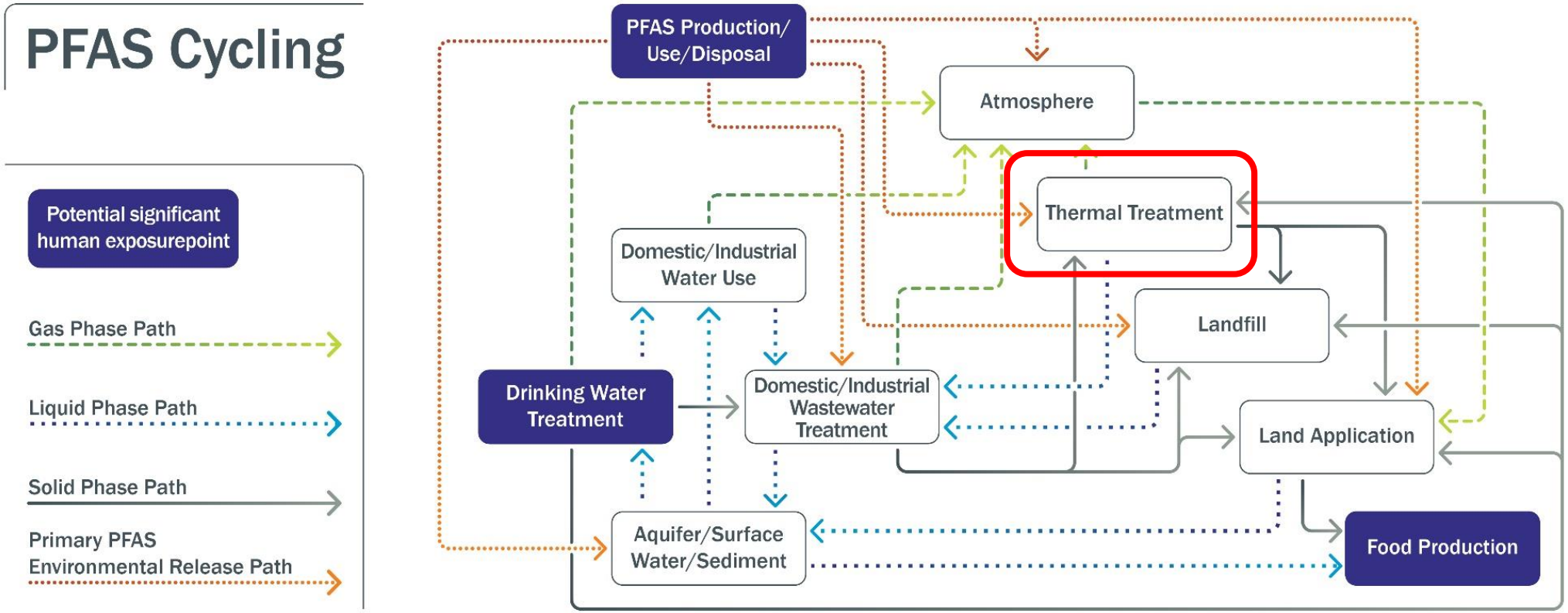
Water Environment Federation
the water quality people

Per- and polyfluoroalkyl substances thermal destruction at water resource recovery facilities: A state of the science review

Lloyd J. Winchell,[1,*] John J. Ross,[1] Martha J. M. Wells,[2] Xavier Fonoll,[3] John W. Norton Jr,[3] Katherine Y. Bell[1]

Winchell, L.J., Wells, M.J., Ross, J.J., Fonoll, X., Norton Jr., J.W., Bell, K.Y. PFAS Thermal Destruction at Wastewater Treatment Facilities: A State of the Science Review. *Water Environ. Res.* http://dx.doi.org/10.1002/wer.1483

Interrupting the PFAS environmental cycle

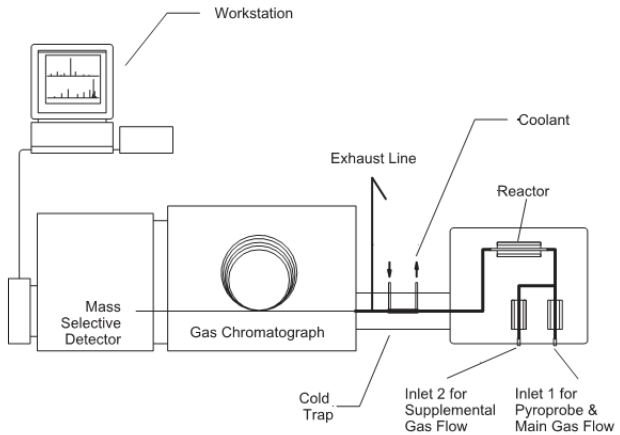


Winchell, L. J., Wells, M. J. M., Ross, J. J., Fonoll, X., Norton, Jr., J. W., Kuplicki, S., Khan, M., and Bell, K. Y. (2021c). Per- and Polyfluoroalkyl Substances (PFAS) Presence, Pathways, and Cycling through Drinking Water and Wastewater Treatment: A State-of-the-art Review. Journal of Environmental Engineering. https://doi.org/10.1061/(ASCE)EE.1943-7870.0001943. In Press.

Thermal treatment offers the only established PFAS destruction process for biosolids

PFAS thermal destruction requirements

- Guidance typically based on lab-scale data or guidelines for hazardous waste and does not consider:
  - Fuel chemistry unique to sludge
  - Turbulence
  - Residence time
  - Oxidation conditions



Yamada, T., Taylor, P. H., Buck, R. C., Kaiser, M. A., & Giraud, R. J. (2005). Thermal degradation of fluorotelomer treated articles and related materials. *Chemosphere*, 61(7), 974–984. https://doi.org/10.1016/j.chemo sphere.2005.03.025

Table 3. Recent guidance and literature basis for PFAS thermal destruction

SOURCE	TEMPERATURE NOTED
Pancras et al. (2016)	1,000–1,200°C
Kucharzyk et al. (2017)	1,000°C or greater
USEPA (2020c)	1,000°C
UNEP (2019a)	1,100°C
Ross et al. (2018)	1,100°C
ITRC (2020)	1,000°C or greater

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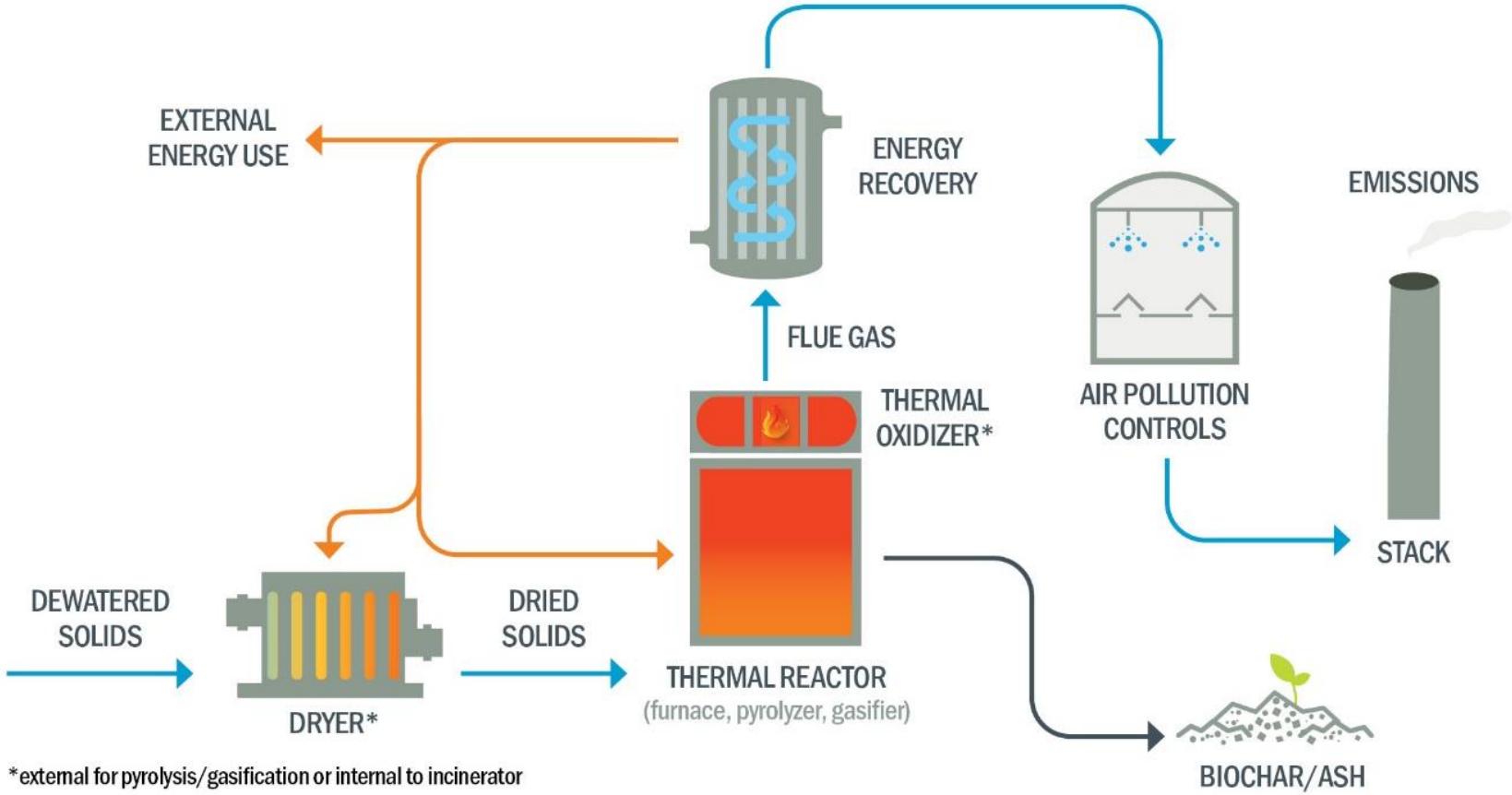
EPA www.epa.gov/research Technical BRIEF
INNOVATIVE RESEARCH FOR A SUSTAINABLE FUTURE

Per- and Polyfluoroalkyl Substances (PFAS): Incineration to Manage PFAS Waste Streams

Incineration of halogenated organic compounds occurs via unimolecular decomposition and radical reaction. For unimolecular decomposition, fluorinated organic compounds require temperatures above 1,000°C to achieve 99.99% destruction in 1 second residence time. Unimolecular decomposition of highly fluorinated organics most likely occurs through breakage of C-C or C-F bonds (Tsang et al., 1998). The most difficult fluorinated organic compound to decompose is CF_4, requiring temperatures over 1,400°C, but is easily monitored, making it a potential candidate for destructibility trials.

Thermal treatment technologies

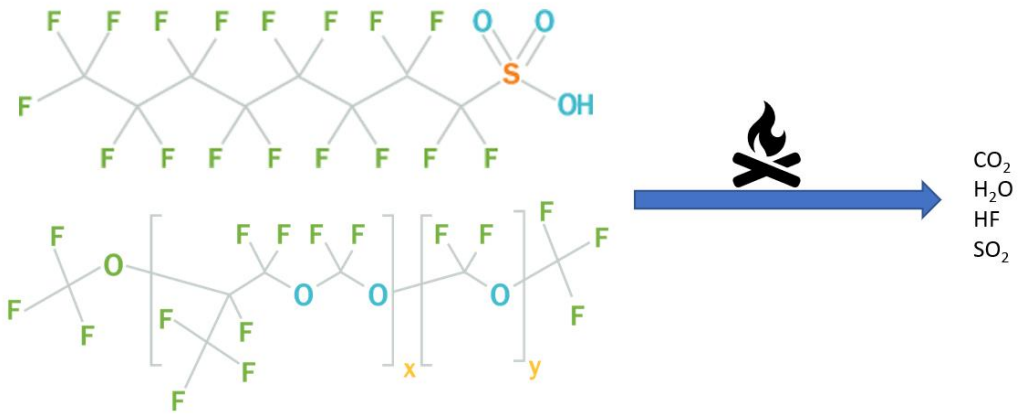
- Mature
  - Incineration
  - MHF and FBF
- Innovative
  - Pyrolysis/gasification
  - Renewed interest in biosolids applications
- Emerging
  - Hydrothermal liquefaction
  - Supercritical water oxidation
  - Smoldering



Winchell, L.J., Ross, J.J., Brose, D. A., Pluth, T. B., Fonoll, X., Norton Jr., J.W., Bell, K.Y. High-temperature Technology Survey and Comparison among Incineration, Pyrolysis, and Gasification Systems for Water Resource Recovery Facilities Water Environ. Res. http://dx.doi.org/10.1002/wer.10715

PFAS in Thermal Processes

- Will thermal processes degrade PFAS? **Yes, but to what extent?**
- Not all PFAS equal, polymeric may readily degrade while CF_4 may prove difficult
- Fuel chemistry of sludge expected to bolster destruction
  - PFAS levels low relative to hazardous waste or MSW
- APC expected to capture PFAS as well

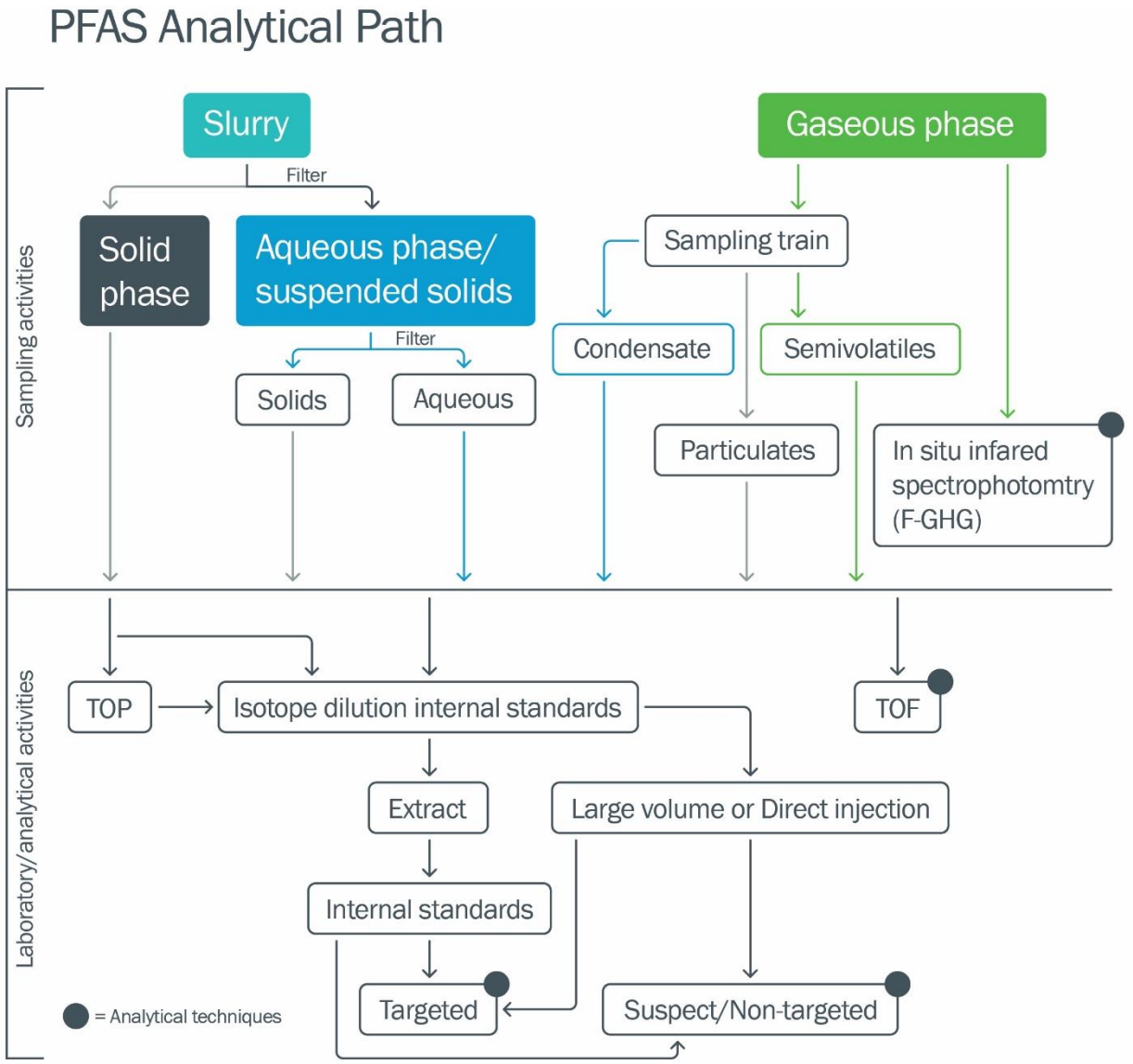


How much is enough?

EPA initiating risk assessment

PFAS Analytics

- Quasi mass balance:
  - Targeted
  - Non-targeted
  - Total organic fluorine
  - Fourier Transform Infrared



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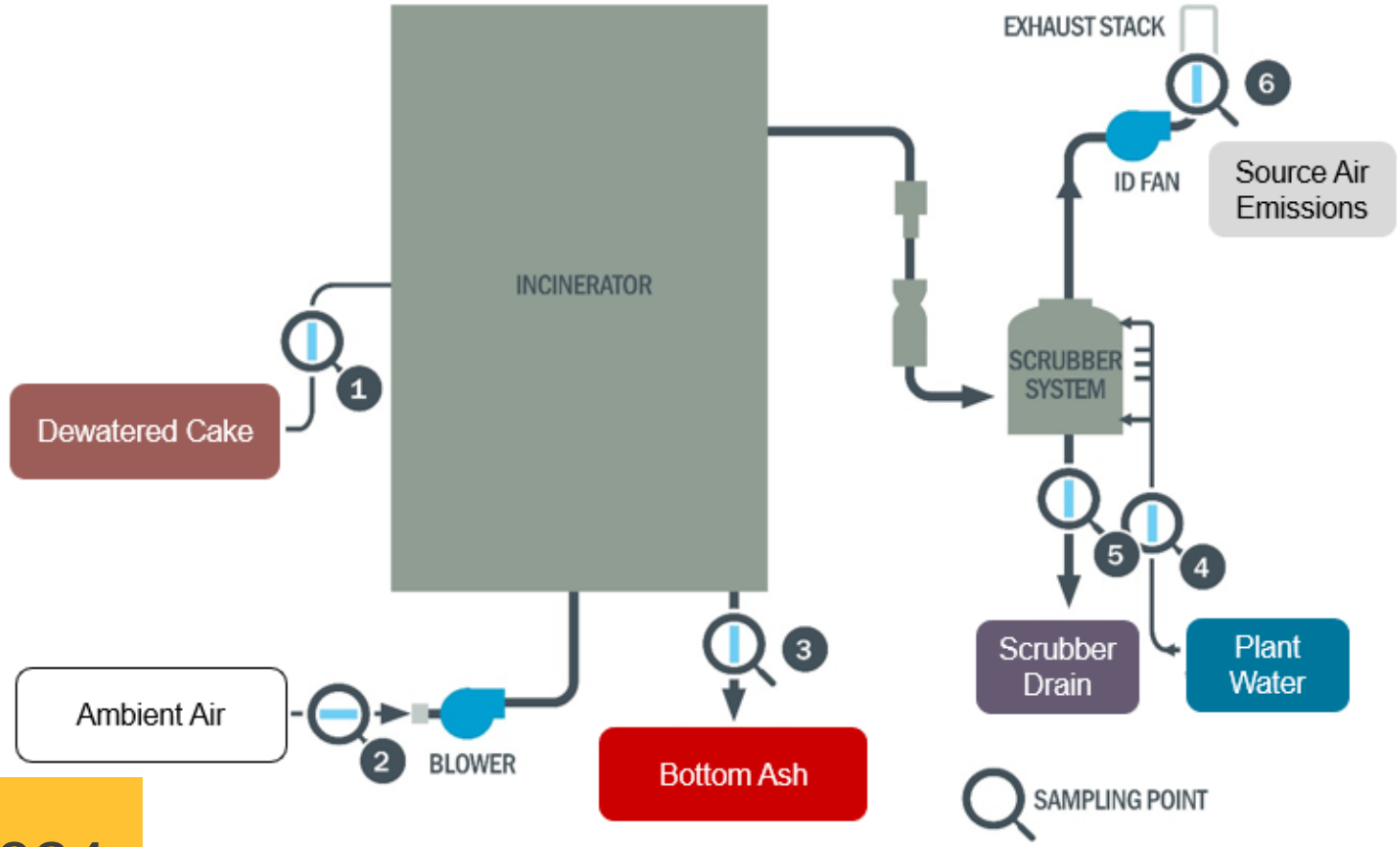
WRF Tailored Collaboration 5111: Incineration

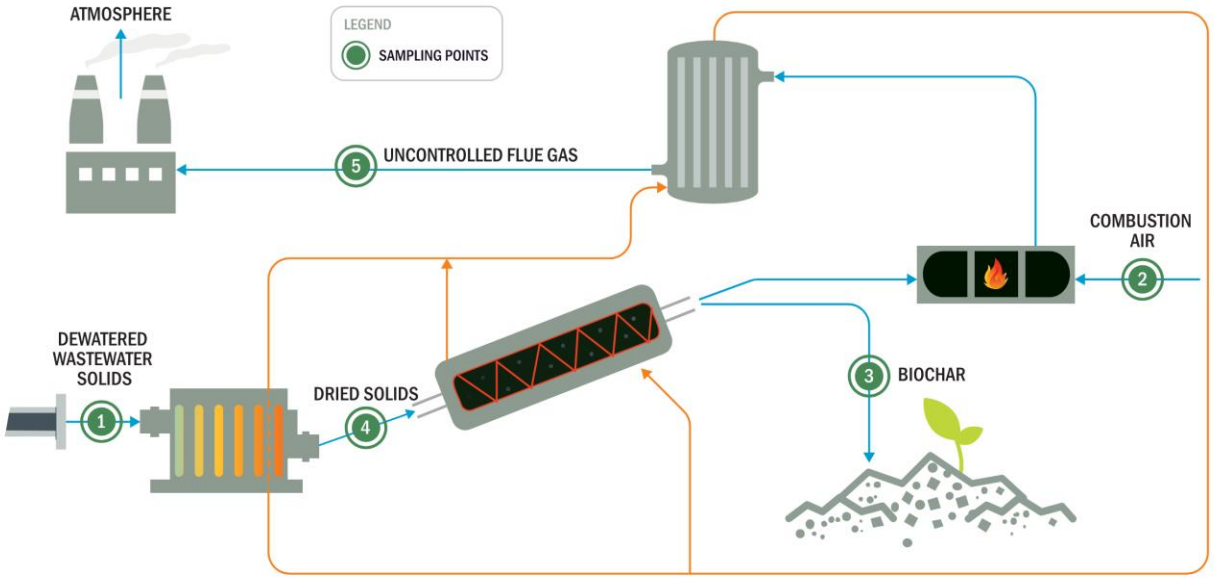
- FBF and MHF, one each
  - Sampling complete
- Evaluating results and drafting report
  - Degradation occurring
  - DRE tough to quantify
  - Organic fluorine input not being measured

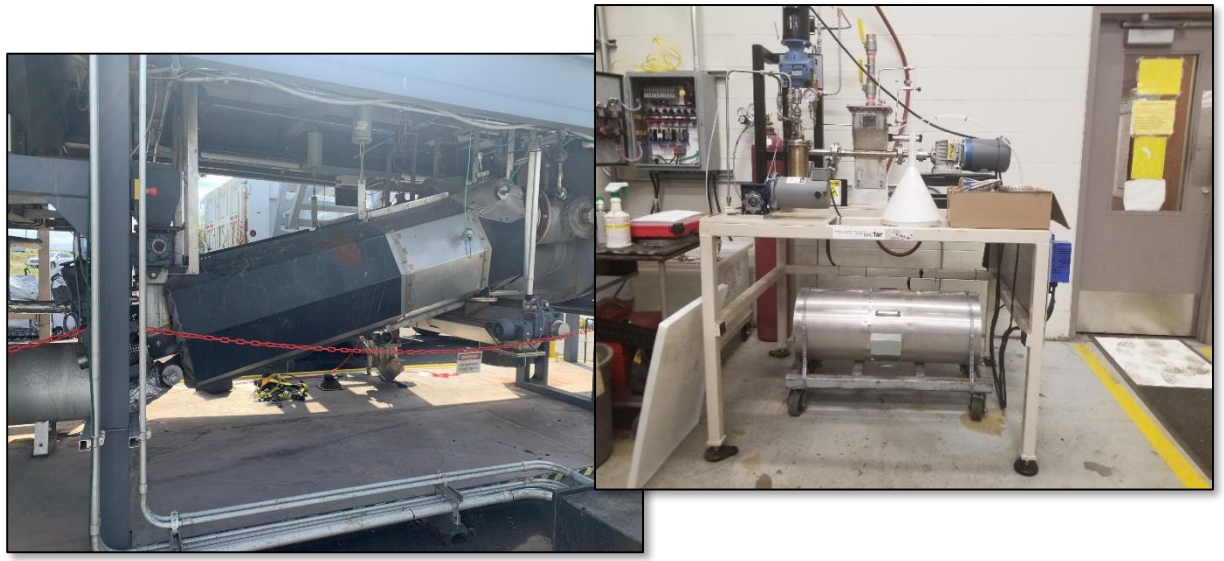


Final report – Spring/Summer 2024

WEF Study

- Characterize the fate of PFAS through both a lab scale pyrolysis system and a full-scale system - **equivalent?**
- Publish results 2024





Publish results – Summer/Fall 2024

QUESTIONS?

it's about connecting

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