

Assessing PFAS in Agricultural Settings

“Things we have learned in the past 5 years”

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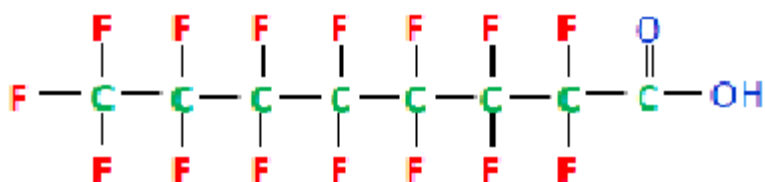
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PFAS – Perfluoroalkyl Substances

Naming conventions



Perfluorooctanoic acid (PFOA)

8 carbons

Perfluoroheptanoic acid (PFHpA)

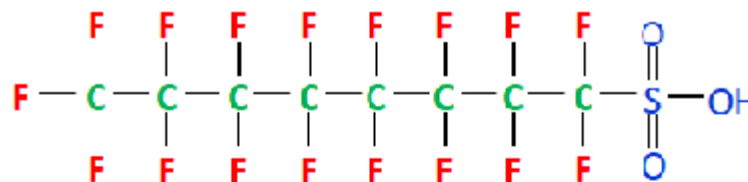
7 carbons

Perfluorononanoic acid (PFNA)

9 carbons

Perfluorodecanoic acid (PFDA)

10 carbons



Perfluorooctanesulfonic acid (PFOS)

8 carbons

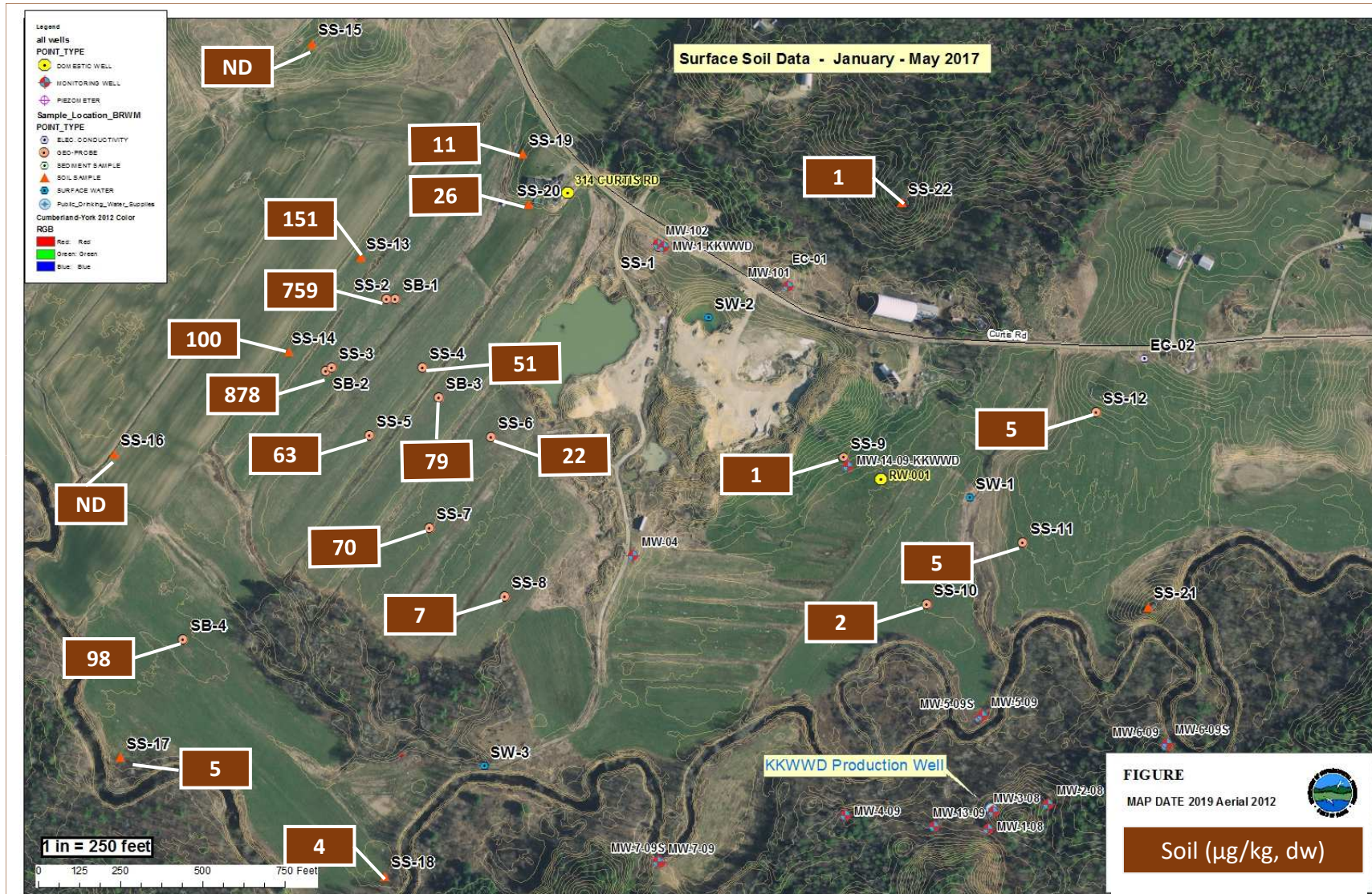
Perfluorohexanesulfonic acid (PFHxS)

6 carbons

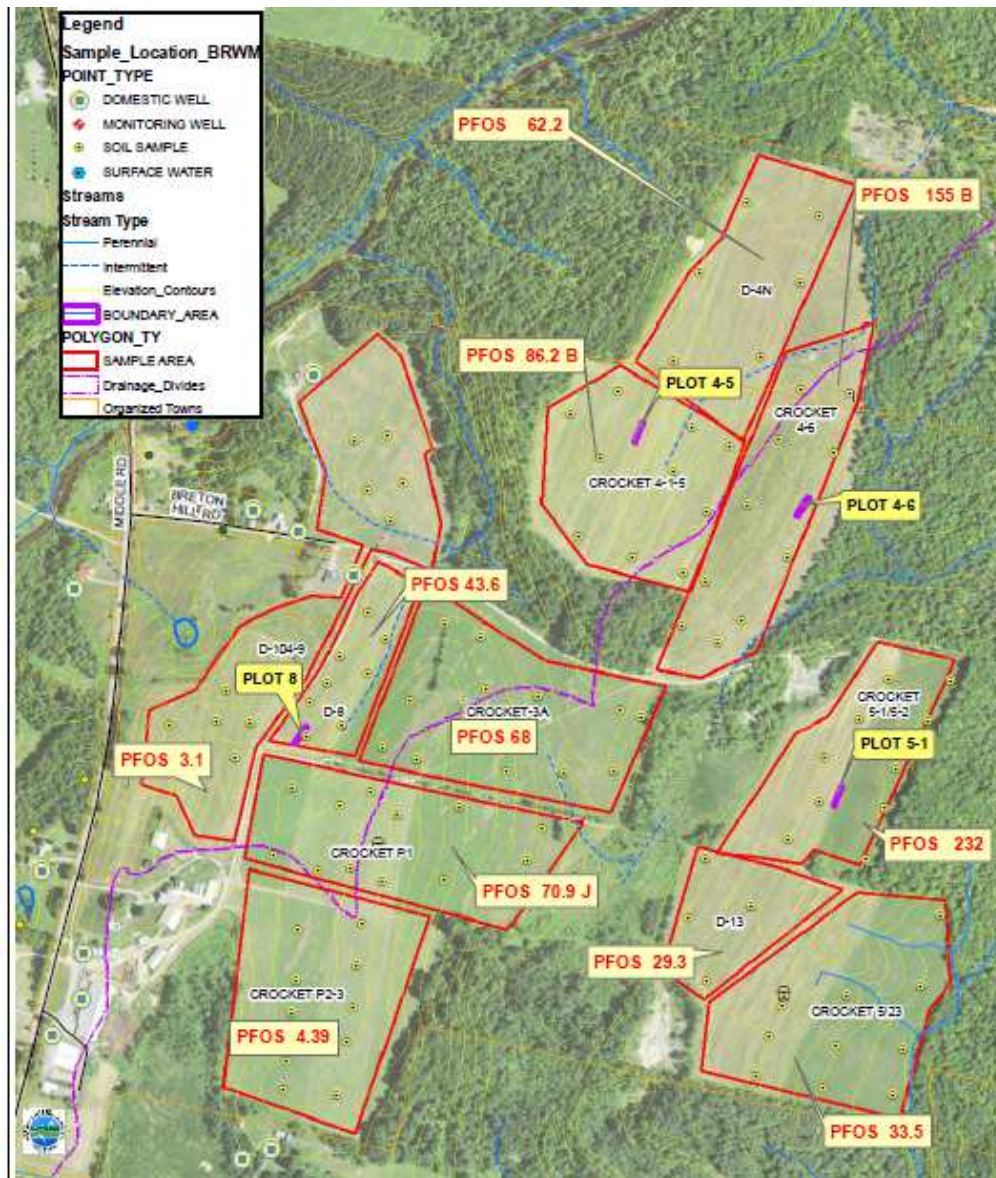
Perfluorobutanesulfonic acid (PFBS)

4 carbons

PFAS soil levels can vary a lot within a field



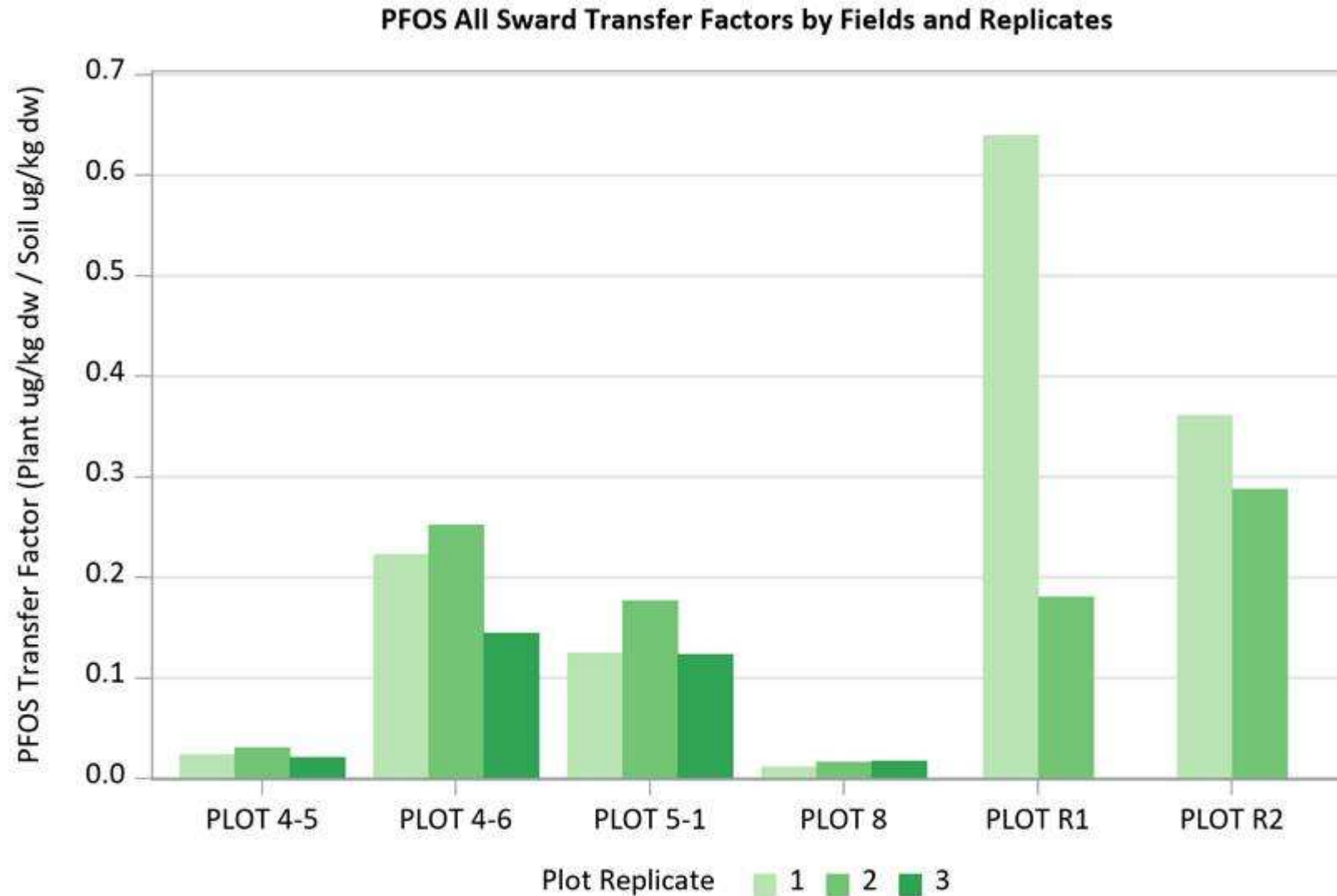
PFAS soil levels can vary a lot between fields



- Fields range from low of 29 ppb PFOS to high of 232 ppb.

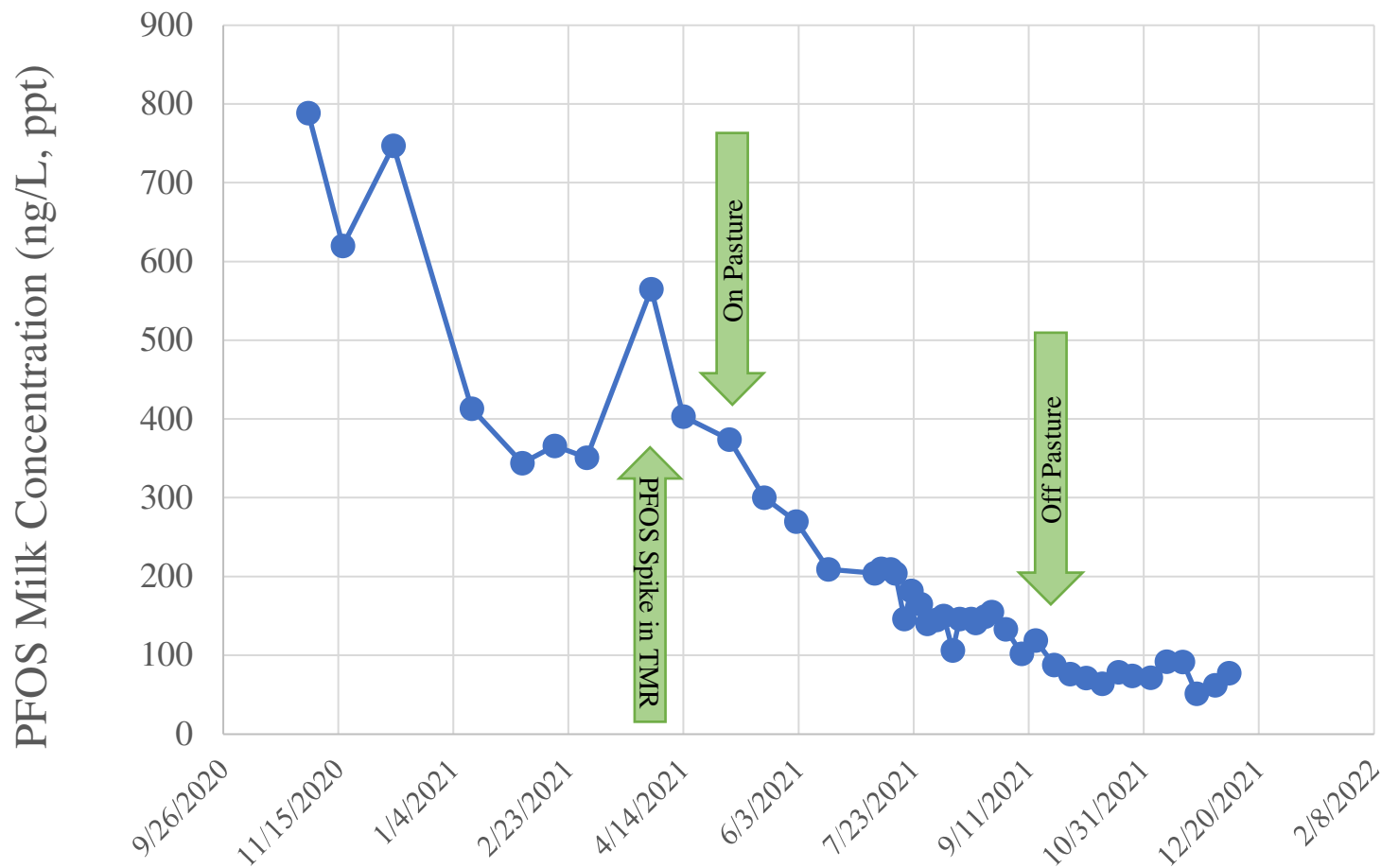
Uptake of PFOS by hay can vary by field

- Preliminary Results -

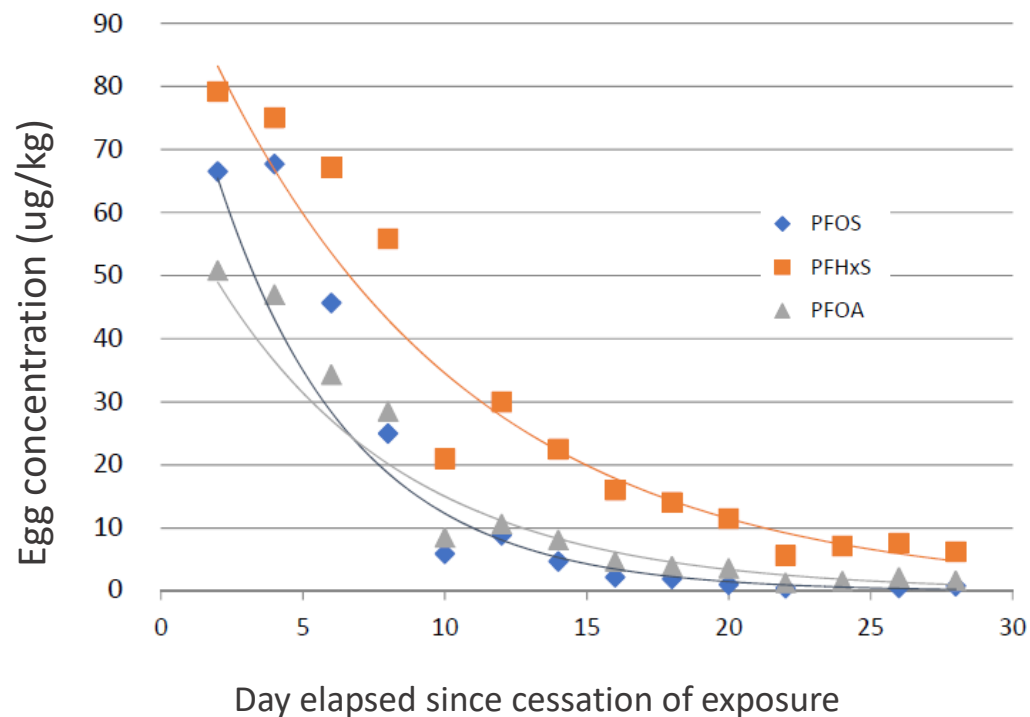


The “Forever Chemicals” are not forever in milk

PFOS Milk levels at a Dairy Farm Nov 2020 – Dec 2021



The “Forever Chemicals” are not forever in eggs



Australian PFAS water
chicken egg study

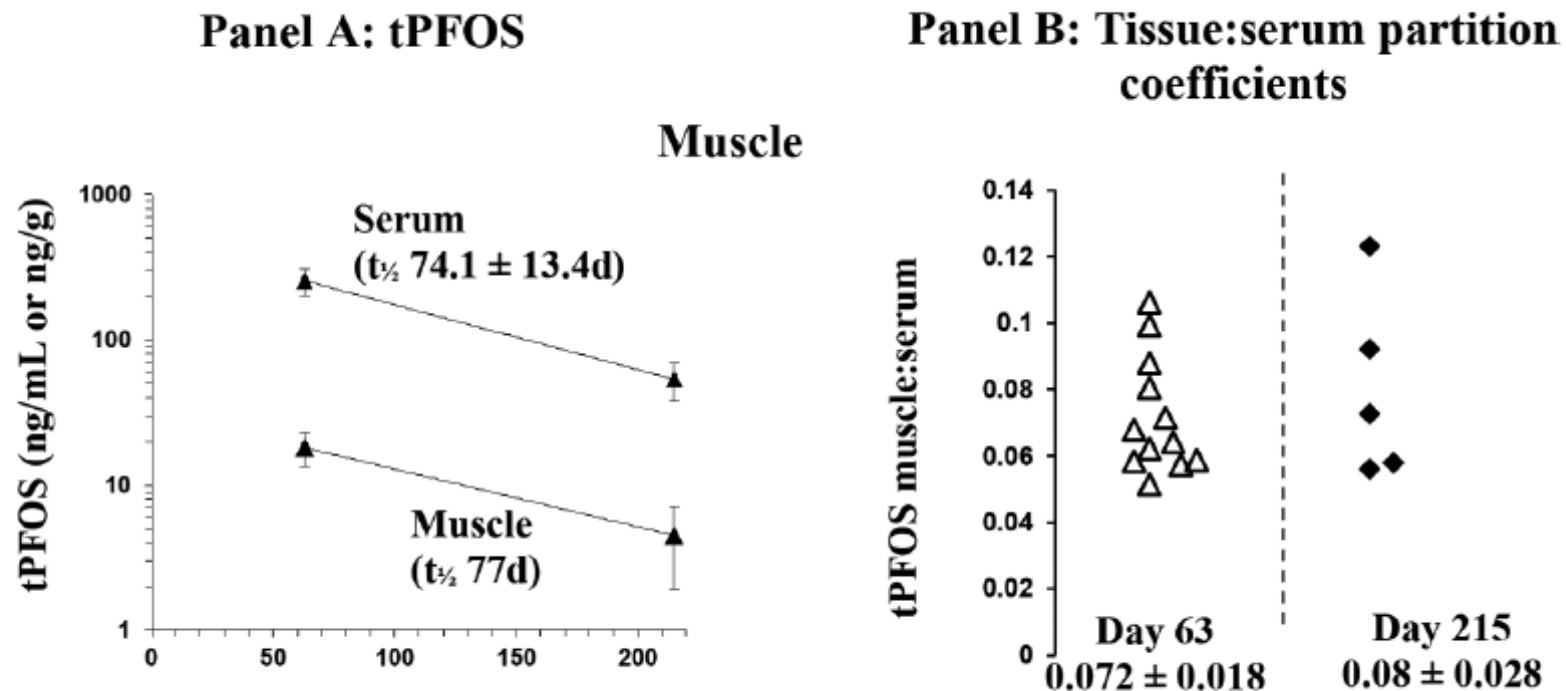
	Half-life
PFOS	3.5 days
PFOA	5.4 days

Source:

AECOM. 2017. Off-Site Human Health Risk Assessment -

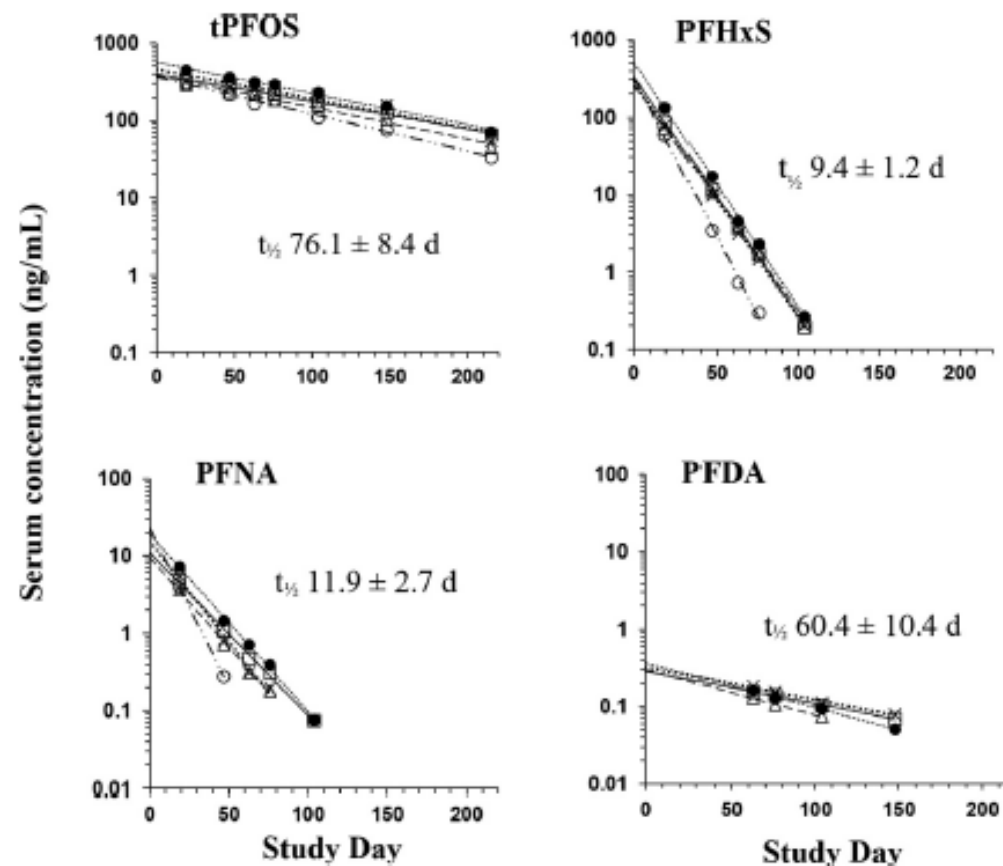
<https://www.defence.gov.au/environment/pfas/williamtown/publications.asp>

The “Forever Chemicals” are not forever in beef



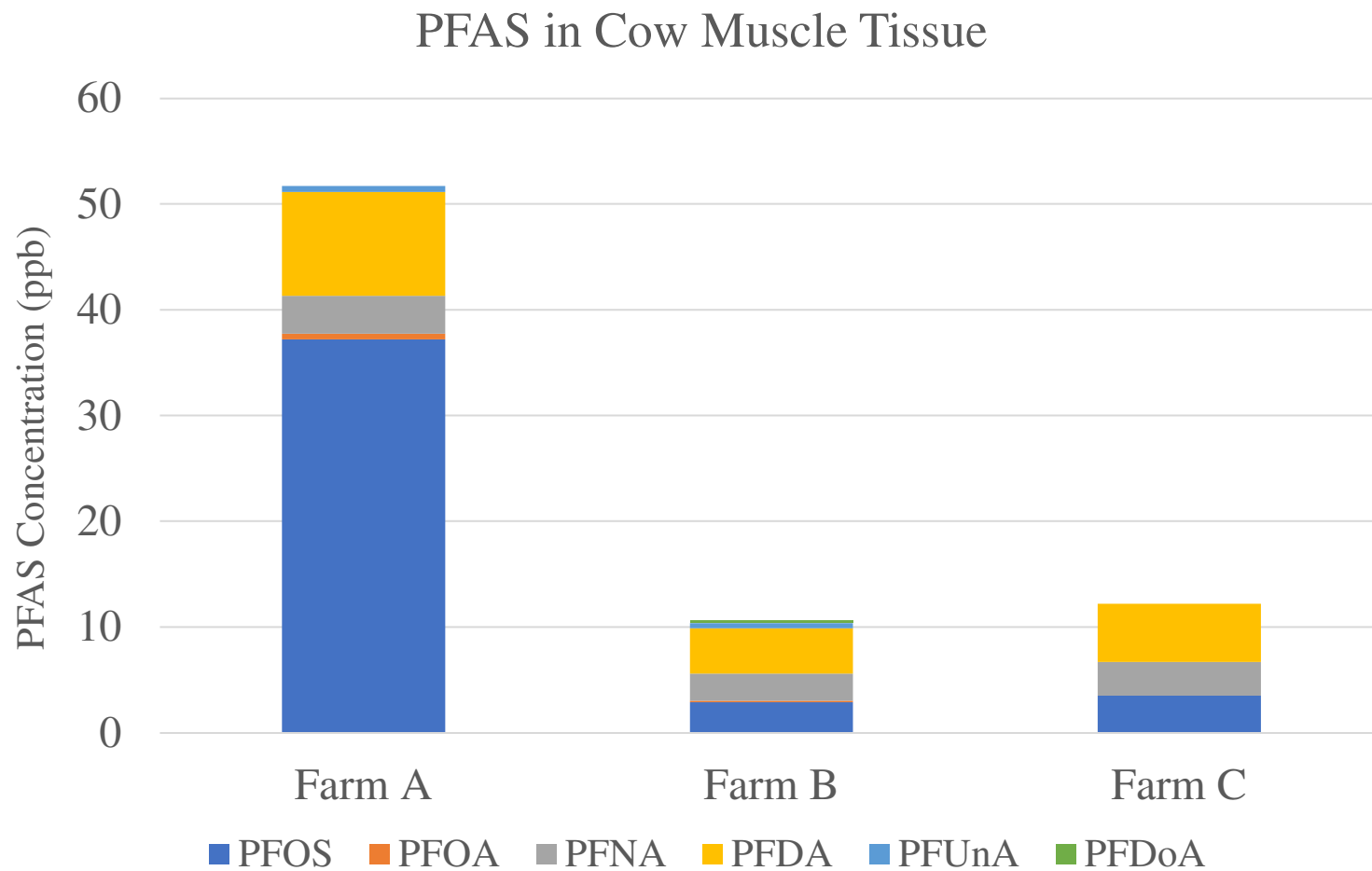
Source: Drew et al., 2021. <https://doi.org/10.1080/19440049.2021.1991004>

The “Forever Chemicals” are not forever in beef

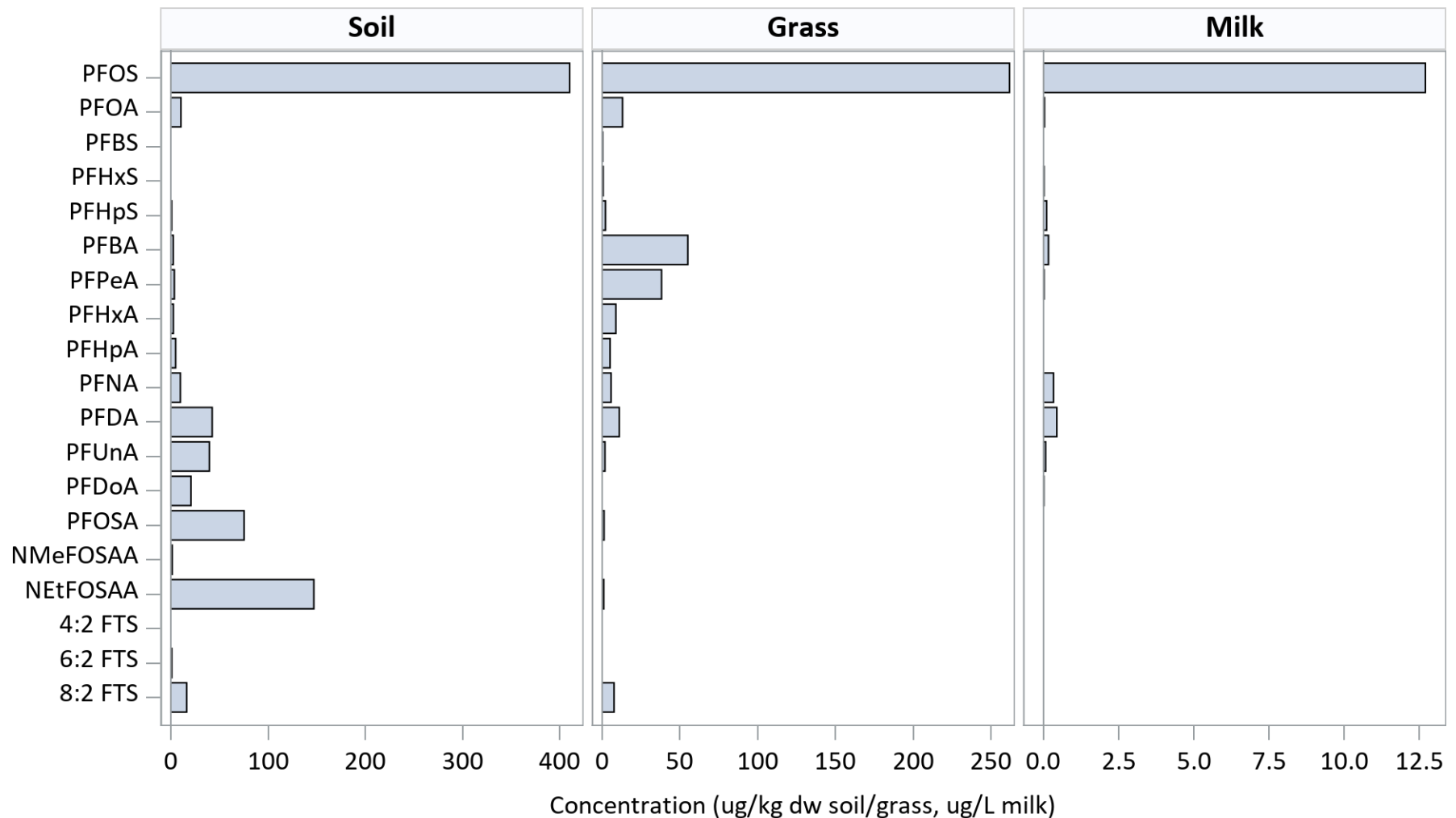


Source: Drew et al., 2021. <https://doi.org/10.1080/19440049.2021.1991004>

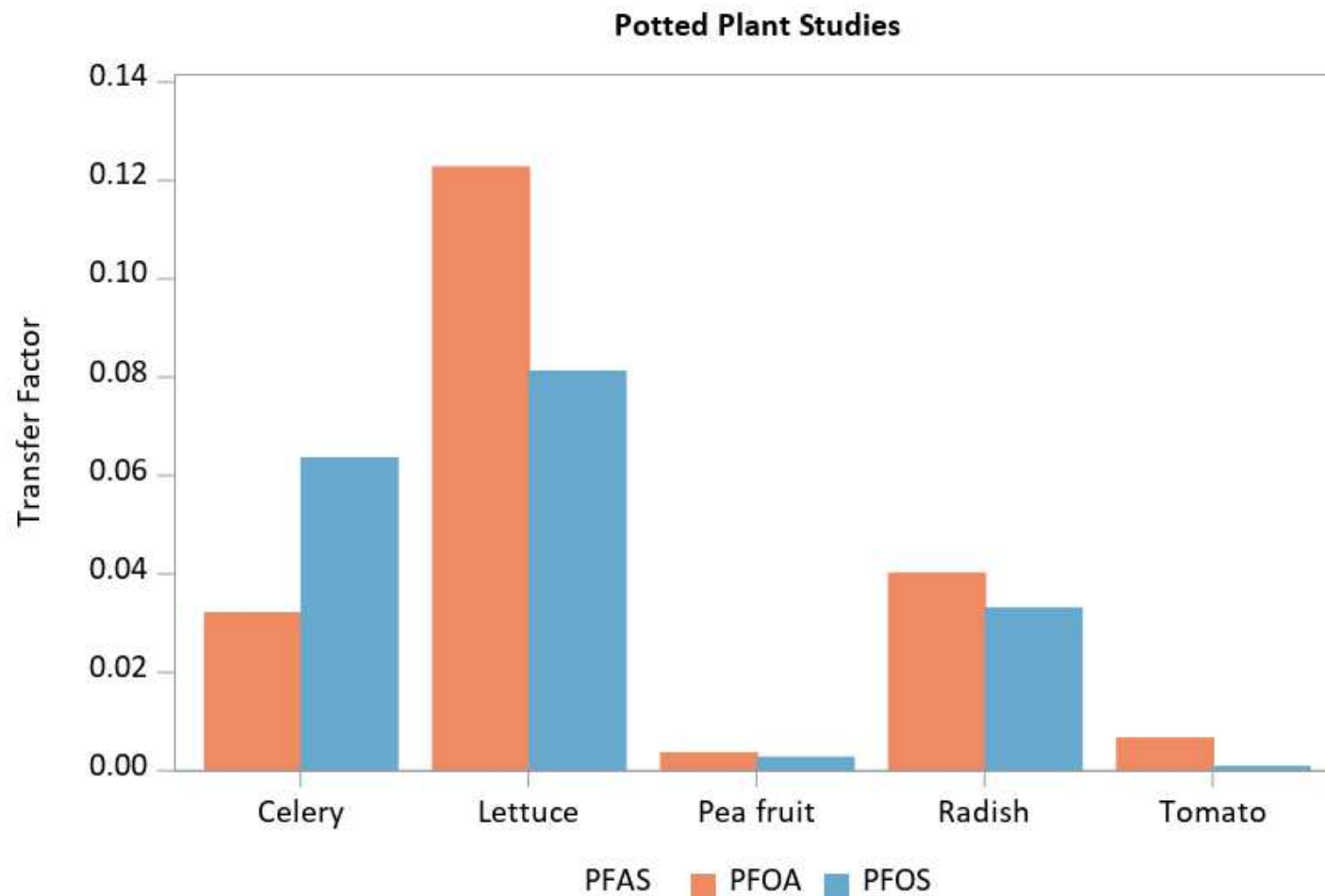
PFAS in Beef



PFAS move differently between media

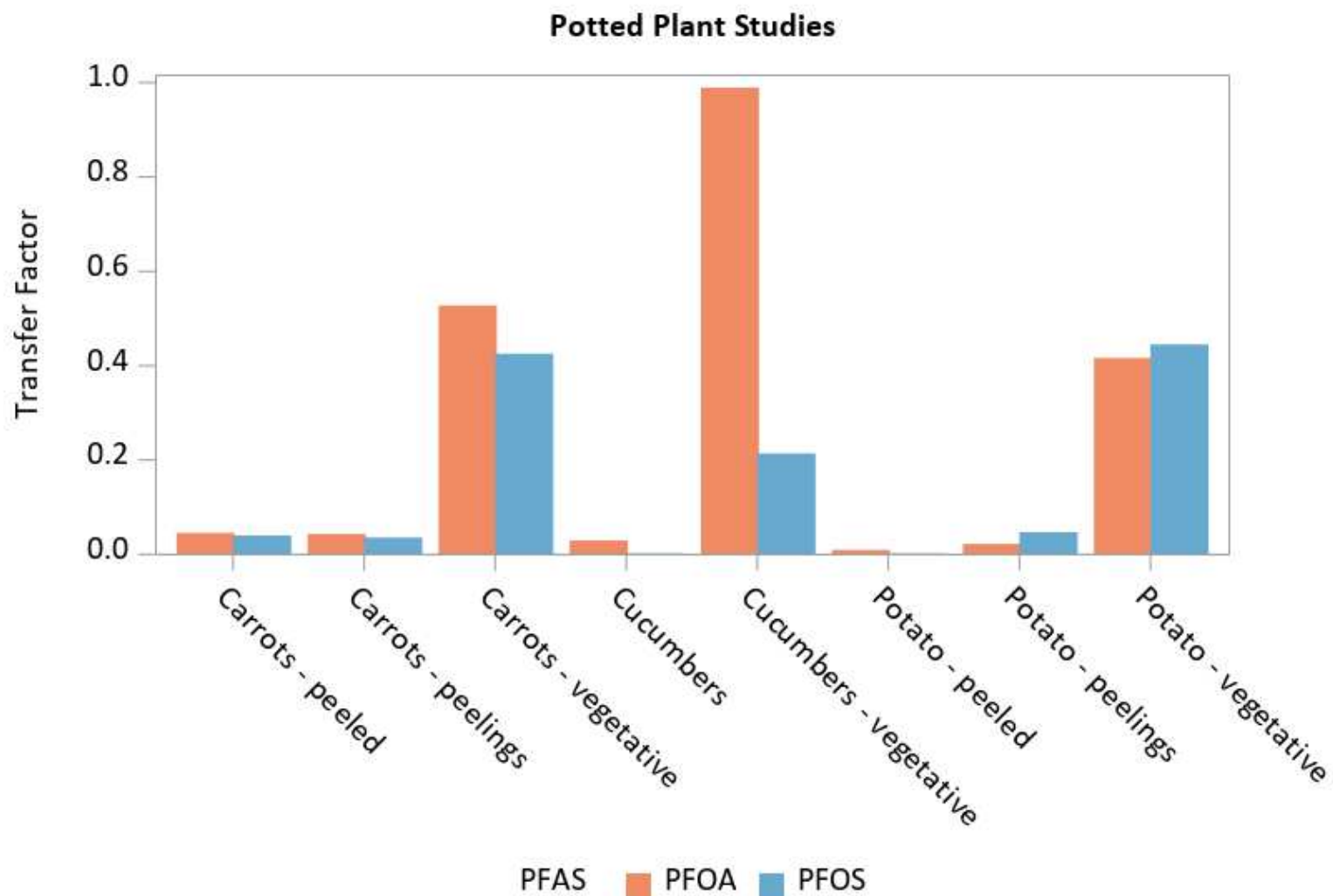


PFAS move differently within plants



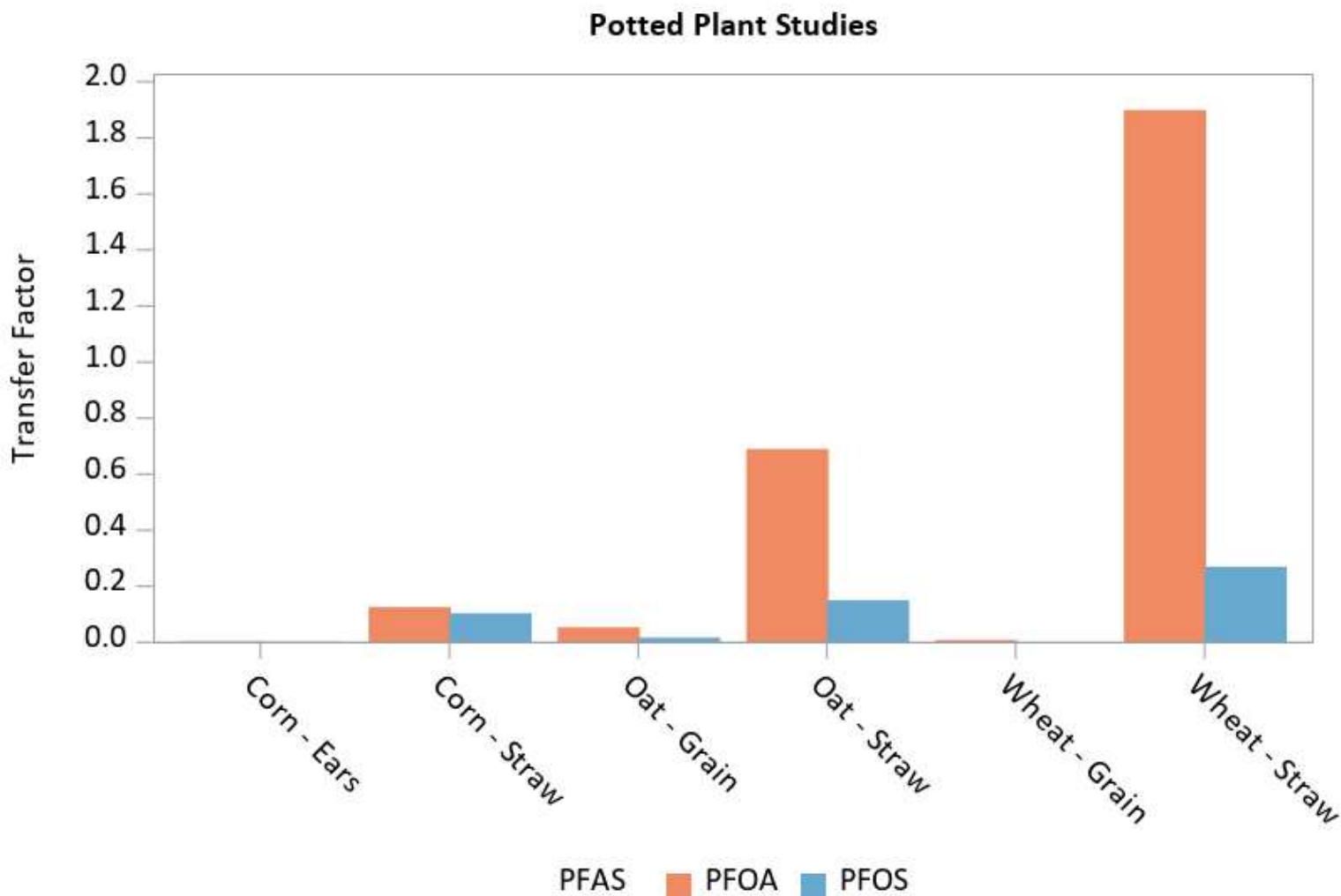
Source: Blaine et al. 2013 - <https://pubs.acs.org/doi/abs/10.1021/es403094g> and
Blaine et al. 2014 - <https://pubs.acs.org/doi/abs/10.1021/es500016s>

PFAS move differently within plants



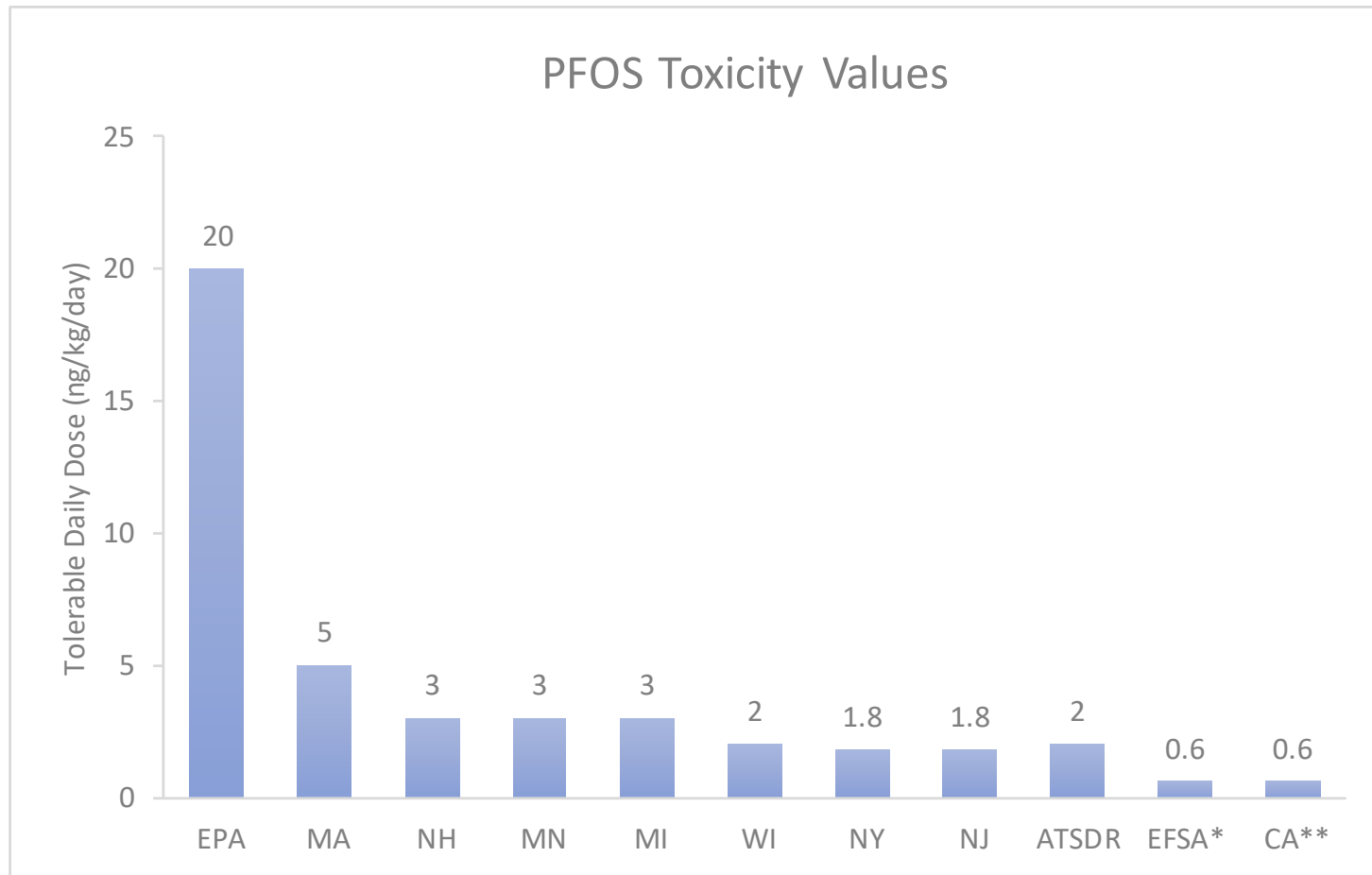
Source: Lechner and Knapp. 2011. <https://pubs.acs.org/doi/10.1021/jf201355y>

PFAS move differently within plants



Source: Stahl et al. 2009. <https://link.springer.com/article/10.1007%2Fs00244-008-9272-9>

Changing thinking on the toxicity of PFAS



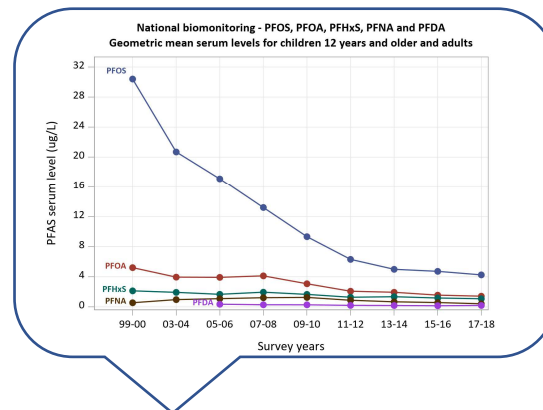
EFSA* - Human data, immune system toxicity, sum of PFOA, PFOS, PFNA, PFHxS

CA** - Human data, changes in cholesterol, proposed

How much is too much PFAS in food?

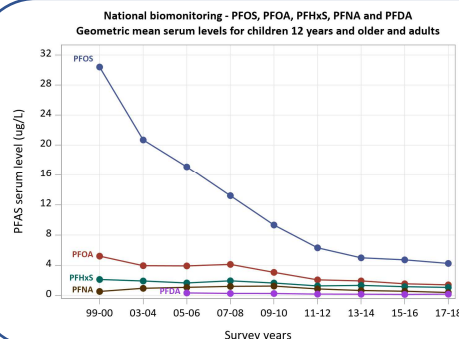


$$\frac{\text{Toxicity Value}}{\text{Consumption Rate}} \times \text{Relative Source Contribution}$$



How much is too much PFOS in milk?

What we currently have...



$$\frac{20 \text{ ng/kg/day}}{0.074 \text{ L/kg/day}} \times 0.80 = 210 \text{ ng/L}$$



How much is too much PFOS in milk?

If we do things as FDA does

ATSDR

FDA does not
apply an RSC

$$\frac{2 \text{ ng/kg/day}}{0.040 \text{ L/kg/day}} \times 1 = 50 \text{ ng/L}$$



How much is too much PFOS in soil

$$SL_{soil} = \frac{C_{milk} \times (D_{milk})^{-1}}{TF_{milk} \times \left[(I_{fodder} \times F_{land-f} \times F_{year-f} \times (TF_{plant} + MLF)) + (I_{soil} \times F_{land-g} \times F_{year-g}) \right]}$$

Diagram illustrating the components of the equation for Soil Lead (SL_{soil}):

- Numerator:**
 - C_{milk}**: Milk Action Level "adulterated" (indicated by a red arrow pointing to the variable).
 - (D_{milk})⁻¹**: Milk density (indicated by a blue arrow pointing to the variable).
- Denominator:**
 - TF_{milk}**: Transfer factor intake to milk (indicated by a red arrow pointing to the variable).
 - I_{fodder}**: Feed ingestion rate (indicated by a blue arrow pointing to the variable).
 - F_{land-f}**: Fraction of time exposed to contaminated feed (indicated by a blue arrow pointing to the variable).
 - F_{year-f}**: Fraction of time exposed to contaminated feed (indicated by a blue arrow pointing to the variable).
 - TF_{plant}**: Plant transfer factor (indicated by a red arrow pointing to the variable).
 - MLF**: Soil mass loading factor (indicated by a blue arrow pointing to the variable).
 - I_{soil}**: Soil ingestion rate (indicated by a blue arrow pointing to the variable).
 - F_{land-g}**: Fraction of time exposed to contaminated soil (indicated by a blue arrow pointing to the variable).
 - F_{year-g}**: Fraction of time exposed to contaminated soil (indicated by a blue arrow pointing to the variable).

Source: Modified equation from U.S. EPA Preliminary Remediation Goals for Radionuclides, consumption of milk back calculated to soil - https://epa-prgs.ornl.gov/radionuclides/users_guide.html

How much is too much PFOS in soil

Grass-based Dairy Farm



Pasture Fodder Only

SSL = $6.8 \mu\text{g/kg}$, *dw*



Corn-Silage Fodder Only

SSL = $120 \mu\text{g/kg}$, *dw*

<https://www.maine.gov/dep/spills/topics/pfas/Agronomic-Pathway-Soil-Screening-Levels-Soil-Fodder-Cows-Milk-09.16.20.pdf>

For more information

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