Some observations on the similarity of tracer data from a small river

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Some preliminaries ……

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Content

- Background
- Murray Burn experimental programme
- Similarity of tracer concentration profiles
- Application
- Conclusions

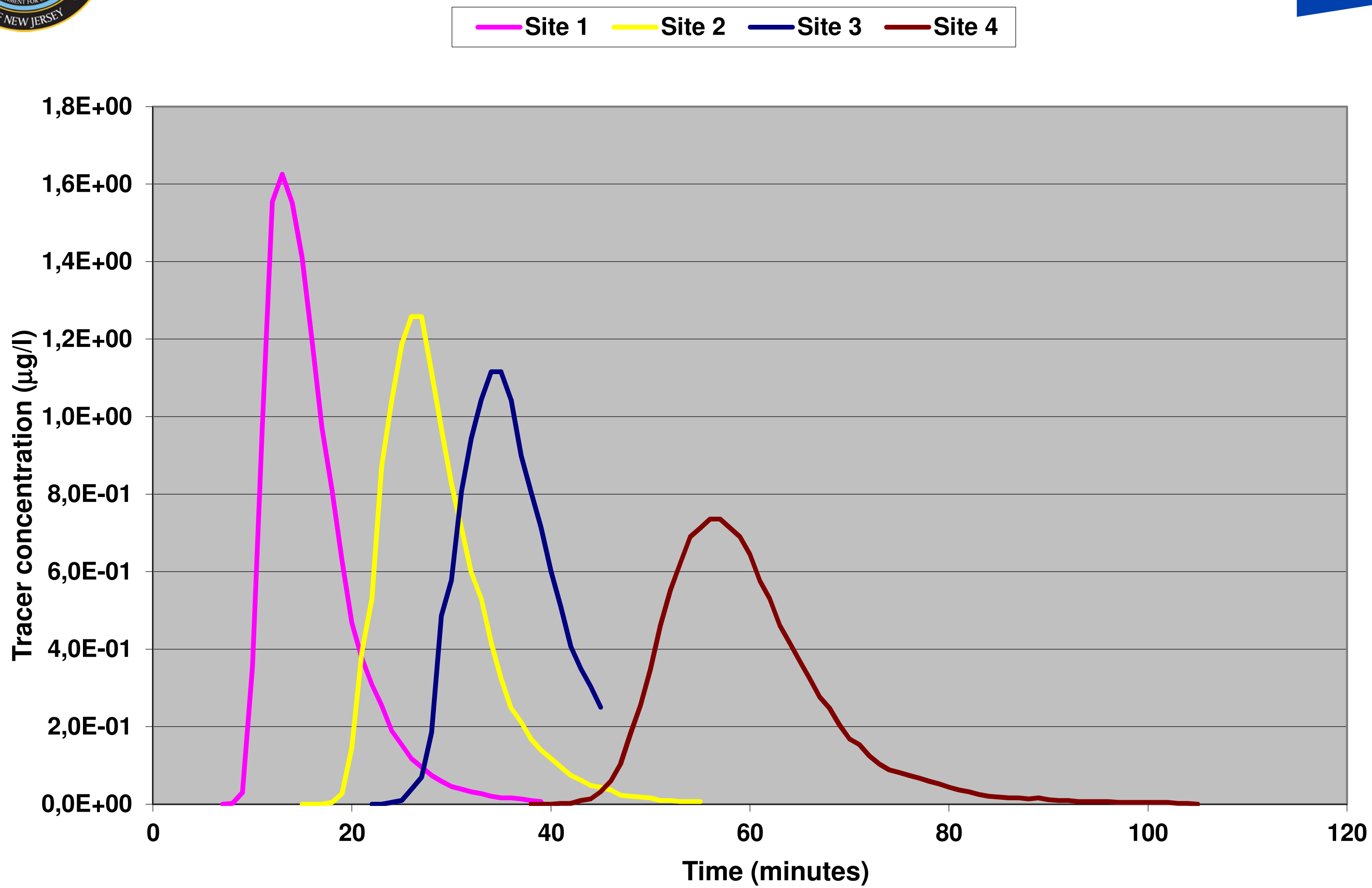
Background

- Pollutant transport in rivers
  - Simplest characterisation employs reach-average values of velocity, U, and dispersion coefficient, D
  - In principle, U and D are most reliably estimated using a tracer experiment
    - Discrete release of tracer
    - Observe temporal tracer concentration profiles
    - Analysis of profiles yields U and D
  - Undertaking several experiments allows U and D to be correlated with stream flow

Background

- **Method of moments (MoM)**
  - **Traditional approach**
  - **U and D are proportional to rates of change of centroid time and variance of concentration profiles, respectively**
  - **Major weakness is that results (particularly for D) are unreliable when concentration profiles are incomplete**

Background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6,0E-01
4,0E-01
2,0E-01
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Tracer concentration (µg/l)
0
20
40
60
80
100
120
Time (minutes)

Background

- **Aim of presentation**
  - **Introduce concept of similarity of tracer profiles**
  - **Show how the application of the concept can improve the quality of the information derived from the profiles**

Murray Burn Experiments

- **Study reach**
  - Length 184 m
  - Mean width 2.4 m
  - Mean slope 0.009

- **Tracer experiments**
  - Rhodamine WT released 236 m upstream of reach
  - Water samples collected at regular time intervals
  - Laboratory analysis (Turner Designs Fluorometer)
  - Sampling designed to capture well resolved and complete profiles at both ends of the reach
  - 6 experiments during autumn 2009

Murray Burn Experiments

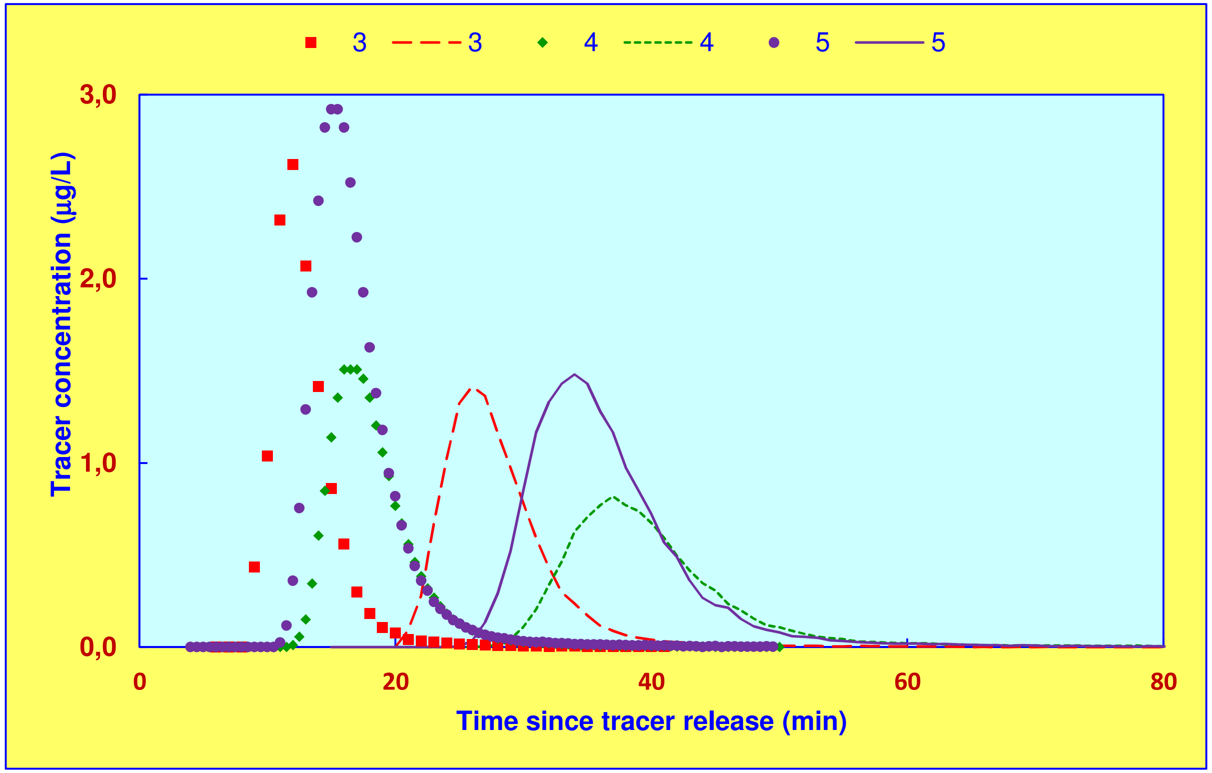
Initial mixing reach

Upper part of study reach

Lower part of study reach

Similarity

- **Observed profiles**

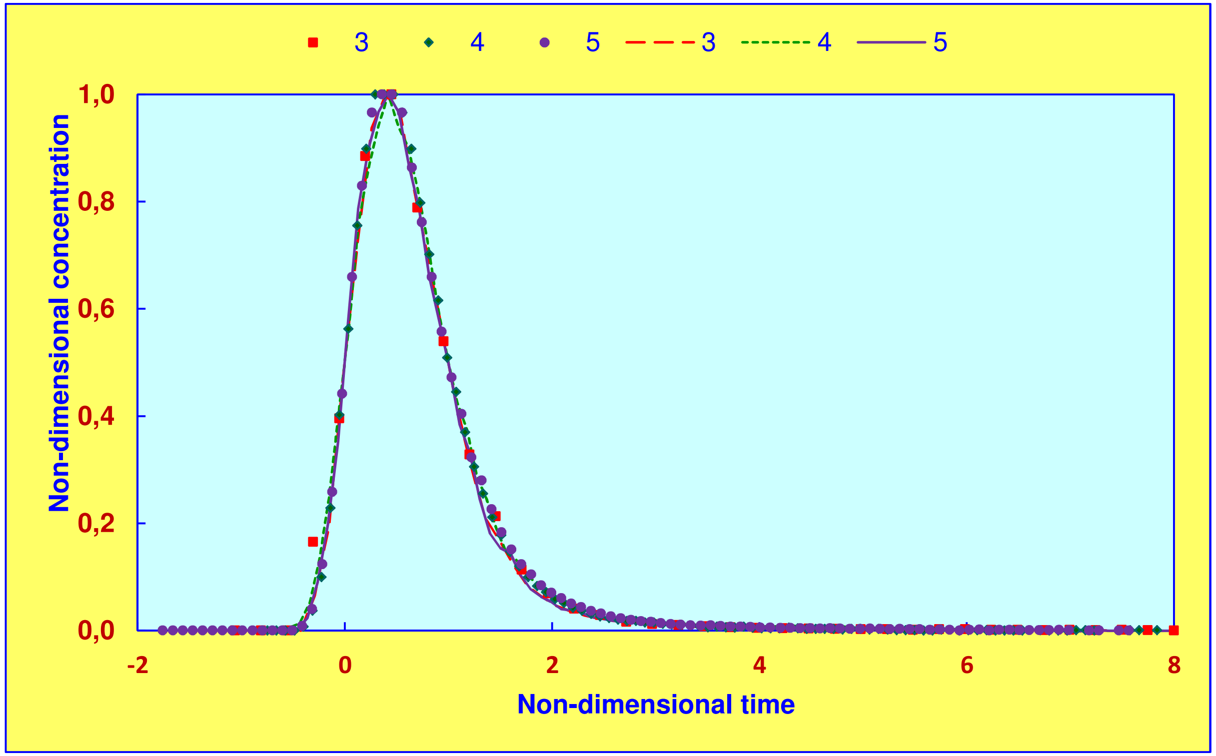


Similarity

- **Transformation of concentration-time profile**
  - **Concentration** $$C = \frac{c}{c_p}$$
    - **Where:** C is non-dimensional concentration
      c is concentration (mg/l)
      c_p is peak concentration (mg/l)
  - **Time** $$\tau = \frac{t - t_L}{t_T - t_L}$$
    - **Where:** τ is non-dimensional time
      t is time (s)
      t_L is time of leading edge [$c = 0.5c_p$] (s)
      t_T is time of trailing edge [$c = 0.5c_p$] (s)

Similarity

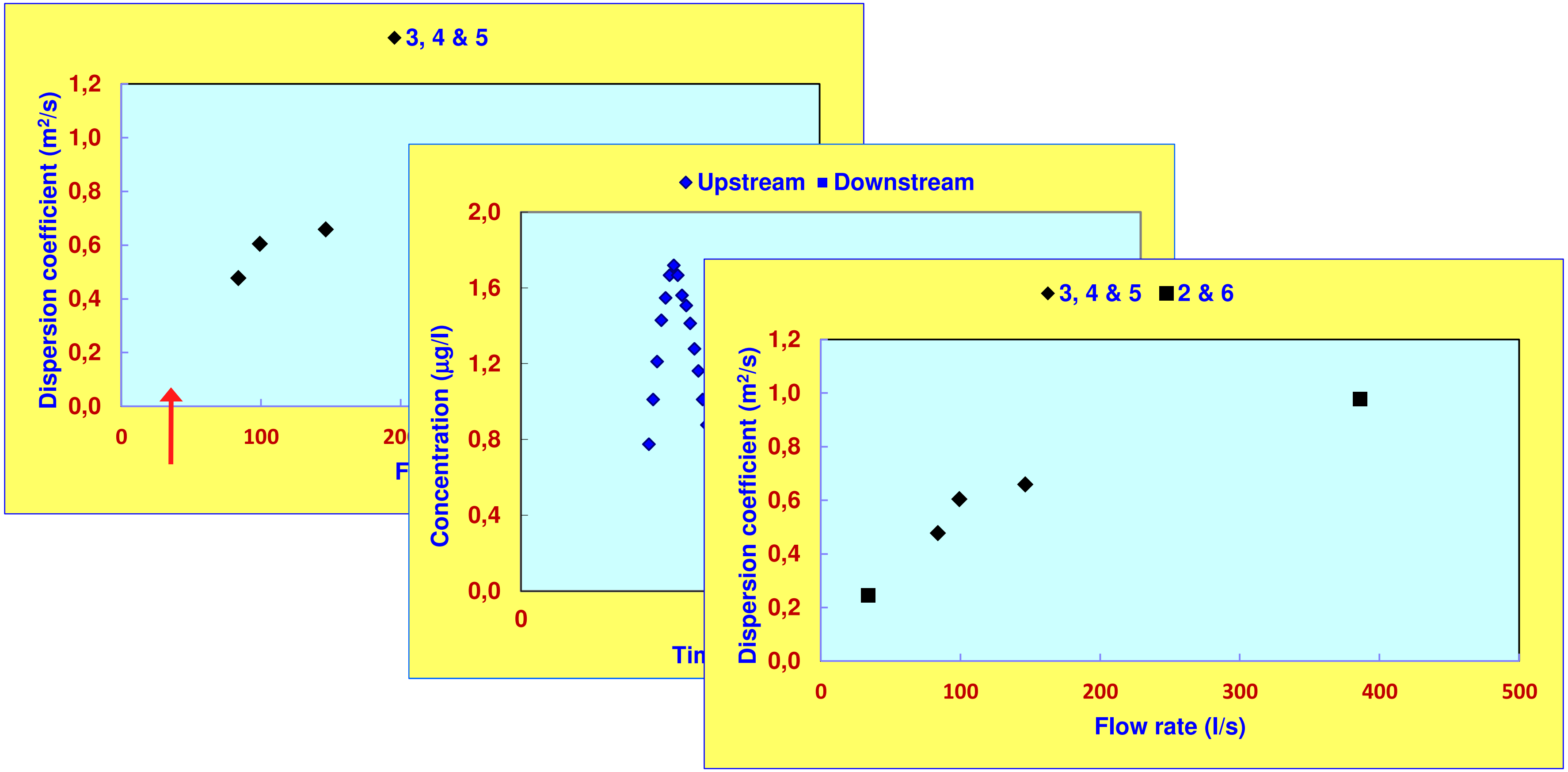
- **Non-dimensional profiles**



- A common shape, therefore the same properties
- Each profile yields an estimate of the properties of the common shape
- More robust properties of the common shape found by averaging over all profiles
- Use properties of common shape to evaluate U and D for each experiment
- Enhanced method of moments (EMoM)

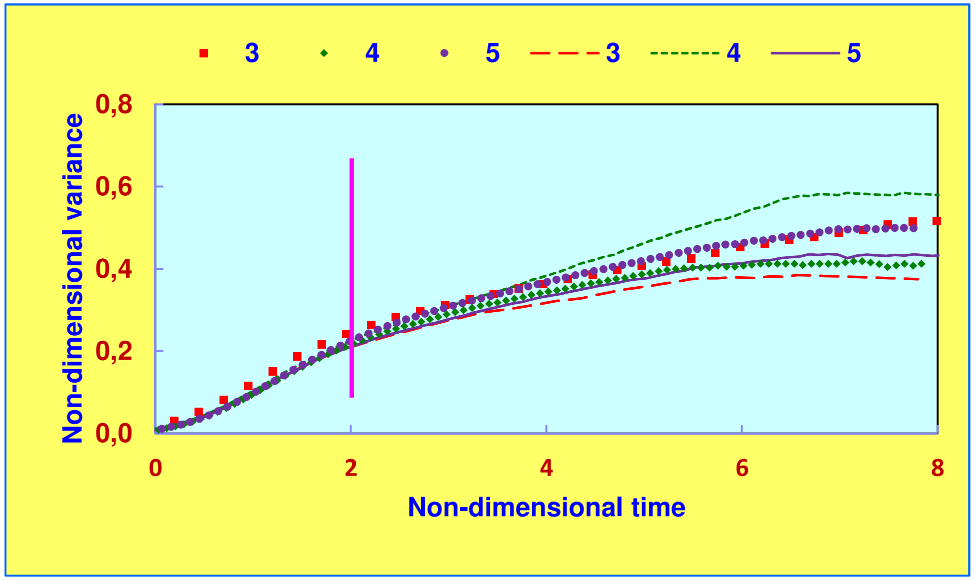
Application

- **Determining the flow dependence of D**



Afterthoughts ….

- The written paper also discusses one crucial aspect of MoM and EMoM that is exposed if the cumulative development of profile properties is examined:



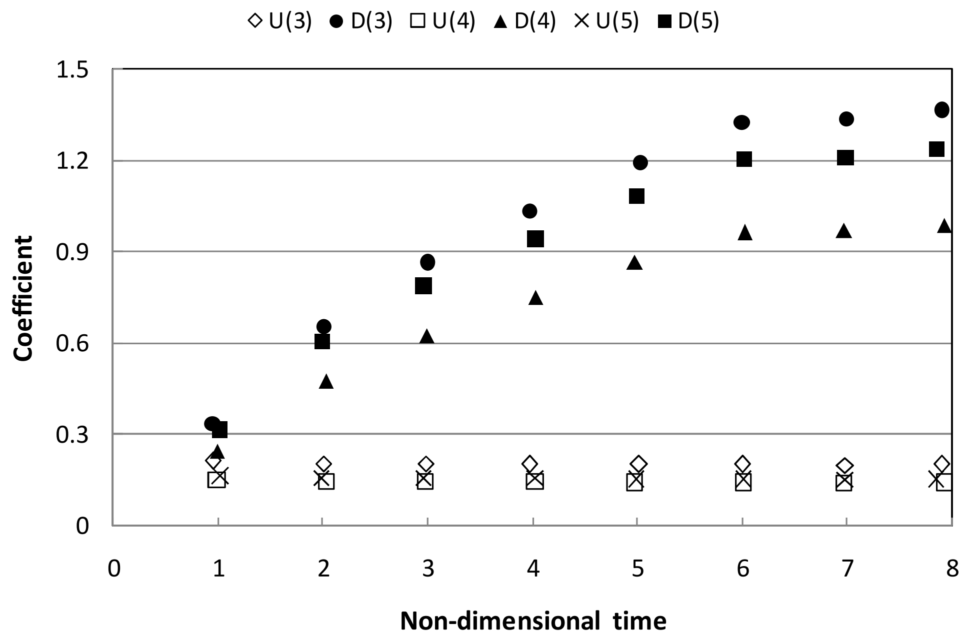
- At what value of τ should profile properties be evaluated?
- Hypothesis:
  - $0 < \tau < 2$ - shear flow
  - $\tau > 2$ - transient storage
- So evaluate properties:
  - at t = 2 for D
  - at t = 8 for ??

Conclusions

- The concept of similarity of tracer profiles is not a new idea, but it has not yet been fully exploited
- Similarity enables information from several tracer profiles to be pooled, thus providing a mechanism for enhancing the application of the method of moments to poor quality data
- Improved estimation of dispersion coefficients in rivers is a likely consequence

Barbecue time!

Profile properties



- **Comments**
  - **U decreases slightly as τ increases, but D increases significantly as τ increases**
  - **Asymptotic values achieved for $\tau > 6$**
  - **Weakness of MoM exposed (D doubles for $\tau = 2$ to 6)**
  - **Interpretation of U and D changes as τ increases**