Investigation of the use of a SUDS Management Train to reduce flooding in an urban environment

Craig Lashford, Dr Susanne Charlesworth, Dr Matthew Blackett, Frank Warwick

SUDS Applied Research Group, Coventry University, CV1 5LW
Tel: +44. 2476 887688 Fax: +44 2476 888400,
craig.lashford@coventry.ac.uk

Summary: The project aims to examine the possibility for a sustainable drainage system (SUDS) management train at the proposed Canley regeneration plan, Coventry. *WinDes*® drainage software will be used to simulate rainfall to examine areas that would be highly susceptible to flooding or ponding. The software will then be used to input differing SUDS devices into the plan to investigate their benefits for runoff reduction. Multiple combinations of devices will be linked together to assess their use as a management train to ultimately provide a 'best fit' scenario for Canley.

KEYWORDS: Canley, *WinDes*®, flooding, SUDS management train, runoff reduction

1. Introduction

This project intends to assess the capabilities of a sustainable drainage system management trains ability to reduce both fluvial (river) and pluvial (rainfall) flood risk. SUDS aim to change the principle that water should be rapidly transported away from towns and cities (Jones and Macdonald, 2007). They mimic the natural hydrological processes associated with water flows which have been lost due to the high rate of urbanisation and impermeable surfaces (Semadeni-Davies *et al*, 2008). A SUDS management train is a process whereby SUDS devices are connected rather than each device being utilised as a standalone unit (Fig 1).

In the last ten years in England flooding has been in the spotlight due to the risk it poses to people and infrastructure. It is estimated that six million people live at risk of flooding (Carter *et al* 2009) with approximately 1.7 million homes at risk (Treby *et al* 2006). The problem is exacerbated by the increasing need for new development, known as urbanisation which has occurred since the 18th century as the industrial revolution saw a need for an increase in housing and development (Wood, 1990).

A change in land use results in an increase in impermeable surfaces, such as roofs and roads (Dale, 2005). A common material used for development is asphalt which has a runoff co-efficient of 0.95, therefore producing large amounts of runoff (Newson, 1994). Additional impacts of urbanisation are that soil becomes compacted and there is a change in vegetation which reduces the land's ability to infiltrate storm water effectively, increasing the amount of overland flow. Furthermore urbanisation results in the implementation of a hydraulically efficient pipe based drainage system (Elliot and Trowsdale, 2007) which creates high peak river flows. Due to the efficient nature of a pipe based system, the lag time between a rainfall event and runoff reaching the river is reduced and results in an estimated increase of 75% of storm water in stream flow (Semademi-Davies *et al*, 2008).

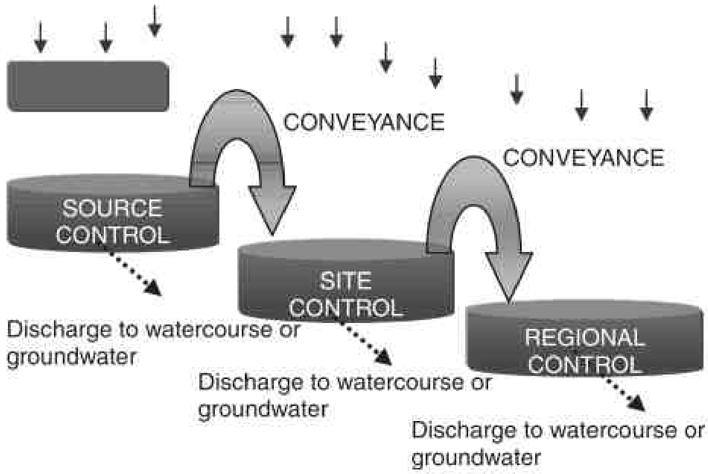

Figure 1: A SUDS management train
(Kirby, 2005)

A management train sets out a plan to deal with runoff. A successful management train (Fig 1) starts with source control; SUDS that tackle water directly after precipitation. Runoff is likely to be lost at this point through infiltration to either the water course or the groundwater. What remains would be conveyed to a site control. Site control devices deal with small amounts of runoff but are components that can again allow for infiltration to the surrounding soils and pollutant removal. The remaining water is then again conveyed to another site for regional control. These SUDS components usually deal with high volumes of water and are the last point to deal with runoff. They should allow for moderate levels of pollutant removal, although much should already have been filtered out. Detention basins are an example of a regional control that allow for high volumes of water detention. After this step, it is probable that the water would slowly be released to a water body or would infiltrate out of the system (Kirby, 2005).

A computer program, *WinDes®* will be used to evaluate the capabilities of the SUDS management train. The chosen site is the proposed Canley Regeneration Plan (WSP Environmental Ltd, Coventry City Council, 2008) which consists of a total of 710 new dwellings being developed across parkland and brownfield sites. Development at this scale which reduces green sites therefore reducing infiltration would benefit from SUDS to allow for more natural, slower flows to a water course, reducing the potential for flooding (Charlesworth, 2010).

2. Methodology

2.1 Study Area

The site chosen for the study is a 16 ha site at Canley (Figure 2), an area located approximately 2 miles west of Coventry city centre.

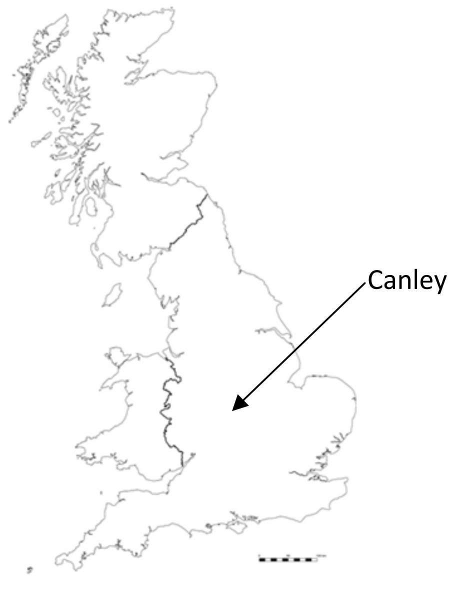

Figure 2: A site location of Canley, Coventry
(Ordnance Survey, 2011)

The site is subject to a regeneration proposal (Figure 3) to demolish 30 of the existing houses and replace them with a further 731 dwellings (WSP Environmental Ltd, Coventry City Council, 2008). The main site for change is a local park that will see over 250 houses developed, a public house, a restaurant and a motel. The flood risk assessment (Halcrow Group Limited, 2009) suggested the need for SUDS at the site although gave no indication of which devices or where they can be implemented. The site characteristics and underlying clay lithology (Coventry City Council, 2008) limit the sites ability for infiltration and therefore the effectiveness of infiltration SUDS.

Figure 3 The Canley Regeneration Plan
(WSP Environmental Ltd, Coventry City Council, 2008)

2.2 Method Used

This project adapts the methodology of Viavatenne *et al* (2010) who simulated runoff reduction for individual SUDS devices at a site in Birmingham. Firstly, *WinDes*® is the chosen package as it has a specialist SUDS selection tool allowing for rainfall to be simulated across a site, giving runoff reduction values. Secondly, where Viavatenne *et al* (2010) evaluated each device and their benefits individually, this project will investigate the use of a management train.

To generate the results, 1m resolution light detection and ranging (Lidar) data of Canley will be input into *WinDes*® to ascertain areas that are likely to be susceptible to ponding or flooding. This will give both an indication of where flooding is likely to occur and also the potential volume of runoff. Multiple connected SUDS devices will then be input into the model to determine the probable reductions in runoff which will generate a reduction value for the management train.

3. Expected Results

As the research is at an early stage, no results have been generated yet. However it is possible to predict the results that are likely to be produced and the impacts that they can have.

From a literature review undertaken for the study, it would be expected that certain SUDS devices, as set out by CIRIA's SUDS manual C697 (Woods-Ballard *et al*, 2007) are more successful at reducing the possibility of flooding than others. Although their ability to reduce flows is generally acknowledged, the sites where they would suitably be deployed are not fully understood. It is likely that an effective management train would be able to reduce runoff significantly (Jefferies *et al*, 2009), however their arrangement and suitability for a 'best fit scenario' remains relatively unknown.

Green roofs are a device that involves vegetating a roof to reduce runoff rates and promote infiltration and will be considered at the first stage of the management train. They act successfully to reduce runoff at source level; when precipitation first falls to a surface. CIRIA C697 (Woods-Ballard *et al*, 2007) suggests that they work to a 'medium' level at reducing runoff peaks. If included in the design stage, all roofs could be 'greened'. Green roofs can also remove pollutants from runoff (van Woert *et al*, 2005).

The next step along the 'train' could be permeable paving, another device that act at source level. It is generally implemented in low frequency traffic zones and car parks. Permeable paving allow for water to be directly infiltrated through the voids in their surface to the underlying soil. It has been suggested that as an individual device, they can reduce runoff by up to 75% based on the best value from 150 different storm events (Viavatenne *et al*, 2010). Furthermore, permeable paving can improve runoff water quality (Scholz and Grabowiecki, 2007).

Swales are a vegetated drainage device which aid conveyance of water to another device or outlet structure and also allows for storage and therefore infiltration (Woods, Ballard *et al*, 2007). Swales can be sited next to roads and provide green space for the Canley site.

Detention basins create large stores of water after a runoff event. They allow for the slow release of water to the surrounding soils through infiltration therefore reducing runoff peaks and flow volumes at the water body (Travis and Mays, 2008). For this reason it is likely that they will be implemented at the site.

The project will assess whether, by combining these devices, a near total runoff reduction could occur and will investigate the number of each type of device required to achieve this.

4. Conclusion

The information generated from the project is beneficial for a range of sources. Developers and researchers have limited information currently available regarding the use of a management train for reducing runoff. Furthermore the regeneration plan is expected to commence in the near future and will require a drainage plan which incorporates SUDS. The project will provide a basis to demonstrate the benefits of creating a management train over stand alone devices but also the potential locations and use of SUDS at Canley.

5. Acknowledgments

Thanks go to Micro Drainage for supplying the *WinDes®* software. Further thanks are extended to BWB Consulting for their aid in training in *WinDes®* and for their overall support of the project.

6. References

Carter, J. White, I. Richards, J, 2009. Sustainability Appraisal and Flood Risk Management, *Environment Impact Assessment Review*, 29, 7-14

Charlesworth, S, 2010. A review of the adaption and mitigation of global climate using sustainable drainage cities, *Journal of Water and Climate Change*, 1 (3) 165-180

Coventry City Council, 2008. Geo-Environmental Desk Study Canley Regeneration Area, Coventry [online] <http://planning.coventry.gov.uk/portal/servlets/AttachmentShowServlet?ImageName=791758> [17 October]

Dale,M, 2005. Impact of Climate Change on UK Flooding and Future Predictions, *Water Management*, 158, 135-140

Elliott, A. Trowsdale, S, 2007. A Review of Models of Low Impact Urban Stormwater Drainage, *Environmental Modelling and Software*, 22, 394-405

Halcrow Group Limited, Coventry City Council, 2009. Canley Regeneration Flood Risk Assessment – Addendum July 2009 [online] < http://planning.coventry.gov.uk/portal/servlets/AttachmentShowServlet?ImageName=817732> [15 September]

Jefferies, C. Duffy, A. Berwick, N. McLean, N. Hemingway, 2009. Sustainable Urban Drainage Systems (SUDS) treatment train assessment tool, *Water Science & Technology*, 60 (5) 1233-1240

Kirby, A., 2005. SuDS – innovation or a tried and tested practice?, *Municipal Engineer*, 158 115-122

Newson, M, 1994. *Hydrology and the River Environment*, Oxford: Clarendon Press

Ordnance Survey, 2011. Free Outline Maps of Britain [online] <http://www.ordnancesurvey.co.uk/oswebsite/freefun/outlinemaps/> [accessed 24th November 2011]

VanWoert, N. D., Rowe, D. B., Andresen, J. A., Rugh, C. L., Fernandez, R. T., and Xiao, L, 2005. Green Roof Stormwater Retention: Effects of Roof Surface, Slope, and Media Depth. *Journal of Environmental Quality* 34 (3), 1036-1044

Viavatenne, C., Ellis, B., Revitt, M., Seiker, H., and Peters, C. (eds.) *NovaTech 2010, 7th International Conference on 'Sustainable Techniques and Strategies in Urban Water Management*. 'The Application of a GIS-Based BMP Selection Tool for the Evaluation of Hydrologic Performance and Storm Flow Reduction'. held 27 June - 1 July 2010 at Lyon, France

Semademi-Davies, A., Hernebring, C., Svensson, G., and Gustafsson, L, 2008. The Impacts of Climate Change and Urbanisation on Drainage in Helsingborg, Sweden: Suburban Stormwater. *Journal of Hydrology* 350 (1-2), 114-125

Scholz, M. Grabowiecki, P, 2007. 'Review of permeable pavement systems', *Building and Environment* 42, 3830-3836

Travis, Q. Mays, L. (2008) 'Optimizing retention basin networks', *Journal of Water Resources Planning and Management*, 134 (5) 432-439

Treby, E. Clark, M. Priest, S, 2006. Confronting flood risk: implications for insurance and risk transfer, *Journal of Environmental Management*, 81, 351-359

Wood, R, 1990. Population growth and economic change in the eighteenth and nineteenth centuries, *The First Industrial Revolutions*, 127-153

Woods-Ballard, B. Kellagher, R. Martin, P. Jefferies, C. Bray, R. Shaffer, P. 2007. The SUDS Manual [online] < http://www.ciria.org.uk/suds/publications.htm> [1 November 2011]

WSP Environmental Ltd, Coventry City Council, 2008. *Canley Regeneration Project - Outline Planning Application Environment Statement: Non-Technical Summary* [online] <http://planning.coventry.gov.uk/portal/servlets/AttachmentShowServlet?ImageName=791587> [17 September 2011]

7. Biography

Craig Lashford is a current MSc by research student at Coventry University, investigating the effectiveness of a SUDS management train for reducing pluvial and fluvial flooding. Craig graduated from Coventry University with a BSc in Geography and Natural Hazards.

Dr. Susanne Charlesworth is a Reader at Coventry University and director of its Sustainable Drainage Applied Research Group. She has particular interests in Sustainable Drainage and urban physical processes.

Dr. Matthew Blackett is a senior lecturer in Geography at Coventry University. After obtaining his PhD from King's College London, he has pursued his main research interests; satellite remote sensing, largely for the monitoring of natural hazard events. Matthew is also becoming involved in studies in the field of SUDS.

Frank Warwick is a PhD student at Coventry University, UK, investigating techniques to determine the feasibility of sustainable drainage devices.