Institution: Brunel University

Unit of Assessment: 7 – Earth Systems and Environmental Sciences

a. Context

The Institute for the Environment (IfE) undertakes far reaching interdisciplinary research in priority areas related to environmental hazards of benefit to a range of non-academic user groups. These include the health effects of environmental chemical exposures on human and wildlife health, and the impacts of past and future climate change. Research on exposures and effects of chemicals on human, wildlife and environmental health has been of significant benefit to UK Government (DEFRA and EA), the water industry both as a whole (through UKWIR) and through specific companies (Severn Trent Water/Thames Water) and chemical/pharmaceutical industries (Pfizer, GSK and AstraZeneca). As international experts, our staff are authors and editors of WHO/UNEP and European Environment Agency state of the science publications on endocrine disrupting chemicals, ensuring global reach resulting in changing global regulation of chemicals. The application of our cutting edge research to emerging environmental concerns is assisting the British water industry to develop holistic approaches for the assessment of health based risks associated with indirect potable reuse (IPR) of water. This will have long term impacts on the strategies and technologies adopted to ensure the sustainability of water in the South East of England. IfE research is also benefitting regulatory agencies in government, mostly at the European level (EFSA, European Commission) for research relating to combination effects and defining criteria for the regulation of endocrine disrupting chemicals. For example, the OECD has benefitted from our contribution as UK Government Representatives to the development of the TG231 Amphibian metamorphosis assay and the fish reproduction assay, for the purpose of detecting thyroid disrupting and oestrogen disrupting effects, respectively. This will diminish the risks from exposure to chemicals in the environment and will support wider EU legislation (PPP regs, 1107/2009, REACH and biocides directive), US (in the two-tier-EDSP) and the Japanese testing framework.

Research on the impacts of climate and environmental exposures associated with air quality on human health are far reaching, with societal and economic benefits ranging from policy interventions of benefit to human health to mechanisms to evaluate the economic significance of these interventions. For example, cold weather and mortality in Ireland carried out with the Irish Institute of Public Health will feed directly into preventative policies to manage cold-weather mortality. IfE paleoclimate research is benefitting the petrochemical industry (BP) by improving the rate of success of oil exploration in the Caspian Sea leading to economic benefits. Earlier forecasts of Caspian Sea level changes will have important environmental, economic and commercial benefits across society, including the caviar industry (by informing future trends in salinity, temperature and ocean currents that affect marine ecosystems), petroleum infrastructure and meteorological organisations such as The European Centre for Medium-Range Weather Forecasts. In the UK similar research is informing EA mitigation plans in preparation for predicted sea level rise. Climate research, specifically severe storms, is feeding directly into the development of better predictive models by the UK Met Office and DWD in Germany, leading to improved numerical weather predictions and forecasting of convective storms with benefits to society at large. Although it is difficult to calculate the financial benefit of this impact, it is known that individual storms and flood events can cause damage upwards of £1bn.

b. Approach to impact

We believe that our research is not complete until it has had impact. A core component of Brunel's mission and strategic plan since Brunel received its Royal Charter in 1966 has been engagement with industry and demonstrable impact derived from this activity; the research culture at Brunel reflects enterprise 'for the benefit of individuals and society at large'. Therefore, research activities within IfE are largely Industry and Government led (contract research), and the applied nature of the research brings inherent benefits to stakeholders by addressing important knowledge gaps that enable better decision making within a regulatory context. The Institute's mission includes a commitment to knowledge translation and transformation and so is embedded into the culture of IfE, our recruitment and staffing policy, and the appraisal process. This is evidenced by the recent recruitment of Prof. Kortenkamp and Prof. Kanda, both of whom are impact champions (see

Section C). The commitment of IfE to furthering and framing policy agendas is evidenced in commentaries and news features in many scientific journals (e.g. The hidden costs of flexible fertility, *Nature* 485, 441 (23 May 2012), Drug-pollution law all washed up, EU initiative to clean up waterways faces tough opposition, *Nature* 21 November 2012, Science and policy on endocrine disrupters must not be mixed: a reply to a "common sense" intervention by toxicology journal editors *Environmental Health* 2013, **12**:69).

IfE research outputs (publications, final reports and state of the science reviews) are integrated into decision making frameworks and know-how. Contract Research typically involves close contact with stakeholders and funders throughout the contract with regular meetings with Steering Committees at predetermined intervals to discuss progress towards milestones and deliverables. All our research is published in high impact peer reviewed international journals (including PNAS, EST and EHP), which maximises benefits of all research to similar stakeholders globally. Key to impact has been our thorough and logical (step-wise) approach to addressing key environmental problems in collaboration with Government and industry.

IfE promotes an impact culture through outreach activities with local schools, foundations (The Nuffield Foundation) and public lectures (e.g. at the Natural History Museum) and national science ambassador schemes (EPSRC's NOISEmakers) and science festivals. Climate change research is associated with strong public engagement with over 50 national and local media pieces (BBC1, the Guardian, Nature, BBC Radio 4) on the subject of precipitation, storms and climate change. Staff have created their own websites (e.g. earthsurfaceprocesses.com), blogs (andyrussell.wordpress.org) and participate actively in social media (twitter). Russell was recently awarded (2012) the RMET's Michael Hunt Award for Excellence in increasing the public understanding of weather and climate science. The University introduced BURA in 2007 to provide an on-line archive of all research outputs and an Open Access Publishing Fund in 2011 as part of the Open Access Mandate (2010). These support free access to our research and help further creation of impact through enhanced visibility. Many of our staff are found on research networks, including Research Gate which provides an international forum for discussion and access to research outputs. This is especially valuable for newer researchers and those in developing countries. Using these forums we are able to use our considerable knowledge of environmental science research to provide advice to scientists at all career stages with their research whilst ensuring further impact from our research.

c. Strategy and plans

The Institute competed and *won a prestigious Queens Anniversary Trust Prize at the end of 2011* for the socioeconomic impact of two decades of excellent research on hormonally active chemicals in the aquatic environment and for the transformational contribution of this work to the field of toxicology. We will build on this success, and work towards our strategic goal of becoming a global leading institution engaging with the major global challenges facing earth and society through a number of measures in addition to existing activities. It is recognised that present and emerging environmental challenges of global significance cannot be addressed by individuals, but rather require a multidisciplinary approach and global participation. Our plan is therefore to develop and build upon strategic alliances with industry, academia and governments globally (e.g. Australia, China, USA, Africa) in order to enhance our capacity to undertake interdisciplinary and transdisciplinary research needed to tackle national and global environmental challenges, whilst overcoming barriers (usually economic) to new policy implementation. We recognise that in order to affect change it is necessary to impact policy at the highest levels, and we will develop strategies to ensure that our research continues to reach the heart of European environmental policy-making, and that both scientific and economic arguments are effectively explained in lobbying activities so that policy makers are equipped to make informed cost (of mitigation) vs. benefit (to society and environmental health, environmental economics) judgements.

Building on our success in ecotoxicology research we have recruited a Chair and lecturer in human toxicology/mixtures (Kortenkamp\Silva), and a Chair in environmental exposures (recently filled by an industrial chemist – Kanda). These strategic appointments will ensure future impact of IfE research through greater integration of these disciplines. This strategy will create new opportunities for IfE to undertake research into the control and prevention of diseases and disorders. A greater understanding of the associations between human and wildlife health consequent to chemical

exposure are needed to transition our research impacts from population level effects to ecosystem level interactions. Therefore, future strategic plans will involve strengthening our ecology focus by further strategic collaborations with ecologists and by interacting further with epidemiologists. We also plan to strengthen our links with economists and lawyers with expertise in environment issues to become even more effective at translating our science into policy by understanding the economic and policy barriers to innovation. Restructuring of the Research Institutes is planned in 2013-2014 and IfE is planned to integrate with Health and Societies.

Our external strategy for impact will involve conducting more research in collaboration with SMEs and industry to fuel sustainable development in these industries. By their nature, these research activities will generate IP and commercialisation opportunities which we aim to exploit with industry to develop far reaching technological solutions to global concerns, including water sustainability. Our plan is therefore to increase interdisciplinary research (especially at the interface between environmental science and engineering and design) to develop new technologies to enable the transition of society towards a sustainable future. A collaboration between Carnegie Mellon University, USA, and Brunel) in the area of using Green Chemistry to remove hazardous contaminants from wastewater is currently gaining central support for commercialisation from the Research Support and Development Office.

Internally IfE has recently established an Academic Research Committee which is responsible for identifying research opportunities, implementing research strategies, overseeing impact activities, and reviewing research outputs (manuscripts and grants) for significance, originality, rigour and impact. Two members of the ARC are known nationally and internationally for their impact activities including lobbying the EU and through the effective use of social media. We will therefore capitalise on their skill sets to develop an effective impact framework for all IfE staff. An important strategy for future impact will be for academics to engage directly with the media and participate more widely in Policy decisions relevant to their research expertise, thereby ensuring social, economic and environmental impacts of their research. Our strategy is to set the research agenda rather than to follow it. Some of these efforts will be coordinated through established networks (including the Collaborative Research Network - Energy and Environmental Sustainability) which is spearheading the unit responses to major research questions (through engagement with EU Horizon 2020 programme), increasing the social, cultural and economic impacts of research and actively pursuing partnerships and collaborations with universities, businesses and public sector organisations through high profile networking events. Importantly, we will develop an internal strategy to ensure that our staff and students are trained in how to communicate their research to the media by fostering closer relationships with the Brunel Press Office and through specific workshops and training events aligned to performance review targets. This will ensure that staff are given the necessary tools to engage confidently with the media at different stages of their research as impact develops, and to ensure that the scientific messages are delivered accurately to society in a timely manner.

d. Relationship to case studies

The case studies provide benchmarks against which our strategy towards impact can be directed and future strategy mapped out. The case studies show clear evidence of the translation of academic knowledge to societal impact by addressing the likely risks of harm to wildlife and humans through exposure to endocrine disrupting chemicals and pharmaceuticals in water, and developing the tools and framework for a better understanding of the risks from mixture effects. In doing so the research has influenced, refined and developed policy leading to improved regulations around environmental quality and health. Importantly, this research has helped to close a regulatory gap in the EU that left pregnant mothers and their unborn children insufficiently protected, and has re-opened important questions about the application of other regulatory tools, including the Precautionary Principle to protect the vulnerable from detrimental health effects from environmental exposures. Increased emphasis on stakeholder engagement in research (from the outset) and making impact a feature of all new staff programmes is also a direct result of the case studies. Finally publication in high impact Journals and Conferences as a result of the case-study research has helped co-evolve the Open Access Mandate and initiatives such as BURA.