Contamination fingerprinting techniques for private water supply wells: Identifying the impact from domestic water treatment systems

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epa
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NUI Galway
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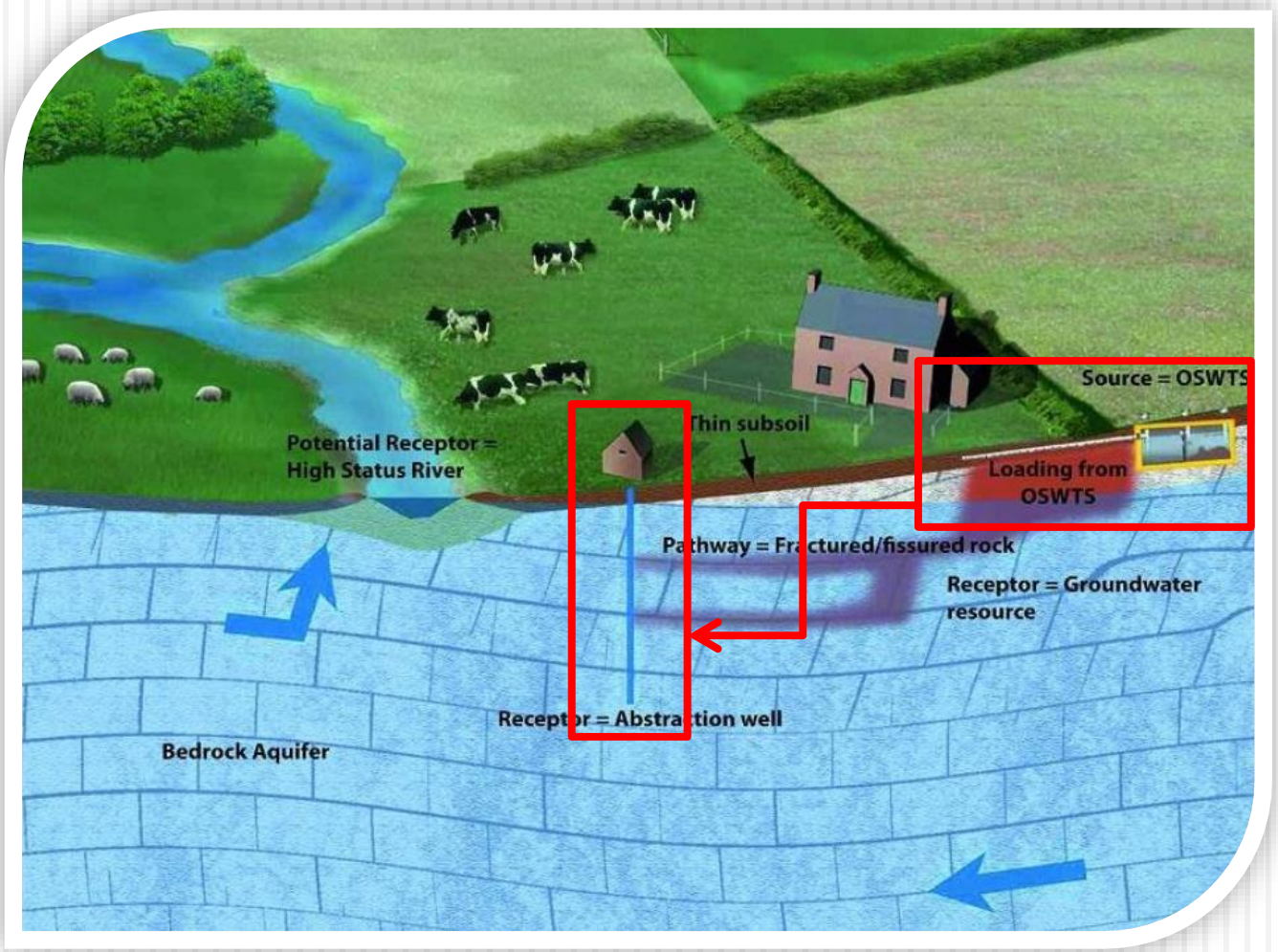
Private water wells & septic tanks

- Groundwater ac 25% of Ireland's total water abst
- Approximately rely on private water sources, r

Problem: Private wells in Ireland are largely unregulated, and as a result are often poorly located and constructed leaving them vulnerable to contamination

Approx. 500,000 houses also rely on domestic wastewater treatment systems, of which more than 87% are septic tanks

Wells & contamination pressures



EPA, 2013

Identifying contamination in wells

FAECAL INDICATOR BACTERIA ARE NOT SOURCE SPECIFIC

Research Aim: Evaluate contamination tracers and their ability to attribute private well contamination to a specific source

Study sites

County Cavan
(Low Vulnerability, Sandstones, Limestone, Conglomerates)

County Kilkenny
(Extreme Vulnerability, Dinantian Limestone)

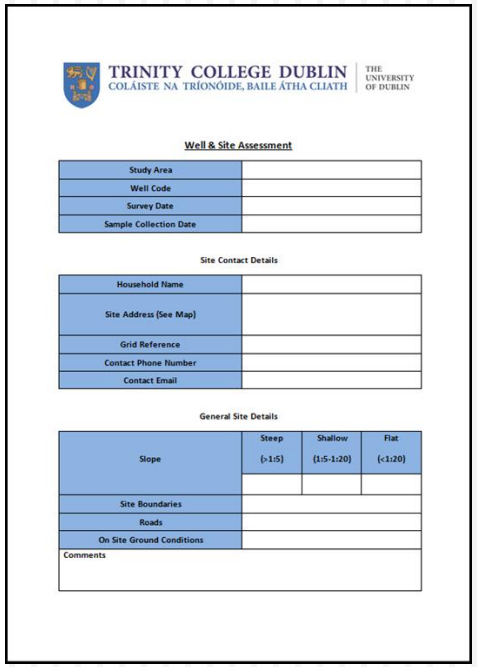
County Wexford
(Extreme Vulnerability, Ordovician Metasediments)

County Wexford
(Low Vulnerability, Felsic volcanics)

Sampling & Analysis

212 wells surveyed, sampled and analysed for microbial and chemical parameters

Site assessment survey



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Well & Site Assessment

Study Area	
Well Code	
Survey Date	
Sample Collection Date	

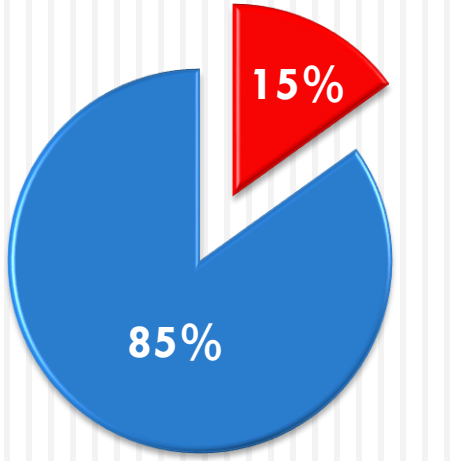
Site Contact Details

Household Name	
Site Address (See Map)	
Grid Reference	
Contact Phone Number	
Contact Email	

General Site Details

Slope	Steep (>1:5)	Shallow (1:5-1:20)	Flat (<1:20)
Site Boundaries			
Roads			
On Site Ground Conditions			
Comments			

One-off Sampling



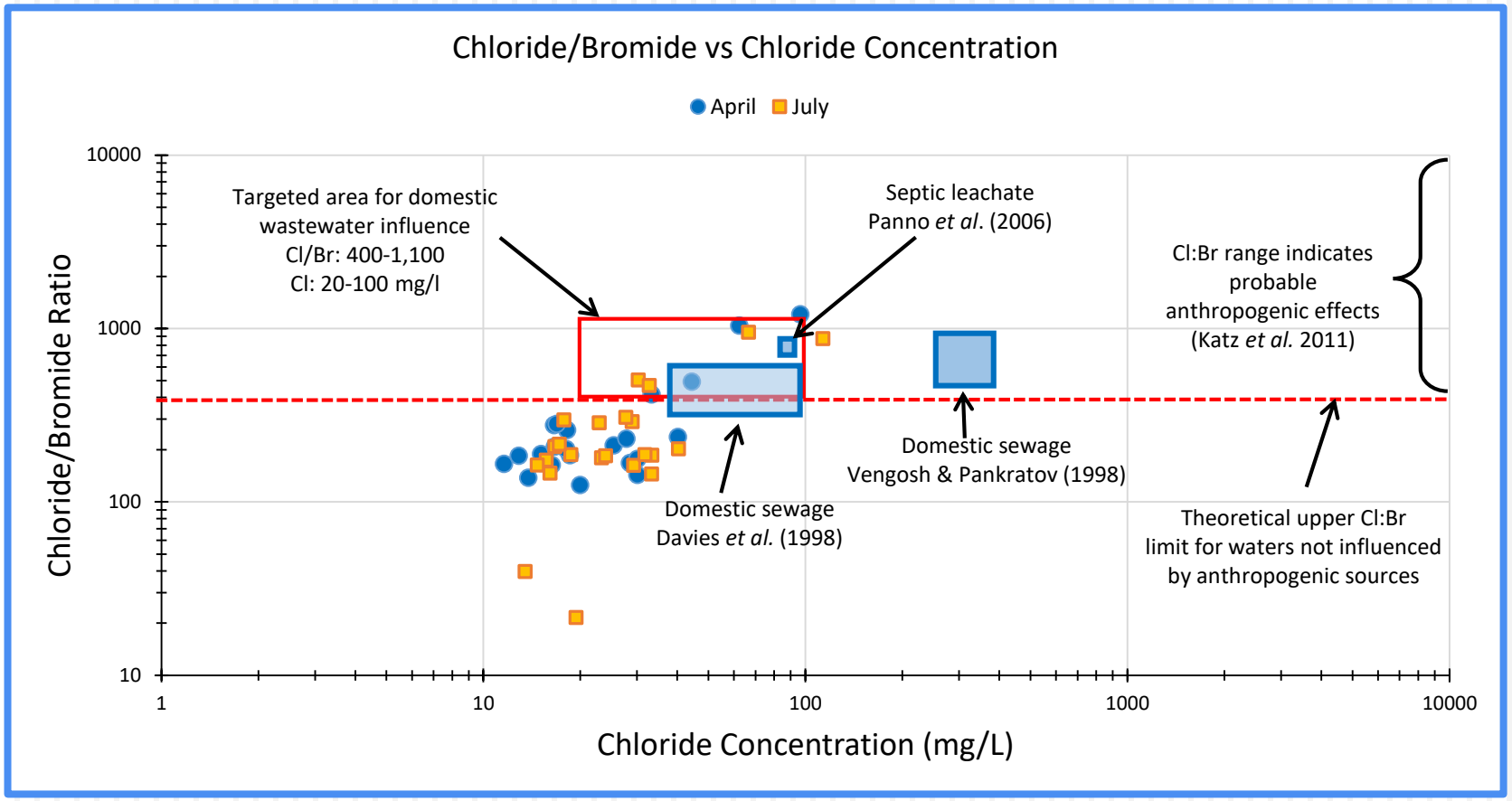
Monthly monitoring & multiple tracer evaluation events

- Monthly monitoring of 24 wells
- Two monitoring events where potential human specific tracers were evaluated.

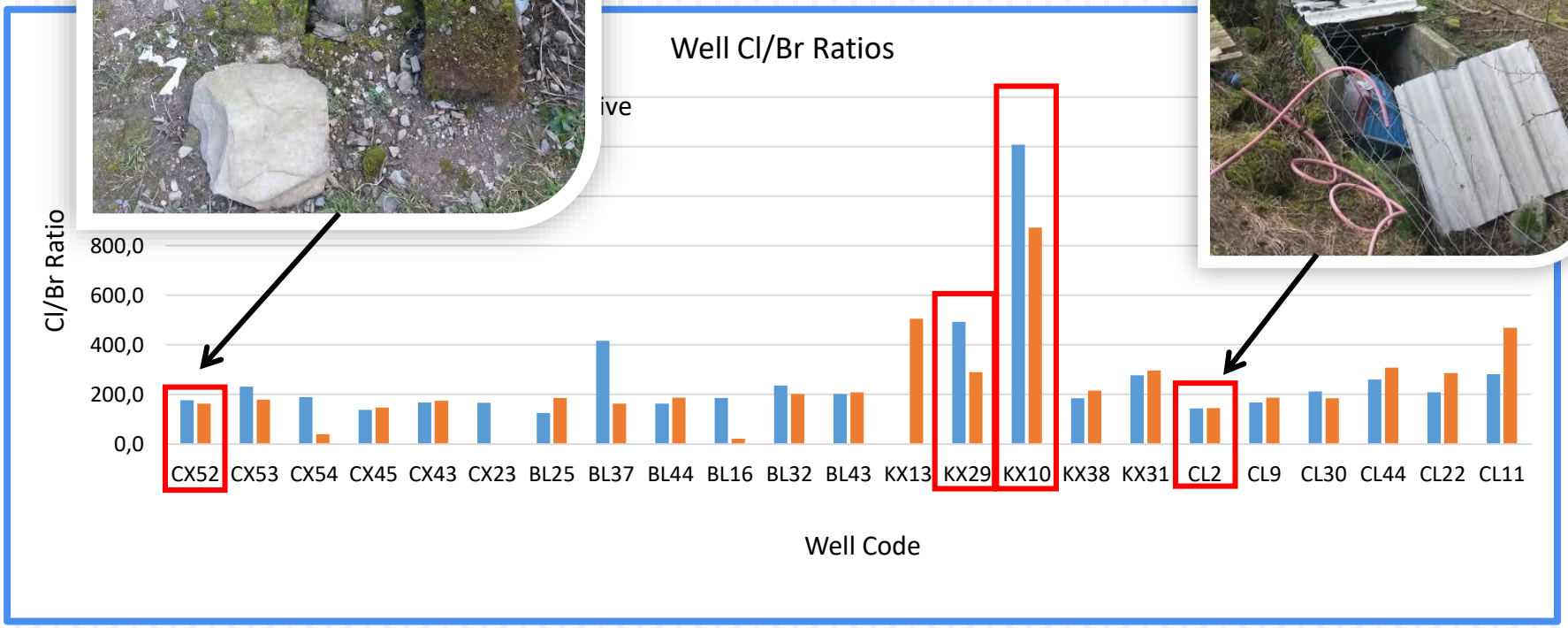
Fluorescent Whitening Compounds
Sterols
Ionic Ratios (Cl/Br & K/Na)
Artificial Sweeteners
Pharmaceuticals
Caffeine
MST (Bacteriodales)*
Phages*

Ionic Ratios: Cl/Br

Theory: Distinct Cl/Br for different waters
(e.g. natural GW 100-200, DWW 300-600*)



Ionic Ratios: Cl/Br

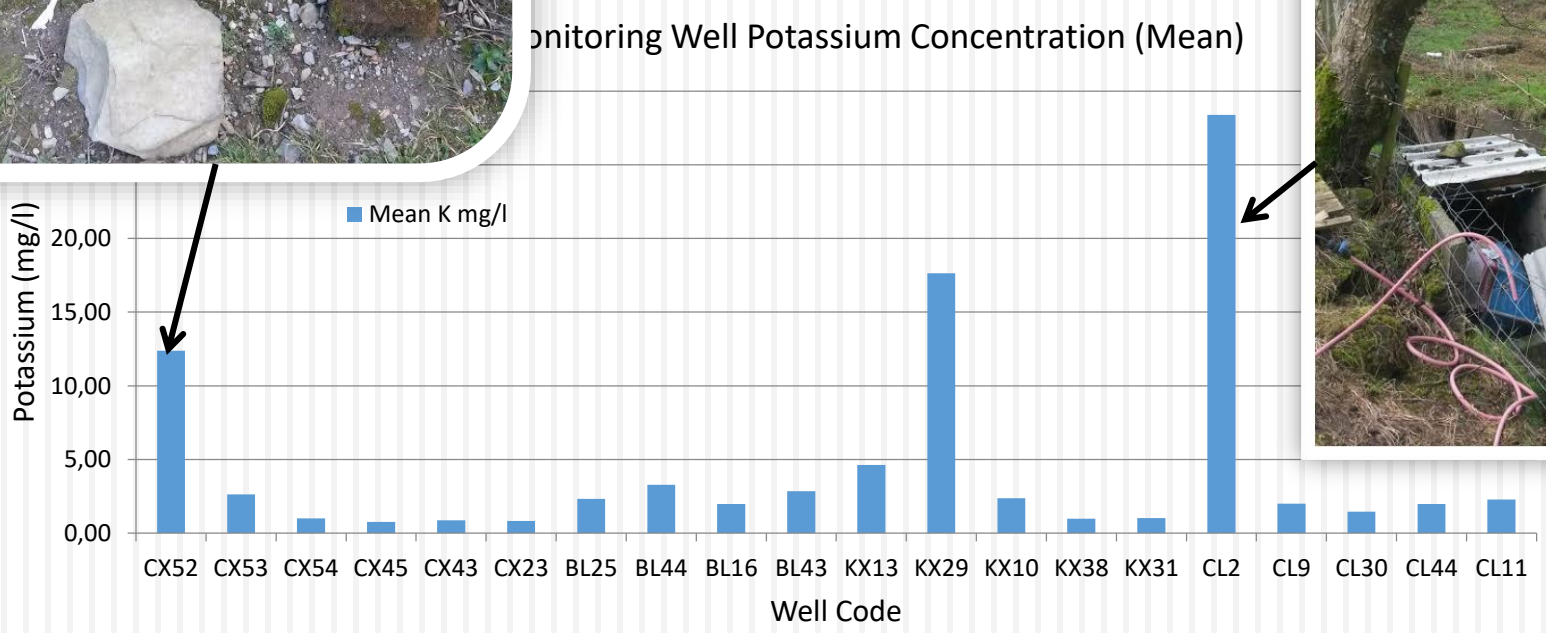


Ionic Ratios: K/Na

lly less than 3.0 mg/l K, with K/Na generally less then

0.4 indicative of contamination fro
natter e.g. farmyards.

K/Na lower (approx. 0.3)



Collaboration: Dr Donata Dubber

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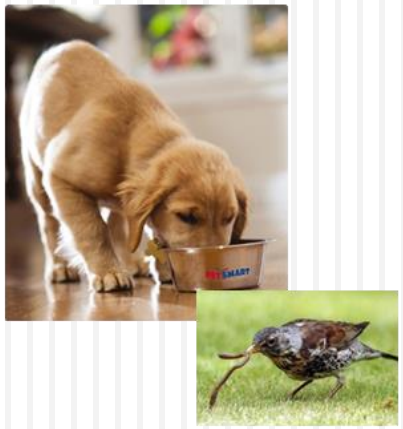
Sterols

- Animals have a distinguishable faecal sterol profile based on an their diet & the bacterial community in their digestive tract

Sterol in animal cell membrane:

Cholesterol

Coprostanol



Cholesterol

Sterol common in plant material:

24-ethyl-cholesterol

24-ethyl-coprostanol

24-ethyl-epi-coprostanol

Sterols

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	Cavan				Kilkenny				Clogh				Ballymoney			
	CL 2	CL 9	CL 11	CL 44	KX 10	KX 13	KX 29	KX 31	CX 52	CX 43	CX 53	CX 54	BL 16	BL 25	BL 32	BL 44
Total sterol concentration [ug/L]	0.62	0.47	0.33	0.46	0.66	0.77	0.52	0.50	0.89	1.24	0.81	0.56	1.01	0.95	0.51	0.61
Human faecal stanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cholesterol	-	-	-	-	-	-	-	-	-	x	x	-	x	-	-	-
Herbivore faecal stanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sheep faecal stanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plant sterols	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

- Very low concentrations (close to detection limit) so difficult to draw conclusions
- Requires filtration of large quantities of water (20l)
- Do negative results mean no impact or unsuitable method (*NB the presence of plant sterols)?

Artificial Sweeteners, Caffeine & PCPs

Collaboration:
Dr David O'Connell
Dr Martin Danaher

- **Artificial Sweeteners** are commonly used in modern diets as an alternative to sugar e.g. **acesulfame**, cyclamate, saccharin, sucralose.
- **Pharmaceuticals and personal care products** e.g. sulfamethoxazole, carbamazepine and many more!!
- **Caffeine**: only a small proportion is metabolised by humans

Applicability to a domestic scale?

Artificial Sweeteners/Caffeine/PCPs

- Artificial sweeteners/Caffeine and PCP found in Irish groundwaters for the 1st Time !!
- Significant occurrence of Acesulfame in some wells

* Preliminary results

	Cavan				Kilkenny				Clogh				Ballymoney			
Compounds (µg l^{-1})	CL2	CL30	CL11	CL44	KX4	KX13	KX29	KX31	CX43	CX52	CX53	CX54	BL16	BL25	BL32	BL44
Acesulfame-K	+	+	+	+	+	0	+	+	+	+	0	+	0	0	0	0
Aspartame	+	+	+	+	+	+	+	+	+	+	0	+	+	+	+	+
Saccharin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sucralose	0	0	0	0	0	+	+	0	0	0	0	0	0	0	0	0
Cyclamate	0	+	0	0	0	0	+	+	0	0	+	0	0	0	0	0
Caffeine	+	+	+	+	0	+	+	+	0	+	+	0	0	+	0	+
Carbamazepine	0	+	0	0	+	+	+	+	0	0	0	+	+	+	+	+
Sulfamethoxazole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Conclusions

- Current lack of knowledge when associating contamination to a specific source on a domestic scale
- Varied suitability of tracers tested to date
- Requirement to evaluate various tracer techniques and develop a “toolbox” of methods to better understand contamination processes.
- Important implications in understanding and managing DWWTS, private wells, with obvious links on human health.

Thank you!

Questions?

Acknowledgments

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