



British
Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Gateway to the Earth

Developing a voluntary European groundwater watch list for substances of emerging concern

Moving on from 'stamp collecting' towards targeted monitoring

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Outline

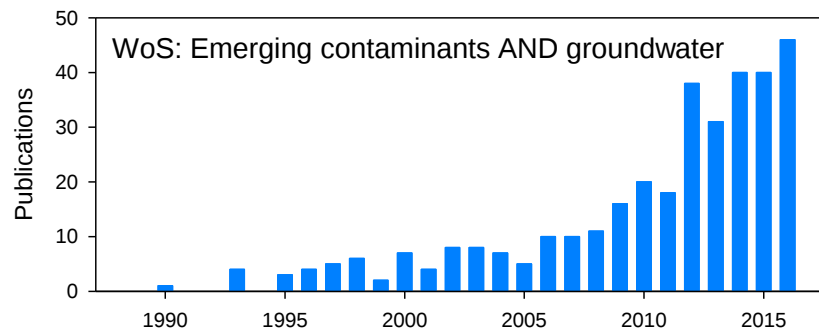
- Introduction: substance of emerging concern in groundwater
- Motivation for developing a voluntary GWWL
- Current methodology
- Some case studies – existing evidence
- Initial results from GWWL and future outlook

Lapworth, D.J., Lopez, B., Laabs, V., Kozel, R., Wolter, R., Ward, R., Vargas-Amelin, E., Besien, T., Claessens, J., Delloye, F. and Ferretti, E., 2019. Developing a groundwater watch list for substances of emerging concern: a European perspective. *Environmental Research Letters*. **14** 035004. <https://iopscience.iop.org/article/10.1088/1748-9326/aaf4d7/pdf>

Gaston, L., Lapworth, D.J., Stuart, M., Arnscheidt, J., 2019. Prioritisation approaches for substances of emerging concern in groundwater: a critical review. *Environ. Sci. & Tech.* 53 (11) 6107-6122

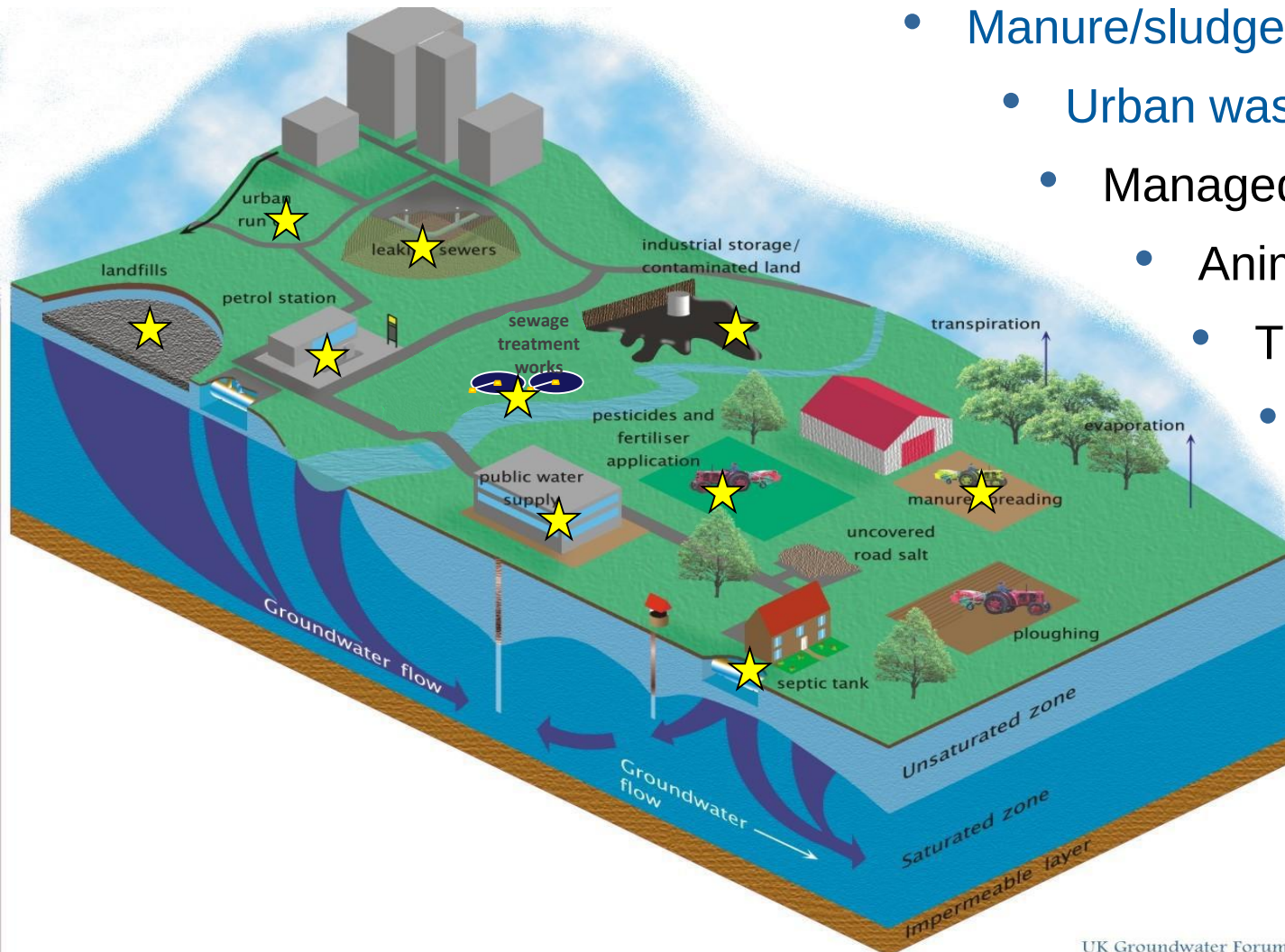
Substance of emerging concern in groundwater

- Anthropogenic organic compounds and their transformation products
- Emerge as result of:
 - Changes in use/new manufactured chemicals
 - Advances in analytical techniques
 - Better monitoring
- ECs in groundwater less well characterised than surface water, mainly due to lower concentrations and perception of lower risk for groundwater
- Most do not have quality standards for either surface or groundwater under the Drinking Water Directive or the WFD (Priority Substances Directive)

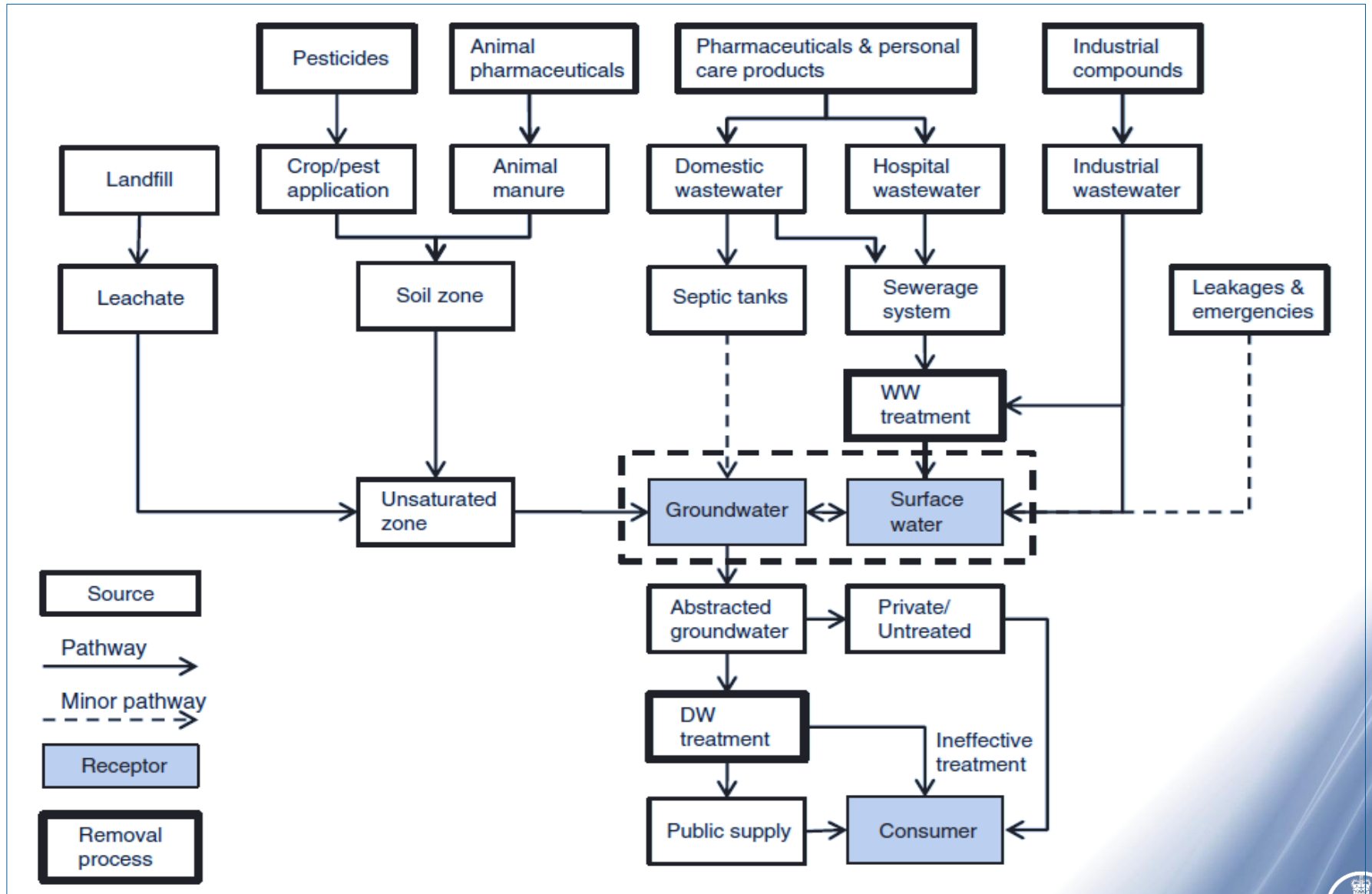


Sources of emerging contaminants (ECs) in groundwater

- Treated wastewater discharge to surface water
 - Manure/sludge application to soil
 - Urban waste water drainage
 - Managed aquifer recharge
 - Animal waste lagoons
 - Transport networks
 - Water treatment
 - Septic tanks
 - Landfill



Key pathways to groundwater



Some examples of emerging(ed) organic contaminants

- Pesticides – parent compounds (e.g. metaldehyde),
metabolites
- Pharmaceuticals – human, veterinary, illicit substances...
- “Life style” – nicotine, caffeine, artificial sweeteners
- Personal care – DEET, parabens, triclosan, musks, UV filters
- Industrial additives and by-products – dioxanes, bisphenols,
MTBE, phthalates, N-butyl benzene sulfonamide (BBSA)
- Food additives – BHA, BHT
- Water and wastewater treatment by-products – NDMA, THM
- Flame/fire retardants – PBDE, alkyl phosphates, triazoles
- Surfactants – alkyl ethoxylates, PFOS & PFOA
- Hormones and sterols – estradiol, cholesterol

Transformation products

- May be more toxic, polar or persistent than the parent
- TP concs >parent have been seen for*:
 - Cotinine from nicotine
 - Clofibric acid from clofibrate
 - Nonyl phenol from NPE
 - Desethyl, desisopropyl - atrazine
 - BAM from diclobenil
 - AMPA from glyphosate
- Cannot be reliably predicted from surface environments data due to different geochemical conditions and long residence times
- May have long arrival time due to thick unsaturated zone or low aquifer permeability

*Stuart & Lapworth (2014) Transformation products of emerging organic compounds as future groundwater and drinking water contaminants. In: Transformation products of emerging contaminants in the environment: analysis, processes, occurrence, effects and risks. Wiley

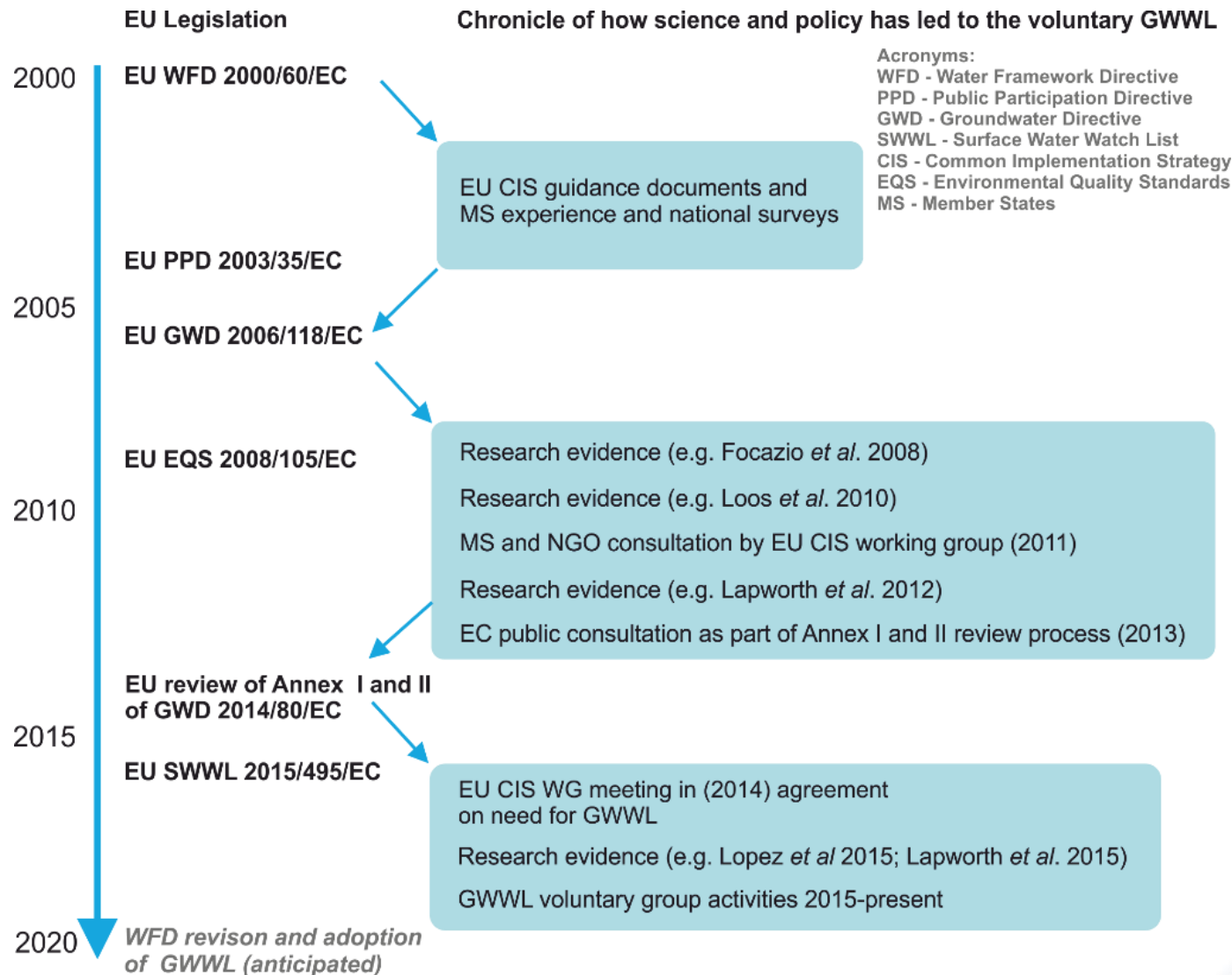
Past example: metaldehyde

- 2007 Bristol Water detected it in finished drinking water
- Reasons for metaldehyde problem – resistance to DW treatment and difficulties of detection. Low affinity for organic carbon.
- Only emerged as a problem due to developments in analytical methods ^[4]
- Accounted for a significant proportion of failures in drinking water standards in UK (2009) onwards
- Guardian 2013: ‘Slug poison found in one in eight of England’s drinking water sources’



[4] Hall (2010)

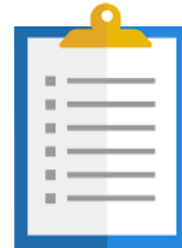
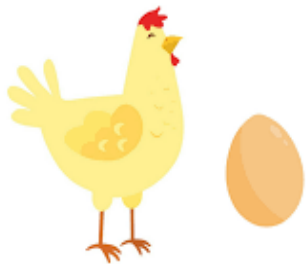
Prelude: working towards to the GWWL



Lapworth et al., 2019. *ERL*

Context & motivation for a GWWL

- Enough evidence from some compounds (e.g. some PFAS)
- But.. limited evidence available for a large number of compounds
- Difficult to form policy for potentially new substances of concern
- No strong regulatory driver to monitor for new ECs
- High cost of monitoring and the need to prioritise effort
- Few groundwater specific prioritisation studies for ECs [5]
- Limited sharing of information on ECs between states and/or agencies



[5] Gaston et al 2019, ES&T

Principles behind the GWWL

GWWL – dynamic list of c. 10 organic compounds

Striking a pragmatic balance between:

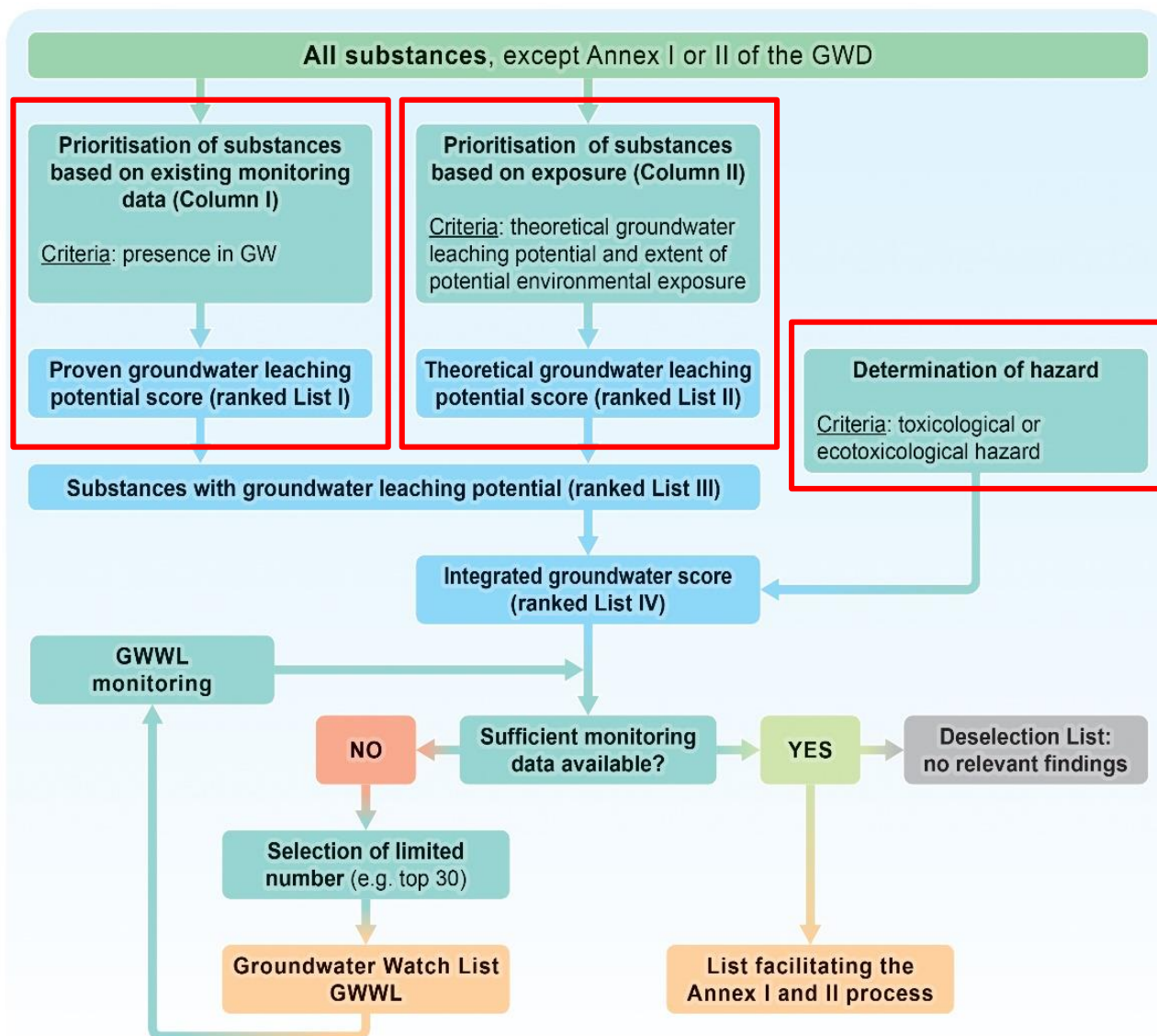
- Safeguarding drinking water supply for future generations & costs associated with monitoring for ECs

Prioritise based on:

- *Existing monitoring data*
- *Environmental exposure, mobility data*
- *Toxicity and relative risks posed to groundwater*
- Multi stakeholder input to develop methodology
- Voluntary initiative between European countries/agencies
- Regular meetings of the GWWL working group to develop a GWWL methodology

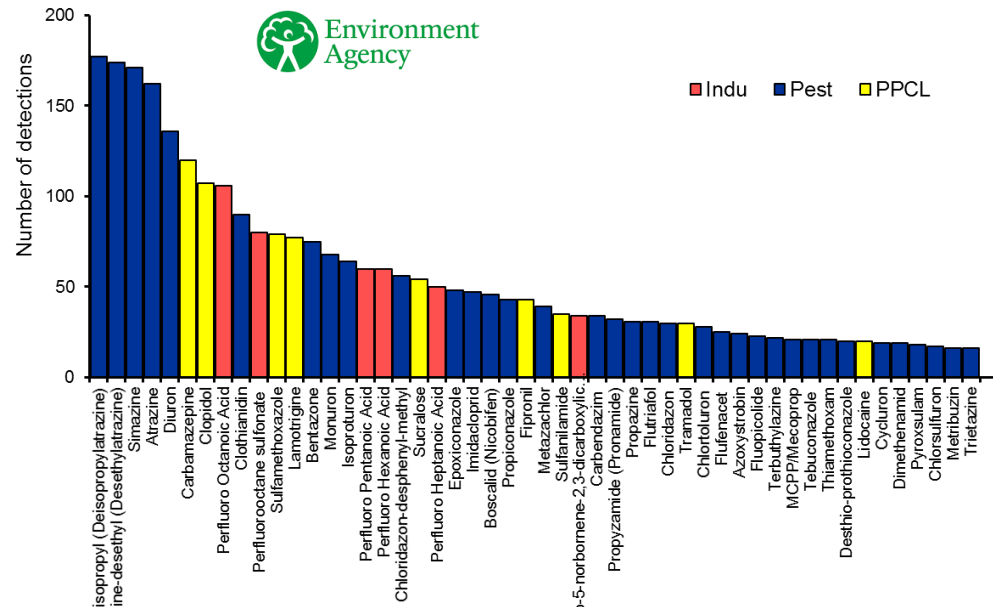
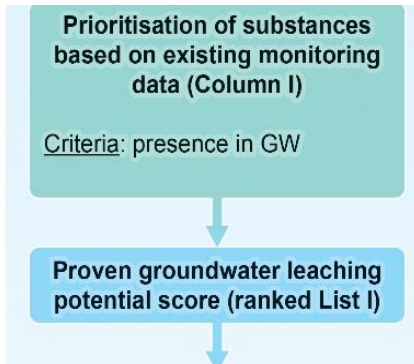


Overview of prioritisation methodology – Data input



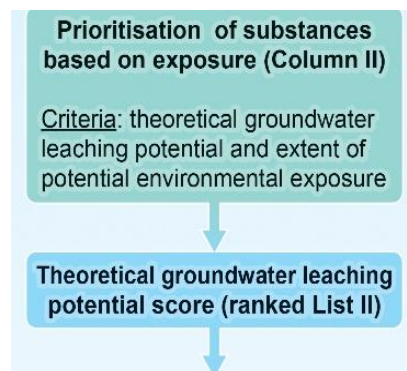
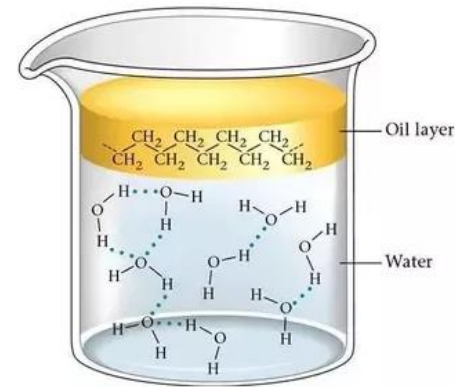
Prioritisation based on occurrence data

- Aggregate all available groundwater data for ECs
- Ranked list of substances based on frequency of detections and number of countries (*i.e. not a local issue*)
- Pilot studies for pharmaceuticals and PFAS helped develop a reporting protocols for this step
- Generates a ranked list of substances based on occurrence



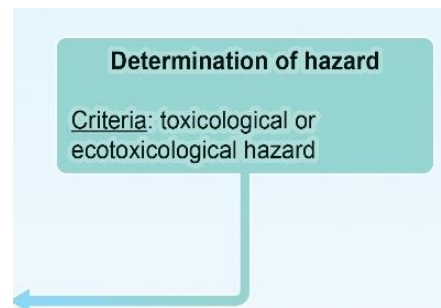
Prioritisation based on persistence and mobility

- Assess leaching potential to groundwater and mobility in groundwater
- Combination of measured and theoretical physio-chemical properties
- Persistence – half life in soil or water
- Mobility – potential to move conservatively in water (K_{ow} , K_{oc} ionic form etc)
- Scores combined to give a ranked list of substances based on persistence and mobility

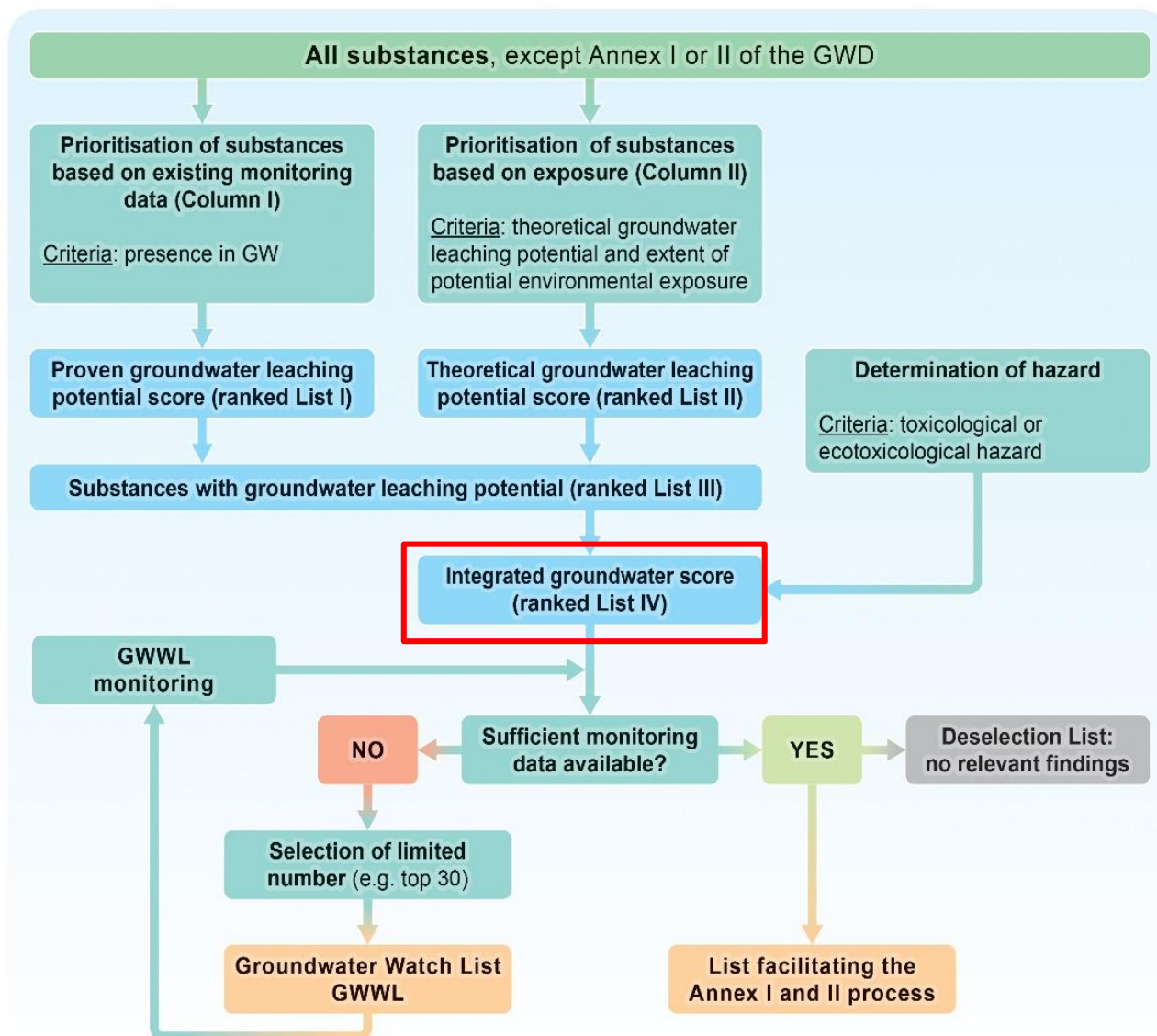


Prioritisation based on hazard - toxicity

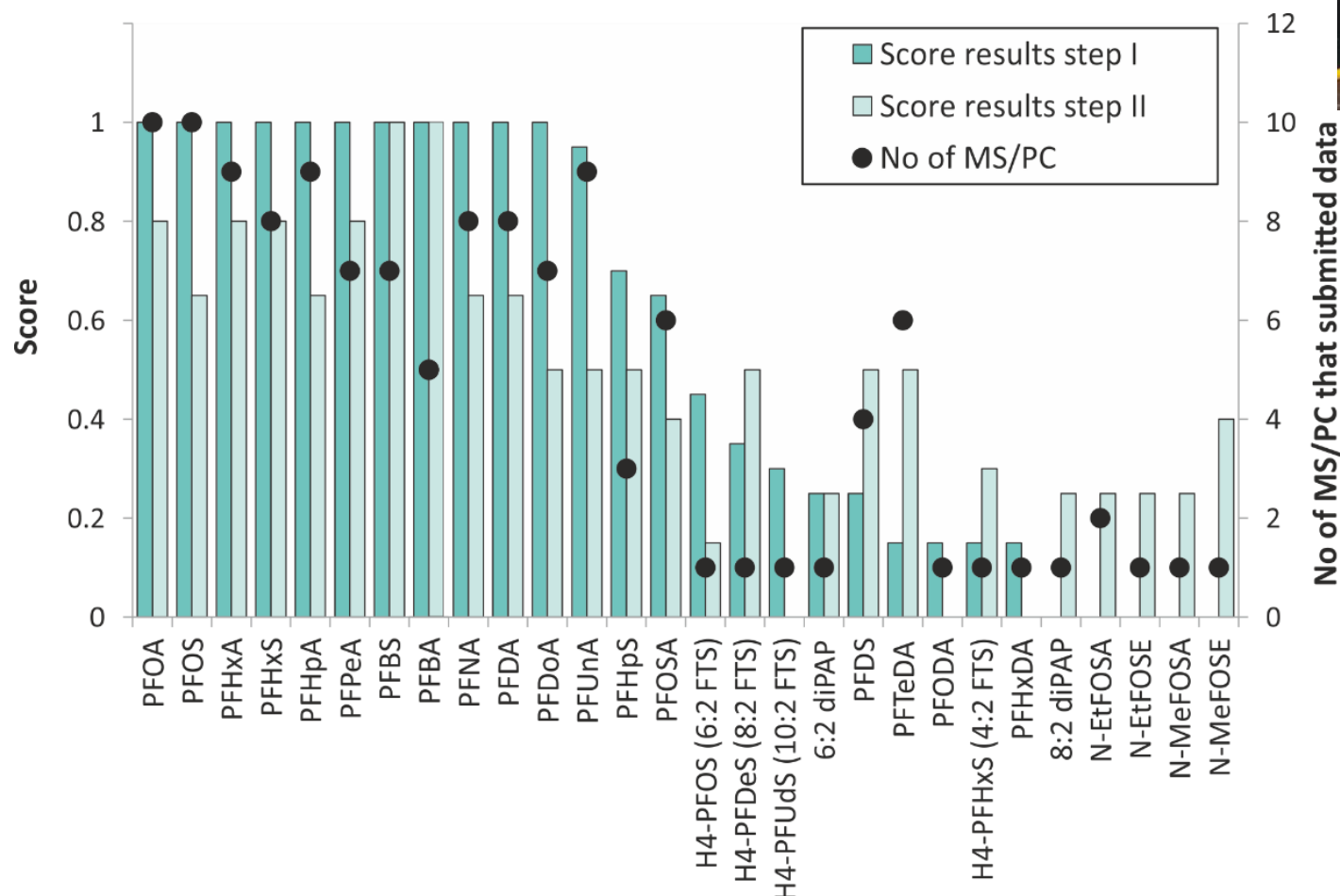
- Hazard score based on persistent, bioaccumulative, and toxic (PBT), vPvB (very persistent and very bioaccumulative), carcinogenicity-mutagenicity-reprotoxicity (CMR) or endocrine disrupting (ED) potential
- High uncertainty in this step due to paucity of data for some substances
- Combined hazard score produces a ranked list based on potential bioaccumulation and toxicity hazards



Overview of prioritisation methodology



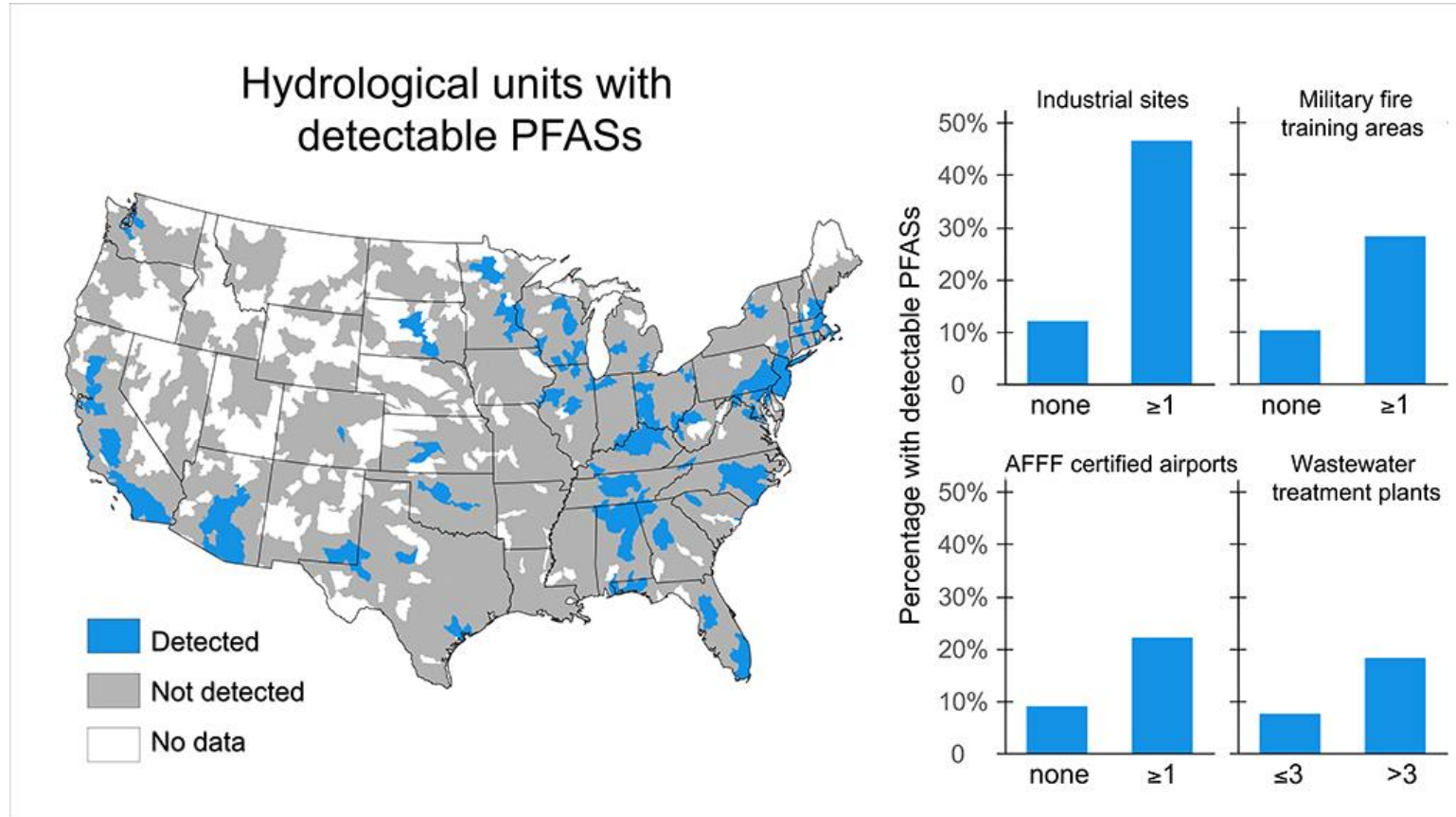
I) Perfluoralkyl substances (PFAS) in Europe



Good agreement between step I and II for top ranked substances and overall relationship between score and participant numbers – also, good evidence that voluntary participation can deliver meaningful results

Lapworth et al., 2018. *ERL*

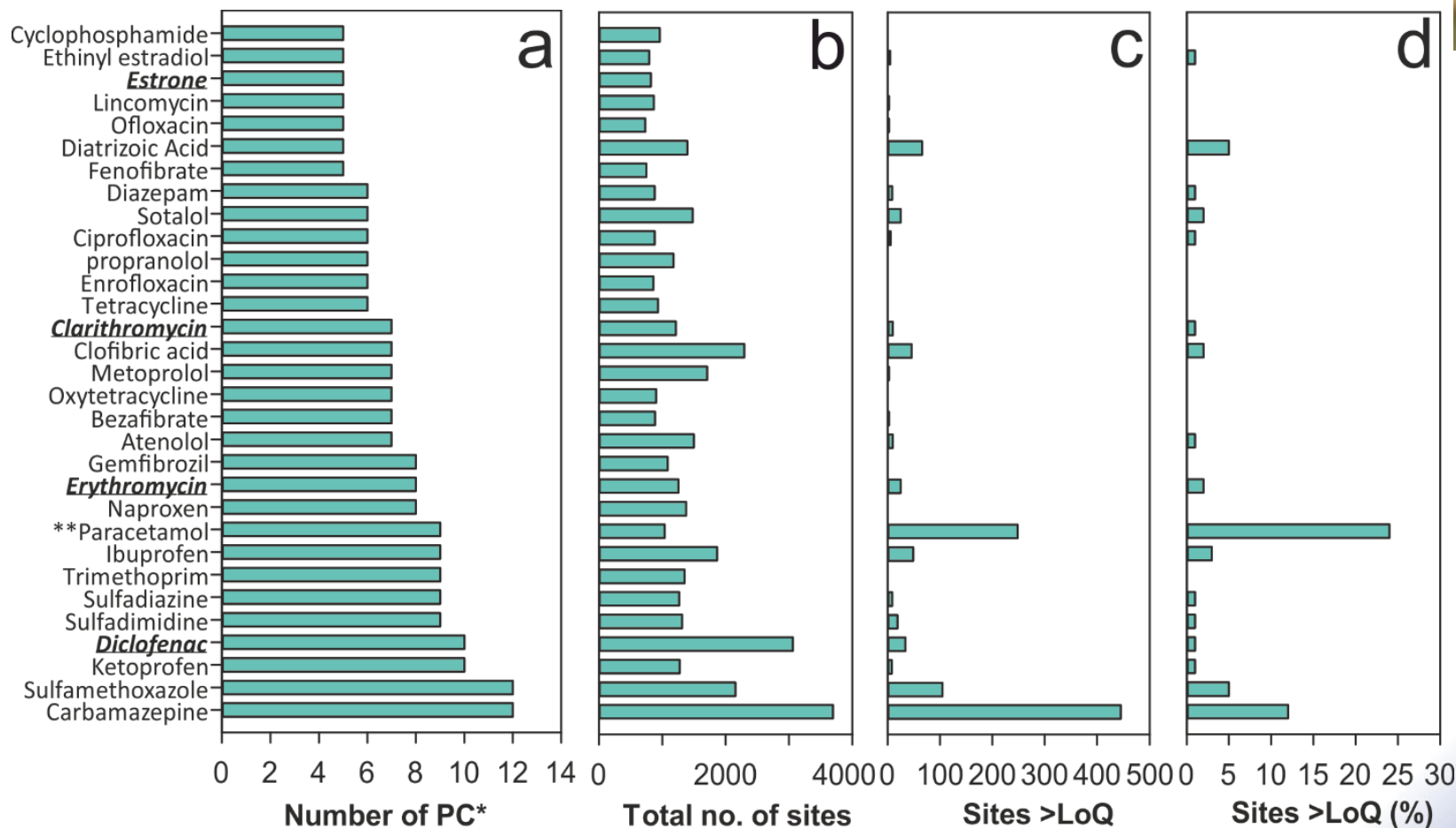
August 2016: Unsafe levels of PFAS detected in drinking water for 6 million Americans



Hu et al 2016, *ES&T Letters*

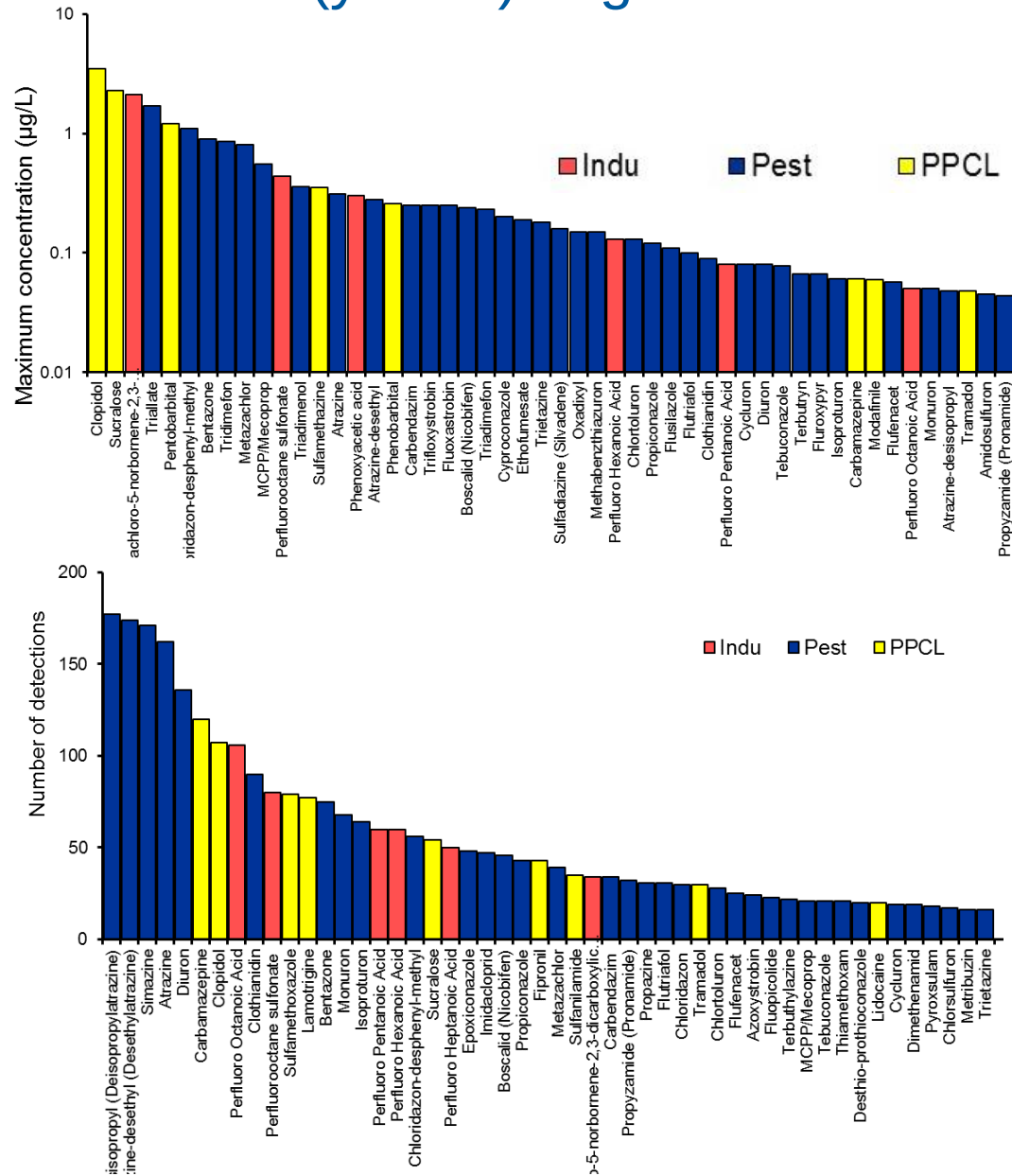
II) Pharmaceuticals in European groundwater

Results from top 30 substances ranked by number of participating countries



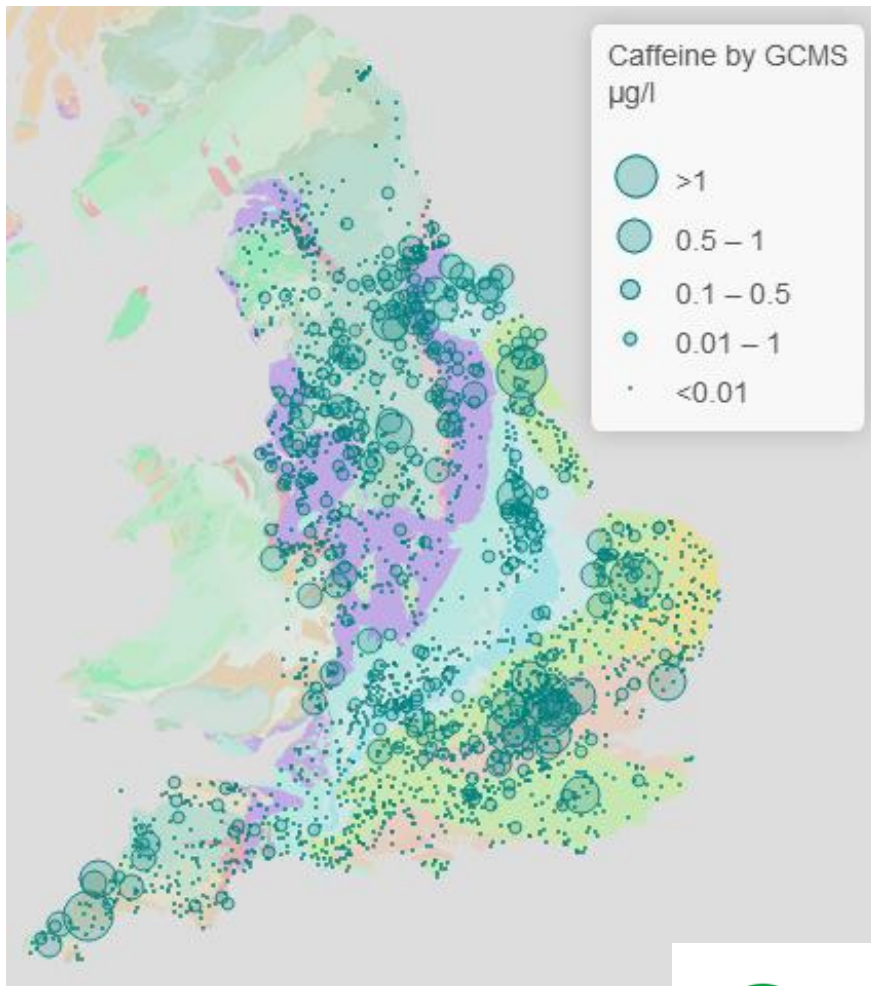
Lapworth et al., 2018. *ERL*

Pharmaceuticals (yellow) in groundwater in England

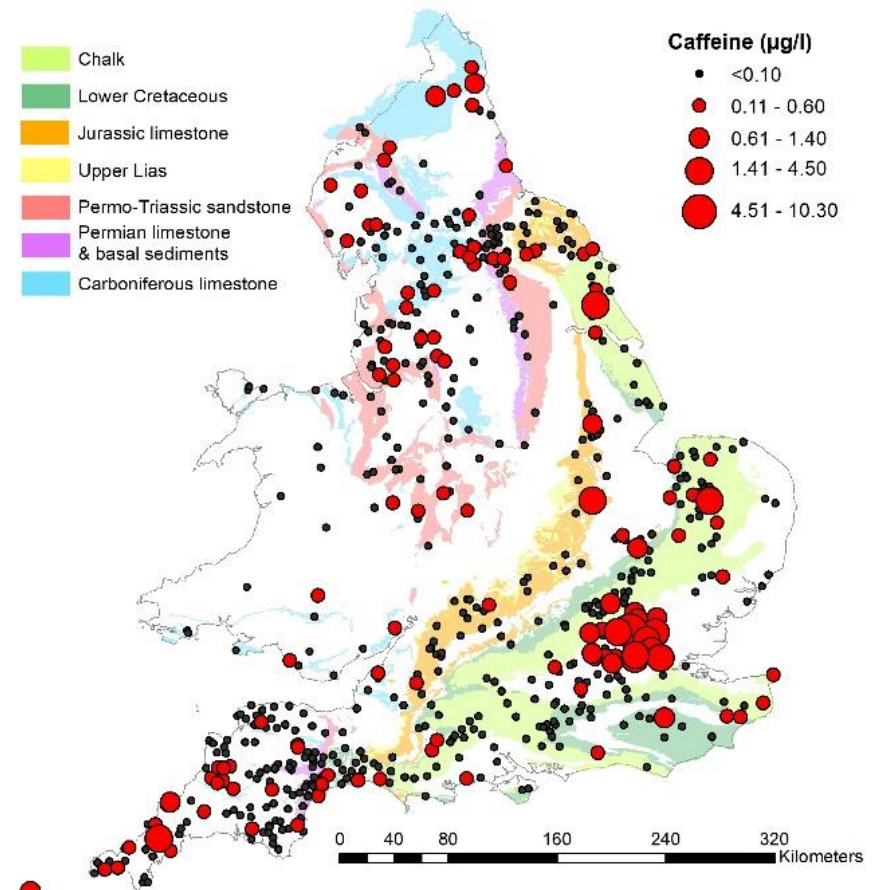


Good coverage for parts of England – poorer coverage for large parts of UK and elsewhere in Europe – limited LCMS data available

2019



2016



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Summary

GWWL: recent activities

- Case studies on PFAS and pharmaceuticals show there are 12 substances which fulfil the criteria to integrate in to the 'list facilitating Annex I/II process' – *i.e. there is adequate evidence and will not be part of the GWWL*
- 2 pharmaceuticals (carbamazepine and sulfamethoxazole)
- 10 PFAS (top 10 from combined ranked list)

GWWL: new candidates

- 2 further PFAS substances which are highly ranked
- 9 further pharmaceuticals including 2 substances on the SWWL
- First GWWL formally agreed by EU working group on groundwater in April 2019 in Bucharest
- Future work to focus on following groups of compounds: Vet. medicines, plasticisers, surfactants, biocides, PMT list

Conclusions

- Success story: 10 substance now can be considered under review of current priority substances and taken off the GWWL
- Good example of how voluntary schemes can work well in helping prioritise groundwater monitoring!
- But... relies on continued participation from European countries in voluntary monitoring and data sharing
- New GWWL substances can be included for which there is currently inadequate data for assessing as part of annex I and II of GWD review.

Future outlook

- Current political context may make this more difficult in the future
- Great potential for use of low cost broad screening methods – in many ways it is now difficult to make arguments for not monitoring purely on basis of cost
- GWWL makes it difficult to argue for not monitoring on the basis of ‘limited prioritisation’
- Anti Microbial Resistance (AMR) is starting to make people sit up and think about the impact of complex mixtures of organics in the environment

*Moving on from 'stamp collecting' towards
targeted monitoring*

Acknowledgements

BGS colleagues – particularly Marianne Stuart

Lopez, B., Laabs, V., Kozel, R., Wolter, R., Ward, R.,
Vargas-Amelin, E., Besien, T., Claessens, J., Delloye,
F. and Ferretti, E., Gaston, L.....

Thanks for listening



Any questions?