Office for Nuclear Regulation

Environment Agency

Cyfoeth Naturiol Cymru Natural Resources Wales

SEPA Scottish Environment Protection Agency Buidheann Dìon Àrainneachd na h-Alba

Use of UK Climate Projections 2018 (UKCP18)

Position Statement

July 2022 – Revision 2

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Office for Nuclear Regulation, Environment Agency, Natural Resources Wales and Scottish Environment Protection Agency

Contents

Revision 2 – July 2022

The 'Use of UK Climate Projections 2018 (UKCP18) Position Statement' has been updated to provide further clarity on the regulators' expectations for the use of UKCP18 and credible maximum scenarios. This position statement has also been aligned with revised regulatory guidance including the joint ONR and Environment Agency 'Principles for Flood and Coastal Erosion Risk Management' [1].

Introduction and Scope

This position statement sets out the expectations of the Office for Nuclear Regulation (ONR), the Environment Agency (EA), Natural Resources Wales (NRW) and the Scottish Environment Protection Agency (SEPA) [referred to hereafter as the regulators] regarding the UK Climate Projections 2018 (UKCP18) and their application in safety submissions or permit applications. The statement provides guidance to dutyholders[1] for nuclear installations when undertaking climate change assessments in support of, for example, planning permission/development consent, environmental permit applications or safety cases.

The Nuclear Installations Act 1965 (NIA65) requires that certain installations, including nuclear reactors and other installations as defined in the Nuclear Installations Regulations 1971 [2], require a nuclear site licence[2] [3]. Therefore, this guidance applies to nuclear power stations and other installations which hold a nuclear site licence. Dutyholders of nuclear installations are also required to hold an environmental permit[3] issued by the relevant environment agency for radioactive substances activities on nuclear licensed sites[4].

Policy across the UK on disposal of higher activity radioactive waste (HAW) may result in changes to the list of nuclear installations requiring a nuclear site licence from ONR. For example, in England, Wales and Northern Ireland the policy documents 'Implementing Geological Disposal – Working with Communities' [4] and 'Geological Disposal of Higher Activity Radioactive Waste: Working with Communities' [5] are explicit that a Geological Disposal Facility (GDF) will be a nuclear installation under NIA65. Therefore, this guidance should be applied to any UK licensed disposal facilities which are jointly regulated by ONR

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1 In this UKCP18 Position Statement, the term 'dutyholder' refers to nuclear site licensees, potential licensees, current and potential environmental permit holders for radioactive waste disposal, applicants for planning consents and Requesting Parties undergoing the Generic Design Assessment process.

2 For further details on nuclear installations, see ONR guidance 'Licensing Nuclear Installations' [3].

3 Facilities for the disposal of solid radioactive wastes permitted or to be permitted under the Environmental Permitting (England and Wales) Regulations 2016 or the Environmental Authorisations (Scotland) Regulations 2018.

4 The scope of radioactive substances activities on a nuclear licensed site varies to that on a non-nuclear licensed site and primarily relate to the receiving (transfer) and disposal of radioactive wastes.

and the relevant environment agency, to demonstrate that their proposals have a high level of climate resilience built-in from the outset.

The relevant environment agency may choose to apply the principles set out in this guidance to sites permitted for the disposal of low-level radioactive waste that are not located on nuclear licensed sites and not subject to the nuclear site licensing regime.

This position statement also provides dutyholders in the nuclear industry with some background on UKCP18, its use in climate change assessments and information on some of the most significant areas of change from the UK Climate Projections 2009 (UKCP09), namely:

- the use of Representative Concentration Pathways (RCPs) instead of the Special Report on Emission Scenarios (SRES) used in UKCP09; and
- provision of projections at a higher spatial and temporal resolution in UKCP18 than has been previously available, for example daily and sub-daily.

The regulators will continue to keep the position on the use of UKCP18 under review, and if appropriate, reconsider this statement in light of any relevant developments in relevant good practice and climate science. Dutyholders should take account of updates to relevant good practice when any new analysis of climate change is undertaken.

What is UKCP18?

UKCP18, released in November 2018, is a set of climate model projections for the UK produced by the UK Meteorological Office (Met Office) and partners [6]. A second set of outputs, the 2.2km local projections, were released in September 2019. They include information on temperature, precipitation, wind, sea level rise and storm surge, snow and weather types [7]. UKCP18 is based on developments in climate science since UKCP09 to provide updated observations and climate change projections out to 2100 in the UK and globally. UKCP18 also provides sea level rise projections up to 2300 using an ‘exploratory’ approach. The impacts of climate change on hazard magnitude and frequency for some natural hazards could be significant over the lifetime of nuclear licensed sites and disposal sites for radioactive waste. The use of UKCP18 is currently considered relevant good practice in determining climate change allowances for relevant natural hazards at existing or proposed sites.

UKCP18 has been produced by the Met Office with expert input from the Environment Agency and funded by the Department for Environment, Food and Rural Affairs (Defra) and the Department for Business, Energy and Industrial Strategy (BEIS). UKCP18 projections have been developed from recent advances in modelling the climate system, and the use of the new Met Office supercomputing facilities has enabled higher resolution climate projections to be produced compared with UKCP09.

Although UKCP18 provides the latest information on our future climate, it does not provide information on impacts. This information will need to be derived, taking into account the UKCP18 projections.

The Regulators' Expectations on the Use of UKCP18

Transitioning to UKCP18

The regulators expect that dutyholders in the nuclear industry will take account of UKCP18 when assessing the impacts of climate change in their safety submissions or permit applications. This includes taking UKCP18 into account at all stages of the facility lifecycle, from design, planning, construction, operation, and through to decommissioning and eventual release from regulation[5]. For existing sites, the implications of UKCP18 for climate change considerations should be considered when any new analysis of climate change is undertaken and, during Periodic Reviews required by Licence Condition 15 [11]. For new build sites, the regulators expect dutyholders to update their safety cases to take UKCP18 into account within a reasonable timeframe and to provide the regulators with a programme of work describing when and how they will do this. The regulators will evaluate this on a case-by-case basis.

The service providing UKCP09 data closed in December 2018. The UKCP09 website remains available in an archived format and the underlying UKCP09 data is available from the Centre for Environmental Data Analysis (CEDA) catalogue. However, there will be no further updates to material on the UKCP09 website [12]. There is no longer access to the UKCP09 helpdesk or User Interface and the associated weather generator that was part of UKCP09 has been shut down (see section below on Extreme Value Analysis).

The Environment Agency's advice on preparing strategic and site-specific flood risk assessments [0] was updated in December 2019 to reflect the UKCP18 sea level rise data. It was updated in July 2020 to incorporate H++ allowances (see section below on Credible Maximum Scenarios) that were previously set out in separate guidance, again in October 2021 to update peak river flow allowances and guidance on their application and again in May 2022 to update peak rainfall allowances and guidance on their application.

In Wales, advice on climate change allowances to be used when preparing flood consequence assessments is set out in Welsh Government guidance [14]. This guidance [14] was updated in September 2021 to reflect the UKCP18 sea level rise data. There has been no change to the guidance [14] for peak river flows or wave climate projections. An update to these allowances will be made following analysis of the impacts of UKCP18. Allowances related to extreme rainfall can be found in the Welsh Government's guidance for flood and coastal erosion risk management [15]. There is currently no requirement at this time to incorporate an allowance for increased storm surge when estimating design flood levels for future scenarios.

[5] Environmental permit holders should ensure that the various forms of environmental safety cases take into account the potential consequences of climate change [8] [9] [10].

In Scotland, guidance on climate change allowances for use in preparing flood risk assessments is produced by the Scottish Environment Protection Agency [16]. These allowances remain the best national representation of how climate change is likely to affect flood risk for peak river flow, peak rainfall intensity and sea level rise. The allowances for sea level rise, peak river flow and rainfall in the March 2022 guidance are based on UKCP18.

ONR's expectations for climate change allowances for nuclear sites are described below and in Appendix 1. More general guidance in relation to climate change is provided in the Safety Assessment Principles [17] and Technical Assessment Guide NS-TAST-GD-013 [18] for external hazards. The 'Principles for Flood and Coastal Erosion Risk Management' [1] also provides guidance on climate change in relation to these hazards.

Representative Concentration Pathways

UKCP18 uses RCPs, which were used in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). These replace the SRES used in UKCP09.

RCPs specify the concentrations of greenhouse gases that will result in the total radiative forcing[6] increasing by a specified amount by 2100, relative to pre-industrial levels [19]. Radiative forcing scenarios for 2100 have been set at 2.6, 4.5, 6.0 and 8.5W/m^2 and these are reflected in the four RCPs; RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 [19]. Each RCP results in a different range of global mean temperature increases until 2100 (Table 1). Each RCP can be met by a combination of different socioeconomic assumptions [19].

In UKCP18, probabilistic projections at 25km spatial resolution over land are available for RCP 2.6, 4.5, 6.0 and 8.5. SRES A1B has been included in the probabilistic projections to enable direct comparison between UKCP09 and UKCP18. Marine and coastal projections are available for RCP 2.6, 4.5 and 8.5 in UKCP18. RCP 6.0 was excluded because it produced very similar global mean sea level rise as RCP 4.5, with less data availability [20].

RCP	Change in temperature (°C) by 2081 - 2100
2.6	1.6 (0.9 - 2.3)
4.5	2.4 (1.7 - 3.2)
6.0	2.8 (2.0 - 3.7)
8.5	4.3 (3.2 - 5.4)

Table 1: The increase in global mean surface temperature averaged over 2081-2100 compared to the pre-industrial period (averaged between 1850 and 1900) for the RCPs (best estimate, 5-95% range). From IPCC AR5 WG1 Table 12.3 [21].

6 Total radiative forcing is the difference between the incoming and outgoing radiation at the top of the atmosphere [19].

As SRES scenarios and RCPs were derived using different methods, it is not possible to directly compare the two. However, there are some similarities between RCPs and SRES scenarios in terms of median global temperature increase by 2100 (Table 2).

RCP	Most similar SRES scenario (in terms of temperature)
2.6	None
4.5	SRES B1 (low emissions scenario in UKCP09)
6.0	SRES B2 (between the low and medium emissions scenarios in UKCP09)
8.5	SRES A1F1 (high emissions scenario in UKCP09)

Table 2: SRES scenarios that are most similar to RCPs, in terms of median global temperature increase by 2100 [19].

Detailed advice from ONR, the Environment Agency, Natural Resources Wales and the Scottish Environment Protection Agency on the use of RCPs, annual exceedance probabilities[7], and sensitivity studies is provided in Appendix 1.

Extreme Value Analysis

Extreme value analysis (EVA) is a branch of statistics that seeks to assess the probability of events that are more extreme than any previously observed. The regulators expect dutyholders to make use of EVA techniques when analysing the impacts of climate change. EVA can be used, for example, to derive the design basis event for natural hazards.

In UKCP09, many dutyholders used the weather generator facility to generate data that could be used to undertake EVA. The weather generator is not included in UKCP18 and is no longer being updated. Dutyholders may still wish to undertake EVA and one way of doing this in UKCP18 could be to use the 2.2km sub-daily data for RCP 8.5 (see section on 2.2km Local Projections below). Whilst the regulators do not prescribe a methodology for EVA, dutyholders should discuss and agree their EVA approach early in the process.

[7] An annual exceedance probability (or annual probability of exceedance) is the probability of an event being exceeded in a given year. Typically, ONR refers to annual frequency of exceedance which is the frequency with which a particular hazard severity is predicted to be exceeded in a given year. For low frequency events (below 0.01 per year), the two terms are numerically equivalent. On this basis, this document uses the terminology annual exceedance probability for consistency.

2.2km Local Projections

In September 2019, the 2.2km local projections were released as part of the UKCP18 suite of projections. The UKCP local (2.2km) projections are a new set of 12 climate projections using a model as detailed as those typically used for weather forecasts. The 2.2km local projections represent an ensemble of climate projections at convection-permitting scale and are sometimes referred to as a 'Convection Permitting Model' (CPM) [1]. The 2.2km local projections provide data on hourly timescales. The 2.2km local projections are considered to better represent small scale behaviour in the atmosphere, such as convection, than the 12km regional projections. The high resolution also better captures the local variability in climate that is particularly significant in mountainous, coastal and urban areas.

Additional analysis of the 2.2km local projections has been undertaken as part of the 'Future Drainage Project' led by Newcastle University [23]. Natural Resources Wales is currently considering the implications of this work. Natural Resources Wales is planning to update the allowances for peak river flow and peak rainfall intensity in 2022. Natural Resources Wales' interim position is that until this work is completed, dutyholders should continue to use its existing guidance for peak river flow [14] and peak rainfall intensity [15]. The Environment Agency updated the allowances for peak rainfall intensity in May 2022 [13]. The Scottish Environment Protection Agency has analysed the outputs of the Future Drainage project and used this to inform the March 2022 update to its guidance [16].

Credible Maximum Scenarios

UK infrastructure planning policy for energy is presented in the 'Overarching National Policy Statement for Energy' (EN-1) [24], with nuclear power addressed in the associated 'National Policy Statement for Nuclear Power Generation' (EN-6) [25]. Both policies highlight the importance of applicants being able to demonstrate that their proposals for an application for a nuclear development/installation have a high level of climate resilience built-in from the outset. Applicants should also be able to demonstrate their proposals can be adapted over their predicted lifetimes to remain resilient to a credible maximum climate change scenario. Further detail on a managed adaptive approach is provided in the following section.

Credible maximum scenarios are peer-reviewed, high end, plausible scenarios of climate change. The current set of credible maximum scenarios are used to assess the impacts of low probability, high impact climate events including heat waves, drought, extreme winds, sea level rise and storm surge. Credible maximum scenarios can also be used for sensitivity testing different adaptation options over time periods appropriate for the nuclear industry.

In line with the guidance in EN-1 [24] and EN-6 [25], dutyholders should identify the potential effects of the credible maximum scenarios in the evaluation of natural hazards affected by climate change. Dutyholders should be able to demonstrate that adaptation of Structures, Systems and Components important to safety would be possible. Guidance on the managed adaptive approach is provided below.

An example of a credible maximum scenario is H++ from UKCP09. This provides allowances for sea level rise, wind speed, wave height and storm surge [26]. H++ is a credible maximum scenario to 2100. For credible maximum scenarios beyond 2100, the approach should be discussed with the relevant regulator(s).

Managed Adaptive Approach

Dutyholders may consider a managed adaptive approach (sometimes referred to as an adaptive approach) to flood and coastal erosion risk management when planning for long term climate change or more extreme climate scenarios [1]. The managed adaptive approach is based on taking action when particular trigger points are observed. It is most likely to be appropriate in cases where ongoing responsibility is assigned to tracking the change in risk and managing that risk through pre-determined interventions. The managed adaptive approach sets out a way for dealing with the significant uncertainty surrounding climate change in the future.

The aim of the managed adaptive approach is to build flexibility into options and decisions today so that they can be adjusted depending on what happens in future.

There are two elements of the managed adaptive approach. One element is to build in the ability to adjust an option should it be required. The second element is for dutyholders to develop plans that build flexibility into the decision process itself through waiting and learning as scientific understanding of climate-related risks increases.

Not all of the options to manage future climate change will be suitable for a managed adaptive approach of waiting and learning, so a combination of a design containing precautionary elements and the managed adaptive approach is likely to be the most suitable approach for nuclear sites.

Components of a managed adaptive approach:

- Understanding the full range of risks that might need to be managed. This comes from performing analysis of climate change using a range of climate scenarios, annual exceedance probabilities[7] and sensitivity studies. This should include consideration of the credible maximum scenario. The regulators expect dutyholders to use the most up to date credible maximum scenarios in any new analysis of climate change.

- Understanding how much flexibility and what options might be needed, and when, depending on the different climate change projections, so as to not foreclose modifications needed to enhance resilience in the future.

- Iterative decision-making (evaluating results and adjusting actions on the basis of what has been learned).

- Feedback between monitoring and decisions (learning). Knowing when a decision will be needed given the changing risks and the lead time to make an adjustment, or implement a new option.

- The sustainability of the managed adaptive approach must be demonstrated. In other words, that the responsibility for adaptation can reasonably and effectively be passed on to future dutyholder(s).

For aspects covered by the nuclear safety case, these can be controlled on an ongoing basis by the nuclear site licence and attached licence conditions. For aspects outside the nuclear safety case, in other words, non-safety critical elements, appropriate planning controls would be needed, such as DCO planning requirements or legal agreements, to ensure the approach is implemented, as needed, at the required time.

More information on the managed adaptive approach can be found in [1].

Exploratory post-2100 sea level rise scenarios

Some nuclear licensed sites will have lifetimes that will extend well beyond 2100. Assessments will therefore need to cover the full lifetime of the development proposed. There is now a large body of literature that suggests that increasing sea level is likely to continue beyond 2100 for a considerable period of time, even if global greenhouse gas emissions are restricted. Therefore, UKCP18 has produced some extended projections for sea level rise beyond 2100 for RCP 2.6, RCP 4.5 and RCP 8.5 – these are referred to as ‘exploratory post-2100 sea level rise scenarios’ [27]. These scenarios are based on idealised assumptions about emissions (rather than being linked to specific technologies and societal actions) and extend to 2300. These extended projections show uncertainty increasing with time and have much wider confidence intervals than projections up to 2100 [27]. For projections beyond 2100, dutyholders are encouraged to use the exploratory post-2100 sea level rise dataset (also called the UKCP18 Exploratory Extended Time-mean Sea Level Projections) provided by the UKCP18 project, rather than extrapolating the UKCP18 sea level rise dataset (see also Appendix 1). Regardless of the methodology selected beyond 2100, dutyholders should be aware that a high degree of uncertainty is present and dutyholders should also consider the managed adaptive approach (see section on Managed Adaptive Approach above).

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Appendix 1

The use of RCPs, annual exceedance probabilities[7], and sensitivity studies in climate change assessments – ONR, the Environment Agency, Natural Resources Wales and the Scottish Environment Protection Agency expectations.

The regulators' expectations for use of UKCP18 are provided in the following table. Dutyholders will need to satisfy the requirements of the regulators and, where relevant, the planning authorities, with respect to their consideration of climate change. The submissions will respond to different regulatory requirements and expectations as set out in the following table. Where they overlap in their predictions and associated effects on the site, the predictions should be consistent. Differences in data, methods used, and judgments should be reconcilable and justified between the analyses. Further information can be found in [1].

For example, dutyholders could satisfy the regulators and planning authorities while maintaining this consistency by performing analysis of climate change using a range of climate scenarios, annual exceedance probabilities[7], and sensitivity studies. To satisfy expectations, this analysis should include consideration of RCP 4.5, RCP 8.5 and credible maximum scenarios. This analysis would then feed into individual submissions to each regulator in accordance with their expectations and would holistically demonstrate a consistent approach has been used across all submissions.

Expectation	Office for Nuclear Regulation	Environment Agency	Natural Resources Wales	Scottish Environment Protection Agency
RCP to select	ONR does not prescribe the use of a particular RCP to define a design basis event[8]. The dutyholder will need to provide evidence that the RCP that they have selected is adequately conservative in line with	The Environment Agency 'Flood Risk Assessments: Climate Change Allowances' guidance [0] provides allowances for peak rainfall intensity, peak river flow, sea level	The Welsh Government 'Climate Change Allowances and Flood Consequences Assessments' guidance [14] has been updated to provide allowances for sea level rise based on UKCP18. It presents	All of the allowances in Scottish Environment Protection Agency guidance [16] are based on RCP 8.5 from UKCP18.

[8] In addition, dutyholders are expected to ensure that there is no disproportionate increase in risk for events more severe than the design basis. They are also required to provide enhanced protection against even more severe events and provisions for recovery in the unlikely event that the protection capability is exceeded. Further information can be found in ONR's External Hazards TAG [18] [28] and ONR's External Hazards SAPs [17].

Expectation	Office for Nuclear Regulation	Environment Agency	Natural Resources Wales	Scottish Environment Protection Agency
RCP to select	ONR's Safety Assessment Principles (SAPs) [17]. ONR expects that there would not be a reduction in conservatism from the approaches that have been used in UKCP09 (ONR has generally accepted the UKCP09 medium emissions scenario at the 84th percentile as adequately conservative for defining a design basis (more information on this is available in [28])).	rise, offshore wind speed and extreme wave height. For sea level rise, the allowances are based on the 70th and 95th percentiles of RCP 8.5. For peak river flow, the allowances are based on the 70th and 95th percentiles of RCP 8.5. For peak rainfall, the allowances are based on 50th and 95th percentiles of RCP 8.5. For projections beyond 2125, RCP 8.5 should be used from the exploratory post-2100 sea level rise dataset (also called the UKCP18 Exploratory Extended Time-mean Sea Level Projections) provided by the UKCP18 project [27].	allowances based on the 70th and 95th percentiles of RCP 8.5. There has been no change in the guidance for peak river flows, extreme rainfall or storm surge data [14] [15] which is based on an assessment of UKCP09 data undertaken by the Environment Agency between 2013 and 2015. There has also been no change to wave climate projections. For peak river flow, an assessment of risk should be undertaken for both the central estimate and the upper end estimate to inform mitigation measures and ensure long term resilience of the development. The allowances are based on the UKCP09 medium and high emissions scenarios.	The peak river flow allowances are based on the 67th percentile of RCP 8.5. The peak rainfall intensity allowances are based on the 50th percentile of RCP 8.5. The sea level rise allowances are based on the 95th percentile of RCP 8.5.

Expectation	Office for Nuclear Regulation	Environment Agency	Natural Resources Wales	Scottish Environment Protection Agency
RCP to select			The Welsh Government climate change guidance is currently being reviewed to align with revised UKCP18 data.	
Hazard definitions	Design basis analysis for events that have an annual frequency of exceedance[7] of 10^{-4} (SAP EHA.4, para. 239). Beyond design basis analysis - assess cliff edge effects etc. (SAPs EHA.7 and EHA.18, paras. 246-248). Probabilistic safety analysis (SAP EHA.18, para. 246(c)). Severe accident analysis (SAP EHA.18, para. 246(e)).	Tidal flooding – 5%, 0.5% and 0.1% annual exceedance probability[7] with and without climate change allowances. Fluvial flooding – 5%, 1% and 0.1% annual exceedance probability with and without climate change allowances. Surface water flooding – 3.3%, 1% and 0.1% annual exceedance probability with and without climate change allowances. Groundwater flooding where relevant. Any other artificial sources of flooding, where relevant.	Tidal flooding – 0.5% and 0.1% annual exceedance probability[7] with and without climate change allowances. Fluvial flooding – 1% and 0.1% annual exceedance probability with and without climate change allowances. Surface water flooding – 3.3%, 1% and 0.1% annual exceedance probability with and without climate change allowances. Groundwater flooding where relevant. Any other artificial sources of flooding, where relevant.	0.5% annual exceedance probability[7] for all flood sources.

Expectation	Office for Nuclear Regulation	Environment Agency	Natural Resources Wales	Scottish Environment Protection Agency
Sensitivity Studies	Regardless of the RCP selected, sensitivity studies are also needed against more onerous scenarios including credible maximum scenarios (see section on Credible Maximum Scenarios above). Further information can be found in [1] [18] and [28].	Credible maximum scenarios should be assessed for developments that could be particularly vulnerable to the impacts of climate change, such as major infrastructure projects [0]. To assess a credible maximum climate change scenario use: • H++ allowances for sea level rise • the upper end allowance for peak river flow • the sensitivity test allowances for offshore wind speed and extreme wave height • an additional 2mm for each year on top of sea level rise allowances from 2017 for storm surge.	Consideration of the H++ 'credible maximum' climate change scenario is helpful for contingency planning and should be assessed for those developments that are very sensitive to flood risk and have lifetimes beyond the end of the century, for example major infrastructure projects. Welsh Government guidance [14] states that the Local Planning Authority should be contacted to establish whether an assessment of the H++ scenario is required as part of a flood consequences assessment.	Scottish Environment Protection Agency guidance specifies a range of sensitivity testing for developments that are particularly likely to be vulnerable to climate change; this includes nuclear sites [16] [29].

Expectation	Office for Nuclear Regulation	Environment Agency	Natural Resources Wales	Scottish Environment Protection Agency
Sensitivity Studies		The current credible maximum allowances for sea level rise, wind speed, wave height and storm surge are based on UKCP09 [0]. The Environment Agency expects that these allowances are not extrapolated beyond 2100. The current credible maximum allowance for peak river flow is based on the 95th percentile of UKCP18 RCP 8.5 for 2125. Dutyholders who wish to extrapolate beyond 2125 should discuss the extrapolation methodology with the Environment Agency.		

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Published July 2022