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COLLABORATIVE, IMPARTIAL RESEARCH

National Chemical Investigations Programme ("CIP2") – Emerging outputs and implications

Howard Brett, Thames Water

National Collaborative Project

CIP2 and the Water Framework Directive/Priority Substances

- Latest in a succession of projects to understand and evaluate the impact of the Water Framework Directive (WFD) and the Environmental Quality Standards Directive (aka Priority Substances Directive) together with 'emerging substances'
- The EQSD itself supplanted the long-standing (but ill-considered and poorly implemented) Dangerous Substances Directive
- Standards derived without full appreciation of either the current environmental concentrations seen or the relevance of STW inputs
- The recent directives give more flexibility in terms of implementation, but underlying knowledge base still often poor
- Before looking at CIP2, a quick review of its predecessor, CIP1

CIP1 (2010-2013)

Establish priorities to ensure surface waters meet EQS, inform policy and investment

- Determine effectiveness of existing treatment processes
- 45 substances targeted at 162 sewage treatment works across England and Wales
- Removal of trace substances by 'conventional treatment' studied at 28 sewage treatment works
- 9 catchment studies
- Pilot and lab scale tests

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CIP1 - Outputs

- Confirmed the presence of many Priority Substances in effluent
- Effluent concentration often close to that 'environmentally relevant', so regulatory regime would dictate consequences for STWs
- Reduction as high as 80-90% for some parameters, but more needed to achieve EQS if dilution poor
- Principal source of many substances is domestic sewage
- Very limited environmental data to support

Revision of EQSD

- Proposals emerged for revision of EQSD
  - More parameters (incl pharmaceuticals)
  - Revised EQSs for others
- Reliant on biological impact assessment datasets/toxicity data of variable quality and provenance
- Innately precautionary
- CIP1 provided unique and comprehensive monitoring dataset
- Indicated that 'potable treatment' would need to be added to STWs to achieve compliance
- Huge potential cost to UK – estimated as some £27bn, plus carbon impact
- Final version of rEQSD omitted pharmaceuticals, which are now on 'watch list'

CIP1 impact assessment – numbers of STWs

Substance	EQS inland surface waters µg/l AA (MAC where given)	100% EQS	50% EQS	10% EQS
BDEs	0.0005[d] (0.14)	523	864	2228
PAHs (BAP)	1.7×10^{-4} (0.27)	866	1392	2952
Tributyltin	0.0002 (0.0015)	286	523	1417
Nonylphenol	0.3 (2.0)	144	383	903
DEHP	1.3	48	238	696
Nickel	8.63[a]	48	192	656
Zinc	24.04[a]	48	142	288
Copper	11.04 [a]	48	236	650
Triclosan	0.1 (0.28) [c]	286	511	1508
EE2	3.5×10^{-5} [b]	1296	2144	3928
E2	4.0×10^{-5} [b]	622	1034	2055
Diclofenac	0.1 [b]	383	610	2042
Ibuprofen	0.01[c]	2262	2953	4588

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CIP2 (2015-2020)

- Recognised as essential precursor to significant investment in PR19 and beyond
- Inform and influence UK 'chemicals' policy
- Understand contribution from STWs:
  - Evaluation of many more STW discharges
  - Assessment of EQS compliance up and downstream of discharges
  - For subset of discharges, evaluate 'emerging substances' reduction
- Assess effectiveness and cost of pilot plant and also demonstrate feasibility of other processes
- Further catchment studies

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CIP2 – Scale of programme

- 600 STWs and receiving watercourses by 2020 = 60,000+ samples (four tranches)
- Chemical analysis for:
  - 19 metals
  - 18 priority substances
  - 12 sanitary determinands
  - 3 steroids
  - 20 pharmaceuticals
  - 3 emerging pollutants
- 5 catchment studies
- 3 pilot studies
- 11 demonstration trials
- Budget estimate of £140m

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CIP2 – Technologies under evaluation

Water Co	Type	Technology
Anglian	AOP	Arvia - Nyex
Northumbrian	3°	NSAF + Sand filter
Severn Trent	3°	Iron dosed sand filter
	3°	Algae bioreactor
Southern	3°	Nitrifying sand filter
Thames	2°	Nereda
	AOP	Advanced Oxidation
	AOP	Membrane + Advanced Oxidation
United Utilities	AOP	Ozone + Hydrogen Peroxide
	AOP	BlueCAT
Wessex	2°	Reed bed
	2°	Reed bed
Yorkshire	3°	Nitrifying trickling filter (single pass)
	3°	Nitrifying trickling filter (alternating double filtration)

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CIP2 – Technologies under Evaluation

- Different approaches;
  - 'More of the same'
  - Novel secondary (Granular Activated Sludge)
  - Filtration of various sorts
  - Advanced Oxidation of differing types and combinations
- No one process is likely to address all parameters – no magic bullet
- Solids reduction likely to help but no impact on dissolved substances
  - Impact on sludge?
- Risk of by-product formation with harsh oxidation
  - Important if water is reused

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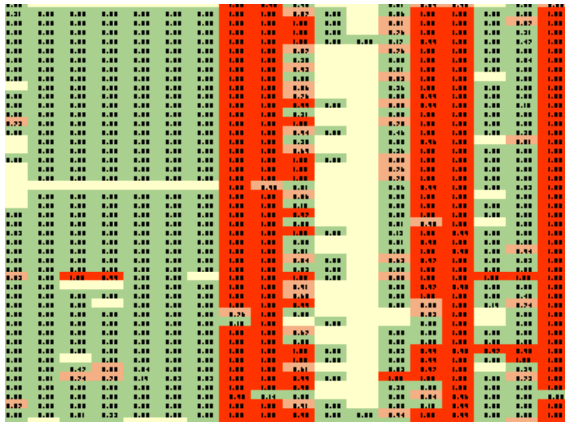
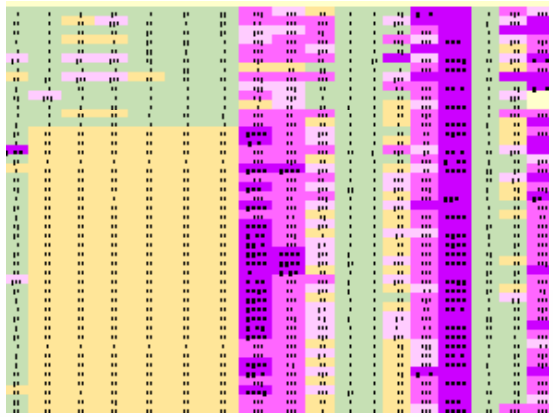
Early indications 1 – Priority Substances (main programme)

- Seven substances are showing probable non-compliance with current EQS;
  - PFOS, PFOA, benzo(a)pyrene, fluoranthene, HBCDD, tributyltin, cypermethrin
- Localised elevated iron and zinc, may be amenable to local solution
- Other metals & trace organics show marginal potential failures, some sites with known issues, i.e. mine waters
- Upstream quality often poorer than anticipated
- Some substances show increase with STW effluent discharges, but not all





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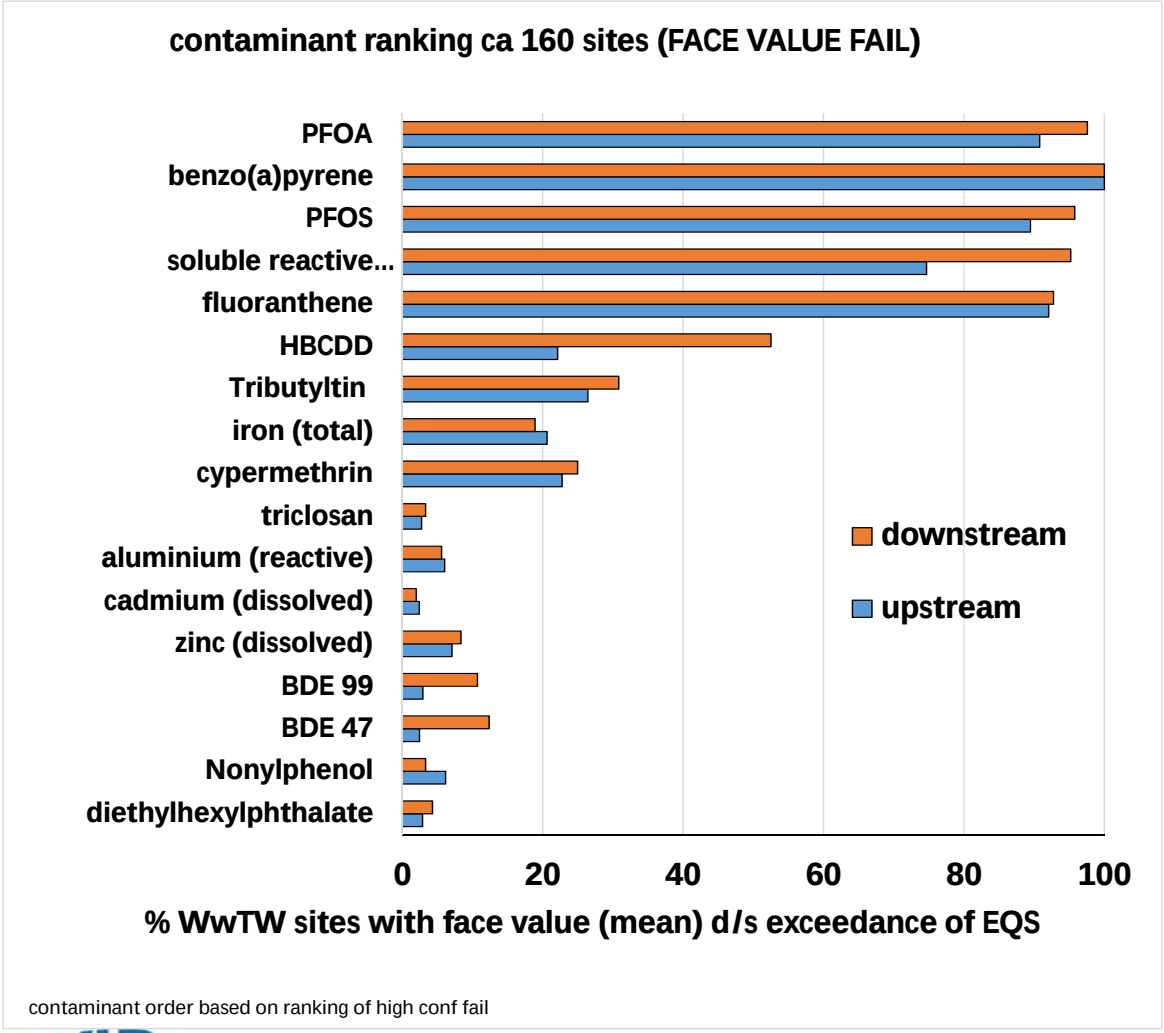
Preliminary data:



contaminant order based on ranking of high conf fail

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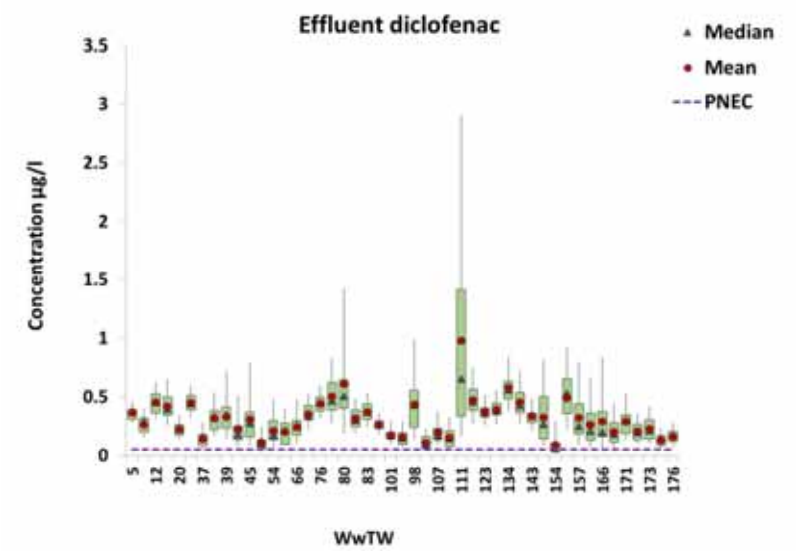
Early indications 2 – 'emerging substances'

All subject to how EQS is set



- Emerging contaminants concentrations at, or near, potential EQS
- Diclofenac and potentially ibuprofen likely to have widespread compliance concerns, control at source to reduce risk?
- STW solutions may be option for steroids, including EE2
- Non-pharmaceuticals; trixylenyl phosphate (flame retardant) rarely detected and the two triazole anticorrosive substances (benzotriazole and tolyltriazole) exceeded notional limit value almost everywhere

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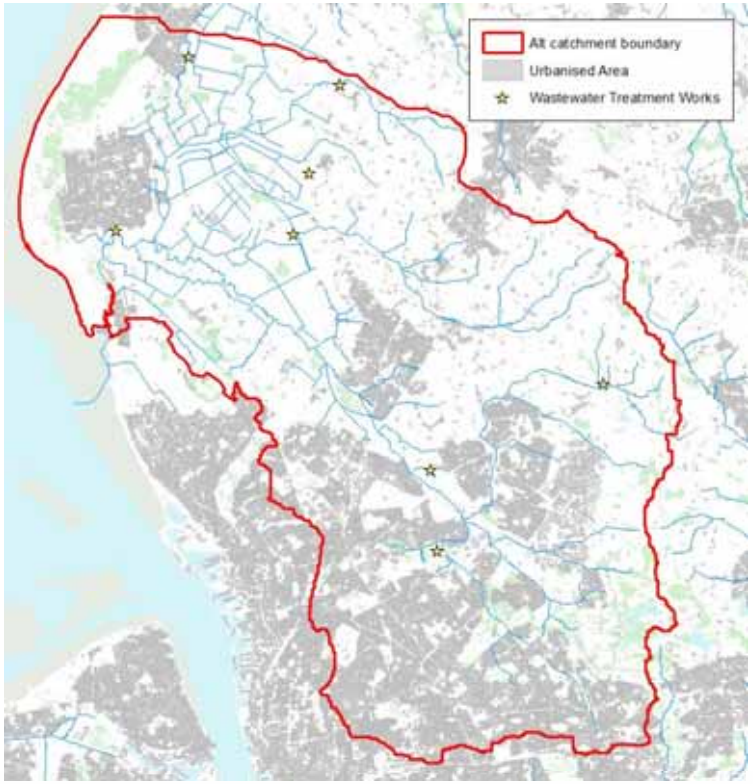
Early indications 3 – Pilot and feasibility

- Sampling started at most sites, but limited data so far
- Reductions highly variable between trials; one suggests an increase across the plant, whilst others a significant reduction
- Highest removals across all trials often suspended solids, steroids (E1 & E2), some pharmaceuticals and some total metal determinands

Early indications 4 – Catchments

- Data reported from all five trials, but none yet completed
- Little evidence of trends of key substances from top → bottom of catchments
- Dissolved zinc and DEHP generally compliant with EQS
- PFOS exceeds EQS at almost all locations
- Reports due from April 2017



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CIP2 –next steps

- Results for tranche 1 and catchment studies to be submitted by April 2017
- Pending EA criteria, selection of STWs to have a 'site-specific options appraisal' ("SSOA") by early 2017
  - Based on effectiveness of proven technology and compliance gap
  - These costs to be collated by EA/Defra
  - Inclusion in business plans/implementation will be subject to cost/benefit and affordability
- Context – other priorities for 'water', overall bill impact
- So this leads to three probable 'challenges'
  - EQS setting
    - Extent of precaution?
  - UK domestic permitting policy
  - Assessment of cost/benefit or willingness-to-pay

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SSOA – technology/determinand matrix from CIP1

Substance	NSF	NTF	AOP (including ozone, UV and peroxide)	Reed Bed	Bauxsol	GAC	MF / RO
TBT	H	L	M	L	L	M	H
BDEs	M	L	L	M	H	H	H
BAP	nd	M	nd	M	nd	nd	nd
Nonylphenol	M	M	L	nd	L	M	H
DEHP	M	M	L	M	H	H	H
nickel (dissolved)	L	L	L	nd	L	L	nd
nickel (total)	L	L	L	L	L	L	H
triclosan	L	M	H	L	L	nd	H
zinc (dissolved)	L	H	L	nd	M	L	nd
zinc (total)	L	H	L	nd	M	L	H
copper (total)	L	M	L	M	L	L	H
17α ethinylestradiol (EE2)	L	L	H	H	L	H	H
17β estradiol (E2)	H	M	H	H	H	M	H
diclofenac	L	nd	M	L	L	M	H
ibuprofen	H	H	M	M	L	M	H

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EQS setting

- Using the rEQSD proposal as an example:
  - Parameter selected /promoted (vested interest?)
  - Dossier compiled, using available toxicity data – so variable end-points, species, reliability etc
  - EQS derived using methodology set out in technical guidance document (TGD) This employs assessment [safety] factors to reflect uncertainty
- Principle is fine, but using EE2 as example....
  - What is end point for protection – NOEC?
  - Saline value reduced from that for freshwaters due to lack of data (5-fold)
- This matters as the observed concentrations are very close to these theoretical figures. A small change in assessment factor is the difference between compliance and non-compliance – and hence major investment

UK permitting policy

- Two/three fundamental points
  - Apportionment of contribution/how much contribution is allowed
  - Where is EQS to be met
- If there is an 'upstream' load, how is the STW contribution to be reduced fairly (if at all)
- If there is no upstream contribution, can the STW 'use' the full EQS?
- Application of 'standstill conditions'
- At what point is the EQS compliance assessment made – does the EQS apply to all waters?

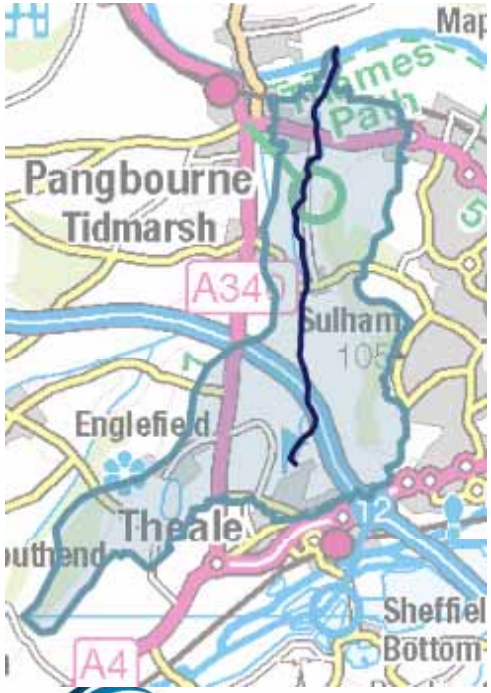
Pangbourne STW and Sul

Pangbourne STW pe 12,300

'Typical' filter plant, 45/15/5/2

Sul is 6km of 'main river'

Picture shows final 600 m



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Sul classification (catchment data explorer)

Water body classification

Select year: 2009 Cycle 1 Select year: 2015 Cycle 2

	2009 Cycle 1	2015 Cycle 2	Objectives
Overall Water Body	Moderate	Moderate	Good by 2027
Ecological	Moderate	Moderate	Good by 2027
Biological quality elements	Moderate	Good	Good by 2015
Hydromorphological Supporting Elements	Supports good	Supports good	Supports good by 2015
Physico-chemical quality elements	Good	Moderate	Good by 2027
Specific pollutants	Good	-	Not Assessed by 2015
Supporting elements (Surface Water)	-	-	Not Assessed by 2015
Chemical	Does not require assessment	Good	Good by 2015
Other Pollutants	Does not require assessment	Does not require assessment	Does not require assessment
Priority hazardous substances	Does not require assessment	Does not require assessment	Does not require assessment
Cadmium and Its Compounds	-	-	-
Di(2-ethylhexyl)phthalate (Priority hazardous)	-	-	-
Nonylphenol	-	-	-
Tributyltin Compounds	-	-	-
Priority substances	Does not require assessment	Does not require assessment	Does not require assessment
Lead and Its Compounds	-	-	-
Nickel and Its Compounds	-	-	-

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Pangbourne STW and Sul

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Costs and benefits

- A very difficult area
- Unlikely to be able to show tangible benefits to customers
- Probable test is ‘compliance’ - but how to value it
- What price ‘precaution’?
- EA/Defra carrying out work at present but not due to complete until next year
- Companies likely to be carrying out their own customer surveys but this may not align

So…..implications

- Many substances causing EQS ‘fail’ are ubiquitous –
  - Source control may work over time (eg PFOS)
  - Others – the combustion products – have no obvious answer
- A few substances may be amenable to reduction by additional treatment at STWs if cost benefit tests are met
  - Mixture of dissolved metals, perhaps pharmaceuticals. These are likely to involve investment, but previous costs for pharmaceuticals excessive
  - Scale and cost yet to be understood/agreed
- Value of ‘standstill’ limits for ‘domestic’ inputs?
  - A ‘no growth’ option unlikely to be supported

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Final thoughts.....

- The question for this conference was "Priority Substances – where should we control them?"
- Perhaps the better question is "To what extent do they need to be controlled?" Or even "To what extent can we afford to control them?
- In the alternative, (or as well as) is it time to reconsider the Imperative/Guideline standards approach of yore?

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Questions?

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