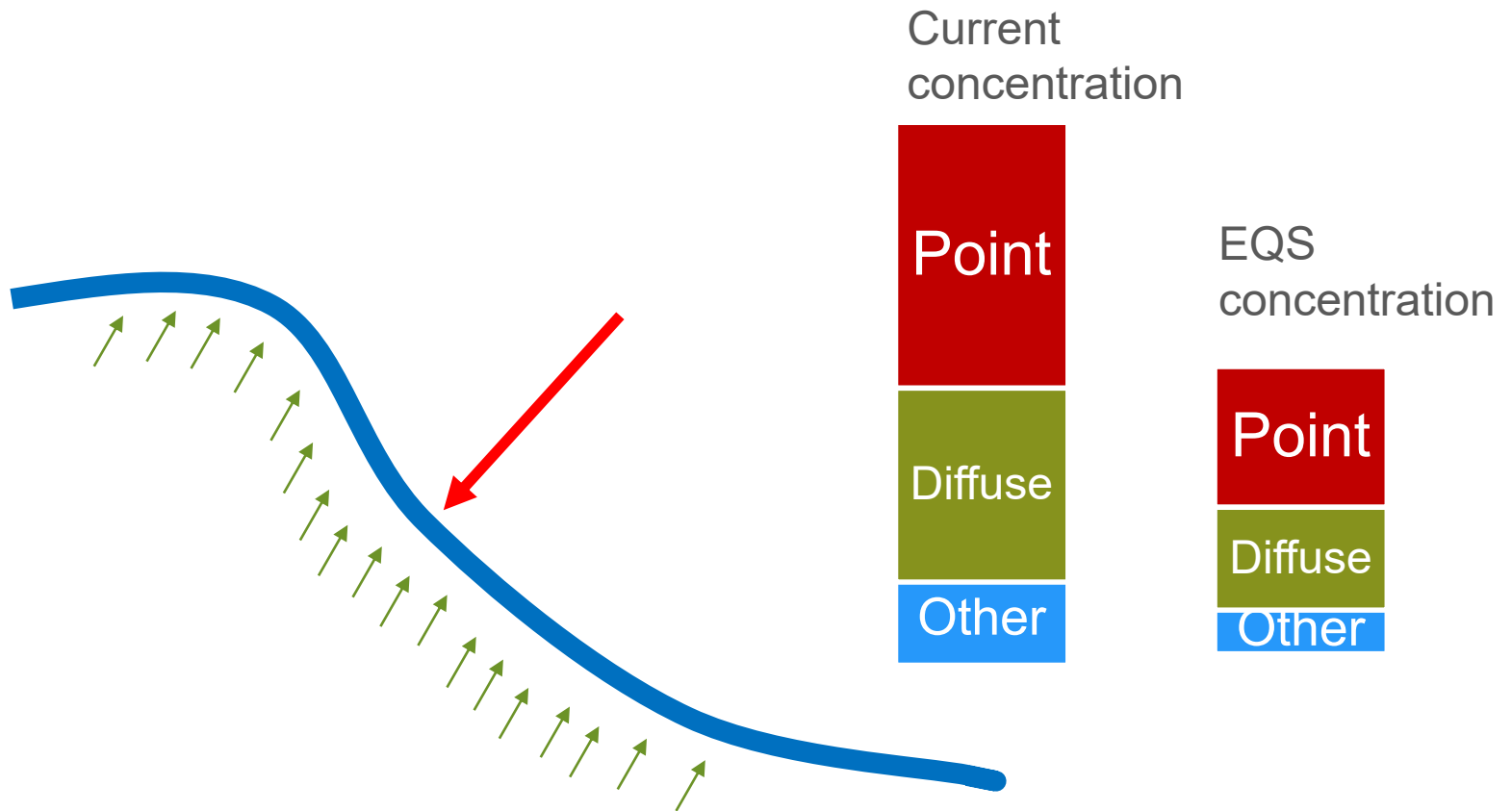# Paradoxes of fare share in catchments and their resolution

Neil Murdoch
August 2019

Environment Agency

Managing WQ in Catchments

- Polluter Pays Principle

- => Fair Share

- => Polluters have to reduce their pollution in relation to its impact

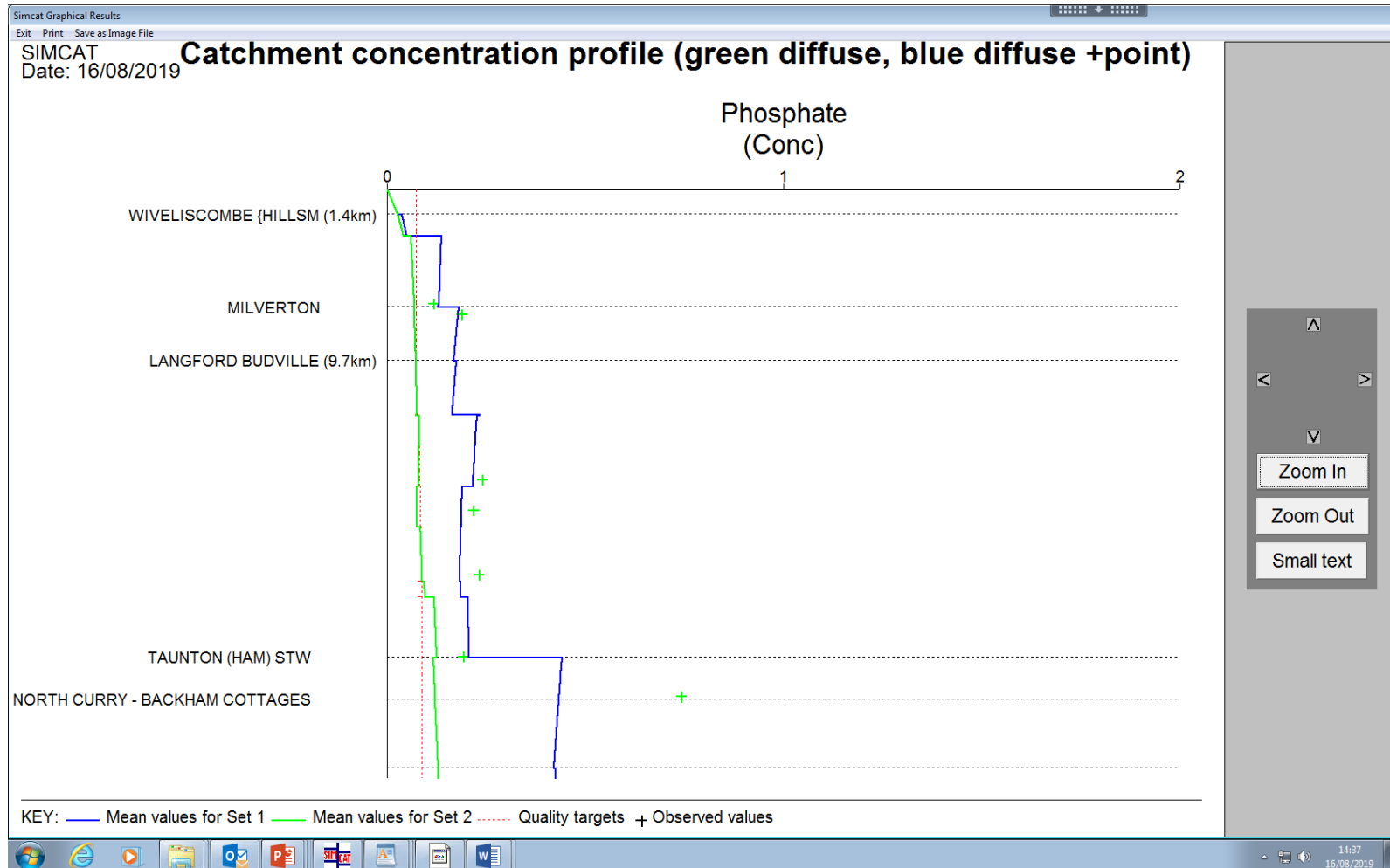- **Amount of reduction is determined by Fair Share and hence how we determine Fair Share is important**

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Fair Share – Principle

Current
concentration

Point
Diffuse
Other

EQS
concentration

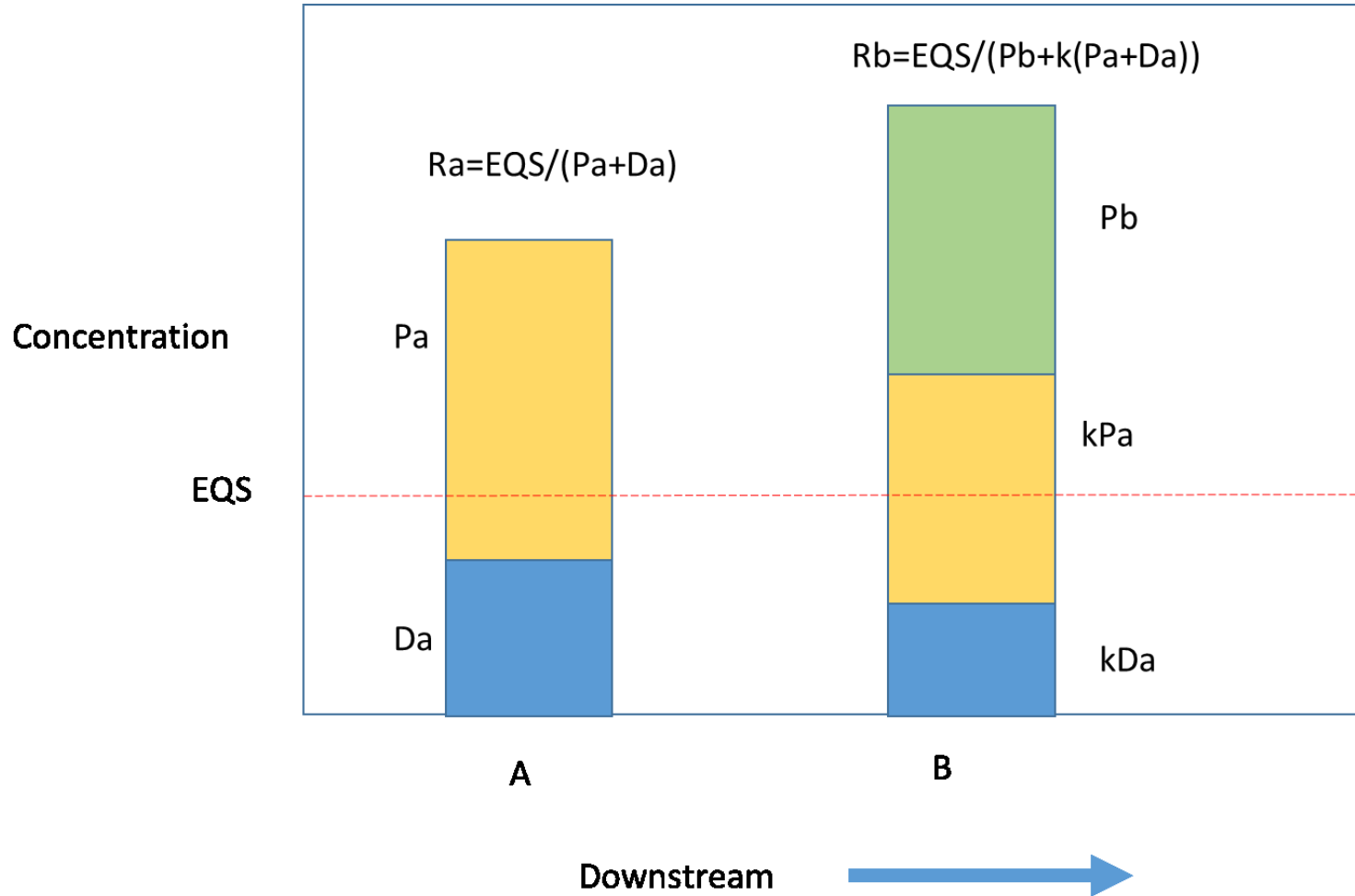| Point |
| :---: |
| Diffuse |
| Other |

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Fair share - problem

- EQS – (Environmental Quality Standard)

  - Achieve compliance in a catchment

- Sectors
  - STWs – point sources
  - Agriculture – diffuse sources

- Issue
  - By how much does each sector have to reduce?
  - How do we calculate this to make it 'fair'

Fair share - problem

Consider 2 discharges

Rb=EQS/(Pb+k(Pa+Da))

Ra=EQS/(Pa+Da)

Concentration

Pa

Pb

EQS

kPa

Da

kDa

A

B
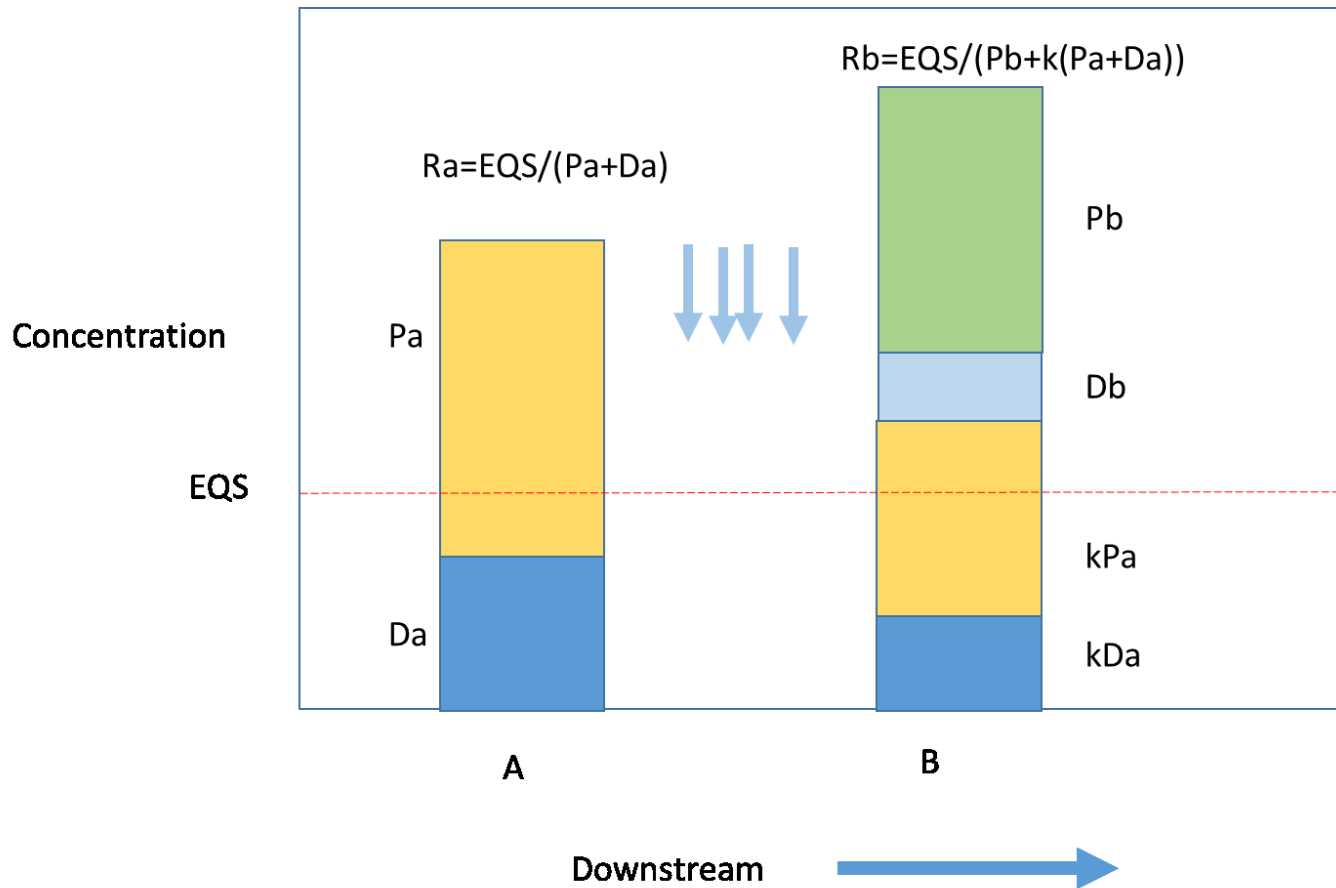
Downstream

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Reductions at 2 points

- Reduce by factor 'a' at point A

- Reduce by factor 'b' at point B

- Can't be done!

- **Sources (point and diffuse) influence all of the downstream catchment, not just the point of entry**

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Consider 2 discharges
– with intervening diffuse inputs

$R_b = EQS/(P_b + k(P_a + D_a))$

$R_a = EQS/(P_a + D_a)$

Concentration

P_a

P_b

D_b

EQS

kP_a

D_a

kD_a

A

B

Downstream

Reductions at 2 points
- with intervening diffuse

- If we set reduction at A as 'a'

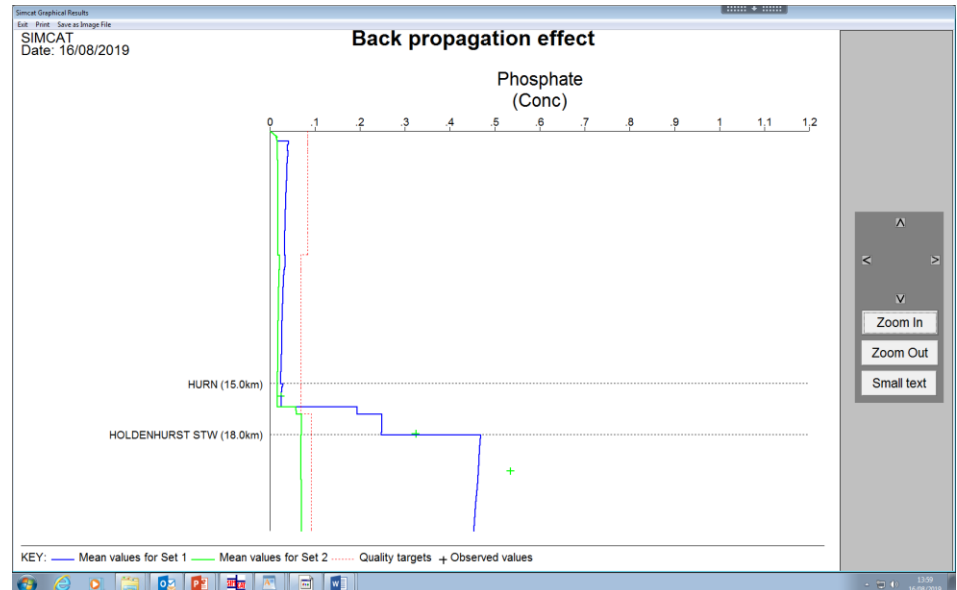- Then reduction for intervening diffuse will have to take up the slack

- Not 'fair'

$$Rb\left(Db + k(Pa + da)\right) = Ri * Db + Ra * k(Pa + da)$$
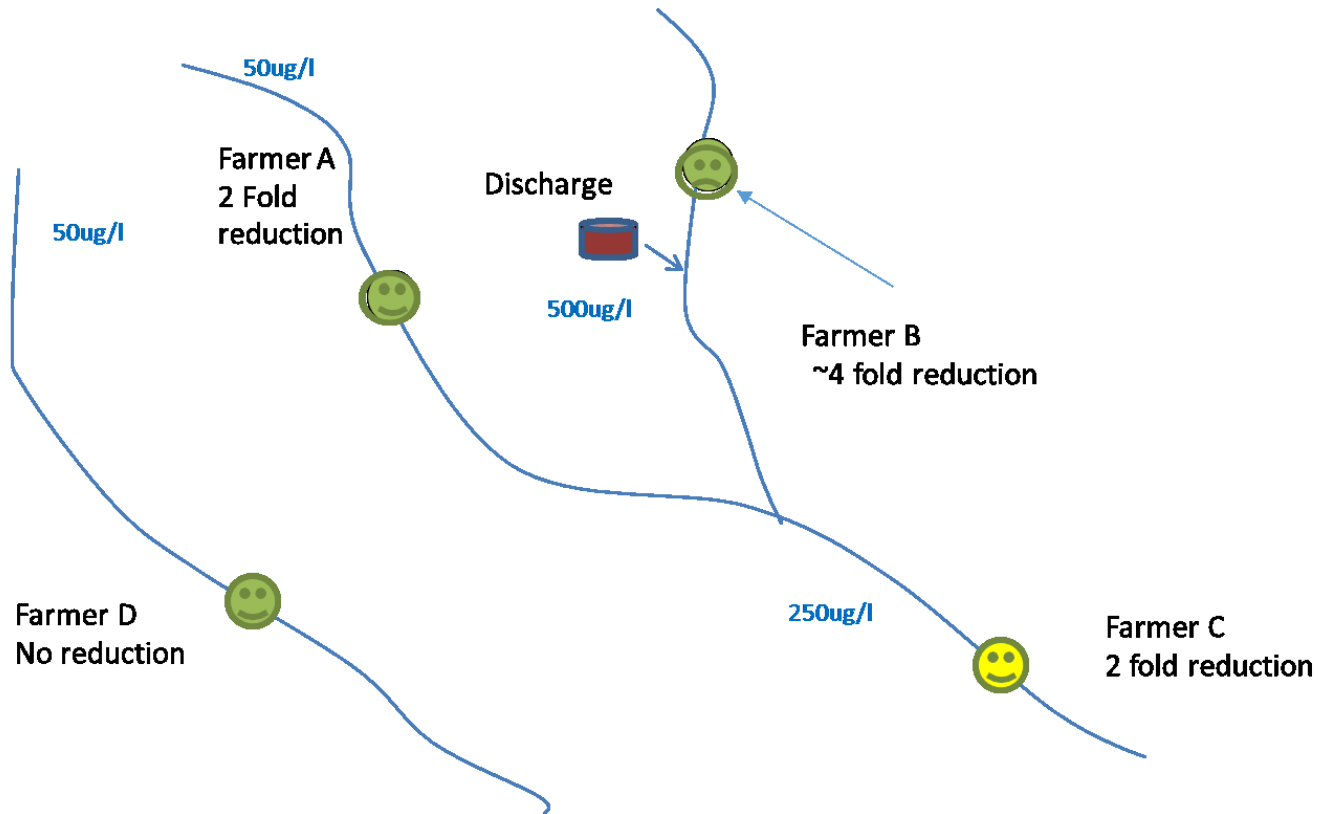
$$Ri = \frac{Rb(Db + k(Pa + Da)) - Ra * k(Pa + Da)}{Db}$$

$$Ri = Rb - \frac{(Ra - Rb) * k * (Pa + Da)}{Db}$$

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'Back propagation' effect

- Reduction at STW applies to all sources

- **All sources includes all upstream sources**

- Hence compliant upstream sources have to have 5 fold reduction

Equity – for farmers?

50ug/l

Farmer A
2 Fold
reduction

50ug/l

Discharge

500ug/l

Farmer B
~4 fold reduction

Farmer D
No reduction

250ug/l

Farmer C
2 fold reduction

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Catchment 'fair share'

- Point by point is problematic

- Other options

  - End of catchment

  - Catchment statistics

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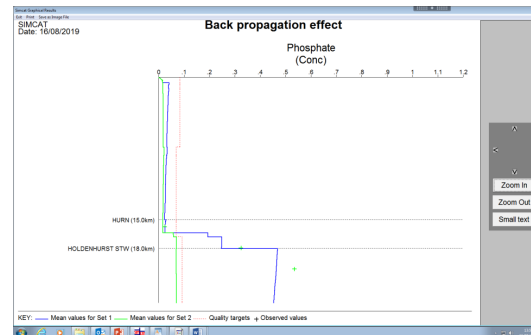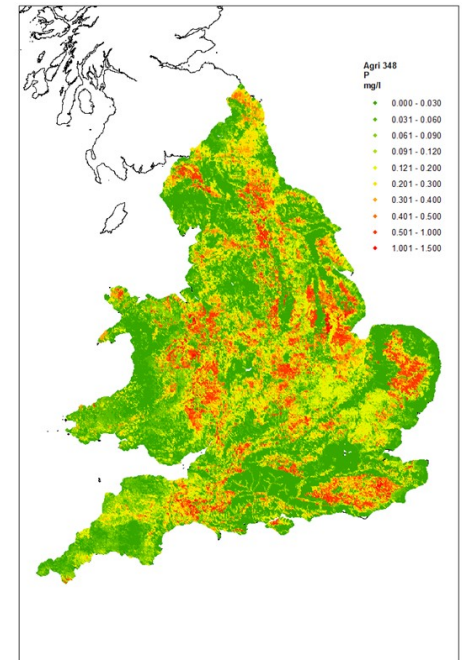# Catchment statistics

- Fair share on basis of ratio of point source and diffuse SPATIAL statistics

- Which statistic – diffuse
  - Average – seems reasonable – catchment ~homogeneous

- Which statistic -point

  - Average
  - Percentile
    - represents impulsive nature
    - Provides management tool
 - Other possibilities

13

Benefits of statistical approach

- Simplification

- One target for point sources
  - Water companies can optimise STW operation within this
  - Quick calculation using modes 7 or 8 in SIMCAT

- One target for diffuse
  - All farmers treated the same
  - More robust
    - estimation of local diffuse concentration –errors
    - Catchment average – more reliable
 - Measures – at catchment scale

Catchment 'fair share'

- Point by point does not work - inconsistent

- Catchments

  - Same principle as for points, but based on catchment stats

  - 2 parameters – mean and percentile

  - Aim for sectors to have same mean share and percentile 'shape' before and after

  - => share as ratio of STW percentile/Diffuse mean

  - Which percentile? – 85th, 75th

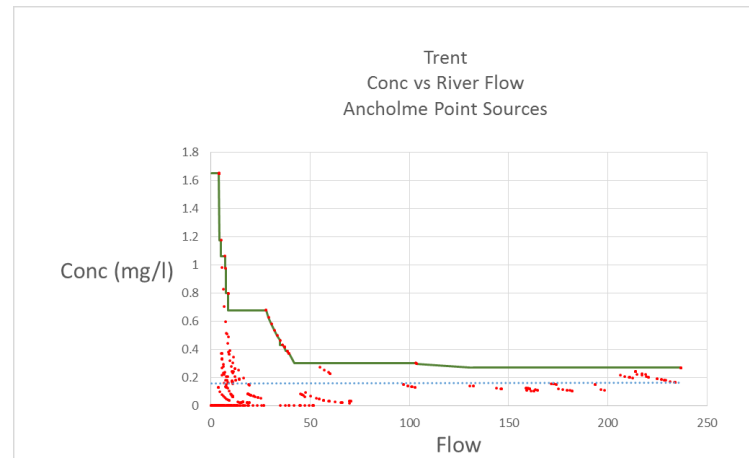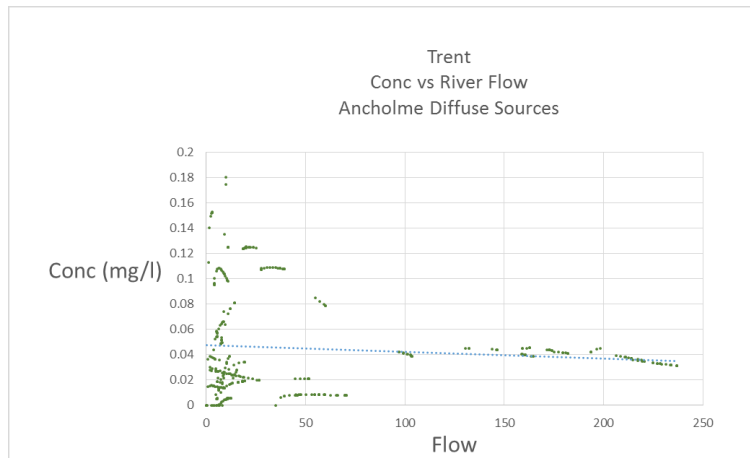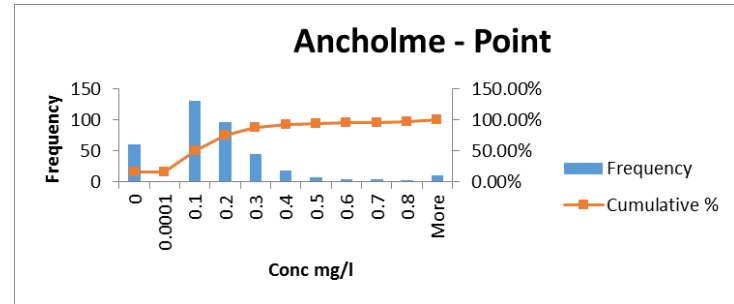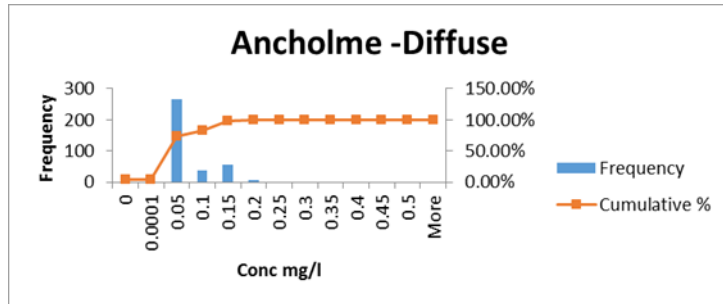 - Percentile filters out influence of large singular discharges

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Application – SIMCAT mode 7
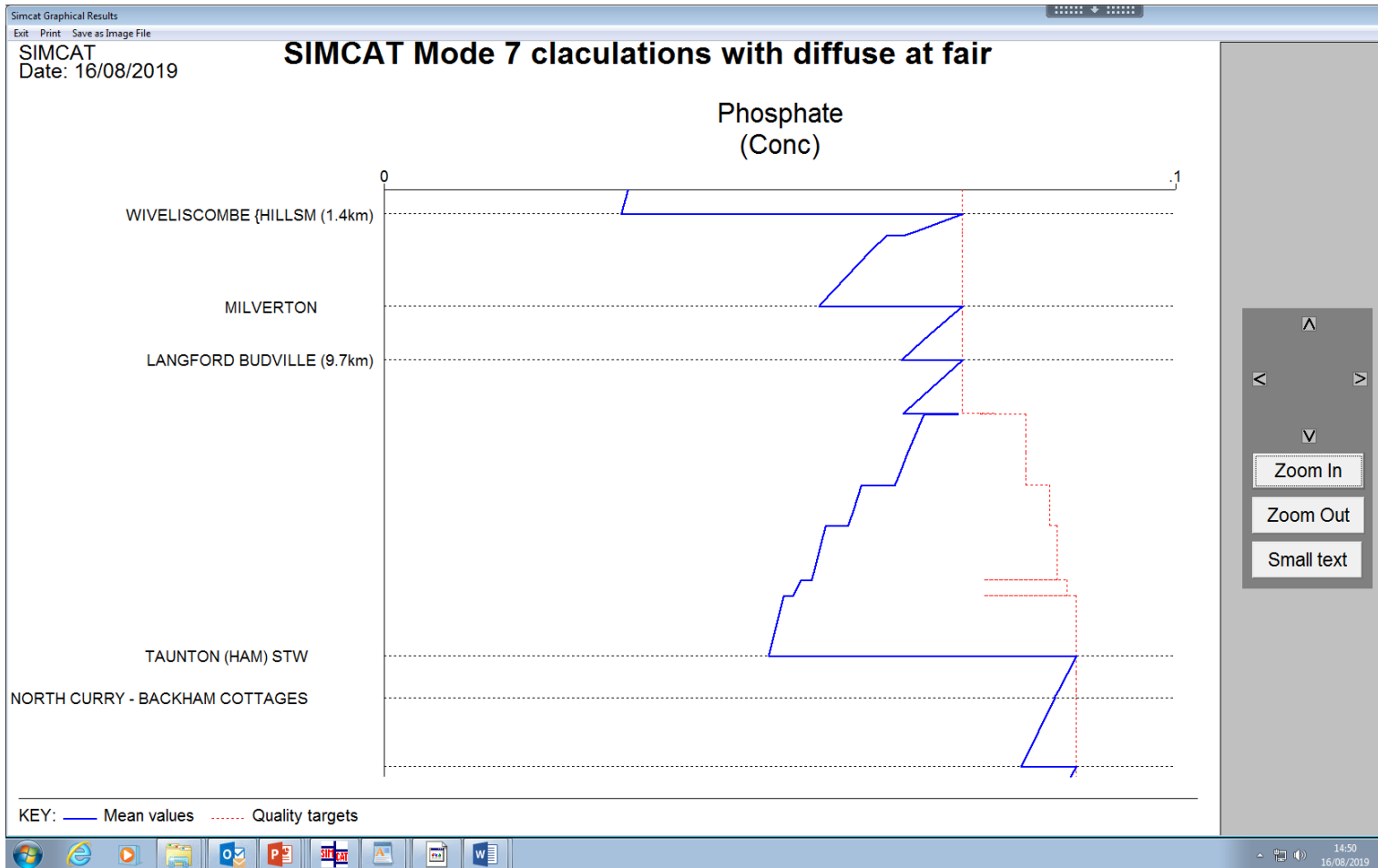
Parametric or Non Parametric?
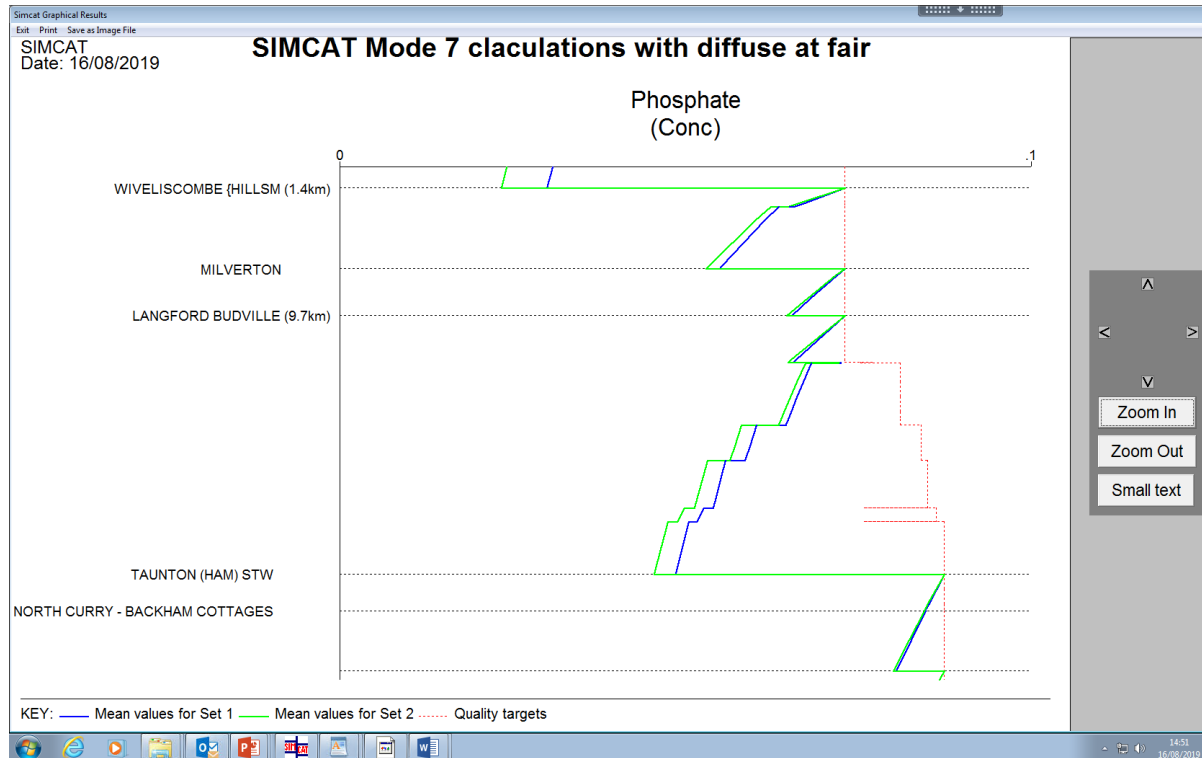
What do catchment distributions look like?

Summary

- Point by point share based on 1 parameter
  - Mean
  - Fails for catchments

- Catchment share allocation based on 2 parameters
  - Mean
  - Percentile

- Analogies with temporal stats
  - Temporal – high percentile –CSO events
  - Spatial – high percentile – 'difficult' part of catchment
  - (river flow correlation => spatial variation)

- Policy/management
  - Percentile choice
  - Compliance target (by river length) for catchment

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