

## Impact case study (REF3)

<b>Institution:</b> Coventry University		
<b>Unit of Assessment:</b> 14		
<b>Title of case study:</b> Developing Sustainable Drainage Systems (SuDS) for Improved Water Management, Pollution Reduction and Ecological Water Treatment		
<b>Period when the underpinning research was undertaken:</b> 2000-2020.		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Steve Coupe	Assistant professor	2003 – Present
Sue Charlesworth	Professor	1990 – Present
Alan Newman	Visiting professor	1990 – Present
Liz Trenchard	Assistant professor	2008 – Present
Luis Sañudo Fontaneda	Research fellow	2014 – 2016
Craig Lashford	Assistant professor	2016 – Present
Fredrick Mbanaso	Senior Lecturer	2016 – Present
<b>Period when the claimed impact occurred:</b>	August 2013-July2020	
<b>Is this case study continued from a case study submitted in 2014? Y/N</b> No		

**1. Summary of the impact** (indicative maximum 100 words)

Flooding and pollution are increasing worldwide. Urbanisation and climate change are producing insecure, degraded ecosystems. Coventry University (CU) has pioneered research in Sustainable Drainage Systems (SuDS) that has revolutionised the way infrastructure and ecology can combine. Our work has discovered new ways to deactivate pollution, enhanced ecology and assisted world-famous sporting icons. Our research has guided sector expertise for practitioners draining catchments, resulting in landscape transformation. Informed by CU work, over 100 km<sup>2</sup> of permeable paving (PP) has been installed in the UK alone, since conception. Marshalls paving, for example, have applied CU's contribution to SuDS development globally, installing 5 million m<sup>2</sup> of PP since 2014.

**2. Underpinning research** (indicative maximum 500 words)

SuDS research at CU has aimed to discover and improve measures that facilitate rainfall soaking into the ground, rather than running off and generating flooding. Once the water is below ground, work has investigated ways to remove pollutants, deactivating toxins in-situ by microbiological processes. The innovative nature of the research has led to numerous collaborations with partners including the EU, Highways England, charities and SMEs. In 2003, CU researchers were first to identify the importance of biology in engineered SuDS, which could improve pollution prevention properties in engineered permeable pavement (PP) (R1). Research in this area, focussed on microbiological remediation of pollution in stormwater, contaminated from urban and industrial runoff, continues to the present day (R5).

In a KTP beginning in 2004 (G1), Coupe was the first to investigate the impact of herbicides on PP and from 2012-15, work on herbicides in SuDS was advanced by Mbanaso, Charlesworth and Coupe, working with Interpave, a major UK paving and landscaping trade body. Research demonstrated that herbicides brought considerable environmental risk to SuDS; researchers documented methodologies for (and tested the feasibility of) deactivating the much-used herbicide Roundup, within these systems (R2).

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CU research also established that pollution in water and gases can be remediated by SuDS. From 2011-2014, Newman, Coupe and Mbanaso investigated the potential application of SuDS for landfill gas remediation, working with the company SEL Environmental. Landfill produces methane, a greenhouse gas, from waste disposal. Research assessed how SuDS could be used to soak up harmful gases, to vent explosive gases away from nearby buildings. Coupe and Newman showed how this technology could combine with stormwater recovery to both reduce flood risk and provide treatment sites for removing urban contaminants (R3).

From 2014-16 Marshalls sponsored a £100,000 programme of research (G2), led by Coupe and Sañudo Fontaneda, to examine the benefits of new PP designs and new paradigms on water quality, whilst supporting risk analysis on disposal of SuDS after use (R4). Pollution receptors inside SuDS are not inert, but strongly biologically active, with microbial communities that remove biodegradable material and toxic non-biodegradable metals by biological interaction. This work is being continued in the CU contribution to a 30 partner, 15 university, €3.8m Marie Curie ITN project led by Coupe, named SAFERUP! (R5).

Since 2017, field-scale green infrastructure devices were tested onsite at CU by Sañudo Fontaneda, Lashford and Coupe (2020), with research on swales (R6) and green roofs. Green roof work was led by Coupe and Trenchard in a Knowledge Transfer Partnership (G3), proving the potential for green roofs to enhance insect and plant biodiversity (2017-2019). 68 plant species were established on a retrofitted green roof incorporating the SEL/Permavoid blue green roof design beneath, replicating a wildflower meadow. Beneficial ecological function is shown in SuDS microbiological action, including bioremediation and in our new blue and green roof designs that demonstrably facilitate biodiversity. Discovery and elucidation of beneficial biological action in engineered stormwater infrastructure, is unique to CU SuDS, explaining the novelty of our work and enthusiasm of funders to collaborate.

### **3. References to the research** (indicative maximum of six references)

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R1. Coupe, S.J., Smith, H.G., Newman, A.P., and Puehmeier, T. (2003). Biodegradation and microbial diversity within permeable pavements. *European Journal of Protistology*. 39: 495-498. <https://doi.org/10.1078/0932-4739-00027>

R2. Mbanaso, F.U., Coupe, S.J., Charlesworth, S.M., Nnadi, E.O. and Ifelebuego, A.O. (2013). Potential microbial toxicity and non-target impact of different concentrations of glyphosate-containing herbicide (GCH) in a model pervious paving system. *Chemosphere*. 100: 34-41. <https://doi.org/10.1016/j.chemosphere.2012.09.058>

R3. Coupe, S.J., Nnadi, E.O., Newman, A.P. and Mbanaso, F.U. (2017). An Assessment of the Potential Use of Compost Filled Plastic Void Forming Units to Serve as Vents on Historic Landfills and Related Sites. *Environmental Science and Pollution Research*. 19238–19246. <https://doi.org/10.1007/s11356-017-0208-7>

R4. Mbanaso, F.U., Charlesworth, S.M., Coupe, S.J., Newman, A.P., and Nnadi, E.O. (2019). Reuse of materials from a Sustainable Drainage System device: Health, Safety and Environment assessment for an end-of-life Pervious Pavement Structure. *Science of the Total Environment*. Volume 650, (2), 1759-1770. <https://doi.org/10.1016/j.scitotenv.2018.09.224>

R5. Fathollahi, A., Coupe, S.J., El-Sheikh, A. and Sañudo-Fontaneda, L.A. (2020). The biosorption of mercury by permeable pavement biofilms in stormwater attenuation. *Science of the Total Environment*. 741 (2020) 140411. <https://doi.org/10.1016/j.scitotenv.2020.140411>

R6. Sañudo-Fontaneda, L.A., Coupe, S.J., Barrios-Crespo, E., Rey-Mahía, C., Álvarez-Rabanal, F.P. and Lashford, C. (2020). Descriptive Analysis of the Performance of a Vegetated Swale through Long-Term Hydrological Monitoring: A Case Study from Coventry, UK. *Water*. 12 (10), 2781. <https://doi.org/10.3390/w12102781>

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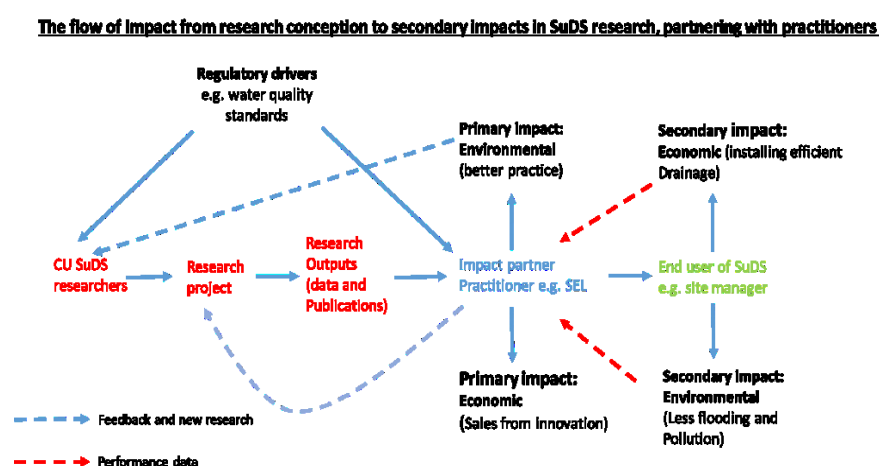
G1. Newman, A., (PI) 'Formpave Limited and Coventry University' (2004-6). KTP. Innovate UK, European Social Fund. Total grant £67,524.

G2. Coupe, S. (PI), Sañudo Fontaneda, L. (2014-16). 'Pervious Pavement Designs to Control Urban Flooding and Pollution'. Marshalls Mono Ltd. Total grant £100,000

G3. Coupe, S. (PI), Trenchard, L. (2016-19). 'SEL Environmental and Coventry University. KTP, Innovate UK. Total grant, £130,247.

### 4. Details of the impact (indicative maximum 750 words)

CU researchers have worked extensively with industry to bring new knowledge to SuDS, enabling the effective integration of these techniques into drainage designs. Introducing paving surface permeability and plants to SuDs, has resulted in tangible impacts on companies working with CU; this has been both in terms of product development and compliance, benefiting the downstream environments (please see the chart below for a summary of impact flow).



A major project has been the development of permeable pavement, an innovative drainage solution, which CU was involved in from the earliest stages. The journey began through the creation of a joint patent with the company Formpave in 2000, the first move to establish PP in a way that replaced traditional, often inadequate pipe and gully drainage. The UK Committee on Climate Change stated that during 2009-13, “an estimated 5,100,000m<sup>2</sup> (510 ha) of permeable paving was installed in England” - 8% of the total area of block paving (S1, p.1). The market has grown since then, led by Marshalls, the UK’s largest SuDS installer; since 2014 they have generated a profit of £14 million based on turnover of £2.5 billion, of which £500 million is in permeable paving (S3). They alone were responsible for installation of 5,000,000 m<sup>2</sup> of PP during 2014-2020, which has led to around 1,500,000 m<sup>3</sup> of stormwater being diverted from the UK’s overloaded and flood prone sewer network. Marshalls observed the success of improving water quality in their offer, changing their design to include filtering geotextiles, after research at CU (S2). Explaining the impact of CU research in 2020, Marshalls head of SuDS said: “we lead the market because of this relationship with Coventry University...the collaboration with CU helps us in staying at the front of the sector. Coventry University is the only institution that we have active research with” (S3, S10).

CU and SEL Environmental have collaborated since 2000. CU research rigorously tested the properties of the Permavoid module, a key water storage element, found in all SEL designs since its initial development. SEL’s managing director, stated that Permavoid-related products, drawing on this research, make up 60% of total sales for the company, who in 2019 had a turnover of £2 million (S5).

He noted that much of the SEL collaboration with CU, “related to Permavoid systems and the many ways that they can be deployed, to attenuate water, gases and pollution (and) has been

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fundamental to our technical and commercial development as a company. As described in the case study, we have won many drainage and gas migration installations due to our collaboration with Coventry University” (S5,S10).

As acknowledged above, CU research revealing new SuDS properties has been invested in product development, generating new designs, new products and impact in the environmental sector. Testing of Permavoid at CU has inspired a range of new patented SEL drainage products, brought to market from 2004-2020. Of these, SEL have sold kilometres of novel linear drainage and water treatment products including Permaceptors, Permachannels and virtual curtain explosive gas migration barriers, with 50 UK schemes (S5).



Permavoid drainage is now used at Tottenham football stadium (2019) and the refurbished Anfield Stadium, Liverpool (2017, pictured above), where it prevents match postponement for a combined 2.2m supporters per annum – a significant cultural impact (S9). The Chief Executive Office of the Institute of Groundmanship attributes Liverpool’s 2019-20 Premier League title win in part to the “revitalised pitch benefits” delivered through the CU-informed Permavoid design, which contributed to their achievement of “100 points from their last 102 available on offer at home” (S9). Permavoid systems drain 161,860 m<sup>2</sup> of sports pitches in the UK alone representing 5 sports (S5, S8).

SEL used CU research on gas migration prevention technology to develop gas protection schemes, protecting human life from explosions arising from landfill gases leaking into buildings, and enabling regeneration of difficult environments. Using CU-trialled Permavoid design criteria to separate methane and water, in 2017, SEL vented gases from a site in Warrington, allowing safe construction of an £11,850,000 development: 104 low-rise dwellings, roads and parking. (S4). This achievement also built on our original publication (R3). SEL have installed Permavoid in 9 countries: UK, Ireland, USA, Bahrain, Netherlands, Germany, New Zealand, Belgium, Poland (S5).



The KTP project with SEL from 2017 – 2019, demonstrated ecological impact, placing retrofit green roofs onto existing infrastructure (pictured above). Research has enabled better water management

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alongside habitat enhancement (S6,). An independently conducted ecological survey revealed 5 insect species with national and local rarity value, from a total of 120 insect species on the green roofs at Coventry University (S7). The innovation in green roofs improved and increased the total constructed habitat for rare insects (S6). This research has been incorporated into SEL's product range, where green roofs are now used across four sites in Coventry, London, Aylesford and Blackburn.

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

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S1 –Final Report, Adaptation Sub-Committee, UK Committee on Climate Change.

<[https://www.theccc.org.uk/wp-content/uploads/2014/07/7-ASC-paving-survey-report\\_for-publication.pdf](https://www.theccc.org.uk/wp-content/uploads/2014/07/7-ASC-paving-survey-report_for-publication.pdf)> [Accessed 31.12.20].

S2 –'Water Quality Research', Marshalls PLC.

<[https://media.marshalls.co.uk/image/upload/v1581417666/Marshalls\\_Water\\_Quality\\_Research\\_with\\_Coventry\\_University.pdf](https://media.marshalls.co.uk/image/upload/v1581417666/Marshalls_Water_Quality_Research_with_Coventry_University.pdf)> [Accessed 31.12.20].

S3 – Transcript. Interview, Marshalls PLC.

S4 – 'Virtual Curtain Gas Migration Barrier - Housing, Marsden Avenue, Warrington ', Virtual Curtain Webpage, SEL Environmental. <<https://virtual-curtain.com/Case-Studies.php>> [Accessed 31.12.20].

S5 – Transcript. Interview, SEL Environmental.

S6– Webpage. 'Case Studies: SEL Environmental, Green Roofs Project'. Coventry University Website. <<https://www.coventry.ac.uk/business/our-services/projects/sel-environmental/>> [Accessed 31.12.20].

S7 – Report. Steve Falk, 'Insect Samples from the CAWR 2018 Green Roof Survey, identified by Steven Falk'. October 2019.

S8 – 'Permavoid System technical Manual Permavoid: Planning, Design, Specification and Installation Guide, SEL Environmental (recently acquired by Polypipe), January 2016.

<[https://www.polypipe.com/sites/default/files/WEB\\_PCL\\_14\\_234\\_Permavoid\\_Technical\\_Manual\\_2015\\_4.pdf](https://www.polypipe.com/sites/default/files/WEB_PCL_14_234_Permavoid_Technical_Manual_2015_4.pdf)> Page 7, [Accessed 31.12.20].

S9 – Collated articles on the use of 'Permavoid' SuDS by Liverpool Football Club, 03.02.20.

S10 – Collated testimonials. Marshalls PLC, and SEL Environmental.