

Adaptation to Climate Change

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Document information

Document prepared for
Letchworth Investment LLP for Wrenbridge

Date of issue
24/04/2025

Issue no.
2

Our reference
11467 - Avenue One, Letchworth-Wst 05 Adaptation to Climate Change Stage 2-2503-31ba

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Adaptation to Climate Change

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Executive summary

Introduction

Annual average UK temperature was 0.9°C higher during the period 2005-2014 compared to 1961-1990¹. Moreover, sea levels around the UK have risen by 15-20 centimetres since 1900¹. These figures are forecast to continue to increase as a result of climate change. At the same time, there are upward trends in rainfall across the UK. Higher levels of winter rainfall have been experienced, often in increasingly heavy rainfall events leading to more flooding and damage to buildings and infrastructure. These patterns are consistent with projections of increased and heavier rainfall for the UK in a warmer global atmosphere.

These changes increase health, wellbeing and safety risks to people and the built environment, increasing costs and disruption for repair and adaptation. The building stock will largely remain as it currently is for the next 50 to 60 years, given the relatively low levels of replacement that are likely to occur.

Therefore, there is a need for strategies to mitigate the impact of these events on the building stock overall and in particular to ensure that new buildings are designed and constructed to minimise future risks while avoiding over-specification and resource use in the meantime.

Climate change adaptation and BREEAM

A number of BREEAM issues contain assessment criteria that aim to support mitigation of the impacts of extreme weather events, or hazards, arising from climate change. Hazards applicable to the developments in the UK include:

- Flooding
- Overheating and the urban heat island effect
- Sea-level rise
- Water scarcity and supply
- Decline of biodiversity and natural habitats
- Subsidence
- Extreme cold

About the scheme

The planning application consists of the erection of two buildings for Flexible Use Classes including Eg (ii) (iii), B2, B8, including servicing, parking access, landscaping. The BREEAM assessment will be undertaken using the Similar Buildings approach, with a single certificate issued upon completion that lists all assessed units.

The development is required to achieve a BREEAM 'Excellent' rating under the BREEAM New Construction V6 methodology.

Project Team

To ensure that all aspects of the potential for climate change adaptation were considered for the project at the early design stages, a workshop was carried out by Eight Versa on 13.03.2025 (RIBA Stage 2), with key members of the design team, as outlined below:

- Letchworth Investment LLP for Wrenbridge - client
- KAM - project manager
- CMP Architects - architect
- Burrows Graham - structural engineer
- MBA Consulting - services engineer

The workshop enabled a climate change adaptation strategy appraisal to be carried out for structural and fabric resilience of the building. This was done to evaluate the impact on the building over its projected life cycle from expected extreme weather conditions arising from climate change and, where feasible, how these impacts could be mitigated. The following stages were considered:

- Hazard identification
- Hazard assessment
- Risk estimation
- Risk evaluation
- Risk management

All findings are recorded and outlined within this report.

¹ UK Climate Change Risk Assessment 2017, Committee on Climate Change (2016)

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Hazard identification and assessment

Following a review of information from the relevant bodies the following hazards were identified as being likely to affect the building:

- Warmer, wetter winters
- Hotter, drier summers
- More extreme weather events (increased rainfall and flooding, stronger winds and an increase in periods of extreme temperatures).

Hazard assessment summary

This report has determined that the following levels of hazard would present an unacceptable risk to the development:

- Increased temperatures resulting in overheating and therefore reduction in user thermal comfort within their internal and external environments.
- Increased temperatures causing an increased impact on the heat island effect.
- High levels of solar radiation and dry conditions impacting levels of wellbeing and comfort (from increased levels of glare), biodiversity and green infrastructure, and water scarcity.
- High levels of solar radiation and dry conditions impacting robustness and causing material degradation.
- Rising sea levels and increased duration of prolonged rainfall increasing flood risk to the building, its contents and users, and potential increased risk of material degradation.
- Extreme flood events increasing risk to building contents, its users and potential impact on business continuity.
- Extreme temperatures compromising material durability.

Recommended risk management measures

Mitigation measures to reduce the risk posed by each of the hazards include:

- Thermal comfort modelling carried out for the building, including a projected climate change scenario.
- High building fabric performance and lighter coloured materials to be utilised within the design.
- Green infrastructure (trees and planting) to be installed on site to encourage evapotranspiration.
- The Flood Risk Assessment recommendations and drainage design are to be implemented within the development, utilising SuDS measures where feasible.

- Maintenance plans to be produced and implemented to ensure building fabric is maintained appropriately during high temperatures.

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UK Climate Projections

UK Climate Projections

The Met Office Hadley Centre has been producing climate projections for the UK since the 1990s, with the latest set being UKCP18 (UK Climate Projections 2018)². These UKCP18 projections provide access to a new set of climate projection data and tools, which represents a key resource for anyone involved in preparing for climate change and is widely used by government departments as well as research organisations.

The UKCP18 climate projections are developed from climate models from around the world and the results from latest Met Office global and regional climate models. These have provided a greater span of outcomes and therefore a variety of weather and climate data, including the following:

- Updated probabilistic projections, giving estimates of different future climate outcomes generated from a number of climate models. These outcomes have been weighted by comparing models of historical climate with real world observations, including the inclusion of simulated natural interannual variability;
- A new set of 28 global climate model projections, comprising a set of 15 projections from the latest Met Office Hadley Centre climate model and 13 from global climate models from around the world that informed the IPCC 5th assessment (CMIP5);
- A set of regional climate model projections on a finer scale (12km) for the UK and Europe, however these do not yet cover the full range of all 28 global climate projections.

It is also important to note that UKCP18 utilises four RCP scenarios: RCP2.6, RCP4.5, RCP6.0, RCP8.5. Each of these scenarios represents a specific concentration of atmospheric CO₂ (as shown below) resulting from a different range of demographic, social, economic and technological factors.

UKCP18 scenario	Key features	Atmospheric CO ₂ /PPM
RCP2.6	CO ₂ peaks by 2020. Global population peaks mid-century at 9 billion. Oil use declines and some renewable energy.	440
RCP4.5	CO ₂ peaks around mid-century. Moderate population and economic growth. Consistent oil consumption with nuclear and renewables.	520

RCP6.0	CO ₂ doubles by 2060. Slightly high population growth. Higher oil consumption.	620
RCP8.5	CO ₂ stabilises by 2100. High population growth. Coal supplies most of the large increase in energy consumption.	950

As carbon dioxide emissions (and therefore CO₂ in the atmosphere) are ultimately determined by human actions and choices it is impossible to assign a likelihood to each of the above scenarios; however, Gething (2013) notes that to date, global emissions have risen 'in line with the upper range of selected scenarios, checked only slightly by the effects of the recession.'³

For the purposes of this report the RCP4.5 emissions scenario has been used.

Key Trends

The UKCP18 projections run up until 2099 and identify the following key trends:

- Warmer, wetter winters
- Hotter, drier summers
- Rising sea levels
- More extreme weather events

The UKCP18 projected general trends of climate changes in the 21st century are therefore similar to the previously reported UKCP09. However, the Met Office do note that natural variations mean that some cold winters, some dry winters, some cool summers and some wet summers will still occur, and that this may still need to be factored into decision-making.

An additional trend that could be added to the above is an increase in the frequency and magnitude of the urban heat island effect. This is not picked up in UKCP18, as the projections do not include an explicit representation of urban areas (other than the underlying base data at the resolution of a 25 km² grid). It should, however, be noted that the relationship between climate change and the urban heat island effect is inherently difficult to model.

² IPCC Expert Meeting Report, Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts, and Response Strategies, IPCC (2007)

³ Design for Climate Change, Bill Gething, Katie Puckett (2013)

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Probabilistic projections

UKCP18 uses the following probability levels (linked to statistical percentages) to describe the likelihood of certain outcomes occurring as a result of each climate scenario.

- Virtually certain: > 99% probability
- Extremely likely: > 95%
- Very likely: > 90%
- Likely: > 66%
- More likely than not: > 50%
- As likely as not: 50%
- About as likely as not: 33-66%
- Unlikely: < 33%
- Very unlikely: < 10%
- Extremely unlikely: < 5%
- Exceptionally unlikely: < 1%

Projections typically discount all values outside of the 10 - 90% probability range (representing the lower and upper limits of the "likely" band of outcomes). For the purposes of this the 10 - 90% probability range have been referenced for the most extreme scenarios (for the 10% probability range for RCP2.6 and the 90% probability range for RCP8.5), but the central (50%) estimate has been considered the appropriate basis for analysis.

Methodology

Using UKCP18 we have identified the following probabilistic climate change prediction trends for the area in which the project is located:

Hotter drier summers:

- Maximum peak temperature (°C)
- Percentage precipitation decrease (mm/day)

Warmer wetter winters

- Mean temperature (°C)
- Percentage precipitation increase (mm/day)

The projections identified on the following pages outline the central (50% probability) data set for each of the four climate change scenarios. The results for the RCP4.5 climate change scenario (atmospheric CO₂ levels at 520 PPM) have been reported within this document as these are considered to be the most meaningful results at present.

The economic life of the building has been set at 60 years; the climate change impacts have therefore been considered over this time period, using the UKCP18 dataset for the time period 2049-2079.

The UKCP18 does not currently report probabilistic projections for extreme weather events. Therefore, this data is based on historical Met Office records.

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Hazard Identification and Assessment

Warmer winters

The modelled UKCP18 data for the site, and the table below demonstrate a general trend in increased average winter temperatures over the 30-year and 60-year life cycle periods of the building. The data in the graph below outlines the central estimate (50th percentile) for the 60-year life of the building, which suggests that winter temperatures are likely to increase between 1.2°C and 1.7°C.

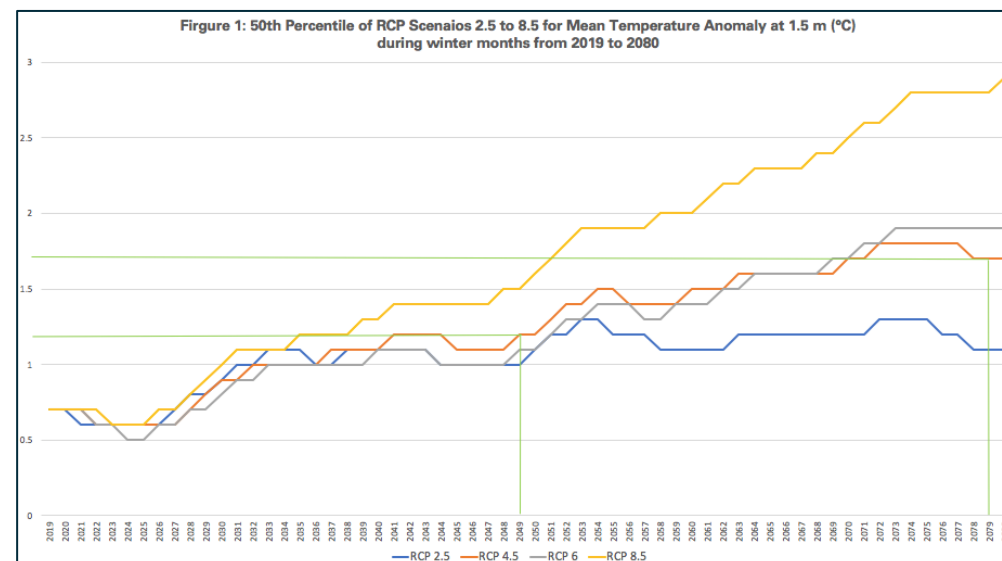
UKCP18 data: Change in winter temperature

The table below outlines the most extreme cases for the climate change projections (the 10th percentile for the RCP2.6 scenario, and the 90th percentile for the RCP8.5 scenario) and the 50% percentile for RCP4.5. For the purpose of this analysis, RCP4.5 has been assumed as the most likely outcome that we should design for at present.

Time period	10 th (RCP2.6) – 90 th (RCP8.5) percentile probabilistic range (very likely to fall within this range)	Central (50 th percentile) estimate for RCP4.5
30-year period (2049)	Between -0.7°C and 3.5°C increase in average winter temperature	1.2°C increase in average winter temperature
60-year period (2079)	Between 1.1°C and 5.2°C increase in average winter temperature	1.7°C increase in average winter temperature

Table 1 – the extreme (10-90% probabilistic range) and most likely (50% RCP4.5) change in temperatures expected for the change in average winter temperature.

It is therefore predicted that within the expected life of the building (2049-2079) we could see an increase in winter temperature from -0.7°C – 5.2°C. The 50th percentile results for all RCP scenarios are illustrated in Figure 1, with the 30-year and 60-year results for RCP4.5 identified in green. It should be considered that the central estimate outlines an increase in winter temperatures from 1.2°C – 1.7°C, and therefore it is recommended that the site is designed to adapt to an average winter temperature increase of 1.7°C.



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Wetter winters

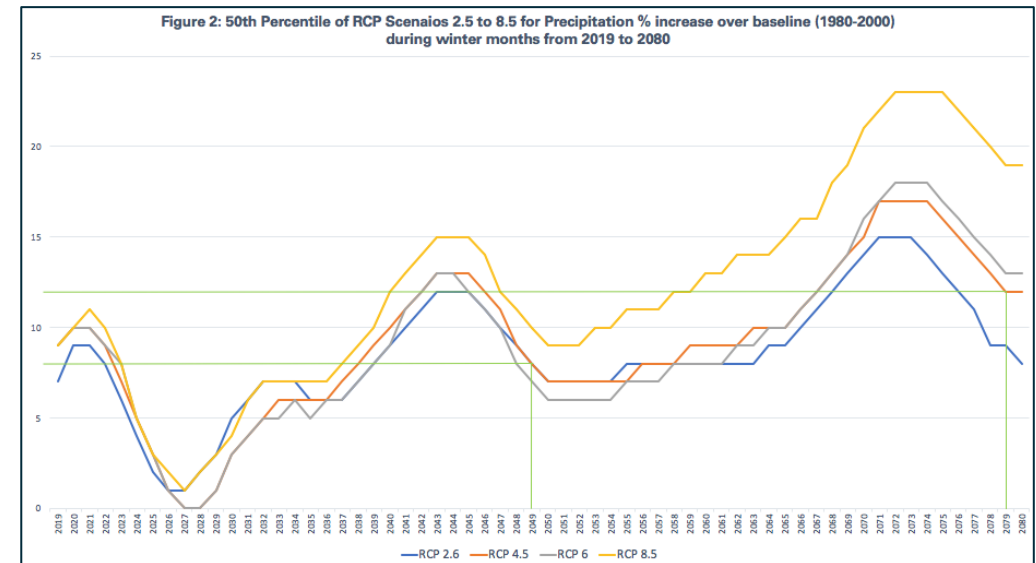
As shown in the graph below, UKCP18 projections suggest that between 2049 and 2079 it would appear that precipitation during the winter months will have increased over the 30-year and 60-year life cycle periods of the building. The central estimate (50th percentile) for the 60-year life of the building suggests that winter precipitation will increase between 8 and 12%.

UKCP18 data: Change in winter precipitation

Time period	10 th (RCP2.6) – 90 th (RCP8.5) percentile probabilistic range (very likely to fall within this range)	Central (50 th percentile) estimate for RCP4.5
30-year period (2049)	Between -25% and 43% increase in winter precipitation	8% increase in winter precipitation
60-year period (2079)	Between -30% and 62% increase in winter precipitation	12% increase in winter precipitation

Table 2 – the extreme (10-90% probabilistic range) and most likely (50% RCP4.5) variation expected for the change in average winter rainfall.

It is therefore predicted that within the expected life of the building (2049-2079) we could see anything from a 25% decrease to a 62% increase in winter rainfall. As previously mentioned, the RCP4.5 projection scenario is being assumed as the most likely outcome for this analysis. The 50th percentile results for the time period 2049 and 2079 are shown below in green. It is predicted that 2049 will have an 8% increase in precipitation over the 1981-2000 baseline and 2079 will have a 12% increase. It is worth noting that the upper end of the current UK government's peak rainfall intensity allowance in small and urban catchments is between 20-40%, which would not be sufficient to address the RCP8.5 scenario of a 62% increase but would accommodate the 12% of the RCP4.5 scenario.



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Hotter Summers

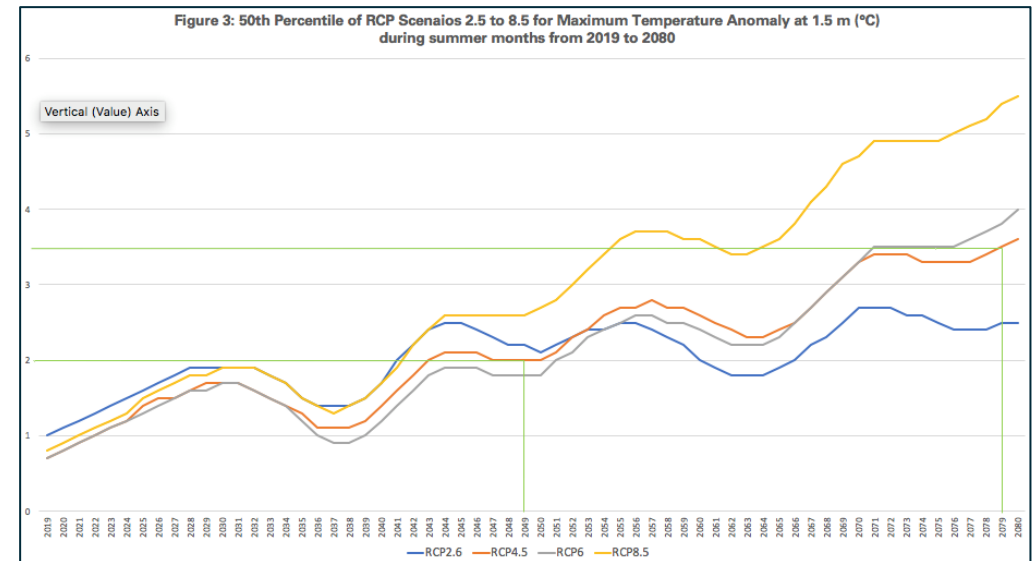
The UKCP18 projections, shown below, suggest that there will be a gradual increase of average summer temperatures over the 30-year and 60-year life cycle periods of the building. The information in the graph below shows the central estimate (50th probabilistic range) for the 30 and 60-year life of the building, suggesting that summer temperatures are likely to increase between 2°C and 3.5°C. The central estimate within this probabilistic range suggests that summer temperatures will increase by an average of a 1.8°C.

UKCP18 data: Change in winter temperature

Time period	10 th (RCP2.6) – 90 th (RCP8.5) percentile probabilistic range (very likely to fall within this range)	Central (50 th percentile) estimate for RCP4.5
30-year period (2049)	Between -0.7°C and 5.8°C increase in average summer temperature	2°C increase in average summer temperature
60-year period (2079)	Between -0.9°C and 9.8°C increase in average summer temperature	3.5°C increase in average summer temperature

Table 3 – the extreme (10-90% probabilistic range) and most likely (50% RCP4.5) change in temperatures expected for the change in average summer temperature.

It is therefore predicted that within the expected life of the building (2049-2079) we could see a significant increase in summer temperature from -0.7°C – 9.8°C. The 50th percentile results for all RCP scenarios are illustrated below in Figure 3, with the 30-year and 60-year results for RCP4.5 identified in green. It should be considered that the central estimate outlines an increase in summer temperatures from 2°C – 3.5°C, and therefore it is recommended that the site is designed to adapt to an average summer temperature increase of 3.5°C.



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Drier Summers

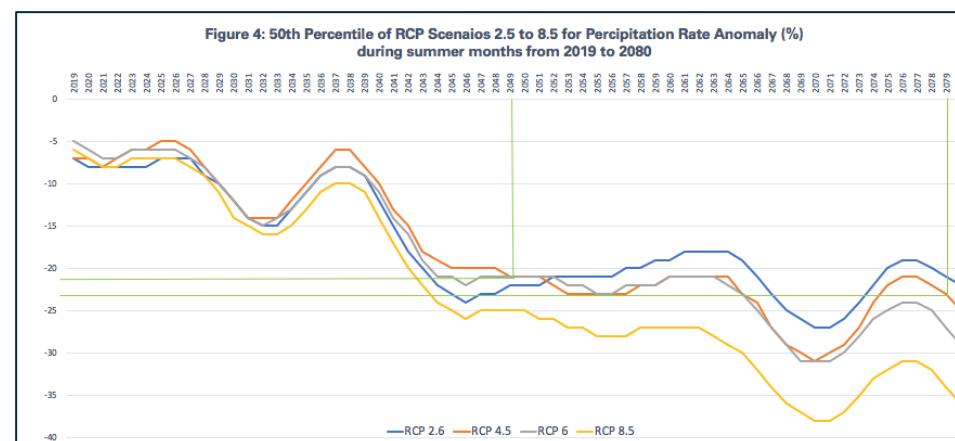
There is various data available for summer precipitation, which does not show a definitive decrease in precipitation levels. As shown in Table 4 below, the UKCP18 projections suggest that between 2049 and 2079 precipitation during summer could have decreased by 66% or increased by 24% (compared to the 1981-2000 baseline). The central 50th percentile estimate of the RCP4.5 projection scenario shows a 21-23% decrease in precipitation over the next 30-60 years.

UKCP18 data: Change in summer precipitation

Time period	10 th (RCP2.6) – 90 th (RCP8.5) percentile probabilistic range (very likely to fall within this range)	Central (50 th percentile) estimate for RCP4.5
30-year period (2049)	Between -66% and 24% increase in summer precipitation	21% decrease in summer precipitation
60-year period (2079)	Between -66% and 24% increase in summer precipitation	23% decrease in summer precipitation

Table 4 – the extreme (10-90% probabilistic range) and most likely (50% RCP4.5) variation expected for the change in average summer rainfall.

The general trend shown in Figure 4 below, appears to be a general decline in the amount of precipitation experience in the UK over the summer, although outlier predictions include some increase. The 50th percentile results of the RCP4.5 scenario for the time period 2049 and 2079 are shown below in green. It is predicted that 2049 will have a 21% decrease in precipitation over the 1981-2000 baseline and 2079 will have about a 23% decrease. Although the trend is showing a decline it may be worth noting that the rain received over the summer would more likely be in the form of sudden storms, generating severe amounts of rain and the potential for flash flooding.



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Rising sea levels and flooding

The development is located away from any major rivers and is not at risk from rising sea levels (see flood map below). The development site is classed as Flood Zone 1 (low probability to flooding).

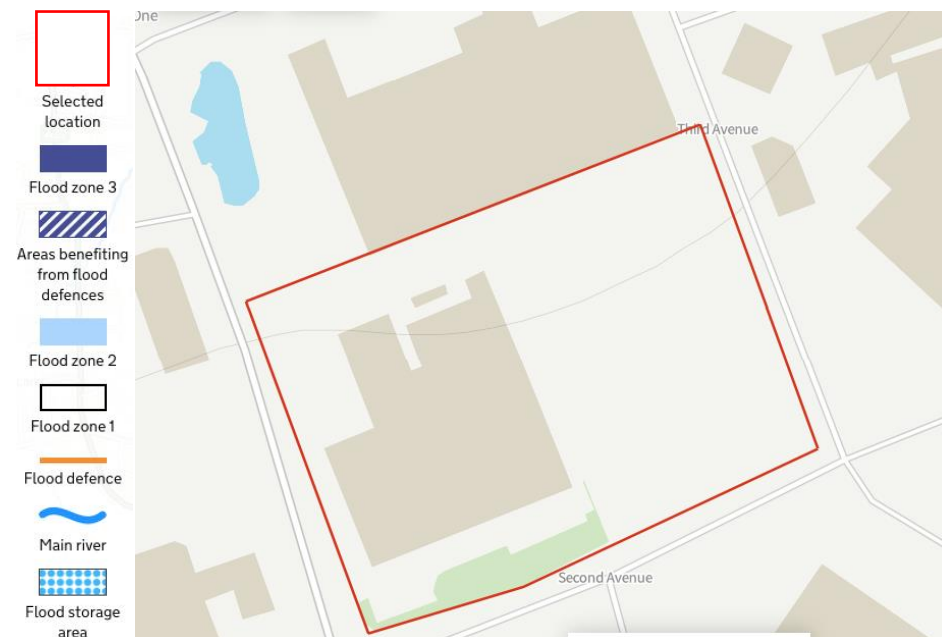


Figure 1: Likelihood of flooding at Project Name. Taken from the Flood Map Planning UK Government website - <https://flood-map-for-planning.service.gov.uk/>

Extreme weather events

Although the difficulty in attributing individual extreme weather events to anthropogenic climate change is widely recognised, there is a consensus that extreme events are likely to increase in frequency and/or magnitude as a result of climate change. To ascertain the type of extreme weather that is likely to affect the UK in the future, Eight Versa has analysed notable extreme weather events that have occurred over the last 29 years (as recorded by the Met Office). Although this is not a definitive list, it does allow insights to be gained on the types extreme event that are likely to affect the UK and how these vary across the year. The graph below (figure 2) shows the number and type of extreme events (as recorded by the Met Office between 1990 and 2019) occurring each month. This data shows that most extreme weather events take place during the late autumn and winter months (October to January).

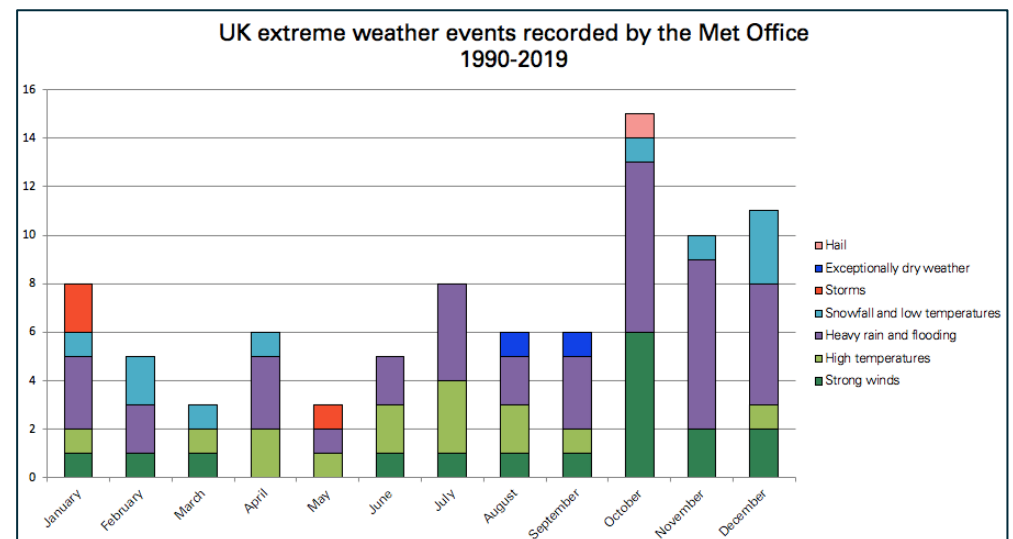


Figure 2: UK extreme weather events recorded by the Met Office (1990-2019)

The pie chart in figure 3 below shows how the total number of extreme weather events recorded by the Met Office (for the period between 1990 and 2019) broken down into different weather types. Almost half of the recorded extreme weather events affecting the UK fall under the definition 'heavy rain and flooding' at 39%. This is followed by 'strong winds' at 17% and 'high temperatures' at 14%, which each

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make up about a third of the total recorded events, with 'snowfall and low temperatures' totalling 10% of the recorded events.

It is by no means certain that future extreme weather events will follow a similar pattern. However, it is reasonable to assume that the predominant forms of extreme weather that will affect the development are:

- Heavy rainfall and flooding
- Strong winds
- Periods of high and low temperature

With the exception of 'high temperature' these types of extreme weather are most likely to affect the development during autumn and winter.

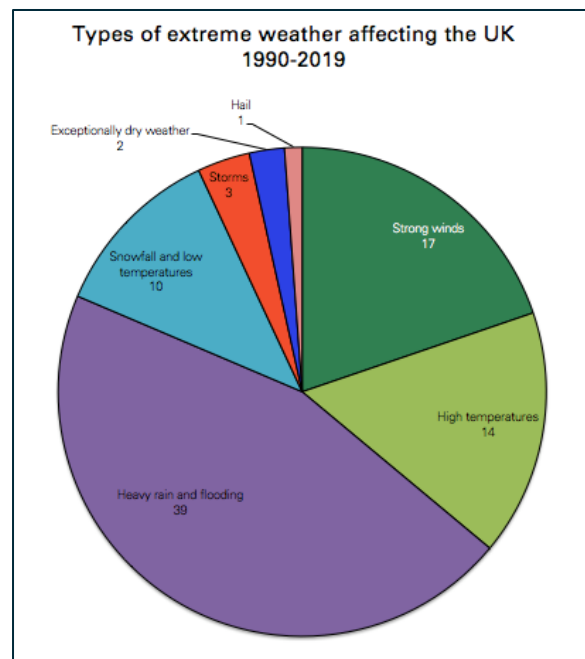


Figure 3: Types of extreme weather affecting the UK (1990-2019)

Summary of hazards

Although the trends are likely to be experienced across the whole of the UK (i.e. on a national scale), the specific changes in precipitation and temperature have been modelled on a local scale (25 km² grid). Rising sea levels and flood risk may affect the project on a regional scale. Extreme weather events have been considered at a national scale due to lack of adequate local data.

Hazard	Description	Scale
Warmer winters	Potential 1.7°C increase in winter temperature over building's lifespan	Local
Wetter winters	Potential 12% increase in winter precipitation over building's lifespan	Local
Hotter summers	Potential 3.5°C increase in summer temperature over building's lifespan	Local
Drier summers	Potential 23% decrease in summer precipitation over building's lifespan	Local
Rising sea level	Not applicable to the development. Flood Risk Assessment and Drainage Strategy are in place.	Regional
Increased frequency of extreme weather events	• Heavy rainfall and flooding • Strong winds • Period of high and low temperature	National

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Risk matrix

A risk matrix on the following page has been used to rank the severity of the risks that have been identified. The level of risk has been determined through a multiplication of the likelihood of a risk occurring and the severity of the consequences of that risk. Using this matrix each risk will be assigned one of the following risk levels:

- Insignificant
- Low
- Medium
- High
- Very high / extreme

The levels above will be used to determine the appropriate action required to manage each risk, each as outlined in the table below the risk matrix. Each level of risk requires a corresponding level of response from the risk assessor.

It is recognised that several problems have been identified with risk matrices, including:

- They can correctly and unambiguously compare only a small fraction of randomly selected pairs of hazards and can assign identical ratings to quantitatively different risks.
- They can mistakenly assign higher qualitative ratings to quantitatively smaller risks to the point where with risks that have negatively correlated frequencies and severities.
- They can result in suboptimal resource allocation as effective allocation of resources to risk treatments cannot be based on the categories provided by risk matrices.
- Categorisations of severity cannot be made objectively for uncertain consequences. Assessment of likelihood and consequence and resulting risk ratings require subjective interpretation, and different users may obtain opposite ratings of the same quantitative risks.

In light of the above limitations, the sensitivity of the risk matrix has been reviewed throughout the risk assessment process to ensure that accurate risk levels have been assigned to each identified risk.

Risk management

The tables on the following pages provide the details of the discussions from the adaption to climate change workshop. All hazards were assessed in relation to the proposed building and scored on the risk matrix. Subsequently the risk recommendations that mitigate the potential climate change risk were proposed and validated by the design team.

Severity Likelihood	Insignificant (1)	Minor (2)	Moderate (3)	Severe (4)	Catastrophic (5)
Very unlikely (1)	1	2	3	4	5
Unlikely (2)	2	4	6	8	10
Likely (3)	3	6	9	12	15
Very likely (4)	4	8	12	16	20
Almost certain (5)	5	10	15	20	25

Risk level	Risk rating	Action required
Very low / insignificant	2–3	No action required.
Low	4–5	Assessor to confirm whether risk has been addressed in design.
Medium	6–12	Assessor to review extent of the risk and determine whether item should be discussed at project team meeting.
High	13–19	Requires additional research to confirm risk level and/or specific project team meeting with relevant consultants to address risk item.
Very high / extreme	20–25	Requires immediate action from project team including specific meeting to address risk item and changes to design.

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Stage 2 Risk Estimation, Evaluation and Management

Climate Change Impacts	Hazard	Hazard Assessment	Likelihood	Severity	Risk Score	Risk Management: design features and techniques for climate change adaptation and mitigation at RIBA Stage 2	Residual Likelihood	Residual Severity	Residual Risk Score
Hotter dryer summers	Temperature variation: increase in summer temperatures	Increase in temperature may result in a risk of overheating and reduction in building user health and comfort levels within their internal environment	5	3	15	Thermal modelling will ensure that cooling loads and cooling strategy are designed to provide appropriate thermal comfort conditions for building occupiers in accordance with CIBSE Guide A guidelines. The thermal comfort modelling also includes results for a projected climate change scenario (30-year weather file) to demonstrate the building could accommodate increased temperatures. Passive design measures are being utilised within the design, with the glazing designed to ensure a balance of high performing g-values and u-values providing adequate levels of daylighting whilst minimising internal solar gains. In addition, rooflights are included over 15% of the roof to provide natural daylighting within the warehouse space. The roof and cladding coating will reflect a proportion of solar energy to reduce internal temperature gains.	3	2	6
	Temperature variation: increase in summer temperatures	Increase in temperature may result in a risk of overheating and reduction in building user comfort within the external environment	4	2	9	Office areas will be ventilated and cooled by ceiling mounted VRF air conditioning units that discharge to external condensers situated away from air intakes. Vegetation will be planted around the perimeter of the site to provide a cooling impact on the external areas through evapotranspiration, helping to create a pleasant external environment during peak summer temperatures.	3	2	6
		Increased temperatures will have a direct impact on the heat island effect	3	3	9	Materials specified will not include reflective materials that could reflect heat to the surrounding buildings and area.	2	2	4
		High levels of solar gain may cause a reduction in wellbeing and comfort levels for building users due to increased impact of disabling glare	4	3	12	Coating finishes will be utilised for the external wall and roof cladding for the building to create an albedo effect, helping to reduce heat gains to building materials. The orientation of the building combined with the location of surrounding developments will provide passive shading for part of the development.	3	2	6

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Climate Change Impacts	Hazard	Hazard Assessment	Likelihood	Severity	Risk Score	Risk Management: design features and techniques for climate change adaptation and mitigation at RIBA Stage 2	Residual Likelihood	Residual Severity	Residual Risk Score
	Higher levels of solar gain and sun exposure	High levels of sun exposure may cause UV damage to building fabric and reduction in material durability and robustness	3	3	9	The roof, rainwater goods and wall cladding is to provide a manufacturer's warranty for the entire installation for a period of 25 years. A building maintenance strategy will be implemented, and maintenance access installed to ensure materials are regularly checked/treated for any UV damage before the material needs replacing.	3	2	6
	Prolonged durations of dry weather	Increased risk of dust and damage to facades may result in increased repair and maintenance requirements	3	3	9	A facade maintenance strategy and programme will be developed and implemented for the building to ensure access for regular cleaning and maintenance. This will help to ensure materials are kept clean of any potential environmental impacts that could cause the material to deteriorate, and to ensure any potential material defects are identified as soon as possible, to help ensure best performance of the building fabric.	3	2	6
		Increased risk of exposed areas of the building degrading and reduced robustness due to longer durations of dry conditions, hot weather and sun-exposure	3	2	6	The building materials will be designed and installed to weather effectively, without risk of warping, blistering, delaminating, fracturing, peeling, or vibrate in the final construction. Regular maintenance will ensure that any signs of degradation are mitigated to reduce the likelihood of the material being replaced. The foundations and frame have been designed to accommodate potential levels of shrinkage determined by geotechnical investigation and testing of the subsoils and strata.	3	2	6
	Prolonged durations of dry weather	Increased risk of extended duration of water scarcity and high water costs	3	3	9	Efficient water fittings will be installed within the building to ensure that water consumption is reduced as much as possible. The development will achieve at least a 40% improvement in water consumption over the BREEAM baseline water consumption requirements.	2	2	4
		Increased risk of drought	3	3	9	Native species have been specified, and the planting strategy will be in accordance with the ecologist and landscape architects' recommendations. The Ecologist has provided guidance regarding appropriate types of planting during times of water scarcity. These are to be installed where appropriate.	3	2	6
Wetter warmer winters	Rising sea levels	Rising sea levels could increase the risk of flooding to the building and the surrounding area	1	2	2	The site is located in Flood Zone 1 on the Environment Agency (EA) flood maps and is therefore defined as having a low probability of flooding. The finished floor levels of the units will be higher than the potential drainage overload flood level.	1	1	1

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Climate Change Impacts	Hazard	Hazard Assessment	Likelihood	Severity	Risk Score	Risk Management: design features and techniques for climate change adaptation and mitigation at RIBA Stage 2	Residual Likelihood	Residual Severity	Residual Risk Score
	Increased levels of precipitation	Increased duration of prolonged rainfall could cause impacts on structural stability within the building	3	4	12	The roof design is curved to avoid pooling in times of prolonged rainfall. Sizing and capacity of syphonic roof outlets exceeds minimum requirements by a factor of 1.5 and the roof is provided with weir overflows which discharge externally if capacity is compromised. Regular roof and gutter inspections are undertaken to avoid blockages. The structural frame has been designed in accordance with relevant British Standards to ensure structural stability in prolonged rainfall.	2	3	6
	Increased risk of surface water flooding	Increased duration of prolonged rainfall could cause an increased risk of surface water flooding	4	4	16	It is likely that most surface water flooding would be due to storm events generating flows that exceed the existing capacity of the surface water sewer network. However, the proposed surface water drainage strategy outlines how the surface water risk will be mitigated and managed appropriately. The surface water flooding shown on the Environment Agency mapping is not considered to be a significant danger to life. Drainage attenuation will be designed for a 1 in 100 year, plus at least 40% storm event and in accordance with the FRA. Flood risk will be managed via the maintenance plan in the FRA to ensure that flooding resulting from silt build up or blockages within the drainage system are minimised.	3	3	9
	Increased risk of groundwater flooding	Risk of material degradation due to extended exposure of building materials to increased moisture levels	3	4	12	Concrete yards have been specified to increase durability in times of prolonged exposure to moisture levels. The impact of any increased moisture levels has been managed by setting the finished floor level of the proposed warehouse buildings higher than external areas, to minimise damage to the façade and building contents to help ensure business continuity. Cycle storage hoops will be constructed from galvanised steel and covered overhead, providing enhanced protection in times of increased moisture levels.	2	2	4

Adaptation to Climate Change

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Climate Change Impacts	Hazard	Hazard Assessment	Likelihood	Severity	Risk Score	Risk Management: design features and techniques for climate change adaptation and mitigation at RIBA Stage 2	Residual Likelihood	Residual Severity	Residual Risk Score
Extreme Weather	Heavy rain and extreme flooding events	Increased risk of flooding causing significant damage to the development and requirements for weather proofing	2	4	8	The main yard slabs will be laid to maximum falls of 1:30 generally (except for level access ramps) and minimum falls of 1:80, with the gradients generally sloping away from the building. All paved areas will drain via separators/interceptors, appropriate to the drained site area with surface water ultimately draining to adoptable surface water sewers.	2	3	6
	Extreme high temperatures and heat waves	Increased risk of damage to building materials in extreme high temperatures	3	3	9	As outlined earlier on in the report, the facade and roof materials will be procured in accordance with the sustainable procurement policy to ensure minimal material degradation.	3	2	6
	Strong winds and gales	Increased risk to structural stability and building movement from strong winds	2	2	4	There are no features of the external facade that could cause any problems in high winds. The roof does have an overhang that would require a risk analysis to be carried out, to ensure no movement issues during high winds. The scale and overall height of the building does not cause any concerns to warrant a wind assessment.	2	2	4
	Extreme cold weather	Increased risk of extreme cold weather and impact of ice and snow	3	3	9	The structure has been designed to allow for extreme levels of snow loading for the extreme weather event in accordance with BS EN 1991. For snow loading a ground snow load map, based on recorded data, is used to determine the basic snow load, or where deemed necessary, provides advice on exceptional load conditions due to snow drift, site constraints or local topography. Factors of safety are built into each load case adding an extra 35% to the dead load and 50% to all imposed loading to cover any eventualities where the structure may be overloaded for a period of time.	2	2	4

Adaptation to Climate Change

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Stage 2 Conclusion

Recommended risk management measures

This report has outlined a comprehensive list of mitigation measures to reduce the risk level for each of the identified hazards. The recommendations to mitigate the risk are as follows:

- Thermal comfort modelling carried out for the building, including a projected climate change scenario.
- High building fabric performance and lighter coloured materials to be utilised within the design.
- Green infrastructure (trees and plants) to be installed on site to encourage evapotranspiration.
- The Flood Risk Assessment recommendations and drainage design are to be implemented within the development, utilising SuDS measures where feasible.
- Maintenance plans to be produced and implemented to ensure building fabric is maintained appropriately during high temperatures.

It is proposed that these risk mitigation measures are confirmed as being included at the end of Technical Design stage.