

# Appendix 23.3 - Climate Change Risk Assessment

## Purpose of the Appendix

1. This Technical Appendix presents the Climate Change Risk Assessment (CCRA) for the Proposed Development which sets out the potential climate change risks which have been used to assist the impact assessment.
2. In January 2012 the government published the UK Climate Change Risk Assessment (UK CCRA) (Ref 1) which sets out the main risks and opportunities arising from climate change over the coming years and provides a reference for key anticipated impacts and opportunities related to the natural environment, buildings and infrastructure, health and wellbeing, business and services, and agriculture and forestry. In 2017 an updated version of the UK CCRA (Ref 2) was published providing greater detail on the potential risks and identifies a number of priority areas for further action.
3. This Appendix sets out the existing and future baseline climatic conditions for the Proposed Development Area based on data from the Met Office and the UKCP09 projections. This Appendix has been prepared under the following headings.
  - **UK Risk Assessment** – Setting out a summary of the UK Climate Change Risk Assessment and relevant risks and opportunities identified which are relevant to the Proposed Development.
  - **Review of Climate Change Guidance** – Setting out a summary of guidance on climate change in the UK relevant to the Proposed Development, i.e. research and reports into how climate change may impact biodiversity, rail infrastructure etc.
  - **Baseline Climate Conditions** – Setting out the baseline climate conditions for the Proposed Development Area drawing on historic climate data from the Met Office.
  - **Future Climate Conditions** – Setting out the predicted impacts of climate change for the East Midlands based on the summary of data from the UKCP09 projections.
  - **Summary of Anticipated Risks** – Setting out a summary of the identified climate change risks relevant to the Proposed Development.
  - **Assessment of Risk Methodology** – Setting out the methodology or assessing climate change risk.
  - **Project Risk Assessment** – Assessment of risk relevant to the proposed project components including the Main SRFI site, the Junction 15a, and the Other minor highways works.

- **Summary** – Setting out a summary of the effects to be considered in the Climate Change Adaptation assessment.
- **Limitations and Assumptions** – Setting out the limitations of future impact scenarios and assumptions made for the Climate Change assessment as set out in Chapter 17.

## UK Risk Assessment

4. The UK Climate Change Risk Assessment sets out the main risks and opportunities to the UK from climate change, providing an overview of main risks in and across sectors to help identify appropriate adaptation measures. First published in 2012 the UK CCRA was updated in 2017 with the latest report taking into account the latest scientific data and the Greenhouse Gas (GHG) emission reduction targets set as part of the Paris Agreement on climate change where 195 countries signed a historic global deal to tackle climate change.

### Climate Change Risk Assessment - 2012

5. With regard to the Proposed Development, the 2012 report sets out the key potential risks and opportunities for a range of sectors including the Natural Environment, Buildings and Infrastructure, Health and Wellbeing, Business and Services, and, Agriculture and Forestry. The key findings which relate to the Proposed Development are summarised below.
6. **The Natural Environment** – The UK CCRA suggests the effects of climate change could be significant by the 2050s, potentially having a negative effect on existing ecosystem pressures. Table 1 below sets out key risks and opportunities and how these may relate to the proposed development.

**Table 1: Natural Environment Risks and Opportunities**

Risks	Opportunities
Increased prevalence of non-native species.	Increased habitat range for some generalist species.
Loss of climate space, with species unable to track climate change.	

7. **Buildings and Infrastructure** – The UK CCRA analysis indicates that buildings and infrastructure will be affected by extreme weather events and long-term climate change, with challenges arising from higher temperatures and changing rainfall patterns. Table 2 below sets out key risks and opportunities and how these may relate to the proposed development.

**Table 2: Buildings and Infrastructure Risks and Opportunities**

Risks	Opportunities
<b>Energy</b>	
Higher energy demand for cooling as a result of higher average and maximum temperatures	Reduced energy demand for heating as a result of warmer winters
Heat damage/disruption to energy infrastructure.	

<b>Transport</b>	
Road and railways at significant risk of flooding	
<b>Water</b>	
Supply-demand pressures as rainfall quantity is reduced.	
<b>Buildings</b>	
Damage to property due to flooding -	
Buildings affected by subsidence.	

8. **Business and Services** – The UK CCRA identifies the main risks and opportunities to the Business sector as being related to flooding, heating and water resources and Table 3 below sets out these key risks and opportunities and how these may relate to the proposed development.

**Table 3: Business and Services Risks and Opportunities**

Risks	Opportunities
Possible decrease in output for UK businesses due to an increase in supply chain disruption as a result of extreme events.	
Risk of monetary loss as a result of operational impacts of flooding.	
Variability in the availability of water during construction and operational stages of development.	
Potential loss of staff hours due to high internal building temperatures.	

#### **Climate Change Risk Assessment – 2017**

9. The 2017 UK CCRA report provides a more focussed review of priority risks and opportunities in the UK identifying where more action is needed to strengthen policies to reduce long-term vulnerability to climate change.
10. The report sets out six areas of inter-related climate change risks for the UK which have high long term risks where more action is need, these include:
- Flooding and coastal change to communities, businesses and infrastructure.

- Risks to health, wellbeing and productivity from high temperatures.
- Risk of shortages in public water supply, and for agriculture, energy generation and industry.
- Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity.
- Risks to domestic and international food production and trade.
- In addition additional research is required focussing on new and emerging pests and diseases, and invasive and non-native species, affecting people, plants and animals.

11. The report goes on to set out 56 individual risks and opportunities identified in the UK Climate Change Risk Assessment 2017 Evidence Report (Ref 3). These include risks and opportunities in the Natural Environment (Ne), Infrastructure (In), People and the Built Environment (PB), and Business and Industry (Bu). In relation to the Proposed Development key risks and opportunities highlighted are set out in Table 4 below.

**Table 4: UK Climate Change Risks and Opportunities**

More Action Needed	Research Priority	Sustain Current Action	Watching Brief
Ne1 – Risks to species and habitats from changing climate space	Ne7 – Risks to freshwater supplies from high temperatures	In13 – Extreme heat risks to rail, road, ICT and energy infrastructure	In8 – Subsidence risks to buried surface infrastructure
Ne2 – Opportunities from new species colonisations	In11 – Risks to energy, transport and ICT from high winds and lighting	In14 – Benefits for infrastructure from reduced extreme cold events	
In1 – Risk of cascading infrastructure failures across interdependent networks	PB7 – Risks to building fabric from moisture, wind and driving rain	Bu3 – Risks to business operations from water scarcity	
In2 – Risks to infrastructure from river, surface/groundwater flooding	Bu5 – Employee productivity impacts in heatwaves and from severe weather infrastructure disruption		
In4 – Risks of sewer flooding due to heavy rainfall			
In9 – Risks to public water supplies from			

drought and low river flows			
PB1 – Risks to public health and wellbeing from high temperatures			
PB4 – Potential benefits to health and wellbeing from reduced cold			
PB5 – Risks to people, communities and buildings from flooding			
Bu1 – Risks to business sites from flooding			

12. In response to the identified climate change risks the second National Adaptation Programme is to be published in 2018 setting out actions for the UK Government, businesses, Councils, civil society and academia to address these findings and build the UK's resilience to climate change.

## **Review of Climate Change Guidance**

13. This section sets out a review of relevant guidance and evidence regarding potential impacts and risk associated with climate change which are relevant to the proposed development. Based on the risk set out in the UK risk Assessment and knowledge of the Proposed Development relevant areas of research have included:

- Biodiversity;
- Flood risk;
- Infrastructure (Rail, Road etc)

### **Biodiversity**

#### ***Biodiversity and Climate Change – A Summary of Impacts in the UK (Ref 4)***

14. The JNCC is a statutory advisor to the UK government and its work contributes to maintaining and enriching biological diversity, conserving geological features and sustaining natural features.
15. The 2010 report on Biodiversity and Climate Change sets out evidence about known interactions between climate change and biodiversity. This includes details on the impacts of climate change on terrestrial and freshwater biodiversity and marine and coastal ecosystems.
16. In terms of terrestrial and freshwater ecosystems one of the primary observed impacts of climate change in the UK has been a northward movement of species which prefer warmer climates and a retreat of northerly species, for example a review of data on bird distribution notes that the northern margins of many species have moved further north. This is having both a positive and negative impact on species, widening areas for some and narrowing of others.
17. In addition there is increasing evidence that the rise in UK temperature is impacting on natural events, for example many plants are now flowering earlier in the year. This can extend breeding periods but also has the potential to impact on a mismatch between natural systems in place resulting in increased species competition.
18. **Summary** – The report concludes that diverse biological communities are more likely to adapt to climate change.

#### ***Assessment of Climate Change Impacts on UK natural assets (Ref 5)***

19. The report from AECOM forms part of a four project series commissioned by the CCC to support the evidence base for the UK CCRA. This report includes an aggregate assessment of climate change impacts on goods and benefits provided by the UK's natural assets.

20. Modelling of native British species finds that many species groups can expect to see their climate space significantly expanded, colonising new areas, potentially benefitting from the projected changes in climate. In theory, a warmer climate could result in richer and more diverse wildlife; however this relies on habitat strength and biodiversity.
21. While some species are anticipated to experience a growth in climate space others are expected to experience shrinking areas, this is particularly the case for mosses which favour wet and cold conditions. Mossy habitats such as peat bogs provide a significant carbon capture and store in the UK. Erosion of these habitats through a northward shift could lead to a significant CO<sub>2</sub> release.
22. The report concludes that while in theory there may be potential benefits there is also the potential for negative impacts. To mitigate the impact of climate change action is needed to restore degraded habitats so UK species have the best chance of adapting to climate change.
23. **Summary** - A review of current evidence demonstrates that the impacts of climate change are already being felt by UK species and further changes are anticipated as a result of climate change including the expansion of species climate space and colonisation of new areas providing a potential benefit. Conversely warming climate is also anticipated to cause shrinkage of other habitats and species climate space. Ensuring habitats are of a high quality with good biodiversity will help with climate change adaptation.

## **Flood Risk**

### ***Flood risk assessments: Climate change allowances (Ref 6)***

24. The Government guidance on flood risk assessments includes guidelines on the application of climate change allowances in the assessment of flood risk and provision of drainage and flood risk management systems. This includes allowances for changes to peak river flows and peak rainfall intensity which have the potential to impact on fluvial and surface water flooding.

### ***Climate Change Risk Assessment 2017 – Projections of future flood risk in the UK, 2015 (Ref 7)***

25. This report prepared in 2015 forms part of the evidence base for the 2017 UK Climate Change Risk Assessment and sets out the assessment of future flood risk considering different climate change scenarios, and population growth.
26. The report states that in the future all forms of flooding will increase and key impacts of future flooding include and increase if risk of flooding to residential homes, protected habitats and social infrastructure.
27. In terms of national infrastructure these assets will be subject to significant increase in risk with the number of sites exposed to the highest chance of flooding increasing by 30%. In particular local actions to protect assets such as electricity substations are effective to 2050 but action is needed to protect these for the anticipated changes for the 2080s.



28. At this stage it is anticipated that current levels of adaption will offset a proportion of the projected increase in risk but is currently not sufficient, and under extreme climate change scenarios will do little to prevent significant risk. In this context action is needed and the report lists a number of recommendations including a need to improve the linkage between adaptation and investment planning.
29. **Summary** - In this context it is anticipated that climate change will have a significant effect on flood risk and should be a key consideration for new development. Current adaptation measures and assessment methods as set out by the government currently provide developments with a mechanism for incorporating climate change adaptation, however long term changes will need to be taken into account by key infrastructure.

## **Rail Infrastructure**

### ***Climate Change Adaptation Report (Ref 8)***

30. The Climate Change Adaptation report prepared in 2015 sets out the potential rail infrastructure risks associated with climate change and measures and programmes put into place to adapt to and mitigate the impacts of climate change.
31. Key rail infrastructure related risks identified which may be applicable to the Proposed Development are set out in Table 5.

**Table 5: Rail Infrastructure Risks**

Climate Impact	Rail Infrastructure Asset	Effect
Temperature changes (high/low)	Track	Buckles and breaks and derailment risk Reduced opportunities for track maintenance
Temperature changes (high/low)	Switches and crossings	Frozen or snow blocked points Failure of point operating system
High temperatures	Overhead line equipment	Sag of overhead line and risk of dewirement
High temperature	Lineside equipment	Failure of temperature controls and overheating of electronic equipment
Increase in rainfall and flooding	All	Closure of line due to track flooding Failure of lineside equipment due to flooding Scour of embankment material
Increased rainfall	Earthworks	Landslip and earthwork failure and risk to rolling stock and staff
Decreased rainfall	Earthworks	Desiccation of embankments resulting in

		track geometry faults and failures in lineside equipment
Lightning	Lineside equipment	Asset failure as a result of lightning strikes and electrical surges

32. **Summary** – The potential impacts of climate change on the rail network could lead to potentially severe damage regarding the foundations and movement of rail, or major operational loss through overheating or damage to infrastructure and lineside equipment. In response to these risks Network Rail includes consideration of climate change in its asset management model and where appropriate includes consideration of climate change in design processes.

### **Road Infrastructure**

#### ***Climate Adaptation Risk Assessment Progress Update – 2016***

33. Prepared in 2016 the Highways England Progress Update builds upon the 2011 Risk Assessment (Add REF) which provided an initial assessment of the climate change risks and vulnerabilities to highways in England, key climate change vulnerabilities relevant to the Proposed Development include:
- The design of existing and new foundations
  - Surface water drainage
  - Attenuation
34. The latest adaptation plans set out actions to respond to the identified vulnerabilities ranging from ‘do minimum’ i.e. it is considered there is sufficient resilience in place to address the risk, to, ‘develop contingency plans’ and ‘retro-fit solutions’ which includes pre-planned responses to climate change or adaptation measures applied to existing assets outside of normal cycles.
35. The 2016 update sets out progress against addressing the vulnerabilities identified, in relation to Rail Central, this includes:
- The design of foundations – Development of Future Proof Designs, Interim advice on pavement foundations will be updated – In progress.
  - The design and construction of surfaces – Monitoring, Feedback from surfacing contractors – Ongoing
36. **Summary** – Highways England has identified a wide range of risks associated with the impacts of climate change and has put in place an action plan for dealing with the highlights risks including those associated with the design of new infrastructure elements such as those incorporated into the Proposed Development.

## Baseline Climate Conditions

37. The current climate position within the Proposed Development area is based on the long term average data from the UK Met Office (Ref 10). The Met Office continually records climate data from over 300 locations around the UK and long term average data from 1981-2010 is available.

## Current Climate Conditions

38. The nearest climate station to the Proposed Development site is Northampton Moulton Park approximately 12km to the North East and is considered appropriate to use in setting out the baseline conditions for the site.
39. The existing climate for the Proposed Development Area, covering all of the proposed development works is demonstrated in Table 6 setting out average climate data from 1981 to 2010.

**Table 6: Baseline Climate Data**

Month	Max. temp (°C) (°C)	Min. temp(°C) (°C)	Days of air frost (days)	Sunshine (hours)	Rainfall (mm)	Days of rainfall >= 1 mm (days)
Jan	6.8	1.1	10.9	55.7	54	11.4
Feb	7.1	0.9	11.1	77.9	41.1	9.4
Mar	10	2.7	6.3	108.2	44.1	9.8
Apr	12.8	4	3	151.4	49.4	10
May	16.2	6.8	0.2	189.9	54.4	9.6
Jun	19.2	9.7	0	173.8	54.9	9.4
Jul	21.7	11.9	0	199.3	49.2	8.1
Aug	21.5	11.8	0	185.2	54.5	8.5
Sep	18.4	9.8	0	134	57.6	8.9
Oct	14.1	7	0.8	109.6	63.9	10.2
Nov	9.7	3.7	4.5	64.4	60	10.8
Dec	7	1.5	10.6	49.5	55.3	10.8
Annual	13.7	5.9	47.3	1498.9	638.1	116.9

## **Historic Weather Events**

40. In addition to the historic climate data for locations across the UK the Met Office includes details of Past Weather Events (Ref 11) setting out a summary of the event and impacts. A short review of events from the last ten years (2007 – 2017) has been undertaken to review the potential impacts from extreme weather events to help identify potential risks from future climate change. Particular attention has been paid to events which reflect the anticipated climate changes and impacts on the East Midlands.

### ***Hot Spell June 2017***

41. The UK experienced a spell of hot, sunny weather in June 2017 with temperatures across some location in the UK reaching 30-32 degrees. This resulted in some speed restrictions on rail lines to avoid buckling, and an increased risk of air pollution for congested areas such as the East Midlands.

### ***Exceptional Warmth, December 2015***

42. December 2015 was the warmest December on record across the UK with temperatures 7-9degrees higher than might be expected at this time of year. This led to an increase in monthly rainfall of nearly 200%. Further storms during December led to flooding across parts of Lancashire, North Manchester and Yorkshire.

### ***Winter Storms, January to February 2014***

43. The UK experienced a spell of extreme weather from late January to mid-February with a succession of storms. The storms resulted in major flooding problems affecting much of the River Thames and large swathes of the River Severn floodplain. As well as flooding to properties and businesses transport infrastructure was also affected.

### ***Hot Dry Spell July 2013***

44. From 3 – 23 July the UK experiences a prolonged period of hot, dry weather with daily maximum temperatures exceeding 28 degrees. This resulted in little or no rainfall for 19 days, when this period broke a number of storms resulted in flash flooding, with lightning affecting trains and tram services in parts of Manchester, Birmingham and Edinburgh.

### ***Exceptionally Wet Weather, November 2012***

45. A series of heavy rainfall events in 2012 resulted in one of the wettest weeks in England in the last 50 years with areas of South West England, the Midlands and North East England experiencing >150% of the average monthly rainfall resulting in flooding.
46. The review of historic weather events highlights the risks of increased temperatures which can affect rail lines and air quality, and extended periods of rain which can cause flooding leading to significant damage to infrastructure. With climate change anticipated to increase

temperatures and winter rainfall these events highlight potential climate change risks to the Proposed Development.

### **Future Climatic Baseline**

47. The Future Baseline and climate change adaptation assessment has been based upon data sourced from the UKCP09 website which is the source of the climate projections data for the United Kingdom (UK). The UKCP09 website (Ref 12) is managed by the Environment Agency working with the Met Office.
48. The UKCP09 website allows users to access information on plausible changes in 21st century climate for the United Kingdom. UKCP09 provides future climate projections for land and marine regions as well as observed (past) climate data for the UK.
49. UKCP09 was produced in 2009, funded by a number of agencies led by Defra. It is based on sophisticated scientific methods provided by the Met Office, with input from over 30 contributing organisations. UKCP09 can be used to help organisations assess potential impacts of the projected future climate and to explore adaptation options to address those impacts.
50. UKCP09 provides climate projections for the UK for three different future greenhouse gas emissions scenarios: a low emissions scenario, a medium emissions scenario and a high emissions scenario, all three of which are based upon the scenarios presented by the Intergovernmental Panel on Climate Change (IPCC) report (Ref 13). The climate projections under each scenario differ with greater variability in climate impacts projected using the high emissions scenario with corresponding lower variability from the low emissions scenario.
51. The Government's National Policy Statement for National Networks (Ref 14) includes guidance on the assessment of Climate Change and states 'Where transport infrastructure has safety-critical elements and the design life of the asset is 60 years or greater, the applicant should apply the UKCP09 high emissions scenario against the 2080 projections at the 50% probability level.
52. The latest update on the UK progress to meeting the UK Carbon Plan targets identifies the UK is currently at risk of meeting its targets and new policy is required to address the current gap.
53. In this context and given the nature of the proposed development on the national rail network and its anticipated life of 60 years it is considered appropriate to follow the Government's guidance and use the high emissions scenario, 2080 projections.

### ***Project Assessment Timeframe***

54. The consideration of potential climate change impacts have been undertaken in accordance with defined and agreed timeframes for construction and operation. Table 7 below details the anticipated project construction and operational timescales.

55. It should also be noted that the Government have recently provided funding to update the UKCP09 datasets in line with recent trends in global GHG emissions and internationally significant GHG reduction agreements such as the Paris Accord.

**Table 7: Project and UKCPO9 timeframes**

Timeframe	Construction	First Occupation	Short term Operation	Long Term Operation
Project Timeframe	2019-2029	2021	2029-2039	2039-2089
Corresponding UKCPO9 Timeframe	2020	2020	2050	2080

56. Given the scale and nature of the Proposed Development, professional judgement has been used to confirm that the most suitable climate change projections to be used for the assessment is the high emissions scenario for East Midlands and that the worst case assessment would be to consider the impacts at 2080 which can be considered as the long term operation of the development.

#### ***Future Climate Predictions – Temperature and Rainfall***

57. Table 8 below summarises the UKCP09 dataset for East Midlands for the 2020s, 2050s and 2080s (Ref 15, 16, 17) high emissions scenario in line with the construction, long-term operational and decommissioning phases of the Proposed Development covering all of the proposed works.
58. The future baseline climatic conditions cover the whole of the Proposed Development site and are relevant to all of the proposed development components.

**Table 8: UKCP09 North West England Climate Change projections as obtained from the UKCP09 website**

Timeframe	2020s	2050s	2080s
Temperature	Under high emission, the central estimate of increase in winter mean temperature is 1.3C	Under high emission, the central estimate of increase in winter mean temperature is 2.5C	Under high emissions, the central estimate of increase in winter mean temperature is 3.6C
	Under high emissions, the central estimate in summer mean temperature is 1.4C	Under high emissions, the central estimate in summer mean temperature is 2.8C	Under high emissions the central estimate of increase in summer mean temperature is 4.4C
	Under high emissions, the central estimate of	Under high emissions, the central estimate of	Under high emissions, the central estimate of

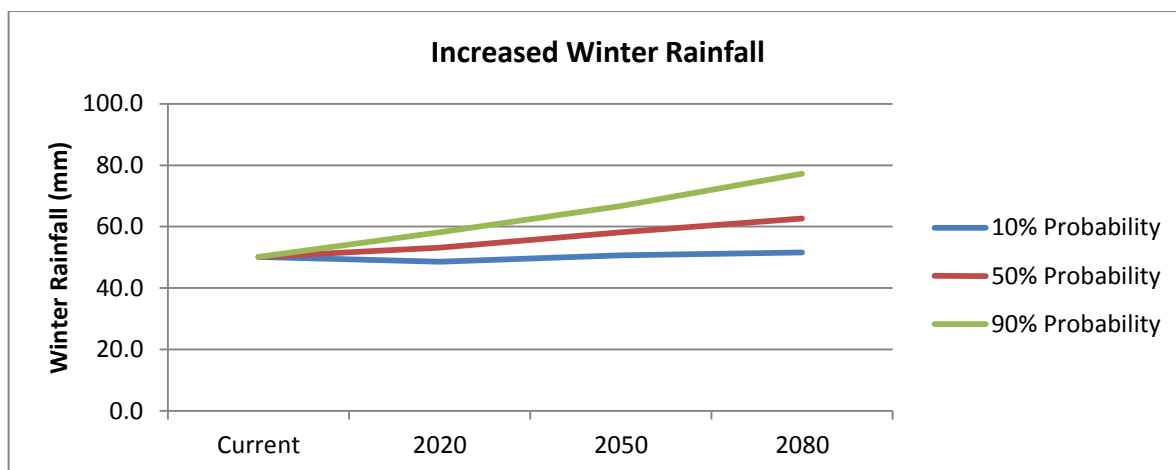
	increase in summer mean maximum temperature is 1.8C	increase in summer mean maximum temperature is 3.8C	increase in summer mean daily maximum temperature is 6C
	Under high emissions, the central estimate of increase in summer mean daily minimum temperature is 1.5C	Under high emissions, the central estimate of increase in summer mean daily minimum temperature is 3.1C	Under high emissions, the central estimate of increase in summer mean daily minimum temperature is 4.9C
Rainfall	Under the high emissions, the central estimate of change in annual mean precipitation is 0%	Under the high emissions, the central estimate of change in annual mean precipitation is 0%	Under the high emissions, the central estimate of change in annual mean precipitation is 1%
	Under high emissions, the central estimate of change in winter mean precipitation is 6%	Under high emissions, the central estimate of change in winter mean precipitation is 16%	Under high emissions, the central estimate of change in winter mean precipitation is 25%
	Under high emissions, the central estimate of change in summer mean precipitation is -- 4%	Under high emissions, the central estimate of change in summer mean precipitation is - 17%	Under high emissions, the central estimate of change in summer mean precipitation is - 25%

### ***Future Climate Variance***

59. The NPSNN guidance on Climate Change states developments should use the UKCP09 high emissions scenario against the 2080 projections at the 50% probability level and Table 8 sets out how the projections change over time to 2080 showing the 50% probability scenario.
60. While the central estimate provides the most likely prediction the 10% and 90% probability figures given as part of the high emissions scenario provide a wide range where the impacts of climate change are expected to fall.
61. The following graphs demonstrate the variance in the climate change predictions for four of the key impacts anticipated to affect the Proposed Development using the baseline climate data as the starting point showing how the climate for the East Midlands is expected to change over time.

### ***Increase in Winter Rainfall***

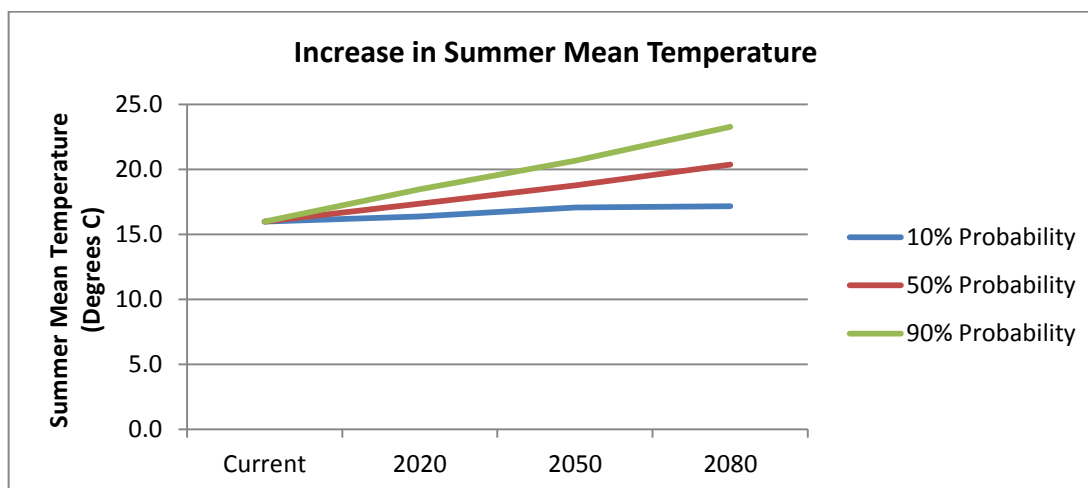
62. The UKCP09 projections note a potential increase in winter rainfall. Figure 1 shows the predicted rise in winter rainfall from 2020 to 2080 showing the potential variance between the 10% and 90% probability.



**Figure 1: Increase in Winter Rainfall**

***Increase in Summer Mean Temperature***

63. The UKCP09 projections note a potential increase in summer mean and daily maximum temperature. Figure 2 shows the predicted rise in summer mean temperature from 2020 to 2080 showing the potential variance between the 10% and 90% probability.

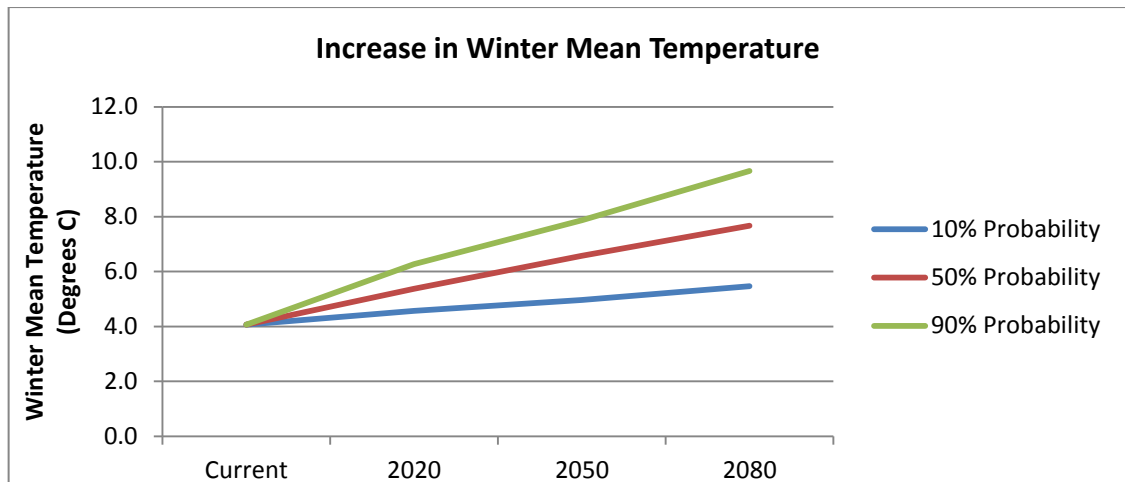


**Figure 2: Increase in Summer Mean Temperature**

***Increase in Winter Mean Temperature***

64. The UKCP09 projections note a potential increase in winter mean temperature. Figure 3 shows the predicted rise in winter mean temperature from 2020 to 2080 showing the potential variance between the 10% and 90% probability.

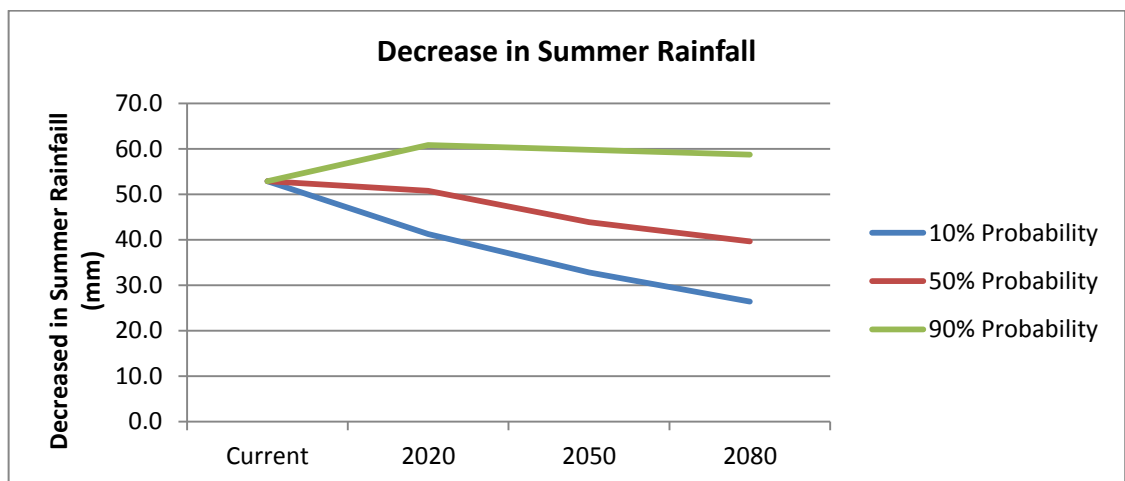




**Figure 3: Increase in Winter Mean Temperature**

#### ***Decrease in Summer Rainfall***

65. The UKCP09 projections note a potential decrease in summer rainfall. Figure 4 shows the predicted fall in summer rainfall from 2020 to 2080 showing the potential variance between the 10% and 90% probability.



**Figure 4: Decrease in Summer Rainfall**

66. These graphs demonstrate the potential future climate for the East Midlands. Generally it is expected there will be an increase in annual temperatures, increase in winter rain fall and decrease in summer rainfall; however, there is a wide range of variance in these predictions. It is possible the impacts of climate change may be significantly higher, or lower than the 50% probability scenario highlighted for use by the NPSNN.

### ***Future Climate Predictions- Wind, Storms, Lightning, Snow and Fog***

67. In addition to the summary of findings set out in Table 8, Table 9 presents the UKCP09 climate change predictions of potential changes relating to wind, storms, lightning, snow and fog where possible for the period up to 2080.
68. For each of the climate variables below, where available the change described is specific to the period up to 2080 and takes into account the 50% probability estimated and is used on the basis that it is considered a worst case scenario for assessment.

**Table 9: Climate Change Predictions - Wind, Storms, Lightning, Snow and Fog**

Climate Variable	Estimated potential changes at 2080
Wind – (Ref 18)	Minor decrease in wind speed of between -0.1m/s in winter and -0.2 in summer under the high emissions scenario.
Storms – (Ref 19)	There is no consistent signal of change in either storms or blocking near the UK. Such changes as are seen are relatively modest, and the potential for substantial change appears to be small. Data is not time specific
Lightning – (Ref 20)	Increase in lightning projected for all four seasons across the UK up to the period of 2080
Snow – (Ref 21)	Reduced snowfall - Snow days projected to reduce by 80-90% in winter and 60-80% in Spring due to a shift from snow to rain up to the period of 2080
Fog – (Ref 22)	Reduced fog predicted across the UK between 10-40% through to the year 2080.

## Summary of Climate Change Impacts

69. Qualitatively the future climate of the project location at 2050 and with increasing variability up to 2080 will likely include:
- An increase in annual average temperature by 3.6 degrees in winter and 4.4 degrees in summer;
  - More very hot days particularly in long term operation with an increase in daily maximum temperature of 6 degrees;
  - More intense downpours of rain;
  - Increase in winter rainfall with reduced snowfall and winter rainfall increasing by 25%;
  - An increase in dry spells particularly in summer months with summer rainfall dropping by 25%;
  - Minimal change in wind speed;
  - No consistent change in storm frequency;
  - Increase in lightning events; and
  - Reduced fog and snowfall.
70. Given the nature of the Proposed Development a number of the potential impacts have been scoped out of the assessment which are summarised below.
71. **Wind and Storms** - Potential impacts associated with wind and storms: Given the marginal projected difference in the 2080 (worst case) scenario from the current baseline no significant effects from climate change influenced wind or storms are anticipated.
72. **Lightning** - Although there is an anticipated increase in lightning events from the current baseline these are relatively rare with the vast majority confined to the atmosphere with little or no impact upon the built environment, new buildings and structures include lightning protection as standard. It is therefore not considered appropriate to assess the potential effects and impacts of lightning further.
73. **Fog** - The occurrence of fog is also thought to reduce as a result of climate change and as this is a phenomenon that currently does not appear to have any negative impact upon the built environment it is not considered appropriate to assess this further.
74. **Snowfall** - A significantly reduced occurrence of snowfall is likely to have a projected benefit upon the Project in terms of reduced disruption due to a decrease in snowdays however it is noted that the reduced snowfall will transfer to an increase in rainfall.

75. In this context the following impacts have been identified and will be used in reviewing the potential climate change risks to the development and in the assessment of effects in the Climate Change chapter.

- Increase in winter mean temperature.
- Increase in summer mean and daily maximum temperature.
- Decrease in summer rainfall.
- Increase in winter rainfall.

76. The following section reviews the potential Project Risks associated with these impacts.

## Summary of Anticipated Risks

77. Following a review of the UK Risk Assessment, relevant guidance and the anticipated future climate within the East Midlands following climate change risks and opportunities have been identified that are specific to the Proposed Development.
78. Table 10 set out the likely potential risks and opportunities based on the anticipated future climate within the East Midlands

**Table 10: Summary of Anticipated Risks**

Climate Change Impact	Risk	Opportunity
Increase in winter mean temperature	Risk to species and habitats from changing climate space	Opportunity for new species colonisation and increase in climate space
		Opportunity for improvement in health and wellbeing, i.e. during construction
		Opportunity for reduced energy use and therefore reduced GHG emissions
Increased summer mean and daily maximum temperature	Risk to species and habitats from changing climate space	Opportunity for new species colonisation and increase in climate space
	Increase in energy demand from additional cooling required in buildings	
	Damage to electrical infrastructure, i.e. substation overheating	
	Risk of overheating impacting health and wellbeing	
	Risk of damage to rail infrastructure including rail and electrical equipment	
Decrease in summer rainfall	Risk to species and habitats from water restrictions	
	Risk to fresh water supplies	
	Risk to building and infrastructure foundations from ground movement	
Increase in	Risk of increase in flooding (fluvial and surface water) due	

winter rainfall	to increased rainfall	
	Risk to building and infrastructure foundations from ground movement	

- 79.** The following sections set out the methodology for assessing the potential severity of the risks posed by the changing climate in relation to the proposed development.

## Assessment of Risk Methodology

80. This section sets out the methodology for the assessment of the risks associated with the identified likely climate change impacts and the key components of the Proposed Development. To determine the potential risk of the impacts of climate change with relation to the proposed development the following tables will be used to define the severity of the risk, and the nature of the risk and then the overall risk to the Proposed Development.
81. The criteria adopted for this assessment have been developed based on the application of professional judgement. The tables in this section provide a summary of how the level of climate change risk has been assessed with relation to the Proposed Development.

### Severity of Risk

82. Table 11 sets out the definition for the severity of the risk posed. The identified risks have the potential to have impact on the Proposed Development through effects to the infrastructure including structural failure and damage, and during the operation of the development leading to a loss of operation.

**Table 11: Severity of Impact**

Severity of Impact	
High	Severe risk, i.e risk of structural failure to infrastructure such as roads, rail and buildings, or, risk of total loss of species or habitats
Moderate	Moderate risk, i.e. risk of structural damage to infrastructure, or loss of species or habitats
Low	Low risk, i.e. significant operational loss/change to the site, a negative impact on site species
Very Low	Very Low risk i.e. minor operational loss/change to site operation.
Negligible	Increased site maintenance requirement

### Nature of Risk

83. Table 12 sets out the definition for the nature of the impact posed. The identified risks are characterised by their nature, i.e. some are continual, others are seasonal, and others may have a short term daily effect.

**Table 12: Nature of Impact**

Nature of Impact	
Continual	Continual impact likely to have an effect all year and ongoing, for example increased winter and summer temperatures

Seasonal	Seasonal impacts, i.e. increased winter rainfall and decreased summer
Frequent	A frequent or short term continuous impact i.e. a long period of rainfall or increased temperature.
Infrequent	Infrequent impact from climate change, i.e. a rise in daily maximum temperature
Very infrequently	Occasional impact as a result of climate change.

### Level of Risk

84. The level of risk posed by the identified risks has been assessed using Table 13, which defines the level of risk from Negligible to High; the higher the risk the greater potential impact posed to the proposed development.

**Table 13: Level of Risk**

	Severity of Impact				
Nature of Impact	High	Moderate	Low	Very low	Negligible
Continual	Very High	High	Moderate	Low	Low
Seasonal	High	High	Moderate	Low	Low
Frequent	Moderate	Moderate	Moderate/Low	Low	Very low
Infrequent	Moderate	Moderate	Low	Very low	Very low
Very infrequently	Moderate	Low	Low	Very low	Negligible

85. At this stage it is considered that any risk which is assessed to be moderate or higher should be considered when assessing the effects of climate change on development.



## Project Risk Assessment

86. This section provides a summary of the risk assessment carried out to determine the potential risk climate change poses to the Proposed Development. The Table below reviews the severity and nature of each risk to determine the overall risk and potential likelihood for an impact. Those with a moderate or higher risk are considered significant and will be considered in the assessment of Climate Change effects in the Climate Change Adaptation chapter.

**Table 14: Project Risk Assessment Summary**

Climate Change Impact	Risk	Severity of Impact	Nature of Impact	Risk Assessment
Increase in Winter Mean Temperature	Risk to landscape and mitigation species and habitats from changing climate space	Moderate – Potential for the loss of species through climate space changes	Continual – Linked to a rise in summer temperature this risk is considered to be continual	High
Increased summer mean and daily maximum temperature	Risk to landscape and mitigation species and habitats from changing climate space	Moderate – Potential for the loss of species through climate space changes	Continual – Linked to a rise in summer temperature this risk is considered to be continual	High
	Increase in energy demand from additional cooling required in buildings	Low – Likely to have minor change to operational energy	Frequent/Seasonal – Linked to periods of extreme temperature, likely to be short lived	Moderate
	Damage to electrical infrastructure, i.e. substation overheating	High – Potential damage to electrical equipment likely to be a severe impact	Frequent/Seasonal – Linked to periods of extreme temperature, likely to be short lived	High
	Risk of overheating impacting health and wellbeing	Low – Likely to have minor impact on wellbeing	Frequent/Seasonal – Linked to periods of extreme temperature, likely to be short lived	Moderate
	Risk of damage to rail infrastructure including rail and electrical equipment	High – Potential damage to electrical equipment likely to be a severe impact	Frequent/Seasonal – Linked to periods of extreme temperature, likely to be short lived	High

Decrease in summer rainfall	Risk to landscape and mitigation species and habitats from changing climate space	Moderate – Potential for the loss of biodiversity /severe impact on habitats and species	Seasonal – Linked to increased summer rainfall and a decrease in rainfall over the same period	High
	Risk to fresh water supplies	Low – Likely to have minor impact on operation	Seasonal – Linked to increased summer rainfall and a decrease in rainfall over the same period	Moderate
	Risk to building and infrastructure foundations from ground movement	High – Potential damage to infrastructure and have a severe impact	Seasonal – Linked to periods of extreme temperature and reduction in summer rainfall	High
Increase in winter rainfall	Risk of increase in flooding (fluvial and surface water) due to increased rainfall	High – Potential damage to infrastructure and have a severe impact	Seasonal – Increase in winter rainfall also linked to an increase in winter temperature	High
	Risk to building and infrastructure foundations from ground movement	High – Potential damage to infrastructure and have a severe impact	Seasonal – Linked to an increase in winter temperature and saturated ground	High

87. In addition to the project risks identified above and number of opportunities were identified during this assessment that have the potential to provide benefits to the Proposed Development and should also be considered in the assessment of effects within the Climate Change EIA chapter.

**Table 15: Climate Change Opportunities**

Climate Change Impact	Opportunity
Increase in winter mean temperature	Opportunity for new species colonisation and increase in climate space
	Opportunity for improvement in health and wellbeing
	Opportunity for reduced energy use and therefore reduced GHG emissions

Increased summer mean and daily maximum temperature	Opportunity for new species colonisation and increase in climate space
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## **Limitations and Assumptions**

88. There is strong scientific evidence that climate change will impact on the environment as well as having economic and social effects due to global warming and changes in climate. While it is accepted average UK temperatures will continue to rise it is less clear how other climate variable will change as a result and therefore the assessment of future climate risks needs to take into account a range of outcomes.
89. The key limitation of the Risk Assessment and Climate Change Chapter is the potential variability in the Climate Change predictions. Climate modelling is in its nature extremely difficult and understanding how increasing GHG emissions will interact with global climate and weather patterns in the future is challenging.
90. As stated the UKCP09 projections are based upon scenarios presented by the IPPC, the high emissions scenario used for the assessment of the proposed development itself includes a degree of potential variation as set out in this appendix.
91. While the exact magnitude of the impacts is not known the general trends of climate change are well established and the effects are already evident, in this context the use of the projections as suggested in the NPSNN are assumed to be suitable for the assessment of potential risks.

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