Institution: Keele University

Unit of Assessment: B7 Earth Systems and Environmental Sciences

a. Overview

Research at Keele University is strategically managed and administratively organised through a number of multi-disciplinary Research Institutes that offer bespoke, high-quality support to research staff at all levels (from research students through to established professors). Earth and Environmental Sciences (E&ES) research is represented by a single Cluster within the multi-disciplinary Environment, Physical Sciences and Applied Mathematics (EPSAM) Research Institute. Incorporating geophysical staff from the RAE 2008 General Engineering submission (Styles, Cassidy and Pringle), it has dedicated facilities in the William Smith Building (in the School of Physical and Geographical Sciences). Five new additional staff members have been strategically appointed during the REF period (Cage, O'Driscoll, Oliver, Ullah and Willmott) to create a new Earth and Environmental Sciences Cluster that is aligned with the University's institutional vision for environmental sustainability research. The University is committed to "*developing an environmentally aware and sustainable outward-facing campus community*" (Institutional Strategic Plan 2010-2015), and research into sustainability is one of the major pan-University themes. With an emphasis on high quality international research, the research Cluster is sub-divided into two complimentary and overlapping research groups:

Geoscience/Geophysics: UoA staff – Styles (Chair of Applied and Environmental Geophysics), Cassidy (Reader), Gertisser (Senior Lecturer), O'Driscoll and Pringle (Lecturers). The group focuses on the application of geophysics to environmental and geotechnical problems, and the dynamics and processes associated with igneous and volcanic systems, including natural hazards.

- Styles: has developed a range of geophysical techniques for mapping deep subterranean features, with particular expertise in cleaner fossil fuel extraction (including an influential government report on fracking), and the propagation of waves from wind turbines (especially relevant to MOD seismic monitoring).
- Cassidy: has developed a number of engineering and geophysical site investigation and numerical modelling tools, particularly ground penetrating radar, to provide data of environmental and geotechnical importance.
- Gertisser: conducts fundamental research on volcanic and magmatic processes (including associated hazards at active volcanoes).
- O'Driscoll: conducts fundamental research on mantle processes and layered igneous intrusions (including associated mineral deposits).
- Pringle: uses near-surface geophysical methods with applications in forensic and environmental science, military geology and archaeology.

Environmental Sciences and Sustainability: UoA staff – Willmott (appointed in 2013 to the newly created Chair of Marine and Climate Sciences), Waller and Robinson (Senior Lecturers), newly appointed Cage, Ullah and Oliver, who are all in their first permanent lectureship positions. Research within the group concentrates on glacial geomorphology, palaeo-ice-sheet reconstruction/behaviour, environmental sustainability and the resilience of natural systems to climatic variation.

- Willmott: is a mathematical modeller with expertise on ocean current analysis and prediction, with a specific focus on the impact of climate change.
- Cage: is a palaeo-oceanographer with specific interests in Holocene shelf-sea and marginal marine environments.
- Oliver: studies the behaviour of a range of contaminants in terrestrial and aquatic environments.
- Robinson: studies the impacts of glaciological changes on hydrological systems, and also carries out interdisciplinary research on environmental technologies (with Ormerod – UoA15) and their uptake by communities (with political/social scientist colleagues – UoA21).
- Ullah: is an environmental scientist with specific interests in greenhouse gas fluxes from forest and wetland soils and the human impacts on water quality.
- Waller: is a glaciologist with particular interests in ice-marginal processes and glacier-permafrost interactions.

The two cross-disciplinary groups work together to share research resources, expertise, facilities/equipment, and PGR studentships, and they collaborate on a number of large multidisciplinary RCUK, EU and industrially funded grants. The research environment is enriched by a number of colleagues not submitted to UoA7, notably Montenari (palaeontology), Stimpson (seismology), Williams (structural geology) and Clarke (petroleum geology) in the geoscience area, and Knight (glaciology), Szkornik (sea-level change) and Thomas and Taylor (both forest ecology) in the environmental area. The E&ES Cluster has been strategically formed to promote and develop research across the traditional disciplinary boundaries, and there are strong collaborations within EPSAM (with colleagues in environmental engineering, chemistry and applied mathematics), with environmental politics in the Social Sciences RI, and with colleagues in biomedical engineering in the Institute of Science and Technology of Medicine (ISTM).

An additional valuable resource is the Sustainability Hub, which opened in 2011, and is a £3.5M exemplar 'sustainable' building that supports postgraduate and undergraduate teaching, research and external engagement and outreach activities. Located in what were previously derelict farm buildings, the renovation was achieved with a successful bid to the HEFCE Strategic Development Fund (£2.5M) and additional funding from the Wolfson Foundation and the University. The Hub provides a focus for research and teaching collaborations across Keele, and has been an essential means for outreach to the wider community and dissemination of the results of our environmental projects. The Hub has attracted >10,000 users per annum, and is the base for our MSc in Environmental Sustainability & Green Technology which attracts *ca* 25 students per annum; the 5-month MSc research projects are mostly supervised by the E&ES group, and contribute significantly to the research environment.

b. Research strategy

Keele University is a highly-focused, research-led institution committed to excellence in both research and education. Keele's strategic vision emphasises the importance of research excellence, with environmental and sustainability-related research being a particularly important aspect of Keele's overarching strategic plan (http://www.keele.ac.uk/strategicplan/ Aim 5). The Earth and Environmental Sciences research Cluster plays a key role in delivering this plan, and aims to provide a vibrant research culture that is attractive to new researchers, supports and nurtures staff at all stages of their careers, and creates international opportunities for individuals to become research leaders of the future. The University places Research Institutes at the centre of this strategy so that investment, staffing and infrastructure support can be appropriately allocated to discipline-specific needs in focused areas of research strength. This strategy has helped deliver significant growth in research grant income (50%) and PGR numbers (more than 50%) in the past three years alone.

Keele's institutional vision maps directly onto the Earth and Environmental Sciences research Cluster's own strategic plan, i.e. to be *"recognised internationally for excellence in environmental education and research"* and *"deliver international excellence and impact in focused areas of research expertise"*. In order to achieve these aims, the E&ES Cluster has been extremely well-supported by the University, and has benefited from access to over £2 million of dedicated analytical, field and laboratory equipment (including ICP, GC/MS, LC/MS, ion chromatography, Raman, FTIR and NMR spectroscopy, SEM, XRF and XRD facilities) as well as high-end computing and software resources in the REF period. It also receives significant research-related financial, infrastructure and administrative support institutionally, which includes;

- Dedicated allocated time for research including PhD supervision and training, proposal writing, research mentoring, dissemination activities, speculative research, external engagement and impact activities, attendance at international conferences/seminars and research/career development events.
- Reduced teaching and administration loads for newly appointed staff for the first three years of appointment, with priority access to RI and University pump-priming, innovation and research development funding initiatives.
- Access to HEFCE research capital funding for equipment and research infrastructure.
- Matched funding support for PhD studentships (£450,000 per year) via the Keele Acorn

Programme, fees waivers and bursaries for international PGR students.
- Replacement teaching and administration support (e.g. graduate research and teaching assistantships and part-time Teaching Fellows) and additional research time for research grant holders.
- Dedicated research governance, ethics, finance, management and training, business engagement and technology transfer support from RI staff and the University's Research and Enterprise Services (RES).
- Discipline-specific guidance, support and internal peer review of grant applications.

An important part of the Cluster's research strategy has been the development of a competitive, yet collaborative, research environment with an emphasis on the publication of high-quality research, gaining significant research income and the development of a multi-disciplinary international profile. Over this REF period, E&ES staff have published over 100 papers in international peer-reviewed journals. Total spend on grants either worked on or secured within the REF period is well in excess of £3 million. These grants have been secured from a number of competitive sources, including the EU, EPSRC, NERC and the Royal Society, as well as directly from industry. All staff are approved (or associate) PhD supervisors, act as research mentors to staff or PDRA/PGRs, and have significantly contributed to the training and research development of over 30 PhD students both at Keele and externally.

Since RAE2008, there has been a continuing enhancement of the research environment at Keele of which E&ES-based research has been an integral part of the strategy. Of direct relevance to E&ES research has been the capital expenditure of £3.5M on the new Sustainability Hub (see above), revamped laboratories/facilities, refurbished PGR/researcher offices and new research equipment (e.g. SEM/EDX, portable XRF, laser particle sizer, gamma ray spectrometer, UV spectrophotometer, digital microscopes and magnetic susceptibility equipment). There are much improved PGR student facilities, such as the new microscope and analytical imaging suite, and a recently renovated PhD Laboratory in the William Smith Building. These investments are complimented by upgraded analytical chemistry facilities in the adjacent Lennard-Jones building including around £2 million of ICP OES, X-ray diffraction, GC/LCMS, FTIR, near infrared, Raman and NMR spectroscopy equipment. This level of strategic investment continues into the next REF cycle, with over £200,000 of HEFCE Research Capital Funding allocated to E&ES Cluster staff (including ground-based Lidar, digital microscopy, solid-state C/N/P analysis equipment), as well as investment in new solid-state NMR spectroscopy, near infrared spectroscopy and mercury porosimetry. This investment underpins the Cluster's (and Keele's) ambitious planned continual growth in research income and international collaborative research, including significant increases in international PGR numbers. Through strong engagement with various government schemes (e.g. Iraq, Libya) and strategic academic partnerships in the US, Africa, South America, Middle East and Asia, some of these plans are already taking shape. Collaborative links have been forged with the University of Port Harcourt, Nigeria (TET Funded PhD), Universidad Nacional de Colombia (Santander Incoming Research Fellow), Chinese Academy of Sciences, Guiyang (visiting researcher programme) and King Abdulaziz University, Saudi Arabia (PhD/ECR research exchange programme).

Fostering new industrial collaboration is an important part of the Cluster's current and future strategic research aims. E&ES staff, particularly in the environmental and sustainability disciplines, have been successful in gaining significant funding for applied, practical research that has had immediate and practical end-user impact. This includes a 4-year Royal Society Industrial Fellowship (Cassidy), UK DECC/MOD funding for renewable energy research (Styles), industrially funded PhDs (e.g. RSK, Infront Solutions Ltd, Cairn India) and substantial funding from EPSRC, ESRC, DEFRA, local authorities and industry (e.g. Veolia, Valpak) for business-related research in clean energy, environmental policy and sustainable practices (Robinson); we see applied research, both for commercial and governmental initiatives, to be really important to the development of the E&ES Cluster.

c. People, including:

i. Staffing strategy and staff development

There is a strong recognition of research achievements, grants, impact and external visibility

through Keele's staff development and strategic appointment polices. New ECR appointments are mentored by senior staff and attend a structured staff development programme, including training for PGR supervision, career/research strategy planning, research governance, proposal writing and grant management, ethics and equality and diversity. The staffing strategy is linked to the University's strategic planning process by supporting focused areas of research excellence within the RI and matching it to existing and developing areas of research strength. For the Earth and Environmental Sciences Cluster, this has resulted in the appointment of four new members of ECR staff in key discipline areas in order to expand and improve the research profile of the Cluster - Cage, ocean sciences; O'Driscoll, igneous and metamorphic petrology; Ullah, biogeochemistry; Oliver, environment contamination and pollution. E&ES staff have been particularly successful at obtaining highly competitive NERC and EPSRC "new investigator" awards (e.g. O'Driscoll, Gertisser and Cassidy) and these collective experiences are an important part of developing the research portfolios of new staff, who are actively mentored and supported in their applications for new investigator and ECR awards as an early priority for their independent research strategy.

As well as attracting younger researchers to the University, we have also sought to ensure that more experienced academics are appointed to key positions of leadership. For the E&ES Cluster, Willmott was appointed to the Chair of Marine and Climate Sciences in mid-2013 (Director of the NERC Proudman Institute 2005-10, and Director of Science at the National Oceanographic Centre 2010-13). He now heads the E&ES Cluster, and his experience of both blue-sky and commercial research is invaluable for advising and supporting new and existing staff, particularly with regard to grant applications and the development of new environmental science research programmes.

Existing staff are encouraged to strategically develop their research careers through involvement in Keele's staff development programme, RI/Faculty training and discipline-specific CPD via professional bodies (e.g. the Geological Society). During the REF period, Cassidy has been promoted to Reader, and Gertisser, Waller and Robinson to Senior Lecturer.

International collaboration is an important part of the Cluster's research strategy. Cluster members are particularly active in international research and have well-established international collaborations. The Cluster has hosted more than 20 research-focused academic and industrial visitors from 16 countries, and staff have presented at more than 200 leading international conferences during the REF period. The enhanced international profile of the group has resulted in staff participating in, and leading, numerous RCUK and externally funded international collaborative projects, e.g. Indonesia (Gertisser, NERC £60,000) and the CNR Electromagnetics lab, Naples, Italy (Cassidy, EPSRC £260,000), and a growing intake of international PGR and research Masters students.

Keele is a Member of the Athena SWAN Charter, and the School of Physical and Geographical Sciences (to which members of the Cluster belong) has held the silver award since 2007. There is close to a 50:50 gender balance across E&ES staff with flexible working arrangements, family-friendly working policies and the practices of the Institutional Equality and Diversity programme (and Concordat) actively integrated into RI research strategy and policy. Staff and PGR students have access to the University's Counselling and Development Support Services, which includes dedicated support for personal matters, well-being, disability and dyslexia, and RI-specific occupational health and safety officers who provide assistance to all E&ES staff/PGR students. Keele University has recently achieved the European Commission's HR Excellence in Research Award for implementation of the Concordat to Support the Career Development of Researchers.

ii. Research students

Research students are supported through the Research Institute structure, and more specifically by their Cluster. RIs provide a well-resourced research and training environment for students (and supervisors), including career development advice, infrastructure support, ICT facilities, and financial support for research consumables, materials, travel, dissemination activities and conference attendance. Each PGR student is a member of a Cluster, as well as the RI, which provides an excellent, integrated research environment for discipline-specific research development and peer support. Each RI has a PGR Director, dedicated PGR Administrators, a PGR Committee (chaired by the PGR Director), which reports to the University Research Degrees

Committee), and staff-student representation at RI and discipline level.

PhD students at Keele are allocated a lead and a secondary supervisor, to provide guidance throughout their PhD, and to ensure that research is planned and progress is monitored. All staff must undergo supervisor training, and can only act as lead supervisor once they have seen a student through to completion. In their first weeks, the students complete a work plan to identify key skills and the actions needed to attain them. This is updated as they proceed through their research, and formally reviewed every six months by the RI PGR Committee, when they are graded and given feedback. A rigorous formal written and oral doctoral progression takes place after ten to twelve months, with interviews conducted by the Research Institute PGR Director and two independent academics. At a 30-month review, a comprehensive plan for the thesis is presented and discussed.

All PhD students take the Research Institute "Core Training Module" on generic research skills, and a further four postgraduate modules that are selected in discussion with their supervisors. In addition, they participate in internal research seminars and symposia, including presenting their work to colleagues and receiving feedback from their supervisors. Students are strongly encouraged (and funded) to give external research presentations at symposia in the UK and/or abroad, during their 2nd and 3rd year of full-time study. Most of the PhD students act as demonstrators for undergraduate labs, problem classes, and field trips, for which they receive training in teaching, and we regard this as an important part of their career development.

Keele's 50% increase in PGR student numbers are reflected in E&ES PGR figures. There were almost 2 doctoral awards per staff FTE over the REF period, and there are currently 27 PGR students in the E&ES Cluster, equating to 2.6 per supervisor; this is predicted to rise by over 30% in 2014 (particularly from overseas), in line with the institutional growth in the Natural Sciences and Health Faculties. This growth will be further supported by the Cluster's involvement in the £1 million+ NERC Oil and Gas Doctoral Training Centre (DTC) recently awarded to Heriot Watt University, BGS, Keele University, and a number of other collaborating institutions. Doctoral awards in the next REF period will follow suit, with awards predicted to increase almost three-fold to around five per FTE. These figures demonstrate the vibrancy and sustainability of the research community within the Cluster.

d. Income, infrastructure and facilities

Institutionally there has been very significant growth in research income (50%) over the census period, with EPSAM seeing considerable increases in research funding to over £5 million per annum. Compared with 2008, the Earth and Environment Sciences Cluster has seen an 80% increase in new staff during the REF period, a portfolio of over £1 million of research grant income, and the growth of PGR numbers to 2.6 per FTE. Major grants awarded to EES staff include:

Robinson: Reducing Energy Consumption through Knowledge Networks (ESRC/EPSRC £370k); Sustainable Energy Approaches for Sustainable Communities (EPSRC £90k); Promoting Public Awareness of Climate Change and Embracing Environmental Citizenship (DEFRA £60k; Staffordshire County Council, Veolia, Valpak £80k).

Ullah: Large scale interactions of C/N/P in freshwater & atmospheric systems (NERC £270k).

Cassidy: Inversion, Modelling and Analysis of GPR (EPSRC £260k); Advanced Imaging Methodologies for High-Resolution GPR applications (Royal Society Industrial Fellowship £105k).

Styles: Effects of Windfarms on Seismic Arrays (MOD £90k; National Grid Carbon Ltd £90k); Vibrational Monitoring of Wind turbines (Wind Energy Ltd, Proven Energy Ltd, Endurance Wind Power, Mather Dairy Utensils Company Ltd - £80k).

O'Driscoll: Preservation/cause of mantle heterogeneities in the mantle (NERC £60k)

Gertisser: Driving forces behind the behaviour of Merapi volcano, Java (NERC £32k).

Pringle: Environmental forensic geophysics (Nigerian TET Fund £30k).

The range, scale and diversity of these awards illustrate the multi-disciplinary nature and

international relevance of the E&ES Cluster's externally funded research. These successes have been underpinned by significant institutional investment that not only includes the £3.5M capital expenditure on the Sustainability Hub, but also some £450k investment in improved E&ES laboratory infrastructure facilities in the William Smith Building (for microscope and analytical imaging, dry and wet sedimentary analysis, rock/sample preparation, ion chromatography, SEM/EDX, portable XRF, laser particle sizer) and around £1M investment in analytical facilities in the adjacent Lennard-Jones Laboratories (XRD, ICP, GC/MS, LC/MS and GC analysis, surface area, mercury porosimetry, solid-state NMR, FTIR, Raman and near infrared spectroscopy). E&ES staff and PGR students enjoy some of the best research infrastructure and facilities in the University, including dedicated equipment/sample storage facilities (e.g., cold stores, clean rooms, rock stores), fieldwork equipment/facilities (£500k of environmental, geophysical and survey equipment, including departmental vehicles), digital imaging and graphic design facilities, thin section and specialist sample preparation facilities, which are all supported by dedicated technical staff. E&ES PGR students are particularly well-resourced with a recent £100k+ refurbishment of their PhD offices/laboratories in the William Smith building, providing excellent office space, personal library/IT resources, dedicated social space and full access to research facilities during their PhD 'writing up' and post-submission phases. This level of strategic investment continues into the next REF cycle, with a planned £1 million+ refurbishment of the William Smith Building, new equipment funded by HEFCE Research Capital Funding (Lidar, C/N/P analysis, digital microscopy), and the purchase of a new departmental vehicle for fieldwork and research use.

At the institutional and RI level, there has been significant investment and enhancement of research support infrastructure, including specialised support for identifying funding opportunities, developing grant applications, managing finances and IPR/contractual obligations, commercialisation, enterprise and knowledge exchange/transfer activities. This has been augmented by new central support in RES specialised areas including impact and public engagement, marketing and communication and Technology Transfer. This includes the appointments of a new Technology Transfer Manager, Contracts Manager and Officer, Head of Employer Engagement and a new Employer Engagement team and a European Research Funding Officer, together with re-focusing of the Enterprise Business Managers to align with institutional strategic priorities.

The significant and ongoing financial and infrastructure support of E&ES-related research by Keele provides the platform for the Cluster's future plans and the development of its research portfolio. E&ES Staff have over £1.2 million of pending grant applications (e.g. NERC, BBSRC, Perry Foundation, Royal Academy of Engineering – Gertisser, Cassidy, Ullah, Styles) and the Cluster's priority over the next REF period is to increase the quantity, quality, value and success rate of its grant applications with a particular focus on targeted industrial, EU and international funding (including growth in PGR numbers). Knowledge exchange, impact-driven research and long-term industrial collaboration are also an important feature of this funding strategy, with Keele's involvement in the recently announced RCUK and industrially funded "ReFINE" (Researching Fracking in Europe) Consortium with Durham, Newcastle and Heriot-Watt as University partners representing a clear example of the strategy's success.

e. Collaboration and contribution to the discipline or research base

Cluster members are pro-active in the international scientific community, and provide their energy and expertise to a number of high-profile committees, journals and organisations. Since RAE 2008, E&ES staff members have served as NERC College members (Gertisser, Cassidy and Oliver); edited/reviewed for high-impact international discipline-leading journals (e.g. Environmental Toxicology and Chemistry, Geophysical Research Letters, Earth and Planetary Sciences Letters, Water Resources Research); been members of Government and RCUK strategic advisory boards (e.g. Robinson, Higher Education Academy 'Education for Sustainable Development' Advisory group; Cassidy, NERC Training Advisory Group); committee members of well-respected academic and industrial organisations (e.g. BGS, Geological Society, EUROGPR, NSGG, VMSG, RICS, Metamorphic Studies Group, Forensic Geology Group, Geological Society Accreditation Panel) and examined over 30 external PhD theses both nationally and internationally.

Staff contribute actively to the peer-review process of the international scientific community by reviewing RCUK and international grant proposals (e.g. EU, DFG, ANR, NSF, NRF South Africa, Swiss National Science Foundation) and sit on the technical and scientific review panels of major international conferences (e.g. AGU, IGARSS, IEEE, EGU, EAGE).

E&ES Cluster staff are also regularly invited to convene sessions and give keynote/plenary presentations at international conferences held by AGU, EAGE, SEG, Geological society, etc. Recent examples include; Pringle – EAGE International Conference on Engineering Geophysics, UAE 2013 (invited oral); Cassidy - SAGEEP 2012 25th Anniversary meeting, Tuscon, Arizona (Invited International Plenary as best of EAGE-NSG); Styles - 19th Annual Energy Conference, Abu Dhabi, 2013 (invited Keynote). E&ES Staff have received international recognition for their research including Pringle (William Smith Fund 2011, Geological Society of London) and Cassidy (Ludger Mintrop Award, 2009 from the European Association of Geoscientists and Engineers).

Senior E&ES staff have had key leadership/policy roles, with Willmott, as former Director of Science and Technology at the National Oceanography Centre, having substantial experience of senior management policy and strategy within national research institutes, including the NERC Executive Board, Governing Board for the National Centre for Ocean Forecasting and the Co-operative Arrangement for Research in Ocean Sciences – CAROS. Styles has served on, and chaired, the DEFRA/DTI Criteria Proposals Group (CPG), the NDA Geosphere Characterisation Panel (2008-), the Royal Society Committee on Non-Proliferation of Nuclear Weapons (2010-), and the 2011 DECC independent evaluation of microseismicity associated with “Shale Gas Hydraulic Fracturing”; his role led to Keele’s involvement in the RCUK ReFINE project.

The very nature of the E&ES Cluster’s research fosters cross-disciplinary collaboration with other Keele-based and external staff. For example, Robinson works closely with social scientists Dobson, Catney and MacGregor in Keele’s Centre for Politics, International Relations and Environment (UoA21), and was co-I on a £450k ESRC/EPSRC project funded under the Energy and Communities call to investigate how different communities can be encouraged to engage with energy-saving technologies; she has also worked closely with Ormerod (Professor of Clean Technology, UoA15) on a large number of research projects based around sustainable energy (funded by EPSRC, ESRC, Defra, HEA, Staffordshire County Council, various District and Borough Councils, Veolia and Valpak, with total funding exceeding £350k), as well as establishing ‘Science for Sustainability’, an environmental educational unit that has developed an environmental roadshow and environmental education resources that has reached over 25,000 schoolchildren and members of the public (see impact case study).

Some of the geophysics technologies can be adapted to very different problems, and Cassidy has been exploring the effect of electrical stimulation on stem cell growth (with colleagues in Biomedical Engineering in ISTM and the University of Manchester) and has been funded by Orthopaedic Research UK (£50k) and EPSRC (£20k); his research into plant pathogen pathways (funded by the EPSRC ‘Bridging the Gaps’ initiative jointly with ISTM) has led to a £670k multidisciplinary funding proposal recently submitted to BBSRC. Across the institution, E&ES staff actively collaborate in cross-disciplinary RCUK and industrially funded research projects. For example, Ullah, Oliver, Pringle and Gertisser all work closely with colleagues in Analytical and Materials Chemistry and Forensic Science, whilst Styles, Willmott and Cassidy have strong links with staff in Applied Mathematics (mathematics of waves and fluid dynamics) and Computer Science (numerical modelling and parallel computing).

Impact and end-user engagement is also an important part of the Cluster’s research programme, and is exemplified by industrially-funded collaborations with DEFRA, MOD, Anglo American Mining, BGS, WS Atkins, Environment Agency, Nuclear Decommission Authority, National Grid, Cairn Energy, CTBTO, Advantage West Midlands, and RSK during this REF period. This collaborative integration of E&ES Cluster staff with end-user communities has not only helped disseminate and deliver important knowledge exchange, therefore widening the impact of the research, but has also provided vital feedback to help structure the Cluster’s strategic research direction for the next REF period.