

# Two technological advances in continuous monitoring of suspended sediment transport and particle characteristics

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## EXTENDED ABSTRACT

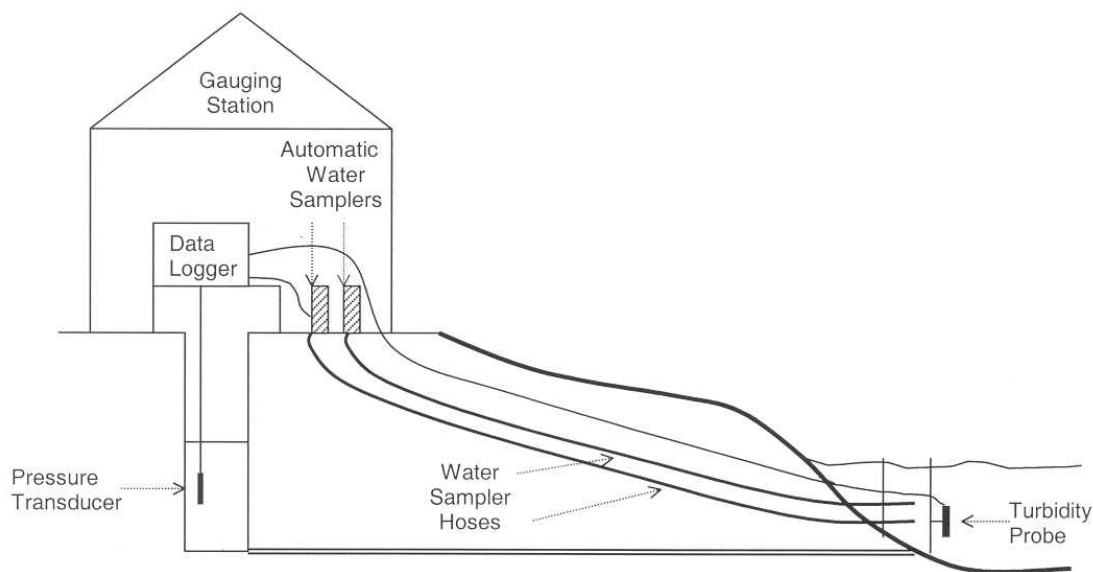
This paper describes two instrumental developments in the field of fluvial suspended sediment monitoring and describes the significance of their data outputs to understanding sediment dynamics. The technologies are: (1) WISER (Wallingford Integrated System for Environmental monitoring in Rivers); and (2) OPTIMO (Optical Technology for Intelligent Monitoring Online). This paper focuses on the WISER system and its application in extreme urban environments where the extremely rapid flow and sediment transport response to rainfall necessitates the use of an intelligent sampling strategy.

Most studies of suspended sediment transport adopt a continuously recording turbidimeter; an optical device determining turbidity from the scattering of light. However, as well as reflecting the suspended sediment concentration, turbidity is also influenced by the size distribution and optical properties of the suspended particles and the water colour (e.g. Foster *et al.*, 1992; Gippel, 1995; Lawler, 1995). Therefore, turbidity is usually calibrated to suspended sediment concentration determined from a concurrent river water sampling programme on a site by site basis. Water and sediment samples are often taken from the river using an automatic water sampler.

The WISER system was developed to allow the adoption of a range of efficient sampling strategies (Evans *et al.*, 1997). The technology enables manual and time triggered automatic water sampling to be supplemented by sampling usually triggered in response to stage and/or turbidity threshold values being exceeded. This allows water samples to be collected during short lived flow events when significant sediment transport occurs (90% of a river's annual sediment transport usually occurs in less than 25% of the time e.g. Old *et al.*, 2002; Wass & Leeks, 1999). It is essential to sample high sediment concentrations during flow events to allow the calibration of the full range of turbidity measurements. However, the WISER system can accommodate a wide variety of online sensors that may be used to trigger an automatic water sampler.

The WISER technology has been used successfully in a two year study (1999 to 2001) of fine sediment transport in Bradford Beck, UK. This research was part of the Natural Environment Research Council's Urban Regeneration and the Environment (URGENT) thematic programme. Bradford Beck drains the small (58 km<sup>2</sup>), steep and highly urbanised catchment of Bradford. In this application the WISER technology, integrated a range of commercially available equipment as shown in Fig. 1. It included a pressure transducer, a turbidity sensor, two automatic water samplers and a data logger.

Fig. 1. Wallingford Integrated System for Environmental monitoring in Rivers (WISER)



An example of the rapid response of flow and sediment transport, in Bradford Beck, to rainfall is shown in Fig. 2. River flow and sediment transport data are presented for Shipley Weir; a site close to the catchment outlet. The rainfall data on Fig. 2 were recorded at Lister Park which is approximately 2 km from Shipley Weir. Frequent fouling of turbidity sensors with algae, litter and sanitary products resulted in many false triggers of samplers when turbidity activation was used. However, samplers triggered on a river stage basis operated successfully and this is recommended for urban streams. Fig. 3 illustrates successful sampling of an extreme flow event that occurred in Bradford Beck in response to an intense summer rainfall event (15 June 2001). Flow rose from  $0.4 \text{ m}^3 \text{ s}^{-1}$  to  $34.6 \text{ m}^3 \text{ s}^{-1}$  in just 15 mins and receded to  $3.3 \text{ m}^3 \text{ s}^{-1}$  within 1.25 hours. Unless field scientists are on site, it is unlikely that samples would be collected throughout such extreme and short duration flow events that are typical of many urban river systems.

Sampled suspended sediment concentrations are used to calibrate the continuous turbidity record. Fig. 4 illustrates the relationship between sampled suspended sediment concentration and turbidity in Bradford Beck (Shipley Weir) using data from January to June 2001. Although useable relationships are found in most river systems, significant scatter normally occurs about the regression line (Fig. 4). This is largely due to ambiguity in the interpretation of turbidity data as a result of temporal variability in the size distribution and optical properties of suspended particles.

A major aim of the OPTIMO technology is to contribute towards resolving this ambiguity in turbidity measurement. The technology measures characteristics of particulate suspensions using an optical sensor head with a series of multi-wavelength light sources and multi-angle detectors. Neural networks are used to calibrate OPTIMO output data to suspended sediment concentration (0-1000 mg/l) and the proportions of 4 particle size classes (0-3, 3-10, 10-20 and 20-120  $\mu\text{m}$ ). Although this new technology is at an early stage in field trials it is potentially a significant contribution to continuous, and more direct, monitoring of fluvial suspended sediment concentration and particle size.

Therefore, WISER and potentially OPTIMO represent significant developments in monitoring sediment transport. WISER has proven to be reliable and particularly useful in harsh urban environments where river flow and sediment transport are extremely responsive to rainfall. OPTIMO has the potential to contribute to resolving the ambiguity in turbidity measurements. It is likely that it will provide continuous suspended sediment concentration data with the added value of an indication of its particle size distribution.

Fig. 2. Rapid response of flow and sediment transport to rainfall in Bradford Beck (ShIPLEY Weir) from January to June 2001

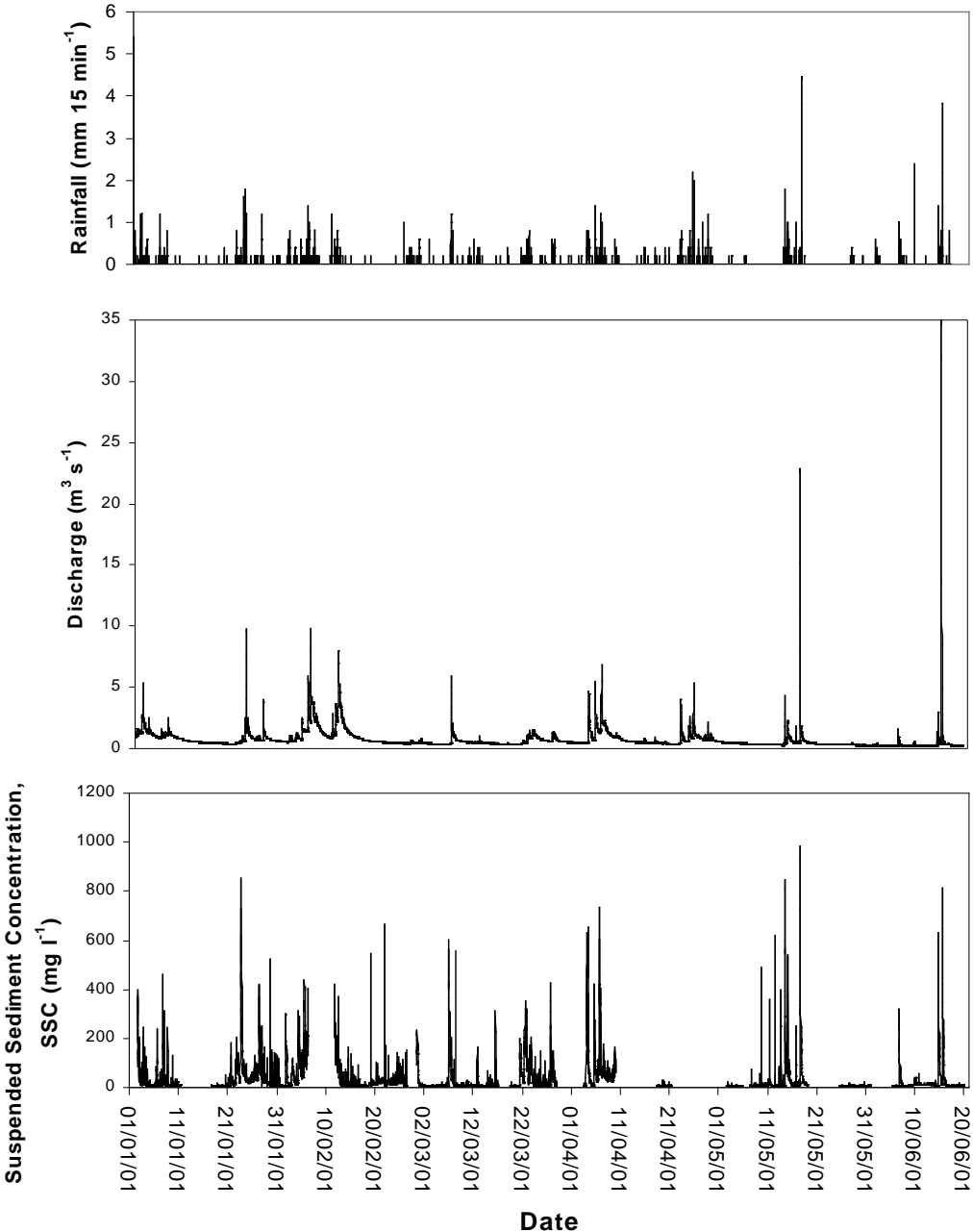


Fig. 3. Suspended sediment samples extracted from Bradford Beck (Shipley Weir) using the Wallingford Integrated System for Environmental monitoring in Rivers (WISER) during an extreme, short duration, summer flow event (June 15<sup>th</sup> 2001)

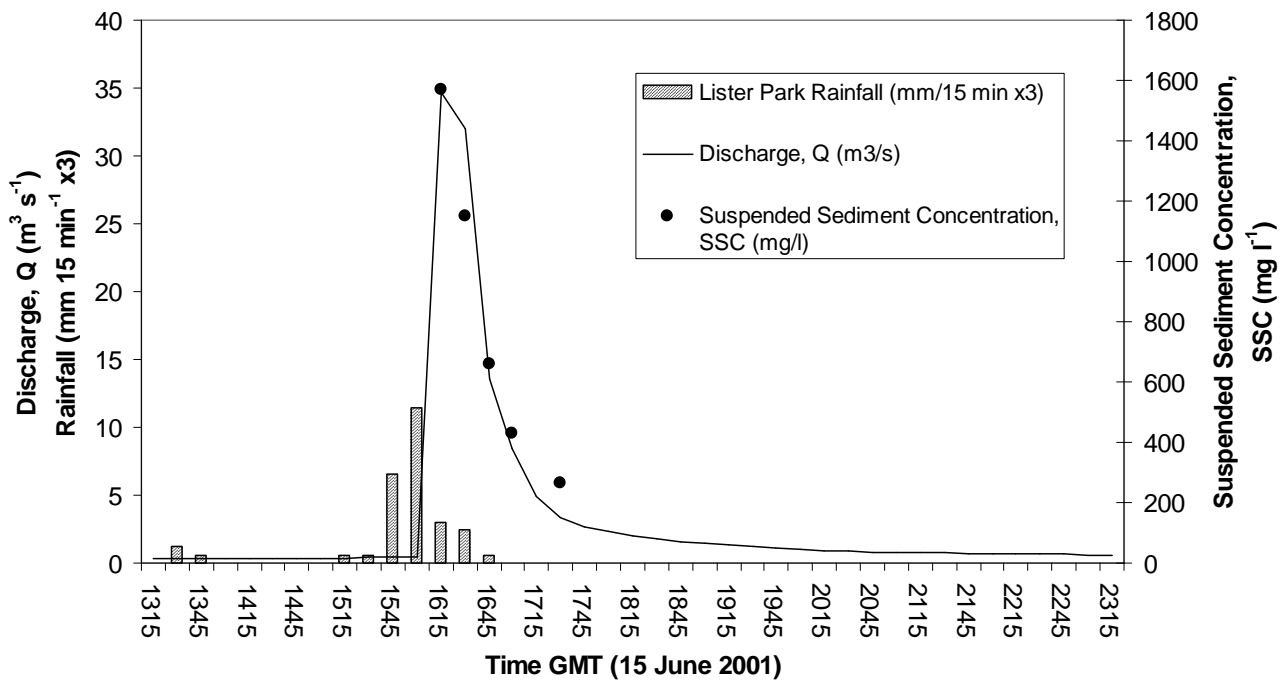
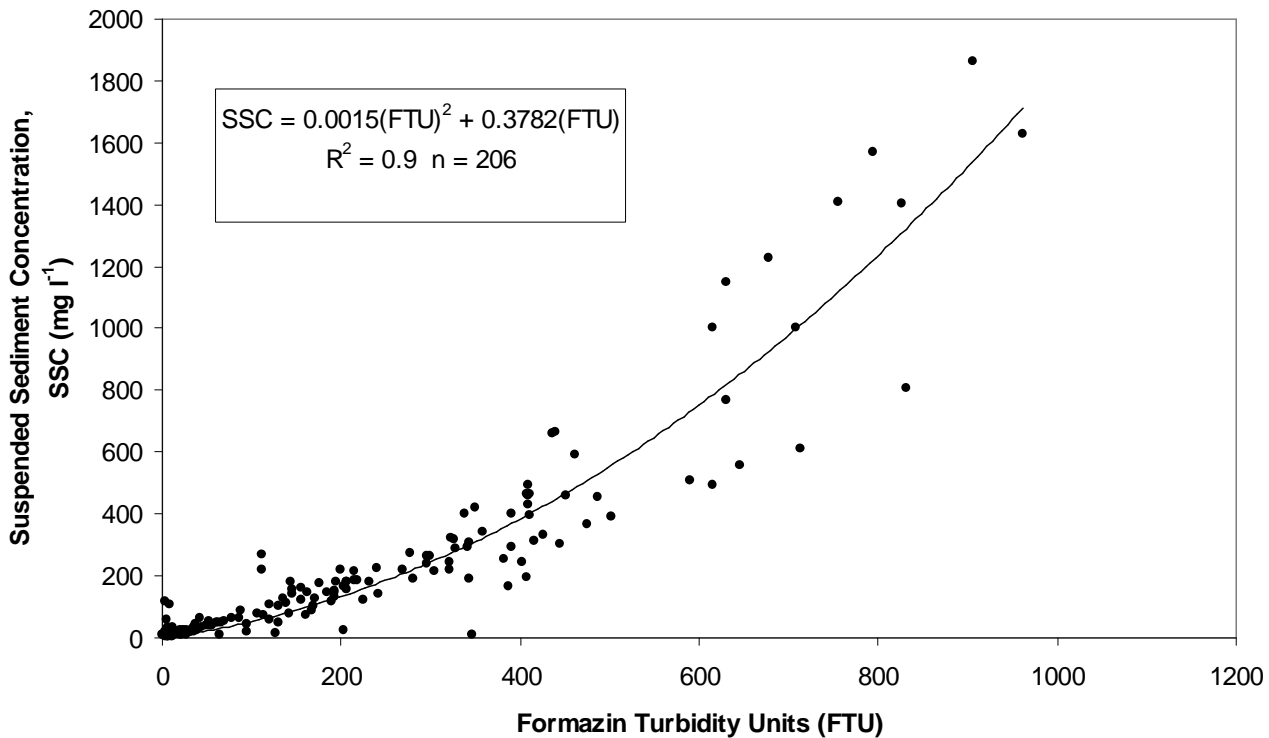


Fig. 4. Relationship between turbidity and sampled suspended sediment concentration in Bradford Beck (Shipley Weir) from January to June 2001



## REFERENCES

Evans, J.G., Wass, P.D. & Hodgson, P. (1997) Integrated continuous water quality monitoring for the LOIS rivers programme. *Sci. Total Environ.*, **194/195**, 111-118.

Foster, I.D.L., Millington, R. & Grew, R.G. (1992) The impact of particle size controls on stream turbidity measurement; some implications for suspended sediment yield estimation. *Int. Assoc. Hydrol. Sci.*, **210**, 51-62.

Gippel, C.J., 1995. Potential of turbidity monitoring for measuring the transport of suspended solids in streams. *Hydrol. Processes*, **9**, 83-97.

Lawler, D.M. (1995) Turbidity and Nephelometry. *Encyclopedia of Analytical Science.*, **9**, 5289-5297.

Old, G.H., Leeks, G.J.L., Packman, J.C.P., Smith, B.P.G., Goodwin, T., Guymer, I., Hewitt, N., Holmes, M., Shepherd, W. & Young, A. (2002) Fine sediment dynamics in urban systems. Report submitted to Environment Agency (North East Region).

Wass, P.D. & Leeks, G.J.L. (1999) Suspended sediment fluxes in the Humber catchment, UK. *Hydrol. Processes.*, **13**: 935-953.