

# RSO PhD call: Guidance for submission and evaluation criteria

The Radioactive Waste Management Research Support Office (RWM RSO) is requesting applications for two PhD studentships in the Gas Generation, Migration and Reactivity theme.

The aim of the RWM RSO PhD programme is to develop a portfolio of PhD projects focused on key RWM research priorities. The specific aims of the programme are to:

* Develop key skills required for RWM’s research mission over the coming decades, and to help deliver the next generation of geological disposal scientists, engineers and other researchers;
* Expand all aspects of the geological disposal research community throughout the UK;
* Encourage collaboration and communication between RWM and the academic community.

The two PhD studentships in the Gas Generation, Migration and Reactivity theme will run in parallel with the RWM RSO PhD studentship scheme. As such, we are looking for projects that will start in October 2021. Students funded by RWM through the RSO have access to a growing geological disposal research community, training, and networking opportunities. Each project proposal is expected to have a total cost of less than £120,000 and RWM is, where possible, seeking co-funding from universities or third parties (either anticipated or confirmed) and/or in-kind contributions. Universities and research groups that have not previously received funding from RWM are particularly encouraged to apply. The contractual arrangements for the PhD studentships will be administered by RWM.

# Call structure

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| Request for proposal sent on: | 1st February 2021 |
| Clarifications period closes on: | 17th February 2021 |
| Request for proposal closes on: | 5th March 2021 |

All clarification questions (including commercial, technical and terms and conditions) should be sent before the clarification period is closed and addressed to the RSO via rso-gdf@manchester.ac.uk.

Proposals will be accepted until 12:00 on Friday 5th March 2021 as Word documents and supporting materials emailed to the RSO inbox: rso-gdf@manchester.ac.uk. Applications will be assessed by a panel led by RWM.

# Research topics

Four broad gas-related research topics were identified by the RSO following the Gas Generation, Migration and Reactivity workshop at the RSO Launch event held in September 2020. These topics are:

1. Gas generation from corrosion of stable metals
2. Relevance of microbial processes to gas generation, migration and reactivity
3. Gas migration and reactivity in the Engineered Barrier System (EBS)
4. Gas migration and reactivity in the geosphere/biosphere

RWM, via the RSO, aims to establish a research consortium focussed on gas generation, migration and reactivity, with PhD projects across these topics. The consortium will aim to encourage focussed collaboration and communication between different areas of research expertise and provide the opportunity to link academic capability with RWM’s research priorities in this area over the next 5 years.

The following two PhD projects will form the initial phase of this consortium and sit within topics 2 and 3, respectively.

## Project 1 Microbial gas consumption processes in the GDF safety case for Low Heat Generating Wastes

Microbial populations have been shown to exist in the environmental conditions expected in the near-field and far-field of a GDF. Microbial populations will also be introduced to the GDF in the operational period, via disposed wastes and as a consequence of operational processes. It is likely that the microbiome will adapt to the changing conditions present in and around the GDF as the GDF itself evolves.

Microbial processes have the potential to contribute to bulk and radioactive gas generation related to waste disposed in the GDF. Microbial degradation of some organic materials present within a UK GDF, including those arising from the hydrolysis of cellulose to smaller organic molecules, generates gases - primarily hydrogen, with lesser amounts of methane and carbon dioxide. Additionally, microbes may consume gases, and microbially-affected reactions may act to seal fractures and porosity in rock mass via mineralisation reactions. The rates of gas generation and consumption from microbial processes are affected by conditions present in the GDF and the surrounding geology, including the presence or absence of water and oxygen, dissolved ion concentrations, pH and temperature – all of which evolve over the GDF’s operational and post-closure periods. RWM currently treats gas generation from microbial processes in a generalised manner in the GDF safety case, using bounding assumptions to make conservative calculations. Short-term laboratory experiments may act to build some confidence in relation to these approaches, noting the extrapolation of understanding to the longer term and larger scale remains problematic.

There is, therefore, uncertainty surrounding the role that microbes will play in the ‘gas pathway’ in an evolving GDF, due to a combination of phenomenological knowledge gaps, scaling (from laboratory scale to GDF scale), and a need to consider the behaviour of microbial populations in the longer-term. The role of microbially-mediated gas consumption is particularly subject to these uncertainties and, as a result, is not currently considered by RWM in the GDF safety case. Although this is arguably a conservative approach, it may lead to an over-estimation of the gas ‘source term’ and associated issues (e.g. GDF pressurisation). Additionally, the potential for microbial processes to lead to mineralisation and/or precipitation reactions in the EBS or host rock is also not considered.

To complement the current consideration of gas generation processes in GDF safety case work, RWM now invites proposals to investigate how microbially-mediated gas consumption (i.e. net loss of gas) processes could be considered in the long-term safety case, covering the (1 million years) evolution of the GDF. This research should help to further bound uncertainties associated with microbial activity, the survivability of microbes in the GDF and the key sensitivities in relation to biogenic gas processes.

The study should focus on the processes of gas consumption by microbes rather than specific microbial species; a focus on microbial functional genomics would be welcome. A mixture of experimental, numerical modelling, and in-situ experiments in underground research laboratories could be utilised, to inform hypotheses and propose conceptual models. The project shall consider UK LHGW only, and shall consider lower strength sedimentary rocks and evaporites as the GDF host rock. The project shall make recommendations to RWM regarding how microbially mediated gas consumption processes can be robustly considered in the GDF long term safety case.

## Project 2 Managing LHGW-derived gas via innovative Engineered Barrier System (EBS) materials

Gas will be generated in a Geological Disposal Facility (GDF) due to corrosion of metals, microbial metabolism and radiolysis of water/organic materials. Once generated, gas may dissolve in water, undergo chemical reactions, or may persist as a separate gas phase which may interact with EBS components and/or migrate to the geosphere.

Beyond the waste container, the EBS may comprise a range of materials, including a local buffer/backfill material, a mass backfill material, and may also include a vault liner and/or a series of plugs and seals to control gas flow between areas of the GDF. The EBS must fulfil a series of requirements and safety functions, depending on the nature of the site selected to host the GDF. The role of the EBS in relation to gas is to manage:

* The rate of gas generation reactions;
* The release of any gaseous species to the geosphere; and
* Gas pressurisation, preventing potential damage to the GDF.

RWM currently employs illustrative EBS concepts for different waste types and host rock geologies. This call is to focus on low heat generating waste (LHGW) disposal in lower strength sedimentary rocks (LSSR) and evaporites.

The illustrative EBS buffer/backfill material for LHGW is cementitious, characterised by:

* An ability to condition the near-field to a high pH, limiting gas generating processes such as corrosion of certain metals and microbial degradation;
* An ability to undergo carbonation reactions, thereby acting as a long-term sink for CO2 (including 14CO2);
* High permeabilities and low gas entry pressures, enabling fluid migration and preventing over-pressurisation; and
* A high capacity for sorbing radionuclides, thus limiting radionuclide migration beyond the EBS.

Given the generic stage of RWM’s current site selection process, no firm decisions have yet been made on the choice of EBS materials that will be used in the GDF. In particular, the cementitious materials that form the bulk of previous research (i.e. Nirex Reference Vault Backfill) likely do not meet the requirements for the current GDF programme. Additionally, the use of cementitious materials may be detrimental to the environment; cement production has a significant embodied carbon footprint and the associated chemical alteration of the GDF near-field may pose subsequent hazards to the biosphere. Therefore, the current proposal is not bound by cementitious EBS materials.

RWM is currently funding a multi-year, integrated project with the aim of identifying robust options for backfill materials given its evolving requirements. Gas management has been a key theme of development in this area – it is expected that any project funded under this theme will work in consideration of findings from RWM’s backfill integrated project team.

To further inform its decision-making process, RWM now invites proposals for research to identify novel EBS materials for LHGW – including alternatives to, or variations on, cementitious materials – that offer favourable gas-related properties whilst maintaining the key design requirements. Such properties may enable, but are not limited to, processes such as managed gas migration within the GDF (considering vaults, tunnels, plugs and seals, shaft etc.), long-term gas “sink” mechanisms (processes leading to loss of free gas), managed microbial degradation promoting bulk gas consumption, or any other relevant processes. Proposals may choose to focus on any component of the EBS.

RWM particularly welcomes highly innovative solutions and a focus on material behaviour over the 1 million-year timescale (the period considered in the GDF long term safety case) and under a range of UK-relevant GDF conditions. As noted, work is to focus on a GDF hosted in lower strength sedimentary rock and in an evaporite.

**Proposals acceptance and evaluation**

The details requested from applicants and how these will be evaluated are as follows:

1. **Confirm that the PhD project would start October 2021 and complete in 4 years (not evaluated)**

Applicants are requested to confirm the project will be able to start in October 2021 and be completed within 4 years.

1. **Acceptance of the attached terms and conditions of the grant is mandatory (pass or fail question):**

Acceptance of the attached RWM terms and conditions is mandatory.

If the grant agreement is not signed on award, then funding will not be issued.

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| **PASS/FAIL** |  |

1. **Evaluation criteria:**

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| ***Scoring criteria***  | ***Score***  | ***Weighting (out of 100%)***  | ***Description and guidance notes*** |
| Please provide a clear proposal taking into account the necessary timescales, including a project work plan and/or Gannt chart. If experimental work will be undertaken, a clear strategy for delivering, analysing and synthesising appropriate data should be detailed. | /4 | 35% | Responses should include:- A project plan / Gannt chart showing key phases of work, milestones and deliverables including completing within required period of time;- Clearly defined input / time / resources that would be required from RWM, excluding industrial supervision, to support or enable the project, such as security clearance, sample access or site visit to a licensed site;- Identify any major risks to the research and mitigation that can be considered against these risks, including any risks of the research to be extended past agreed period of time;- Identify any use of external facilities, such as NNUF or other national / international infrastructure and demonstrate that proposed activity has been discussed in advance with the relevant facility owners and is feasible within the bounds of the proposal. |
| Please give clear details of any experiments and / or modelling proposed, identifying how these provide necessary input for the PhD and how they build on the existing knowledge base. | /4 | 30% | Clear research delivery approaches (modelling / experimentation), demonstrating awareness of existing knowledge base and overall strategic thinking across the PhD project overall (e.g. how does planned experimentation address aspects of the problem posed?) |
| Please show how the supervisory team has the required expertise in the relevant areas. | /4 | 15% | Expertise required in gas in the context of the GDF, evidenced by e.g. journal papers, reports. |
| Please provide a costed proposal, identifying additional ‘in-kind’ contributions which you can bring to the PhD project.  | /4 | 20% | Identify cost breakdown between Tuition Fees, Stipend and Research & Training Grant. If applicable demonstrate ability to secure any further required funds or in-kind contributions to enhance the PhD.  |

***Scoring criteria:***

0= No response or response does not meet any requirements

1= Marginal response with significant drawbacks or omissions

2= Acceptable response, meeting most criteria with only minor drawbacks or omissions

3= Good response which meets all requirements

4= Excellent response which meets and exceeds requirements