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research bulletin

CL:AIRE research bulletins describe specific, practical aspects of research which have direct application to the characterisation, monitoring or remediation of contaminated soil or groundwater. This bulletin describes the main outputs from the ROBUST project.



# Regeneration of Brownfield Land Using Sustainable Technologies (ROBUST)

## 1. INTRODUCTION

ROBUST was a 5-year EPSRC funded project, approved as CL:AIRE Research Project 23, investigating the Regeneration of Brownfield Land Using Sustainable Technologies and involved a group of researchers at Durham University in NE England. The interdisciplinary collaboration was headed by Dr Karen Johnson and Professor Clare Bambra from the departments of Engineering and Geography respectively.

Brownfield land is previously developed land, but not always contaminated. Brownfield land for which there is no drive for redevelopment for residential or commercial use can be defined as 'low-value' brownfield land (in commercial terms). Often low-value brownfield sites can be marginally contaminated, situated in the heart of communities and, if regenerated, have the potential to provide people with important green space. ROBUST was particularly interested in sites in areas with a long-term history of low land values and with little prospect of regeneration by other means. ROBUST aimed to engage with local communities to reclaim and remediate these low-value brownfield sites with the aim of improving the local environment and enhancing wellbeing.

The sustainable technologies in ROBUST involve using 'waste' products from industries including the water treatment, mineral extraction and steel making sectors. Minerals, such as manganese oxide, are already naturally present in soil and form a large part of the soil's defence system against man-made industrial pollution. In their 'waste' form, these minerals can be added to the soil on brownfield sites and help transform organic contaminants such as tars into harmless by-products and immobilise metal contaminants within the ground. Using 'waste' products means sending less material to landfill and extracting smaller quantities of natural resources all of which makes our society more sustainable.

The ROBUST project bridged the gap between engineering and social science to consider the social impact of brownfield sites. This keyed into research based around the idea that green space can improve community health and wellbeing of local people living near the site. ROBUST examined whether brownfield land had a negative effect on community health and wellbeing.

Figure 1: Photos showing progress of the site works in Easington Colliery. Clockwise from top left: Initial site conditions; Site following surface strip; Spreading of compost; Initial grass sward

The main objectives of the ROBUST project were to:

- develop novel 'waste' based remediation technologies
- assess the impact of brownfield land on the health and wellbeing of local communities
- evaluate the success and assess the transferability of the ROBUST methodology

The project had a steering group made up of experts from external project partners, including industry, local government, regulators, academia and NGOs (see section 9). Although the project finished at the end of 2014, it is hoped that its impact on local communities will continue to be felt for many years to come (see section 7.4).

This bulletin describes the main outputs from the ROBUST project, it also includes research that is related to the objectives of ROBUST, that happened prior to or concurrent with ROBUST and was funded from separate sources (see section 9).

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ROBUST

## 2. USING WASTE MATERIALS IN REMEDIATION

Investigating the remediation of brownfield land using materials that would otherwise be classed as "wastes" was an integral part of the ROBUST project. These materials could provide a low tech and crucially, low cost, remediation technique particularly suited to small, low value sites where the question isn't so much "how fast can we get the site ready for a client?" but "will the local community see any regeneration happen at all?" Manganese oxides (in the form of clean water treatment sludges or mine tailings) are one waste type with particular promise, as previous research at Durham University has shown that these manganese oxides are capable of both oxidising organic molecules (including certain recalcitrant PAHs like anthracene e.g. Clarke *et al.,* 2012) and of immobilising metals (e.g. McCann *et al.,* 2015).

Another potential waste stream was identified following discussions with Northumbrian Water Ltd, namely water treatment residual (WTR). WTR is the sludge produced during the early stages of drinking water treatment, its precise composition is waterworks dependent, but it is predominantly iron or aluminium oxides and oxyhydroxides, with smaller amounts of manganese oxides plus organic matter and flocculant chemicals - often starch. WTR is typically 80% water, but behaves like a soft solid. Depending on their capacity, each waterworks may produce several tonnes or more of WTR each day, all of which requires disposal either to land or to landfill. The focus of ROBUST shifted to the investigation of WTR as a remediation amendment in conjunction with compost amendments which are required to improve soil health (SNIFFER, 2010; Jones and Healey, 2010; Makris *et al.*, 2006; Wang *et al.*, 2013).

It is important to remember that not all brownfield sites will have contaminants that need to be treated by the amendments and may only require them to provide a base for grass to grow. This was the case with the field trial site which is described in the following section.

## 3. ROBUST FIELD TRIAL

One of the original aims of the ROBUST project was to regenerate a small, low-value brownfield site using waste-based technologies developed during the research programme. The semi-rural areas surrounding Durham City, including numerous former mining villages, provided significant scope for identification of a suitable site.

Discussions with the local authority, Easington District Council, led to a former coach garage on Crawlaw Road to be put forward, known by various names including "Pygall Old Coachworks". This site had the advantages of:

- being owned by the local authority,
- having existing local desire to see the site regenerated; and
- an existing and relatively recent site investigation report.

Early plans had recognised the importance of developing a local group having an interest in the field trial site, and then to work with the newly formed group on the site regeneration work. However, it became apparent that the local authority already had an effective community liaison and support team in place and that local interest groups, primarily the Easington Colliery Regeneration Partnership (ECRP), already had an interest in the site.

Karen Johnson was active in attending meetings of the ECRP and explaining the ROBUST plans. Engaging with the ECRP also allowed for the creation of links with local ward councillors, and particularly with Dr David Boyes, who was able to provide significant support as the project progressed, and subsequently allocated ward improvement funds to complete footpath and amenity enhancement works that integrated the site more effectively into the surroundings.

The main groups involved in undertaking the ROBUST field trial were:

- Local community
- Local authority / other site owner
- University (for soil health expertise)
- Contractors (needed to remove any tarmac/concrete waste material)
- Material suppliers (industry for minerals, local authority for compost)

The design of the field trials, although led by the research team, was aided by voluntary input from steering group member URS consultants (now AECOM), following provision of the site investigation report and a draft of the field trial plans. It was evident from the site data that this was not a site that was heavily impacted by contaminants. None of the soil contaminant concentrations exceeded human health risk assessment criteria for public open space, neither was there a significant risk to controlled waters.

The ROBUST trial made use of a mixture of Publicly Available Specification (PAS) 100 quality protocol compost and WTR to create an artificial soil on the site which would serve as a base for establishment of grass. PAS100 compost has been produced to a quality protocol standard and, as such, is not classed as a waste and could be applied to land without restriction. However, WTR is not a quality protocol product and does therefore require permission - the combination of compost and WTR representing an experimental treatment. An application describing the trial and proposed amendments was made to the Environment Agency's "modernising regulation" panel for the reassurance of all parties (academics, the local authority and local community), and a regulatory position statement was issued by the Environment Agency.

Three key contracts or agreements were required for the trials to progress - one between the University and the local authority for control/access to the site during the trial establishment, one between the University and the contractors for the undertaking of the site-works and one between the University and the water company to provide WTR.

The site was approximately 50m by 20m. Herras-type fencing was used to secure the perimeter before stripping the site using a JCB backhoe. The compost and WTR were spread and mixed as extensively as possible using the backhoe.

Grass establishment was carried out by a landscaping contractor approximately one week after the compost load had been spread. Grass established relatively rapidly, with no need for a second seed spreading.

Soil was sampled before grass establishment and sent for analysis. Approximately 18 months after the completion of establishment works, resampling was undertaken with a view to meeting the requirements of the Environment Agency's position statement on the trial and compiling a final report. Samples were taken across the site using a hand-auger to a depth of around 20cm and sent for analysis to a UKAS accredited laboratory following MCERTS standards.

Assessment of the data indicated that the material would present minimal risk in a scenario where the land was used as public open space.

In order for the site to become designated public open space, a change of usage planning application was required, from commercial to public open space. Minor works were undertaken by the council to extend the pavement and full height kerbing across the former entrance to the site and to install a new dropped kerb at the North Western corner to allow access by maintenance teams.

Following grass establishment, the site was incorporated into Durham County Council's green space maintenance programme and has been maintained since by periodic mowing.

Photographs of the site as it underwent regeneration are shown in Figure 1.

## 4. THE ROBUST METHODOLOGY

The work involved in preparing for and carrying out the field trial enabled the research team to identify seven main stages in the process, which are described in Table 1 as the ROBUST Methodology. The aim being to develop a methodology that can be repeated on similar sites in the future.

Table 1: The seven stages of the ROBUST Methodology

| Stage of Methodology | Description of Stage |
|---|---|
| Assemble team | A team of willing participants is key to implement the ROBUST Methodology. The team is likely to comprise the following groups:<br>• Local community (need to have local support; help to develop community support group if none exists)<br>• Local authority / other willing site owner<br>• University (for soil health expertise and basic site assessment)<br>• Consultant (for detailed risk assessment and design of works)<br>• Contractors (to remove any tarmac/concrete waste material)<br>• Material suppliers (industry for minerals, local authority for compost)<br><br>Decide who will manage the project. Likely to be the university, but could be from local community. Note, on simple sites, a consultant may not be necessary. |
| Secure funding | Identify and secure the funding, possibly from more than one source. This may be from Ward funds, Lottery grants, Landfill Communities Fund and others. Universities may be able to cover the cost of soil analysis and treatability studies via student projects and/or research funding. |
| Gather site information | Locate recent site investigation reports. Assess degree (if any) of contamination and assess risks. Commission own site investigation / risk assessment if no data available. |
| Design site works | The design of the site works must be carried out by a competent person. This person can be from the university or from elsewhere. The degree of competence will depend on the hazards on the site (e.g. presence of asbestos or underground fuel tanks). Treatability tests will be needed to select the most appropriate mineral amendments for the site in question, taking into consideration the type and concentration of any contaminants. |
| Obtain permissions | Permission will be needed from the site owner, the local authority (if it is not also the site owner) and the Environment Agency (depending on the type of works to be undertaken). |
| Manage and undertake the works | Contracts or agreements will be needed between the main participants (e.g. between the university and the site owner, the contractor, the materials suppliers).<br><br>Works will be site specific but will typically involve the following steps - secure the site, strip and remove existing cover material, add amendments, establish grass. |
| Compliance and completion | Take post-remediation samples and interpret data to ensure site is suitable for intended use. Prepare completion report for regulator sign-off. Check if planning application for change of usage is required. |

## 5. INDICATIVE COSTS OF ROBUST METHODOLOGY

Although the field study was part of a research project and not a commercial project, it is possible to estimate the likely costs of undertaking a similar project elsewhere. The main costs will be for contractors removing and disposing of material from site and digging in the minerals and compost materials and could be up to £10,000 for a plot-size of 50m x 20m. This amount of money can sometimes be accessible to community groups via Ward funding.

Treatability testing and soil analysis could be conducted via student projects at the university and these costs can often be covered by the university. It is anticipated that materials could be provided for free (i.e. water industry could be persuaded to divert lorries of WTR to land rather than landfill and that the local authorities could provide PAS100 compost).

Another potential cost would be for a preliminary site investigation as part of the information gathering stage. Ideally, the site put forward would already have had a recent site investigation and risk assessment undertaken but, if not, these costs will need to be factored in.

## 6. BROWNFIELD LAND AND HEALTH

The social science element of the ROBUST project focused on an analysis of the associations between brownfield land and health, based on statistical analysis of data at a national scale. Data sources included the National Land Use Database, the Census and the Office for National Statistics. This was conceived as a "first step" in a wider research programme, and acknowledged the existing, comprehensive literature on the links between positive mental health and wellbeing associated with access to green space. The research gap lay in investigating the effects of brownfield land in particular on health and wellbeing. Since brownfield land may or may not be contaminated, it is not possible to separate between potential toxicological or psychological effects on community health and wellbeing.

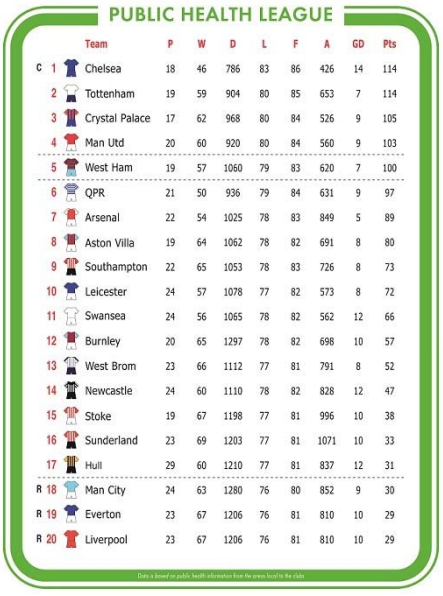
Two publications have been produced which present negative health associations with exposure to brownfield land and, by inference, the positive benefits that could be delivered by the redevelopment of this land.

One was the first to examine the area-level association between brownfield land and health using national-level data (Bambra *et al.,* 2014). It has demonstrated a strong, significant, small-area-level, independent association between brownfield land and morbidity in England. This suggests that exposure to brownfield land could be an important environmental determinant of population health and a hitherto overlooked additional element of environmental deprivation. The remediation and redevelopment of brownfield land should therefore be considered as a public health policy issue. However, the mechanisms underpinning the association need to be explored further.

The ROBUST research team was invited to present their findings at the Chartered Institute of Environmental Health Standing Conference on Land Contamination in summer 2014.

The second study was the first to examine the association between brownfield land and spatial inequalities in health using the example of England (Bambra *et al.,* 2015). The researchers found that brownfield exposure has an association with regional inequalities in mortality and morbidity within regions (particularly in the North West); that brownfield has an association with inequalities between regions (particularly between the North West and the South East); and that brownfield land makes a small contribution to the North-South health divide in England. Whilst this study is subject to a number of limitations, it suggests that the environmental (as well as the economic) effects of deindustrialisation – in the form of brownfield land - should be considered when analysing spatial inequalities in health and in discussions about the North South health divide. However, there are exceptions in the association between exposure to brownfield land and spatial inequalities in health as demonstrated for London. Nonetheless, the remediation and redevelopment of brownfield land should be considered as a public health issue and a subject of analysis for future geographical research.

Linked to this study, Professor Clare Bambra created a Public Health League based on the 2014/15 Premier League football teams to demonstrate the North/South health divide in England. This was picked up nationally and internationally including, The Daily Mirror (http://www.mirror.co.uk/news/uk-news/shock-figures-reveal-premier-league-5722952), The Daily Mail and the Australian edition of The Telegraph and Professor Bambra also wrote a piece for The Conversation on the same subject. The league table is shown in Figure 2.



PUBLIC HEALTH LEAGUE

| | | Team | P | W | D | L | F | A | GD | Pts |
|---|---|---|---|---|---|---|---|---|---|---|
| C | 1 | Chelsea | 18 | 46 | 786 | 83 | 86 | 426 | 14 | 114 |
| | 2 | Tottenham | 19 | 59 | 904 | 80 | 85 | 653 | 7 | 114 |
| | 3 | Crystal Palace | 17 | 62 | 968 | 80 | 84 | 526 | 9 | 105 |
| | 4 | Man Utd | 20 | 60 | 920 | 80 | 84 | 560 | 9 | 103 |
| | 5 | West Ham | 19 | 57 | 1060 | 79 | 83 | 620 | 7 | 100 |
| | 6 | QPR | 21 | 50 | 936 | 79 | 84 | 631 | 9 | 97 |
| | 7 | Arsenal | 22 | 54 | 1025 | 78 | 83 | 849 | 5 | 89 |
| | 8 | Aston Villa | 19 | 64 | 1062 | 78 | 82 | 691 | 8 | 80 |
| | 9 | Southampton | 22 | 65 | 1053 | 78 | 83 | 726 | 8 | 73 |
| | 10 | Leicester | 24 | 57 | 1078 | 77 | 82 | 573 | 8 | 72 |
| | 11 | Swansea | 24 | 56 | 1065 | 78 | 82 | 562 | 12 | 66 |
| | 12 | Burnley | 20 | 65 | 1297 | 78 | 82 | 698 | 10 | 57 |
| | 13 | West Brom | 23 | 66 | 1112 | 77 | 81 | 791 | 8 | 52 |
| | 14 | Newcastle | 24 | 60 | 1110 | 78 | 82 | 828 | 12 | 47 |
| | 15 | Stoke | 19 | 67 | 1198 | 77 | 81 | 996 | 10 | 38 |
| | 16 | Sunderland | 23 | 69 | 1203 | 77 | 81 | 1071 | 10 | 33 |
| | 17 | Hull | 29 | 60 | 1210 | 77 | 81 | 837 | 12 | 31 |
| R | 18 | Man City | 24 | 63 | 1280 | 76 | 80 | 852 | 9 | 30 |
| R | 19 | Everton | 23 | 67 | 1206 | 76 | 81 | 810 | 10 | 29 |
| R | 20 | Liverpool | 23 | 67 | 1206 | 76 | 81 | 810 | 10 | 29 |

**Figure 2:The Public Health League ranks the areas local to each of the 2014-15 Premier League football clubs from best to worst using the following key health indicators:**

**P (Played) Percentage of smokers; W (Won) Weight - percentage of obesity and overweight; D (Drawn) Deaths - all cause mortality rates per 100,000 people; L (Lost) Life expectancy for males in years; F (For) Female life expectancy in years; A (Against) Alcohol-related hospital admissions per 100,000 people; GD (Goal Difference) Gap or Difference in life expectancy for men between the most and least deprived areas of the local authority in years; Pts (Points)* Points representing the sum of ranks for each health indicator. Full explanation of the table can be found at https://www.dur.ac.uk/chir/healthleague/**

## 7. DISSEMINATION & IMPACT

This section describes the dissemination and knowledge transfer activities that were undertaken within the ROBUST project, and also reports how the local community has welcomed the regenerated site and dedicated it to a World War II war hero.

### 7.1 ROBUST workshops

A ROBUST discussion workshop, called 'Rescuing Our Brownfield Spaces' was held in April 2014 and was highly successful, drawing in people from throughout the North East to talk about what should be done with brownfield land. The event was in partnership with the Institute of Hazard, Risk and Resilience and Great North Festival as part of the ROBUST and ETUDE projects. It was funded by the Royal Academy of Engineering. The dialogue event was successful in bringing together a dedicated group of people to discuss how brownfield land can be reused and restored. It was facilitated by Caspar Hewett and Perry Walker from The Great Debate (https://vimeo.com/92922701).

In October 2014, ROBUST organised a workshop called, 'A Nation that Destroys its Soil Destroys itself', at the Institution of Civil Engineers in London. The workshop included speakers from Durham University, University of Birmingham, University of Sheffield, Land Trust, British Geological Survey, Climate Change Committee and many others. The focus of the workshop was to discuss how to combine expertise in engineering and science to regenerate the UK's soil.

Following the success of this workshop, in November 2015, the Durham University team organised a World Soil's Day Event with the same theme in conjunction with the Parliamentary Office of Science and Technology and chaired by Huw Irranca-Davies MP. Further details are available at http://www.durham.ac.uk/robust

### 7.2 Animation

ROBUST has developed an animation to support the theme of the project and to help in getting the project's messages across to a broad range of stakeholders (Figure 3). It shows how adding minerals and organic matter back into the soil can regenerate brownfield land and potentially help reduce flooding. The animation can be viewed at http://www.durham.ac.uk/robust

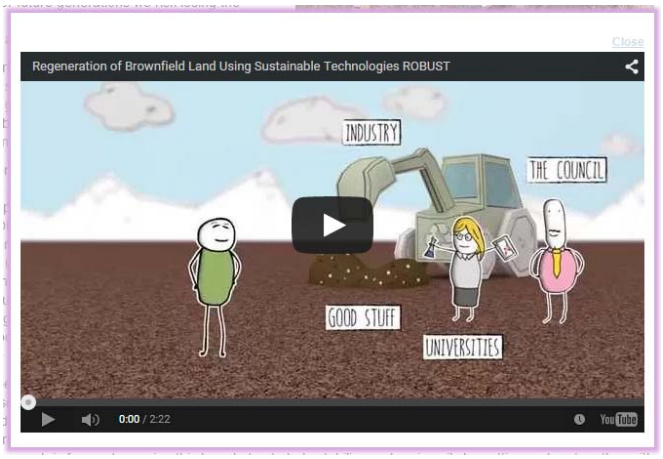



Figure 3: A screen shot from the ROBUST animation.

### 7.3 Comic

Dr Steve Robertson, an engineering researcher on the ROBUST project, created a comic book, "How on Earth…?" which introduces young people (and adults) to what brownfield land is and how it can be regenerated (Figure 4). Focusing on community led initiatives to regenerate small brownfield sites, it illustrates how university researchers, local communities and industry can work together to clean up brownfield land. The comic book is free to print and distribute, and is a useful tool for learning and thinking about ways brownfield sites can be restored, especially within urban environments where they tend to be overlooked or simply abandoned. The comic can be viewed here http://issuu.com/_ihrr/docs/how_on_earth_-_robust_brownfield_re?e=0/10900404

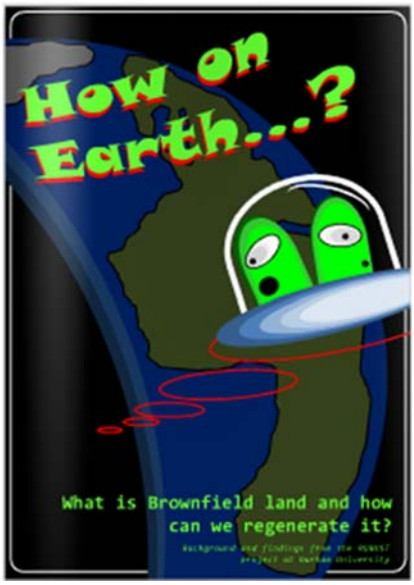



Figure 4: Front page of the ROBUST comic book.

### 7.4 Impact

#### Raising awareness in Government

In 2014, Karen Johnson was quoted in the House of Commons Environmental Audit Committee's Environmental Scorecard about the impacts of brownfield land on public health. Dr Johnson saw remediation and redevelopment of brownfield land as a public health issue. She told them that:

"It is important to recognise that the implications of poor soil quality are not only environmental. For example, our current research exploring the regeneration of brownfield land shows that it [brownfield land] has wider negative impacts on the general health of communities that live in proximity to it. I recommend that further progress on England's soil management should emphasise the development of techniques for processing and reintroducing organic wastes into the soil, working closely with engineers in industry and academia. Such an approach would not only increase the sequestration of carbon in soils but make them more resilient to flooding risks by more readily holding water."

In May 2015, ROBUST wrote a Policy Briefing on urban soils and sent this to the newly elected members of the Government's new Environmental Audit Committee and Environment Food and Rural Affairs Committee (the Policy Briefing is available at https://www.dur.ac.uk/resources/ihrr/projects/ROBUST-Policy_Brief2015.pdf).

Dr Johnson has also been invited to give oral evidence at the Government's Environmental Audit Committee's Soil Health Inquiry in 2016.

### Changing Community Perceptions

In 2014, Dr David Boyes, County Councillor (Easington Division) wrote the following to Dr Johnson:

"On behalf of the community I would like to thank you and your team for the work you have done at the Pygall site. The area was not a particularly pleasant place to be, and certainly not one frequented too often by people from Easington. I believe that once the work is completed at the site it will be an asset to Easington Colliery, and may well be a catalyst for further regeneration in that part of the village. Once again, thanks very much for your hard work."

Going one step further in 2015, the Easington Regeneration Partnership has recognised the bravery of a World War II hero by naming the ROBUST study site after him at a Dedication Ceremony. Dennis Donnini was awarded the Victoria Cross (VC) posthumously in recognition of the part he played in the war. The Sunderland Echo reports that "A war hero's memory has been honoured after wasteland was transformed into a picturesque park." The full article is available to read at the following link http://www.sunderlandecho.com/news/community/vc-hero-s-name-lives-on-in-new-east-durham-park-1-7264456

## 8. FUTURE WORK

Urban soils - essential to the resilience and prosperity of our cities and the wellbeing of our population - are under threat. Urban soils are unprotected by UK and international law and are not included as a resource worth protecting in negotiations over the United Nation's Sustainable Development Goals. The ROBUST team's policy briefing 'A nation that destroys its soils destroys itself' calls on policy-makers to work closely with the engineering and environment sectors to implement a framework that values and protects urban soils as a resource for future generations (section 7.4).

The ROBUST team has also started an informal network of like-minded individuals and organisations called 'A Nation That Destroys its Soils'. The engineering work in this field is all about improving soil by adding mineral and organic matter (compost) amendments, regenerating wastelands for community health and wellbeing. However, there are many other potential benefits in restoring and improving soil health, not only for improved public health, but for improved water quality, flood resilience, improved transport infrastructure and climate change mitigation. The network is working closely with the Government's Environmental Audit Committee. The network will persuade the policy-makers and funders that engineers must be involved in soil policy. The network also makes the case that the UK can lead in safeguarding and regenerating soil. Currently opportunities for engineers to work with soil scientists and industry to improve soil health are being missed. Creating this large body of significant stakeholders will have an impact on UK policy and EU, UN policy. Network meetings have taken place annually (28 October 2014, 13 November 2015), and more details can be found by contacting Dr Karen Johnson.

## 9. ACKNOWLEDGEMENTS

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Peter Swift, Vice Master at Grey College Durham and Teaching Fellow in Physics.

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