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| **Research Group** | **MES** |
| **Date due** | **w/c 11/1/2021** |

Please complete this form to tell us about your future plans for your Research Group. You are asked to complete a 1 page strategic three-year plan for your Research Group and also to detail your plans for infrastructure and technical support, highlighting areas where investment is required, what academic hires would help to deliver your strategy, and outline your expected research income generation over the next year.

**Strategic Research Plan for next 3 years 2021-2023**

*Please provide a one page strategic plan for your area outlining the following:*

* ***Likely long-term directions which may require addressing through academic hires/infrastructure***
* *main goals and targets to be achieved.*
* *current activities that will grow or reduce.*
* *future areas for expansion and development.*
* *interactions with other RGs, institutes, departments, faculties*
* *brief reflection on impacts to UN Sustainability goals and CO2 footprint*

*MES hosts a vibrant cohort of PhDs and PDRAs which we plan to maintain* *by focusing on the following areas:*

**Environmental Radioactivity**: We will continue to build on the significant successes of the RCRD and WRC-based research and facilities programmes linking to Dalton infrastructure and the wider UK Community; the MES group is the hub for Manchester’s “Nuclear Environment and Waste (NEW)” initiative, bolstered by the ongoing EPSRC RADER and UoM investment into the WRC infrastructure, which will deliver a NNUF facility for Manchester researchers working in the area, and the wider national research community. The ongoing investment, made even during the Covid 19 pandemic is £4M, with additional funding available to support access to the new RADER labs, which will open in 2021. This area has been strengthened further by the group securing funding in 2020 (£2.6M) to lead the UK’s Nuclear Decommissioning Authority - Radioactive Waste Management (RWM) University Research Support Office (RSO, 5–10 year programme), continued support for the Sellafield Ltd. UoM Effluent and Decontamination Centre and recent alignment of Livens and Heath with the group (whose research will be based in the RADER labs in Williamson). We will also continue to build responsive mode applications in the geodisposal/contaminated land areas over the next 3+ years **(*this is strongly dependent of staffing within the group, and recruitment of new staff/independent Fellows in this area to build on our extensive success remains a priority*)** and the effluents treatment area. Additionally, we will continue to exploit the research base within MES at the industrial interface with applications for NERC Knowledge Exchange Fellowships, alongside the Sellafield Ltd. Effluent and Decontamination Centre and other opportunities/links. We will also continue to develop EU programmes, with the support of EURAD and waste management organisations, and influence UKRI and industry funding. We will engage with opportunities within UoM FSE (e.g. exploiting wider NNUF capabilities in transuranic chemistry and electron microscopy/ imaging) and within wider UK developments including active engagement in forward programmes developing from the RWM-RSO, and bridging to other DEES research units as well as engaging in national initiatives (e.g. the proposed £100 M BEIS / EPSRC National Decomissioning Research Centre).

**Environmental Mineralogy***:* This area of MES remains a high priority, where core activities will include: (i)Fundamental mineralogical research focused on understanding the nano/atomic scale mechanisms and kinetics of mineral reactions e.g. nucleation and growth, crystallisation and electron transfer processes. (ii) Applied research studying the interaction of contaminants with mineral phases. In particular, key questions related to radioactive waste geodisposal and contaminated land including chemical coordination during uptake onto mineral surfaces e.g. for U, Sr, Cs., with a key focus of developing industrial partnerships (e.g. Sellafield, RWM and BP) *(iii)* Development of advanced X-ray/electron beam/laser/electron/infra-red spectroscopy techniques to characterise processes described above (and feeding into wider MES programmes and exploiting the new NNUF/RADER facilities), with a particular focus on synchrotron techniques (a major focus for Shaw, Coker and others). This includes a long term (2 year) beam time allocation (Diamond) focused on contaminant geochemistry. Current work on redox active chemical species in bio-mineral systems will build on our increasing involvement in imaging systems at the DLS and MXIF (STXM, Tomography) to provide molecular scale mechanistic understanding of the processes. (iv) Recent interest in NERC (after 25 years) of elemental cycling and Earth resources through the SoS and RRW programmes provided the opportunity to reinvigorate our mineral deposits expertise with specific interests in Co/Se/REEs, and also the platinum group elements in collaboration with (geology) e.g. O’Driscoll, and this area is set to develop with cross-council support (EPSRC/BBSRC/industry; see Geomicrobiology below).

**Hydrogeochemistry**Building on long-term success in the area of metals/metalloids behaviour in natural environments, the WRC team led by Polya will focus on 5 key areas. (i) Understanding and predicting the behaviour of arsenic and other trace elements in natural environments, for applications to environmental monitoring, remediation, protection & regulation. (ii) Medical geochemistry for application of principles of geochemistry to better understanding and predicting the *in vivo* behaviour of arsenic. (iii) Environmental health risks and informing government and non-government policy, building on international links developed through UKIERI PRAMA, EU ASIA-LINK CALIBRE, NERC-DST FAR-GANGA and also recent work with Public Health England as well as industrial links through NICOLE. (iv) Understanding and predicting the behaviour of arsenic and other trace elements in natural environments - for contributing to maximising the efficiency of planning of land use and food production (linking to water@manchester, food@manchester and Manchester Environmental Research Institute (MERI) networking initiatives). Field based research particularly in GCRF relevant ODA countries has been strengthened by the appointment of Richards to a tenure-track DKO Postdoctoral Fellowship. The organic geochemistry group of van Dongen use new bespoke labs and support several areas of MES (e.g. aspects of arsenic biogeochemistry and palaeontology research with ALG), while continuing to develop high profile core research interests in the impact of climate change on carbon and nitrogen fluxes through NERC and EU funding. This includes organic matter degradation in Arctic rivers and the impact of terrestrial derived nitrogen on the Arctic food web. KTP work in this area will include work with Arvia Technology on the treatment of toxic organics and dyes in water, the treatment of pathogenic microorganisms and the recovery of valuable metals. **To support both Hydrogeochemistry and Field monitoring technologies (below) there is need to recruit a modeller that bridges across hydrology and socioeconomic/health impacts working at catchment-scale and above and linking into large data/ digital futures initiatives at Manchester and more widely. Such a person would be valuable in bidding for GCRF funds and should be someone already connected to stakeholders in this area.**

**Field monitoring technologies** Developing monitoring and modelling infrastructure for key utilities, brownfield land use and wider environmental applications led by Boult. Strategic goals are to develop cross-disciplinary collaborations within academia – DEES Atmospheric, DEES Ecology/Evolution, SEED Hydrology, MACE Water Security and University of Sheffield Civil Engineering - and critically with industrial partners e.g. Siemens. We plan to further develop at least 2 fully instrumented field sites, and develop programmes with laboratory simulation and field measurement in parallel. Topics to be addressed include (i) carbon mass balances in upland peat, past, present and future, (ii) organic carbon composition in catchment water and distribution (iii) proactive “smart water” management of water quality in water distribution networks using high spatio-temporal resolution monitoring and machine learning.

**Geomicrobiology** links to the mineralogy and hydrochemistry themes in MES, and forms a unique interface with SBS and MIB. Priority areas include the following. (i) Microbiology of the nuclear fuel cycle encompassing microbial impacts on plant operation, contaminated land remediation and radwaste decommissioning and disposal with RCRD/industry. (ii) Bionanotechnology with future proposals planned on synthetic biology/biocatalysis (with MIB), the scalable production and exploitation of functional nanobiomaterials and metal recovery/biofabrication (EU/NERC/BBSRC/GCRF). In this area MES leads environmental aspects of BBSRC Metals in Biology NIBB, which is developing a metal biorecovery “Big Idea” with the BBSRC (potentially £6-20M if funded). (iii) Fundamental work on subsurface microbial ecology including microbial impacts on subsurface utilisation e.g. for radwaste geodisposal, fracking and the safe exploitation of aquifers worldwide (NERC/EPSRC/NSF). (iv) Further development of a successful new research area with Gallagher and colleagues in AS on quantifying the microbiome of atmospheric samples (from NERC flights and urban monitoring sites). (iv) Fungal ecology of polar environments responding to climate change (NERC Antarctic Funding Initiative) and fungal-soil-plant interactions in response to long-lived radionuclides (NERC Radioactivity and the Environment). Also towards a microbial process-based understanding of the resilience of UK peatland systems (NERC UK Climate Resilience). These will continue to be developed with our EE staff and others in SBS, Geography and MIB. There remains a need for staff recruitment into these areas, and we are particularly interested in appointments that can help develop research and teaching around large environmental datasets, especially from omics technologies (e.g. with MIB). **Nixon progresses to a DK fellowship in this area after her maternity leave in late 2021, and follow up developments in bioinformatics will be required to support this area further (potentially with EE/MIB). This is a rapidly expanding area that underpins work across many areas across the dept/faculty, and will need investment for DEES to stay competitive.**

**Key interfaces with other DEES groups** MES will continue to develop new areas of research with other key groups in DEES including:

* With Basins Studies including work on carbon capture and storage and stromatolites (potentially with RCUK and industry funding) and paleoclimate reconstructions (current joint NERC grant with Jerret).
* With Isotopes (PES), application of infra-red and X-ray spectroscopy to non-terrestrial material in order to characterize rare specimens as well as to interface with the Mercury probe data to enhance our interpretation of remote sensing data in collaboration with PES (Joy). Also work on the nanoSIMS and new laser ablation ICP-MS system on metal biogeochemistry and nuclear research on clays and particles between MES/PES.
* With Atmospheric Sciences, to (i) quantify the microbiome of the Earth’s atmosphere and its impact on climate and microbial transportation, (ii) better understand methane cycling in terrestrial environments, (iii) understand the role of minerals in ice nucleation and (iv) use scanning X-ray microscope (SXM) at Diamond to chemically map individual black carbon and other atmospheric particles from a number of field campaigns, including those to Beijing, Ascension Island and W. Coast of Africa.
* With other members of EE in core areas including biogeochemistry, agriculture, microbial ecology, and metagenomics
* With CEAS providing environmental biogeochemistry and health context for contaminant transport modelling
* With ICAM/Materials/CEAS in relation to 3-D x-ray tomography of sub-surface formations for improved prediction of contaminant transport; functional bionanomaterials for biotechnology and catalysis, graphene in environmental applications.
* With Ancient Life, in the area of fossil biochemistry and spectroscopy (including organic geochemistry).
* The RWM RSO, hosted by Morris and Shaw provides an exciting new platform across the DEES with clear links to the geosciences capabilities (Kevin Taylor is engaged in the RWM RSO) and wider with interfaces across faculty and beyond.

**Synopsis of staffing requirements (from areas above):**

**New** **academic staff** positions are highlighted as critical in the above research plans:

In environmental radioactivity the opportunities afforded by the recent successes in RADER labs and the RWM RSO are significant. To consolidate these opportunities and build on these successes and it is clear that new staffing is required to achieve optimal value from these investments. We note the opportunity to develop a cross faculty, research led teaching opportunity in nuclear environmental has been identified by HoD and also at Faculty Level and this aligns with a new appointment. We also note the growth in the environmental science area within the School and note any appointment in Environmental Radioactivity could actively engage across the environmental sciences area.

Our other prioritised academic positions target research and teaching opportunities around large environmental data sets, including (1) a bioinformatics position that will support the integration of environmental “omics” data, with other meta datasets to address high profile research questions that cut across MES and other DEES/MIB groups, and (2) a modeller that works across hydrology and socioeconomic/health impacts as noted above.

**There is also a critical need to address gaps in the DEES technical provision**, which impact heavily on MES. These are outlined below, but include a long-standing need for an additional appointment in the basement mineralogical analyses area, and the replacement of the two technical staff that underpinned MAGU for >20 years (until 2020). The current situation in MAGU is currently backfilled with excellent seconded staff, but a long-term solution needs to be determined within the next 6 months.

**Impacts to UN Sustainability goals and CO2 footprint** Many of the MES core research programmes clearly address UN Sustainability goals including: clean water and sanitation, affordable and clean energy, industry/innovation and infrastructure, sustainable cities and communities, responsible consumption and production (e.g. circular economy), climate action, life below water and life on land. MES outreach work, including overseas KE also addresses good health and quality education. We endeavor to minimise our CO2 footprint through both active engagement in research addressing sustainable technologies in the environmental sector, and also more directly, e.g. through reducing travel via the use of e-meetings whenever possible. Our laboratories have a strong track record in obtaining UoM Green Impact awards.

*Please provide evidence to support the aspirations and how new developments will be realised. It is important that you consider the staff, technical support and infrastructure resources that will be necessary to deliver any increase in activity and to justify these in your plan. Please also indicate any plans for increasing your number of research fellows and how you see PhD studentship increase being generated and grown. Please indicate where you have staff or Early Career Researchers that would benefit from additional support in preparing applications for funding from either your Research Support Manager or an academic mentor.*

* ***Whats gone well/less well?***

Gone well: NNUF and RWM RSO consolidate DEES as a leading Environmental Radioactivity capability, strong REF performance (good spread of 4\*/3\* papers plus 3 impact cases going forward), large/vibrant PhD cohort, two excellent independent fellows (Nixon and Richards) in place in strategic areas, labs opened up and operated safely/effectively post first lockdown. Strong performance maintained alongside disproportionately heavy loads on academic team in leadership roles and delivery of MPEC and Env programmes.

Not gone well: Apart from COVID challenges, technical infrastructure has been eroded (especially in MAGU) with the way forward not clear yet (pending technical review). Staff are at capacity in MES, and growth in MPEC and Environmental Sciences areas within the Department needs to be matched with new staffing in the MES area.

**Outline how you will use university/department infrastructure and technical support in the next year, highlighting where any investment is required**

MES researchers will need to be integrated with nuclear research infrastructure across campus (Dalton, NNUF, Royce), also MIB (Nixon Lloyd), FBMH (Lloyd, Nixon, Robinson), Royce (e.g. for materials characterisation across group). Outcome of technical review is key here (including successful integration of WRC with FSE/SBS infrastructure). Investment needed to firm up MAGU for current and future research programmes and wider Dept research/teaching support. A clear deadline for finalising long-term staffing of MAGU is needed, as >40 current MES projects, and £14 million future/pending research funding has been identified as vulnerable (spreadsheet available). There are also urgent needs for extra imaging/characterisation in basement area, and easier access to facilities outside the WRC e.g. TEM/XPS/nanoSIMS.

**Outline any upcoming staffing changes or gaps and opportunities to achieve strategic goals or maintain existing strengths**

Key vulnerabilities reside in capacity in MES. There is potential for a high-level appointment at interface with MES and Geosciences with an eminent Professor wishing to return to the UK from Canada. Other posts highlighted above are essential – maintaining the status quo will not capitalise on key successes. In addition, fellowships will be encouraged in analysing large environmental datasets, bioinformatics, env biotech (with MIB), waste management/circular economy, environmental radioactivity and nuclear security.

**Research Income Generation for the next year**

Please detail your future plans for research income generation over the next 12 months (identifying the lead academic where possible). Please detail any planned applications in the table provided on the last page.

**UKRI and other UK funders (eg Royal Society, Leverhulme)**

*Please identify developing research programmes, highlight topics, large grant opportunities, UK/US collaborations and fellowships in your research area and your plans for targeting these programmes? When will they occur and who in the group will lead and who will contribute to the activity? Are there any obstacles to delivery?*

**Proposals planned include the following (major challenge is time to prepare proposals):**

Lloyd, Coker and others: Developing BBSRC Big Idea (up to £15M) programme grant with UKRI, and also IAA and IB applications on metal biorecovery and biometallic catalysts. MIB/FBMH and Chem Eng involved.

Lloyd and Nixon and others may also lead on potential major NERC grant application linking to the UK GEOS programme (on subsurface microbial ecology) later in 2021.

van Dongen, Boult, Polya, Wogelius, NERC Industrial Case studentships with Arvia. Removal of organometallic compounds from wastewater using a novel water treatment methods on hold since COVID. £100K  approx 10% standard likelihood of success if company can support post pandemic.

Coker will also apply for a new investigators nanoscale interactions of minerals and microplastics. NERC reponsive mode grant in this area in July 2021.

REE accumulation in modern river systems as analogues for sediment-hosted REE resources (Worden (Liverpool), Polya and others). NERC Standard Grant proposal planned July 2020 (£750K)

EPSRC Effluent Treatment (Shaw, Morris, NNL, Sellafield) Future Effluents from Decommissioning – Underpinning Processes with Chemsitry. £1.2 M

EPSRC Contaminated land (KM/JRL/GTWL/ SS) In situ disposal £800K also planned in the future (date TBC)

Robinson resub of Evans NERC standard grant: Carbon fluxes from upland peat £800K

Boult £560k application lead by Siemens - "big data" in managing water distribution networks.

Laura Richards UKRI Future Leaders Fellowship Round 6 application (groundwater arsenic processes, remediation, decision support systems); decision June/July

Nixon awaiting interview for David Phillips BBSRC (details not available due to maternity leave)

**Other funding sources**

*Please identify developing research programmes funded from non-UK sources*

EU. Several MES staff have strong links to the EU and now BREXIT position is clearer will target again e.g. EURAD MAGIC consortium (Lloyd and others)

Several staff e.g. Polya, Lloyd and Richards building links with CUG Bejing, and other overseas partners e.g. cases being developed around environmental challenges in Indonesia, Vietnam from a range of funding streams.

**Business engagement**

*Please describe the development of current industrial relationships or consortia and your plans for them. Are there any new industrial partnerships or areas of engagement that you see developing? Who in the group will lead these and what is the projected size and timescale? What plans do you have for applications for Industry Collaboration Funding (IAAs, KTPs) Innovate UK competitions and the Industrial Strategy Challenge Fund competitions?*

Nuclear: Major industrial activity led by Morris, Lloyd, Shaw, Livens, Heath and other RCRD colleagues. Sellafield, AWE, BP, NDA RWMD – all wanting research links (strengthened by NNUF RADER) and publications. We will need to be responsive and utilise new staff to exploit opportunities. Contracts support has been challenging. Complexity of funding streams also, alongside integration of nuclear facility access across Manchester and NNL. New opportunity in 2021 will be NDA Direct Research Portfolio, where we plan to team up with key industrial partners via Dalton. Key challenges around technical support to maintain infrastructure.

Boult : Good opportunities to partner with water service providers (WSP). Initial immediate interest in controls on water quality, i.e. fairly specific processes that are of interest to a small section within the business. Larger interest and larger funding for broader decision-aiding that can incorporate continually developing knowledge. We can contribute to the former and should be able to contribute to the latter if we can make partnerships within UoM.

Lloyd, Coker and others are working actively with catalysis, energy and environmental companies via BBSRC NIBB and EPSRC IAA programmes (on metals in the circular economy), and this is seen as a growth area for the group.

Links with local SMEs e.g. water treatment sector Arvia (van Dongen, Polya, Lloyd, Boult), and energy partners e.g. Rawwater engineering (Lloyd/Nixon).

*Would you like to enlist the help of the Business Engagement Office to support any of the planned activities of your Group?* **More important is a stable adequately resourced RSO, with greatly improved contract support. This is critical. Current situation is unworkable.**

*Please list any planned applications over the next 12 months:*

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| **PI and team** | **Sponsor/Call** | **Research Area/Proposal Title** | **Date** | **Value** | **Chance of success (%)** | **Comments** |
| Foster (with Lloyd/Morris) | NERC KE Fellow | Lynn Foster fellowship | March 2021 | £250K | 25%? | Strong support from nuclear industry and links to RADER |
| Lloyd, Polya, Richards and others | GCRF Networking Grants | A UK-Vietnam geomicrobiology consortium for resource recovery (CORE): | March/April 2021 | £25K | Don't know | With VNU University of Science, Vietnam |
| Lloyd, Polya, Richards, Coe, Johnson and others | NERC/UKRI | Sustainable mineral resources in the Philippines (with Loughborough) | January 2021 | £50K | Don’t know | Being lead by Loughborough (who will hold grant). Grant to build consortium for full bid if funded. |
| Lloyd, Morris, Shaw | EU-EURAD | MAGIC | March 2021 | Approx 250K EUR | 50% | Split funding with EPSRC Green |
| Lloyd, Coker, ODriscoll and others | BBSRC | Big ideas; metal biorecovery programme | Ongoing | Up to £25M | Don’t know | Being developed through BBSRC NIBB by invitation |
| Lloyd, Coker MIB | BBSRC | Scale-up of biometallic catalysts | 2021 | £250K | 10% | Waiting for correct IB call |
| Lloyd, Coker | BBSRC NIB/IAA | Cu recovery from distillery wastes | 2021 | £100K | 20% | Approach from company to support tjhis (continuattion of proof concept award) |
| Lloyd | ERC | ERC Advanced on nuclear microbiology? | 2021 | £2M | 10% | Resubmission under consideration (from several years back, now Brexit is cleared) |
| Lloyd | RWM | RWM framework (gases .. microbial with Jacobs) | Feb 2021 | Not sure | 50% | By invitation from Jacobs (lead) |
| Lloyd, Bassil and RSO | RWM | RWM framework (micro safety case with BGS) | Jan 2021 | £25K | 50% | By invitation from BGS (lead) |
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| Morris/Shaw | RWM RSO and DNI | RWM RSO Research Fellow | Sept 21 – Aug 24 | £180K | Funded | Candidate under discussion |
| Morris/Shaw | RWM | RWM PhD with Green CDT | Feb 2021 | £120K |  |  |
| Shaw, Morris and others | RWM | Gases call …. £2M call | 2021 | TBC |  | Under development |
| Morris, Livens, Lloyd, Shaw and others | NDA | NDA x 3 PhD @120K each | Jan 2021 | £120K | 10%? |  |
| Nixon | BBSRC | David Phillips fellowship (has interview) | Feb 2021 | £1M???? | 10% | Sorry don’t have details, Sophie on maternity |
| LR DP & others (non-DEES) | UKRI FLF | Laura Richards FLF | Oct 2021 (4 years) | £ 1.5 M FEC | standard | resubmission of previous shortlisted proposal |
| LR DP & others (non DEES) | Manchester-Melbourne scheme | Manchester – Melbourne Dual PhDs |  | 2 x PhD |  |  |
| KM JRL SS VC  KM FRL SS  SS SH KM  SS KM JRL | NDA  Sellafield/GREEN  Sellafield/GREEN  EPSRC BEIS | NDA PhD Contaminated land  Sellafield PhD Contaminated Land  Sellafield PhD  Nuclear Decomissioning Research Centre |  | 137  60  60  100,000,000 | 25  50  50%  Don’t know |  |