

Radiological Characterisation and Decommissioning in the UK Non-nuclear Industry: Project Experience, Challenges and Solutions

**Authors; Dave Cannon MSci (Hons) PGCert (RWMD), Principal Consultant
Simon McLauchlan BSc (Hons), MSRP, MInstP, Radiation Protection Adviser**

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**Address; RPS Planning and Development, Conrad House, Beaufort Square,
Chepstow, Monmouthshire NP16 5EP**

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Abstract: This paper describes the work carried out to deal with existing low levels of radioactivity in buildings and land for two different sites. The first had a very long and varied history of the use of radioactive materials. This brings the challenge of poor or absent historical information requiring a very careful approach to survey design. The second was a large (around 1000 rooms) building with a much greater degree of confidence in the record keeping system, though as described, capable of providing surprises with contamination discovered in places where it was not expected. The existing exposure levels before remediation were low. A challenge arises from both the real and probable increase in exposure affecting investigators, decontamination and remediation operations when material is disturbed or uncovered. Stakeholders must receive timely and appropriate communication to permit the demonstration of compliance with both the As Low as Reasonably Practicable requirements of the safety regulations, and the proper and cost effective application of the waste regulations.

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1 National Physical Laboratory

RPS was commissioned by a principal contractor to provide radiological and environmental services to support the redevelopment of the National Physical Laboratory (NPL) site. This involved 20 buildings and over 75,000 square metres of land formerly used for a variety of processes associated with defining measurement techniques and standards. The NPL is an important national establishment dealing with the setting of standards for measurement including those associated with radioisotope measurement and traceable calibration standards.

The aims of the radiological support work were to;

- identify whether any radioactive contamination was present associated with the buildings or land
- determine the extent of any radioactive contamination
- determine the appropriate radioactive waste classification
- remediate the radioactive contamination to allow for safe demolition of buildings
- remediation of any radioactive contamination of the land
- undertake verification of land remediation and assessment of potential risk to human health for future site occupants based on the proposed land use

RPS were provided with historical information associated with the former uses of the buildings and land in order that an initial radiological characterisation plan could be developed which included for both general coverage and targeted investigation of locations where contamination could be present based on the historical information provided. Given the long history of work with radioactive substances at the site (approximately 100 years), the multitude of radionuclides used and the use of radium post WWII the site presented the potential to have radiological contamination in many locations.

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The first building available for survey in 2006 identified the presence of radium-226 to be associated with the flooring, comprising wooden parquet and the underlying concrete. The

remediation of the contamination generated a low volume of Exempt waste (Phosphatic Substances and Rare Earth Exemption Order) and also a single 200 litre drum of Low Level Waste (LLW), the disposal of which was deemed to be most cost effective through the site tenants Environmental Permit (formerly Certificate of Authorisation) for radioactive waste disposal.

Subsequent to this work the principal contractors programming changed so as to allow for multiple building and areas of land to become available for radiological survey and characterisation. This then allowed for an extended period of site surveys to be undertaken culminating in over 20 buildings and approximately 75,000 m² of land being surveyed.

Prior to the commencement of this main phase of works RPS discussed with the client the implications of finding radioactive contamination and the requirements for authorised radioactive waste disposal within the UK i.e. gaining a Permit for accumulation and disposal of radioactive wastes, with the associated timeframes and costs. As with any site re-development work the programme and costs are at the forefront of project decision making (subject to health and safety requirements).

At this stage the previous arrangements for disposal of radioactive wastes through the site tenant's Environmental Permit was adopted unless it was shown that the extent of contamination was such that this may not be the most efficient mechanism.

The following findings of radiological interest were identified;

- Radium-226 contamination on a wall in the 4th room surveyed as part of the works. This was in a building which was not in itself identified to have used radioactive substances but was surveyed on the basis of proximity to other radiological findings.
- Spot of radium-226 contamination in a redundant pump house
- Spots of radium-226 contamination associated with soils
- Radium-226 contamination associated with wooden parquet flooring and underlying concrete. Significant spillages were identified with multiple hot spots present across multiple locations. This was identified in a number of buildings
- NORM contamination beneath floor screeds. Past practice had apparently been to cover over contamination rather than undertake remediation
- Potassium-40 residue on floor lino in the centre of a room
- Plutonium, uranium, cobalt and other radionuclides contaminating fume cupboards and associated vent discharge systems
- Elevated activity (3 x background) at the base of an old source well - believed to be due to a radium/beryllium source previously rupturing
- Tritium contamination throughout some building fabric at low levels and also in asbestos containing materials
- Discharge pipe work containing NORM radionuclides and also containing elemental mercury mixed in with the radioactive contamination
- NORM radionuclides beneath building floor slabs. Had the building been built on the contaminated material?
- Strontium contamination associated with a redundant brick lined discharge tank which was set within soils. The tank base was found to be below the local water table level and required continuous pumping out to allow for remediation

Based on the broad range of radionuclides identified RPS undertook close liaison with the laboratory undertaking the radiological analysis in order to ensure that the techniques being employed were appropriate, cost savings could be achieved through screening techniques and that laboratory results correlated with field monitoring findings. A good example of this last point is due to the very high heterogeneity associated with some of the sample materials

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identified, such as wooden parquet that could have 2000 cps at only one end of the block and background activity at the other end. Therefore, ensuring samples were suitably marked prior to dispatch to the laboratory was paramount as well as ensuring the laboratory were made aware of such information.

Based on the characterisation works undertaken in some buildings it was identified that there were low levels of tritium contamination at activity levels both above and below the radioactive exempt waste classification criteria in force at that time of 0.4 Bq/g. RPS prepared assessments of the laboratory data generated and provided submissions to the Environment Agency regulators on behalf of the client in order to justify that building fabric materials could be sentenced as Exempt under the Substances of Low Activity Exemption Order for disposal.

Prior to the progression of the remediation works a bespoke Environmental Permit was gained for the principal contractor as the radionuclides, activities and volumes of radioactive waste anticipated to be generated were no longer consistent with the site tenant permit.

Due to the extent of contamination identified and the nature of the remediation requirements associated with the site it was deemed appropriate to tender the works to contractors capable of providing Suitably Qualified and Experienced Persons with RPS providing verification and technical oversight of the works.

The remediation works generated over 50 drums of Low Level Waste which was disposed of from site to a suitable recipient with Very Low Level Waste and exempt waste being disposed off site to landfill.

Verification sampling of the remaining soils on site was undertaken to support demonstration that there was no materials which could be classified as radioactive waste remaining and that the risk to future site occupants was below all national and international thresholds for future site occupants.

A turnkey service was provided to the client in respect of the Environmental Permit with a submission provided to the Environment Agency by RPS which provided a ready means of correlating the site characterisation works, radioactive wastes identified and records of disposal so that the project could be brought to a close through Surrender of the Environmental Permit.

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2 University of Southampton

The University of Southampton had a requirement for radiological survey and characterisation works associated with a large former Biosciences building which was scheduled for demolition to allow the site to be redeveloped.

This work had some similarities to that of NPL in that the objective was to support demolition and site redevelopment activities with the extent of any radiological contamination and requirements for remediation unknown. The project did however have the following differences from the NPL works;

- The radionuclides used were less diverse (primarily tritium, carbon-14, P-32) with many being of short enough half life to not be relevant for the decommissioning
- The building had a more recent history – from 1970's, so there was a greater level of confidence in the extent of potential contamination
- We were dealing with a single building with a single history rather than multiple buildings with different histories

This project had three discreet but interlinked work streams which comprised;

- Building characterisation – wooden benching, fume cupboards, vents and concrete walls/floors
- Effluent discharge system characterisation internal to building – constructed from mostly glass and associated with the majority of rooms within the building
- Characterisation of external pipe work and tanks associated with effluent discharge system and surrounding soils.

Again with such projects there was an emphasis on programme to ensure that all contractors met the timescales for allowing for building demolition and site redevelopment. Pressures included the commencement of the non-intrusive survey building survey with building occupants still present. Care had to be taken to ensure that no radiological works were undertaken in rooms which had been subject to survey so as to not invalidate the results.

2.1 Building Characterisation

The building survey was designed using the United States Environmental Protection Agency Data Quality Objectives (DQO) process to ensure that the data was of the right type and quality to make defensible decisions when subject to assessment. However, due to programme requirements, implementation of the non-intrusive and intrusive survey works were not scheduled in a manner which allowed for the DQO generated data to be assessed as a compiled data set for the soft building fabric materials which were to be stripped out e.g. benches, floor lino, fume cupboards. As such decisions associated with the wooden benching etc was undertaken on a sample by sample basis rather than allowing for a holistic approach to the data assessment, though still applying the Nuclear Industry Code of Practice (NICoP) which addresses clearance and exemption of potentially radioactive materials.

The main findings of the building characterisation works were;

- Identification of contamination in a randomly selected ‘clean’ room’ which required a revision to the Sampling and Analysis Plan
- Discreet spots of contamination on wooden benching identified in 18 rooms within the building, primarily carbon-14, although uranium was also identified in the former Radiation Suite
- Low levels of tritium and carbon-14 contamination associated with the fume cupboard extraction system
- Tritium contamination associated with the bulk fabric of the wooden benching and floor lino across many of the rooms sampled
- Tritium contamination of the concrete floor in 3 former cold rooms
- Tritium contamination associated with the benching, floor screed and some of the walls associated with the former radiation suite
- Elevated radiological reading associated with an individual who had just undergone a medical procedure.

Hot spots of contamination on wooden benching were not individually remediated as it was identified as part of the characterisation works that the bulk bench fabric was contaminated at Very Low Level Waste (VLLW) activity levels.

Exempt and VLLW waste were disposed to landfill through established arrangements with no LLW generated from the building characterisation works. The VLLW volume approached 50 m³ though it was demonstrated that the total activity disposed was only a small percentage of that allowed in the regulations and as discussed with the Environment Agency regulator.

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2.2 External Tank and Pipe Work Investigation

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The building effluent discharge system was designed with pipe work which extended underground from the basement and through a large tank. The effluent did not discharge directly into this large tank and some University staff commented they thought the design may have been changed from a 'settling tank' to a 'direct discharge' system.

RPS undertook a ground investigation surrounding the tanks and pipe work which identified three discreet locations of tritium contamination in the soils which classified the soil as Very Low Level Waste for disposal. Further instances of Exempt levels of tritium were identified within the soils which were below the requirements for remediation as radioactive waste and, through risk assessment, were demonstrated to not pose an unacceptable risk to future site users.

All the tanks present were subject to direct monitoring and physical sampling with no elevated activity identified to be associated with the tanks fabric materials.

Investigation and removal of the redundant pipe work identified that ground contamination was present in 3 discreet locations due to previous breakages of the pipes. Due to the nature of the system design the small breakages in the pipe work could not have been identified through any inspection programme or effluent accountancy procedures. The small leaks are likely to have been occurring for a number of years as the remediation required the removal of contaminated soil and clay materials below the pipe work to a depth of over 1 metre.

Following removal of the contaminated materials verification sampling and associated laboratory analysis was undertaken to demonstrate that no materials remained which could be classified as radioactive waste or pose a significant risk to future site users.

2.3 Effluent Discharge System

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As part of the project there was a requirement for the characterisation of the building internal effluent discharge system which was largely constructed of toughened glass. A strategy was designed by RPS to allow for the removal, monitoring and segregation of the discharge system as it was removed from the building for both radiological and chemical characterisation. The waste was segregated on a floor by floor basis and also based on the findings of direct monitoring and swab collection. No decontamination of the system was undertaken as a Best Available Techniques review had assessed this to not be a cost effective option.

This resulted in a total of 17 different waste streams being generated which also included mercury containing pipe work. The chemical analysis identified that all the waste, apart from the mercury containing pipework, were suitable for disposal as non-hazardous waste. The external effluent discharge system pipe work characterisation data was included within the relevant data sets for the internal effluent discharge system pipe work to ensure waste volumes were properly amalgamated and characterised as a whole. The radiological characterisation identified that pipe work from 4 floors was suitable for disposal as exempt waste, pipe work from 2 floors was suitable for disposal as VLLW and the pipe work associated with the former radiation suite was classified as LLW for disposal.

Arrangements were made with waste disposal contractors for acceptance of the exempt and VLLW to be disposed of direct to landfill with monitoring support and briefings provided to their operatives in order to alleviate any concerns over the radiological content.

The LLW disposal options were reviewed on the basis of cost-benefit in order to provide the client with an understanding of the relative costs and merits associated with the LLW disposal. Given the relatively low volume of LLW (<3 m³) it was decided to utilise the disposal route which had been gained within the Environmental Permit as part of the decommissioning project rather than seek a relatively small saving through gaining a new disposal route.

In summary the project required a variety of sampling and characterisation techniques for different materials, good understanding of the limitations and capabilities of instrumentation and through use of the Nuclear Industry Code of Practice allowed for appropriate, targeted and justifiable sampling and remediation of contaminated materials. From a project management perspective the work required the ability to deliver dynamic solutions to the client in a timely manner and respond to changes in programming while still ensuring regulatory compliance for radiation protection and radioactive waste management and disposal.

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