Developing PFOS Soil Screening levels for a soil-to-fodder-to-cow's milk agronomic pathway

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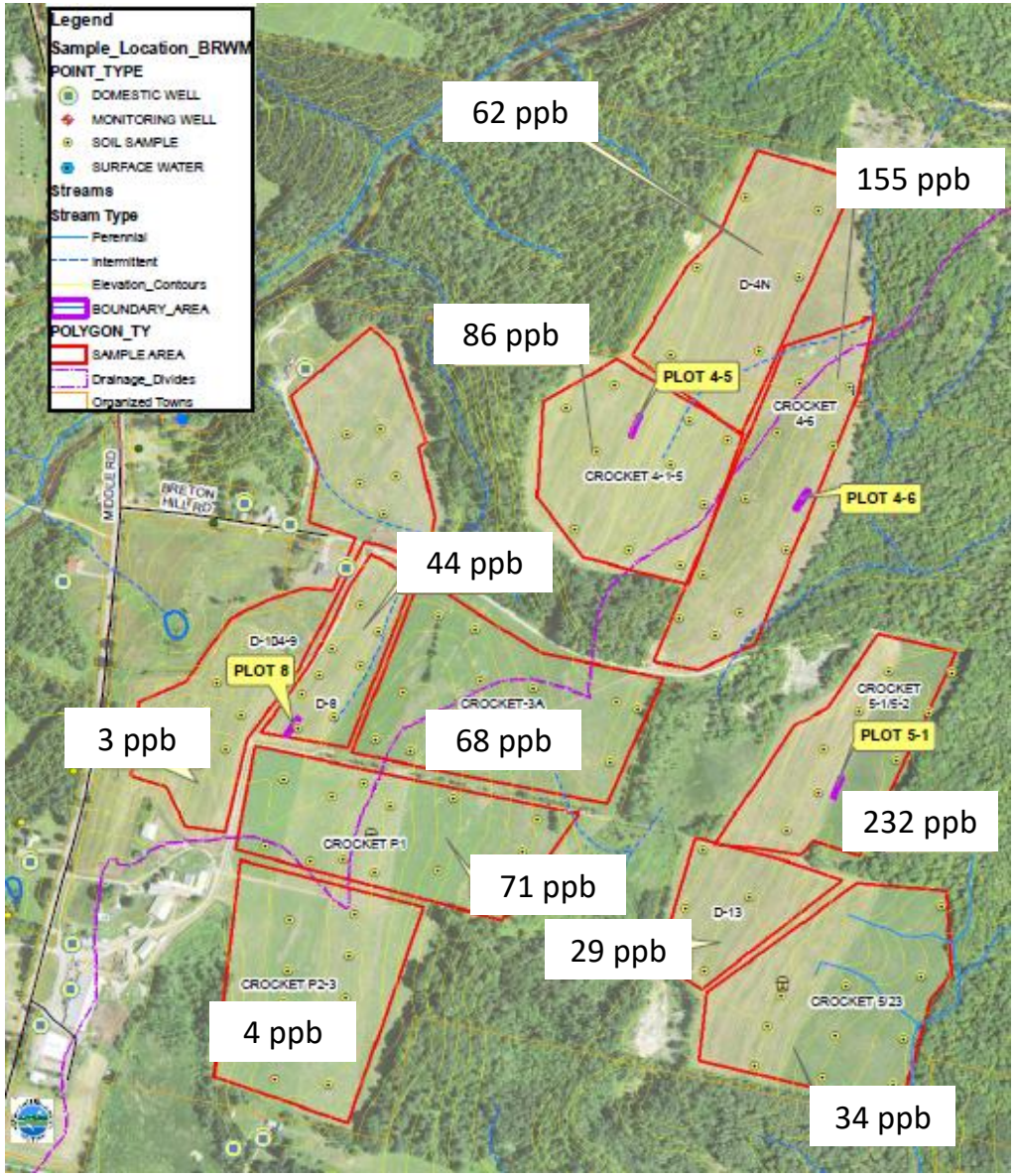
Why develop soil screening levels for a soil-to-fodder-to-cow's milk pathway?



- Average PFOS soil levels in impacted fields range from 29 to 232 ppb
- Current soil screening level for a child incidental soil ingestion pathway is 1,700 ppb
- Initial milk PFOS level was 800 ppt

Modified EPA Soil Screening Level Equation

PFOS-specific parameters

Action level for adulterated milk

Milk density

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

Transfer factor intake to milk

Feed ingestion rate

Fraction of time exposed to contaminated feed

Plant transfer factor + soil mass loading factor

Soil ingestion rate

Fraction of time exposed to contaminated soil

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

DRAFT Milk Action Level Update

ATSDR
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Toxicity value
2 ng/kg/day

0- to 6-year-old

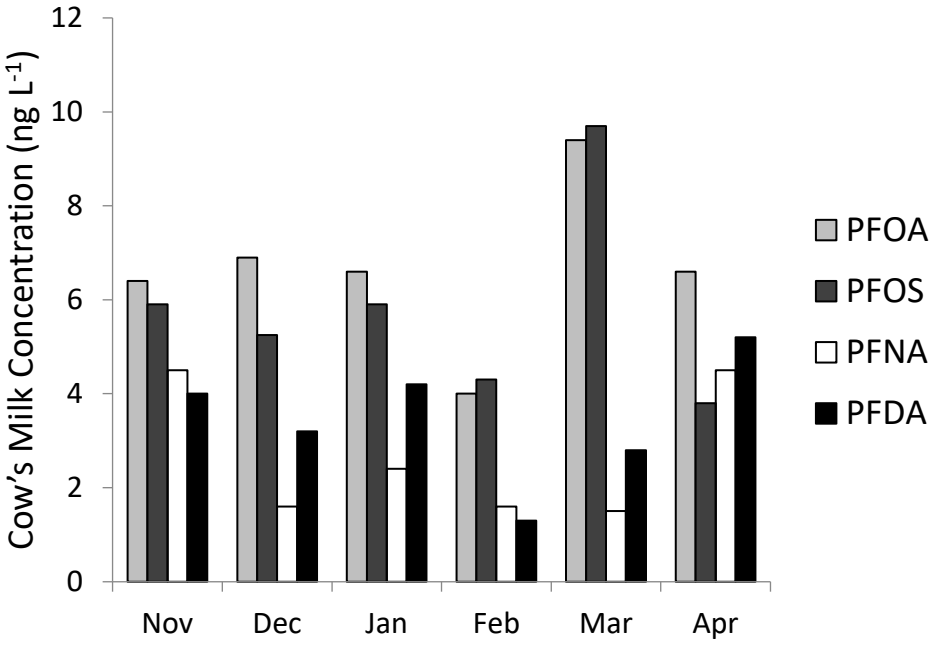
90th Percentile
milk intake
0.045 L/kg/day

44 ng/L

Draft milk action level

PFOS Transfer Factor Intake to Milk

Background dairy cow exposure study



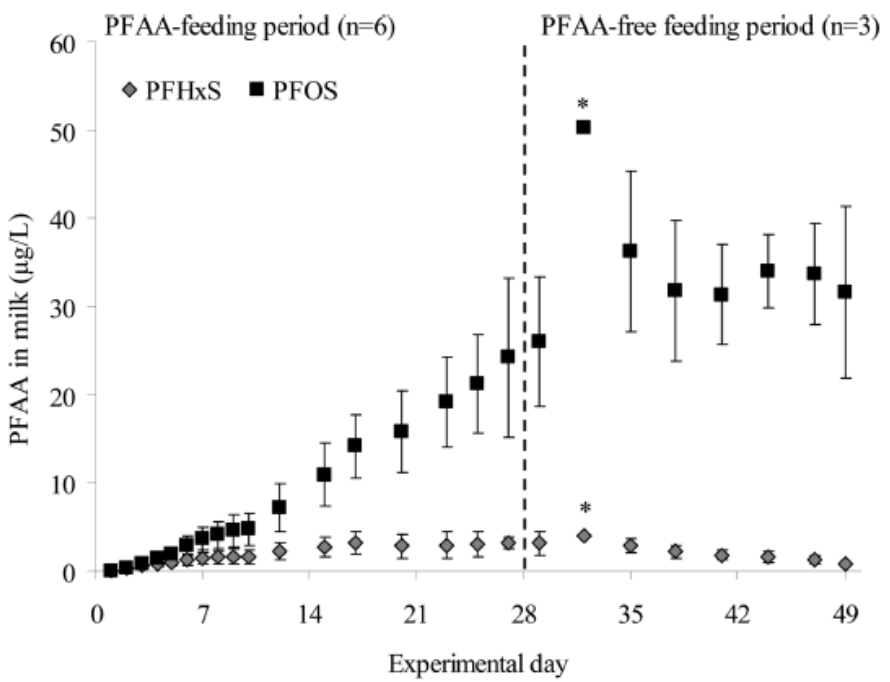
Background exposure study milk transfer factor (day/kg) –

- Calculated TF_{milk} = 0.02

Source:
Vestergren et al. 2013. https://doi.org/10.1007/s11356-013-1722-x

PFOS Transfer Factor Intake to Milk

Contaminated feed dairy cow exposure study



Controlled feeding study milk transfer factors (day/kg) –

- Calculated TF_{milk} = 0.005
- Modeled TF_{milk} = 0.02 to 0.08

Source:
Kowalczyk et al. 2013. https://doi.org/10.1021/jf304680j

Dairy Farm Exposure Scenarios

Grass based dairy farm

- Hay/grass primary feed source
- Hay - 65%

Average Maine dairy farm

- Corn silage primary feed source
- Hay - 28%

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

PFOS Hay Transfer Factor from Literature

Field studies

$TF_{hay} = 0.07$

(range 0.034 - 0.13)

$TF_{hay} = 0.1$

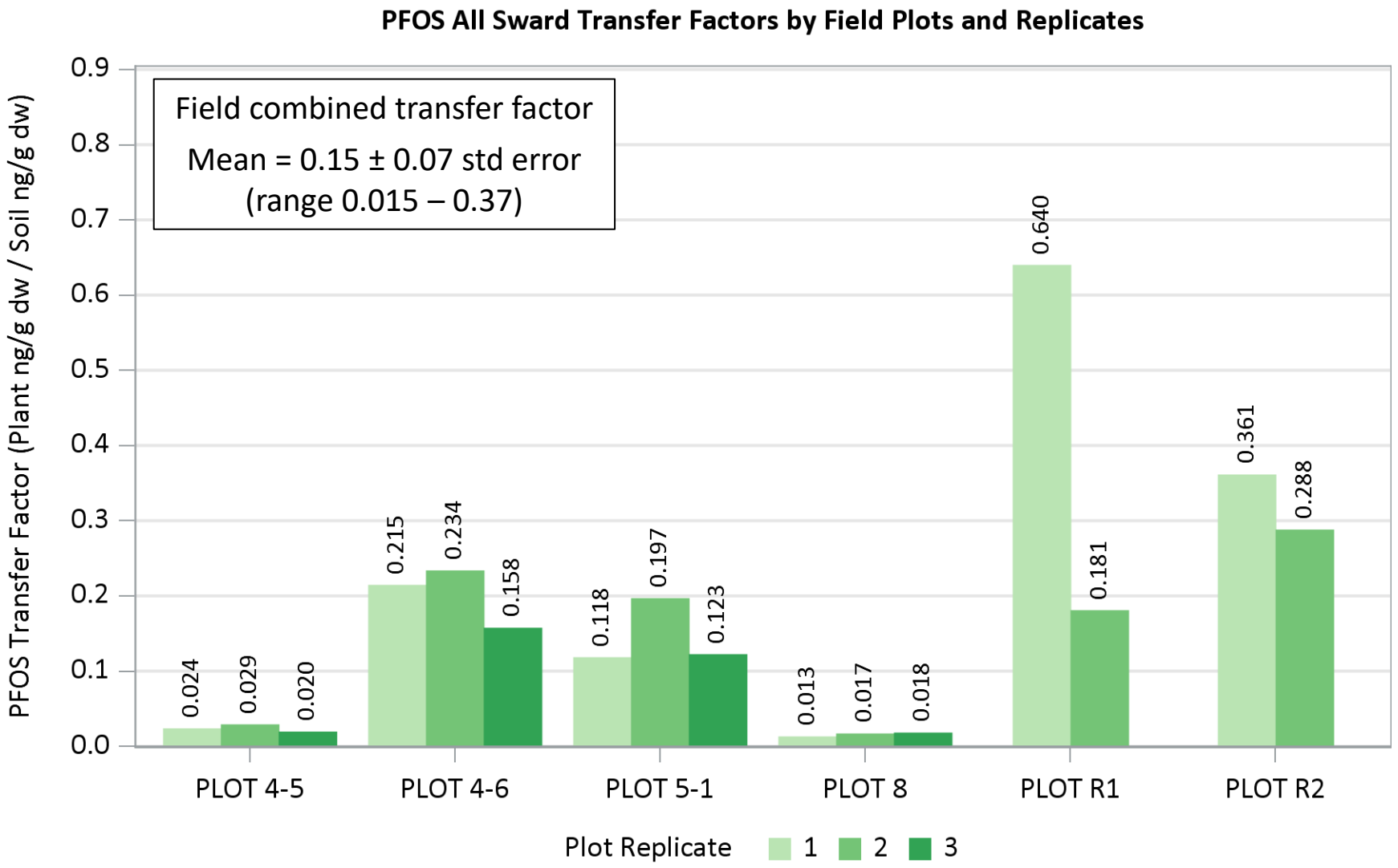
(range 0.054 - 0.33)

Source:
Yoo et al. 2011. https://doi.org/10.1021/es102972m
Fischer et al. 2008/2009 https://www.lanuv.nrw.de/fileadmin/lanuv/verbraucher/pdf/transfer_pft.pdf
https://www.lanuv.nrw.de/fileadmin/lanuv/verbraucher/pdf/transfer_pft_2008.pdf

Hay Uptake Study

Hay Uptake Study

Hay Uptake - Preliminary Results



Example Soil Screening Level - Hay

PFOS-specific parameters

1.0 ug/kg

0.044 ug/L **1.03 kg/L**

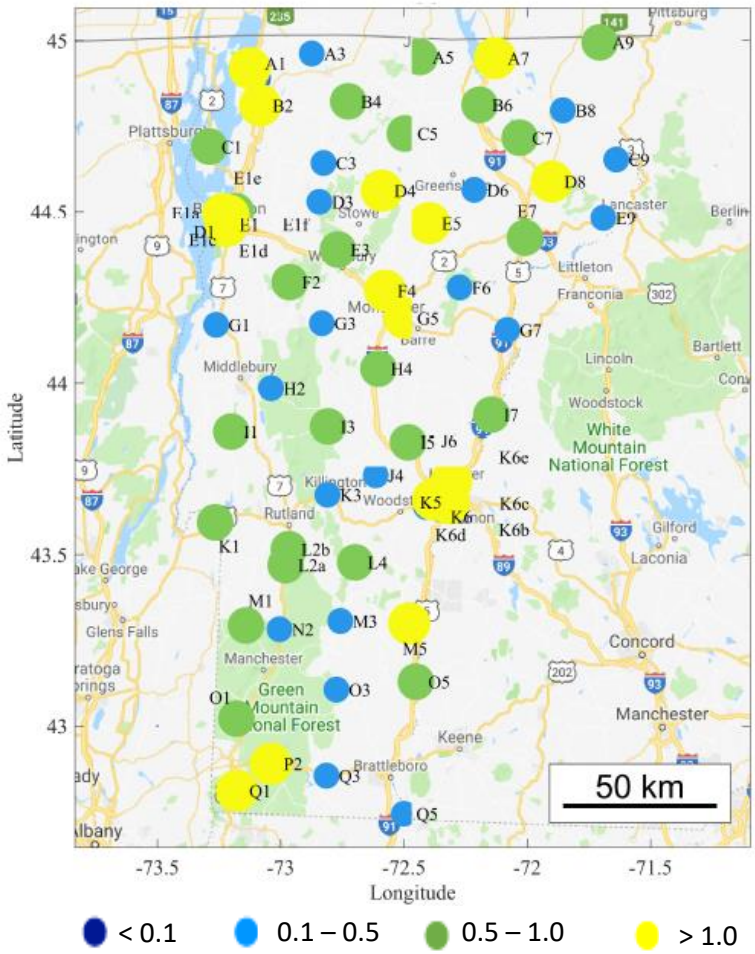
$$SL_{soil} = \frac{C_{milk} \times (D_{milk})^{-1}}{TF_{milk} \times \left[\left(I_{fodder} \times F_{land-f} \times F_{year-f} \times \left(TF_{plant} + MLF\right)\right) + \left(I_{soil} \times F_{land-g} \times F_{year-g}\right)\right]}$$

0.02 day/kg **13.2 kg/day** **1** **1** **0.15** **0.26 kg/day** **1** **0.5**

1.98 kg/day **0.13 kg/day**

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

Soil Screening Levels Approaching Background



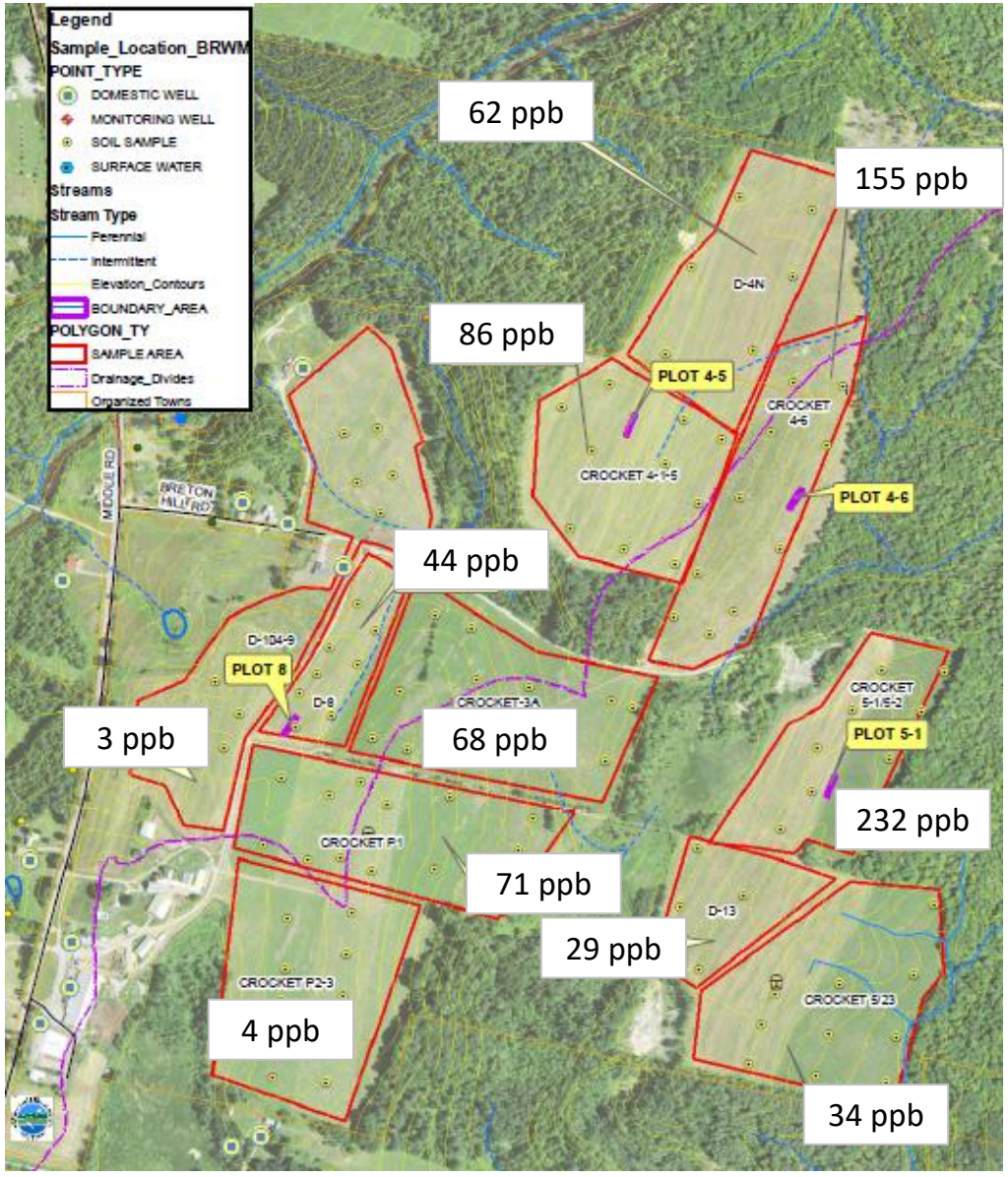
Background Soil Levels

Mean = 0.97 µg/kg, *dw*

95th %tile = 3.0 µg/kg, *dw*

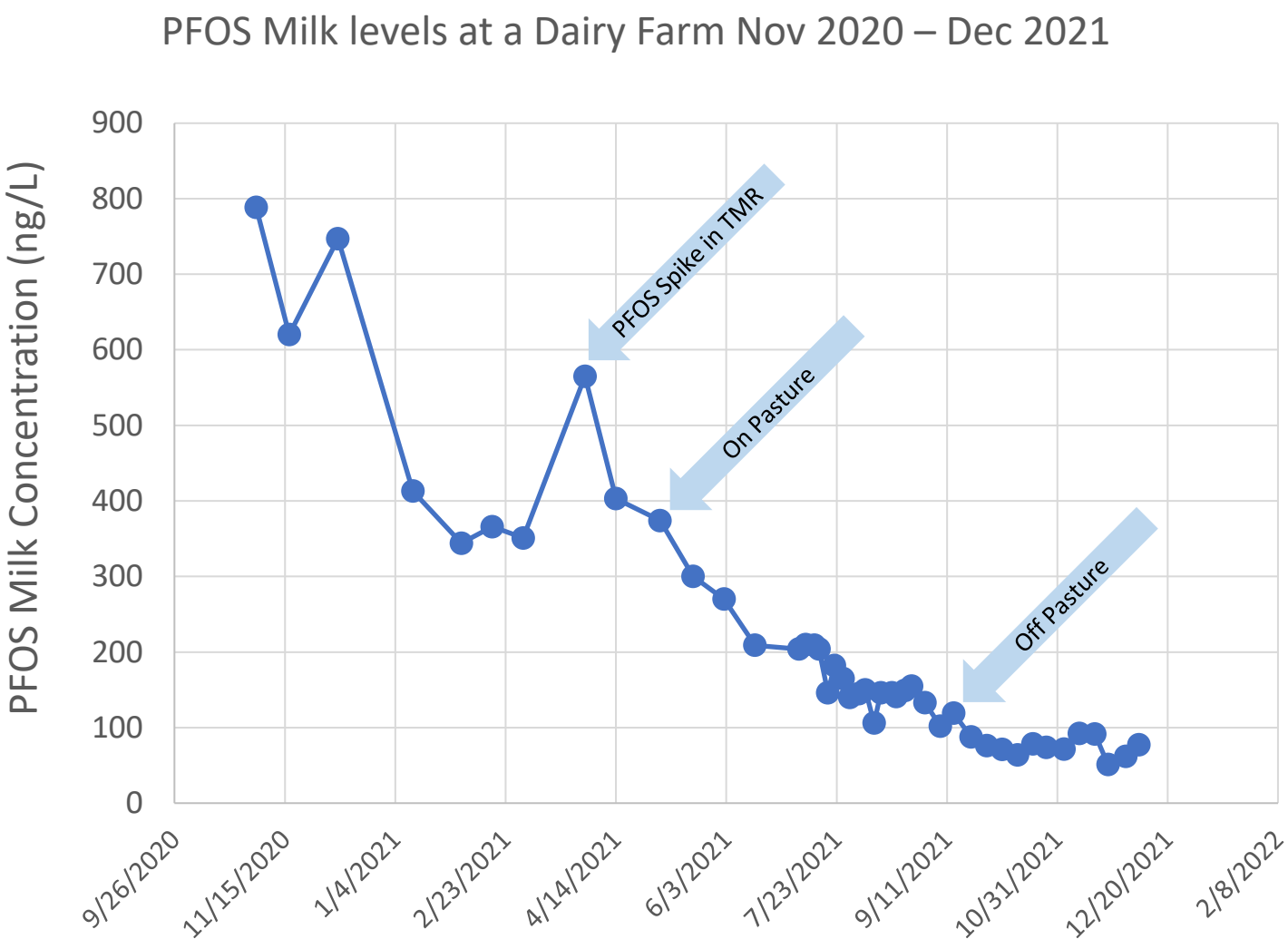
Source:
https://anrweb.vt.gov/PubDocs/DEC/PFOA/Soil-Background/PFAS-Background-Vermont-Shallow-Soils-03-24-19.pdf

How well does the model work?



- Initial milk PFOS level was 800 ppt
- Average PFOS level across all impacted fields is 87 ppb
- At the time of the initial milk sample only 30% of the herds feed was hay from impacted fields
- Model predicts about 940 ppt PFOS in milk

Model and Data Put to Use



Corn Plant Uptake Study

Questions?

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