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# River flow and associated transport of sediments and solutes through a highly urbanised catchment, Bradford, West Yorkshire

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**Abstract**

The hydrological characteristics of catchments become drastically modified in response to urbanisation. The total contributions and dynamics of runoff, suspended sediment and solutes may change significantly and have important implications downstream where they may affect flooding, instream ecological habitat, water quality and siltation of river channels and lakes. Although an appreciation of the likely hydrological changes is crucial for effective catchment management they are still poorly understood. In this paper we present data from a network of river monitoring stations throughout the heavily urbanised Bradford catchment, West Yorkshire. Sites are upstream, within and downstream of the highly urbanised central part of the catchment. Flow, turbidity (calibrated to suspended sediment concentration) and specific conductance (surrogate for solute concentration), logged at 15-min intervals, are presented for a 12-month period (June 2000 to June 2001). The total amounts and dynamics of flow, solute and suspended sediment transport were investigated.

Estimated total flow and suspended sediment transport for the monitoring period were found to be high in response to the high total rainfall. Flow and sediment transport regimes were extremely 'flashy' throughout the catchment and became increasingly flashy in a downstream direction. Suspended sediment discharged from the Bradford subcatchment makes an important contribution to downstream sediment transport on the river Aire at Beal. Data suggest that the urbanised part of the Bradford catchment is extremely important in contributing solutes to the Beck (river). Although flow and sediment are also contributed to the Bradford Beck in the urbanised part of the catchment the data suggest that significant amounts may enter the combined sewer system and bypass the river. Understanding the spatial and temporal variations of flow and the transport of suspended sediment and solutes in rivers in urbanized subcatchments is crucial to their effective management and monitoring. Furthermore, this knowledge may be extremely important to the management and monitoring of downstream rivers in large scale mixed catchments.
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## 1. Introduction

A large number of catchments in the UK are affected by urbanisation (Marsh and Lees, 2003). During this process semi-natural vegetated landscapes become predominantly impervious surfaces with artificial stormwater drainage systems that efficiently divert surface runoff to river channels (Hall, 1984). Sewer systems

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carry foul sewage to sewage treatment works and, in the case of combined sewer systems, foul sewage and surface runoff are transported together. During periods of high rainfall combined sewer systems are designed to overflow into river channels via Combined Sewer Overflows (CSOs). Surface runoff draining via storm-water systems and CSO spills are important sources of sediment for urban rivers (Ashley et al., 1992; Ellis, 1979).

This paper adds to current scientific knowledge on the flow and transport of suspended sediment and solutes of urban rivers by presenting high resolution data from a network of sites in the highly urbanised Bradford catchment, UK. This knowledge is vital for the effective future management and monitoring of urban river systems and their wider catchments. A detailed field monitoring programme was necessary as the authors are unaware of suitably long and high resolution water quality dataset from a network of sites throughout an urban catchment. Specifically, the objectives of this study were to: (1) estimate total annual flow and sediment transport at sites along Bradford Beck (river) and illustrate their variability; (2) demonstrate the downstream significance of sediment discharged from the Bradford catchment; (3) consider the changes in flow and transport of sediments and solutes along Bradford Beck using contiguous data from selected sites; and (4) estimate specific runoff and sediment yield at these sites.

## 2. Study area and methodology

### 2.1. Study area

Research was undertaken in the small (58 $km^2$), steep and heavily urbanised catchment of Bradford Beck (West Yorkshire) (Old et al., 2003). The downstream point of the study catchment was Shipley Weir [National Grid Reference (NGR): SE151375]. Bradford has a population of ~259 000 (4465 persons $km^{-2}$). A map of the catchment is presented in Fig. 1. Mean annual rainfall (1983–1995) for the catchment is 915 mm and mean river flow in the Bradford Beck at Shipley Weir is 0.65 $m^3$ $s^{-1}$ (Marsh and Lees, 2003). The river channel is least heavily modified in the upper western part of the catchment; elsewhere it has been culverted. The Bradford Beck has a steep average gradient of >0.0035 (from 1:50 000 map). The heavily urbanised and industrialised city of Bradford lies in the centre of this catchment, ~3 km upstream of the confluence of the Bradford Beck and the River Aire.

The quality of water in Bradford Beck is poor as a result of a combination of urban pollution sources including surface water runoff, drainage from contam-

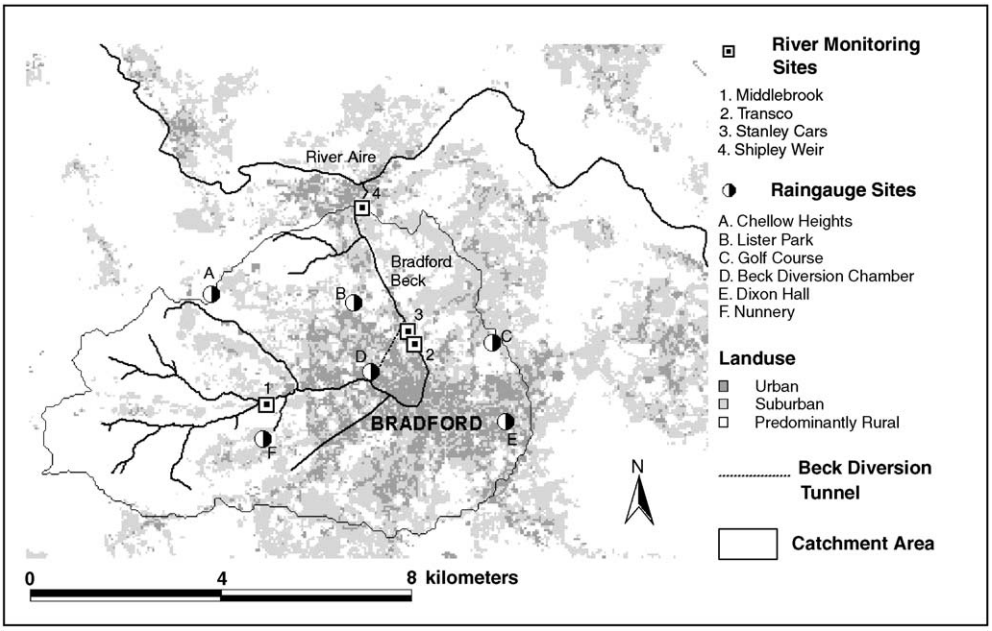


Fig. 1. Map of the Bradford catchment illustrating locations of rain gauges and river monitoring sites.

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