Demonstrating the need for a more sustainable and risk-based approach for dealing with PFAS

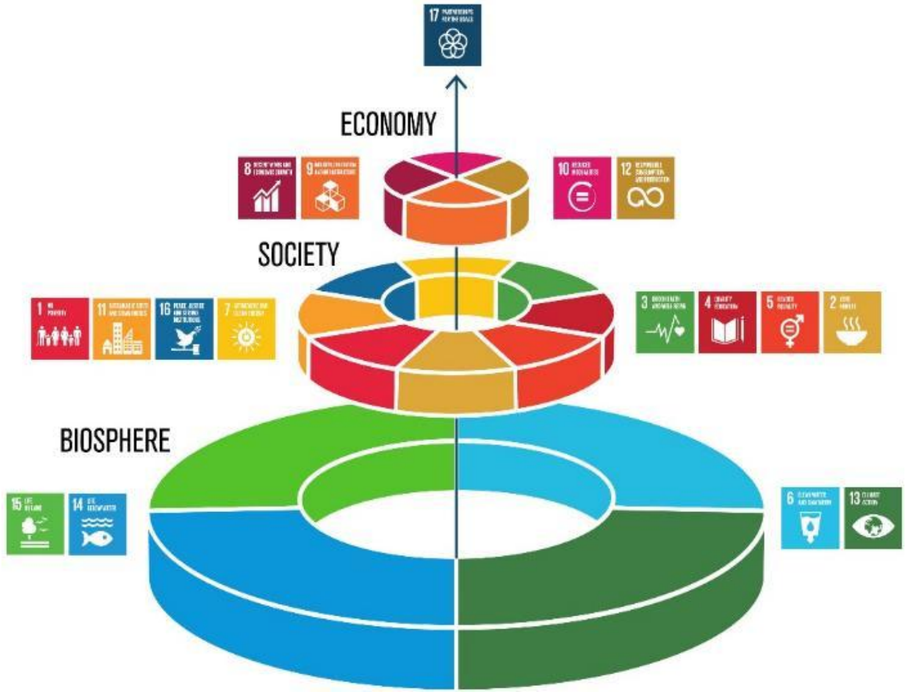
Hans Slenders, ENSOr, 13th October 2025

What is sustainable?

Sustainable: able to be maintained at a certain rate or level (*Oxford Languages)*

Sustainable development: meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. It has three pillars: economic, environmental and social. (Brundtland commission/EU-definition)

Sustainable Remediation: The practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process (SuRF-UK)



Weddingcake SDGs
Source: Stockholm resilience centre

“Beyond the planetary boundary”

Ian Cousins et al. ES&T 2022

PFAS is everywhere!

Environmental quality standards (EQS)
Proposal WFD / GWDD

Surface Water: AA-EQS = 4.4 ng $PFOA_{eq}$/l

Ground Water: AA-EQS = 4.4 ng EFSA4/l or 100 ng/l sum of 20 PFAS

Moreover, the proposal says:

*"If an EQS biota **or sediment** is given, it, rather than the water EQS, shall be applied……'*

Which leads to a value of **7 picogram** PFOS/l or 0,4 picogram PFDoA/l

How much is 1 picogram/liter?

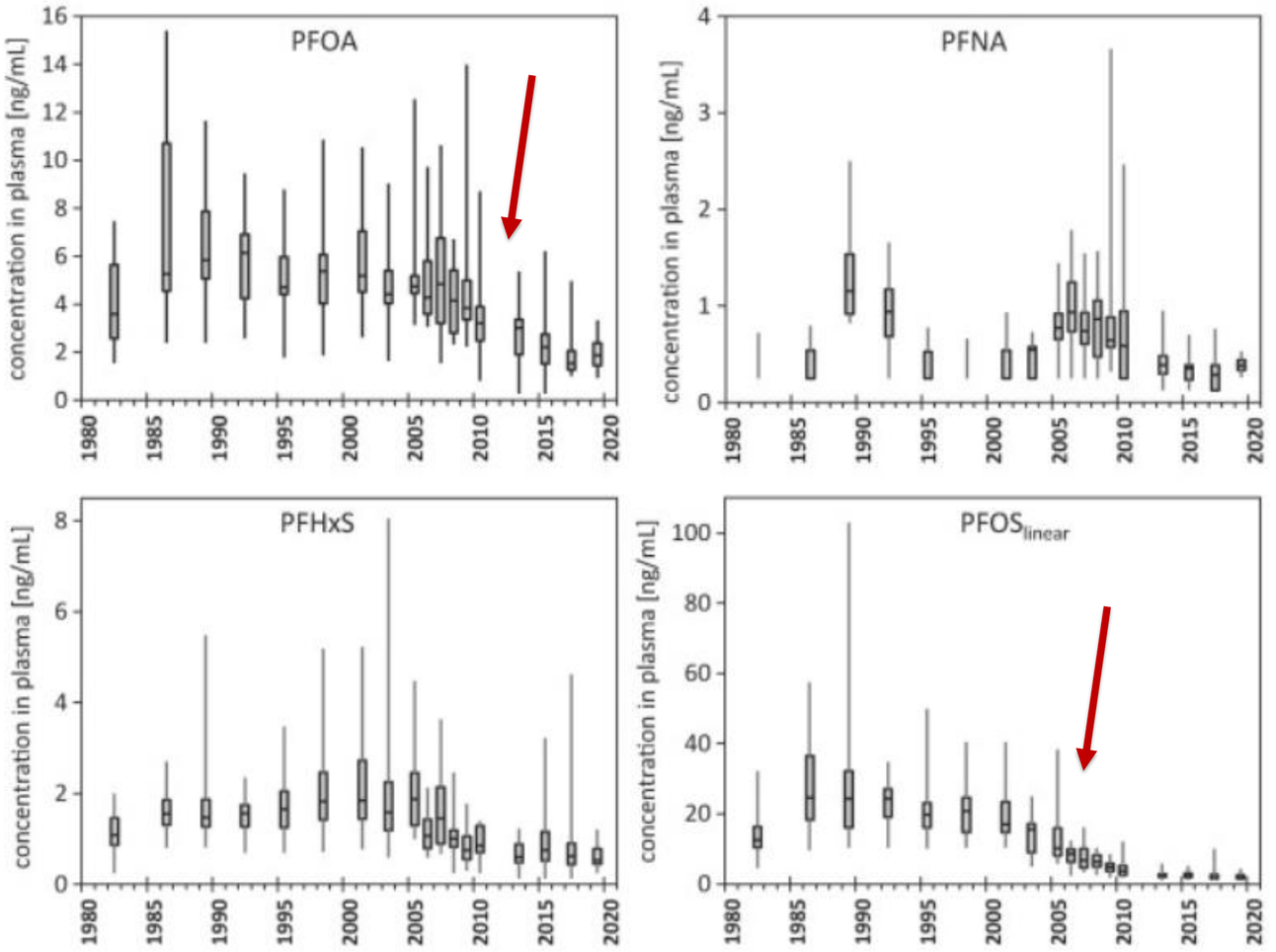
1 human hair out of all the human hair in the world

Q: But how many molecules is 1 picogram of PFOA?

1. 15
2. 7,500
3. 7,500,000
4. 1,500,000,000 

Knowing what the advisory level in drinking water is, what do you think is an average level of sum PFAS in blood?

1. 4 ng/l
2. 100 ng/l
3. 1,000 ng/l
4. 20,000 ng/l



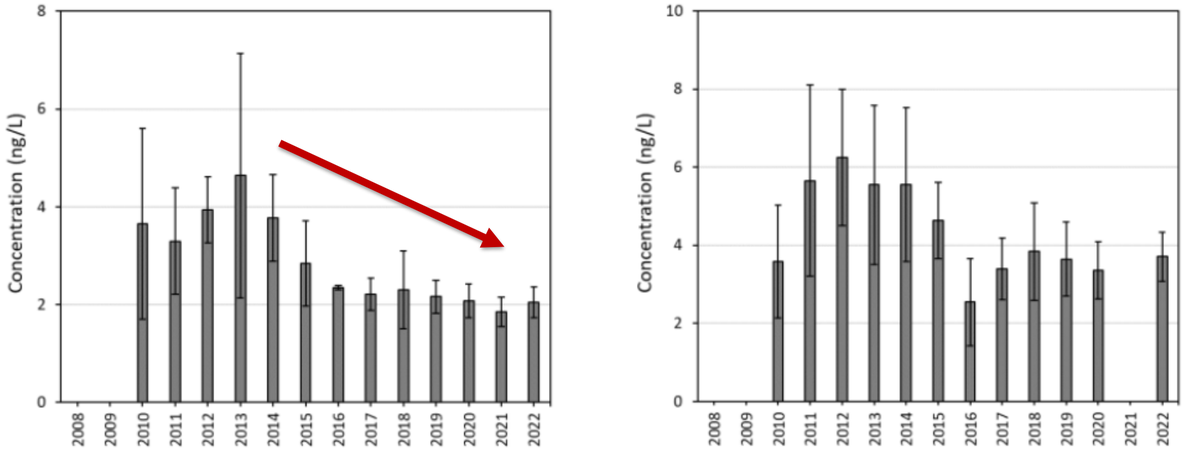
Germany (Göckener et al. 2020)

PFAS in Dutch waters

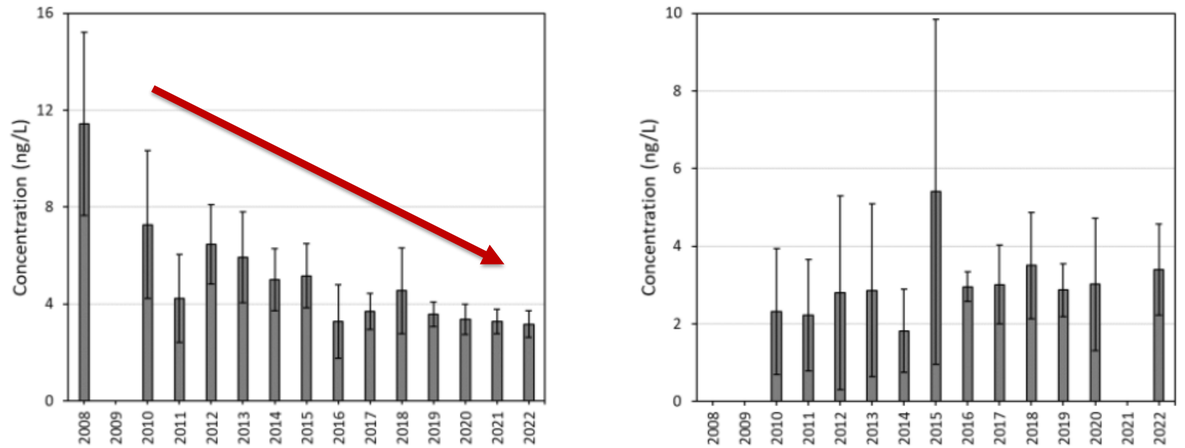
River Rhine

River Meuse

PFOA



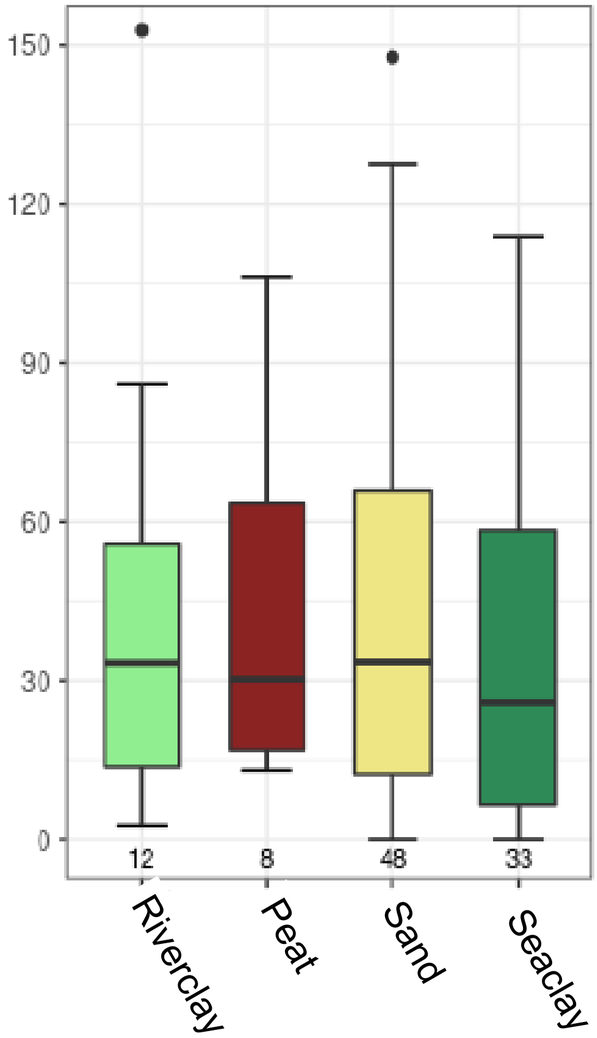
PFOS



Jonker MTO. 2024a. Per- and polyfluoroalkyl substances in water (2008-2022) and fish (2015-2022) in the Netherlands:

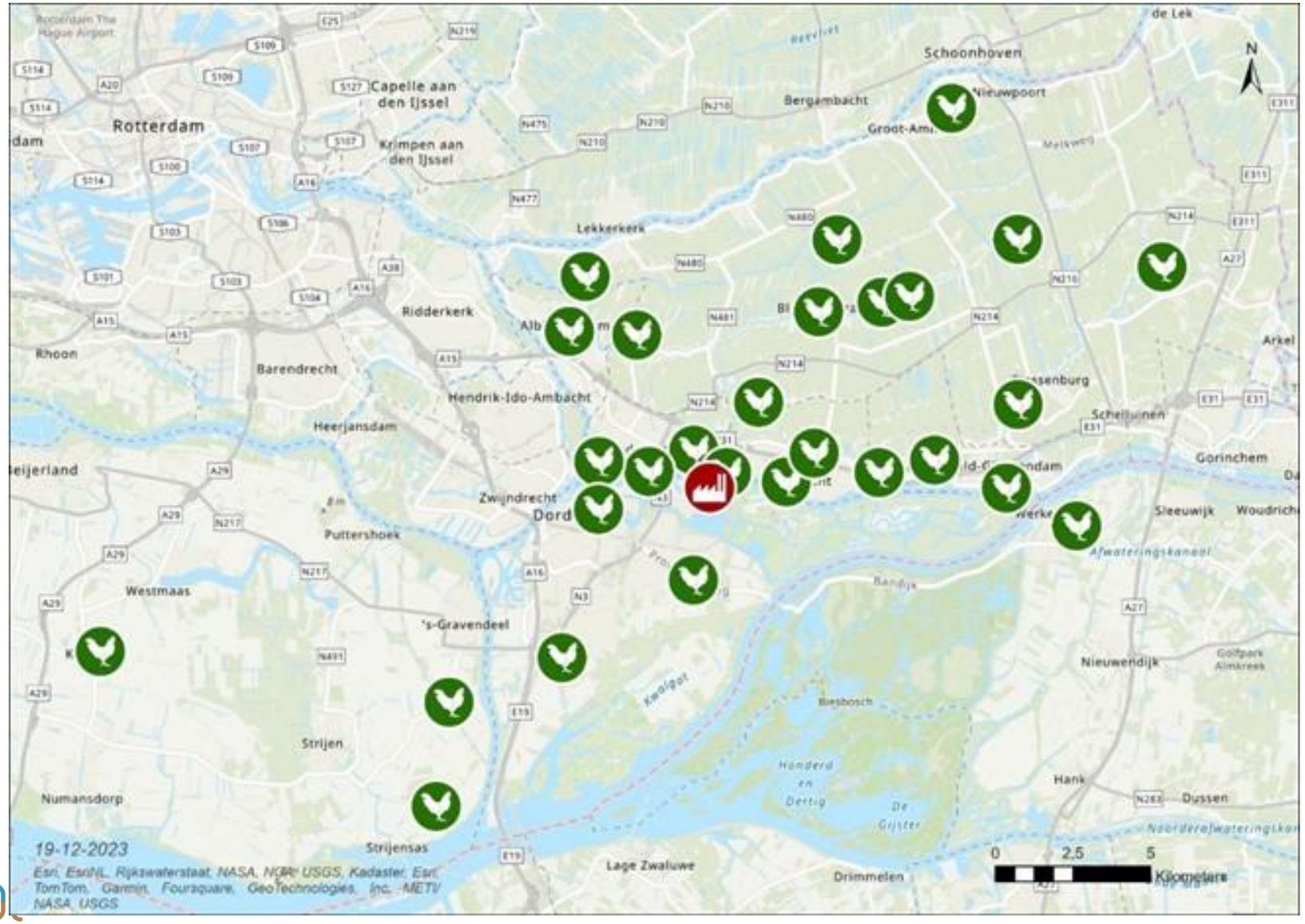
Phreatic groundwater

(sum PFAS ng/l)



RIVM 2021

PFAS in Eggs of hobby hens (Dordrecht area)



- Significantly elevated above risk levels
- Related to ambient/ background concentrations in soil (Mainly PFOS, not Chemours)
- A result of bioaccumulation in earth worms and in hens/eggs
- Similar results can be found nationwide, and most probably for (western) world
- Commercial eggs are not impacted!

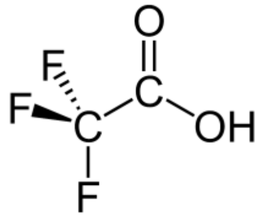
Ambient concentrations in $PFOA_{eq}$ in NL (estimates!)

- Soil background NL/BE ~5,000 – 8,000 ng/kg
- Ground water Phreatic ~20 - 40 ng/l
- Surface water Rhine/Meuse ~20 - 30 ng/l
- Rain ~4 - 6 ng/l
- Vegetables ~10 ng/kg
- Dust households and offices ~1.000.000 ng/kg
- Bloodserum EU ~20,000 ng/l
- Consumergoods ~100,000 ng/l

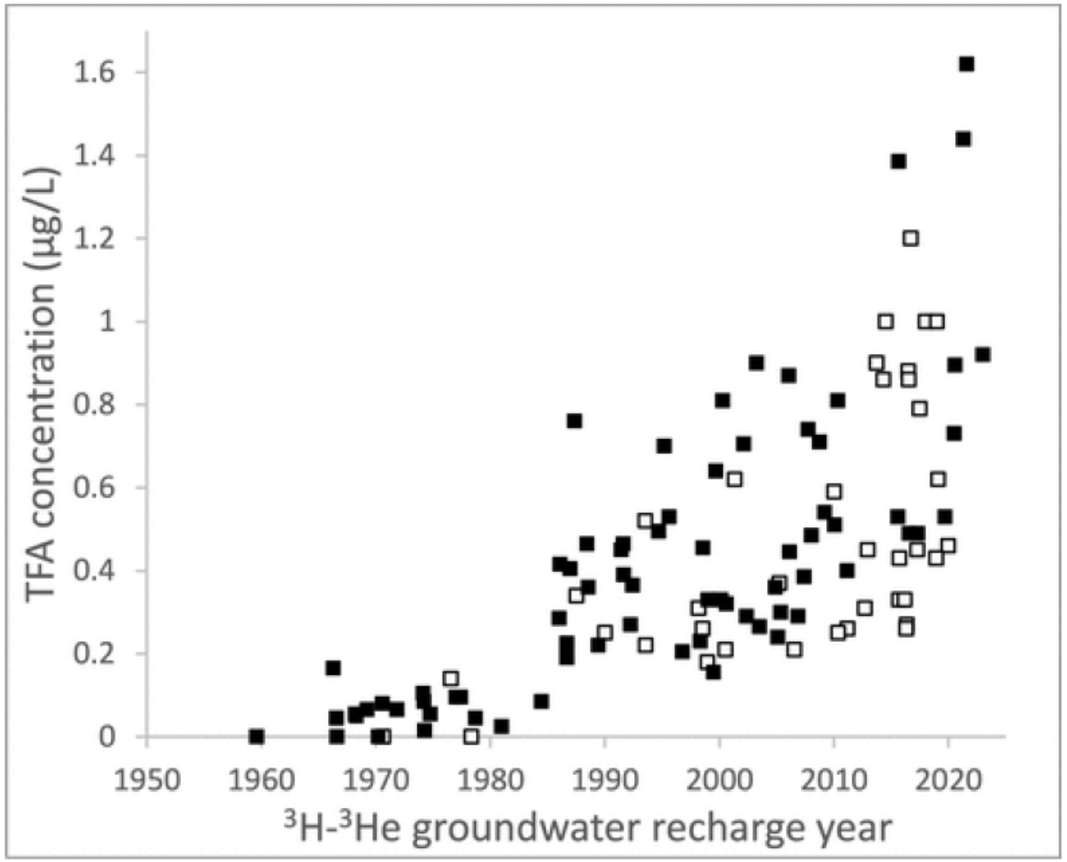
RIVM 2020, 2022, Jonker et al 2024, Arcadis 2023, 2021, Göckener et al 2020, Arcadis 2023

Put this into perspective with the proposal of 4.4 ng/l for EQSs, and it is obvious that there is a strong discrepancy between ambient (background) levels and the EQS.

And then there is TFA, the emerging ultrashort menace



TFA in Danish groundwater



A 60-Year Increase in the Ultrashort-Chain PFAS Trifluoroacetate and Its Suitability as a Tracer for Groundwater Age

Albers and Sültenfuss, Environmental Science & Technology Letters 2024

- TFA is rapidly increasing in ice cores, tree leaves, groundwater ánd wine!
- Sources are mainly refrigerants/blowing agents (CFC, HFCs, HFOs) and pesticides/herbicides
- Also in Dutch Groundwaters 1-2 µg/l is commonly found
- 1 µg/l TFA corresponds to 2 ng/l $PFOA_{eq}$
- TFA alone is responsible for filling a major part of the AA-EQS threshold
- AND TFA IS EXPECTED TO INCREASE FURTHER

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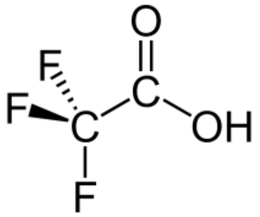

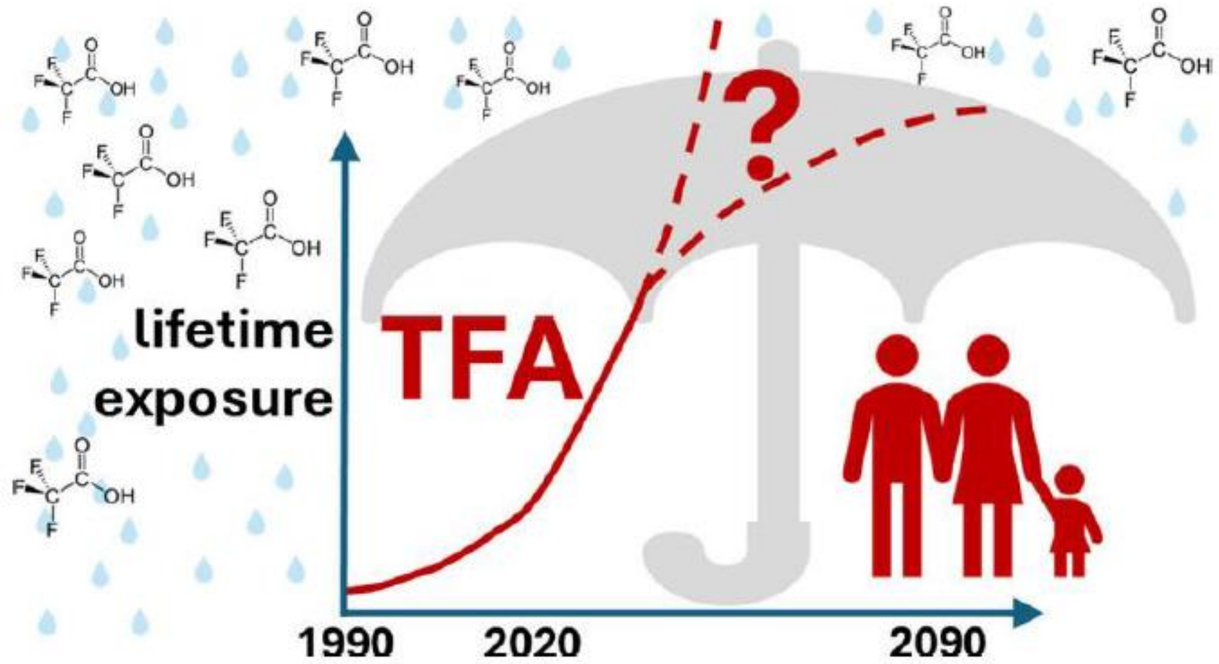

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Health effects

Paracelsus (1493-1541)

- Swiss doctor, philosopher, theologist and alchemist
- Founder of dose-effect relationship
- Predecessor of modern toxicology
- Not without criticism

“Every substance on earth is poisonous, it is the dose that determines the effects”

Some effects of PFAS, >>> papers

- Reduced vaccine response (EFSA 2020, Abraham et al. 2019)
- Liver toxicity (RPF, Zeilmaker et al, 2016)
- Relationship between PFAS and cholesterol (Erikson, 2013)
- Relationship between PFAS and Covid-19 (Grandjean, 2020)
- PFOA and PFOS are (possibly) carcinogenic (IARC 2023, class 1 en 2b)

Tolerable daily intakes

Source	PFOS (ng/kg bw/day)	PFOA (ng/kg bw/day)
EFSA, 2008	150	1500
EPA, 2009	80	190
Denmark, 2015	30	100
EPA, 2016 (RfD)	20	20
RIVM, 2016	-	12.5
Australia, 2017	20	160
ATSDR 2018 (proposed RfD)	2	3
RIVM, 2019 (tox. max. allowed risk level)	(6.25)	12.5
EFSA 2020	0.63	

Animal studies

Epidemiology

PFAS is one of only a few contaminants for which TDIs are based on Epidemiological studies. By far the majority of TDIs is based upon animal studies.

Uncertainty

The EFSA opinion is the basis of EQS framework
But how robust is this basis?

PFAS are PBT.

Dose-effect quantification is weak (WHO, CoT, IARA, RIVM).

Based upon Abraham 2019/2020, *(reduced number of antibodies in one-year old after vaccination (flue, diphtheria, tetanus).*

Q: Which of these statements is true?

1. No real health effects were observed for the diseases for which was vaccinated

2. Abraham only found a relationship for PFOA not for PFOS, PFHxS of PFNA

3. The advisory value in fact is only true for women (breast feeding)

4. The data set used was of blood samples from the nineties with significantly higher blood levels

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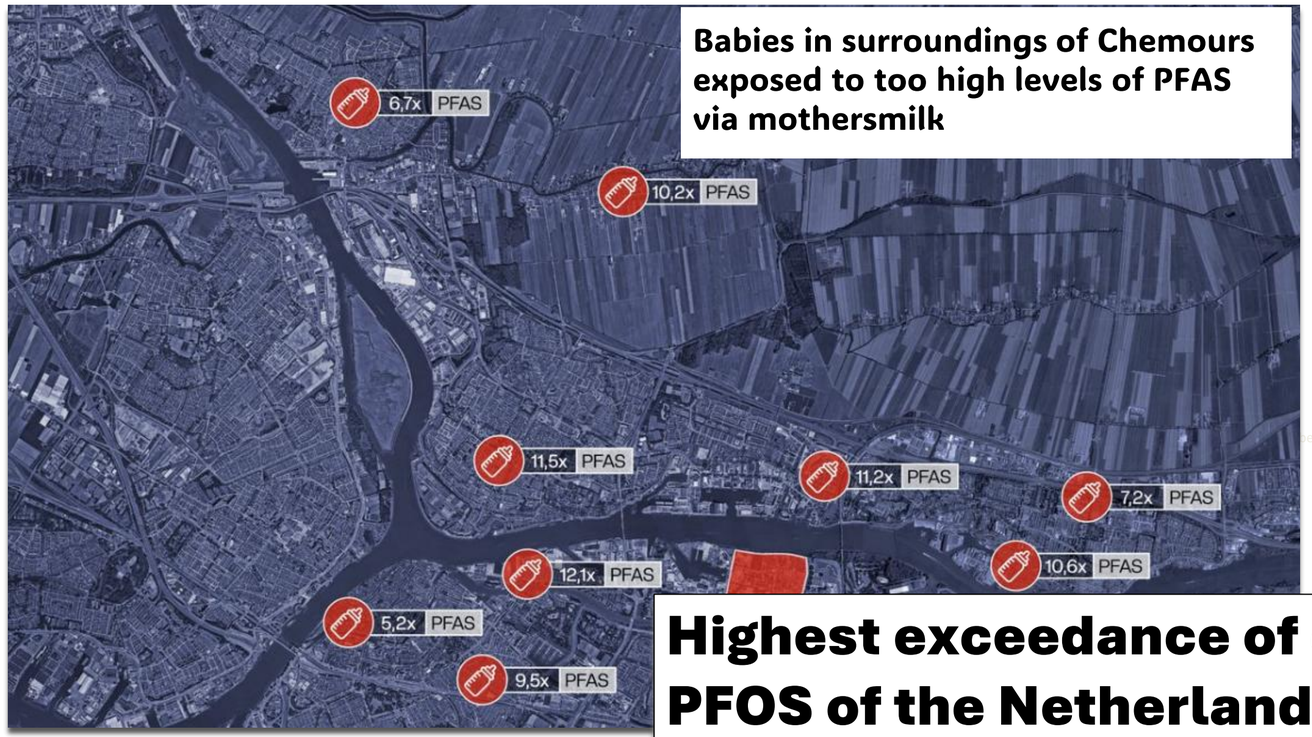
ALL TRUE

PFAS are a very diverse group, the uncertainty in the relative toxicity of PFAS (RPF)

- Based upon animal studies, whereas the TWI is based upon epidemiological work
- In vitro work seems to indicate other relative toxicity factors (E.Corsini et al. EFSA publication 2024.EN-8926)
- PFAS are an extremely complex group of substances of which the relative potency in different situations may be different…..

And we are made uncertain.....



Babies in surroundings of Chemours exposed to too high levels of PFAS via mothersmilk

First Report of the Independent PFAS Scientific Advisory Panel for Jersey – The potential for an interim therapeutic phlebotomy service (DRAFT).

October 2023

(Phlebotomy; Bloodletting)

NOS Nieuws • Dinsdag 15 april, 12:00 • Aangepast dinsdag 15 april, 14:14

RIVM: Don't eat homegrown eggs, PFAS may damage your health

Sarah Bürmann

en uit eigen tuin, moestuinen, dierenweitjes en
t schrijft het RIVM in een advies. Eieren van
unnen vervuild zijn met PFAS. Als je daar te veel
ijk voor de gezondheid.

Highest exceedance of carcinogenic PFOS of the Netherlands found in ditch in Housing Area The Hague

Concentrations of a carcinogenic substance in water are 25.000 times above the safe screening value, as was found in research by Pointer (KRO-NCRV)

The precautionary principle

- Take extra certainty in case of uncertain dose-effect relationships
- And the RPFs are the best we have

But

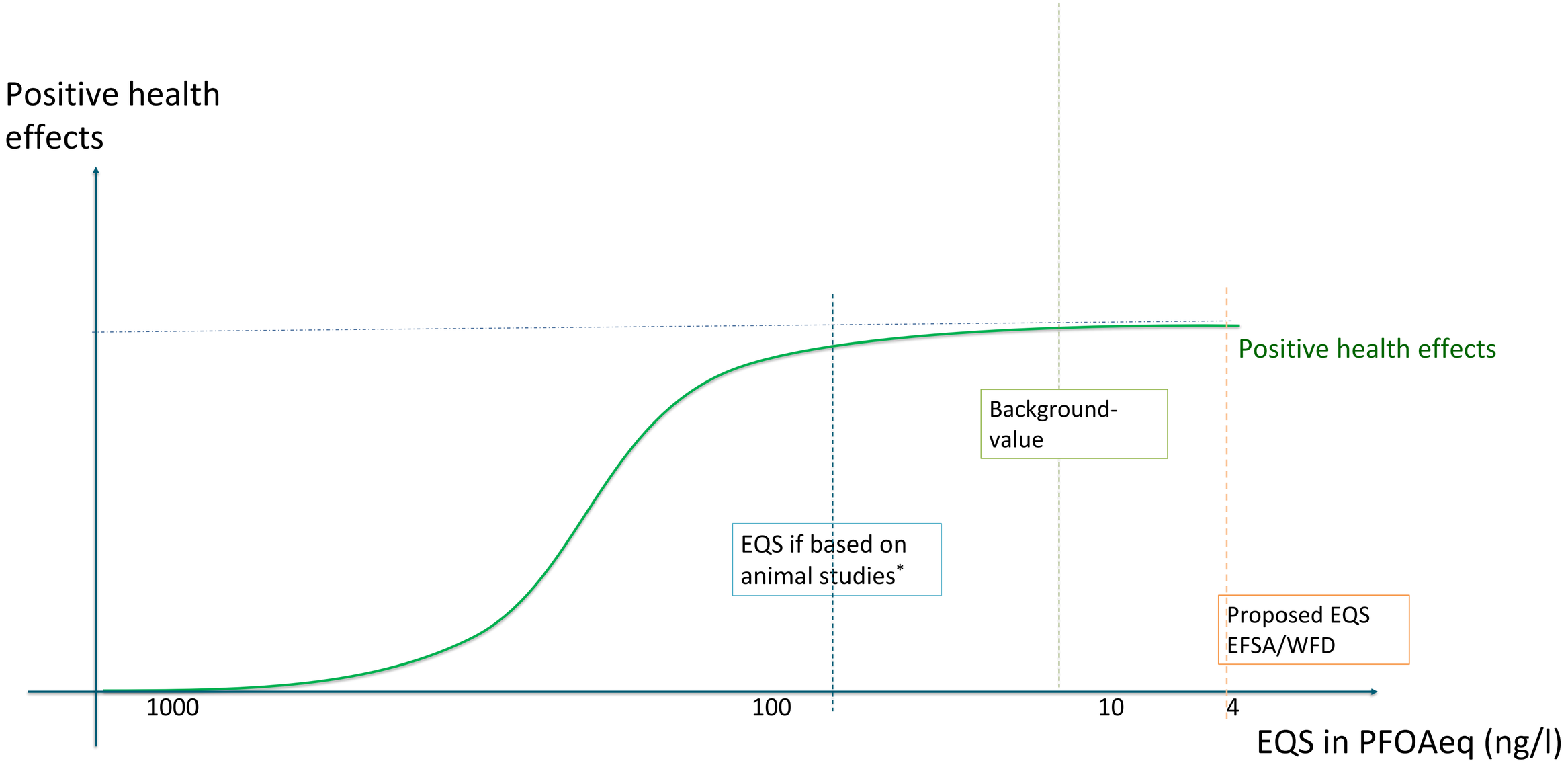
- Shouldn’t we also take a precautionary approach with the known impacts (cost of treatment, energy, non renewables, waste etc.)?

Or,

- Isn’t there always a balance between health benefits and wider impacts; proportionality?
- In the EU food directive proportionality is used!

Proportionality, Benefits and Impacts

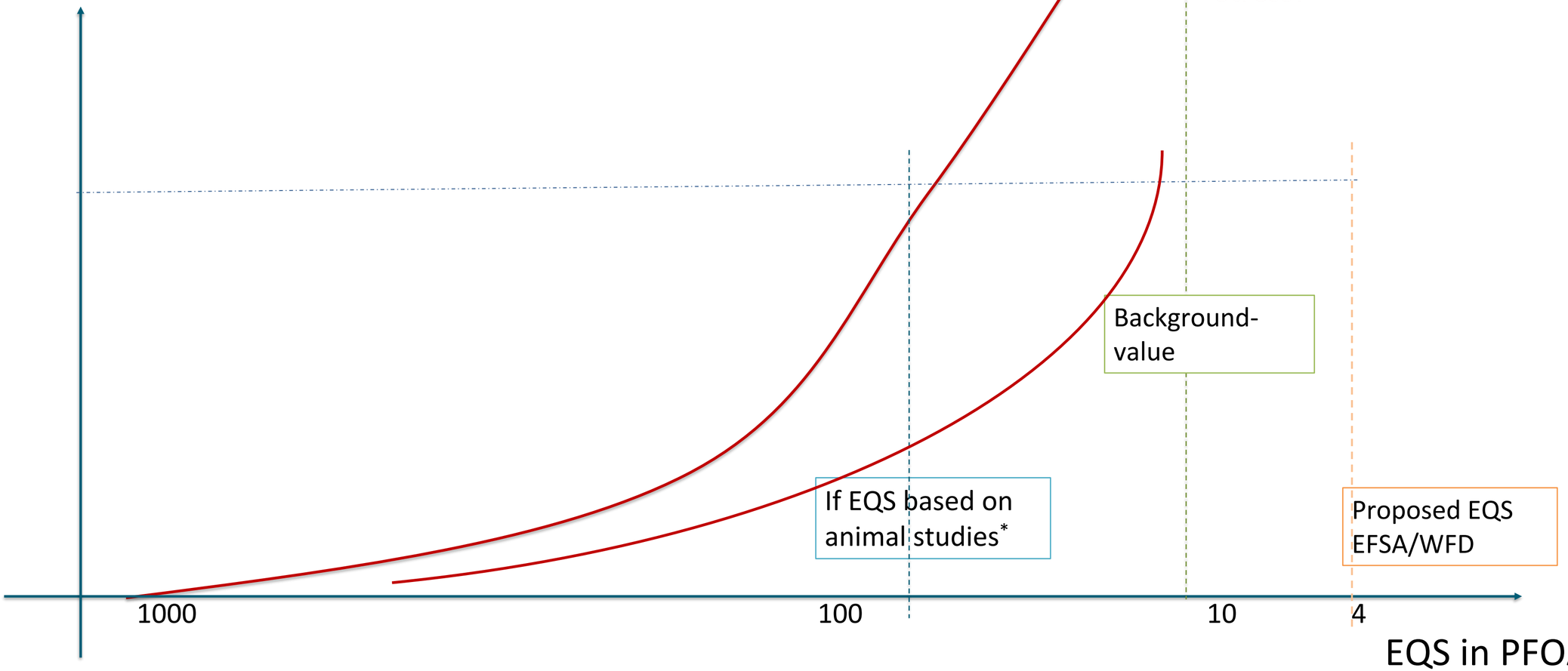
How does the selection of a EQS relate to potential health effects



*RIVM 2016, Burgoon 2022

Negative impacts EQS as strict remediation requirement

Negative impacts??:
- Cost
- Emissions/exposure
- Stagnation
- Energy consumption
- Waste
- Accidental risks
- Stress!



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Balancing benefits and impacts

Negative impacts??:
- Cost
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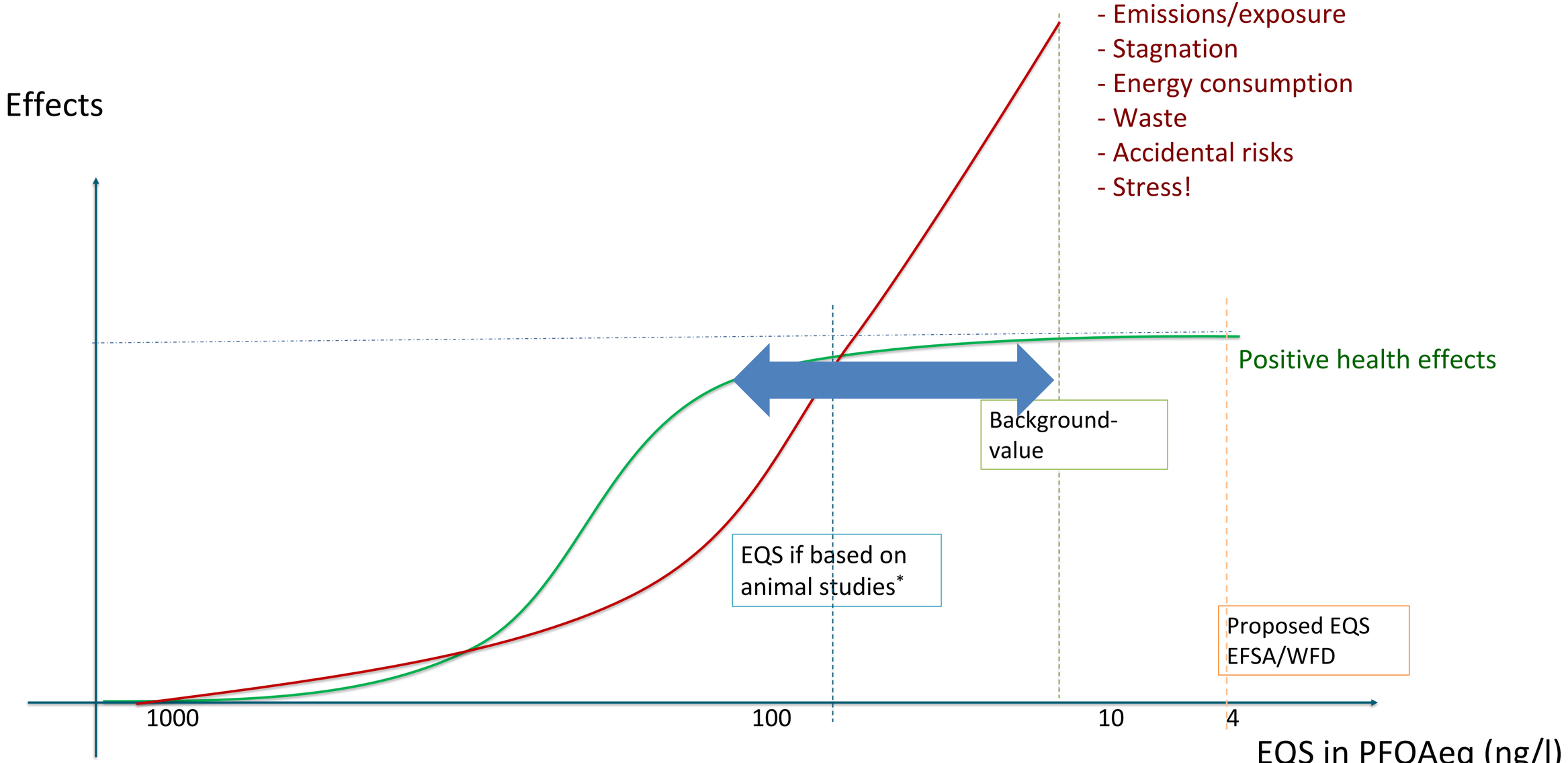

*RIVM 2016, Burgoon 2022

Concluding

- 0?
- Ambient versus EQS?
- Restriction!
- Hot-spots?
- Sustainable?
- TFA?

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RIVM
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