

# PFOS, Land Application of Residuals, Dairy Farms and Milk

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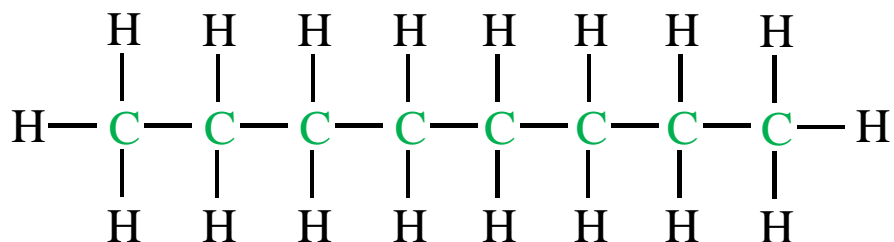
January 14, 2020



# What is PFOS?

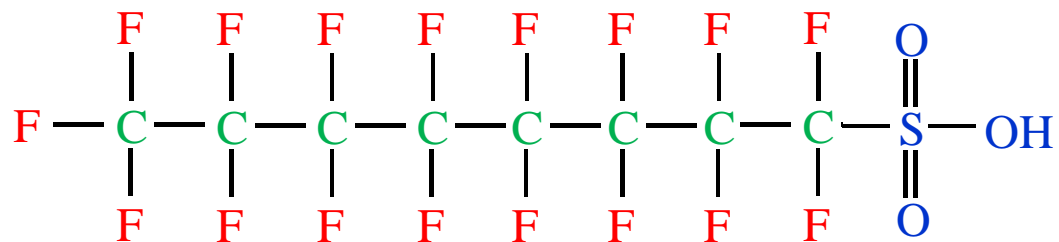
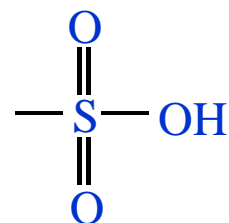
(perfluorooctane sulfonic acid)

Carbon backbone



Octane

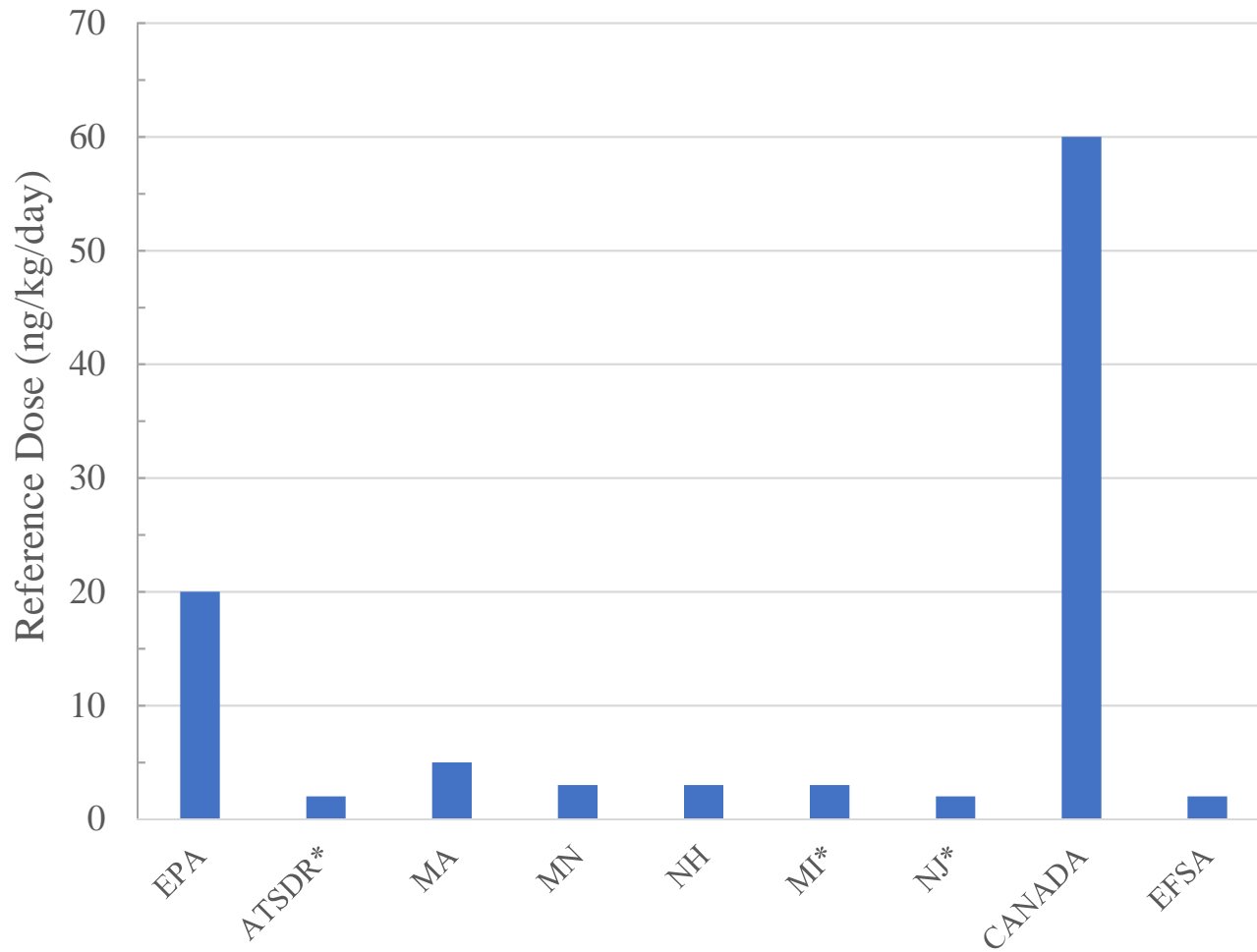
Acid Group



Perfluorooctane sulfonic acid (PFOS)

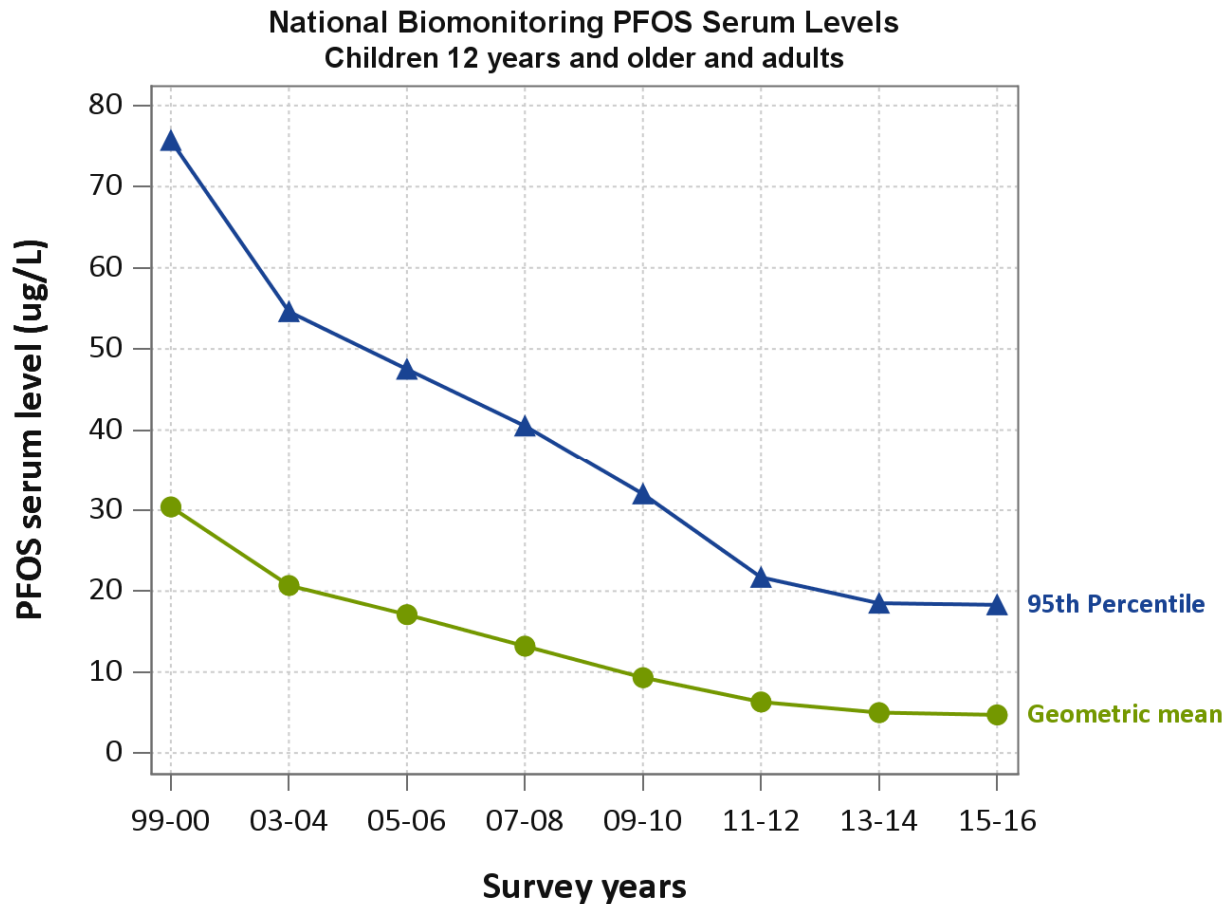
# PFOS is Toxic

Toxicity Values for PFOS



\* Proposed

# Why are we concerned about PFOS?

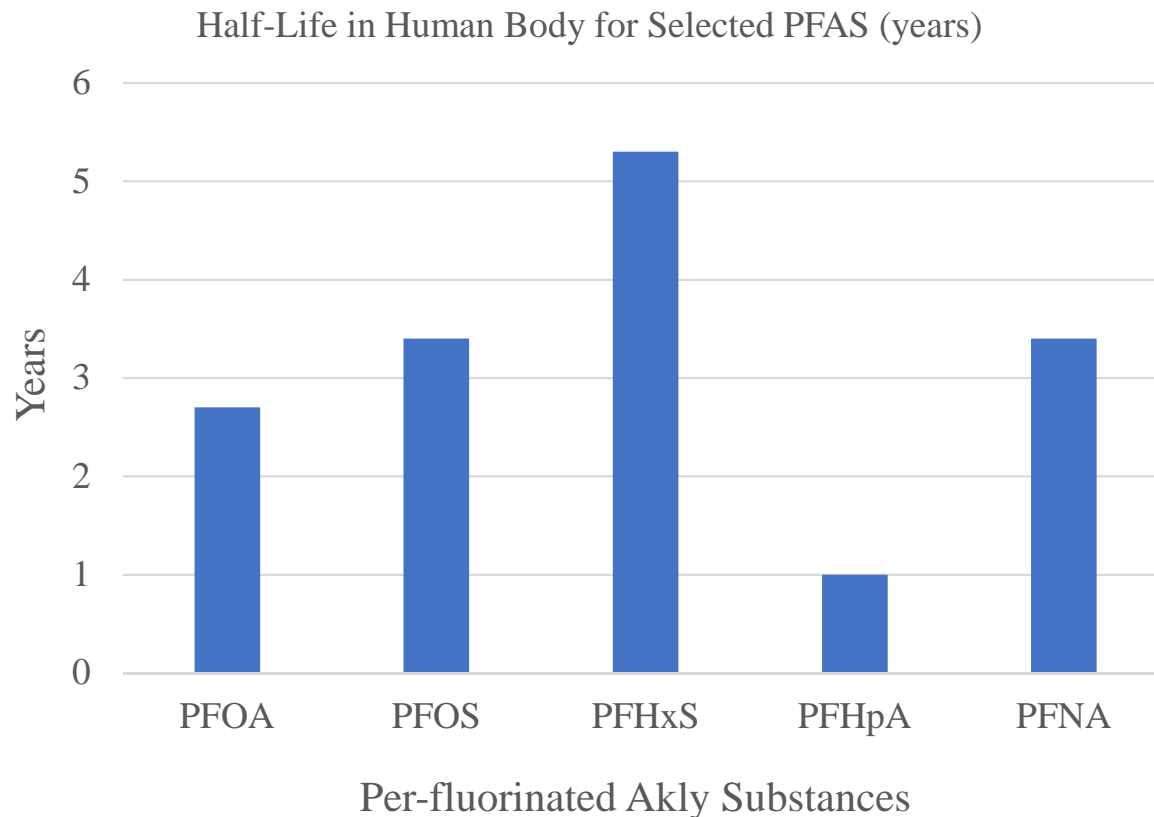


We are all  
exposed to  
PFOS.

Source:

National Report on Human Exposure to Environmental Chemicals – US CDC: <https://www.cdc.gov/exposurereport/index.html>

# Why are we concerned about PFOS?



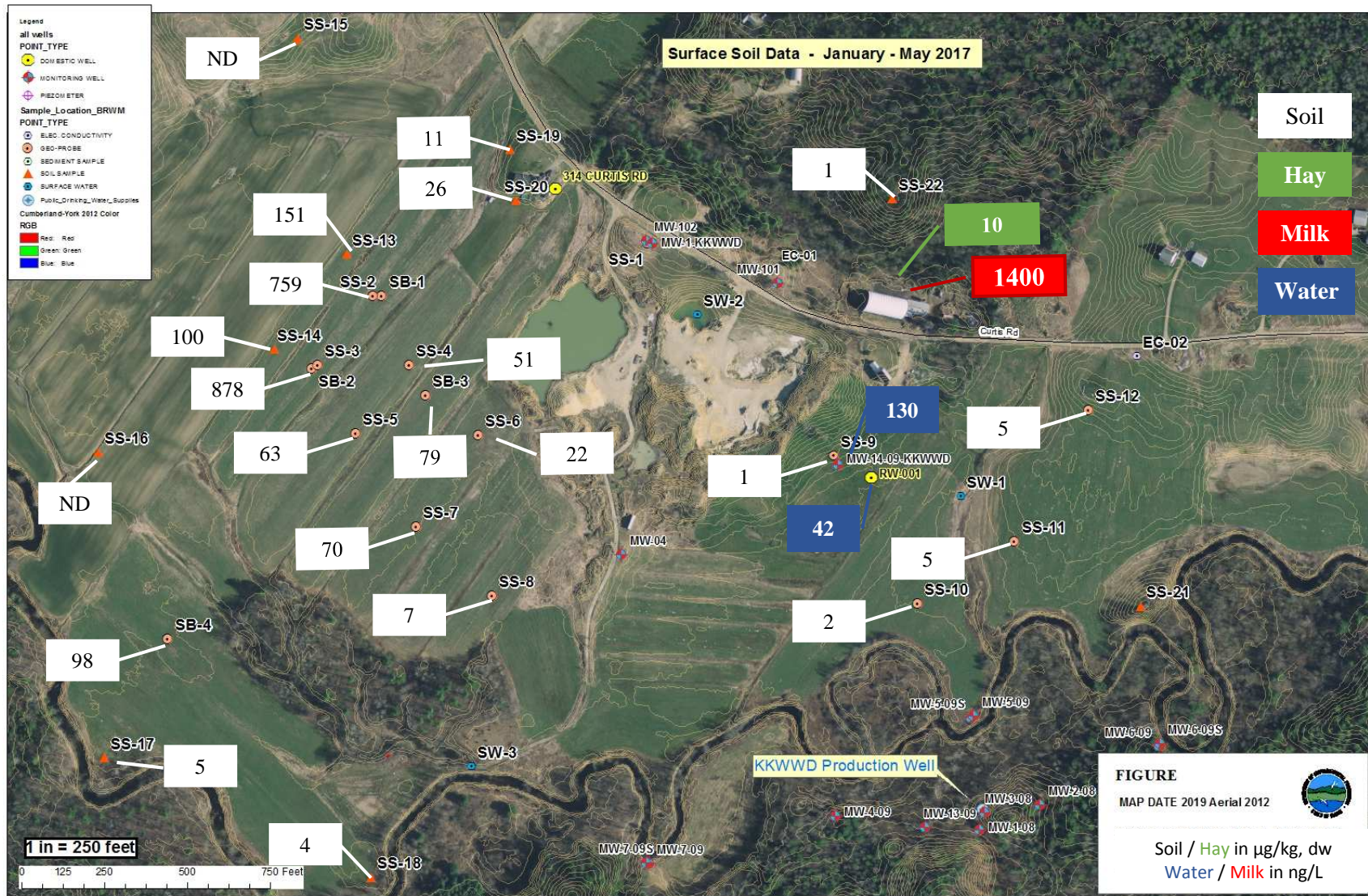
**PFOS**  
stays in  
our bodies  
for years.

Sources:

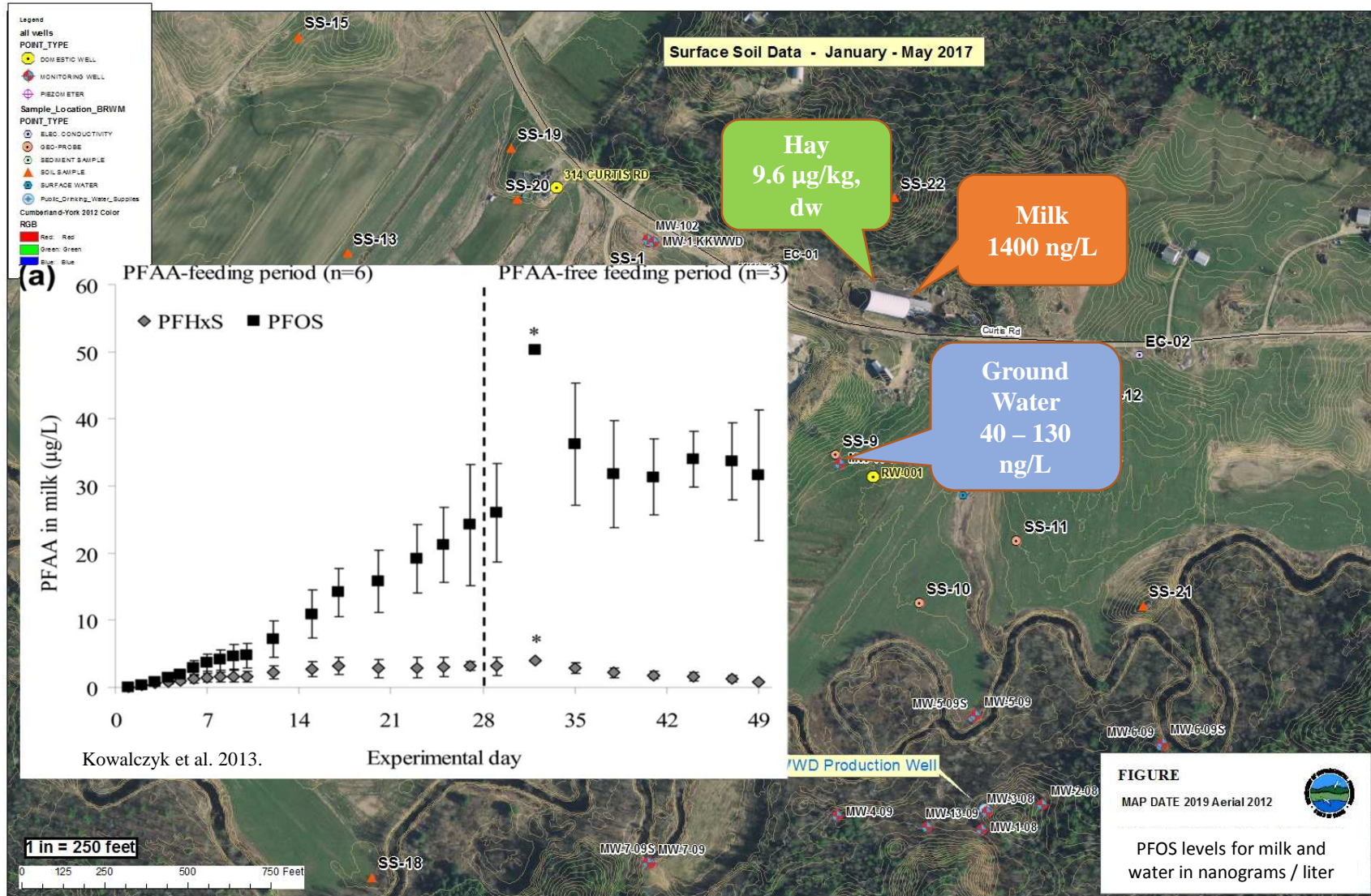
Li et al., *Occup. Environ. Med.* Vol. 75:46-51 (2018). Zhang et al. *Environ. Sci. Technol.* Vol 47:10619-27 (2013)

# PFOS is Persistent and Mobile

## - Stoneridge Farm -



# Is it the hay or the water?



CT1  
ST2

# PFOS Soil Screening Levels for Residential Soil Exposure Pathway - 2017



PFOS

2700  $\mu\text{g}/\text{kg}$ , dw

Based on USEPA RfD of 20 ng/kg/day, 95<sup>th</sup> percentile incidental soil ingestion rate for a 1-6 year old child, 150 days / year.



## Slide 8

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**ST1** I would use the RAG here as the chapter 418 standard wouldn't necessarily be the applicable standard applied in this case, i.e., that is a new site with contaminated soils where you don't know the source. DEP would use the soil RAG to evaluate.

Simones, Thomas, 9/11/2019

**ST2** I would also use the 2018 RAG of 1700 ug/kg to avoid any confusion and mention that at the time of discovery the RAG was 2700.

Simones, Thomas, 9/11/2019

# What would be a PFOS soil screening level for the dairy farming scenario?



Soil → Hay/Corn → Cow → Milk → Child

# EPA PRGR Soil Screening Level Equation Agronomic Pathway

Milk Action  
Level  
“Adulterated”

↓

$C_{milk}$

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

↑ ↑ ↑ ↑  
 Transfer Factor from Intake to Milk      Fraction of time exposed to contaminated feed      Plant uptake and soil loading      Fraction of time exposed to contaminated soil

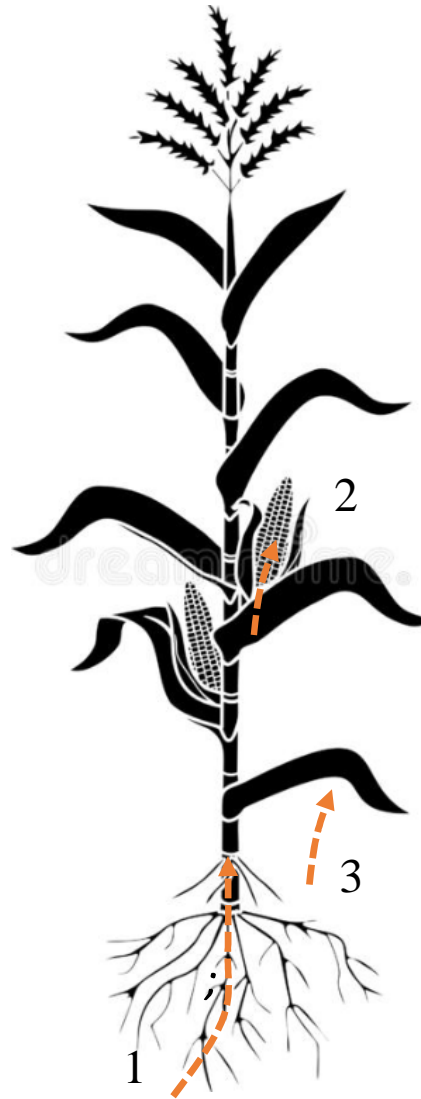
↓  
 Animal ingestion rates

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](https://epa-prgs.ornl.gov/radionuclides/users_guide.html)

# Plant Uptake – Plant Transfer Factors



Transfer pathways:

1. Root uptake
2. Translocation
3. Soil resuspension

# PFOS Corn Transfer Factor ( $TF_{plant}$ )



$$TF_{corn} = < 0.08$$



$$TF_{corn} = 0.04$$



$$TF_{corn} = 0.16$$

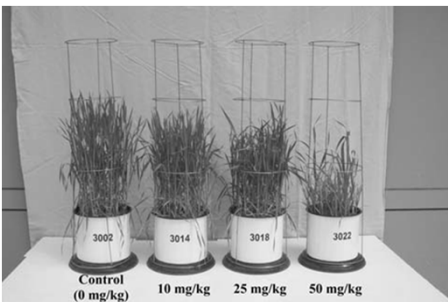
# PFOS Hay Transfer Factor ( $TF_{plant}$ )



$$TF_{hay} = 0.07$$



$$TF_{hay} = 0.1$$



$$TF_{hay} = 0.5$$

# Plant Soil Mass Loading Factor (*MLF*)



## Processes for transfer of soil to plant surface

- Rain splash
- Wind erosion
- Soil disturbance by mechanical equipment

## USEPA PRGR Defaults

- Default = 0.25, range 0.001 to 0.5
- Geometric mean of 11 studies\* = 0.034  
(pasture plants only)

$$MLF = 0.034$$

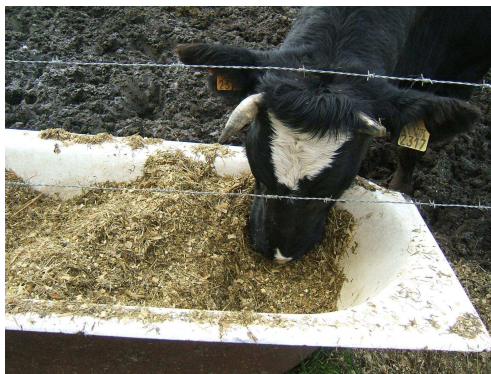
CORN\*\*  
0.0014

Source:

\*Hinton, T.G. 1992. Contamination of plants by resuspension: a review, with critique of measurement methods. *Sci Total Environ.* 121:117-193. DOI: [https://doi.org/10.1016/0048-9697\(92\)90314-I](https://doi.org/10.1016/0048-9697(92)90314-I)

\*\*Pinder III, J.E. et al. 1989. Mass loading of soil particles on plant surfaces. *Health Physics.* 57(6):935-942.

# Dairy Farm Scenarios



## Grass-fed Dairy Farm

Hay (65%)

Corn Silage (20%)

Grain (15%)

## “Average” Maine Dairy Farm

Hay (20%)

Corn Silage (37%)

Grain (35%)



# Soil Ingestion while Grazing

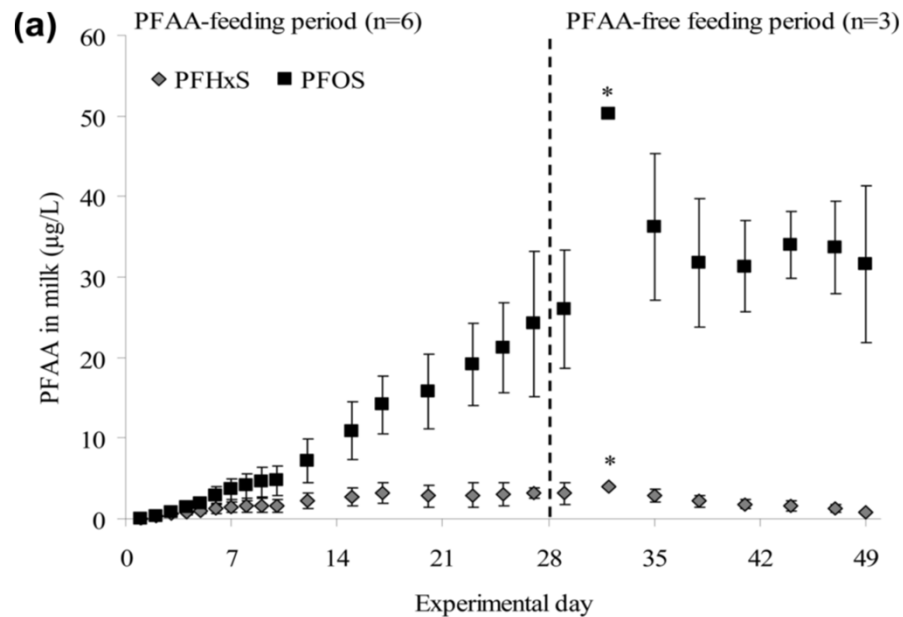


## **USEPA PRGR Defaults**

- 2 % of total dry matter intake

# PFOS Milk Transfer Factor ( $TF_{milk}$ )

## PFOS in Milk Feeding Study



- Observed  $TF_{milk} = 0.005$
- Steady-state  $TF_{milk} = 0.02$  to  $0.08$

Source:

Kowalczyk et al. 2013. Absorption, distribution, and milk secretion of the perfluoroalkyl acids PFBS, PFHxS, PFOS, and PFOA by dairy cows fed naturally contaminated feed. J Agric Food Chem. 61(12):2903-12. <https://doi.org/10.1021/jf304680j>

Vestergren et al. 2013. Bioaccumulation of perfluoroalkyl acids in dairy cows in a naturally contaminated environment. Environ Sci Pollut Res Int. 20(11):7959-69. <https://doi.org/10.1007/s11356-013-1722-x>

# Action Level for “adulterated” Milk

Toxicity Value  
20 ng/kg/day

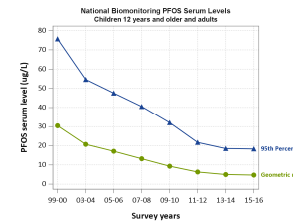
90<sup>th</sup> Percentile  
Milk Intake  
0.074 L/kg/day



1-2 year old

270  
ng/L

Milk Exposure  
Limit

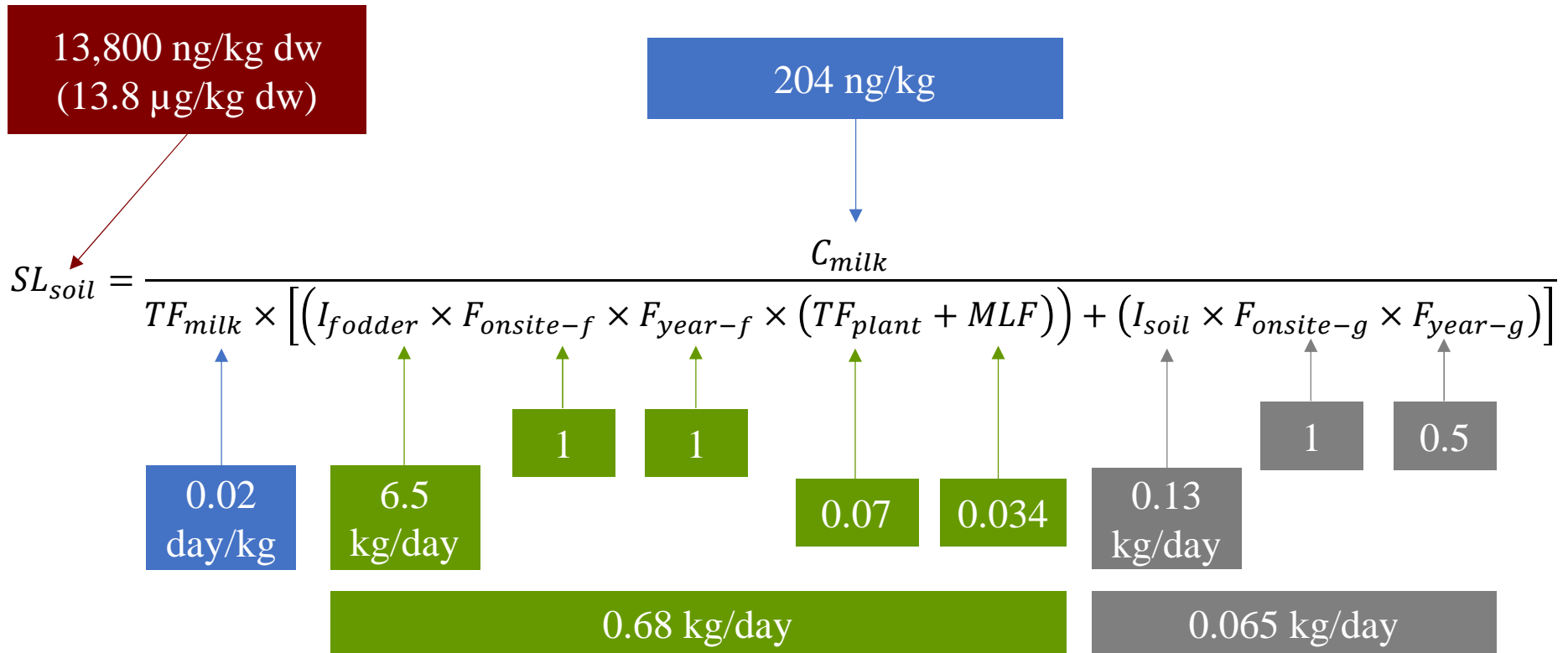


Relative  
Source  
Contribution  
80%

210  
ng/L

Action  
Level

# Example Soil SL Calculation for Hay

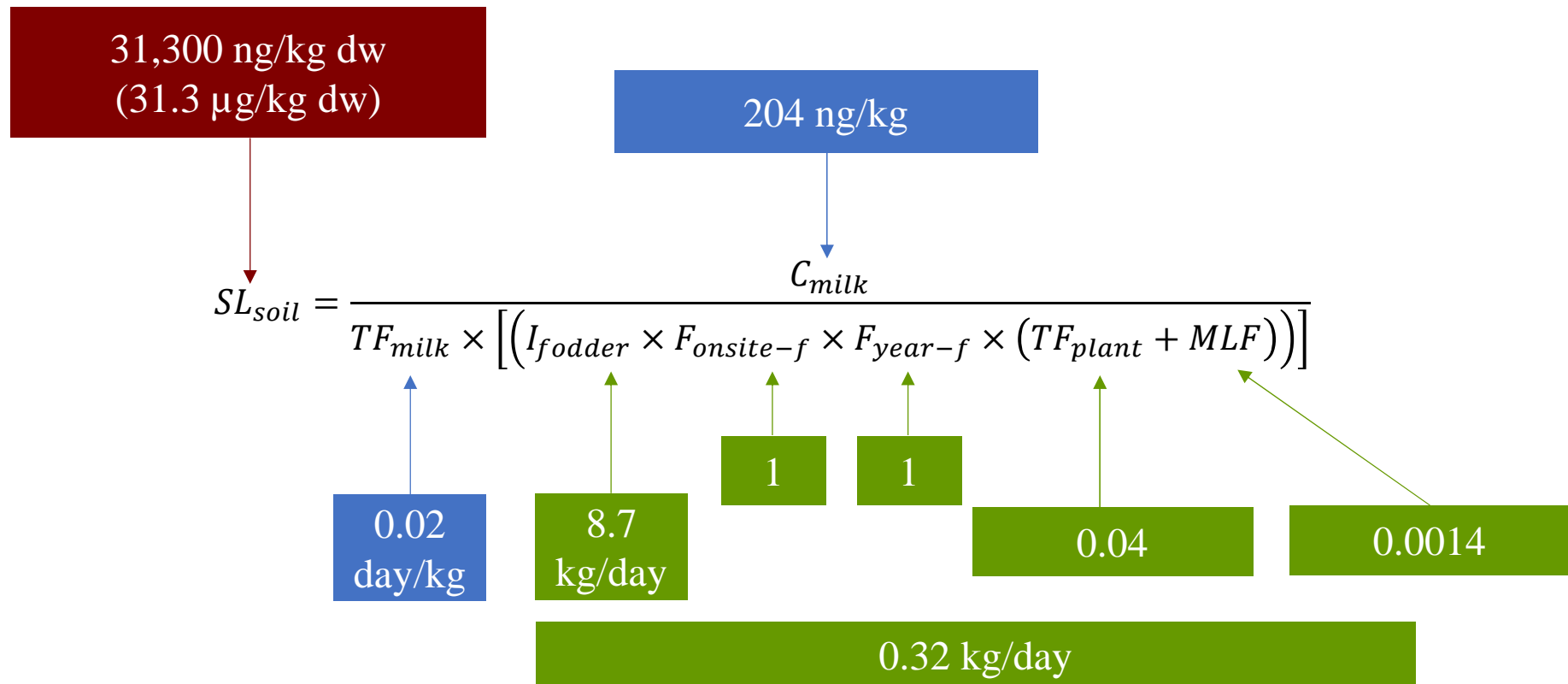


Source:

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](https://epa-prgs.ornl.gov/radionuclides/users_guide.html)

# Example Soil SL Calculation for Corn Silage



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](https://epa-prgs.ornl.gov/radionuclides/users_guide.html)

# Example Soil Screening Levels for Dairy Farm Scenarios



## EPA “Subsistence Dairy Farm”

- Diet: Hay (65%) Corn (20%) Grain (15%)

$$\text{SSL} = 6 \mu\text{g}/\text{kg}, dw$$

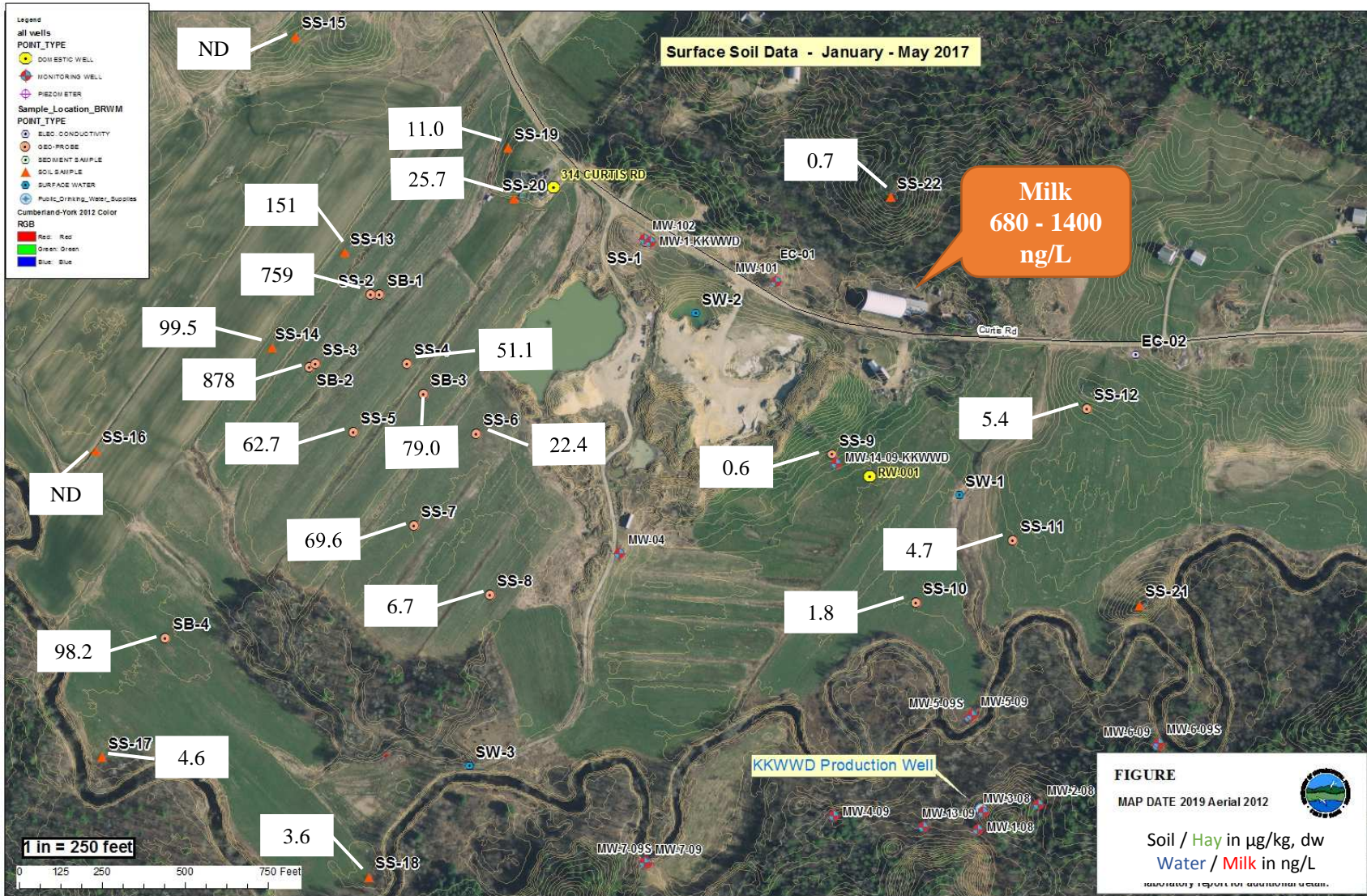


## Average Maine Dairy Farm

- Diet: Hay (28%) Corn (37%) Grain (35%)

$$\text{SSL} = 10 \mu\text{g}/\text{kg}, dw$$

# Ground-truthing Model Predictions



# Model Estimated PFOS Milk Levels based on Stoneridge Farms Average Soil Levels

Stoneridge Farms PFOS site-wide soil level estimates (ug/kg dry weight)	Model estimated PFOS milk (ng/L)
123 (arithmetic average)	3,808
25 (geometric mean)	734

Initial average measured PFOS milk levels at Stoneridge Farms = 1,117 ng/L

NOTE – Does not include water contribution, which could add 90 – 200 ppt to milk.



# Next Steps



## Soil-to-Corn PFOS Uptake Study (DEP, MECDC, DACF)

- Collected matched soil and silage corn samples for PFOS analysis
- Identified a laboratory to perform plant PFOS analyses
- Awaiting plant data to derive a transfer factor



## Ongoing model refinements

- Evaluating consensus on toxicity values
- Monitoring new literature / reports on plant uptake
- Looking for more farms to test model against

# Questions?

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