Flow dependence of the parameters of the transient storage model

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Content

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- Transient storage model
- River Brock experiments
- Calibration of transient storage model
- Flow dependence of model parameters
- Conclusions and further work

Background

- **River pollution modelling**
  - **Given information on pollutant concentrations at an upstream location, predict future conditions at one or more locations downstream**
  - **Several approaches developed since 1960s:**
    - **Advection-dispersion**
    - **Transient storage**
    - **Aggregated dead zone**
    - **Unitized peak**
    - **Similarity**

Background

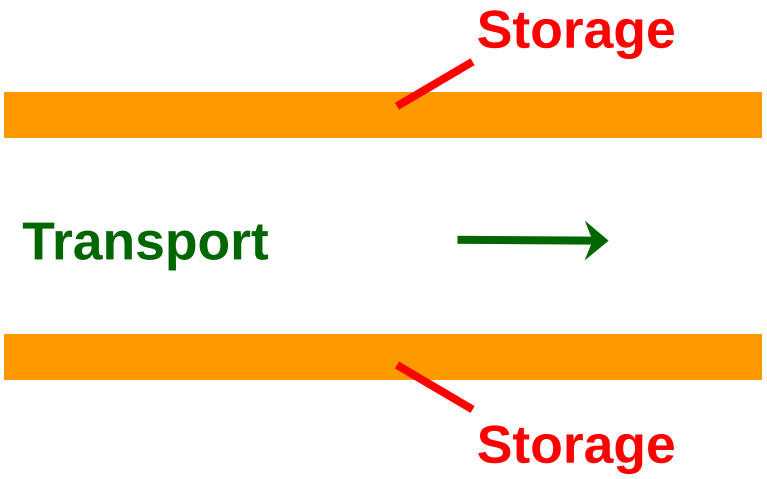
- **Stream ecology**
  - **An interest in improving the health of riverine ecosystems has driven recent studies on stream metabolism and nutrient cycling**
  - **Transient storage zones are key locations for promoting the bio-geochemical conditions required to maintain good ecological status**
  - **Hence, using the Transient Storage Model to estimate the transient storage characteristics of rivers has become a popular strategy**

Background

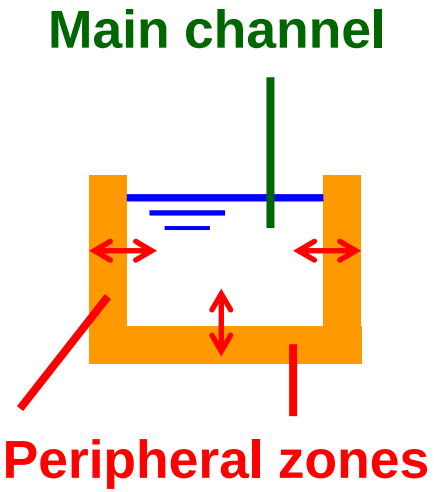
- **Aims of presentation**
  - **Introduce the Transient Storage Model**
  - **Illustrate how the model's parameters vary with river flow rate using River Brock tracer data**
    - **Very few previous such studies**
    - **Hart et al 1999 (20)**
    - **Gooseff et al 2003 (3)**
    - **Jin & Ward 2005 (15)**
    - **Camacho & Gonzalez 2008 (6)**

Transient Storage Model

- **Original physical concept**



Plan view



Cross-section

- **Transport: advection-dispersion in main channel**
- **Storage: trapping in, and exchange with, peripheral zones**

Transient Storage Model

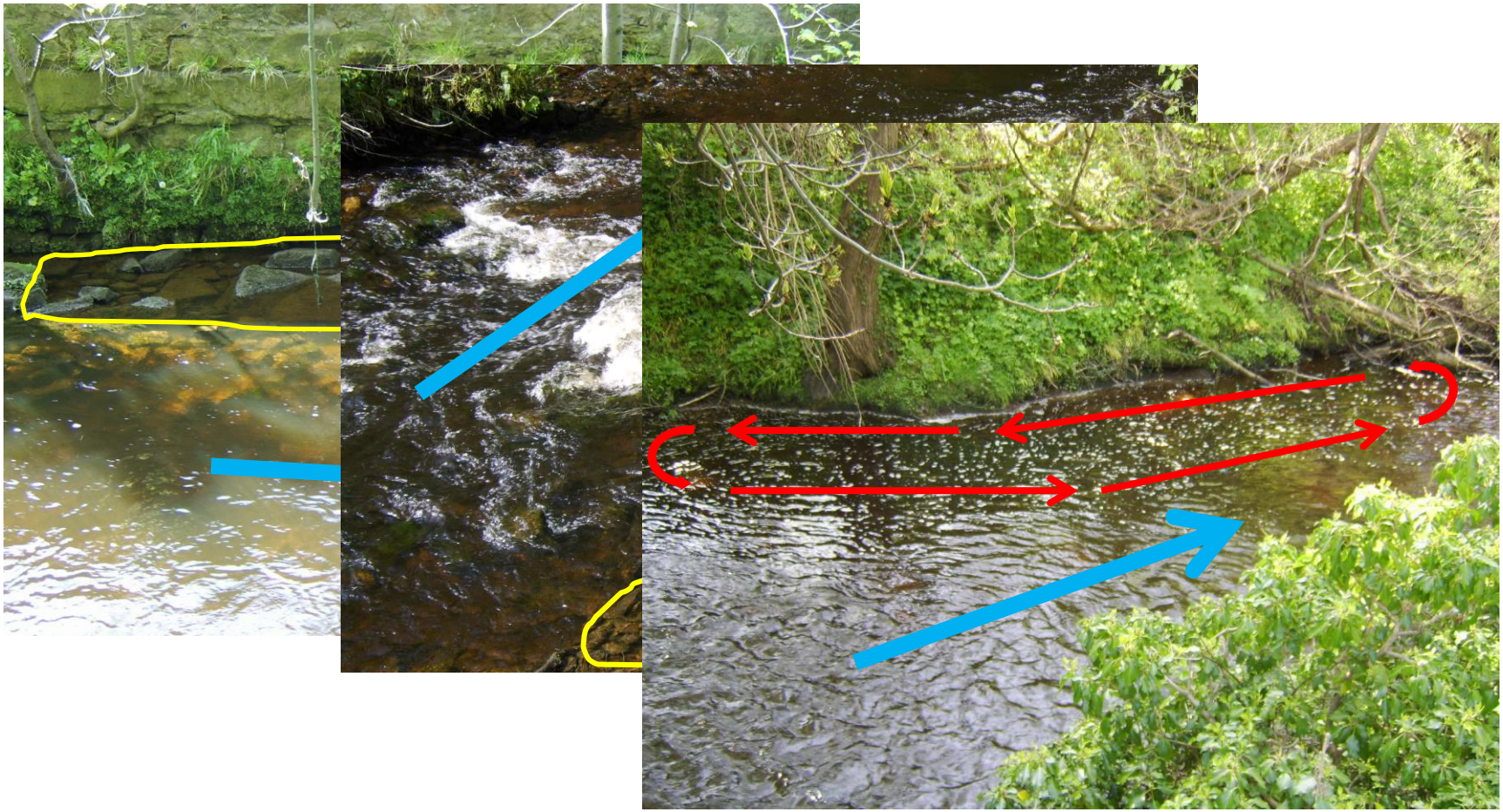
$$\frac{\partial C}{\partial t} + U\frac{\partial C}{\partial x} = D\frac{\partial^2 C}{\partial x^2} + k_1(S - C)$$

$$\frac{\partial S}{\partial t} = -k_2(S - C)$$

- C – pollutant concentration in main channel
- S – pollutant concentration in storage zones
- U – flow velocity in main channel
- D – dispersion coefficient in main channel
- k_1 – pollutant exchange rate (main channel to storage zones)
- k_2 – pollutant exchange rate (storage zones to main channel)
- x – longitudinal space co-ordinate
- t – time

Transient Storage Model

- **Reality check**



River Brock Experiments

- **Study site**

River Brock Experiments

- **Study reach**

River Brock Experiments

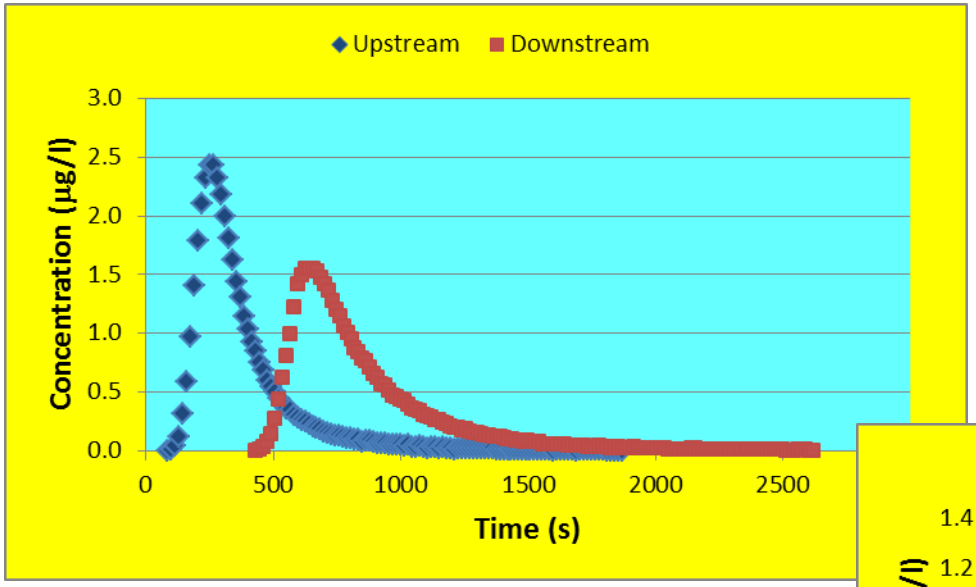
- **Study reach**

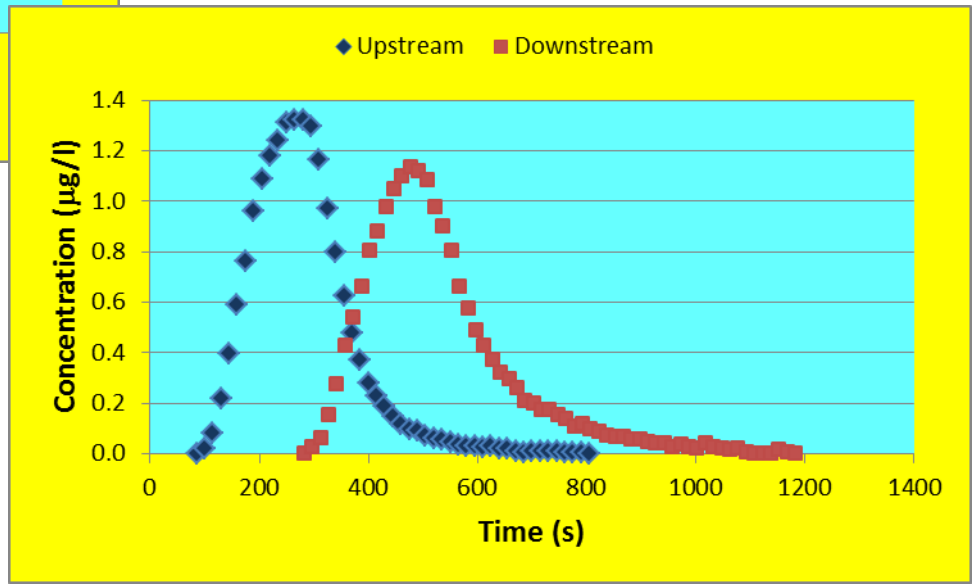
River Brock Experiments

- **Study reach**
  - **Length 128 m**
  - **Mean width 8.5 m**
  - **Mean slope 0.006**

- **Tracer experiments**
  - **25 experiments**
  - **Short-duration release of Rhodamine WT**
  - **Concentration-time profiles observed in main channel at both ends of reach**
  - **Flow rate range: 300 – 2000 L/s**
  - **Sampling interval 15 s**

River Brock Experiments

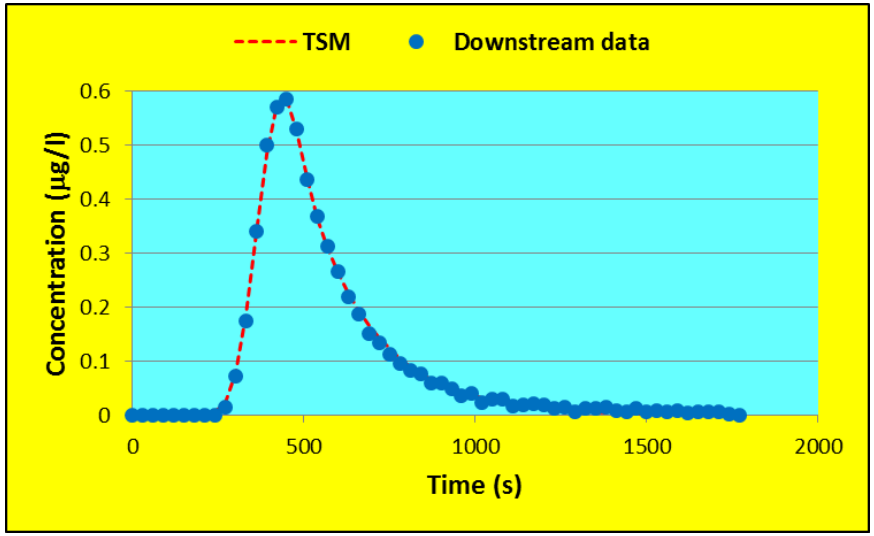




River Brock Modelling

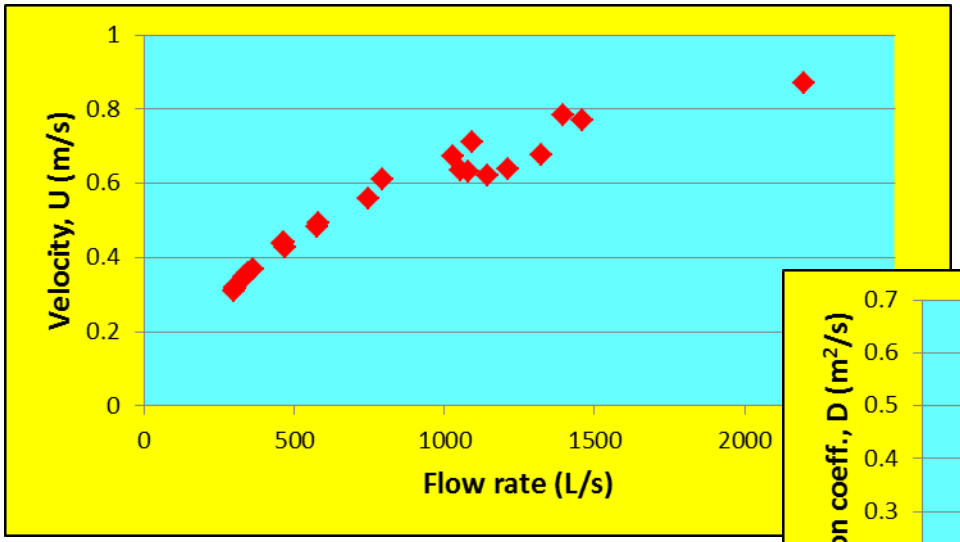
- **Parameter optimisation**
  - **Downstream temporal concentration profile simulated by the TSM was fitted to the corresponding observed profile**
  - **Modified Levenberg-Marquardt algorithm**

- **Typical fit**

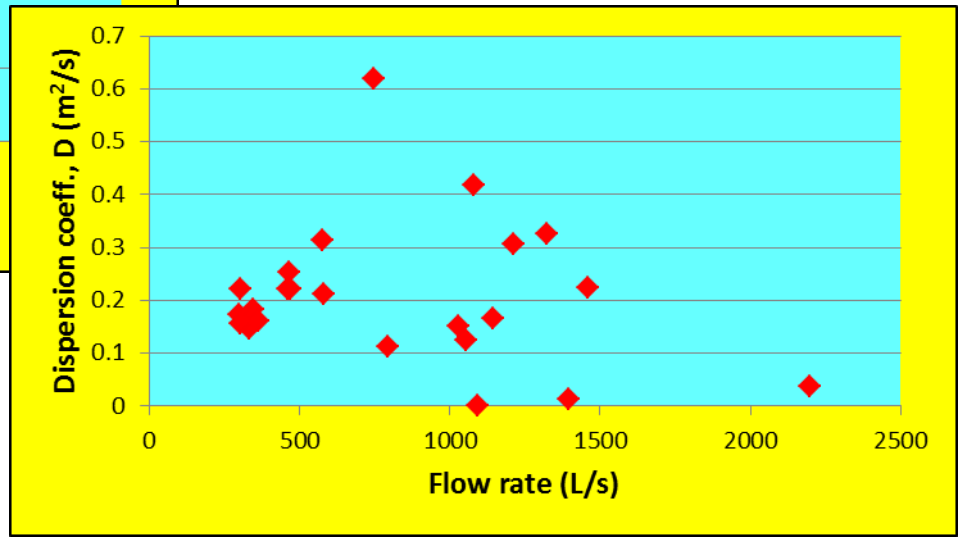


River Brock Modelling

- **Results from all experiments**



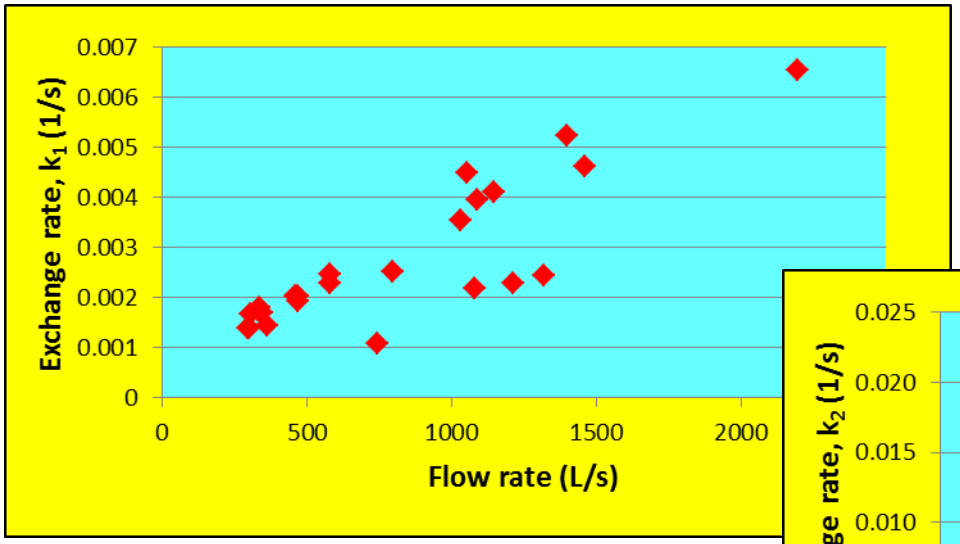
Values consistent with previous studies, but not trend



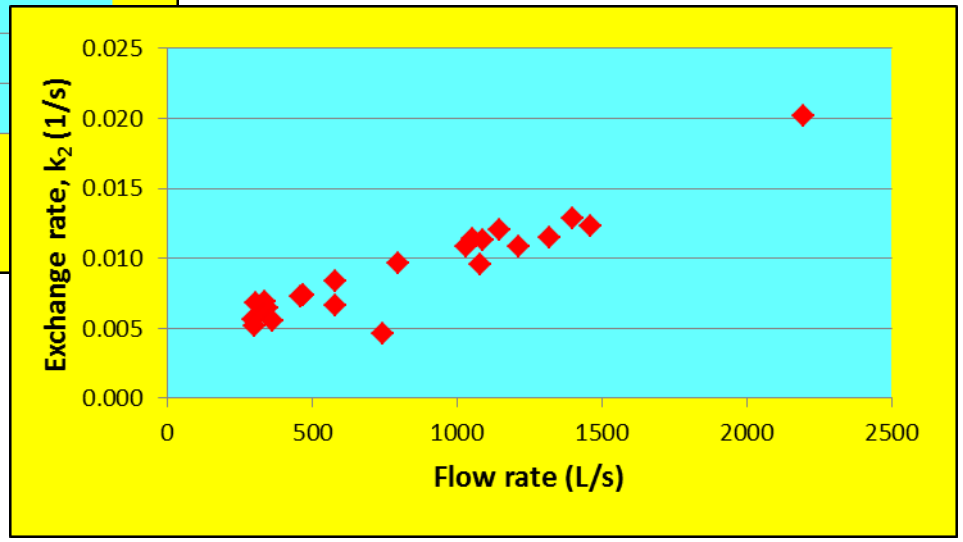
Values and trend consistent with previous studies

River Brock Modelling

- **Results from all experiments**



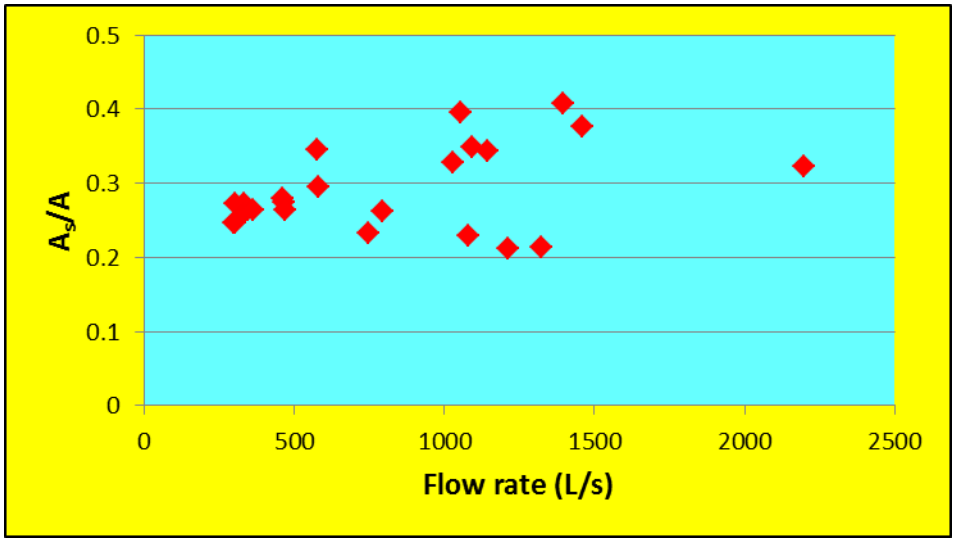
Values and trend consistent with most previous studies



Values and trend consistent with most previous studies

River Brock Modelling

- **Results from all experiments**

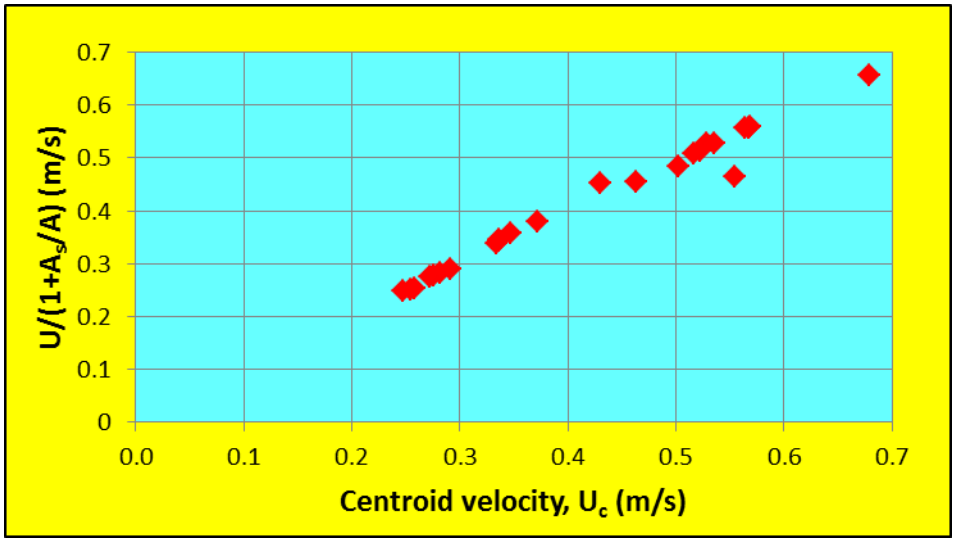


Values and trend consistent with most previous studies

River Brock Modelling

- **Reliability check**
  - **Analysis of TSM equations reveals a relationship between the centroid velocity, U_c, and the main channel velocity, U**

$$U_c = U/(1 + A_s/A)$$



River Brock Modelling

- **Initial conclusions**
  - **TSM parameters appear to be sound; values and variation with flow rate being consistent with most previous work**
  - **Dispersion coefficient behaviour is unusual**

- **Further work**
  - **Sensitivity to discretisation**
  - **Sensitivity to profile tails**
  - **Predictive model**
  - **Empirical equations for parameters**
  - **3 parameter model**