HORIZON NUCLEAR POWER

WYLFA NEWYDD

ENERGY WORKING FOR BRITAIN

Wylfa Newydd Project

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14 Radiological effects

14.1 Introduction

14.1.1 This chapter describes the assessment of potential radiological effects resulting from the construction, operation and decommissioning of the Power Station.

14.1.2 Please refer to chapter B14 (radiological effects) (Application Reference Number: 6.2.14) for the technical basis for the assessment including a summary of legislation, policy and guidance; key points arising in consultation that have guided the radiological effects assessment; and assessment methodologies and criteria.

14.1.3 The *National Policy Statement for Nuclear Power Generation (EN-6)* [RD1] recognises that "*The UK has robust legislative and regulatory systems in place for the management (including interim storage, disposal and transport) of all forms of radioactive waste that will be produced by new nuclear power stations*".

14.1.4 Much of the information presented here is taken from the permit submission made as part of the application under the Environmental Permitting (Radioactive Substances Regulation) (EP-RSR). It is not the intention in this chapter to replicate that work entirely, but sufficient information has been presented to enable the assessment to be meaningfully described as part of this Environmental Statement. More detailed information is available within the EP-RSR submission [RD2]. Many of the assumptions made in this assessment are those used in the EP-RSR and are referenced accordingly.

14.1.5 The management of radioactive wastes at the Power Station during operation and decommissioning is described in appendix D14-1 (radioactive waste) (Application Reference Number: 6.4.97).

14.1.6 The assessment of effects from potential accidental release scenarios is described in appendix D14-2 (analysis of accidental releases) (Application Reference Number: 6.4.98). All of the scenarios are assessed as having negligible environmental impact using the methodology described in the appendix, even the identified severe accident scenario.

14.2 Study area

14.2.1 This section describes the study area(s) relevant to this radiological effects assessment.

14.2.2 The approach used to define the study area for radiological effects is different to other technical sections. This is because doses to exposure groups are defined by habit data, which may not always be associated with specific geographic locations. In addition, collective doses are evaluated as population doses from exposures in large geographic areas: the UK, Europe and the world (see chapter B14, Application Reference Number: 6.2.14, and paragraph 14.2.44). Because of this, this section describes the habit data and modelling assumptions used to define exposure via these pathways:

- radiation exposures to individuals and populations arising from authorised gaseous and aqueous discharges of radioactivity;
- radiation exposures arising from direct irradiation from the turbine buildings and from the storage of radioactive wastes and spent fuel in engineered facilities on the Power Station Site (doses from other sources have been found to be negligible, see [RD2]);
- radiation exposures arising from transport of radioactive materials to and from the Power Station Site; and
- radiation exposures to non-human species arising from the authorised discharge of radioactivity to air and the marine environment.

14.2.3 The basis of assessing the potential effects arising from exposure to radiological discharges is the identification of groups of individuals and non-human species whose behaviour and habits are likely to mean they would receive the highest individual radiological doses.

14.2.4 The study area for human and non-human species is defined by a combination of the locations with the highest predicted concentrations of radioactivity in environmental media and foodstuffs, combined with the habits and consumption rates of those groups.

14.2.5 As it is not practicable to assess doses to each individual member of the public, the 'most exposed individual' and 'Representative Person(s)' approach [RD3] was used where:

- the most exposed individual is the person receiving the highest dose from a single discharge pathway, for example an individual who receives a dose from aqueous discharges only or an individual who receives a dose from gaseous discharges only; and
- the Representative Person is an individual receiving a dose that is representative of the more highly exposed individuals in the population due to both aqueous and gaseous discharges and also direct radiation.

Assessment of doses to humans from discharges

14.2.6 Radiation effects due to radioactive discharges into the environment may result in the exposure of members of the public from a number of pathways. Doses are calculated to three age groups; infant (one year old), child (10 years old) and adult (18 years old or greater). Doses to the foetus are also considered.

14.2.7 Assessments are required for the impacts of discharges of gaseous and aqueous radioactive emissions. Computer modelling is used to predict the dispersion of discharged radioactivity in the environment and the resulting concentrations of radioactivity in environmental media and foodstuffs. PC-CREAM 08® [RD4] enables the assessment of individual and collective doses due to gaseous and aqueous discharges via:

- inhalation of material in the plume;
- external irradiation from material in the plume;

- external irradiation from ground-deposited material and absorbed on sediments;
- inhalation of re-suspended material including sea spray; and
- ingestion of contaminated foodstuffs grown or reared locally.

14.2.8 An assessment was made of doses to representative members of the public to enable identification of the Representative Person in the vicinity of the Power Station resulting from the following radioactive discharges, with all assumed to occur continuously:

- gaseous discharges from the Unit 1 and Unit 2 reactor building stacks at the proposed annual discharge limits (see table D14-15); and
- aqueous discharges from the main cooling water outfall, also at the proposed annual discharge limits (table D14-16).

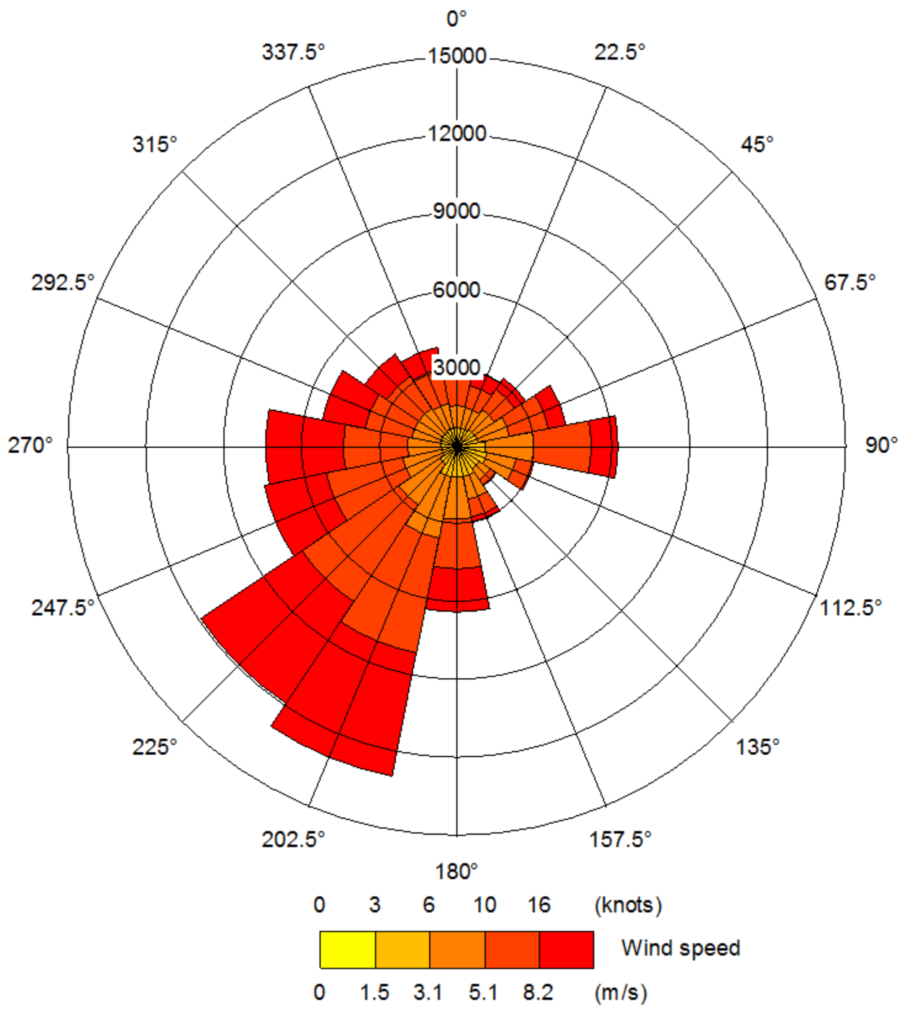
Model parameters

14.2.9 The following data inputs relate to this radiological assessment undertaken with PC-CREAM 08®.

Site-specific meteorological data

14.2.10 Ten years of site-specific weather data (2007-2016) based on the Numerical Weather Prediction model were procured from the UK Meteorological Office. The weather data files were formatted into PC-CREAM 08® compatible files, and used for the atmospheric dispersion model for gaseous discharges. The associated windrose is shown in figure D14-1. The yellow, orange and red shaded areas on the windrose indicate the prevailing direction of the wind (predominantly from the south-west).

Figure D14-1 Windrose for the Power Station Site (2007-2016 average)



Surface roughness

14.2.11 A surface roughness of 0.3 was used in the radiological assessment for gaseous releases. The factor of 0.3 is representative of agricultural land, which is the dominant land use of the areas surrounding the Power Station Site.

Ground deposition and resuspension rates

14.2.12 Default PC-CREAM 08® ground deposition factors and resuspension rates were used in the assessments.

Model parameters defining the marine environment

14.2.13 The model calculates the dispersion of material between different regions of the marine environment, with defined volumes and flows, which are conventionally called "Compartments". A variety of parameters were used to specify the marine environment. Some, such as the local compartment coastline length, sediment density and diffusion rate, were PC-CREAM 08®

default values. Others, such as the local compartment volume, depth and volumetric exchange rate, were user-specified, based upon values recommended by the Environment Agency [RD5]. Parameters defining the marine environment considered for the dispersion of aqueous discharges are outlined in table D14-1.

Table D14-1 Model parameters for the marine environment

Parameter	Value used for assessment	Origin
Regional compartment	Irish Sea West	PC-CREAM 08® default
Local compartment volume (m^3)	2.7E+09	Parameters for Cemaes coast [RD5].
Local compartment depth (m)	2.7E+01	Parameters for Cemaes coast [RD5].
Local compartment coastline length (m)	1.0E+04	PC-CREAM 08® default
Local compartment volumetric exchange rate (m^3/y)	3.2E+10	Parameters for Cemaes coast [RD5].
Local compartment suspended sediment load (t/m^3)	4.9E-06	Parameters for Cemaes coast [RD5].
Local compartment sedimentation rate (t/m^2/y)	1.0E-04	Parameters for Cemaes coast [RD5].
Local compartment sediment density (t/m^3)	2.6E+00	PC-CREAM 08® default
Local compartment diffusion rate (m^2/y)	3.15E-02	PC-CREAM 08® default

14.2.14 In addition, PC-CREAM 08® recommends specific values to be used for coastal sediment distribution coefficients (Kd, which describe the affinity of sediment material to bind each element) for all Irish Sea compartments for cobalt, ruthenium, caesium and americium. These values are presented in table D14-2. For other elements, the PC-CREAM 08® default values are used.

Table D14-2 Non-default element specific coastal sediment distribution coefficients

Parameter	Coastal Kd (Bq/t per Bq/m^3)
Cobalt	2.5E+03
Ruthenium	7.1E+02
Caesium	2.3E+02
Americium	1.0E+05

Habits data and assumptions

14.2.15 A number of assumptions were made in order to ensure that predicted doses are bounding (i.e. are unlikely to be greater than those presented). These assumptions are described below.

14.2.16 The Centre for Environment, Fisheries and Aquaculture Science (Cefas) has performed three recent habits surveys for the Existing Power Station (referred to as Wylfa in the Cefas reports) ([RD6], [RD7], [RD8]). These cover the areas that are most likely to be impacted by discharges to the marine environment, discharges to air and from direct radiation emanating from the Existing Power Station. The Power Station Site is situated immediately adjacent to the Existing Power Station site, and so the habits data presented in the Cefas habits survey reports for the Existing Power Station are considered to be directly applicable to the Power Station.

Most exposed members of the public for gaseous discharges

14.2.17 The most exposed members of the public for gaseous discharges were assumed to be a farming family who live at a nearby dwelling and consume 100% locally produced terrestrial food. The dwelling is assumed to be located at the receptor point which corresponds to the most restrictive residential location (i.e. the location with the highest deposition rate). Adults, children and infants are assumed to spend some time outdoors.

14.2.18 Adult ingestion rates are based on the two foodstuffs with the highest consumption rates (root vegetables and milk) being consumed at 97.5th percentile rates. Other foods are assumed to be consumed at mean rates. Consumption rates for children and infants were derived from the adult values using Cefas scaling factors in Annex 4 of the habits survey [RD6].

14.2.19 Cefas habit data extend to a radius of 5km from the Existing Power Station. Following a review of the data from the last three habits surveys, consumption of milk products made from locally produced milk was not identified and so was not considered in this assessment. Grain was also not considered as only one of the three Cefas surveys identified a farmer who sold barley nationally for human consumption. Grain produced for human consumption is normally mixed with other grain obtained over a wide geographical area before processing and distribution, and therefore it is unlikely that an individual or group of individuals would consume grain produced by a single producer.

14.2.20 Products from pigs and poultry were not included due to these livestock normally being supplied with feed from a number of sources, most of which would be located at some distance from the Power Station Site [RD9]. Cow's milk, beef and sheep meat were all assumed to be produced at a local farm location whilst green vegetables, root vegetables and fruit were assumed to be grown in a garden or allotment adjacent to the residential location.

14.2.21 Occupancy was taken as the highest occupancy of residency recorded in the last three habit surveys. The fraction of time spent outdoors was taken to be 50% for adults, 20% for children and 10% for infants [RD2]. Inhalation rates for the farming family were derived from data published by the National Radiological Protection Board (NRPB) [RD10].

14.2.22 While indoors, there is some shielding of external dose by building materials. The resulting reduction in external dose from material in the plume or deposited on the ground is shown as the cloud shine or ground shine factor respectively in the following tables.

14.2.23 The habit data and other assessment parameters used to estimate the radiological dose to the farming family are summarised in table D14-3.

Table D14-3 Assessment parameters for the farming family (gaseous discharges)

Parameter	Adult	Child	Infant
Cow's milk* (kg/y)	193.1	193.1	257.4
Root vegetables* (kg/y)	172.4	110.5	54.9
Green vegetables (kg/y)	47.4	22.2	10.1
Fruit and wild food** (kg/y)	34.2	21.7	13.8
Beef (kg/y)	31.5	21.0	7.0
Sheep meat (kg/y)	12.2	4.9	1.5
Occupancy (hr/y)	8,656	8,656	8,656
Fraction of time indoors (-)	0.5	0.8	0.9
Cloud shine factor (-)	0.2	0.2	0.2
Ground shine factor (-)	0.1	0.1	0.1
Inhalation rates (m^3/hr)	1.12	0.64	0.22

* Top two foodstuffs, 97.5th percentile consumption rates

** The values presented for fruit are the sum of the consumption rates of domestic fruit and wild/free foods, which is comprised of blackberries, sloes, crab apples and damsons.

Most exposed members of the public for aqueous discharges

14.2.24 The most exposed members of the public for aqueous discharges were assumed to be a fishing family who consume seafood at the highest critical rates [RD2]. The adults go fishing near to the coast and the children and infants spend time playing on the beach. All ingestion rates and occupancies were assumed to be at the 97.5th percentile, using the median value of the 97.5th percentile values from the three Cefas reports ([RD6], [RD7] and [RD8]).

14.2.25 For marine foodstuffs, 100% of crustaceans and molluscs were assumed to be caught in the local marine waters adjacent to the Power Station Site, whereas 50% of the fish consumed were assumed to be caught in the local compartment with the remaining 50% caught from regional waters further offshore from the coast of north Wales [RD2]. Consumption of seaweed was not considered as no observations of seaweed consumption were reported [RD6].

14.2.26 The activities that were assumed to be carried out in intertidal areas are boat maintenance, dog walking, beach warden and nature reserve duties, walking and angling [RD2]. For the purposes of the assessment, the combination of these activities undertaken on sand, sand and stone, and mud and sand, was utilised to establish the number of hours spent per year in the intertidal zone and the median of the 97.5th percentile values was used. As the activities are located in the intertidal zone, they have been conservatively assumed to occur at a distance of 1m from the sea and so lead to exposure to sea spray.

14.2.27 Adult members of the fishing family were considered to handle fishing gear in the intertidal area in addition to the time spent on the beach.

14.2.28 The habit data used to estimate the radiological dose to the fishing family are summarised in table D14-4. Inhalation rates are derived from NRPB data [RD10].

Table D14-4 Habit data for the fishing family (aqueous discharges)

Parameter	Adult	Child	Infant
Fish (kg/y)	35.4	7.1	1.8
Crustaceans (kg/y)	9.9	2.5	0.5
Molluscs (kg/y)	4.5	1.1	0.2
Intertidal activities (hr/y)	1,207	604	36
Handling fishing gear, catch and sediment (hr/y)	1,679	20	0
Inhalation rates (m^3/hr)	1.69	0.64	0.22

Candidates for the Representative Person from exposure to gaseous and aqueous discharges

14.2.29 In order to determine the exposure of the candidates for the Representative Person (CRPs) from both aqueous and gaseous discharges, three cases were considered:

- the most exposed member of the public for gaseous discharges (the farming family) also consumes locally sourced seafood at mean rates, and spends time at a local beach;
- the most exposed member of the public for aqueous discharges (the fishing family) also consumes locally produced terrestrial foodstuffs at mean rates, and lives in close proximity to the Power Station Site; and
- a worker at the Existing Power Station.

14.2.30 CRPs were selected on the basis of regulatory guidance [RD3]. Section 6.6 of the guidance advocates the determination of CRPs from consideration of realistic combinations of habits and a full range of exposure pathways; and suggests that habit survey reports are a basis for such determination.

14.2.31 A dose contribution from the direct radiation pathway is also included in the final assessment total, as calculated by the methods described in paragraphs 14.2.47 to 14.2.53.

Farming family

14.2.32 In the case of the farming family the following combined exposure pathways were assessed:

- external exposure to beach sediments;
- inhalation of sea spray when on the coast;
- consumption of sea fish, crustaceans and molluscs caught locally;
- internal irradiation from inhalation of radionuclides in the plume and re-suspended following deposition;
- external irradiation from radionuclides in the plume;
- external irradiation from radionuclides deposited on the ground;
- consumption of contaminated terrestrial foodstuffs following deposition on the ground; and
- direct radiation from Power station buildings.

14.2.33 The consumption rates of seafood were assumed to be at mean rates, using the median of the mean values from the last three Cefas reports. It was, however, assumed that the farming family would spend the same amount of time in a year in the intertidal zone as the fishing family, and so the median of the 97.5th percentile values have each been used for intertidal occupancy [RD2]. The habit data used to estimate the radiological impact to the farming family CRPs are provided in table D14-5.

Table D14-5 Farming family habit data (gaseous and aqueous discharges)

Parameter	Adult	Child	Infant
Gaseous discharge exposure			
Cow’s milk* (kg/y)	193.1	193.1	257.4
Root vegetables* (kg/y)	172.4	110.5	54.9
Green vegetables (kg/y)	47.4	22.2	10.1
Fruit and wild food** (kg/y)	34.2	21.7	13.8
Beef (kg/y)	31.5	21.0	7.0
Sheep meat (kg/y)	12.2	4.9	1.5
Occupancy (hr/y)	8,656	8,656	8,656
Fraction of time indoors	0.5	0.8	0.9
Cloud shine factor (-)	0.2	0.2	0.2
Ground shine factor (-)	0.1	0.1	0.1
Inhalation rates (m^3/hr)	1.12	0.64	0.22
Aqueous discharge exposure			

Parameter	Adult	Child	Infant
Fish (kg/y)	29.0	5.8	1.5
Crustaceans (kg/y)	7.9	2.0	0.4
Molluscs (kg/y)	1.8	0.5	0.1
Intertidal activities (hr/y)	1,207	604	36

* Top two foodstuffs, 97.5th percentile consumption rates.

** The values presented for fruit are the sum of the consumption rates of domestic fruit and wild/free foods, which is comprised of blackberries, sloes, crab apples and damsons.

(-) denotes unit-less parameters.

Fishing family

14.2.34 In the case of the fishing family the following combined exposure pathways were assessed:

- external exposure to beach sediments;
- inhalation of sea spray when on the coast;
- consumption of sea fish, crustaceans and molluscs caught locally;
- internal irradiation from inhalation of radionuclides in the plume and re-suspended following deposition;
- external irradiation from radionuclides in the plume;
- external irradiation from radionuclides deposited on the ground;
- consumption of contaminated terrestrial foodstuffs following deposition on the ground; and
- direct radiation from Power Station buildings.

14.2.35 This family was assumed to live in close proximity to the Power Station Site, and be exposed to the same pathways as the farming family, i.e. the plume (inhalation and external exposure) and deposited radionuclides (including the consumption of terrestrial foodstuffs) from gaseous discharges [RD2]. However, the consumption rates of terrestrial foodstuffs were assumed to be at mean rates, using the median of the mean values from the three latest Cefas reports.

14.2.36 The occupancy rates for the fishing family at its residence were not captured in the Cefas habits survey. Therefore, a conservative assumption was made that the family has 100% occupancy at the residence when not at work (fishing at sea) or spending time at the beach (including handling fishing gear). The fraction of time spent outdoors was assumed to be 50% for adults, 20% for children and 10% for infants [RD2]. The habit data used to estimate the radiological impact to the fishing family CRPs are provided in table D14-6.

Table D14-6 Fishing family habit (aqueous and gaseous discharges)

Parameter	Adult	Child	Infant
Aqueous discharge exposure			
Fish (kg/y)	35.4	7.1	1.8
Crustaceans (kg/y)	9.9	2.5	0.5
Molluscs (kg/y)	4.5	1.1	0.2
Intertidal activities (hr/y)	1,207	604	36
Handling fishing gear, catch and sediment (hr/y)	1,679	20	0
Inhalation rates (m^3/hr)	1.69	0.64	0.22
Gaseous discharge exposure			
Cow's milk* (kg/y)	140.3	140.3	187.0
Root vegetables* (kg/y)	141.3	91.5	44.7
Green vegetables (kg/y)	47.4	22.2	10.1
Fruit and wild food** (kg/y)	34.2	21.7	13.8
Beef (kg/y)	31.5	21.0	7.0
Sheep meat (kg/y)	12.2	4.9	1.5
Occupancy (hr/y)	5,874	8,136	8,724
Fraction of time indoors (-)	0.5	0.8	0.9
Cloud shine factor (-)	0.2	0.2	0.2
Ground shine factor (-)	0.1	0.1	0.1

* Top two foodstuffs, mean consumption rates.

** The values presented for fruit are the sum of the consumption rates of domestic fruit and wild/free foods, which is comprised of blackberries, sloes, crab apples and damsons.

(-) denotes unit-less parameters.

Existing Power Station workers

14.2.37 An additional CRP for gaseous discharges is a worker at the Existing Power Station. This individual is assumed to live outside of the local area and only be exposed to gaseous discharges during the working day.

14.2.38 As decommissioning of the Existing Power Station progresses, workers from non-nuclear sectors (e.g. construction and demolition firms) could be contracted to support the effort and could potentially be exposed to radioactivity from the Power Station. These contractors are generally more likely to live away from the immediate local area. It was also considered that food pathways would be excluded from the assessment, i.e. that the Existing Power Station worker(s) would only be exposed to direct radiation and non-ingestion pathways relating to gaseous discharges during their hours of work at the Existing Power Station.

14.2.39 It has been assumed that the Existing Power Station worker(s) are always outdoors and work at ground level, at a receptor location that is 480m and 34° from the Power Station's reference stack [RD2]. The Existing Power Station worker dose assessment is for an adult only. Habit data for the Existing Power Station worker are presented in table D14-7.

Table D14-7 Habit data for the Existing Power Station worker (gaseous discharges)

Parameter	Adult
Time at location (hr/y)	2,000
Fraction of time indoors (-)	0
Inhalation rate (m^3/hr)	1.12

(-) denotes unit-less parameters.

Assessment of doses to the foetus and breast-fed infants

14.2.40 Guidance from Public Health England [RD11] suggests that doses to the foetus need only be considered for four radionuclides (i.e. phosphorus-32, phosphorus-33, calcium-45 and strontium-89) in assessments where these radionuclides form a significant part of any release to the environment. Only strontium-89 has been identified as a constituent of the radioactive inventory to be discharged from the Power Station, and it is expected that this radionuclide would form only a very small part (very much less than 0.1%) of the release to the environment.

14.2.41 Assessment results show that foetal exposure is lower than that to one-year-old infants. Assessments of foetal impacts would therefore not be explicitly reported.

Assessment of collective dose to populations

14.2.42 Collective doses have been estimated using PC-CREAM 08®. Population and agricultural production distribution within Europe is provided by the in-built database for each site on the PC-CREAM 08® database, as is the regional marine compartment that the discharge is released into. The Existing Power Station is in the database and is a suitable model representation for the Power Station.

14.2.43 The collective dose methodology [RD4] makes the assumption that the magnitude of the population of the European Union remains constant over all time, that habits remain the same and that the whole population are adults. The models, food production and population data provided in that document have been integrated into PC-CREAM 08®.

14.2.44 Collective doses were determined for the UK, European and world populations for both first pass (doses from the initial release) and global circulation scenarios, truncated at 500 years in accordance with statutory guidance. In addition, average individual doses have been calculated based on the population data for UK, EU12, EU25 and the world assumed in PC-CREAM 08® to be 59.6 million, 360 million, 456 million and 10 billion respectively [RD4].

14.2.45 For clarity, EU12 is the population representing the 12 European countries that were member states when the European Union was first established in 1993. EU25 is the number of member states (25) that were included in the European Union when PC-CREAM 08® was developed (recognising that this number has since risen again).

14.2.46 The first pass collective dose is the collective dose due to the initial dispersion of the discharge, whereas the global circulation collective dose is that due to circulation of mobile, longer-lived radionuclides in the oceans and in the atmosphere, i.e. carbon-14, tritium and krypton-85.

Assessment of doses from direct radiation exposure

Direct radiation sources

14.2.47 Doses from direct radiation exposure are calculated on the basis of computer modelling of the external doses resulting from operations at the Power Station. There are two potential radiation sources likely to result in off-site doses: the turbine buildings and the spent fuel storage facility. Off-site external doses from the Intermediate Level Waste (ILW) storage and the lower activity waste management facilities have been assessed as negligible. The dose rates due to direct radiation from radioactive sources on the Power Station Site were calculated using the software package MCNP5 (see section 14.4 in chapter B14, Application Reference Number: 6.2.14).

Most exposed members of the public for direct radiation

14.2.48 The locations at which receptor external doses were evaluated in the assessment were as follows.

- Residential location – a representative location for a family who lives near to the Power Station Site (who also happens to eat food grown and produced locally).
- Existing Power Station worker – a worker on the Existing Power Station site which lies to the north of the Power Station Site.
- Tregele – a settlement located approximately 600m from the Power Station Site.
- Cemaes – a settlement located approximately 1.2km from the Power Station Site.
- Walkers – three scenarios for walkers on paths around the Power Station Site.

14.2.49 The following scenarios are outlined for walkers on the paths around the Power Station Site (i.e. existing footpaths around the Power Station Site or paths that have been rerouted) shown on the illustrative layout in figure D14-2 (Application Reference Number: 6.4.101).

- Walker 1 – someone who parks to the south-east of the Power Station site and walks their dog every day, starting in a north-westerly direction (see location 1 in figure D14-2, Application Reference Number: 6.4.101).

- Walker 2 – someone who parks to the south-east of the Power Station site and walks their dog every day, starting in a north-easterly direction (see location 2 in figure D14-2, Application Reference Number: 6.4.101).
- Walker 3 – assumes that, once per week, Walker 2 spends 20 minutes on the hill to the east of the Power Station Site (see figure D14-2, Application Reference Number: 6.4.101).

14.2.50 It is assumed that each walker walks at a constant speed of 1.3m/s every day of the year and performs a round trip along the appropriate length of path identified as important for the dose rate assessments [RD2].

14.2.51 In order to model the paths shown in figure D14-2 (Application Reference Number: 6.4.101) explicitly, each path was split into three sections with an associated length and time for walking. The walker was assumed to travel the length of the relevant path two times per day, i.e. an outward and a return journey. These individual sections of path were input into the MCNP models to allow the average dose rate over each section to be calculated.

14.2.52 It is highlighted that changes to the layout of paths shown on the illustrative layout figure D14-2 (Application Reference Number: 6.4.101) within the parameters sought (as described in chapter D1 (proposed development) (Application Reference Number: 6.4.1)) would not affect the assessment of doses from direct radiation for walkers.

Habit data and assumptions

14.2.53 The modelling for the direct dose rates assumed that both of the proposed reactors were in place and operating at full power. All waste storage facilities were assumed to contain the total inventory expected after 60 years of operation. This scenario is considered to be the most conservative of all scenarios in the operational lifetime of the Power Station.

14.2.54 For each of the receptors (except the walkers) the following are assumed [RD2]:

- 2,000 hours occupancy per year for a worker on the adjacent Existing Power Station site; and
- for the residential location plus the nearest points to the Power Station Site of the villages of Tregele and Cemaes:
  - occupancy of 24 hours per day for 365 days (i.e. 8,760 hours); and
  - fractions of time assumed indoors: adult 0.5, child 0.8, infant 0.9.

Assessment of doses from the transport of radioactive materials

14.2.55 This section presents the input data for the assessment of the radiological effects to a member of the public due to the transport of radioactive materials to and from the Power Station Site under normal conditions of operation (movements of material on the Power Station Site itself are not included). The approach taken is similar to that used in a review of doses from transport of radioactive materials in the UK [RD12]. The approach is judged to be reasonably conservative and it should be noted that actual operational transports would be subject to strict regulatory control.

14.2.56 The method requires data for:

- radioactive materials to be transported and vehicle numbers;
- likely routes of travel; and
- exposure assumptions (durations, locations etc.).

14.2.57 Assumptions on vehicle movements involved with the transport of radioactive material to and from the Power Station Site are design information and are described in section 14.4.

Individual exposure parameters and assumptions

14.2.58 The transport from the Power Station Site could take two different routes within the local area (the Isle of Anglesey), and these routes have been considered in the assessment.

14.2.59 Both routes begin or end using the A5025, which would pass through or close to the villages of Tregele, Llanrhuddlad, Llanynghenedl and Valley. Between the Power Station Site and Valley (detailed below), there are no traffic signals or roundabouts, so any extended exposure to the villages listed above would be due to traffic congestion. The route of the existing A5025 has been modelled, which leads to a more conservative assessment (since there is more potential for delays due to traffic conditions).

14.2.60 If the shipments begin or end at the port or railhead in Holyhead, the route is via the A55 between Junction 1 and Junction 3, where vehicles would be forced to stop at several pinch-points such as roundabouts and traffic signals, some of which are near shops and residential areas.

14.2.61 The other route would be via the A55 Junction 3 and the M6. If the material is heading to Lancashire or Cumbria, the route would be north on the M6. If the material is heading south to Southampton or Northamptonshire, the route would be south on the M6 then the M1 (for Northamptonshire) or M1, A43, M40 and A34 past Oxford and Newbury (for Southampton). For incoming materials, the route is reversed.

14.2.62 The route toward the Holyhead railhead has several areas where a transport vehicle would have to stop, for either traffic lights or a give way junction, as described below.

Junction of A55 and A5, London Road, Valley

14.2.63 There is a supermarket, two public houses, a takeaway restaurant and several houses near to the junction. Time spent at the junction would be dependent on traffic conditions.

Junction of Kingsland Road and London Road

14.2.64 There are several houses, a hotel and several small businesses on the other side of a low wall, dividing the A55 from lower residential streets. Time spent at the junction would depend upon traffic conditions.

A55 Junction 1 roundabout

14.2.65 On the west-bound approach to the roundabout is a fast-food restaurant and a supermarket. On the roundabout, there is a fire station and several businesses. Times spent adjacent to these businesses would be dependent upon congestion at the roundabout and is expected to be longer during the weekday rush hour.

A55 Junction 3 roundabout

14.2.66 There are no businesses or residences around this roundabout, so the only people to be considered for dose exposure would be other motorists.

Junction of Holyhead Road and A5025, Valley crossroads

14.2.67 There are several businesses located around the junction, including a petrol station, barber's shop and public house. There are also several houses located on the south-bound A5025, approaching the traffic lights. The proposed improvements to the A5025 would mean that transport traffic is unlikely to pass this crossroads, but the receptors are included within this assessment to give a conservative estimate of effects.

14.2.68 The route for material leaving the Power Station Site by road towards the rest of the UK would be via the A55 towards the M6. The identified pinch-points for these routes are detailed below.

Britannia Bridge, A55

14.2.69 Congestion is expected on Britannia Bridge during peak hours on weekdays and possibly Saturday mornings and Sunday evenings during summer and Bank Holidays. There are no residences or businesses near the bridge and buildings along the congestion tailback are protected by raised concrete barriers; therefore, only other motorists would be affected.

A55 Junction 15A roundabout, between Llanfairfechan and Penmaenmawr

14.2.70 Part-time traffic signals are in place at this roundabout, so there is potential for exposure to the buildings nearby, which include several residences situated adjacent to the roundabout.

14.2.71 Where houses are close to junctions, it is reasonable to assume full-time occupancy during the transport of radioactive materials and that the same person is in the house and, therefore, potentially exposed to radioactive material transports for 52 weeks in a year.

14.2.72 Table D14-8 presents the scenarios to be considered in the assessment of transport effects, providing a matrix of radioactive sources and target locations where members of the public could be exposed to a radiological dose.

Table D14-8 Scenarios considered for probable dose exposure to members of the public

Location	New fuel	Low Level Waste (LLW)	Very Low Level Waste (VLLW)	Spent fuel
Shops and public house near Valley crossroads	Yes	Yes	Yes	Yes
Shops near A55 Junction 1 roundabout	No	No	No	Yes
Shops and residences near Kingsland Road and London Road junction	No	No	No	Yes
Shops, public house and residences near A5 and A55 junction	No	No	No	Yes
Residences near A55 Junction 15A roundabout	Yes	Yes	Yes	No

14.2.73 Table D14-8 shows that the Valley crossroads has the potential for the highest exposure to the public, as all the transports to and from the Power Station must pass through this junction. It is assumed that each transported package spends one minute stopped at the traffic signals.

Assessment of doses to non-human species from discharges

Local area habitat designations

14.2.74 European Designated Sites within the vicinity of the Power Station have been identified (see figure D9-2, Application Reference Number: 6.4.101). Figure A3-2 (Application Reference Number: 6.1.10) shows the identified ecologically sensitive locations in the area.

14.2.75 The most notable of the sites subject to ecological conservation designations include Cemlyn Bay Site of Special Scientific Interest (SSSI), which forms part of the Anglesey Terns Special Protection Area, and the Cemlyn Bay Special Area of Conservation (SAC) to the west of the Power Station Site. The Wylfa Newydd Development Area is also located within the North Anglesey Marine candidate SAC (proposed for harbour porpoise, *Phocoena phocoena*) which covers area of approximately 325,000 hectares around the northern half of Anglesey [RD13].

14.2.76 Three distinct habitat types, representative of the designated sites (European Designated Sites or otherwise), have been identified as being potentially sensitive to gaseous and aqueous radioactive effluent released from the Power Station on account of their ecological significance and their proximity. These are the closest habitats of these types to the Power Station which would result in the highest calculated environmental concentrations and doses to species at these locations (see chapter B14, Application Reference Number: 6.2.14). These habitat types are set out below.

- A terrestrial habitat, which lies on the Power Station Site boundary immediately to the east of the Power Station Site, just outside the Power Station fence. This habitat is the area where deposited activity from gaseous releases to the atmosphere is predicted to be greatest. It is considered that this approach would result in a realistic but conservative assessment of the effects on non-human species and so would provide conservative assessments for any designated terrestrial conservation sites near the Power Station.
- A marine habitat, in the coastal waters to the north and west of the Power Station Site. This habitat is analogous to the 100km^2 local (Wylfa) marine compartment within the DORIS marine dispersion module of PC-CREAM 08® and represents the Anglesey Terns Special Protection Area, and the candidate SAC Gogledd Môn Forol/North Anglesey Marine.
- A freshwater habitat, assumed to consist of a small lake at Tre'r Gof SSSI to the north-east of the Power Station. Tre'r Gof SSSI is situated in the predominant wind direction and its catchment includes the area receiving the highest deposition rates for gaseous radionuclides released from the Power Station. The SSSI is therefore considered to be more limiting than the other important freshwater habitat Cae Gwyn, which is situated to the south of the Power Station Site. For the purposes of this assessment, the location of the freshwater habitat is based on the food production area used in the human dose assessment.

14.2.77 Llanbadrig – Dinas Gynfor has been designated as a SSSI because of its geological significance. As such, it is not relevant to the assessment of radiation impact on non-human species.

14.2.78 A fourth important habitat, a brackish lagoon designated as the Cemlyn Bay SAC was also considered. However, current assessment methodologies do not facilitate direct assessment of radiological impacts to brackish habitats. In addition, given that the Cemlyn Bay SAC is fed by seawater (from the marine habitat identified above) and freshwater from local watercourses, it is considered that activity concentration in the brackish water and sediment within this habitat would be less than, and therefore bounded by, the activity concentrations in the marine habitat.

Calculation of radionuclide concentrations in the environment

14.2.79 The assessment of radiological impacts on non-human species was based on the ERICA Integrated Approach [RD14] (also see chapter B14, Application Reference Number: 6.2.14). In order to carry out an assessment of impacts on non-human species, it is necessary to determine the activity concentrations of discharged radionuclides in water and soil. The concentrations are used as an input to ERICA.

14.2.80 The dispersion and resulting concentrations in environmental media of radionuclides originating from effluents discharged from the Power Station were modelled using the dispersion modules of PC-CREAM 08®. The methods for determination of concentrations of radionuclides in the terrestrial and marine environment due to gaseous and aqueous discharges are the same as those described earlier in this section.

14.2.81 The accumulation of radionuclides in a representative freshwater lake habitat based on Tre'r Gof SSSI dimensions from deposition of gaseous releases was calculated using the International Atomic Energy Agency (IAEA) SRS-19 model for a small lake [RD15].

14.2.82 The SRS-19 model takes account of both direct deposition of radionuclides into the lake and indirect contribution due to runoff and washout of radionuclides deposited within the lake catchment. The model assumes that the catchment is 100 times the lake surface area, and that 2% of radionuclides deposited on to the catchment reach the water body.

14.2.83 The SSSI has an area of 10.1 hectares [RD16], so the default modelled catchment area is likely to be conservative.

14.2.84 The deposition rates derived for the terrestrial habitat were conservatively adopted for assessing the radiological impacts to the freshwater habitat.

14.2.85 Table D14-9 presents the parameter values used to model the concentration of radionuclides in the Tre'r Gof freshwater habitat.

Table D14-9 Model parameter values for a small lake

Parameter	Value
Catchment area	0.92km^2
Lake surface area	9,200m^2
Flow rate	0.0125m^3/s
Lake depth	0.3m
Lake volume	2,760m^3
Discharge duration	60 years

14.3 Baseline environment

14.3.1 This section provides a summary of the baseline conditions for radiological effects within the study area described in section 14.2.

UK annual radiation exposure

14.3.2 The Centre for Radiation, Chemical and Environmental Hazards, a department of Public Health England, has calculated that the average annual dose to people in the UK from ionising radiation is about 2,700µSv/y (micro sieverts per year) [RD17]. The sources of radiation giving rise to these doses can be grouped into two broad categories; exposures to artificial and to natural sources. Figure D14-3 illustrates the contribution from natural and artificial sources.

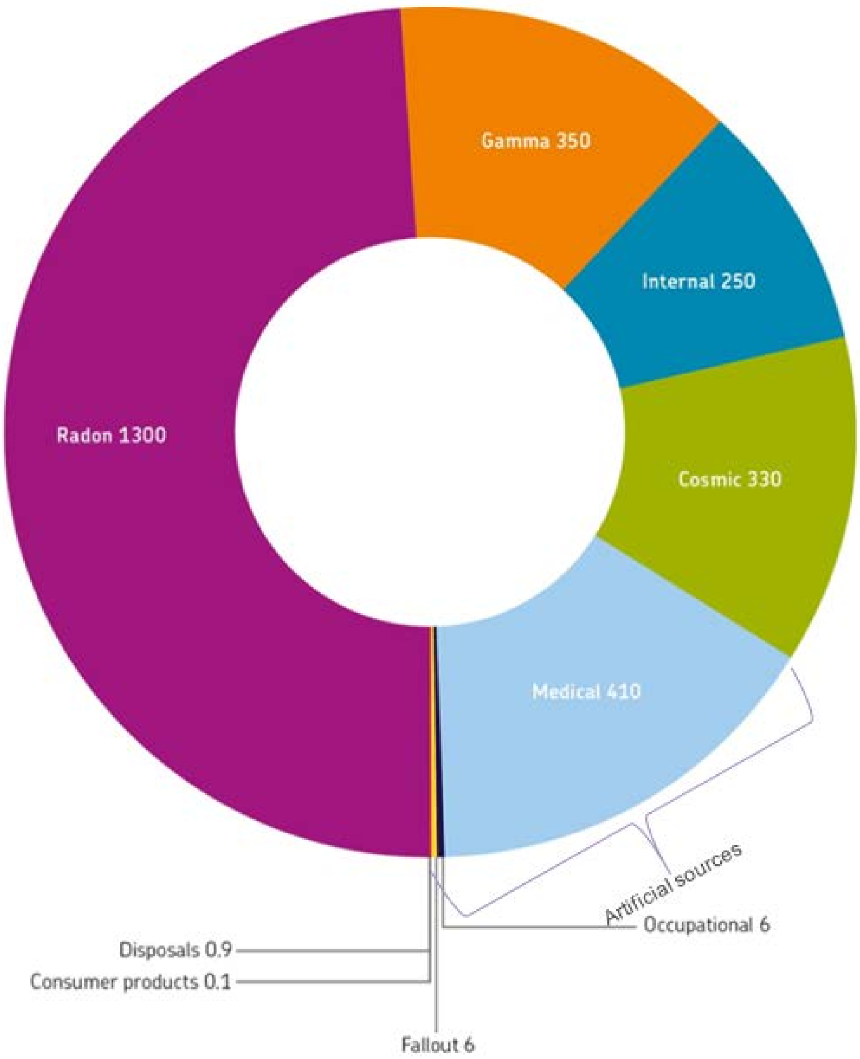
14.3.3 The main contribution to exposure to radiation from artificial sources is from medical procedures (410µSv/y). Smaller doses are received due to occupational exposure, exposure to historic radioactive contamination from nuclear accidents and weapons testing, and a small exposure from consumer products. The dose resulting from exposure to disposals of radioactive material indicated in figure D14-3 is 0.9µSv/y. The total dose from artificial sources is 423µSv/y.

14.3.4 Exposures to natural sources of radiation are due to the presence of naturally occurring radioactive minerals found in the environment (including building materials) which lead to exposure via gamma rays and also via radon inhalation, in food and drink (described as 'internal' in figure D14-3), and to cosmic radiation from outer space. Natural radiation accounts for about 85% (2,230µSv/y) of the average exposure of UK individuals.

14.3.5 The main factor contributing to variation in UK natural background radiation doses is differences in radon concentrations from the underlying rock composition. This leads to a variation in dose from radon inhalation across the UK.

14.3.6 With regards to the variation in natural radiation local to the Wylfa Newydd Development Area, measurements on Anglesey show that radon concentrations are relatively low (compared to the UK average) over the majority of the island, but with a band of higher radon concentrations observed towards the east of the island. Annual average radiation doses around the Wylfa Newydd Development Area would typically be lower than the national average as a result of lower radon concentrations in the environment [RD18].

Figure D14-3 Contributions to the average UK annual radiation dose (μSv/y)



Radioactivity concentrations in the local environment

14.3.7 Routine monitoring of the local environment around the Existing Power Station has been carried out for many years by a number of bodies (e.g. the operators of the Existing Power Station and UK regulatory bodies), and a substantial body of data on radioactivity in various environmental media exists [RD19]. The UK environment agencies and the Food Standards Agency publish an annual summary of the independent radioactivity monitoring programmes in the UK, known as Radioactivity in Food and the Environment (RIFE) ([RD20], [RD21], [RD22], [RD23], [RD24], [RD25], [RD26], [RD27]), including data from around the Existing Power Station. The distribution of radionuclide concentrations in the Irish Sea has been reviewed and reported by the Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) [RD28].

14.3.8 The radioactivity levels in the Eastern Irish Sea are influenced mainly by discharges from the reprocessing plant at Sellafield in Cumbria, and to a lesser extent the fuel fabrication plant at Springfields in Salwick, Lancashire, the nuclear power station at Heysham in Lancashire, and the Existing Power Station.

14.3.9 It should be noted that the objectives of the various sampling programmes reviewed are different and, as such, would focus on different radionuclides and sampling media. In addition, because discharges from the Existing Power Station are low and, hence, local anthropogenic radioactivity levels are low, many of the sample results return values below the minimum detectable amount (sometimes reported as "less-than" values). The following sections have been extracted from the literature and present the significant features of the underlying data relevant to developing an understanding of the current radiological conditions of the region.

Gamma monitoring

14.3.10 For the assessment of background radiation, an estimate of baseline ambient radiation dose in the study area is required. The operator of the Existing Power Station undertakes terrestrial gamma monitoring in the local area around the Existing Power Station [RD19]. The measurements are of dose rate (nanograys per hour – nGy/hr) in the environment and this comprises components due to natural terrestrial radioactivity, cosmic contribution, inherent instrument background and man-made sources. Quarterly dose rate measurements are carried out at nine or more inner locations (4km from the Existing Power Station), and nine or more outer locations (10km from the Existing Power Station), together with five or more beach sites.

14.3.11 In 2013, the annual mean data for the inner ring locations had a lower net dose rate than the outer ring locations (34.3nGy/hr compared to 43.9nGy/hr).

14.3.12 Power generation ceased at the Existing Power Station at the end of 2015, which would result in a reduced contribution from anthropogenic sources to external gamma doses.

Soil radioactivity concentrations

14.3.13 Horizon has conducted a baseline survey of soil radioactivity concentrations in trial pits in the Wylfa Newydd Development Area ([RD29], [RD30]). All surface soils were found to be within normal background concentration ranges.

14.3.14 Horizon also undertook a rock and soil sampling survey of the Wylfa Newydd Development Area [RD29]. The results of the survey found no samples with elevated concentrations of naturally occurring radioactive material. In addition, no artificial radionuclides were detected other than trace amounts of caesium-137, which is a common component from weapons testing and fallout from past accidents (such as Chernobyl). Caesium-137 is present at low concentrations across the Power Station Site, with no indication of variation with distance from the Existing Power Station, suggesting no historic contamination has resulted from releases of radioactive material from local sources.

14.3.15 Caesium-137 was detected in 57% of near-surface samples from the Wylfa Newydd Development Area, with a maximum recorded activity of 6.43Bq/kg. The median caesium-137 activity of near-surface samples was 1.23Bq/kg. These values are lower than the assumed background caesium-137 activity based on results from annual Existing Power Station district survey soil cores (quoted in [RD29]) collected between 2006 and 2013 (maximum 36.1Bq/kg, median 17.8Bq/kg). Results indicate that caesium-137 activity is restricted to the surface, with generally reduced activity at 0.5m and no caesium-137 detected in any of the deeper samples. Measurements of caesium-137 above the Limit of Detection were found in samples from six areas. The mean caesium-137 concentration in these areas ranged from 0.9Bq/kg to 2.8Bq/kg.

14.3.16 These soil concentrations are at the lower end of the range of measurements of caesium-137 in soil, made on Anglesey as part of a wider study in north Wales [RD31]. In that study, measurements of between 2Bq/kg and 20Bq/kg were measured.

14.3.17 It is concluded that levels of caesium-137 in soil from the Wylfa Newydd Development Area reflect the typical background for Anglesey.

14.3.18 Radioactivity concentrations measured in the baseline surveys of soils were found to be below the out of scope radioactive material definition for caesium-137 from the Environmental Permitting (England and Wales) Regulations 2016 of 1000Bq/kg and the IAEA clearance and exemption value of 100Bq/kg [RD32].

Sediment radioactivity levels in marine construction areas

14.3.19 As part of the Power Station Site investigation and characterisation programme, Horizon has undertaken an extensive environmental sampling programme in the marine construction areas. As part of this programme, measurements of radioactivity were made in marine rock and sediment samples taken from the vicinity of proposed location of the Marine Off-Loading Facility [RD30].

14.3.20 The only anthropogenic radionuclides measured above the Limits of Detection were americium-241 and caesium-137. These were only detected in surface sediments and had mean concentrations of 1.1Bq/kg of americium-241 (three samples) and 3.3Bq/kg of caesium-137 (four samples). These low levels are similar to those observed in the routine monitoring programme around the Existing Power Station (see below and in table D14-10).

14.3.21 Radioactivity concentrations measured in sediments were found to be below the out of scope radioactive material definition for caesium-137 from the Environmental Permitting (England and Wales) Regulations 2016 of 1,000Bq/kg and for americium-241 of 100Bq/kg, as well as being below the IAEA clearance and exemption value of 100Bq/kg [RD32].

Local marine monitoring

14.3.22 A summary of the measured radioactivity concentrations in local marine samples from the 2016 RIFE report [RD27] is shown in table D14-10. These radioactivity concentrations would all contribute to the assessed Representative Person doses presented in RIFE and comprise the baseline for anthropogenic sources (even if they may not be significant components of the Power Station discharge inventory).

14.3.23 Even though power generation at the Existing Power Station ceased at the end of 2015, it is assumed that marine discharges would not change significantly as defueling commences, since liquid wastes would continue to be generated. Hence, the reported radioactivity levels are assumed to be typical of those likely to be observed over the next few years.

Table D14-10 Concentrations of radionuclides in food and the marine environment near the Existing Power Station, 2016

Material	Mean radioactivity concentration (fresh), Bq/kg											
	No. of sampling locations	H3 (organic)	H3	C14	Tc99	Cs137	Pu238	Pu239 + Pu240	Pu241	Am241	Gross alpha	Gross beta
Plaice	1	<25	<25	40		0.60				<0.13		
Crabs	1	<25	<25	39		<0.08				<0.09		
Lobsters	1	28	33	61	18	0.37	0.0033	0.021	0.30	0.12		110
Winkles	1	<25	<25	42	9.4	0.28	0.025	0.16	0.53	0.24		72
Seaweed	2				15	<0.44				<0.44		
Sediment	2					2.9				1.3		
Sediment	2					2.2				<0.78		
Seawater	2		<3.2			<0.20				<0.28	<3.7	13

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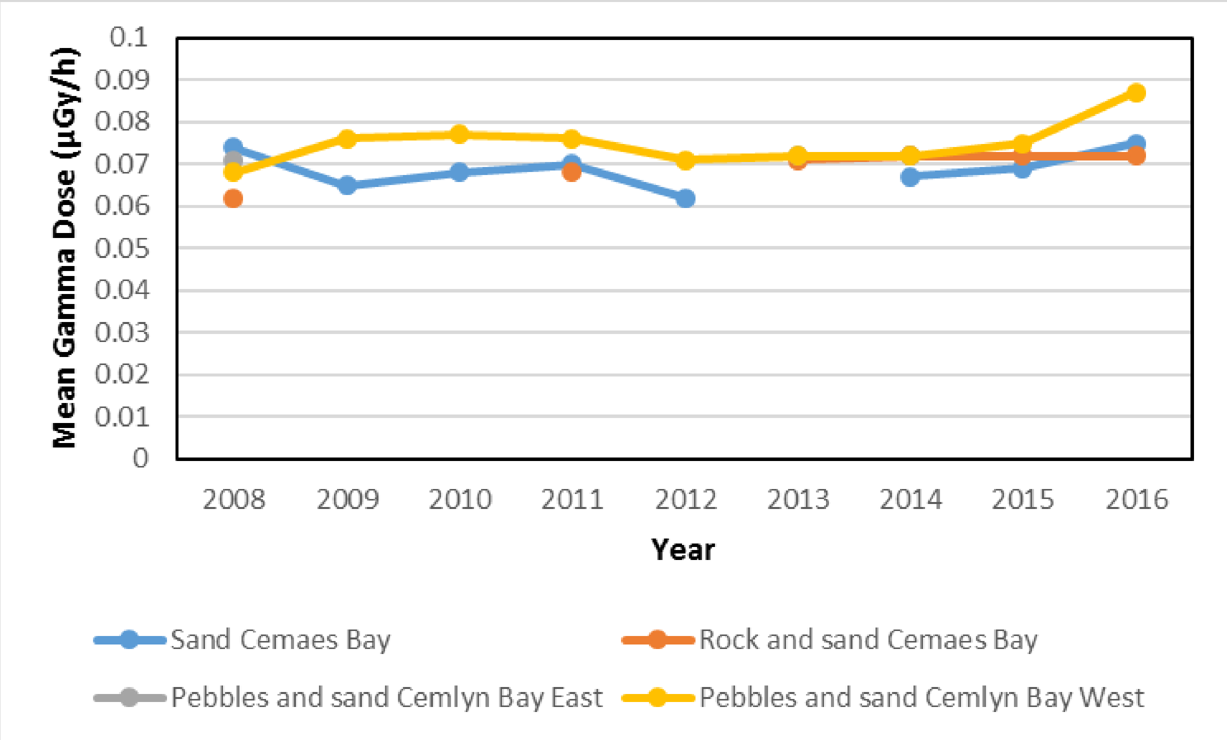
14.3.24 RIFE reports also indicate trends based on radioactivity measurements in environmental media from previous years. Of the radionuclides reported for the local area, the only significant trend is a reduction in concentrations of technetium-99 in environmental media. This is consistent with an observed reduction in technetium-99 discharges from Sellafield.

14.3.25 Gamma dose rates over beach and sediments are also measured by the nuclear regulators and reported in RIFE for local intertidal areas. The measurements over the previous nine years in different locations are shown in figure D14-4. No trends in the data are evident.

Figure D14-4 Trends in mean gamma dose rates over beach and sediments



Local terrestrial monitoring

14.3.26 Gaseous discharges from the Existing Power Station have now reduced following the cessation of power generation at the end of 2015.

14.3.27 Radioactivity measurements in terrestrial foodstuffs for 2013 [RD24] from the RIFE programme are summarised in table D14-11. The results reported from sampling programmes are dependent on particular crops being grown or available in the local district in any given year. As this is not always the case, trends in the data are harder to identify.

14.3.28 Milk is an important indicator of local exposures and has the most sampling locations. In table D14-11 and table D14-12, the first line of milk results reports the mean concentration observed in all samples and locations and the second line reports the highest observed concentration in all samples.

14.3.29 Once again, these radioactivity concentrations would all contribute to the assessed Representative Person doses presented in RIFE and comprise the baseline for anthropogenic sources (even if they may not be significant components of the Power Station discharge inventory). However, for the local terrestrial environment, annual average concentrations in these media are more sensitive to discharges in a given year (unlike concentrations in the marine environment) particularly for tritium, carbon-14 and sulphur-35. Therefore, the baseline in the future would be much more dependent on gaseous discharges defined in the decommissioning strategy of the Existing Power Station.

Table D14-11 Concentrations of radionuclides in food near the Existing Power Station, 2013

Material	No. of sampling locations	Radioactivity concentration (fresh), Bq/kg					
		H3	C14	S35	Cs137	Gross alpha	Gross beta
Milk	5	<2.4	26	<0.57	<0.07		
Milk	Max obs.	<2.7	29	1.1	<0.08		
Apples	1	<2.2	8.5	0.50	<0.06		
Barley	1	<5.4	110	0.50	<0.13		
Beetroot	1	<2.3	15	<0.20	<0.10		
Blackberries	1	<2.2	23	1.4	<0.06		
Broad beans	1	<2.5	29	2.0	<0.06		
Cauliflower	1	<2.0	6.9	0.80	<0.08		
Potatoes	1	<2.4	18	0.30	<0.06		
Squash	1	<2.3	10	0.60	<0.05		
Fresh water (public supply)	1	<3.0		<0.19	<0.20	<0.03	0.16

14.3.30 As radioactivity concentrations of most radionuclides have fallen below Limits of Detection, the sampling programme was reviewed and the number of results reported was reduced. Data from the most recent RIFE programme [RD27] are shown in table D14-12.

Table D14-12 Concentrations of radionuclides in food near the Existing Power Station, 2016

Material	No. of sampling locations	Radioactivity concentration (fresh), Bq/kg			
		H3	C14	S35	Cs137
Milk	2	<3.8	24	<0.36	<0.06
Milk	Max obs.	<5.2		<0.38	
Potatoes	1	<2.2	15	0.50	<0.07
Freshwater (public supply) (2015 results. Sampling not undertaken in 2016)	1	<3.2		<0.98	<0.18

Summary of current local radiation exposure

14.3.31 In the most recent RIFE report [RD27], an assessment is made of doses to the public near nuclear licensed sites using the results of monitoring of radioactivity in food and the environment, supplemented by modelling where appropriate. The assessments use radionuclide concentrations, gamma dose rates and information on the habits of people living near the sites.

14.3.32 Changes in the doses received by people can occur from year to year and are mostly caused by variations in radionuclide concentrations and external dose rates. However, in some years, doses are affected by changes in habits of individuals, particularly the food they eat, as reported in habits surveys.

14.3.33 The dose presented in the report is made up of contributions from all sources of radioactivity from man-made processes. The range of human radiation doses resulting from different pathways around the Existing Power Station is summarised in table D14-13.

Table D14-13 Baseline doses around the Existing Power Station

Component	Source	Dose (µSv/y)
Radon	Uranium in rocks	120 – 3,600
Other components of natural background	Gamma, internal, cosmic	930
Background artificial components	Medical, occupational, fallout, others	420
Existing Power Station discharges – specific pathway	Adult spending time in intertidal areas	7
	Seafood consumer	<5
	Infant inhabitant and consumer of locally	5

Component	Source	Dose (µSv/y)
doses	grown food	

14.3.34 The assessment of radiological effects from the Wylfa Newydd Project contained in this chapter is based on predictive modelling undertaken in support of the EP-RSR, and a comparison of the modelled results with regulatory criteria. To assess the cumulative contribution to public radiation doses from man-made sources, the assessed contribution from the Existing Power Station is required along with baseline data from other nuclear facilities discharging into the Irish Sea.

14.3.35 Baseline data on discharges from other nuclear facilities are defined in RIFE reports. The current assessed overall public dose close to the Existing Power Station resulting from discharges to the Irish Sea is approximately 10µSv/y.

14.3.36 The variation in the total dose from all pathways to the Representative Person from the RIFE reports and the main contributing pathways, are shown in table D14-14. Total doses remained broadly similar from year to year, and are generally very low. Habit data for the RIFE assessment is based on the same survey data described in section 14.2.

Table D14-14 Trends in all pathways dose near the Existing Power Station

Year	Dose(µSv/y)	Main pathways
2010	7	Direct radiation
2011	8	Direct radiation
2012	6	Direct radiation, milk
2013	<5	Fish, gamma dose rate over sediment
2014	7	Fish, gamma dose rate over sediment
2015	13	Direct radiation
2016	8	Direct radiation

Evolution of the baseline

14.3.37 As indicated in the RIFE reports, there has been a progressive reduction in discharges to the Irish Sea from existing nuclear facilities. This is in part due to a regulatory requirement (under the OSPAR treaty) for an ongoing reduction in the discharge of man-made radioactive material into the north-east Atlantic region. This requirement, along with a cessation of operation of some existing nuclear facilities, would result in a continuation of this current downward trend in future years.

14.3.38 Following the cessation of power generation by the Existing Power Station at the end of 2015, there has been an overall reduction in external dose rates close to the Existing Power Station site, but this may vary as active items are removed and stored as waste ready for disposal. Future trends in gaseous and aqueous discharges from the Existing Power Station would depend upon the decommissioning strategy adopted.

14.4 Design basis and activities

14.4.1 This section sets out the design basis for the assessment of effects. It sets out where any assumptions have been made to enable the assessment to be carried out at this stage in the evolution of the design. This section also identifies the embedded and good practice mitigation that will be adopted to reduce adverse effects as inherent design features or by implementation of standard industry good working practice.

14.4.2 As described in chapter D1 (Application Reference Number: 6.4.1), the application for development consent is based on a parameter approach. The assessment described within this chapter has taken into consideration the flexibility afforded within the parameters sought. A worst case scenario has been assessed from a radiological effects perspective based on the information presented in the EP-RSR submission [RD2] which is consistent with the parameters described in chapter D1 (Application Reference Number: 6.4.1).

Construction

14.4.3 During construction, the following activities have the potential to result in inadvertent radiation exposure to workers in construction areas:

- geophysics and radiography would use radioactive sources in a controlled manner; and
- the potential for the discovery of previously contaminated land or of radiation sources used during the time of construction of the Existing Power Station.

Basis of assessment and assumptions

14.4.4 The activities described in paragraph 14.4.3 would be well controlled by the mitigation measures described in paragraphs 14.4.7 to 14.4.12 below.

14.4.5 Exposure to existing baseline radioactivity in soils and sediments during excavation-related works would be based on the existing data from soils and sediments in construction areas (see section 14.3).

Embedded mitigation

14.4.6 No embedded mitigation has been identified for construction.

Good practice mitigation

14.4.7 The hazards associated with the construction activities as described above are primarily related to the control of radioactive sources for geophysics and radiography and the potential to discover radioactive contamination from previous activities on the Power Station Site. There are a number of mitigations in place to prevent or minimise the effect of radioactive sources or radiologically contaminated land, as detailed in the waste and materials management strategy section of the Wylfa Newydd Code of Construction Practice (Application Reference Number: 8.6). Compliance with the Wylfa

Newydd Code of Construction Practice would be secured through a DCO requirement.

14.4.8 Control of radioactive sources is achieved through a combination of stringent management arrangements and supervision of the use of the sources to ensure all the requirements of the Ionising Radiations Regulations 2017 are met. Horizon would ensure it understands at all times what sources are on the Power Station Site and where they are being used. When sources are not in use, they would be kept in secure source stores to prevent loss or damage. Contingency plans for foreseeable incidents would be in place and the response to these plans would be rehearsed. It should be noted that radiography sources are commonly and safely used at major construction sites, and Horizon would adopt good practice with regard to managing these sources of radioactivity.

14.4.9 There is a potential for radiological land contamination to be discovered during construction. Horizon has assessed the construction area through a comprehensive sampling programme to determine the radiological conditions. Horizon has also worked closely with the operators of the Existing Power Station to gather current and historical environmental monitoring data. All information gained to date indicates that there is no radiological land contamination in the construction area [RD29].

14.4.10 Although risks are currently believed to be low, Horizon would adopt a precautionary approach to radiation and environmental protection. Horizon has carried out an assessment process to identify areas of potential risk. Prior to work in the identified areas, additional sampling and monitoring may be carried out. During work in these areas, radiation protection experts would be available with radiological monitoring equipment to provide reassurance monitoring.

14.4.11 Should radioactively contaminated land or radioactive items be discovered, Horizon would have arrangements in place to make the area safe, protect the workforce, prevent the spread of radioactive contamination and manage the radioactive material in consultation with the regulators. Horizon would utilise Radioactive Waste Advisors and other trained staff to implement these arrangements.

14.4.12 Radiological conditions will remain under constant assessment by Horizon’s Radiation Protection Advisors (appointed in compliance with the Ionising Radiations Regulations 2017) to ensure control at all times.

Operation

14.4.13 This section describes features of the design relevant to the assessment of radiological effects during operation. These are as follows:

- the design and assumed heights associated with the main reactor stacks;
- the radioactive discharge inventories for routine releases from the stacks and to the marine outfall;

- the site layout of the turbine buildings and radioactive waste stores and inventories (to inform the direct external dose assessment); and
- the number of vehicle journeys required for transport of radioactive materials to and from the Power Station Site.

Basis of assessment and assumptions

Design of the reactor stacks

14.4.14 A stack height sensitivity study has been performed using Atmospheric Dispersion Modelling Software (ADMS) to determine the optimum height of the reactor stacks based on the dispersion of gaseous radioactive discharges [RD33].

14.4.15 This study predicted the deposition rates and ground level activity concentrations for a range of stack heights between 50m and 100m, and demonstrated that benefits diminished above a stack height of 75m, in terms of dispersion.

14.4.16 This study provided an input in to the Best Available Techniques (BAT) assessment for the reactor stack height, the output of which was that the optimum reactor stack height for the Power Station is 75m [RD33].

14.4.17 However, it is recognised that there are differences between ADMS 5 and the radiological impact assessment software PC-CREAM 08®, in that ADMS takes into account plume rise, building wake and local topography in the dispersion calculations whereas PC-CREAM 08® does not. As a result, the use of a 75m stack height within PC-CREAM 08® for the near-field assessment would potentially result in an under-prediction of concentrations close to the release point.

14.4.18 The atmospheric dispersion model employed within PC-CREAM 08® is based on a Gaussian plume model [RD34]. Gaussian plume models calculate downwind concentrations resulting from advection and dispersion processes on an unobstructed ideal flat plane. To include the effects of plume rise, terrain and building entrainment in these calculations, the concept of “effective stack height” was introduced, which represents the theoretical height of the stack under study that would result in the observed downwind dispersion curves taking into account all of the aforementioned factors.

14.4.19 When calculations of concentrations resulting from a release from the stack are undertaken within PC-CREAM 08®, the effective release height is used as a model input parameter, rather than the actual physical height of the stack.

14.4.20 Effective stack heights have been derived in a number of ways: by use of wind tunnel models, by the use of actual release experiments and by derivation from the results obtained using more complex dispersion models (such as ADMS). To assist users of the standard R91 model [RD34], the UK working group on atmospheric dispersion provided guidance on the derivation of effective stack heights for a site [RD35]. This states that, for a site where entrainment may be an issue, the effective height can be approximated as one-third of the height of the tallest building at the site.

14.4.21 The radiological effects assessment was carried out on the basis of a reactor building height of 45m. One-third of the building height is therefore 15m, and this has been set as the effective discharge height. This value provides a high level of conservatism for the assessment, such that the calculated doses can be considered as conservative. The maximum parameter height for a reactor building (see chapter D1, Application Reference Number: 6.4.1) is 49m. The increase in reactor building height to the maximum of 49m allowed by the parameters would not affect the outcome of this assessment of radiological effects, which as stated above has been carried out on the basis of a reactor building height of 49m.

Discharges

14.4.22 Routine discharge estimates during normal operation have been developed during plant design. Site-specific routine discharges for the Power Station have been estimated as part of the EP-RSR application process.

14.4.23 The methods for deriving the proposed site-specific annual gaseous and aqueous emission limits are detailed in the EP-RSR application [RD2]. The resulting gaseous and aqueous discharge data have been used for the dose assessments and are provided in table D14-15 and table D14-16. These are the proposed discharge limits; operational discharge levels would be lower than these.

14.4.24 Gaseous discharges are the given for each stack (stack 1 includes discharges from the radioactive waste building). The aqueous discharges are mixed with the cooling water outflow.

Table D14-15 Annual gaseous radioactive discharges used in the dose assessment

Radionuclide	Stack 1 (Bq/y)	Stack 2 (Bq/y)
Ag-110m	4.6E+01	3.4E+01
Am-241	7.1E-04	5.6E-04
Ar-41	5.2E+12	5.2E+12
Ba-140	3.6E+04	3.5E+04
C-14	1.7E+12	1.7E+12
Ce-141	4.9E+04	4.8E+04
Ce-144	4.7E+04	4.5E+04
Cm-242	5.4E-01	4.7E-01
Cm-243	5.6E-05	4.4E-05
Cm-244	7.0E-03	5.6E-03
Co-58	1.6E+05	1.4E+05
Co-60	1.8E+05	1.3E+05

Radionuclide	Stack 1 (Bq/y)	Stack 2 (Bq/y)
Cr-51	1.4E+05	1.2E+05
Cs-134	9.6E+03	9.1E+03
Cs-137	6.0E+03	5.5E+03
Fe-59	2.6E+04	2.2E+04
H-3	1.1E+13	9.5E+12
I-131	4.6E+08	2.0E+08
I-132	1.1E+08	1.0E+08
I-133	9.5E+07	4.9E+07
I-135	5.0E+07	3.5E+07
Kr-85	1.3E+09	1.3E+09
Kr-85m	1.0E+10	1.0E+10
Kr-87	9.8E+03	9.8E+03
Kr-88	9.3E+08	9.3E+08
Kr-89	0.0+00	0.0E+00
La-140	4.1E+04	4.1E+04
Mn-54	1.0E+05	7.9E+04
Nb-95	1.2E+05	1.1E+05
Pu-238	1.0E-02	8.1E-03
Pu-239	1.3E-03	1.1E-03
Pu-240	2.1E-03	1.7E-03
Sb-122	4.8E+02	4.8E+02
Sb-124	4.8E+04	4.8E+04
Sb-125	1.0E+04	1.0E+04
Sr-89	4.1E+04	4.0E+04
Sr-90	2.7E+03	2.5E+03
Tc-99	2.7E+00	0.0E+00
Xe-131m	2.9E+09	2.9E+09
Xe-133	2.0E+11	2.0E+11
Xe-133m	1.8E+07	1.8E+07
Xe-135	6.6E-11	6.6E-11
Xe-135m	0.0+00	0.0+00
Xe-137	0.0+00	0.0+00
Xe-138	0.0+00	0.0+00

Radionuclide	Stack 1 (Bq/y)	Stack 2 (Bq/y)
Zn-65	4.5E+04	3.6E+04
Zr-95	5.3E+04	5.1E+04

Table D14-16 Annual aqueous radioactive discharges used in the dose assessment

Radionuclide	Bq/y	Radionuclide	Bq/y
Ag-110m	9.4E+00	I-134	0.0E+00
Am-241	8.9E-02	I-135	0.0E+00
Ba-140	1.2E+04	La-140	1.4E+04
C-14	0.0E+00	Mn-54	3.7E+05
Ce-141	4.8E+04	Nb-95	1.9E+05
Ce-144	2.2E+05	Ni-63	7.2E+05
Cm-242	2.0E+00	Pu-238	2.9E+00
Cm-243	4.2E-03	Pu-239	4.7E-01
Cm-244	3.9E-01	Pu-240	7.4E-01
Co-58	1.2E+05	Ru-103	2.8E+04
Co-60	8.6E+05	Ru-106	1.8E+04
Cr-51	7.2E+04	Sb-122	1.4E+02
Cs-134	1.2E+04	Sb-124	4.7E+04
Cs-137	1.3E+04	Sb-125	6.9E+04
Fe-55	8.0E+06	Sr-89	1.7E+04
Fe-59	2.1E+04	Sr-90	8.5E+03
H-3	1.5E+12	Tc-99	0.0E+00
I-131	1.2E+05	Te-123m	5.3E+01
I-132	0.0E+00	Zn-65	1.3E+05
I-133	0.0E+00	Zr-95	8.3E+04

Design of radioactive waste stores relevant to direct radiation dose assessments

14.4.25 A general description of the radioactive waste facilities at the Power Station Site is described in appendix D14-1 (Application Reference Number: 6.4.97).

14.4.26 Normal nuclear safety design considerations would optimise the amount of shielding required for operational purposes and which reduces the off-site external radiation dose. The requirements of the EP-RSR Permit would require the utilisation of BAT to reduce the impact on the public and environment.

14.4.27 The main plant components within the Power Station Site would be in the twin Units, which includes two reactor buildings, two turbine buildings, two control buildings and a shared services building.

14.4.28 Some of the Cooling Water System elements are common to both Units (namely the Cooling Water System intake, pumping plant, seal pit, discharge tunnel and outfall, and the reserve ultimate heat sink). An indicative layout of the Power Station Site, identifying the positions of the turbine buildings and the position of the spent fuel storage facility, is shown in figure D14-2 (Application Reference Number: 6.4.101).

14.4.29 The present design intent is to have a maximum of 301 spent fuel casks in the spent fuel storage facility at 60 years of operation. Each cask is assumed to contain up to 68 spent fuel assemblies stored dry, and a total of 19,200 spent fuel assemblies are assumed to be generated over the 60-year operational lifetime of the Power Station.

14.4.30 Twenty-two casks would be stored in the dry High Level Waste decay storage facility at the end of the Power Station’s operational life, each assumed to contain 50 control rods.

Design assumptions relevant to transport dose assessments

14.4.31 The radioactive material consignments considered are:

- new fuel;
- neutron sources;
- Low Level Waste (LLW);
- ILW; and
- spent fuel.

Vehicle movement assumptions – new fuel

14.4.32 The largest shipment of new fuel would occur prior to first start-up of the reactors. Each UK Advanced Boiling Water Reactor (UK ABWR) would have a maximum fuel capacity of 872 fuel assemblies, giving a total of 1,744 assemblies across both Units [RD36]. This translates to approximately 44 heavy goods vehicles (HGVs) delivering new fuel to the Power Station Site over the initial fuelling period with a capacity of 40 fuel assemblies per HGV.

14.4.33 Each Unit would require a re-fuelling outage every 18 months. Approximately 12 HGVs per Unit would be required over each outage (see chapter D1, Application Reference Number: 6.4.1).

14.4.34 Fuel is transported in packages, containing two assemblies per package and hence 20 packages per HGV. Manufacturers’ data (pers. comm) for boiling water reactor fuel packages, suggest they have a Transport Index (TI) of 0.2 to 0.5, which equates to a dose rate of 5µSv/hr at 1m from the outside of the package. The higher TI value (0.5) has been used in this assessment.

14.4.35 Paragraph 524 in the IAEA transport regulations [RD37] states that the TI of each conveyance can be determined as the sum of the TIs of all the packages contained within. Therefore, the TI of each HGV can be calculated as 10, with a dose rate of 100µSv/hr at 1m from the outer surface of the conveyance.

Vehicle movement assumptions – neutron sources

14.4.36 Neutron sources are required for reactor start-up and other sources are used for the calibration and monitoring of various fuel route systems and processes. There is no firm strategy for the purchase and management of these items, so a bounding assumption of one delivery per outage (every 18 months) per Unit for transporting these materials onto site is used (included within the new fuel outage totals). As the origin of the source is unknown, it would be assumed that the source would make the final leg of its journey to the Power Station Site via the M6, A55 and A5025, as the most direct route.

14.4.37 A Generic Design Assessment topic report [RD38] details the gamma and neutron dose rates, at 0.5m from the surface of the source shipping container, as 240µSv/hr and 40µSv/hr respectively.

Vehicle movement assumptions - Low Level Waste

14.4.38 It is anticipated that there would be 14 third-height ISO containers (THISO) of cement-encapsulated, wet solid LLW disposed of per year (see appendix D14-1, Application Reference Number: 6.4.97). The destination for this would be the Low Level Waste Repository (LLWR) near Drigg, Cumbria; therefore, the route for these shipments would be via the A5025, A55 and M6.

14.4.39 There are also anticipated to be nine half-height ISO containers (HHISO) and six full-height ISO containers (FHISO) of dry solid LLW and Very Low Level Waste (VLLW) disposed of per year, with different destinations depending on disposal route. Estimates of LLW and VLLW transports are very conservative at this stage of design development. None of the disposal routes are expected to be local to the Power Station Site, so all transports would initially follow the same route as the wet LLW, with the final leg of the journey along the M6 being dependent on the destination, as detailed below.

- 6 x FHISOs for compaction prior to disposal – provider yet to be selected.
- 5 x HHISOs for incineration – multiple locations in the south of England.
- 1 x HHISO for metal recycling – Lillyhall, Cumbria or Tradebe Inutec, Winfrith, Dorset.
- 1 x HHISO of VLLW – multiple landfill locations in the east and north of England.
- 2 x HHISOs for direct disposal – LLWR, Cumbria.

14.4.40 The dose rates for LLW containers and VLLW containers are assumed to be the maximum allowable, according to LLWR guidelines [RD39]; [RD40].

Vehicle movement assumptions – Intermediate Level Waste

14.4.41 Current estimates of amounts of ILW produced in both operations and decommissioning phases is available from the Generic Design Assessment disposability assessment [RD41]. Operational wastes are broken down into "crud" and resins, control rods and operational metals. Decommissioning ILW wastes principally comprise the reactor pressure vessel (RPV) and RPV internal components.

14.4.42 The number of "Cruds and resins" packages generated over the Power Station's lifetime would be 531. The peak dose rate at 1m from the package surface is estimated as 9µSv/hr.

14.4.43 The number of "control rods and mixed metal" packages generated over the Power Station's lifetime would be 21. The peak dose rate at 1m from the package surface is assumed to be 100µSv/hr.

14.4.44 The number of "RPV and RPV internals" packages generated over the Power Station lifetime would be 165. The peak dose rate at 1m from the package surface is estimated to be 12µSv/hr.

14.4.45 It has been assumed that it would take five years for disposal of these ILW materials to the Geological Disposal Facility (GDF), though this would be subject to variation by the national disposal strategy to be developed once the GDF becomes available.

Vehicle movement assumptions – spent nuclear fuel

14.4.46 Spent fuel would be discharged from the reactors every 18 months and placed into a spent fuel pool. It would be stored in the pool for a period of 10 years, to allow the decay heat to reduce to acceptable levels, after which time it is intended to remove the spent fuel to the spent fuel storage facility.

14.4.47 Final disposal of the spent fuel would be to the national GDF. Horizon's strategy is to store the spent fuel until the GDF is made available.

14.4.48 Due to uncertainty in the timings associated with the availability of a GDF, the Power Station Site would have the capability to store spent fuel and ILW for an extended period within facilities such as the spent fuel storage and ILW storage facilities. The storage facilities would be sufficient to accommodate arisings from a 60-year operational lifespan, until a GDF is available.

14.4.49 Once the GDF becomes available, it is assumed transport of spent fuel for storage at the GDF would commence, based on GDF acceptance criteria. Typical spent fuel transport practices for existing UK reactors are one to two fuel flasks per week [RD12]. For the assessment, a despatch rate of 100 flasks per year is assumed.

14.4.50 Dose rates from spent fuel flasks are taken from the Generic Design Assessment disposability assessment [RD41].

14.4.51 Table D14-17 presents the estimated frequency of radioactive packages transported to and from the Power Station Site. These transports would occur at different phases of the Power Station's lifetime.

14.4.52 Prior to start-up, there would be a relatively large number of fuel transports as each Unit is fuelled to capacity. During the operational phase, relative low numbers of transports occur, carrying new fuel for outage fuel replacement, and low number of LLW and VLLW operational radioactive wastes. The relatively large numbers of ILW and spent fuel transports would only occur after the GDF becomes available, and the spent fuel and ILW storage facilities are decommissioned. The annual rate of transports would be dependent on the planned operational timescale for the overall management of UK ILW and spent fuel disposals at the GDF.

Table D14-17 Radioactive packages consigned annually to and from the Power Station

Package contents	Package description	Packages per year
New fuel (start-up)	HGV	44
New fuel (outage)	HGV	16
Wet solid LLW	THISO	14
Incineration LLW	HHISO	5
Metal for recycling	HHISO	1
VLLW	HHISO	1
LLW for LLWR	HHISO	2
LLW for compaction	FHISO	6
ILW packages	ILW transport package	144
Spent fuel	Fuel flask	100

Dose from start-up fuel would only apply during the initial fuelling period.
Outages occur every 18 months, so deliveries are averaged per year – i.e. 24 HGVs every 18 months equates to 16 per year.

14.4.53 Table D14-18 shows the typical dose rates associated with the various containers and conveyances that would be used to transport radioactive material to and from the Power Station Site.

Table D14-18 Dose rates for consignments for the Power Station

Packages	Contents	Typical dose rate at 1m (µSv/hr)
New fuel delivery	New fuel assemblies	100
14 HHISO and FHISO	LLW for incineration, metal for recycling, dry solid LLW for direct disposal	400
14 THISO	Wet solid encapsulated LLW for direct disposal	400
1 HHISO	VLLW for landfill disposal	2.5
106 ILW packages	ILW crud/resin	9
5 ILW packages	ILW control rod/metals	100
33 ILW packages	ILW RPV/internals	12
100 fuel flasks	Spent fuel	76.6

Embedded mitigation

14.4.54 The key mechanism for minimising discharges and disposals and the resulting impact from release of radioactive material to the environment is through demonstration of the application of BAT to the management of radioactive wastes.

14.4.55 BAT covers more than abatement and other end-of-pipe discharge controls. It applies across the whole lifecycle of the plant from design through procurement, construction, commissioning, operation and decommissioning. BAT also applies to operation and maintenance of relevant plant systems and equipment, and to procedures and management systems that may impact on environmental performance.

14.4.56 Demonstration of the application of BAT is a key requirement of the Environmental Permitting (England and Wales) Regulations 2016, and more details can be found in the EP-RSR application [RD2].

14.4.57 Intrinsic to the application of BAT is the minimisation of waste generation and discharges. This could include:

- minimisation at source;
- recycling and reuse of materials (where practicable);
- partitioning of radionuclides (where practicable) for disposal in a manner which causes the least environmental impact; and
- treatment of discharges whether by filtering, by binding onto compounds such as charcoal adsorption plant or ion-exchange resin, or evaporation.

14.4.58 For aqueous discharges, the application of BAT to the generation and disposal of radioactivity to the marine environment would include the following.

- Minimisation of radioactive discharges at source.
- Partitioning of radionuclides for disposal in a manner which causes the least environmental effect.
- Optimisation of dispersion once discharged (e.g. by timing of releases with tide cycle).
- Treatment of discharges whether by filtering, by binding onto compounds such as ion-exchange resin or evaporation.
- Optimisation of the operational regime of the liquid waste management system to minimise the volume and activity of secondary solid radioactive waste arisings (i.e. filters and resins). Integral to the Power Station design is the re-use and recycling of liquid effluent within the reactors, minimising the generation and subsequent discharge of radioactive waste.
- Abatement of the radioactive content of the waste stream as far as reasonably practicable, concentrating and containing the radioactivity in a solid form.

- Monitoring the aqueous effluent prior to discharge.
- Optimisation of the use of storage systems on-site to maximise potential for decay of radioactivity prior to discharge of the effluent.

14.4.59 For gaseous discharges, the application of BAT to the generation and disposal of radioactivity to air would include the following:

- minimisation of radioactive discharges at source;
- partitioning of radionuclides for disposal in a manner which causes the least environmental effect;
- treatment of discharges whether by filtering or by binding onto compounds such as charcoal adsorption plant;
- abatement of the radioactive content of the waste stream as far as reasonably practicable using carbon delay beds and high efficiency particulate filters;
- monitoring of gaseous wastes prior to discharge; and
- optimisation of dispersion once discharged (e.g. by the design of discharge stacks including optimisation of the stack height and location).

14.4.60 For the generation of solid radioactive wastes, the application of BAT would include the following:

- application of the waste management hierarchy;
- waste management strategies including selection of optimal disposal routes to minimise impact on people and the environment;
- minimisation of accumulated radioactive waste on-site (recognising cases where storage is required for decay purposes), and design of the waste storage systems to:
    - minimise release to the environment in normal operation, fault and accident conditions;
    - prevent the spread of contamination from leakage; and
    - incorporate leak detection and alarm capability for liquid and gaseous residues where appropriate.

Good practice mitigation

14.4.61 The use of robust transport containers to transport radioactive materials and waste, in accordance with the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009, would minimise impacts from transport activities, as outlined in the traffic and transport strategy section of the Wylfa Newydd Code of Operational Practice (Application Reference Number: 8.13). Compliance with the Wylfa Newydd Code of Operational Practice would be secured through a Development Consent Order (DCO) requirement.

Decommissioning

14.4.62 As the Power Station enters the decommissioning phase, there would be an immediate reduction in doses via gaseous pathways, as fission and activation products would no longer be produced since the reactor would have ceased power generation. There would also be a reduction in dose resulting from the removal of the direct radiation pathway due to cessation of reactor activities. As decommissioning progresses, it is anticipated that doses from permitted discharges would be reduced overall, but there may be occasional temporary increases as specific projects are executed. Small direct radiation doses would still result from the shielded waste and spent fuel stores. The doses would progressively reduce during treatment and disposal of radioactive material. Direct radiation doses from material in the spent fuel and ILW storage facilities would remain until the spent fuel is removed to the GDF.

Basis of assessment and assumptions

14.4.63 The assessment of decommissioning activities presented here is based on the conservative assumption that, during the initial phases of decommissioning, discharges would be bounded by, and similar to, operational levels. BAT would be used in the management of discharges from the Power Station Site, though it is recognised that adoption of BAT to the management of some wastes may result in short-term increases in discharges of some radionuclides [RD42].

Embedded mitigation

14.4.64 Embedded mitigation during decommissioning would be identical to that described for the operation of the Power Station. This is because discharges of radioactive waste during decommissioning are also regulated by the Environmental Permitting (England and Wales) Regulations 2016, and so the same requirements for the demonstration of BAT would apply.

Good practice mitigation

14.4.65 The use of robust transport containers to transport radioactive materials and waste, in accordance with the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009, would minimise impacts from transport activities, as outlined in the traffic and transport strategy section of the Wylfa Newydd Code of Operational Practice (Application Reference Number: 8.13). Compliance with the Wylfa Newydd Code of Operational Practice would be secured through a DCO requirement.

14.5 Assessment of effects

14.5.1 This section presents the findings of the assessment of effects associated with the construction, operation and decommissioning of the Power Station Site.

Construction

14.5.2 Exposures from geophysics sources and from discovery of contaminated material are well controlled by good practice mitigation required by the Ionising Radiations Regulations 2017, and are judged to have negligible impact and significance.

14.5.3 Construction activities may remobilise soil for onshore activities, and sediments during marine works. Any radionuclide content associated with this material during these movements has the potential to result in radiological effects via resuspension and inhalation of dust or incorporation into the marine food chain for marine sediments.

14.5.4 It is not anticipated that residual radioactive materials from the Existing Power Station would be encountered in soils and sediments excavated during clearance and excavation activities, beyond those already reported in routine monitoring programmes. A rock and soil sampling survey across the Power Station Site found that there was no evidence of elevated radionuclide concentrations above typical backgrounds for Anglesey and north Wales [RD29] (see section 14.3).

14.5.5 Measurements of radioactivity in marine rock and sediment samples taken from the proposed location of the Marine Off-Loading Facility show low levels similar to those observed in the routine monitoring programme around the Existing Power Station (see section 14.3).

14.5.6 The levels of anthropogenic radioactivity in soils and sediments are similar to levels measured across the region as a whole. There is no risk of enhanced exposures above those seen at other construction sites in the area. Construction activities would not lead to redistribution of this material, since the radioactivity levels in the region are relatively homogenous.

14.5.7 The Existing Power Station is designed to minimise the potential for ground contamination. The desk study of potential contamination on the Existing Power Station site (quoted in [RD29]) identified no sources of radioactive ground contamination. It was concluded that the migration of water or liquid contamination on that site would be relatively slow both laterally and vertically within the unsaturated zone (i.e. above the water table), such that, if contamination was present, then it would be likely to remain close to the source. It was stated that contamination which reached groundwater would migrate very slowly towards the coast. Significant contamination migration onto the Power Station Site via groundwater is therefore unlikely.

14.5.8 The only measurements of anthropogenic activity in soil and sediment above Limits of Detection are of caesium-137 and americium-241. Measured concentrations of americium-241 and caesium-137 in recent soil and sediment samples from the construction areas range from 1–7Bq/kg.

14.5.9 The maximum caesium-137 concentration recorded was 6.43Bq/kg, which is substantially below the out of scope radioactive material definition for caesium-137 from the Environmental Permitting (England and Wales) Regulations 2016 of 1000Bq/kg, as well as being below the IAEA clearance and exemption value of 100Bq/kg [RD32].

14.5.10 These levels are below those identified as representing "no danger" on the basis of guidance [RD43]. Exposures to concentrations at these levels result in assessed doses to operators and the public of 10µSv/y or less and risk levels of less than one in a million.

14.5.11 On the basis of the above, it is assessed that doses to construction workers are less than 1µSv/y and therefore as having negligible impact and significance.

14.5.12 The disposal of marine sediments would require an assessment as part of the disposal licensing process. However, the material is taken from the local environment which is already subject to an extensive monitoring programme (see paragraph 14.3.19 onwards in section 14.3), and resulting doses are likely to be bounded by the results from those surveys. In addition, the concentrations are shown to be below out of scope radioactive definition levels. Thus, the disposal of such low radioactivity concentrations can also be assessed as having negligible impact and significance.

Operation

14.5.13 The computer models described in section 14.4 of chapter B14 (Application Reference Number: 6.2.14) were configured with the input parameters described in section 14.2. The environmental radioactivity concentrations at the three non-human species receptor locations were calculated and were used as inputs to the non-human species models.

14.5.14 Doses from exposure to radioactive discharges are assessed assuming all discharges are considered to be planned, continuous and routine, continuing over the operational lifetime of the Power Station.

14.5.15 Detailed model results to the most exposed members of the public and CRPs in each age group are presented in the EP-RSR submission document [RD2].

14.5.16 Doses from the transport of nuclear materials to and from the Power Station Site are calculated at the location with the highest potential exposure: the Valley crossroads. Assuming that each transported package spends one minute stopped at the traffic signals (a typical duration for such a junction), table D14-19 shows the exposure parameters at these locations, and the calculated dose during transport for each package type.

Table D14-19 Annual radioactive material consignments for the Power Station passing Valley crossroads and resulting doses

Package	Location of members of public	Distance between vehicle and member of public	Exposure time per movement (minutes)	Number of movements exposed to per year	Typical dose rate at 1m (µSv/hr)	Annual dose (µSv/y)
Spent fuel	Commercial property	10	1	100	77	1.28
Spent fuel	Petrol	20	1	100	77	0.32

Package	Location of members of public	Distance between vehicle and member of public	Exposure time per movement (minutes)	Number of movements exposed to per year	Typical dose rate at 1m (µSv/hr)	Annual dose (µSv/y)
	station					
Spent fuel	Public house	30	1	100	77	0.14
LLW	Commercial property	10	1	28	400	1.87
LLW	Petrol station	20	1	28	400	0.47
LLW	Public house	30	1	28	400	0.21
VLLW	Commercial property	10	1	1	2.5	4.2E-04
VLLW	Petrol station	20	1	1	2.5	1.0E-04
VLLW	Public house	30	1	1	2.5	4.6E-05
New fuel (start-up)	Commercial property	10	1	44	100	0.73
New fuel (start-up)	Petrol station	20	1	44	100	0.18
New fuel (start-up)	Public house	30	1	44	100	0.08
New fuel (outage)	Commercial property	10	1	16	100	0.27
New fuel (outage)	Petrol station	20	1	16	100	0.07
New fuel (outage)	Public house	30	1	16	100	0.03
ILW Crud/Resin	Commercial property	10	1	107	9	0.16
ILW Crud/Resin	Petrol station	20	1	107	9	0.04
ILW Crud/Resin	Public house	30	1	107	9	0.02
ILW control rod/metal	Commercial property	10	1	5	100	0.08
ILW	Petrol	20	1	5	100	0.02

Package	Location of members of public	Distance between vehicle and member of public	Exposure time per movement (minutes)	Number of movements exposed to per year	Typical dose rate at 1m (µSv/hr)	Annual dose (µSv/y)
control rod/metal	station					
ILW control rod/metal	Public house	30	1	5	100	0.01
ILW RPV	Commercial property	10	1	33	12	0.07
ILW RPV	Petrol station	20	1	33	12	0.02
ILW RPV	Public house	30	1	33	12	0.01

Summary of doses to receptors

14.5.17 The highest doses for the most exposed members of the public via separate pathways and to CRPs are summarised in table D14-20, and these are then assessed using the methodology described in chapter B14 (Application Reference Number: 6.2.14).

Table D14-20 Doses via exposure pathways and to CRPs

CRP or exposure pathway	Dose (µSv/y)	EIA Magnitude
Gaseous discharges CRP – Farming family with contribution from aqueous discharges and external irradiation	37.7 (infant), 20.6 (child), 19.7 (adult)	Small
Aqueous discharges CRP – Fishing family with contribution from gaseous discharges (which dominate the total) and external irradiation	29.1 (infant), 17.0 (child), 16.4 (adult)	Small
Existing Power Station worker	2.66 (adult), including 0.43 external irradiation	Negligible
External irradiation at residential location	0.022 (infant), 0.032 (child), 0.063 (adult)	Negligible
External doses whilst walking at the Power Station Site perimeter	1.78 (Walker 1), 0.004 (Walker 2), 0.008 (Walker 3) (for Walker 1, 90% of the dose	Negligible

CRP or exposure pathway	Dose (µSv/y)	EIA Magnitude
	is due to exposure from the spent fuel storage facility)	
External doses from transport (commercial property) – initial fuel loading	0.73	Negligible
External doses from transport (commercial property) – operations	2.1 (LLW + VLLW + outage refuelling)	Negligible
External doses from transport (commercial property) – ILW disposals	0.31	Negligible
External doses from transport (commercial property) – Spent fuel disposals	1.28	Negligible

14.5.18 Doses from gaseous discharges give the highest contribution to the most exposed members of the public, and the selected Representative Person is for the infant of the farming family who also have exposure to aqueous discharges via their consumption of local seafood and coast occupancy. The major radionuclide contribution to gaseous doses is from carbon-14 and for aqueous discharges is from cobalt-60 and tritium.

14.5.19 Only the most exposed members of the public and CRPs receiving doses resulting from gaseous discharges are judged to have greater than negligible magnitude. It should be noted that the selection of a conservative effective release height as described in section 14.4 would have a large impact on the dose arising from gaseous discharges. The selection of a release height based upon a more detailed analysis of stack dispersion performance is likely to result in a much-reduced estimate of doses to the Representative Person from gaseous discharges.

14.5.20 Doses to Existing Power Station workers on the Existing Power Station site are 2.23µSv/y from gaseous discharge pathways and 0.43µSv/y from external irradiation.

14.5.21 For the external irradiation pathways, the most exposed member of the public who is likely to receive the highest annual dose due to walking in the vicinity of the Power Station Site is 'Walker 1', who incurs an annual dose of 1.78µSv/y (of which 90% is attributable to the spent fuel and ILW storage facilities). The highest external dose at a residential location is 0.063µSv/y for an adult.

14.5.22 The most exposed members of the public likely to receive the highest dose due to the transport of radioactive material to and from the Power Station are located inside the commercial building closest to the Valley crossroads (see table D14-19). It is assumed that such a person is the owner or a worker at this location and would be present for all transports. The member of the public in this location is assumed to receive a total annual dose of 2.1µSv during operational transports to and from the Power Station Site. During the initial fuelling period of the reactors, the member of the public at this location would receive 0.73µSv due to new fuel transports. Annual doses from ILW and spent fuel disposals are 0.31µSv and 1.28µSv respectively, although these doses would only be occurred once the GDF is available.

Uncertainty in assessment

14.5.23 Guidance [RD3] indicates that a semi-quantitative evaluation of uncertainty and variability should be performed, such that:

"…an appropriate level of caution has been applied to the assessment. The review [of uncertainty and variability] will ensure that sufficient caution has been retained such that the dose limit is unlikely to be exceeded on the basis of a retrospective assessment…but balancing this against ensuring that there has not been an undue level of caution applied in the assessment".

14.5.24 Undertaking any assessment of prospective doses necessarily involves the application of models and the making of assumptions regarding future transfers, activities and human behaviour. As a result, varying degrees of uncertainty are present in the assessments presented in this report. The key uncertainties in the assessment process are as follows:

- the estimate of the radioactive discharge to the environment;
- the dispersion of radioactivity following aqueous and gaseous discharges to the environment;
- the transfer of radioactivity in the environment;
- assumed habits; and
- dose coefficients for the inhalation or ingestion of radioactive species.

14.5.25 Uncertainty and sensitivity analyses related to these topics are reported within the EP-RSR application [RD2]. It is concluded that the uncertainties present do not have a significant impact on the magnitude of the radiological effects presented here.

Summary of doses to most affected non-human species in each habitat type

14.5.26 The maximum assessed doses to non-human species in all three habitat types are listed in table D14-21. The table shows the species in which the maximum dose in each habitat is observed. The terrestrial assessment includes results from the ERICA assessment, and results from the R&D128 assessment (see chapter B14, Application Reference Number: 6.2.14) are presented to account for the noble gas component. All magnitudes are assessed as negligible as they are below the ERICA screening level of 10µGy/hr. This is lower than the statutory screening level of 40µGy/hr.

Table D14-21 Peak dose rates in all habitats types

Habitat / Organism	ERICA results (μGy/hr)	R&D128 results (μGy/hr)	Total dose rate per organism (μGy/hr)
Terrestrial			
All mammals, reptiles, birds	6.17E-01	2.76E-04	6.17E-01
Marine			
Mammals	5.01E-05	-	5.01E-05
Freshwater			
Insect larvae	3.90E-02	-	3.90E-02

Summary of effects from operational activities

14.5.27 The assessment of radiological effects due to operational activities is summarised in table D14-25. Only effects relating to the Representative Person for gaseous and aqueous discharges have an impact magnitude of 'small', with all other magnitudes assessed as negligible. As described in chapter B14 (Application Reference Number: 6.2.14), small magnitude impacts are judged to be of negligible significance (see table B14-11 in chapter B14, Application Reference Number: 6.2.14), as doses are well below regulatory limits.

14.5.28 There is an extensive body of knowledge on the operation of nuclear plants, likely radioactive discharges and their environmental effects. There are uncertainties associated with model assumptions and input parameters. The dose assessment for the EP-RSR application is based on realistic but conservative assumptions, and the resulting assessment meets regulatory constraint levels. The doses are at the lower end of the magnitude of impact criteria (see table B14-11 in chapter B14, Application Reference Number: 6.2.14), and as such, the certainty attached to this assessment of effects is judged to be high.

14.5.29 In addition, there is an ongoing requirement as part of EP-RSR to review continuously the application of BAT to minimise the production of waste, discharges and the impact on the environment and the public.

Decommissioning

14.5.30 The decommissioning of nuclear power plants is covered by specific regulation, the Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999, for which a separate environmental statement would be produced to support an application for decommissioning consent.

14.5.31 A qualitative assessment of decommissioning activities is based on the conservative assumption that, during the initial phases of decommissioning, discharges would be similar to operational levels. It is judged that doses to the public arising from these discharges would be bounded by those during operations and are assumed to be identical to those described in table D14-20.

14.5.32 Doses from transport of spent fuel and other wastes are included within the assessment described in sections 14.2 and 14.4. Thus the doses presented in table D14-20 can be used to estimate doses during the decommissioning phase, as contributions from transport of spent fuel and ILW for final disposal at the GDF are also detailed.

Transboundary effects

14.5.33 As noted in the *National Policy Statement for Nuclear Power Generation (EN-6)* [RD1] (para 1.74), "*Due to the robustness of the regulatory regime there is a very low probability of an unintended release of radiation, and routine radioactive discharges will be within legally authorised limits. Significant trans-boundary effects arising from the construction of new nuclear power stations are not considered likely.*" Authorised discharge limits for the Power Station to be set under Schedule 23 of the Environmental Permitting (England and Wales) Regulations 2016 would be set such that the resulting doses to the local population would be below legal dose constraints.

14.5.34 In terms of radiological effects from routine releases (table D14-20 and table D14-21), it can be seen there would be no significant effects resulting from discharges of radioactive waste from the Power Station. As these effects are assessed for receptors to Representative Persons and habitats in the immediate vicinity of the Power Station, it can be assumed that they are bounding, and that equivalent receptors in neighbouring countries would incur much lower doses due to the exponential decreases in radioactivity concentrations seen with distance from release.

14.5.35 It follows there would be no significant transboundary radiological effects from routine releases.

Collective dose results

14.5.36 Collective doses also present an indication of UK national and transboundary doses to European and world populations. Following the methodology described in section 14.2 of chapter B14 (Application Reference Number: 6.2.14), the following results have been calculated for this assessment.

14.5.37 Table D14-22 summarises the collective dose per year of discharge to UK, EU12, EU25 and world populations due to gaseous discharges truncated to 500 years.

Table D14-22 Collective dose per year of discharge due to gaseous discharges

Population	First pass (manSv)	Global circulation (manSv)	Total (manSv)	Average individual dose (Sv)
UK	1.95E-01	3.63E-01	5.58E-01	9.36E-09

Population	First pass (manSv)	Global circulation (manSv)	Total (manSv)	Average individual dose (Sv)
EU	9.63E-01	-	-	-
EU12	-	2.19E+00	3.15E+00	8.75E-09
EU25	-	2.78E+00	3.74E+00	8.20E-09
World	-	6.09E+01	6.09E+01	6.09E-09

14.5.38 UK first pass collective doses (see paragraph 14.2.46) due to gaseous discharges are primarily associated with ingestion of root vegetables (23%) and cow's milk (49%). EU first pass collective doses show a similar distribution, with consumption of root vegetables (24%) and cow's milk products (50%) being the dominant pathways. For both first pass and global circulation, the principal radionuclide was carbon-14, which contributed 94% to UK first pass, 97% to EU first pass and 100% to global circulation doses.

14.5.39 Table D14-23 summarises the collective dose per year of discharge to UK, EU12 and world populations due to aqueous discharges truncated to 500 years.

14.5.40 The first pass collective dose due to aqueous discharges was estimated by summation of fish, crustacean, mollusc and beach sediment gamma contributions.

Table D14-23 Collective dose per year due to aqueous discharges

Population	First pass (manSv)	Global circulation (manSv)	Total (manSv)	Average individual dose (nSv)
UK	4.99E-07	3.03E-07	8.02E-07	1.35E-05
EU12	1.30E-06	1.83E-06	3.12E-06	8.66E-06
World	1.92E-06	5.07E-05	5.26E-05	5.26E-06

14.5.41 The consumption of marine foodstuffs contributes 62% to the UK collective dose, 42% to the EU12 collective dose and only 4% to the world collective dose. For UK, EU12 and the world the contribution from beach sediment is zero.

14.5.42 First pass doses are the most significant for the UK population (62% compared to 38% for global circulation). The EU12 collective dose is more evenly split between first pass and global circulation (42% and 58% respectively), with world collective doses being dominated by global circulation (4% first pass and 96% global circulation). The dominant radionuclide is tritium for UK (84%), EU12 (89%) and the world (99%).

14.5.43 Average individual doses from aqueous discharges from the Power Station are 1.35E-05, 8.66E-06 and 5.26E-06nSv/y for populations of the UK, Europe (assumed to be EU12) and the world, respectively.

14.5.44 Average individual doses from atmospheric discharges from the Power Station are equal to 9.4E-09, 8.8E-09, 8.2E-09 and 6.1E-09Sv/y for populations of the UK, EU12, EU25 and the world respectively.

14.5.45 The IAEA states that discharges giving rise to calculated average annual individual doses for a population group in the nanosievert per year range or below should be ignored in the decision-making process as the associated risks are minuscule [RD32]. The risks presented by the average individual doses presented in this section are therefore of negligible significance.

14.5.46 Within the EU, every time a Member State plans to alter the way it disposes of radioactive waste or proposes a new facility that may increase emissions, it must make a submission to the European Commission as part of the Euratom Treaty, known as an Article 37 submission. This submission must include enough data to determine whether such plans are liable to result in the radioactive contamination of the water, soil or airspace of another Member State. This requires a full assessment of the effects at these locations of gaseous and aqueous discharges and solid waste disposals of radioactive waste from the Wylfa Newydd Project. The Article 37 assessment includes the effects from routine operations and a consideration of potential accident scenarios (also see appendix D14-2, Application Reference Number: 6.4.98).

Treatment of cumulative effects

14.5.47 The methodology for treatment of cumulative effects is described in chapter I3 (methodology) (Application Reference Number: 6.9.3). However, the assessment of cumulative effects is only undertaken for those effects with residual impacts of minor significance or above.

14.5.48 As can be seen in table D14-25, all residual radiological effects are judged to have negligible significance. However, the cumulative effects are presented here for information, and also as presentation of some of these cumulative impacts was requested during recent consultation exercises.

14.5.49 The only other project that could impact the receptors defined for radiological effects from the Power Station is the decommissioning of the Existing Power Station. The projects are both nuclear licensed sites in close proximity to each other. Both would have permits to discharge radioactive material to air and sea. They would both store radioactive material on-site which would result in direct external doses. They would both require the transport of radioactive material either to or from the two sites. Due to the proximity of the two power stations to receptor locations, it is assumed that all receptors identified in this radiological effects chapter would be affected to some extent by activities during decommissioning of the Existing Power Station.

14.5.50 The human receptors identified in section 14.2 are summarised in table D14-20, which also includes the calculated doses for each receptor from the proposed Power Station operation. Non-human species receptors are assumed to exist at the point of maximum local radioactivity concentration in the relevant medium (terrestrial, freshwater or marine).

14.5.51 As a conservative measure, it is assumed that the Representative Persons for the Existing Power Station are identical to those for the Power Station (and so the cumulative doses are calculated by adding the contributions from the two sites).

14.5.52 To enable the calculation of cumulative effects from both developments, estimates of doses for each pathway are required for activities associated with decommissioning the Existing Power Station. These are then combined with the calculated doses for the Power Station to give a total dose for each exposure pathway and Representative Person. These total doses are then assessed according to the methodology described in chapter B14 (Application Reference Number: 6.2.14).

Doses from authorised discharges

14.5.53 Environmental levels of radioactivity and hence doses to local Representative Persons are a reflection of current and past discharges from the Existing Power Station (as well as including contributions from authorised discharge from facilities further afield). Local levels are reported annually in the RIFE series of reports (see section 14.3). Terrestrial and marine doses to the local Representative Persons range from 5µSv/y to 10µSv/y (with a maximum of 13µSv/y). It is conservatively assumed that a value of 13µSv/y is typical of the dose incurred by each group.

14.5.54 It is assumed that, during the initial phases of decommissioning at the Existing Power Station, aqueous discharges remain similar to current levels. This is because the waste treatment plants continue to operate in a similar fashion to during operations. Gaseous discharges would reduce markedly as the reactor power has reduced and defueling commences. However, in the first instance, it is assumed gaseous and aqueous discharges remain similar to those during operations and result in similar doses to members of the public.

14.5.55 Predicted future discharges during decommissioning of the Existing Power Station are included within assessment prepared for the Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999 [RD44]. Doses to the fishing (0.033µSv/y) and farming families (1.1µSv/y) resulting from these discharges are calculated as part of the combined assessment section in the EP-RSR application for the Power Station [RD2].

Doses from external irradiation

14.5.56 External radiation doses would still result from waste stores at the Existing Power Station. It is assumed that external radiation sources and dose rates from these facilities are similar to those calculated for the proposed Power Station. No detailed assessment is available; however, it is stated that direct radiation would not exceed 20µSv/y [RD44].

14.5.57 For the three walking groups, the assumed locations are all at much further distances from the Existing Power Station, and there is no equivalent group in the assessment for the Existing Power Station.

Doses from transport

14.5.58 Doses from transport of radioactive material from the proposed Power Station are reported in section 14.5 (table D14-20). Doses would also result from transport of radioactive materials from the Existing Power Station. There is unlikely to be a synchronous correspondence between the transport activities at the two sites because of the different development phases of each site. For instance, spent fuel would have been removed from the Existing Power Station before the Power Station commences operations. The transport associated with the removal of ILW wastes from both sites and spent fuel from the Power Station would occur over the same periods, following the availability of the GDF.

14.5.59 VLLW and LLW would be removed from the Existing Power Station during decommissioning, and this would occur at the same time as operational transports occur for the Power Station. However, there is no current information available on amounts of decommissioning wastes likely to arise from the Existing Power Station.

Doses to biota

14.5.60 In the Environmental Permit application [RD2], a simple assessment is made of the impact of discharges from the Existing Power Station on non-human biota in each habitat type. These are reported as follows:

- terrestrial wildlife 1.2µGy/hr;
- marine wildlife 0.59µGy/hr; and
- freshwater wildlife 0.15µGy/hr.

14.5.61 Combining these with the highest species doses in each habitat type from table D14-21, gives the following total doses:

- terrestrial birds, mammals and reptiles 1.82µGy/hr;
- marine mammals 0.59µGy/hr; and
- freshwater insect larvae 0.19µGy/hr.

Summary

14.5.62 The cumulative doses and impacts are assessed for the most exposed receptors affected by operation/decommissioning at the Power Station and decommissioning of the Existing Power Station. The total dose to the farming family Representative Person is calculated based on contributions from gaseous and aqueous discharges, external irradiation and current discharges. The magnitude of the effect is calculated using the methodology presented in chapter B14 (Application Reference Number: 6.2.14). In all cases, all regulatory criteria would be met and disposals and discharges from both projects would be continually reduced by the application of BAT, so the effects are judged to be not significant. The results are summarised in table D14-24.

Table D14-24 Combined doses to exposure groups and cumulative effects

Exposure group	Power Station dose (µSv/y)	Existing Power Station dose (µSv/y)	Total (µSv/y)	EIA magnitude/ significance

Exposure group	Power Station dose (µSv/y)	Existing Power Station dose (µSv/y)	Total (µSv/y)	EIA magnitude/ significance
Most exposed persons – Farming family	37.7 (infant)	1.1	38.8	Small/ negligible
Most exposed persons – Fishing family	6.8E-05 (adult)	0.033	0.033	Negligible/ negligible
External irradiation at residential location	0.063 (adult)	20	>20	Small/ negligible
External doses whilst walking at the Power Station Site perimeter	1.78 (Walker 1)	(no equivalent)	1.78	Negligible/ negligible
External doses from transport (commercial property) – initial fuel loading	0.73	0	0.73	Negligible/ negligible
External doses from transport (commercial property) – operations	2.1 (LLW + VLLW + outage refuelling)	No information available	>2.1	Negligible/ negligible
External doses from transport (commercial property) – ILW disposals	0.31	No information available	>0.31	Negligible/ negligible
External doses from transport (commercial property) – Spent fuel disposals	1.28	0	1.28	Negligible/ negligible
CRP – Farming family with contribution from aqueous discharges and external irradiation	37.8	1.1	71.9 (includes a contribution of 13µSv/y from current discharges and 20µSv/y from	Small/ negligible

Exposure group	Power Station dose (µSv/y)	Existing Power Station dose (µSv/y)	Total (µSv/y)	EIA magnitude/ significance
			external irradiation)	
Doses for the following exposure groups are measured in µGy/hr.				
Terrestrial biota (bird, mammal, reptile)	0.62	1.2	1.82	Negligible/ negligible
Marine biota (mammal)	5.0E-05	0.59	0.59	Negligible/ negligible
Freshwater biota (insect larvae)	0.04	0.15	0.19	Negligible/ negligible

14.6 Additional mitigation

14.6.1 In accordance with chapter B1 (introduction to the assessment process) (Application Reference Number: 6.2.1), embedded and good practice mitigation measures relevant to radiological effects were taken into account when determining the 'pre-mitigation' significance of effects. These are detailed in the design basis and activities section of this chapter.

14.6.2 No potential significant effects have been identified; therefore, no additional mitigation measures have been required.

14.7 Residual effects

14.7.1 Minor effects related to the impact of gaseous discharges on the farming and fishing family CRP were assessed (see table D14-20), which were assessed as being of negligible significance (see paragraph 14.5.27).

14.7.2 No significant adverse radiological effects from routine construction, operation and decommissioning were identified, as shown in table D14-25.

14.7.3 There is an extensive body of knowledge on the operation of nuclear plants, likely radioactive discharges and their environmental effects. There are uncertainties associated with model assumptions and input parameters. The dose assessment for the EP-RSR application is based on realistic but conservative assumptions, and the resulting assessment meets regulatory constraint levels. The doses are at the lower end of the magnitude of impact criteria (see table B14-11 in chapter B14, Application Reference Number: 6.2.14), and as such, the certainty attached to this assessment of effects is judged to be high.

14.7.4 In addition, there is an ongoing requirement as part of EP-RSR to review continuously the application of BAT, including a commitment to achieve future incremental reductions in discharges where potential improvements are identified.

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Table D14-25 Summary of residual effects

Receptor (or group of receptors)	Value of receptor(s)	Description of potential effect	Nature of effect	Potential magnitude of change	Potential significance of effect	Additional mitigation	Post-mitigation magnitude of change	Significance of residual effect
Construction								
Construction worker	High	Doses to workers on the Power Station construction sites from potential radioactive contamination in soils and sediments	Adverse Local Short-term	Negligible	Negligible	N/A	Negligible	Negligible
Operation								
Gaseous discharges CRP – farming family with contribution from aqueous discharges and external irradiation	High	Doses to the public from routine gaseous discharges	Adverse Local Long-term	Small	Negligible	N/A	Small	Negligible

Receptor (or group of receptors)	Value of receptor(s)	Description of potential effect	Nature of effect	Potential magnitude of change	Potential significance of effect	Additional mitigation	Post-mitigation magnitude of change	Significance of residual effect
Aqueous discharges CRP – fishing family with contribution from gaseous discharges and external irradiation	High	Doses to the public from routine aqueous discharges	Adverse Local Long - term	Small	Negligible	N/A	Negligible	Negligible
Existing Power Station workers	High	Doses to workers at the Existing Power Station from direct radiation from reactor operations and the generation and storage of solid radioactive wastes at the Power Station	Adverse Local Short-term	Negligible	Negligible	N/A	Negligible	Negligible

Receptor (or group of receptors)	Value of receptor(s)	Description of potential effect	Nature of effect	Potential magnitude of change	Potential significance of effect	Additional mitigation	Post-mitigation magnitude of change	Significance of residual effect
Recreational walkers adjacent to Power Station boundary	High	Doses to the public from direct radiation from reactor operations and the generation and storage of solid radioactive wastes at the Power Station	Adverse Local Short-term	Negligible	Negligible	N/A	Negligible	Negligible
Most exposed residents adjacent to transport routes	High	Direct doses to the public from transport of radioactive materials to and from the Power Station	Adverse Local Short-term	Negligible	Negligible	N/A	Negligible	Negligible

Receptor (or group of receptors)	Value of receptor(s)	Description of potential effect	Nature of effect	Potential magnitude of change	Potential significance of effect	Additional mitigation	Post-mitigation magnitude of change	Significance of residual effect
Non-human species with highest doses in the terrestrial, marine and freshwater environments	High	Doses to non-human species in the terrestrial, marine and freshwater environments close to the Power Station Site	Adverse Regional Long-term	Negligible	Negligible	N/A	Negligible	Negligible
Decommissioning – identical to those for operation								

14.8 References

Table D14-26 Schedule of references

ID	Reference
RD1	Department of Energy and Climate Change. 2011. *National Policy Statement for Nuclear Power Generation (EN-6)*. London: The Stationery Office.
RD2	Horizon. 2017. Wylfa *Newydd Project Radioactive Substances Regulation – Environmental Permit Application*. WN0908-HZCON-PAC-REP-00003.
RD3	Environment Agency. 2012. *Principles for the Assessment of Prospective Public Doses arising from Authorised Discharges of Radioactive Waste*. Bristol: Environment Agency.
RD4	Smith, J.G. and Simmonds, J.R. 2009. *The Methodology for Assessing the Radiological Consequences of Routine Releases of Radionuclides to the Environment Used in PC-CREAM 08®*. HPA-RPD-058. Chilton: Public Health England.
RD5	Environment Agency. 2011. *Parameter Values Used in Coastal Dispersion Modelling for Radiological Assessments*. Report SC060080/R3. Bristol: Environment Agency.
RD6	Centre for Environment and Aquaculture Science. 2005. *Radiological Habits Survey: Wylfa 2004*. Environment Report RL 02/05.
RD7	Centre for Environment and Aquaculture Science. 2010. *Radiological Habits Survey: Wylfa 2009*. Environment Report RL 03/10.
RD8	Centre for Environment and Aquaculture Science. 2014. *Radiological Habits Survey: Wylfa 2013*. Environment Report RL 03/14.
RD9	Health Protection Agency. 2002. *Guidance on the Assessment of Radiation Doses to Members of the Public due to the Operation of Nuclear Installation under Normal Conditions*. HPA-RPD-019.
RD10	Smith, K.R and Jones, A.L. 2003. *Generalised habit data for radiological assessments*. NRPB-W41. Chilton: National Radiological Protection Board.
RD11	Oatway, W.B. *et al*. 2008. *Health Protection Agency Guidance on the application of dose coefficients for the embryo, foetus and breastfed infant in dose assessments for members of the public*. HPA publication RCE-5.
RD12	Watson, S.J., Oatway, W.B., Jones, A.L. and Hughes, J.S. 2005. *Survey into the Radiological Impact of the Normal transport of Radioactive Material in the UK by Road and Rail*. NRPB-W66. Chilton: National Radiological Protection Board.

ID	Reference
RD13	Natural Resources Wales. 2016. *Map of the North Anglesey Marine possible SAC*. [Online] [Accessed: 1 July 2017]. Available from: https://naturalresources.wales/media/675763/north-anglesey-marine-sac-map-final.pdf
RD14	Beresford, N., Brown, J., Copplestone, D., Garnier-Laplace, J., Howard, B., Larsson, C., Oughton, D., Pröhl G. and Zinger, I. 2007. *D-ERICA - An Integrated Approach to the Assessment and Management of Environmental Risks from Ionising Radiation*. Luxembourg: Commission of the European Communities.
RD15	International Atomic Energy Agency. 2001. *Safety Reports Series No.19 Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment*. Vienna: IAEA.
RD16	Countryside Council for Wales (CCW). 2016. *Site of Special Scientific Interest: Citation for Gwynedd/Anglesey Tre'r Gof SSSI*. [Online]. [Accessed: 10 November 2016]. Available from: http://angleseynature.co.uk/webmaps/trergofdesc.htm
RD17	Watson, S.J., Jones, A.L., Oatway, W.B. and Hughes, J.S. 2005. *Ionizing Radiation Exposure of the UK Population: 2005 Review*. RPD-001. Chilton: Public Health England.
RD18	Public Health England. *UK radon*. [Online]. [Accessed: 1 July 2017]. Available from: http://www.ukradon.org/information/ukmaps/
RD19	Horizon. 2015. *Environmental Baseline Report – Radiological Monitoring*. WD03.03.01-S5-PDC-REP-00007, Rev 0.5.
RD20	Centre for Environment, Fisheries and Aquaculture Science. 2010. *Radioactivity in Food and the Environment 2009* RIFE-15.
RD21	Centre for Environment, Fisheries and Aquaculture Science. 2011. *Radioactivity in Food and the Environment 2010* RIFE-16.
RD22	Centre for Environment, Fisheries and Aquaculture Science. 2012. *Radioactivity in Food and the Environment 2011* RIFE-17.
RD23	Centre for Environment, Fisheries and Aquaculture Science. 2013. *Radioactivity in Food and the Environment 2012* RIFE-18.
RD24	Centre for Environment, Fisheries and Aquaculture Science. 2014. *Radioactivity in Food and the Environment 2013* RIFE-19.
RD25	Centre for Environment, Fisheries and Aquaculture Science. 2015. *Radioactivity in Food and the Environment 2014* RIFE-20.
RD26	Centre for Environment, Fisheries and Aquaculture Science. 2016. *Radioactivity in Food and the Environment 2015* RIFE-21.
RD27	Centre for Environment, Fisheries and Aquaculture Science. 2017. *Radioactivity in Food and the Environment 2016* RIFE-22.

ID	Reference
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