TOWN AND COUNTRY PLANNING ACT 1990 (AS AMENDED)

APPEAL AGAINST WOKINGHAM BOROUGH COUNCIL TO REFUSE OUTLINE PLANNING PERMISSION WITH ALL MATTERS RESERVED (EXCEPT FOR ACCESS) FOR:

The development of up to 49 dwellings, with associated access, landscaping and public open space. All matters reserved other than access.

Land west of Kingfisher Grove, Three Mile Cross

18 October 2022

PROOF OF EVIDENCE

On Location within the Detailed Emergency Planning Zone (DEPZ)

Prepared by:

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Reviewed by:

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of Katmal Limited

PINS Ref: APP/P1425/W/22/330091

LPA Ref: LW/21/026

PROOF OF EVIDENCE: M C THORNE

Personal Qualifications

My name is Michael Charles Thorne. My qualifications include a BSc (Hons) degree and a PhD in physics. I am a Fellow of the Institute of Physics, an Honorary Fellow of the Society for Radiological Protection and a Chartered Radiation Protection Professional. I am also Editor-in-Chief of the Journal of Radiological Protection.

I have approximately 47 years of experience in operational and environmental radiological protection. For the last 15 years, I have advised SKB, Sweden on site characterisation activities relating to geological disposal of radioactive wastes. I also provide advice on radioactive waste disposal to organisations in the UK, Finland, France, Spain and the United States. In addition, I have extensive experience in the remediation of former uranium mining and milling sites, having led or participated in projects in Bulgaria, Slovakia, Albania and Romania. In the non-nuclear field, I have provided advice to the Channel Tunnel Safety Authority and on the safety of developments near chemically hazardous installations. I have also appeared as an expert witness in various public inquiries, hearings and civil trials in the UK and the USA and was a member of the WHO expert group that evaluated US liabilities for compensation in relation to residents of the Rongelap Atoll in the Marshall Islands. I have published several books (comprising six volumes on radionuclides in the environment and two volumes on the pharmacodynamics of toxic metals, semi-metals, organic compounds and asbestos) and book chapters, as well as around 100 peer-reviewed journal articles, mainly on the environmental transport of radioactivity.

I have undertaken several radiological impact assessment studies relating to proposed developments around AWE Aldermaston and AWE Burghfield and appeared as an expert witness at the Boundary Hall public inquiry (APP/H1705/V/10/2124548). Specifically, I prepared radiological impact assessments for appeals (dealt with via the written representations procedure) at Diana Close (APP/X0360/W/19/3240232), Croft Road (APP/X0360/W/21/3269790) and Hearn and Bailey Garage (APP/X0360/W/21/3271017) that are referenced in the Statement of Case of Wokingham Borough Council (LPA).

I have reviewed all of the submittal information and have examined the relevant plans and documents for this Appeal.

The evidence which I have prepared and provide for this Appeal in this report is true and has been prepared and is given in accordance with the guidance of my professional institute (the Society for Radiological Protection) and I confirm that the opinions expressed are my true and professional opinions.

This evidence has been reviewed by Keith Ian Pearce in light of his significant experience (as set out below) of emergency planning matters. I confirm though that, notwithstanding Dr Pearce's input, this proof remains my evidence.

Dr Pearce provided me with details of his personal qualifications and experience as follows:

"My name is Keith Ian Pearce. My qualifications include a BSc (Hons) degree in Physics, a PhD in Nuclear Physics and an MSc in Emergency Planning Management. I am a fellow of the Emergency Planning Society and a Chartered Physicist.

I taught Nuclear Physics, Radiation Protection and Emergency Planning at the Royal Naval College between 1987 and 1990.

Between 1990 and 2014 I worked for Nuclear Electric and successor companies[1] in two main roles.

Between 1990 and 2005 I was employed as a mathematical modeller, developing and applying mathematical and computer models of the movement of radionuclides through the atmosphere, waters and food chains and the potential uptake of radiation dose by members of the public and using these to support safety cases and emergency planning preparations for a nuclear generating company.

I helped to develop the computer tools and processes used during an emergency to estimate where accidentally released radioactivity might migrate, the dose implications of this for the public and the strategies that could be employed to reduce the potential for harm to the public.

[1] Magnox Electric, BNFL Magnox Limited, Magnox South Limited and Magnox Limited.

Between 2005 and 2014 I was Head of Emergency Planning, responsible for the developing, maintaining and testing of the on-site emergency plans and responsible for supporting the local authority in the preparation and testing of the off-site plans for 10 reactor sites across the UK. In this role I liaised with local authorities, regulators, emergency responders, health bodies and government departments and played an active role on several national committees.

Between 1992 and 2014 I held radiation monitoring, dose assessment, health physics and command roles within the company emergency scheme in addition to my "day job".

Between 2001 and 2014 I wrote and maintained the REPPIR-01 Hazard Identification and Risk Evaluation (HIRE) reports for ten sites.

I managed and participated in several exchange visits and peer reviews with Russian emergency preparedness experts (2000 – 2003) and participated in inspections and peer reviews on nuclear power stations in the Ukraine (2011), Germany (2012) and Bulgaria (2012) for the International Atomic Energy Agency and the World Association of Nuclear Operators.

As an independent contractor working for my own Company (Katmal Limited) since 2014 I have helped civil operating and new build companies and nuclear dockyard and submarine building companies develop their on-site emergency preparations and helped local authorities develop and audit their off-site plans.

I have run and reported multi-agency workshops for civil and military sites looking at the ability to extend existing nuclear plans if faced with a bigger than planned for event.

I have written the REPPIR-19 Hazard Evaluation and Consequence Assessment and the Consequence Report for a fuel enrichment company.

I have helped local authorities understand the Consequence Report sent to them by operators; helping them understand the risk profile of the site they host and to develop appropriate off-site plans.

I have also provided advice to Companies wishing to develop sites within the DEPZ of AWE Burghfield.

I have written books on the physics of the Chornobyl accident and nuclear emergency planning for local authorities.

I have read the relevant papers associated with this appeal and helped Dr Thorne prepare his evidence by critical review of his draft Proof of Evidence."

Executive Summary and Summary Proof

The appeal scheme comprises a proposed residential development of 49 affordable dwellings, with new publicly accessible open space and access (access to be considered) on land west of Kingfisher Grove, Three Mile Cross, Reading (the Proposed Development). This would involve a likely residential population of about 120 individuals. Until 2019, the Proposed Development would have been located about 1.5 km outside the boundary of the DEPZ for AWE Burghfield. However, under REPPIR [2019] (CD 11.20), a new basis for defining the extent of the DEPZ has been adopted and hence the site of the Proposed Development lies inside the boundary on the new DEPZ. Therefore, because it lies within the expanded DEPZ, its implications for the off-site emergency plan must be addressed.

The risk of an accident at AWE Burghfield with off-site consequences is extremely low. It can reasonably be assumed that the relevant Consequences Report has been prepared on the basis that a reference accident is no more likely than 1 in 10,000 years. Further, taking into account that the probability of the wind blowing any contaminated plume towards the site is no more (and probably quite a bit less than) 10%, and that the adverse weather conditions which are the basis of the increased DEPZ occur about 12% of the time, the worst case dose contour which has informed the revised DEPZ can be assumed to occur in the direction of the Proposed Development around 1 time in 1,000,000 years.

The effective dose that might be received by a resident due to an accident at AWE Burghfield in average weather assuming that the wind is blowing towards the proposed development is estimated at about 1.5 mSv in average weather conditions (which is slightly more than the 1.0 mSv limit on annual effective dose to a member of the public from planned exposures and less than the 2.7 mSv annual effective dose received from natural background) or 9.0 mSv under adverse weather conditions (which occur about 12% of the time). Effective doses of this magnitude are of only limited radiological significance and would not justify disruptive mitigation activities. In average weather conditions, sheltering alone (which would reasonably be anticipated to provide a 40% dose reduction) should be sufficient to decrease the effective dose received to less than 1 mSv, and to about 6 mSv in adverse weather conditions. As discussed in Section 3 of my proof, the risk of an adverse effect on the health of an individual at the site (i.e. a fatal or non-fatal cancer) is somewhere around 1 in 1,200,000,000 years – and this calculation takes no account of the dose reduction achieved by sheltering, which is the primary mitigation measure.

The Proposed Development is so distant from AWE Burghfield that urgent evacuation would not be required even for extreme accidents (as is confirmed in the off-site emergency plan recently provided), and longer-term relocation is not likely to be necessary for those living on the site.

Under REPPIR 2019, regulation 11(1), where there is either a DEPZ or an Outline Planning Zone – and here there are both -- the relevant local authority “must make an adequate off-site emergency plan covering that zone or zones”. The Outline Planning Zone is 12 km in radius and it includes several urban conurbations, including Reading, the southern parts of which are as close to AWE Burghfield as the site. I note below that the adopted off-site emergency plan here contemplates that any event affecting the Outline Planning Zone beyond the DEPZ would be approached by reference to comparable principles that apply to the DEPZ.

It needs to be considered whether the construction of small numbers of properties in the DEPZ could have an impact on the adequacy of the off-site emergency plan. However, the discussion in Sections 4 and 5 of this report shows that, if the proposed development was to be permitted, there would be no impact on responders under the emergency plan and no adverse impact on the access of emergency services to the AWE Burghfield site.

An important supplementary consideration is whether the proposed development would place an additional load on first responders and carers in respect of dealing with medical emergencies and addressing the needs of vulnerable individuals. However, in most accident scenarios sheltering would either not be required or be required for between a few hours and two days. Furthermore, the assessed effective doses are so low that visiting by members of the “blue light” services during the period of sheltering should be acceptable if it were considered necessary for the well-being of one or more residents. In this context, it is important to emphasise to carers and members of the emergency services that entry into areas having low levels of radioactive contamination does not pose a threat to their health. This is a general aspect of their training and does not have any specific implications for the acceptability of the proposed development. In addition, REPPIR 2019, regulation 11(6) requires that emergency responders be provided by their employers with suitable instruction, training and protective equipment.

Any long-term resident relocation would primarily be to dispel anxiety and facilitate clean-up operations. Relocation would not primarily be to avert effective dose, so its timing is not critical. Rather, relocation would properly be focused on properties closer to AWE Burghfield and it is not reasonable to anticipate that it might be required at the periphery of the DEPZ (where the appeal site is located) given the low doses involved, the limited clean-up steps that might be considered (discussed in my proof), and the lack of any material risk subsequent to the initial plume.

Overall, although the location of the proposed development within the DEPZ of AWE Burghfield is a material planning consideration, the arguments presented in this proof show that it is a matter that can be satisfactorily addressed without prejudice to the efficacy of the off-site emergency plan.

This is in accord with the position of the Secretary of State in relation to the Boundary Hall, Tadley development [Nowak, 2011] (CD 6.8) where it was concluded that 'while he does not seek to minimise the potential impact of any individual dose, the Secretary of State considers that this should be placed in the context of the probability of such a dose arising which, while unquantified, has been described as 'extremely remote'... Added to this, he has taken account of the fact that there is no evidence that the Off Site Plan for dealing with such emergencies would fail; and he is satisfied that the intensification of population density is not, in itself, a reason to refuse planning permission. The Secretary of State considers that these factors temper the weight to be attached to the risk of a materially harmful radiation dose relative to the benefits of the proposed scheme. No activity can ever be regarded as being risk free, each case has to be considered on its own merits, and the Secretary of State concludes that the potential benefits of this scheme, coupled with the fact that is generally in accordance with the development plan, outweigh the real, but very small, risks attached.'

Finally, it is appropriate to consider the Proposed Development in the light of the local Development Plan Policy. TB04: Development in vicinity of Atomic Weapons Establishment (AWE), Burghfield states that:

> Development will only be permitted where the applicant demonstrates that the increase in the number of people living, working, shopping and/or visiting the proposal (including at different times of the day) can be safely accommodated having regard to the needs of "Blue Light" services, and the emergency off-site plan for the Atomic Weapons Establishment site at Burghfield.

As shown in Sections 4 and 5, the Proposed Development would place negligible additional demands on the blue light services. Therefore, the Proposed Development could be accommodated within the existing off-site emergency planning arrangements.

CONTENTS

1.0 Background

1.1 This proof of evidence examines the implications of the Proposed Development: 49 affordable dwellings, with new publicly accessible open space and access (access to be considered) (the Proposed Development) at land west of Kingfisher Grove, Three Mile Cross, Reading (the Site) for the off-site emergency plan (and the resulting impact on the "blue light" services) that arise from nuclear activities at AWE Burghfield. In so doing, this proof seeks to address putative reason for refusal 3:

> *"The proposed residential development within Detailed Emergency Planning Zone (DEPZ) for the Atomic Weapons Establishment (AWE at Burghfield cannot be safely accommodated having regard to the needs of 'Blue light' services and the emergency off-site plan for the Atomic Weapons Establishment site at Burghfield, contrary to policy TB04 of the MDD Local Plan and section 8 of the NPPF."*

1.2 Taking a typical occupancy of 2.4 residents per unit, as determined from 2011 census data, the total number of residents of the Proposed Development would be about 120. For comparison with the 49 units proposed, the total number of residential properties within the DEPZ is approximately 7000 [Richardson and Anstey, 2020] (CD 11.1). Therefore, the increase in the population within the DEPZ that would arise from the Proposed Development is 0.7%. It is in this context that it is necessary to consider the implications of the Proposed Development, and the resulting minor increase in the DEPZ population, on the off-site emergency plan in relation to potential accidents occurring at AWE Burghfield, as I do below.

1.3 In this proof, Section 2 describes the activities undertaken at AWE Burghfield and the types and frequencies of accidents that might result in significant off-site releases of radioactive materials. Section 3 then uses this information to assess the radiological impacts of such releases on individuals located at the Proposed Development assuming it to be downwind of the site at the time of an accident (i.e. the worst-case scenario). Section 4 considers potential impacts of the Proposed Development on the off-site emergency plan and Section 5 addresses the specific issue of potential impacts of the Proposed Development on resourcing to implement the off-site emergency plan, with specific emphasis on the emergency (or "blue light") services. Conclusions from this analysis are referred to in Section 6 and are presented in the Executive Summary and Summary Proof above.

2.0 Potential releases of radioactive material

2.1 Activities at AWE Burghfield, rationale for the extent of the DEPZ, and types and magnitudes of accidents addressed in off-site planning

Activities at AWE Burghfield and rationale for the extent of the DEPZ

2.1.1 AWE Plc is the company that provides and maintains nuclear warheads for the UK "continuous at sea" nuclear deterrent known as Trident. AWE Aldermaston and AWE Burghfield are the company's two main sites. Burghfield operated as an ordnance factory until it entered the Atomic Weapons' Programme in 1954. Today, on-site operations at AWE Burghfield include the entire lifecycle of warheads from concept and design, manufacturing, assembly, servicing, decommissioning and disposal [ONR, 2018] (CD 11.17).

2.1.2 Until recently, requirements relating to off-site emergency planning were defined under the Radiation (Emergency Preparedness and Public Information) Regulations 2001 [REPPIR, 2001] (CD 11.19). However, these have now been replaced by the Radiation (Emergency Preparedness and Public Information) Regulations 2019 [REPPIR, 2019] (CD 11.20). Under REPPIR [2001] and REPPIR [2019] the term "Detailed Emergency Planning Zone" ("DEPZ") refers to an area determined in accordance with the Regulations in relation to which an off-site emergency plan must be put in place which dictates what would happen in the event of an incident involving the release of radioactive material.

2.1.3 Whereas under REPPIR [2001] (CD 11.19) the extent of the DEPZ was determined by the Office for Nuclear Regulation (ONR), under REPPIR [2019] (CD 11.20) it is determined by the lead Local Authority (LA), which, in this case is West Berkshire District Council (West Berkshire DC), in consultation with other parties having a role in the development and implementation of the off-site emergency plan. These parties include AWE and ONR (see Section 1.7 of AWE [2022]) (CD 11.5).

2.1.4 As explained in greater detail below, under REPPIR [2001] (CD 11.19) the minimum extent of the DEPZ was based on a "limiting dose contour" of 5 mSv and average weather conditions. In contrast, under REPPIR [2019] (CD 11.20) the limiting dose contour is increased to 7.5 mSv. In isolation, this change would decrease the minimum size of the DEPZ. However, REPPIR [2019] also requires the consideration of various other factors in setting the extent of the DEPZ as summarised below:

- Age and other characteristics that would render specific members of the public especially vulnerable;
- All relevant pathways;
- A range of weather conditions to account for:
  - o the likely consequences of such conditions; and,
  - o consequences which are less likely, but with greater impact.

It is the last bullet point, and the interpretation of this that the minimum extent of the DEPZ should be set with regard to the less likely weather conditions rather than the average, that is the significant methodological change from the requirements of REPPIR [2001] (CD 11.19).

2.1.5 I will now expand on this, to explain in greater detail how the current boundary of the DEPZ (shown in Figure 1) was arrived at.

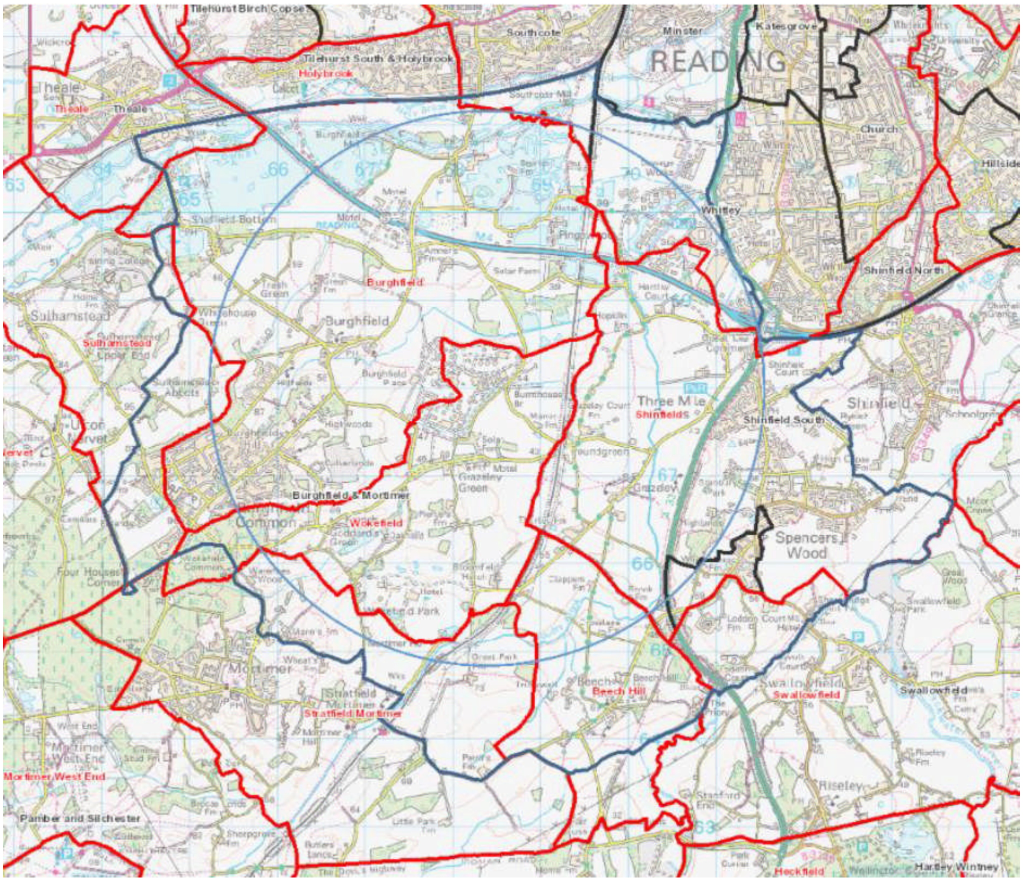

Figure 1: The DEPZ for AWE Burghfield as defined under REPPIR [2019]. The light blue circle is the Urgent Protective Action Area (UPA) that defines the minimum size of the DEPZ, whereas the irregular, darker blue line shows the extent of the DEPZ defined by West Berkshire DC, taking local factors into consideration. Parish boundaries are shown in red. From Richardson and Anstey [2020] (CD 11.1).

2.1.6 To define the location of the 7.5 mSv contour, AWE Burghfield produced a 'Consequences Report' as required under REPPIR [2019] (CD 11.20). This report [AWE, 2019] (CD 11.3) provides details of the environmental pathways of exposure that require consideration and the atmospheric stability conditions (i.e. weather conditions) adopted in calculating the dispersal of radioactive materials beyond the site boundary. The information provided is summarised below.

Environmental pathways

2.1.7 The exposure pathways that require consideration include:

- First-pass inhalation of air in the plume of contamination,
- Short-term external irradiation during the passage of the plume (cloud-shine),
- Long-term inhalation after resuspension from ground contaminated by the plume,
- Long-term external irradiation from ground contaminated by the plume (ground-shine),
- Ingestion of food crops contaminated by the initial plume.

2.1.8 The Consequences Report [AWE, 2019] (CD 11.3) also observed that the most likely predicted accidents would spread material by explosive distribution, where the dominant material would be plutonium in an inhalable particulate form. Section 2.5 of AWE [2022] (CD 11.5) further identifies accidents involving releases of plutonium as potentially the most hazardous requiring consideration. However, for potentially more energetic events (interpreted here to include criticality excursions) a range of fission products would be produced. I note that these fission products would be likely to arise from pre-existing material or a criticality excursion and not from an operating nuclear reactor, as there are no operating reactors present at AWE Burghfield [Section 2.8 of AWE, 2022] (CD 11.5). Although some accidents could result in releases of radioactive hydrogen (tritium), this is of low radiological toxicity and would rapidly disperse in the environment [Section 2.6 of AWE, 2022] (CD 11.5). Specifically, [AWE, 2022] states that:

- Tritium that remained in the form of gas would behave similarly to hydrogen and would disperse rapidly and upwards due to its very low density.
- Both tritiated water and tritium gas might be carried along by the prevailing wind to form a "plume" or cloud. The water content of the atmosphere and the turnover of water in the environment would ensure the rapid dispersion and dilution of any tritium or tritiated water that was released, as a result significant levels of tritium contamination occurring outside the AWE site involved is unlikely.

- Tritium emits very low energy beta particles that are unlikely to penetrate clothing or skin. External radiation from the passing cloud or from deposited material containing tritium would be negligible.
- Dispersed tritium containing material could present a hazard if it were to find its way into the human body. This could occur if airborne tritiated material was inhaled from the passing cloud, was absorbed through the skin, or if contaminated foodstuffs were consumed.
- In the case of breast feeding or pregnant mothers, a proportion of the inhaled/ingested dose will be transferred to the unborn child or passed on to the breast-feeding infant through contaminated mothers' milk. (However, in Section 9.2 of AWE [2022] (CD 11.5), this is considered only to be of relevance for AWE Aldermaston and not AWE Burghfield.)
- If tritium containing material was inhaled or ingested, it would be rapidly dispersed throughout the body tissues (which themselves consist largely of water) and would be excreted in the urine. Measures can be taken to promote excretion of urine (and hence of tritium) and minimise the consequences of any intake of tritium that may have occurred.

2.1.9 Overall, the potential radiological impact of releases of tritium are assessed to be much lower than the potential impacts of releases of plutonium and it is not addressed further. As stated in Section 2.8 of AWE [2022] (CD 11.5) 'An accident involving the dispersion of plutonium would present the greatest potential hazard to the public if it were to occur.'

2.1.10 For most fault sequences, the material released would be in the form of particulates of plutonium and the predominant pathway would be exposure by inhalation (i.e. first-pass inhalation of air in the plume of contamination). Winnowing of larger particles from the plume by deposition as it was transported downwind would result in the remaining aerosol comprising fine, inhalable material at distances of more than a few hundred metres. Therefore, the primary concern for early response decision making in emergencies involving possible accidents at AWE Burghfield only merits consideration of the first-pass inhalation dose. Sheltering would need to be quick in the context of explosive releases because it has been estimated in AWE [2019] (CD 11.3) that there will be an average of twenty-five minutes from the initiation of such an event until the plume reaches the minimum distance recommended for urgent action).

<u>Weather conditions</u>

2.1.11 In respect of atmospheric dispersion, the REPPIR [2001] (CD 11.19) determination of the extent of the DEPZ was based on a 5 mSv contour using 55% stability Category D conditions, i.e. the weather was taken to correspond to average conditions applicable in the UK [Clarke, 1979] (CD 11.7). In contrast, the new REPPIR [2019] (CD 11.20) determination described in the Consequences Report [AWE, 2019] (CD 11.3) is based on a 7.5 mSv contour but on a weather category that is less likely, but which could provide significantly greater doses downwind on the plume centreline[2]. Consideration of less likely weather categories, which occur around 12% of the time in the local geographical area (and only at night), increases the 7.5 mSv dose contour, defining the Urgent Protective Action Area (UPA) to be limited by a contour 3160 m from the centre of the Burghfield site [AWE, 2019] (CD 11.3). This UPA is shown in Figure 1. The UPA defines the minimum size that could be set for the DEPZ. However, the lead LA may define the DEPZ to be larger than the UPA to take account of local considerations, e.g. the desirability of not having the boundary of the DEPZ distinguish two parts of a single community. The extent of the DEPZ adopted is shown in Figure 1 and it encloses a substantially larger area than that defined by the UPA.

2.1.12 The less likely weather categories that could provide significantly greater doses apply only in moderately to extremely stable atmospheric conditions. Such conditions occur only at night and with limited cloud cover (see Figure 2 of Clarke [1979]) (CD 11.7). In interpreting this figure, it is important to realise that the left-hand side refers to daytime conditions when the atmosphere cannot be more stable than Category D, whereas more stable conditions (including Category F) can only occur at night (see text at page 8 of Clarke [1979] (CD 11.7)).

[2] Schedule 3 of REPPIR [2019] states that "The calculations undertaken in order to reach the assessment must consider a range of weather conditions (if weather conditions are capable of affecting the extent of the radiation emergency) to account for — (a) the likely consequences of such conditions; and (b) consequences which are less likely, but with greater impact."

Types and magnitudes of accidents addressed in off-site planning

2.1.13 Because there have been few changes in operations at the Burghfield site over the last few years, a further insight on the types of accident of interest can be obtained from ONR [2018] (CD 11.17).[3] This is based on the reference accident concept[4] and states that AWE Plc identifies the reference accident at AWE Burghfield as a detonation within a cell (meaning a 'hot cell' for the manipulation of radioactive materials). Furthermore, ONR [2018] (CD 11.17) reports that the AWE Plc Report of Assessment (RoA) concludes from the reference accident that the area in which a member of the public might potentially receive a radiation dose of more than 5 mSv is bounded by a circle of radius 1.252 km (1252 m) from the centre of the licensed nuclear site. As I show in Section 3, an accident that produces 5 mSv at 1252 m in average weather conditions would be similar in magnitude to an accident that produces 7.5 mSv at 3160 m under less likely weather conditions.

2.1.14 ONR [2018] (CD 11.17) in its review of the RoA further comments that all accidents that could lead to a reasonably foreseeable radiation emergency result in the release of uranium and/or plutonium compounds. These materials emit alpha and weak gamma radiations. The AWE dose assessment includes internal contributions from plume inhalation over the year following the release. ONR [2018] (CD 11.17) further states that external irradiation from the passing plume or from deposited uranium/plutonium material was assessed as negligible in the RoA due to the nature of these materials. The dose associated with the inhalation of re-suspended radioactive material was also assessed as being less than 1% of the dose uptake.

2.1.15 The exclusion of ingestion dose as adopted by AWE in its assessment was not accepted by ONR [2018] (CD 11.17), as the definition of a radiation emergency according to REPPIR [2001] (CD 11.19) required that the dose averted by urgent early health protection countermeasures initiated during the first 24 hours (such as food bans) should be disregarded when projecting the dose that members of the public are likely to receive. However, an assessment undertaken by the ONR found that the contribution to public dose from ingestion was negligible (i.e. approximately 1% of the total dose) compared with inhalation. This is because ingested uranium and/or plutonium compounds pass through the body quickly and are absorbed from the gastrointestinal tract to a negligible degree, in contrast to inhaled

[3] In the following paragraphs, reliance is placed on the ONR [2018] (CD 11.17) review of documents produced by AWE, because the ONR report is in the public domain.
[4] The ONR defines a reference accident as "one of a spectrum of reasonably foreseeable radiation emergencies that gives rise to the most significant off-site consequences" https://www.onr.org.uk/foi/2022/202112041-1.pdf (CD11.25).

material which remains in the lungs and is subsequently transferred to a significant degree to the systemic circulation. Therefore, ONR concluded that ingestion dose would not be significant.

2.1.16 The ONR [2018] (CD 11.17) further noted that high consequence, low frequency external events such as aircraft impacts were considered in the AWE safety case and no faults were identified that give rise to a significant off-site release of radiation. Also, the inadvertent [nuclear] detonation of a warhead was judged to be well beyond a reasonably foreseeable occurrence (see also Section 2.8 of AWE [2022] (CD 11.5)). A security review was also undertaken by AWE Plc and was assessed separately by the Defence Nuclear Safety Regulator, and ONR [2018] (CD 11.17) judged that it is not reasonably foreseeable for any security related event to lead to public dose consequences beyond the reference accident.

2.1.17 In summary, an accident with potentially significant off-site radiological consequences that could arise at AWE Burghfield would be due to a chemical detonation in a hot cell with the release of plutonium (or enriched uranium) to the atmosphere. Under average weather conditions, such an accident could result in an individual effective dose of about 5 mSv at 1252 m downwind of the centre of the AWE Burghfield site, but under adverse weather conditions that occur for about 12% of the time (and only at night), the individual effective dose could be as large as 7.5 mSv on the plume centreline at 3160 m downwind of the centre of the site. In either case, the dose would be almost entirely due to inhalation of radioactive material from the plume by the individual while they were immersed in the passing plume.

2.2 Frequencies of potential accidents with off-site consequences

2.2.1 Frequencies have not been published for the accidents addressed in AWE Burghfield's Consequences Report [AWE, 2019] (CD 11.3). However, these frequencies are likely to be similar to those estimated previously for reasonably foreseeable accidents under REPPIR [2001] (the radiological consequences of accidents assessed under REPPIR [2001] and REPPIR [2019] (CDs 11.19 and 11.20) are very similar when differences in the weather conditions assumed are taken into account (see paragraphs 3.1 and 3.2).

2.2.2 In that context (i.e. in assessing likely frequency of accidents under the REPPIR [2001] regime), AWE adopted a definition of "reasonably foreseeable" for both AWE Aldermaston and AWE Burghfield that included all fault sequences for which the associated dose has a return frequency of at least one in one hundred thousand per annum [HSE, 2012] (CD 11.11). Therefore, if there were only one relevant fault sequence and this occurred with the threshold frequency of one in one hundred thousand per annum, the overall accident frequency would also be one in one hundred thousand per annum. However, several fault sequences could contribute to the overall frequency, or the worst-case included fault sequence might have a frequency somewhat larger than one in one hundred thousand per annum. As such, these effects would increase the overall accident frequency. Set against this, accidents with higher frequencies would tend to have smaller off-site consequences, because there is usually an inverse relationship between accident magnitude and frequency.

2.2.3 Therefore, in the following analyses, a precautionary basis has been adopted in which the frequency of the reference accident has been taken to be ten times the threshold frequency, i.e. one in ten thousand per annum. This value is supported by the approach adopted by AWE Aldermaston under REPPIR [2001] (CD 11.19), because similar criteria should have been used to define the frequencies of reference accidents at the two sites. For AWE Aldermaston, the basis adopted was that reasonably foreseeable fault sequences comprised those initiated by a seismic event (based on a return frequency of less than one in ten thousand years) that would lead to radionuclide releases from two facilities, due to the seismic event being the common cause initiating releases from both facilities [ONR, 2012] (CD 11.16).

2.2.4 Based on the above analysis, when below I refer to the probability of an accident with off-site consequences taking place, I am assuming that there is a one in ten thousand chance of the accident in question taking place in any given year. I also reiterate, and as explained above, that this represents a precautionary approach.

2.3 Health risks from potential accidents

2.3.1 The annual risk to the health of an individual arising from a potential accident, R, can be expressed as the product of three quantities:

(i) The frequency of occurrence of the potential accident expressed on an annual basis, F,

(ii) The conditional probability that the individual is exposed to the resultant release of radioactive material, P,

(iii) The conditional probability of adverse health effects being induced in an exposed individual, Q.

Thus, $R = F \times P \times Q$.

2.3.2 As to (i), and as discussed in Section 2.2, the frequency of occurrence of the reference accident is assessed as not greater than one in ten thousand per annum, i.e. *F* is less than or equal to 1 10^{-4} $year^{-1}$.

2.3.3 In terms of (ii), the probability of a specific individual being exposed because of such an accident depends upon the angular spread of the plume and the probability of the wind blowing towards that individual. These quantities depend upon details of the meteorological conditions, but, typically, there would be about one chance in ten of a specific individual being located downwind within the angular spread of the plume, i.e. $P = 1\ 10^{-1}$.

2.3.4 Turning to (iii), at the boundary of the UPA, the effective dose arising from a reference accident is assessed as 7.5 mSv. As explained above, this is a precautionary estimate because it applies only in less likely weather conditions occurring only 12% of the time and at night. This effective dose is relatively small and is within the range of doses for which the "linear dose response with no threshold" (LNT) model is generally applied in radiological protection (see paragraph 36 of [ICRP, 2007] (CD 11.14)). The LNT model considers the risk from radiation exposure to be directly proportional to the dose received. Furthermore, it assumes that there is no threshold to this response. This means that even a very small increment of dose is associated with a corresponding increment of risk. In application, ICRP [2007] assigns detriment-adjusted health risk coefficients of 5.5 10^{-5} per mSv for all fatal and non-fatal cancers and 2.0 10^{-6} per mSv for heritable effects in the whole population (including infants, children and adults).[5] The ICRP [2007] does not identify any other adverse health effects that are of significance at doses of this size and the overall risk factor (summing those for cancer in the irradiated individual and hereditary effects in their descendants) is 5.7 10^{-5} per mSv, which may be thought of as equivalent to the risk of death arising from the irradiation. Throughout the remainder of this proof, I refer to this overall risk factor as the risk of harm to health, keeping in mind that it in fact includes the other detriments to health of relevance (i.e. non-fatal cancers and hereditary effects). Thus, for an effective dose of 7.5 mSv, the probability of adverse health effects being induced in the exposed individual or their descendants, *Q*, is $7.5 \times 5.7\ 10^{-5} = 4.3\ 10^{-4}$.

[5] The ICRP [2007] (Core Document 11.14) defines health detriment to include both fatal and non-fatal cancer, as well as hereditary disease, but assigns a lower weight to non-fatal cancers than to fatal cancers. Details of the approach are given in Annex A to ICRP [2007]. The overall health detriment can be thought of as corresponding to the total risk of significant impairment of health or death from the various causes that can be induced by ionising radiations at low doses.

2.3.5 Thus, the annual risk of harm to health to an individual permanently located at the boundary of the UPA, *R*, is given by:

$R = 1\ 10^{-4} \times 1\ 10^{-1} \times 4.3\ 10^{-4} = 4.3\ 10^{-9}\ \text{year}^{-1}$.

This is a risk of one in two hundred and thirty million per year. This risk is infinitesimal compared with other risks of everyday life. This is discussed further in Section 3, where risks to residents of the Proposed Development are assessed specifically.

2.3.6 Also, a value of *Q* of $4.3\ 10^{-4}$ implies that if a population of 10,000 people was to be irradiated such that they each received a dose of 7.5 mSv, the total number of persons whose health was harmed would be about four, with these effects spread over a period of several decades. This clearly demonstrates that even if an accident with off-site consequences were to occur at AWE Burghfield, this would place only a tiny additional burden on public health services.

3.0 The radiological consequences of a release from AWE Burghfield at the Proposed Development

3.1 Using Google Earth Pro, the distance from the Proposed Development to the centre of the AWE Burghfield UPA is estimated as 2800 m. Various studies have shown that the effective dose varies approximately as x^{-n}, where x (m) is the distance downwind from the release location and n is a numerical coefficient that typically takes a value of 1.5 [e.g. page 8 of Highton and Senior, 2008] (CD 11.9). Thus, an effective dose of 5 mSv at 1252 m downwind would correspond to an effective dose of $5 \times (1252/2800)^{1.5} = 1.5$ mSv at 2800 m downwind. In contrast, 7.5 mSv at 3160 m corresponds to $7.5 \times (3160/2800)^{1.5} = 9.0$ mSv at 2800 m downwind.

3.2 If the characteristics of the accidents considered under REPPIR [2001] and REPPIR [2019] (CDs 11.19 and 11.20) are similar, as is expected because activities at the site will not have changed substantially during the period when the update to REPPIR came into force, the adoption of less likely weather conditions under REPPIR [2019] has resulted in an increase in the assessed effective dose at 3160 m downwind by a factor of approximately six. This is as expected, given the degree to which atmospheric dispersion varies between different atmospheric stability categories (see, e.g. Clarke [1979] (CD 11.7))[6]. However, to refine further calculation of the effective dose under various weather conditions, more details would be needed as to how the initial explosive dispersion was modelled and how other factors, such as building entrainment, were represented.

3.3 Based on the above analysis, residents at the Proposed Development would receive an effective dose of about 1.5 mSv if an accident occurred under average weather conditions and about 9.0 mSv if it occurred under weather conditions that occur for only 12% of the time. Furthermore, these effective doses are conditional on the wind blowing toward the Proposed Development at the time of the accident (a conditional probability of about 10%, see Section 2.3) and take no account of sheltering, which is an effective measure in mitigating first-pass inhalation dose if it can be undertaken sufficiently rapidly[7].

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[6] Figure 16 of Clarke [1979] (Core Document 11.7) gives the atmospheric transport factor for Category D conditions at 2800 m downwind as $3\ 10^{-6}$ Bq s m^{-3} for release heights of 0 to 30 m. For Category F conditions, Figure 18 gives an atmospheric transport factor of $2\ 10^{-5}$ Bq s m^{-3}. The ratio of these two quantities is 6.7.

[7] The 7.5 mSv contour is set on the basis that sheltering provides a 40% reduction in the dose, i.e. it decreases the dose by 3 mSv to 4.5 mSv. The averted dose of 3 mSv is the basic criterion used in defining when sheltering is appropriate. In practice, reductions in dose of much more than 40% are achievable, particularly if the release is of short duration, limiting the penetration of aerosols into buildings.

3.4 In practice, the probability of the wind blowing towards the Proposed Development may be rather lower than 10% because winds at in the general area of AWE Burghfield are predominantly from the south-west rather than the west-north-west, as illustrated by the wind-rose for RAF Benson in South Oxfordshire, as shown in Figure 2.

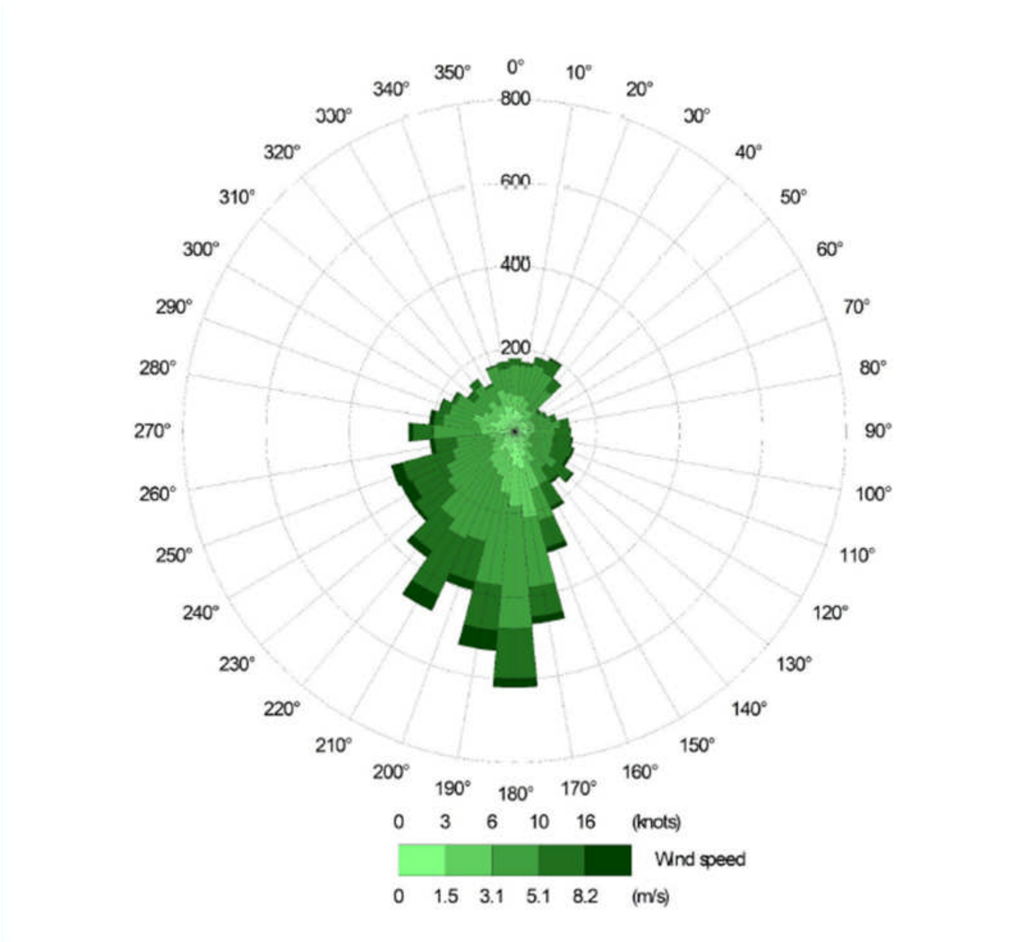

Figure 2: Wind Rose for RAF Benson (Benson, Ewelme, Wallingford OX10 6AA). The lengths of the bars show the frequency with which the wind blows from each sector and the colours show the contributions from different intervals of wind speed.

3.5 Thus, overall, in the event of the reference accident under typical weather conditions with the wind blowing towards the Proposed Development, an unprotected resident would incur an effective dose of about 1.5 mSv. This effective dose is relatively small, i.e. it is less than the annual exposure due to natural background and is only slightly more than the annual limit on effective dose for a member of the public of 1.0 mSv [ICRP, 2007] (CD 11.14)) and is within the range for which the LNT model applies (as discussed in Section 2). It is also relevant to note that the Approved Code of Practice issued in support of REPPIR identifies effective doses in the range of 1 to 10 mSv as “minor” with no potential for deterministic effects and minimal impacts, and unlikely to have life-changing consequences. (Page 180 of the Approved Code of Practice [HSE, 2020] (CD 11.12). In contrast, in the range of effective dose from 10 to 100 mSv, the Approved Code of Practice [HSE, 2020] (CD 11.12) identifies the possibility of life-changing consequences because of a very small (0.5%) increased risk of cancer induction[8].

3.6 As discussed in Section 2.3, the LNT model adopted by the ICRP [2007] (CD 11.14) assigns an overall risk factor is 5.7 10^{-5} per mSv, which may be thought of as equivalent to the risk of death arising from the irradiation. Thus, for a reference accident giving rise to an effective dose of about 1.5 mSv, assuming that the annual probability of such an accident occurring is one in ten thousand and that the Proposed Development is downwind at the time of the accident (a likelihood of about one in ten), the annual risk of an impact on health from accidents up to and including the reference accident in size, *R*, is about $1\ 10^{-4} \times 1\ 10^{-1} \times 1.5 \times 5.7\ 10^{-5} = 8.6\ 10^{-10}$ or one in one thousand and two hundred million per year (accidents substantially smaller than the reference accident would not have significant off-site consequences). Clearly, this is a miniscule risk to health.

3.7 For worse-case weather conditions, the effective dose is increased to 9.0 mSv. However, such conditions apply for only 12% of the time. Therefore, the assessed risk, *R,* is about $1\ 10^{-4} \times 1\ 10^{-1} \times 0.12 \times 9.0 \times 5.7\ 10^{-5} = 6.2\ 10^{-10}$ (one in one thousand and six hundred million). This is lower than the assessed risk of 8.6 10^{-10} under average weather conditions. Thus, the lower frequency of occurrence of worse-case weather conditions more than compensates for the increase in effective dose and demonstrates that the assessment of the annual risk under average weather conditions is a precautionary approach.

3.8 Thus, overall, the annual probability of harm to health for an individual on the Proposed Development due to an accident at AWE Burghfield with significant off-site radiological consequences is assessed as one in one thousand and two hundred million. However, this is based on a risk calculation that makes no allowance for mitigation of the effective dose through sheltering. Sheltering would reduce the effective dose received and would, therefore, reduce the assessed risk proportionately.

[8] The risk of 0.5% applies toward the upper boundary of this dose range. At the lower boundary, the risk is about 0.05%.

3.9 The miniscule nature of the above risk is even more apparent when it is compared to the risk of death arising from other causes. The Health and Safety Executive (HSE) in its report Reducing Risks, Protecting People [HSE, 2001] (CD 11.10) has given annual risks of death from various causes. These include 1 in 16,800 from all forms of road accident, 1 in 29,000 from lung cancer caused by the radioactive gas radon in dwellings, 1 in 510,000 from a gas incident (fire, explosion or carbon monoxide poisoning) and 1 in 18,700,000 from lightning. As such, the annual probability of an impact on health for an individual on the Proposed Development (one in one thousand and two hundred million per year) due to an accident at AWE Burghfield is about a factor of 60 less than the annual probability of being killed by being struck by lightning.

3.10 It is also relevant to note that, when assessing the significance of individual risk, the HSE [2001] (CD 11.10) 'believes that an individual risk of death of one in a million per annum for both workers and the public corresponds to a very low level of risk and should be used as a guideline for the boundary between the broadly acceptable and tolerable regions. As is very apparent from Tables 1-4 at Appendix 4 [of HSE, 2001], we live in an environment of appreciable risks of various kinds which contribute to a background level of risk - typically a risk of death of one in a hundred per year averaged over a lifetime. A residual risk of one in a million per year is extremely small when compared to this background level of risk. Indeed, many activities which people are prepared to accept in their daily lives for the benefits they bring, for example, using gas and electricity, or engaging in air travel, entail or exceed such levels of residual risk.'

3.11 The annual probability of an effect on health for an individual on the Proposed Development due to an accident at AWE Burghfield is more than three orders of magnitude below the boundary of the tolerable region, i.e. it is well within the region where the risk would be judged broadly acceptable by the HSE.

3.12 Notwithstanding the low annual risks arising at the proposed development due to accidents at AWE Burghfield, it is instructive to set the assessed effective dose (1.5 mSv for the reference accident under average weather conditions and 9.0 mSv in adverse weather conditions) in context. The average annual effective dose in the UK, mainly from naturally occurring radioactivity, is around 2.7 mSv. This means that the effective dose from the reference accident, if it occurs under adverse weather conditions, corresponds to just over three years of background exposure. Useful comparisons can also be made with medical exposures. For example, a Computed Tomography (CT) scan of the chest typically delivers 6.6 mSv and a whole-body CT scan typically delivers 10 mSv. There are also considerable regional variations in natural background, with the average annual radon dose to the people of Cornwall being 7.8 mSv, compared with a UK-wide average value of 1.3 mSv[9] (radon gives rise to about half of the average annual effective dose in the UK due naturally occurring radioactivity).

3.13 Thus, the radiological impact of the reference accident at 9.0 mSv (which assumes adverse atmospheric stability conditions, that the individual is located downwind of the Proposed Development and that the individual has failed to shelter) would be:

- About the same as the radiological impact due to exposure to background radiation for just over three years in a typical location in the UK,
- About the same as regional variations in the annual exposure to natural background in the UK,
- About the same as the exposure incurred because of a single medical CT examination.

3.14 This is not to argue that such exposures are of no importance. Indeed, substantial efforts are being made to reduce high regional exposures to radon and the use of CT scanning in medicine is subject to a requirement for justification and optimisation on a case-by-case basis. However, it does show that the radiation doses that could arise if a major accident occurred at the AWE Burghfield site are within the range commonly experienced by members of the public during their everyday life.

[9] All the cited values are from http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/, downloaded 10 February 2014.

4.0 Impact of the Proposed Development on the off-site emergency plan

4.1 In Section 4.1, the general requirements of the off-site plan are described, noting those that do or do not apply to the Proposed Development. This sets a context for Section 4.2 which demonstrates that the Proposed Development would have negligible consequences for the off-site plan, meaning that the implementation of plan would not be compromised in any material way by the Proposed Development and would not therefore have to be modified to accommodate the Proposed Development.

4.2 In outline terms, in the event of an accident with off-site consequences at AWE Burghfield, the plan involves (AWE [2022] (CD 11.5)):

- Warning and informing members of the public of the incident,
- Members of the public taking immediate shelter as the recommended countermeasure,
- Discouraging self-evacuation,
- The potential requirement for evacuating areas close to the boundary of AWE Burghfield, but not in the more peripheral parts of the DEPZ,
- Ensuring that access to AWE Burghfield is not impeded, e.g. for the emergency services,
- Appropriate monitoring and decontamination,
- Longer-term recovery from the incident, including potential demands for relocation.

4.1 Requirements of the off-site emergency plan

Provision of information

4.1.1 Under REPPIR [2019] (CD 11.20), where a DEPZ has been specified and an off-site emergency plan has been prepared in accordance with Regulation 11, the lead LA (in this case WB District Council) must, in co-operation with the operator, ensure that the public are made aware of the relevant information and, where appropriate, are provided with it (Regulation 21). In the event of an emergency, the LA has the responsibility to supply information about and advice on the facts of the emergency, of the steps to be taken and, as appropriate, of the protective action applicable (Regulation 22).

4.1.2 These provisions are broadly like those under REPPIR [2001] (CD 11.19). Therefore, off-site emergency plans made under the former regulations should be readily adapted to the new regulatory regime. For the purposes of this proof, I refer to a version of the current plan (to be reviewed in 2022/2023) [AWE, 2022] (CD 11.5) and a REPPIR leaflet targeted at members of the public resident within the DEPZ that refers to and is in conformance with REPPIR [2019] [West Berkshire Council, 2020] (CD 11.21).

Warning, informing and sheltering

4.1.3 In the event of an off-site emergency being declared, sheltering is the recommended countermeasure (or protective action). This countermeasure would be applicable at the Proposed Development. When an incident had caused, or might cause, an off-site emergency, the following warning and informing actions would take place [AWE, 2022, Section 5.3] (CD 11.5).

- AWE would initiate the automatic telephone alerting system to the public round the affected site. The public will be advised to go inside, stay inside the nearest suitable building and to tune into the radio and television to hear public service broadcasts.
- Information and warnings about the emergency would be regularly reported via TV, local and national radio; social media including AWE Twitter account, and websites as appropriate.
- Other activities, such as loud hailers may be employed to ensure messages are going out. The emergency plan states that all means necessary will be employed to get the messages across.
- Emergency Media Briefing Centres and Emergency Help Lines may also be put in place.

4.1.4 Thus, as summarised in the most recent REPPIR leaflet [West Berkshire Council, 2020] (CD 11.21):

‘Every household and business in the area will automatically receive a pre-recorded telephone message (landline only) from the AWE Alerting System. Local radio and TV stations will broadcast messages. Alongside this emergency service responders will use news websites and social media to issue advice to the public. Please follow the advice IMMEDIATELY.’

4.1.5 Sheltering is the recommended countermeasure because the main potential radiological impact in the initial phase of an accident arises from inhalation of radionuclides from the plume of radioactive material as it disperses downwind of the accident and because the avertable dose is less than the lower Emergency Reference Level (ERL) for evacuation. This advice is set out in some detail in West Berkshire Council [2020] (CD 11.21):

- Go indoors immediately and stay there. Contamination levels are likely to be higher outside buildings than inside. Staying inside is the most important advice because the fabric of the building will provide a layer of protection against any ionising radiation and will reduce exposure to any radioactive particles. If you are not at home, go into the nearest permanent building.
- Keep your pets inside if they were not outside at the time of the emergency; those that have been outside could be kept in a separate room or building.
- Close all windows and doors to stop radioactive particles from entering buildings.
- Turn off boilers and air conditioning units and put out fires and wood-burners. Fans, heating systems, boilers, gas fires and air conditioning all draw in air from outside so these should be shut down to minimise radioactive particles entering buildings.

4.1.6 West Berkshire Council [2020] (CD 11.21) notes that, as a precautionary measure, the advice on sheltering may be sent to the entire DEPZ in the initial response stages of a radiation emergency. Thus, this advice could apply to about 7000 households. Monitoring will then be used to confirm where sheltering needs to remain for longer and to identify those areas where it is no longer required. Because the advice will be updated during an incident West Berkshire Council [2020] (CD 11.21) emphasises the following.

- Listen to local TV and radio for instructions and updates. During a radiation emergency, advice will be broadcast regularly. This will include updates about the care of children at school, food and water supplies and care of farm animals and pets.
- Do not make phone calls by landline or mobile. This is important because the phone system could be overloaded, preventing the emergency services and other responders from receiving or making calls, or from contacting you.

4.1.7 It is worth noting that the government advice on the use of sheltering states that 'The health and wellbeing of sheltered populations may be affected by restricted access to medical care or assistance. In such situations, consideration should be given to supervised entry into the sheltered area by medical professionals and carers, or planned evacuation of these vulnerable groups" [PHE-CRCE-049 Section 5.2.1.1] (CD 11.18) and earlier advice included "To a large extent, these adverse effects of the countermeasure [Shelter] are small, particularly if the sheltering period is kept to a few hours. …. Significant problems can be reduced by advising individuals that short periods out of doors, for necessary activities, will not, in many situations, result in very high exposures. External exposures to people inside a building will not be significantly affected by opening and closing of outside doors, nor will occasional opening and closing of outside doors have a major impact on the radionuclide concentrations in air in the building, and hence on doses by inhalation' [Documents of the NRPB, Vol 1, No 4 1990, Page 8 paragraph 8] (CD 11.24).

Discouragement of self-evacuation

4.1.8 Also, members of the public are strongly counselled against self-evacuation from the affected area. Section 6.7.2 of AWE [2022] (CD 11.5) states that 'The possibility of self-evacuation by members of the public at any time cannot be ignored. The impact of which may cause disruption to the response and may make the situation worse should radioactive particles be resuspended. Case studies show that there is greater risk of accidents during such self-evacuation than a situation of shelter and controlled evacuation if needed. Public Information and local control will be needed to reduce the risk of this taking place.' Further to this point, West Berkshire Council [2020] (CD 11.21) states 'Stay where you are. You will be safer to stay where you are rather than travelling around outside, vehicles provide less protection against ionising radiation than houses and other solid buildings. If you try and leave the area, roads could quickly become gridlocked and prevent access for emergency services. You could also end up in an area with more radioactive contamination unknowingly or by accident. It is very unlikely that an evacuation would be necessary but if that does happen, details of what to do will be given on local radio, TV and social media.'

Longer-term countermeasures, including evacuation

4.1.9 In the longer-term, countermeasures other than sheltering might be initiated. These are set out in Section 6.5 of AWE [2022] (CD 11.5). Specifically, there may be situations in which an urgent evacuation or subsequent evacuation of areas close to the boundary of AWE Burghfield may be necessary. However, such measures would not apply at the location of the proposed development (see below). The potential requirements for evacuation are set out in Section 6.5 of AWE [2022] (CD 11.5).

- Urgent evacuation, at the direction of the emergency services at the scene, may be required for non-radiological scenarios, e.g. releases of asphyxiating gases, or for persons close to the site boundary in some radiological scenarios, e.g. in respect of very severe accidents or those involving the on-site transport of radioactive materials. It may also be required for care homes, schools, caravan sites, boats (liveaboard and pleasure). Also, individual vulnerable clients may require extra support in areas affected and to get this support effectively the individuals may need to be evacuated.
- Subsequent evacuation, on a timescale of days to weeks, of people taking cover in buildings such as factories, offices and other workplaces, or other buildings that may

not be suitable in terms of providing support for the people there for any length of period due to lack of facilities, food and bedding. Such evacuation may also be required as part of the post-accident recovery process, e.g. while decontamination activities are undertaken.

4.1.10 Details of areas potentially requiring urgent or subsequent evacuation are listed in Section 6.7 of AWE [2022] (CD 11.5). Although this information has been redacted in the version of the report supplied, Section 11AA of AWE [2022] (CD 11.5) states that 'The closer to the site boundary the greater the risk for the need for urgent evacuation particularly out to approximately 150m with subsequent evacuation needed out to 600m'.[10] The need for evacuation will depend on the level of projected contamination and of the vulnerability of the community in the area. However, neither urgent nor subsequent evacuation would be required at the Proposed Development, even for accidents more extreme than those considered in defining the DEPZ. In this context, it is relevant to note that evacuation is not considered as a protective action in the underpinning Consequences Report [AWE, 2019] (CD 11.3). Specifically, AWE [2019] states that 'Overall, the primary concern for early response decision-making to radiation emergencies involving possible accidents at the Burghfield Site only merits consideration of the first-pass inhalation dose and therefore sheltering is the recommended urgent protective action.'

Off-site traffic movements

4.1.11 A relevant consideration is whether, in the event of an off-site emergency, traffic movements to and from the Proposed Development could adversely affect access to the AWE Burghfield site, e.g. for the emergency services. In this context, it is relevant to note that access routes for emergency services to AWE Burghfield will be determined, in part, by meteorological conditions at the time of the accident, because it is appropriate to approach from upwind, where possible [Section 3.8 of AWE, 2022] (CD 11.5). However, the Proposed Development is sufficiently far from AWE Burghfield that there is no possibility that access to the site would be adversely affected.

[10] Taking the boundary of the AWE Burghfield site to be about 400 m from the centre of the UPA, a dose of 7.5 mSv at 3160 m corresponds to about 40 mSv at 600 m from the site boundary, i.e. 1000 m from the centre of the UPA. A dose of 40 mSv falls within the range of Emergency Reference Levels (ERLs) proposed for considering evacuation.

Monitoring and decontamination

4.1.12 During and following an accident that resulted in off-site contamination, there would be requirements for monitoring and, possibly, decontamination. These requirements are likely to relate to contamination of people, animals, pets and property, including gardens, homes and businesses [Section 7.3 of AWE, 2022] (CD 11.5). The decontamination process, if needed, would take place sometime after the initial response phase and normally after the risk of any further contamination from the site had stopped. However, in my view, in the outer part of the DEPZ, such monitoring would be primarily for reassurance purposes and would not be likely to result in decisions to undertake decontamination. This is because the levels of contamination would be so low that annual doses to residents would be initially below the dose limit for members of the public and would decrease from year-to-year as any plutonium on surfaces was lost (e.g. by leaching) or became less available for resuspension (e.g. by burial in soil).

Long-term remediation

4.1.13 The remediation process following an accident large enough to result in significant off-site contamination would involve several phases. The early phase, with a duration of a few days, would involve prompt tie-down of contamination and the recovery of items. The intermediate phase would involve treatment of the heaviest or most significant contamination over a few weeks, whereas the late phase would last at least several months and would involve reduction of environmental contamination to acceptable levels [Section 9.6 of AWE, 2022] (CD 11.5).

4.1.14 The approach adopted to remediation would be strongly determined by the extent and nature of the contamination present after a specific accident. However, some options that would be suitable for the type of contamination likely to result from a uranium or plutonium release from AWE Burghfield are given in Section 9.6.1 of [AWE, 2022] (CD 11.5). These are:

- Various tie-down reagents (e.g. water, bitumen emulsion, strippable paints etc.) may be applied to reduce the spread of contamination and reduce re-suspension risks. Selection of the appropriate material and application technique is dependent on many factors (e.g. surface type, weather conditions, coverage required etc.).
- Non-aggressive decontamination techniques (e.g. vacuum, brushing, hosing etc.) are relatively quick and cheap and generally produce small amounts of controllable waste. These are more applicable in areas where contamination is low level and loosely bound to the surface.

- Aggressive decontamination techniques (e.g. road planning (*sic*), high-pressure water, grit blasting etc.) may be required in areas where contamination is higher level and fixed to the surface. These are much slower and expensive and can generate large volumes of waste.[11]

4.2 Implications of the Proposed Development for the off-site emergency plan

4.2.1 Were an off-site incident to be declared at AWE Burghfield, residents of the Proposed Development would be notified by the automatic telephone system and would be able to shelter promptly in their own houses. In view of the small dose that would be incurred even if a resident failed to shelter (typically slightly more than the principal limit on annual effective dose for a member of the public of 1 mSv and at worst slightly more than the annual exposure experienced by those living in Cornwall or less than a full body CT scan), it would not be appropriate to use responders to visit the development and confirm that residents were sheltering. Thus, the process of warning and informing residents would place no additional burden on the off-site emergency plan.

4.2.2 Again, because of the types of accident envisaged, sheltering would be required typically for a few hours and certainly for no more than two days. This is stated explicitly in Part 2, Paragraph 1c of AWE [2019] (CD 11.3) 'This 'sheltering' action may be necessary for a period of up to two days, or at least until the initial contaminated plume has passed and monitoring of ground contamination has been undertaken to determine the level of groundshine'. Residential properties would be very suitable for sheltering for periods of this duration and residents plus visitors should be able to shelter for up to two days without this causing material difficulties. There is no realistic prospect of the requirement for sheltering would exceed two days since the kind of accidents of concern here, those involving the release of plutonium or highly enriched uranium, doses due to groundshine and resuspension would be negligible.

4.2.3 Because the Proposed Development is located about 2.8 km from AWE Burghfield, it is well beyond the range at which immediate or urgent evacuation would be required (out to 600 m from the site boundary, see Section 11AA of AWE [2022] (CD 11.5)), even for the largest accidents considered and under adverse weather conditions. This means that the

[11] Furthermore, plutonium fixed to surfaces has little radiological impact because it emits very little gamma radiation and is not susceptible to resuspension. Therefore, it may be more appropriate to leave it in situ,

Proposed Development does not alter the numbers of people that the existing plan envisages may require immediate or urgent evacuation.

4.2.4 In addition, the absence of the need for urgent evacuation means there would be no difficulty entering this part of the DEPZ if there was a need to attend to a medical emergency or provide support to a vulnerable individual present at the Proposed Development. In most accidents, the effective dose incurred by emergency personnel or carers involved in such activities would be less than the principal annual dose limit for members of the public (see Section 7.7.8 of AWE [2022] (CD 11.5) for Emergency Exposure Levels adopted by AWE and the "blue light" emergency services, which are all 1 mSv or larger). It is recognised that emergency personnel or carers might be reluctant to enter a radioactively contaminated area even if the degree of contamination is extremely low.[12] However, this is a matter to be addressed through training which is in any event necessary for the protection of the existing population in the DPEZ. See also Section 10.4 of AWE [2022] (CD 11.5) which sets out a requirement for suitable and sufficient briefing and training of employees for their required roles. This should also be viewed in the light of Regulation 11.6 of REPPIR [2019] (CD 11.20), which requires that:

The employer of any emergency worker who may be required to participate in the implementation of the off-site emergency plan must ensure that each such emergency worker is provided with:
(a) suitable and sufficient information, instruction and training; and
(b) any equipment necessary to restrict that employee's exposure to ionising radiation
including, where appropriate, the issue of suitable dosemeters or other devices.

4.2.5 It is also important to bear in mind that the types of hot cell accident envisaged at AWE Burghfield would typically result in atmospheric releases of no more than a few hours duration. Therefore, all but genuinely urgent medical interventions and visits to vulnerable persons who require multiple attendances throughout the day could be deferred until the radioactive plume had dispersed, further decreasing any dose incurred by responders.

4.2.6 If individuals were located outside during the passage of the radioactive plume, there might be a requirement for individual monitoring. However, clearly this would not apply to the vast majority (if not all) the residents or the Proposed Development since one would expect them to follow the advice and take shelter. In so far as any residents were outside at the relevant time, it seems almost certain that any monitoring would be precautionary and for

[12] Nevertheless, Section 7.3.3 of AWE [2022] (CD 11.5) states that responding agencies may have to go into the affected area to undertake normal, but life preserving or life maintenance work.

reassurance of individuals as to their health status. It would not be expected to lead to any requirement for decorporation procedures beyond removing and washing contaminated clothing and washing or showering by the individual. Furthermore, there would be no need to prioritise such monitoring, except in so far as to reduce anxiety in the exposed individual. As such, any monitoring of residents of the Proposed Development would be optional. As a result, the plan's monitoring requirements would not be compromised in any material way by the Proposed Development.

4.2.7 In the longer-term, the presence of ground contamination might lead to a desire of some residents of the Proposed Development to relocate. However, any such desire does not affect the plan (and therefore does not require WBC to obtain or provide accommodation). In essence, that is because the levels of ground contamination would be too low justify relocation on a health basis. I expand on this point below.

4.2.8 For the accidents of relevance, I would expect the contamination present at the Proposed Development to be oxide particles of uranium and/or plutonium. These emit only small amounts of photon radiation (x-rays and gamma rays), are poorly absorbed from the gastrointestinal tract and are taken up by plants from soil to only a limited degree. Thus, the main potential route of exposure would be resuspension of this material and its inhalation. However, the concentration of resuspended material in air would be several orders of magnitude smaller than the concentration in air present during the passage of the original plume. Thus, potential doses incurred from this resuspension pathway would be much less than 1 mSv.[13] Consequently, the long-term relocation of residents from the Proposed Development would be inappropriate.

4.2.9 In the highly unlikely event that decontamination of the Proposed Development was to be required, I would expect non-aggressive processes, such as the washing down of hard surfaces, to be appropriate. In this context, it is relevant to note that whereas radioactive isotopes of caesium (which were important after the Chornobyl and Fukushima accidents) bind strongly to urban surfaces, oxide particles of uranium and plutonium would be expected to be only loosely attached and readily removed by simple mechanical processes. Therefore, not only is it extremely unlikely decontamination of the Proposed Development would be required given the low levels of contamination at this location, but even if it were, this would be a relatively straightforward process that would not need to be carried out immediately and therefore would not compromise the effective implementation of the off-site emergency plan or follow-up activities.

[13] This is readily shown. If it is assumed that the original plume gives an air concentration of 1 Bq m^{-3} that persists for 3 hours, then an individual breathing 1.2 m^3 h^{-1} of air (which is typical for light exercise [ICRP, 1994]) (CD 11.13) will inhale 3.6 Bq. For insoluble Pu-239, the committed effective dose per unit intake by inhalation for an adult member of the public is 1.6 10^{-5} Sv Bq^{-1} [ICRP, 2012] (CD 11.15). Therefore, an intake of 3.6 Bq corresponds to a committed effective dose of 5.8 10^{-5} Sv. However, a typical deposition velocity for an aerosol is 1 10^{-3} to 1 10^{-2} m s^{-1} [Sections 2.1.1 and 2.2.1 of Coughtrey and Thorne, 1983] (CD 11.8). Therefore, a concentration of 1 Bq m^{-3} will give a deposition rate of 1 10^{-3} to 1 10^{-2} Bq m^{-2} s^{-1}. Over 3 hours (10,800 s), the cumulative deposition will be 10.8 to 108.0 Bq m^{-2}. Following deposition, typical, long-term resuspension rates are 1 10^{-7} m^{-1} or less [Section 2.1.3 of Coughtrey and Thorne, 1983] (CD 11.8). Thus, the long-term maintained air concentration in the open air could be up to 1.08 10^{-6} to 1.08 10^{-5} Bq m^{-3}. Breathing outdoor air for 8 hours per day, 365 days per year at 1.2 m^3 h^{-1}, would give an annual intake 3.8 10^{-3} to 3.8 10^{-2} Bq, corresponding to a committed annual effective dose of 6.1 10^{-8} to 6.1 10^{-7} Sv, i.e. about 0.1 to 1.0% of the first-pass plume inhalation dose. Thus, for a first-pass effective dose by inhalation of 1.5 mSv, the long-term annual committed effective dose due to resuspension would be no more than about 1.5 µSv. Similar conclusions also arise from the following analysis. When a plume of radioactive dust travels across an area, a fraction of the activity is deposited onto the ground. Of this fraction, a further fraction is resuspended. Taking plausible values for these fractions from the literature (1 x 10^{-2} Bq.m^{-2} per Bq s m^{-3} and 0.75 Bq s m^{-3} per Bq m^{-2} [Public Health England, 2019] (CD 11.18)), it follows that the dose over one year from resuspension is likely to be about 1% or less of the plume transit dose.

4.2.10 Finally, it is noted that because the Proposed Development is some distance from AWE Burghfield, any traffic movements to and from the Proposed Development during an off-site emergency (in so far as there are any given the advice to shelter) would have no material effect on the ability of the emergency services to access the AWE Burghfield site.

5.0 Impact of the Proposed Development on the emergency services and implications of previous planning decisions

5.1 Lack of impact on the emergency services

5.1.1 For much the same reasons that the Proposed Development would not have a material impact on the effective implementation of the off-site emergency plan, it would also not have any material impact on the capacity of the emergency (or "blue light") services. In essence, that is because radiation doses from reference accidents considered in the off-site plan are no more than a few millisieverts in the outer parts of the DEPZ. This means that evacuation would not be required, and sheltering would instead be the protective measure that was carried out. Sheltering is implemented through an automatic warning system and in residential situations no involvement of the emergency services is envisaged. Indeed, for a plume arising from an explosion, it is unlikely that the emergency services could be mobilised sufficiently rapidly to facilitate sheltering (AWE [2019] (CD 11.3) estimates that 'there will be an average of approximately 1500 seconds (25 minutes) from the initiation of the event until the leading edge of any plume travels to the minimum distance recommended for urgent action.')

5.1.2 In its Statement of Case (paragraph 8.34) the LPA has stated that "The council's Emergency planner has recommended refusal because 'The proposed site currently sits within the AWE DEPZ. The current off-site emergency plan for AWE would not be able to accommodate the increase in population in situations where an evacuation centre would need to be set up.'" This assumes that such an evacuation centre would need to be set up to keep residents of the Proposed Development safe. However, that is not the case. As explained above, the plan provides for sheltering (not evacuation) to protect those in the outer parts of the DEPZ, including the location of the Proposed Development.

5.1.3 In so far as there was a genuinely urgent medical emergency which meant an initially sheltering resident had to be evacuated (or provided with urgent medical care in their home), this poses no *additional* pressure on the emergency services than if the Proposed Development was located just outside the DEPZ (where an urgent medical intervention would still have to take place if a resident became seriously ill and/or had significant care needs requiring urgent intervention). The low radiation doses arising, and the short duration of the plume transit (the period of increased dose rates) mean that the resource requirements for attending such emergencies should not differ from the resource requirements in the normal situation in which the off-site emergency plan has not been implemented. In situations where significant resources of the emergency services are focussed on one or more serious events it is operationally usual to “backfill” the area by bringing replacement resources forward from the neighbouring services in case they are needed either to support the response to the event or to respond to other events within the area.

5.1.4 In terms of the potential desire of some residents of the Proposed Development for permanent relocation following an incident, as explained above, while this is a legitimate personal choice for these individuals to make, there would be no justification for it on radiological safety grounds (the levels of residual radioactive contamination would be negligible) with the result that the authorities would not be involved in any such relocation. Further, even if the authorities elected to assist with this process, there would be no time constraints on providing for it. Therefore, any requirements on the emergency services (e.g. moving vulnerable individuals) could be planned to avoid those services being overloaded.

5.1.5 Traffic movements to and from the Proposed Development would be limited (given the sheltering strategy) and any such movements would be monitored and regulated by existing traffic controls and would not require any additional resources.

5.1.6 Further, because of the obligations imposed by REPPIR [2019], it must be assumed (and certainly in the absence of any evidence to the contrary) that the emergency services have sufficient capacity to meet the demands imposed by existing development within the DEPZ in the event of an incident. That is apparent from Regulation 11(1) of REPPIR [2019] (CD 11.20) which requires West Berkshire DC to “make an <u>adequate</u> off-site emergency plan” covering the DEPZ (emphasis added). Clearly, a plan cannot be “adequate” if it relies on the basis of involvement of the emergency services which exceeds their capacity. Indeed, Regulation 11(5) of REPPIR [2019] requires consultation with the emergency services in preparing the plan presumably with the intention of ensuring that it is adequate in precisely this regard.

5.1.7 In conclusion, the Proposed Development would place negligible additional demands on the emergency services even in the context of the relatively recently expanded DEPZ. In this regard, therefore, the Proposed Development complies with Policy TB04.

5.1.8 Finally, there is an important contextual point to be made. If a radioactive plume arising from an incident at AWE Burghfield was blown not towards the Proposed Development but northwards towards the nearby (albeit just outside the DEPZ) outskirts of Reading, this would have the potential to place a considerably greater load on the emergency services than the load arising from the Proposed Development, particularly as automatic warnings would not be provided and sheltering responses could be limited. This area outside the DEPZ is included in the Outline Planning Zone (OPZ) for AWE Burghfield and requirements on responders in the case of an extreme accident affecting this zone are similar to the requirements within the DEPZ. Thus, there is a need to have backup resource capability to address the larger population that might be affected by an extreme accident. This factor should not only inform the application of Policy TB04 but also, in the event of a breach (which does not occur here anyway for the reasons I have given), should reduce the weight that is afforded to it.

5.2 Consideration of the four appeal decisions relied on by the LPA

5.2.1 I have read in draft paragraphs 7.11 to 7.39 of Mr Bond's proof which relate to the four appeal decisions cited by the Council in its Statement of Case that have considered the extended DEPZ recently. In so far as Mr Bond's observations relate to matters that are also within my areas of expertise (i.e. regarding alleged impact on the off-site emergency plan), I confirm that I agree with them.

6.0 Conclusions

See the Executive Summary and Summary Proof.