Best Available Techniques for Accumulation and Disposal of Radioactive Waste

University of Portsmouth

Introduction: What are "Best Available Techniques"?

The Environment Agency requires the use of Best Available Techniques (BAT) in the accumulation, use and disposal of radioactive wastes. The University must comply with this requirement under the Environmental Permitting (England & Wales) Regulations 2016 (as amended). This BAT statement sets out the steps taken by the University to ensure that the activity and quantity of radioactive waste produced on its premises are appropriately minimised so as to ensure that final disposals of waste radioactive material are carried out in a manner so as to minimise the radiological effects on the environment and members of the public.

The principle of optimisation (keeping doses as low as reasonably achievable) requires that:

1. Radioactive materials must only be used where their use can be justified, and no suitable alternative is available.
2. The activity of radioactive material kept and used on the premises is minimised
3. The amount of radioactive waste produced on the premises and the period over which radioactive waste is accumulated must be minimised
4. The activity of gaseous and aqueous waste disposed of by discharge to the environment is minimised
5. The volume of radioactive waste disposed of by transfer to a waste permitted incinerator is minimised
6. Radioactive waste must be disposed of in a form and manner so as to minimise the radiological effects on the environment and members of the public.

This BAT policy relates to the Environmental Permit EPR-UB3298DU issued by the Environment Agency.

Registration and justification of work

All work using radioactive materials must be planned well in advance of that work beginning and approval is required by the local Radiation Protection Supervisor and the University Radiation Protection Officer. At least 4 weeks prior to the start of any new work with radioactive materials, a Registration of Work form (RPR 5) must be completed by the user together with the local Radiation Protection Supervisor and approved by the University Radiation Protection Officer. This form includes a section requiring the justification of use of radioactive materials for the work/process being planned, a requirement to consider whether the amounts of radioactive materials being used could be reduced, and whether alternative, less radiotoxic radioisotopes could be used.

The Registration of Work form (RPR 5) requires the proposed user of radioactive materials to estimate the number of consignments and activities of the isotope which will be used in one year, and the maximum stock of isotope arising. It also includes a risk assessment for the process and an assessment of the amounts and types of radioactive waste which will arise from the process.

Figure 1 illustrates the life cycle of radioactive material at the University of Portsmouth.

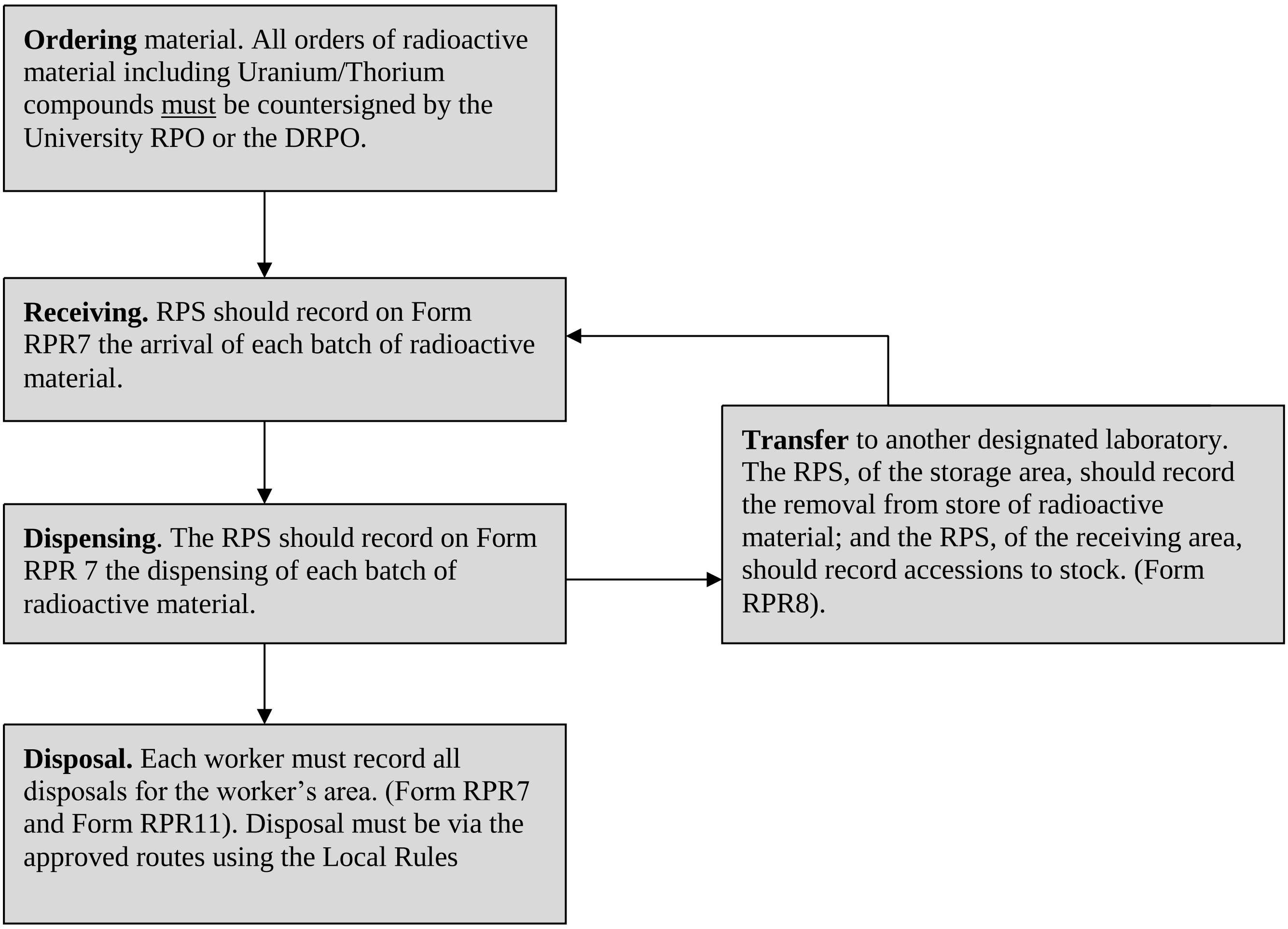

Figure 1. Life cycle of radioactive material at the University of Portsmouth.

Management Structure

Scope

This document describes the management structure for radiation protection and covers general radiation protection issues which may arise including use of X-ray equipment, at the University of Portsmouth for:

The Faculty of Science and Health:
School of Biological Sciences
School of Environment Geography and Geoscience
School of Health and Care Professionals (Radiography)
Dental Academy

The Faculty of Technology:
School of Energy and Electronic Engineering
School of Maths and Physics

Management and reporting structure
Radiation Protection at the University of Portsmouth is operationally managed by the University Radiation Protection Officer (RPO) and the Deputy Radiation Protection Officer, as advised by the external Radiation Protection Adviser and (where appropriate) Radioactive Waste Adviser. The RPO reports to the University Health and Safety Committee, which ultimately reports to the Vice Chancellor and Board of Governors. Any radiation related incidents are reported to the RPO and the relevant Faculty Health & Safety Committee.

Radiation Protection management and reporting is via the University Health and Safety Committee. As a member of the key committees (University Health and Safety Committee, Faculty Health & Safety Committees and Governors), the Head of Health and Safety at the University has an independent watching brief to oversee radiation protection and ensuring that the management system is appropriate. In addition, the Head of Health and Safety is responsible for long-term storage of personal dosimetry records. The structure of management and reporting is shown in Figure 2.

The officers responsible for the key radiation protection posts are shown in Figure 1. Operationally, the RPO is responsible to the Director of Estates and Campus Services.

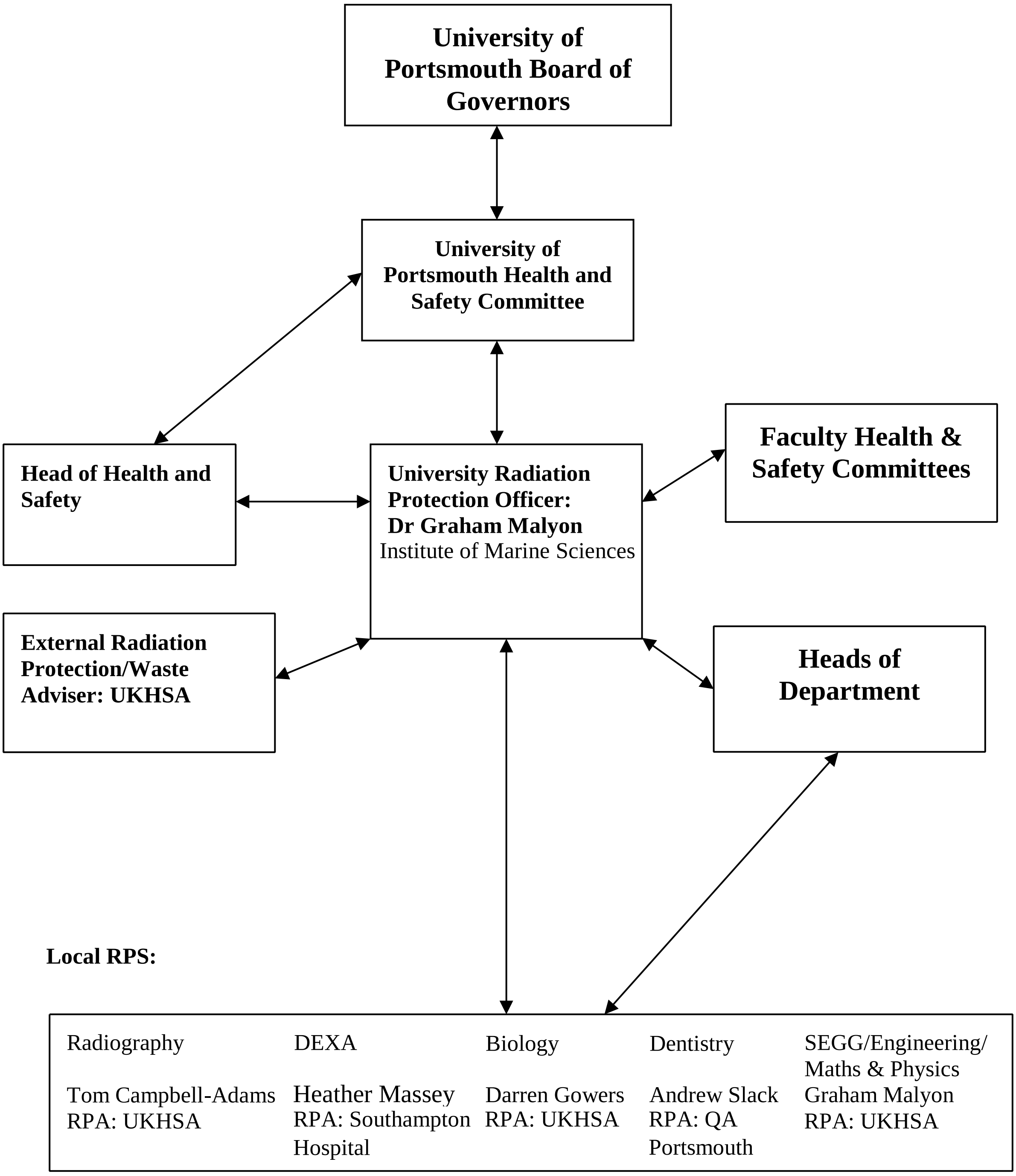

Figure 1. Management and Reporting Structure for Radiation Protection at the University of Portsmouth.

Accumulation and storage of radioactive waste

Small quantities of radioactive waste may be accumulated for short periods of time in marked bins in laboratories. Each isotope has a specific bin, allowing segregation of long- (C-14; H-3) and short- (P32; P-33; S-35) lived wastes. A record of the estimated waste entering each bin should be kept on the form attached to each bin and limits for each bin must not be exceeded (as set out in the relevant operating procedure). Long-lived waste must be removed regularly (at intervals set out in the operating procedure) by the Radiation Protection Supervisor (RPS) and disposed of mixed with normal waste. Short-lived waste must be removed regularly by the Radiation Protection Officer or RPS and stored in the University Radioactive Waste Store. Access to the Radioactive Waste Store is restricted, Dr. Darren Gowers (RPS) and Dr Graham Malyon (URPO). These users of the radioactive waste store must sign the entry/exit book held by Dr. Darren Gowers. The waste storeroom has a secure lock. Short-lived radioactive waste (P-32, P-33, S-35) may be accumulated in the waste store for up to 6 months to allow it to decay. Such waste must be kept in the relevant bin in the waste store, and a record kept of its activity on entry and disposal. The University is authorised to accumulate radioactive waste for a period up to nine months. However, the 6 month storage period is considered to provide a significant reduction in environmental emissions by decay whilst avoiding excessive build-up of radioactive waste materials in the Radioactive Waste Store. As discussed below, limits are placed on the disposal of waste in laboratory bins such that each waste item (defined here as one laboratory bin bag) will, after six months decay, be classed as very low level solid waste. In exceptional circumstances and with the prior authorisation of the RPO, waste may be stored for longer, up to the nine month authorisation limit. These procedures are set out in the operating procedure set out in the Local Rules.

Waste control, minimisation and disposal

Prior to any new work beginning with radioactive materials, Form RPR 5 must be completed and approved by the University Radiation Protection Officer. This form includes requires the user to justify the use of radioactive materials for the work and to minimise the amounts of materials used. It is also a requirement that a waste disposal route has been identified and that use, and disposals are within appropriate limits. Once work has begun, the use and disposal of unsealed radioactive materials is recorded using the Unsealed Radioactive Materials Record (Form RPR 7).

In particular, in recent years, the University has a policy that, where possible, the use of P-32 is replaced by the significantly less radiotoxic P-33.

Disposal of very low level Solid Waste

Exempt (VLL) solid waste is defined as waste in which:

- There are no alpha-emitting radionuclides
- The sum of all radionuclides in any 0.1 m^3 of refuse is less than 400 kBq and less than 40 kBq in any one article **OR** the sum of all Tritium and C-14 in any one 0.1 m^3 of

refuse is less than 4 MBq and less than 400 kBq in any one article and there are no other radionuclides.

The procedures for VLL solid waste disposal are set out in the Local Rules as appropriate.

Disposal of unwanted Closed Sources and Uranium and Thorium compounds

The University has conducted an audit of its stores of Uranium and Thorium compounds. This waste inventory has been removed by disposal via a route authorised by the Environment Agency and based on the Environment Agency Guidance for Schools wishing to dispose of radioactive materials. This disposal programme has led to a greater than 95% reduction in the University's holdings of radioactive materials.

Our programme of disposal of unwanted small, sealed sources has resulted in the disposal of fifty radioactive sources in the period 2009-2020 either by collection by an external agency or as exempt items.

Disposal of aqueous waste

The aqueous disposal limits under which the University operates are summarised in Table 1.

Table 1. Maximum monthly disposal limits via the aqueous disposal route.

Radionuclide	Monthly Disposal Limit (MBq)
H-3, C-14, S-35, I-131	150
P-32	200
P-33	150
Any other beta or gamma emitter.	20

Radioactive liquid waste should be disposed of via one of the designated radioactive waste sinks. Each disposal should be flushed down the sink with copious amounts of tap water.

Liquid scintillant fluids

Biodegradable liquid scintillant fluids may be disposed of via the designated sinks. Non-biodegradable organic liquid scintillant waste must not be used or disposed of via the sinks. Use and disposal of such non-biodegradable scintillants will require authorisation by the Environment Agency and will incur significant cost. Prior to their use, approval must be sought from the University Radiation Protection Officer at least 6 months in advance of use.

Risk Assessment for Aqueous Disposal Route

In view of its relatively high monthly disposal limit, its high bioaccumulation in aquatic systems and its high radiotoxicity, P-32 is the most significant of the discharges detailed in Table 1. We will therefore estimate potential radiation exposures from environmental discharges of P-32.

Aqueous waste from both Burnaby and St Michaels buildings is transferred via the University's wastewater system to Southern Water's Budds Farm Sewage Treatment Works (STW). There, the waste is treated (for this marine effluent, there is no tertiary treatment for phosphorus removal) prior to transfer via pipeline to Eastney Pumping Station. From Eastney, the waste is discharged to sea at NGR SZ66799325 via a 5.7 km pipeline of diameter 1400mm. The average effluent flow through the pipeline is 1200 l/s, with range 600 – 2362 l/s. The average water depth above the pipeline is approximately 17.7 m and the outfall is fitted with a 96 m long diffuser with 9 ports spaced at 12m intervals.

The dispersion of released wastewater is expected to be high in the East Solent area (Riddle and Lewis, 2000). Measurements (Riddle and Lewis, 2000) show full vertical mixing within 1.4 hours, and a lateral dispersion coefficient K_{ys} of 1.85 m^2 s^{-1}. Defining a characteristic lateral mixing length L:

$$L \sim \sqrt{K_{ys} t}$$

gives, over a time period of one month, $L \approx 2200$ m.

Advection of the released wastewater will occur as a result of both tidal movement and residual current flows. The residual water flow in the Solent is mainly in the Westward direction, and residual water currents can exceed 160 cm s^{-1} (Dyer and King, 1975). Assuming a mean residual current of 3 cm s^{-1}, the dispersal plume would travel approximately 80 km in one month.

We assume a mixing volume in one month of width equal to the characteristic dispersion length (2200 m), of length equal to the advection distance (80000 m) and depth 15 m. This gives a mixing volume, for dispersal of discharges over a one month period of 2.6×10^9 m^3.

Dilution of the monthly disposal limit (200 MBq/month) of P-32 within this volume leads to an average seawater concentration of 0.8×10^{-4} Bq/litre. The bioaccumulation factor for stable phosphorus in marine fish is estimated to be 29,000 l kg^{-1} (Kahn and Turgeon, 1984). The P-32 bioaccumulation factor is expected to be significantly lower than this due to radioactive decay during uptake through the food chain. We will therefore assume a lower value for P-32 of 3500 l kg^{-1} as recommended by Kahn and Turgeon (1984). For an average seawater activity concentration of 0.8×10^{-4} Bq l^{-1}, this leads to an estimated average activity concentration in fish of 0.27 Bq kg^{-1} (f.w.).

The ingestion rate of marine fish for the critical group of high intake consumers is 100 kg y^{-1} (Robinson, 1996), leading to (assuming all of the consumption is from the area affected by the discharge) a P-32 intake of 27 Bq. The committed Effective Dose per Unit Intake for ^{32}P is 2.4×10^{-9} Sv Bq^{-1} (Delacroix et al., 2002), giving an estimated dose to the critical group of 0.07 µSv per year.

The estimated maximum dose to the critical group for P-32 is therefore 0.07 µSv per year. Doses from the other radioisotopes in Table 1 are lower than this value. It can be concluded, therefore, that radioactive discharges via the aqueous disposal route do not result in a significant additional dose to members of the public.

Staff training

All new users of radioactive materials are given training as detailed in the Radiation Protection Rules. This outlines the operating procedures to which users must adhere and highlights the importance of waste minimisation and handling.

References

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