

Havant Thicket Reservoir Project

Environmental Statement Volume 2 – Main Report Chapter 17 Vulnerability to Climate Change

Portsmouth Water Ltd.

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Contents

Chapter	Page
17. Vulnerability to climate change	4
Introduction	4
Competent expert experience	4
Legislative and policy framework	4
Study area	8
Assessment methodology	9
Assessment assumptions and limitations	12
Baseline conditions	13
Scope of assessment	21
Design, mitigation and enhancement measures	23
Assessment of vulnerability to climate change	23
Significant and residual effects	50
Monitoring	50
Summary	50

Tables

Table 17-1 - Legislation, regulatory, and policy framework for the vulnerability to climate change assessment	5
Table 17-2 - Overall likelihood score	10
Table 17-3 – Overall consequence score	12
Table 17-4 - Significance of the climate vulnerability	12
Table 17-5 - Climate change risk assessment	24
Table 17-6 - In-combination climate change impact assessment	42

Figures

Figure 17.1 - Long-term average monthly mean temperature (1981-2010)	14
Figure 17.2 - Long-term average monthly maximum temperature (1981-2010)	14
Figure 17.3 - Long-term average days with ground frost (1981-2010)	15
Figure 17.4 - Long-term average monthly rainfall (1981-2010)	15
Figure 17.5 - Long-term average days with rainfall above 10mm (1981-2010)	16
Figure 17.6 - Projected average mean winter temperatures (2071-2089)	17
Figure 17.7 - Projected average maximum summer temperature (2071-2089)	18
Figure 17.8 - Projected average summer precipitation (2071-2089)	19
Figure 17.9 - Projected average winter precipitation (2071-2089)	20

17. Vulnerability to climate change

Introduction

- 17.1. Climate change and climate variability present both challenges and opportunities for the successful construction and operation of the Havant Thicket Reservoir Project - the Scheme. This Environmental Statement assesses these factors in two separate chapters in ES Volume 2:
 - Chapter 16 Effects of the Scheme on climate; and
 - Chapter 17 Vulnerability of the Scheme to climate change (this chapter).
- 17.2. This chapter provides an assessment of the vulnerability of the Scheme to climate change, including:
 - An examination of the current climate baseline using the Met Office's latest regional dataset of 30-year averages and data from nearby long running meteorological stations;
 - A consideration of the projected future climate baseline for the period 2071-89;
 - An assessment of how the Scheme may be vulnerable to the impacts of climate change during its construction and operation;
 - Identification of specific mitigation to adapt the design and operational processes to reduce the Scheme's potential adverse climate vulnerabilities;
 - An assessment of the residual climate change vulnerability of the Scheme that considers both adverse and beneficial vulnerability impacts by quantifying their likelihood and consequence of each potential vulnerability.
- 17.3. The adopted assessment approach reviews how climate change could affect the Scheme's assets, as well as how it could affect the potential environmental impacts identified in the other chapters of this assessment, i.e. how it could impact environmental receptors.
- 17.4. The main objective of the assessment is to ensure that climate change, and impacts associated with extreme weather, are considered during planning so that they can be avoided and, if that is not possible, mitigated during the construction and operation of the Scheme.
- 17.5. The scope of the climate vulnerability assessment overlaps with aspects of other chapters in this ES Volume 2, in particular:
 - Chapter 15 Water environment - which includes consideration of the impact of future climate change on the water environment through, for example, increased high intensity short duration rainfall events; and
 - Chapter 20 Vulnerability to major accidents and disasters - which includes the consideration of the role of climate change in affecting the frequency and severity of major accidents and disasters.

Competent expert experience

- 17.6. This chapter has been prepared by the following individuals who have used their knowledge and professional judgement to undertake this assessment:
 - a Chartered Water and Environmental Manager who is also a Chartered Environmentalist and holds professional memberships including Member of the Chartered Institution of Water and Environmental Management (M.CIWEM) and Fellowship of the Royal Geographical Society (F-RGS). They have 14 years of experience in environmental impact assessment and have used their knowledge and professional judgement to complete this assessment.
 - This chapter was reviewed by a Chartered Environmentalist who holds professional memberships including Membership of Institute of Environment Management and Assessment and Engineer's Australia.

Legislative and policy framework

- 17.7. The following legislation and policies govern assessment of vulnerability to climate change and have been consulted in preparing this chapter, with the relevant portions summarised in Table 17-1.

Table 17-1 - Legislation, regulatory, and policy framework for the vulnerability to climate change assessment

Legislation/ Regulation/ Policy	Summary of requirements
National	
Climate Change Act, 2008 ¹	The Climate Change Act (2008) created a new approach to managing and responding to climate change in the UK, by: • Setting ambitious, legally binding reduction targets; • Taking powers to help meet those targets; • Strengthening the institutional framework; • Enhancing the UK's ability to adapt to the impacts of climate change; and • Establishing clear and regular accountability to the UK Parliament and to the developed legislatures. Key provisions of the Act in respect of climate change adaptation include a requirement for Government to report, at least every five years, on the risks to the UK of climate change, and to publish a programme setting out how these will be addressed. This Act also introduces powers for Government to require public bodies and statutory undertakers to carry out their own risk assessment and make plans to address those risks.
Environmental Impact Assessment Regulations, 2017 ²	The Regulations require a description of the likely significant effects of the project on climate (for example the nature and magnitude of greenhouse gas emissions) and the vulnerability of the project to climate change.
Draft National Policy Statement for Water Resources Infrastructure ³	This draft policy statement sets out how the NPS should put government policy on climate change adaptation into practice for nationally significant infrastructure projects. Whilst the Scheme is not deemed to be a NSIP, the final NPS will be a material consideration in particular in terms of how the applicant and the Secretary of State take into account the effects of climate change when developing and considering applications relating to water resources.
National Infrastructure Commission's Report on Preparing for a Drier Future, 2018 ⁴	This report sets out that climate change, an increasing population and the need to protect the environment are increasing the risk of severe water shortages in England (especially in the drier South and East). Maintaining the current levels of resilience (to the worst historic drought) in the face of rising population, environmental and climate pressures to 2050, would require additional capacity of at least 2,700-3,000 million litres per day (ML/day) in England. Given the uncertainties this figure could be higher. The analysis concludes that concerted action is needed to address these challenges and that this action should be upfront to avoid the risk of drought rather than relying on emergency responses which would generate significant

¹ <http://www.legislation.gov.uk/ukpga/2008/27/contents>

² <http://www.legislation.gov.uk/ukpga/2008/27/contents>

³ https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/draftnpswaterresourcesinfrastructure.pdf

⁴ <https://www.nic.org.uk/wp-content/uploads/NIC-Preparing-for-a-Drier-Future-26-April-2018.pdf>

	environmental and public health impacts. The report also stresses that new reservoirs must be planned well before they are needed because of the delay between planning and their becoming operational.
Water UK's Technical Report on Water Resources Long Term Planning Framework, 2016⁵	Relevant headlines from this report are summarised below: • There is a significant existing level of drought risk that is present across many parts of South East England; • The environmental consequences of relying upon Drought Orders and Permits as a means of deferring expenditure on expensive water resource infrastructure should be carefully considered if enhanced resilience is sought for the industry; • Impacts of climate change on drought risks are uncertain. Some water companies may already be exposed to a level of risk that is larger than their current resilience; • Analysis confirms that a 'twin track' approach of demand management coupled with appropriate development of new resources and potential transfers is the most suitable strategy for providing drought resilience in the future.
Environment Agency's State of the Environment Water Resources Report, 2018⁶	Key findings of the report are summarised below: • Climate change will affect the amount and timing of rainfall that supports river flows and replenishes groundwater. It will also influence the demand for water and its quality, as well as the way land is used – all of which will put pressure on water resources⁷; • Water treatment plants, pumping stations and sewers that are designed to cope with the past and present climate may no longer be adequate. The reliability of existing reservoirs, groundwater sources and river intakes will change. Some infrastructure, critical for providing water supplies, will be more vulnerable to flooding; • If we do not increase water supply, reduce demand and cut down on wastage, many areas will face significant water deficits by 2050, particularly in South East England; The consequences of drought for society, the environment and the economy can be severe. Extreme drought would lead to increased pressure on health services and reductions in power generation and agriculture production. Farmers might lose money through crop damage or animal disease and deaths, as well as having to pay extra for access to water.

⁵ https://www.water.org.uk/wp-content/uploads/2018/11/WaterUK-WRLTPF_Final-Report_FINAL-PUBLISHED-min.pdf

⁶ <https://www.nic.org.uk/wp-content/uploads/NIC-Preparing-for-a-Drier-Future-26-April-2018.pdf>

⁷ Committee on Climate Change (2017). UK Climate Change Risk Assessment 2017. Synthesis report: priorities for the next five years. London: Committee on Climate Change (www.theccc.org.uk/wp-content/uploads/2016/07/UKCCRA-2017-Synthesis-Report-Committee-on-Climate-Change.pdf)

Local

Hampshire County Council Climate Emergency Declaration, 2019 ⁸	Hampshire County Council declared a Climate Emergency in June 2019. The Council is now committed to preparing the area's environment, infrastructure and communities to be resilient to the impacts of climate change. The Council is currently preparing an adaptation framework and carbon pathway to guide its aspirations.
East Hampshire District Council, Draft Local Plan, 2017-36 ⁹	In July 2019 East Hampshire District Council declared a climate emergency ¹⁰ . The Council also announced how it would be taking appropriate urgent, positive and deliverable steps to address the challenges the climate emergency presents. Commitments include: • Core Objective B of the plan is to provide well-designed new developments that are in the right location and adaptable to climate change; • Inappropriate development in areas at risk of flooding (whether existing or future) will be avoided. This will require addressing all sources of flooding and providing consideration of climate change impacts; • Landscaping should encourage adaptation to climate change by providing shade, shelter and cooling.
Havant Borough Council, Local Plan Consultation, 2018 ¹¹	The Council recognises a need to provide additional sustainable housing in the borough and has published outline environmental considerations and constraints on these needs. Feedback is being sought to enable derivation of a Local Plan. With regard to climate vulnerability the outline considerations published recognise that: • Changes in rainfall and rises in temperature are predicted; • It is vital that future development in the borough responds and adapts to the changing climate; • New drainage systems must meet the needs of the development in full over the lifetime of the development and not increase flood risk elsewhere.
Water Resources in the South East (WRSE) - Source to Tap Report on the South East's Strategy for Water, 2018 ¹²	This study modelled possible solutions to fix the predicted shortfall in water in the south east for a wide range of possible future scenarios (varying population, policy and climate change). Havant Thicket Reservoir was one of 16 reservoir and surface water options identified as a possible solution.

⁸ <https://www.hants.gov.uk/landplanningandenvironment/environment/climatechange>

⁹ <https://www.easthants.gov.uk/sites/default/files/documents/Draft%20Local%20Plan.pdf>

¹⁰ <https://www.climateemergency.uk/blog/east-hampshire/>

¹¹

<https://www.havant.gov.uk/sites/default/files/documents/Where%20next%20for%20Environment%20optimised.pdf>

¹² <https://corporate.southeastwater.co.uk/media/2346/water-resources-in-the-south-east-group.pdf>

Portsmouth Water Resource Management Plan, 2019¹³

The plan identifies the Havant Thicket Winter Storage Reservoir as a significant option to help deliver resilience in South East England, providing a large proportion of the additional water supply required to balance regional supply and demand from 2029/30 onwards.

Once constructed, the reservoir will provide a conjunctive use scheme which anticipates the future effects of climate change to store excess water from the source springs in wetter winters, to be supplied to customers in drier summers. However, the WRMP notes that once the water is in the reservoir, it may be affected further by climate change impacts e.g. though evaporation. Impacts of this are mitigated as water taken from the reservoir into supply would be conditional on the ability of the reservoir to maintain sufficient flows (called a hands-off flow constraint) in the reservoir's outlet streams, Brockhampton Mill Lake and Langstone Mill Stream.

Consultation

- 17.8. In relation to flood risk and drainage design, NPPF 2019 planning requirements and EA design guidance relating to climate change apply. Therefore, a separate Flood Risk Assessment (FRA) has been conducted, which includes an assessment of climate change effects on flood risk, taking into account current EA climate change allowances for increases in peak river flow and rainfall intensity. A summary of the consultation on these assessments is presented below and the results are referenced in this chapter as appropriate. A copy of the FRA is included in Appendix A15.2 FRA in ES Volume 4.
- 17.9. Through consultation with the relevant key stakeholders, the scope of the FRA has been designed to include a thorough assessment of baseline flood risk, the potential impact on flood risk of the operation of the scheme, the potential impact on flood risk of the construction of the scheme, and an assessment of the residual risk posed, namely by failure of the reservoir embankment and by emergency rapid drawdown of the reservoir.
- 17.10. Formal consultation meetings regarding the FRA have been held with:
 - Environment Agency;
 - Havant Borough Council (LPA); and,
 - Hampshire County Council (LLFA).
- 17.11. The purpose of consultation has been to agree the scope of the FRA, and agree specific approaches regarding:
 - Assessment of the baseline flood risk - determining the required return periods for modelling;
 - Emergency Drawdown Strategy - agreeing the parameters by which it can be determined whether the Drawdown Strategy is considered acceptable; and
 - Assessment of the with-scheme impacts - determining the required return periods for modelling, and the approach to breach assessment.
- 17.12. As part of the consultation, an updated Infoworks ICM v9.0.2 flood risk model was reviewed and approved by the Environment Agency in 2019. Consultation with the Environment Agency occurred in January 2020 to confirm the required return periods for baseline assessment.

Study area

- 17.13. The study area for assessing the Schemes vulnerability to climate change is based on the red-line boundary of the site (see Figure 2.1 Site Location in Chapter 2 Description of the Development in ES Volume 2) including compounds and temporary land take. The red line boundary of the reservoir is approximately 295 hectares, and the red line boundary of the pipeline corridor is approximately 21 hectares. The study area also incorporates the area of the

¹³ <https://www.portsmouthwater.co.uk/wp-content/uploads/2019/11/Final-Water-Resources-Management-Plan-2019.pdf>

environmental receptors examined by the other topics in this report where associated impacts could be intensified by climate change.

Assessment methodology

- 17.14. The climate vulnerability assessment is broken into two parts; an In-combination Climate Change Impacts assessment (ICCI) and a Climate Change Risk assessment (CCR). Both assessments follow best practice and are aligned with IEMA guidance¹⁴. The objective of each is described below:
- ICCI assessment – examines how the effects of the Scheme that have been identified by other environmental topics could be affected by climate change (for example how a potential impact identified by the water topic could be intensified in the future by projected changes in rainfall);
 - CCR assessment – examines the resilience of the Scheme itself, over its design lifetime (100 years), to projected future changes to the climate, for example the durability of materials used or the suitability of climate change allowances used in the drainage design.
- 17.15. Collectively the ICCI and CCR assessments examine all of the Schemes potential climate vulnerabilities (also referred to as climate vulnerability impacts), i.e. all the ways its construction and operation could be susceptible to being impacted by climate change, including climate variability and extremes.
- 17.16. The assessment method for both the CCR and ICCI assessment is multi staged and was agreed in the EIA Scoping Report Addendum (November 2019). An overview of the method is provided below; this staged process is followed separately for each potential climate vulnerability:
- Stage 1a - Assess the likelihood of the climate hazard occurring;
 - Stage 1b - Assess the likelihood of the climate hazard affecting receptors;
 - Stage 2 - Combine 1a&b to give an overall likelihood score;
 - Stage 3a - Assess the magnitude of consequence;
 - Stage 3b - Assess the regularity and length of consequence (frequency and duration);
 - Stage 4 - Combine 3a&b to give an overall consequence score;
 - Stage 5 - Determine significance based on a combination of likelihood and consequence.
- 17.17. Output from stage 1a and 1b are combined to produce an overall likelihood score in stage 2. Output from stage 3a and 3b are combined to produce an overall consequence score in stage 4. Stage 5 combines these two overall scores (from stage 2 and 4) to determine the significance of the potential climate vulnerability.

Stage 1a - Assess the likelihood of a climate hazard occurring

- 17.18. A climate hazard is a meteorological event that has the potential to do harm to the Scheme or its surrounding environment, for example very heavy rainfall or increased summer temperatures.
- 17.19. The likelihood of each climate hazard occurring is determined using data from the baseline assessment as well as professional judgement. Categories range from:
- High - The climate hazard is expected to occur multiple times during the lifetime of the project, e.g. annually or every other year;
 - Medium - The climate hazard is expected to occur several times during the lifetime of the project, e.g. approximately once every five years;
 - Low - The climate hazard occurs infrequently during the lifetime of the project, e.g. approximately once every 15 years;
 - Negligible - The climate hazard is not expected to occur more than once during the lifetime of the project.

¹⁴

[https://www.iema.net/assets/templates/documents/iema_guidance_documents_eia_climate_change_resilience_and_adaptation%20\(1\).pdf](https://www.iema.net/assets/templates/documents/iema_guidance_documents_eia_climate_change_resilience_and_adaptation%20(1).pdf)

- 17.20. When defining the climate hazard likelihood, consideration has been given to the projected return periods of future events (where known), the confidence in the direction of projected changes, as well as to the extent of that change relative to the climate baseline.

Stage 1b - Assess the likelihood of the climate hazard effecting receptors

- 17.21. Climate hazards can cause damage or interference to the Scheme or its surrounding environment (in construction or operation). The likelihood of this is determined following consideration of the receptor's sensitivity to the climate hazard and its adaptive capacity. For Scheme assets (the CCR assessment) this will include consideration of design adaptation measures (embedded mitigation). Four categories are used in the definition:
- High likelihood of climate hazard affecting receptor - the receptor is directly dependent on existing factors, and reliant on these specific existing climate conditions continuing in future (for example, river flows and groundwater level); or only able to tolerate a very limited variation in climate conditions;
 - Medium likelihood of climate hazard affecting receptor – the receptor is dependent on some climatic factors;
 - Low likelihood of climate hazard affecting receptor – the receptor is dependent on some climatic factors but is able to tolerate some extreme conditions; and
 - Negligible likelihood of climate hazard affecting receptor – climatic factors have very little or no influence on receptor.

Stage 2 – Create an overall likelihood score

- 17.22. For each potential climate hazard the overall likelihood of a climate vulnerability impact occurring has been assessed based on the likelihood of a climate hazard occurring and the likelihood of that hazard affecting a receptor. Table 17-2 below shows how this has been done by combining the outputs of stage 1a and 1b. This is done separately for each potential climate vulnerability rather than by receptor because receptors may be impacted by changes to multiple climate variables and could, for example, be more likely to be impacted by changes in precipitation than temperature.

Table 17-2 - Overall likelihood score

Likelihood of a climate hazard occurring (stage 1a)	Likelihood of climate hazard affecting a receptor (stage 1b)			
	Negligible	Low	Medium	High
Negligible	Negligible	Negligible	Low	Low
Low	Negligible	Low	Medium	Medium
Medium	Low	Medium	Medium	High
High	Low	Medium	High	High

Stage 3a - Assessing consequence magnitude

- 17.23. Consequences are the adverse, or beneficial, outcomes of the effects of climate hazards on receptors. For example financial costs (repair / maintenance), poor operational performance, safety risks, environmental harm and/or negative public perception. Consequence magnitude is a gauge of the size of these consequences. It considers the value of the receptor, for example its quality and importance. For environmental harm, for example, this may be represented by the receptors conservation status and for operational performance this could be based on how critical the failure of a particular performance metric is to the operation of a larger system. Assessing consequences in this way recognises that some receptors are more important than others. As such, where everything else is equal, important receptors are more likely to be significantly affected than those considered to be of low importance.

17.24. The consequence of climate change impacts will be defined as follows:

High

- Consequences have very large economic cost or affect assets that are integral to critically important systems;
- Consequences cause very large safety risks (long term injury/illness or risk of fatality) or very poor performance (e.g. outage or quality problems lasting >48 hours);
- Consequences cause prolonged negative national reporting;
- Consequences cause very large environmental pollution or harm resulting in a major breach in compliance and prosecution or adversely affect internationally important species or habitat.

Medium

- Consequences have a large economic cost or affect important systems;
- Consequences cause large safety risks (short term injury or illness) or poor performance (e.g. moderate outage or quality problems lasting <48 hours);
- Consequences cause negative regional media or social media;
- Consequences cause large environmental pollution or harm resulting in a regulatory non-compliance or affect nationally important species or habitat.

Low

- Consequences have a moderate economic cost or affect systems or assets that can be replaced;
- Consequences cause safety risks (minor harm or near miss) or slightly reduce performance (e.g. outage or quality problems lasting <1 hour);
- Consequences cause negative local media or adverse local stakeholder reaction;
- Consequences cause moderate environmental pollution or harm that may cause non-compliance of regional or local policy or affecting locally important species or habitat.

Negligible

- Consequences have little economic cost or affect individual assets and can be easily repaired or replaced;
- Consequences cause very small or no safety risks or reduced performance;
- Consequences have little or no public interest;
- Consequences have no statutory controls or cause negligible environmental pollution or harm to receptors of little or no importance.

Stage 3b - Assessing timing of consequence

17.25. Consequence timing gives consideration to the expected frequency and duration of consequences. It is categorised as set out below:

- High - consequences occur many times during the life of the Scheme, e.g. could occur seasonally or last for many months/years;
- Medium - consequences occur more than once during the life of the Scheme or lasting several months;
- Low - consequences occur once during the life of the Scheme or last several weeks;
- Negligible - consequences unlikely to occur during Schemes design life or last for only a few days.

Stage 4 – Create an overall consequence score

17.26. Table 17-3 below shows how for each vulnerability the consequence and likelihood ratings are combined.

Table 17-3 – Overall consequence score

Timing of consequence (stage 3b)	Consequence magnitude (stage 3a)			
	Negligible	Low	Medium	High
Negligible	Negligible	Negligible	Low	Low
Low	Negligible	Low	Medium	Medium
Medium	Low	Medium	Medium	High
High	Low	Medium	High	High

Stage 5 - Determining significance

- 17.27. The significance of each potential climate vulnerability is defined based on the matrix shown in Table 17-4 below.

Table 17-4 - Significance of the climate vulnerability

Overall likelihood score (stage 2)	Overall consequence score (stage 4)			
	Negligible	Low	Medium	High
Negligible	Negligible	Negligible	Minor	Minor
Low	Negligible	Minor	Minor	Minor
Medium	Minor	Minor	Moderate	Moderate
High	Minor	Minor	Moderate	Major

- 17.28. Climate vulnerability risks assessed to be ‘moderate’ or ‘major’ (marked red in Table 17-4 above) are considered to result in significant climate change vulnerability effects.

Assessment assumptions and limitations

- 17.29. The assessment provides a broad, high-level indication of the Scheme’s potential climate vulnerabilities.
- 17.30. The climate projections used are from UKCP18 (United Kingdom Climate Projections 2018). These projections have been developed by the Met Office Hadley Centre Climate Programme which is supported by the Department of Business, Energy and Industrial Strategy (BEIS) and the Department for Environment, Food and Rural Affairs (Defra)¹⁵. UKCP18 provides the most up-to-date assessment of how the climate of the UK may change over the 21st century.
- 17.31. The UKCP18 projections do not provide a single precise prediction of how weather and climate will change years into the future. Instead UKCP18 provides ranges that aim to capture a spread of possible climate responses. This better represents the uncertainty of climate prediction science. The level of certainty of the projections is dependent on the climate variable being considered, for example, there is greater confidence around changes in temperature than there is in changes to wind.
- 17.32. The UKCP data used is for a specific Representative Concentration Pathway (RCP). This is a greenhouse gas concentration trajectory that may or may not match the actual future trajectory. Following a precautionary approach, and in accordance with IEMA guidance¹⁶, data from RCP 8.5 is used in the climate vulnerability assessment. Under RCP8.5 it is assumed that emissions continue to rise throughout the 21st century. This is the most extreme emissions scenario, it represents a future where greenhouse gas emissions continue to rise, and the nations of the world choose not to switch to a low carbon future. This is considered appropriate as it provides a precautionary view of possible future climate responses.

¹⁵ <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index>

¹⁶

[https://www.iema.net/assets/templates/documents/iema_guidance_documents_eia_climate_change_resilience_and_adaptation%20\(1\).pdf](https://www.iema.net/assets/templates/documents/iema_guidance_documents_eia_climate_change_resilience_and_adaptation%20(1).pdf)

17.33. Other key caveats and limitations of UKCP18 data can be found online¹⁷.

Baseline conditions

17.34. Climate is defined as the typical weather conditions experienced in a place over a period of time, conventionally expressed as average weather over a 30-year period.

17.35. The baseline for climate change vulnerability is presented in two parts:

- The first section describes the current climatic conditions in the study area;
- The second presents a range of possible future climate projections.

17.36. It should be noted that climate change is not only a challenge of the future. We are already observing changes in the UK climate with, for example, average temperatures having risen by approximately 1°C over the last century.

17.37. In summary the climate vulnerability baseline shows that:

- The current climate in the study area is one of relatively mild winters and warm summers. Monthly average and mean maximum temperatures are amongst the highest in the UK (see Figure 17.2 and Figure 17.3 below). Long-term average monthly rainfall is close to the lowest in the UK for most of the year (see Figure 17.4 below) and the study area receives fewer heavy rainfall days than is usual for the UK (Figure 17.5 below);
- The projected climate in the study area is likely to be hotter (Figure 17.7 below) and drier (Figure 17.8 below) summers and warmer (Figure 17.6 below) and wetter (Figure 17.9 below) winters. Alongside these changes in the average conditions, it is possible, but less certain, that climate change will also increase the frequency and severity of extreme weather events, such as heavy rainfall, storms and heatwaves (see section 17.54).

Current climate

17.38. To inform adaptation decisions this section presents data from the Meteorological Office to summarise the current climate in South East England (specifically the South East England River Basin as defined by the Met Office). The Met Office's standard average data tables are used, they show the latest set of 30-year averages covering the period 1981-2010¹⁸. Context to this is provided by including comparison to the equivalent national dataset (UK minimum, average and maximum).

Temperature

17.39. Observations for the UK show that the decade leading up to the publication of UKCP18¹⁹ (2008-2017) was on average 0.3 °C warmer than the 1981-2010 average and 0.8 °C warmer than 1961-1990. All of the ten warmest years have occurred since 1990.

17.40. The climate in South East England is one of relatively mild winters and warm summers. As shown in Figure 17.1 and Figure 17.2 below, monthly average and the monthly mean of daily maximum temperatures are amongst the highest in the UK. Across the timeseries, 1981-2010, peak summer (July) average maximum temperatures of 21.8 °C in the South East are close to the maximum across the UK, 22.3 °C. Note that mean maximum temperatures are calculated as the monthly average of daily maximums - as such some individual days are likely to have recorded hotter temperatures than those stated.

¹⁷ www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---caveats-and-limitations.pdf

¹⁸ <https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages>

¹⁹ UKCP18 Climate Projections <https://www.metoffice.gov.uk/research/collaboration/ukcp>

Figure 17.1 - Long-term average monthly mean temperature (1981-2010)

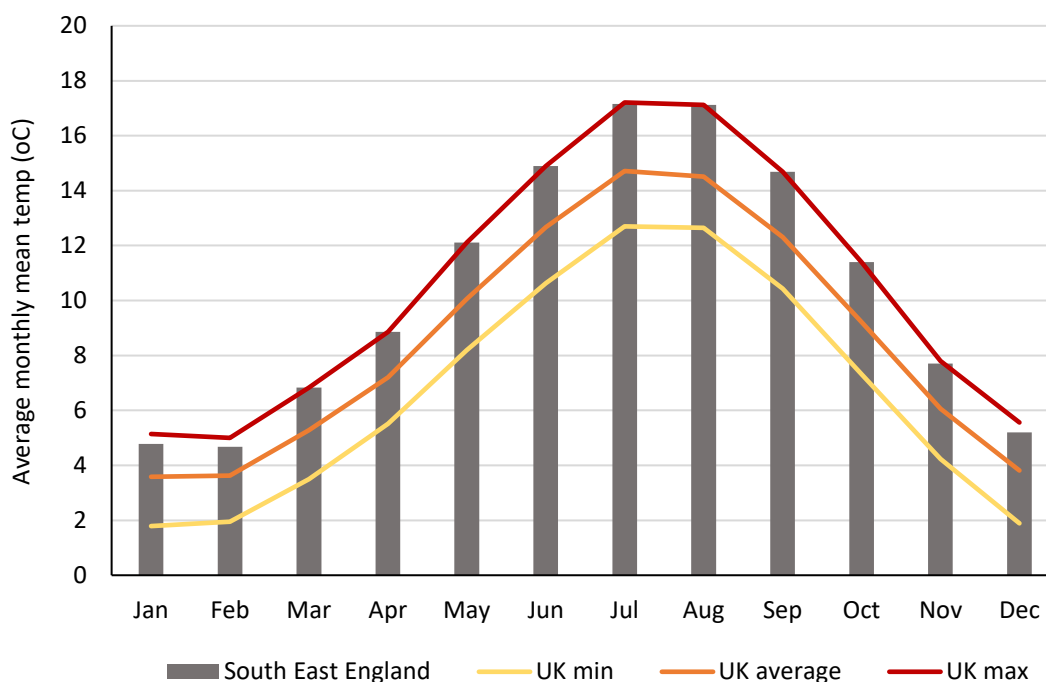
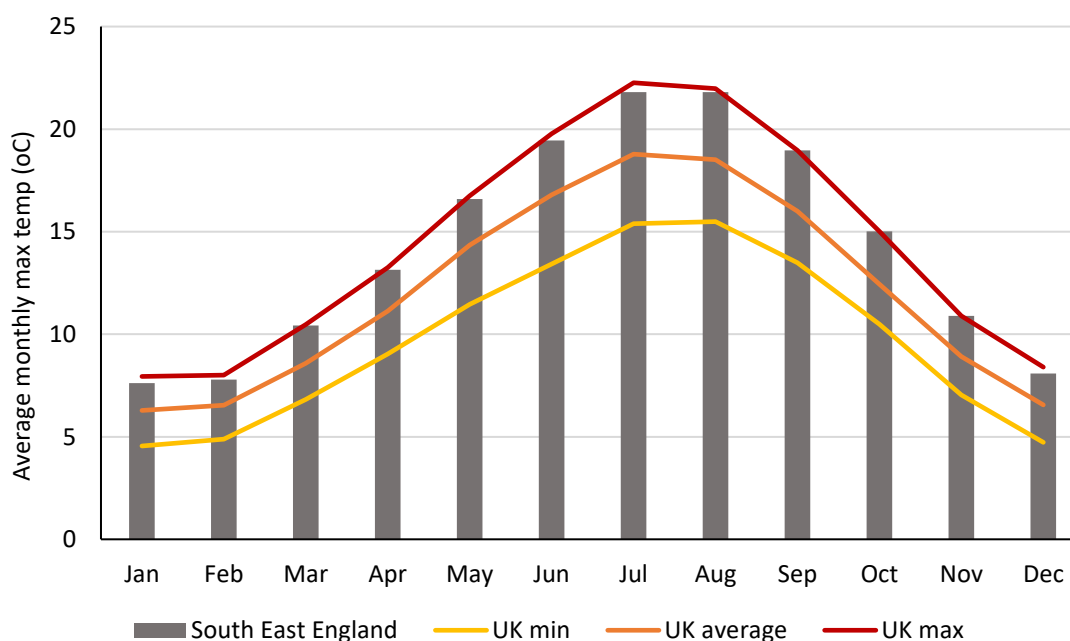


Figure 17.2 - Long-term average monthly maximum temperature (1981-2010)



Note: maximum data is monthly average of daily maximums

- 17.41. The closest long running climate station to the Scheme is located at Southampton (441600E, 111200N)²⁰. It is approximately 20 miles from the project and collected data from 1855 until it was closed in 2000²¹. In this time period the highest monthly mean daily maximum temperature (t-max) it has recorded is 27.1 °C in August 1995. The lowest mean daily minimum temperature (t-

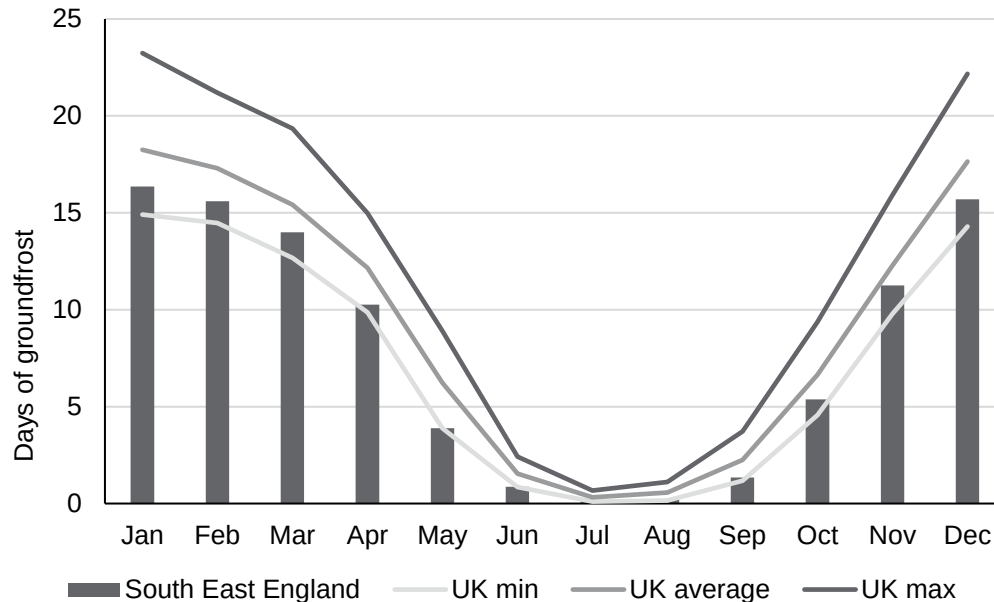
²⁰ Historic Met Station Data, <https://www.metoffice.gov.uk/research/climate/maps-and-data/historic-station-data>

²¹ <https://www.metoffice.gov.uk/pub/data/weather/uk/climate/stationdata/southamptondata.txt>

min) it has recorded is -4.6 °C in January 1963. January 1963 also recorded the stations maximum monthly number of days with air frost, 29 days.

- 17.42. As shown in Figure 17.3 below the long-term average days with ground frost (1981-2010) in the South East are between the minimum and average for the UK.

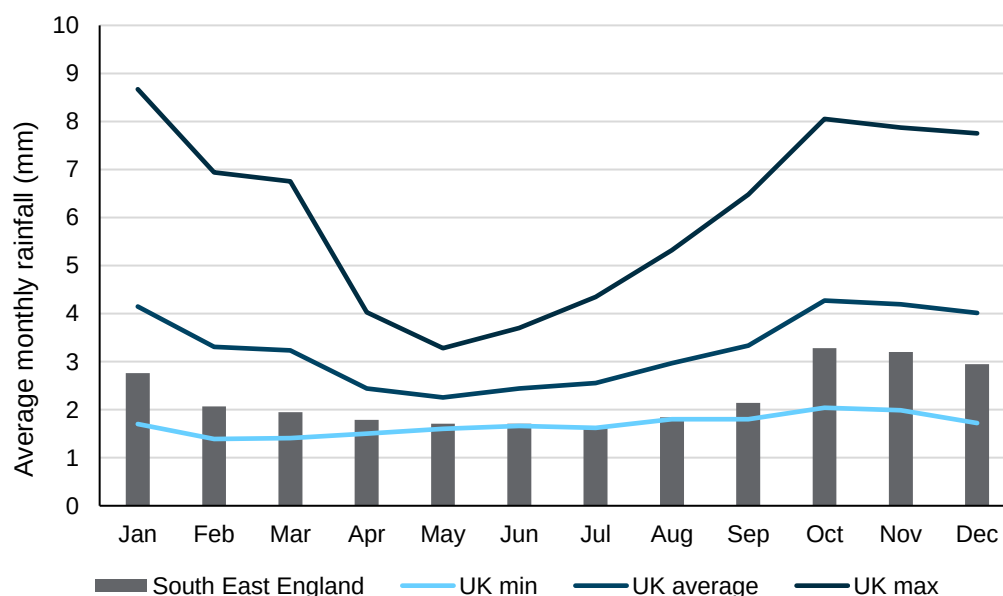
Figure 17.3 - Long-term average days with ground frost (1981-2010)



Precipitation

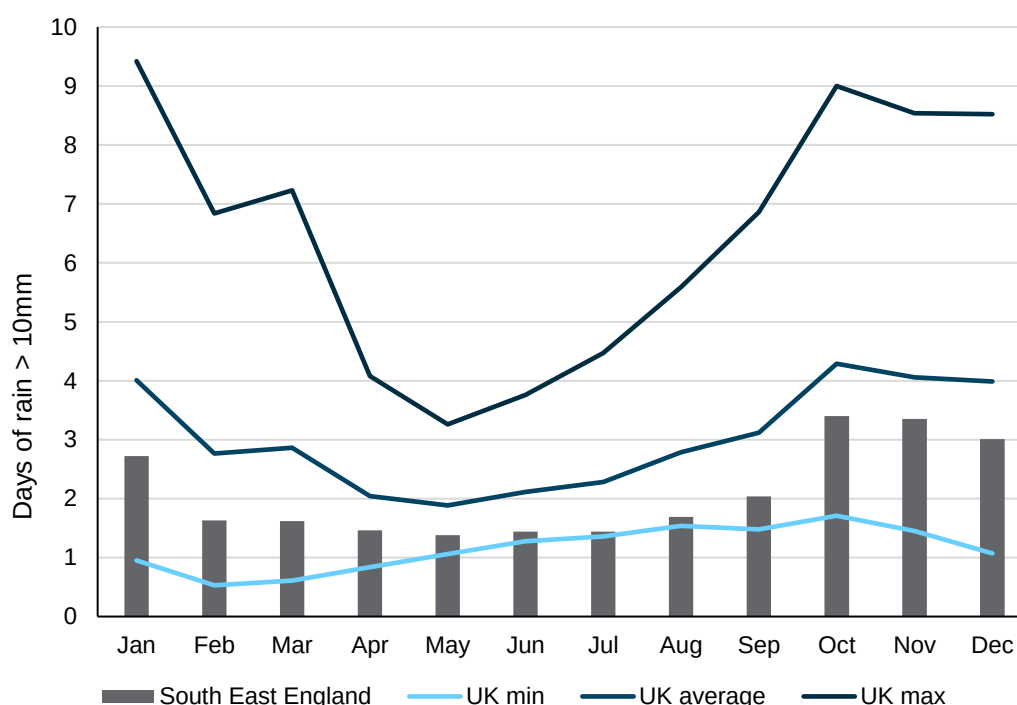
- 17.43. Observations across the UK show a high level of variability in precipitation from year to year, with a slight overall increase in UK winter precipitation in recent decades.
- 17.44. Between 1855 and 2000 the highest total monthly rainfall recorded at the climate station in Southampton was 281 mm in October 1903.
- 17.45. As shown in Figure 17.4 below, long-term average monthly rainfall (1981-2010) in the South East is typically close to the lowest in the UK.

Figure 17.4 - Long-term average monthly rainfall (1981-2010)



- 17.46. Figure 17.5 below shows the long-term average number of days that had rainfall over 10mm. It shows that the South East has experienced fewer heavy rainfall days than is usual for the UK, particularly in the summer.
- 17.47. Across the UK the amount of rain from extremely wet days has increased by 17% when comparing the period 2008-2017 to 1961-1990 period (Met Office, 2018). These changes are largest for Scotland and not significant for most of the southern and eastern areas of England. Other extreme rainfall indices exhibit large inter-annual variability but are broadly consistent with increased rainfall over the UK.
- 17.48. With regard to storminess, across the UK historical data provides no compelling trends as determined by maximum gust speeds from the UK wind network over the last four decades (UKCP18).

Figure 17.5 - Long-term average days with rainfall above 10mm (1981-2010)



Climate change projections

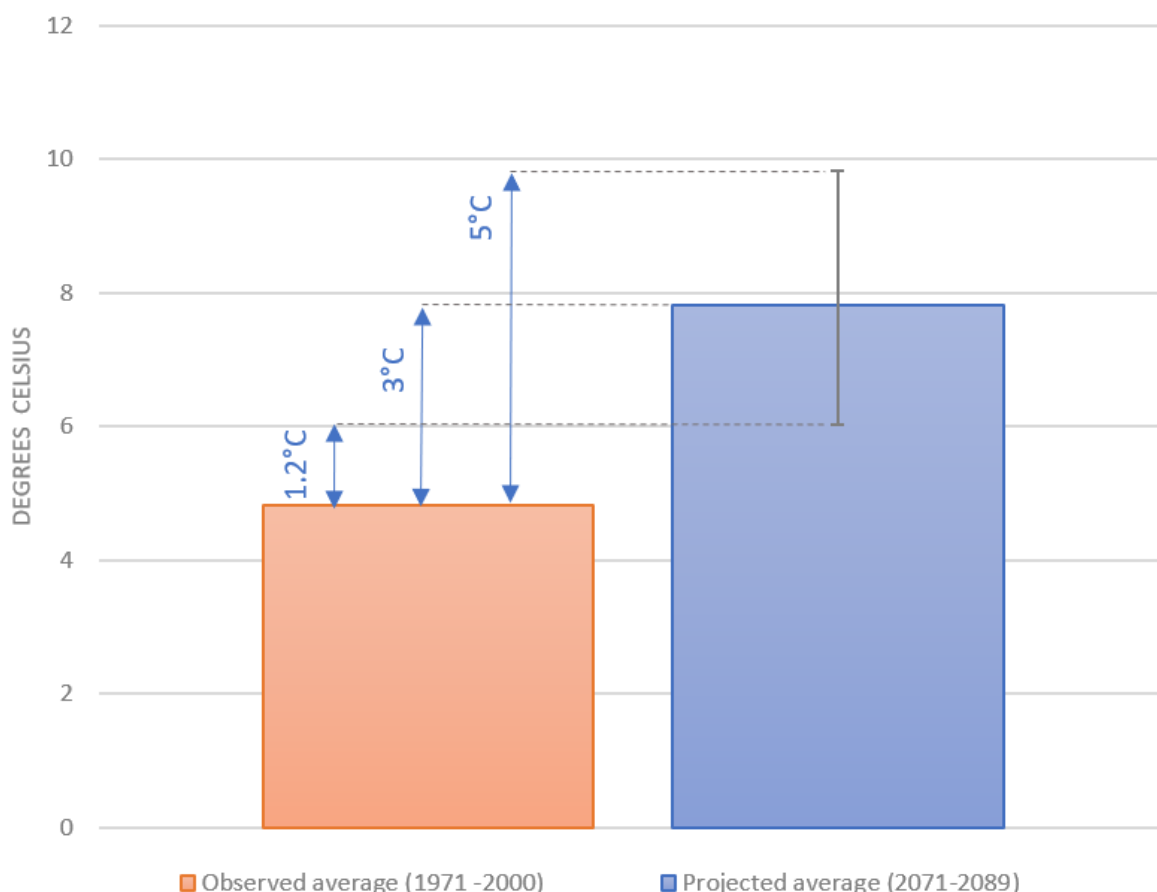
- 17.49. This section presents the output of climate change models that cover the study area. In summary these show that, on average, the UK is likely to experience hotter and drier summers and warmer, wetter winters. This is a widely agreed finding. Alongside these changes in the average conditions, it is possible that climate change will also increase the frequency and severity of extreme weather events, such as heavy rainfall, storms and heatwaves.
- 17.50. Future projections are presented from the United Kingdom Climate Projections 2018 (UKCP18) for the South East River Basin, within which the Scheme is located. The data is presented as averages for 2080 based on climate projections running from 2071 to 2089. For temperature and precipitation seasonal averages are provided for summer and winter, which represent the most extreme changes in response to climate change. The projections are probabilistic, in accordance with IEMA guidance²², those plotted are for the central estimate (i.e. 50th percentile with uncertainty represented by the 10th and 90th percentiles) and use the emissions scenario RCP8.5 (Relative Concentration Pathway 8.5). This is the most extreme emissions scenario, it represents a future where greenhouse gas emissions continue to rise, and the nations of the world choose

not to switch to a low carbon future. This is considered appropriate as it provides a precautionary view of possible future climate responses.

Temperature projections – warmer winters

- 17.51. Figure 17.6 shows that under RCP8.5 average winter temperatures in the South East are expected to increase from 4.8 °C (observed average 1971-2000) to 7.8 °C (projected average 2071-2089), an increase of 3.0°C (based on the central estimate, i.e. 50th percentile). The uncertainty around this estimate of change ranges from ~1.2°C to ~5.0°C (represented by the 10th and 90th percentile projections respectively).

Figure 17.6 - Projected average mean winter temperatures (2071-2089)



NB: The projected data is probabilistic. It shows the central estimate (50th percentile) with error bars that indicate the 10th & 90th percentiles.

- 17.52. In the UK, the heaviest snowfalls tend to occur when the air temperature is between zero and 2°C²³. The projected increase in winter temperatures are therefore expected to reduce mean snowfall, number of snow days and heavy snow events²⁴. While there is less certainty in the magnitude of these changes, there is confidence in the negative direction of the change²⁵. This is supported by the fact that the decade leading up to the publication of UKCP18 (2008-2017) had

²³ Met Office. (2013). Met Office. [online] Available at: <http://www.metoffice.gov.uk/learning/learn-about-the-weather/weather-phenomena>

²⁴ Brown, S., Boorman, P. and Murphy, J. (2010). Interpretation and use of future snow projections from the 11member Met Office Regional Climate Model ensemble. UKCP09 Technical note, Met Office Hadley Centre, Exeter, UK

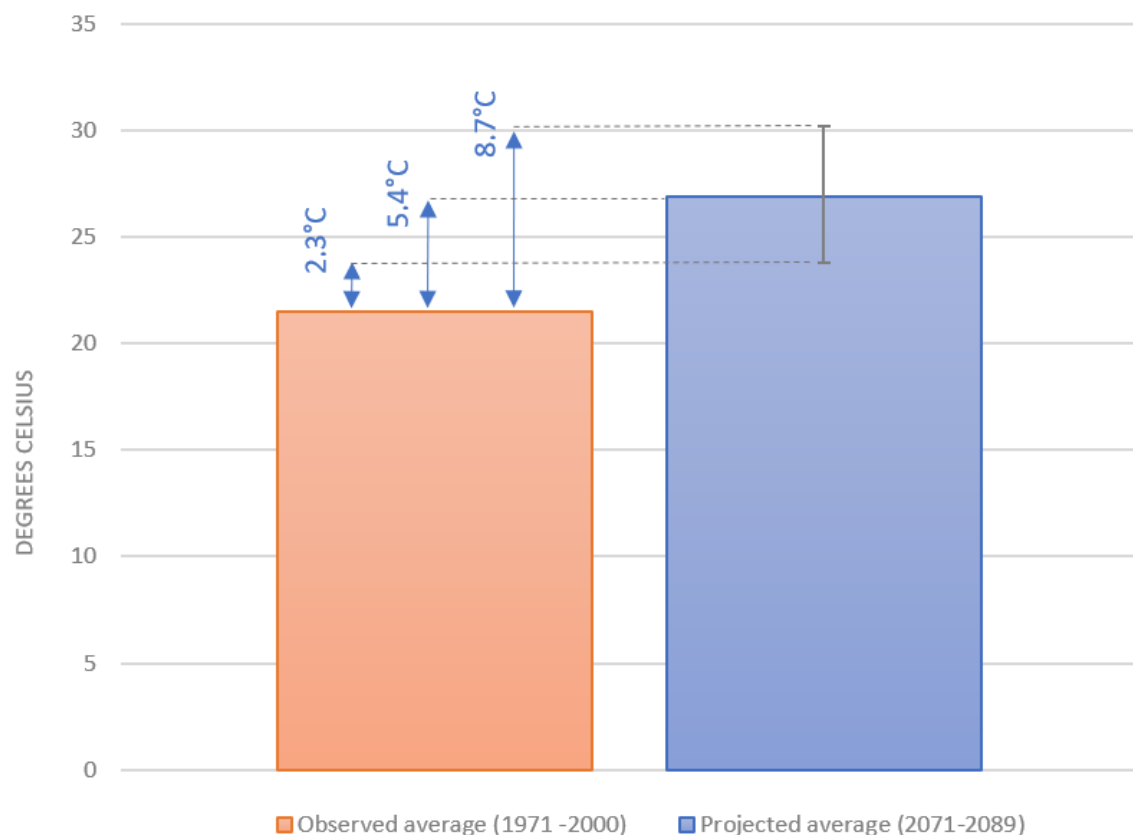
²⁵ McColl, L., Palin, E. J., Thornton, H. E., Sexton, D. M. H., Betts, R. and Mylne, K. (2012). Assessing the potential impact of climate change on the UK's electricity network. Climatic Change, 115: 821-835. OR McColl, L., Angelini, T. and Betts, R. (2012) UK Climate Change Risk Assessment for the Energy Sector. Department for Environment Food and Rural Affairs, London, UK

5% fewer days of air frost and 9% fewer days of ground frost compared to the 1981-2010 average and, respectively, 15% and 14% fewer compared to 1961-1990²⁶.

Temperature projections – hotter summers

- 17.53. In the recent past the probability of seeing a summer as hot as 2018 in the UK was low (<10%). This probability has already increased due to climate change and is now estimated to be between 10-25%. With future warming, hot summers by mid-century could become even more common (with probabilities of the order of 50% depending on the emissions scenario followed)²⁷.
- 17.54. In the South East projected mean daily maximum summer temperatures have been obtained from the UKCP18 probabilistic projections for 2071-89. Since these are an average of daily maximum values it should be noted that some days in this period are likely to be hotter than the values indicated below. Figure 17.7 below shows an increase in summer temperatures is expected by the 2080s under RCP8.5. The central estimate (i.e. 50th percentile) projects an increase in summer mean daily maximum temperatures of ~5.4°C by 2071-89.

Figure 17.7 - Projected average maximum summer temperature (2071-2089)



NB: The projected data is probabilistic. It shows the central estimate (50th percentile) with error bars that indicate the 10th & 90th percentiles

Precipitation projections - drier summers

- 17.55. In UKCP18, the probabilistic projections provide local low, central and high changes across the UK, corresponding to 10%, 50% and 90% probability levels. Projected precipitation levels for RCP8.5 have been averaged across the South East to give a range of projected average rainfall change between the 10% and 90% probability levels. As shown in Figure 17.8 below by 2071-89 this range amounts to -71% to -2% reduction in summer rainfall. The central estimate of change (i.e. 50th percentile) in mean summer precipitation for the same period is -21%. These

²⁶ Met Office, (2019) UKCP18 Science Overview Report, online:

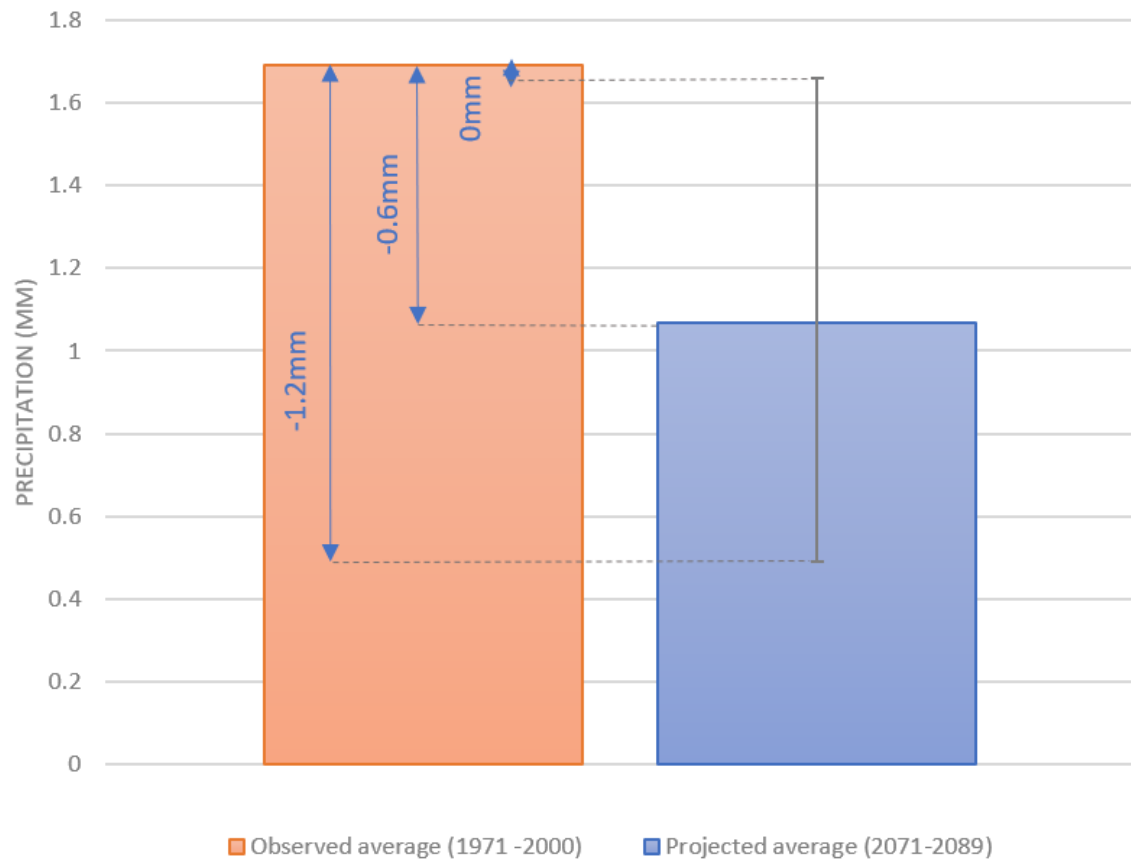
<https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf>

²⁷ Met Office (2019) UKCP18 Science Overview Report, online, available:

<https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf>

projections suggest that future average rainfall trends are uncertain, but it is more likely than not that summer rainfall will decrease.

Figure 17.8 - Projected average summer precipitation (2071-2089)

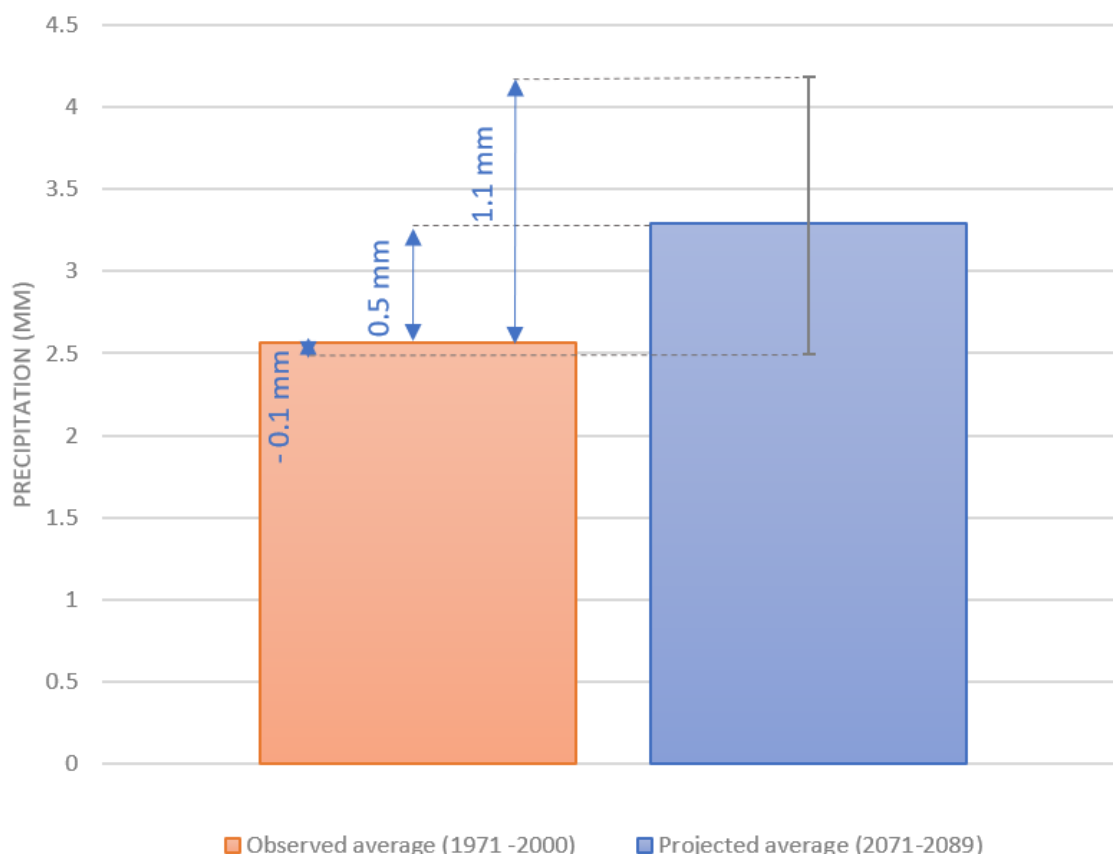


NB: The projected data is probabilistic. It shows the central estimate (50th percentile) with error bars that indicate the 10th & 90th percentiles

Precipitation projections - Heavier rainfall and wetter winters

- 17.56. Figure 17.9 below shows that UKCP18 climate projections forecast that by 2071-89, under RCP8.5 central estimate (i.e. 50th percentile), winter mean precipitation will increase by 0.5mm. However, it should be noted that year to year levels are expected to continue to vary widely as is evident in the historical record collected from Southampton climate station.

Figure 17.9 - Projected average winter precipitation (2071-2089)



NB: The projected data is probabilistic. It shows the central estimate (50th percentile) with error bars that indicate the 10th & 90th percentiles

- 17.57. Across the UK the amount of rain from extremely wet days has increased by 17% when comparing 2008-2017 with the 1961-1990 period²⁸. However, these changes are largest for Scotland and not significant for most of southern and eastern areas of England. Other extreme rainfall indices exhibit large inter-annual variability but are broadly consistent with increased rainfall over the UK.

Extreme weather projections

- 17.58. The Met Office identifies eight different types of extreme weather²⁹. This section focuses on those related to storms. Future predictions of the characteristics of storms are uncertain, for example projections depict a wide spread of future changes in mean surface wind speed³⁰. This is partly due to large uncertainty in projected changes in circulation over the UK and also because of wide ranging natural climate variability³¹. It is therefore difficult to represent extreme winds and gusts within regional climate models³². Global projections show an increase in near surface wind speeds over the UK for the second half of the 21st century for the winter season³³. These studies

²⁸ Met Office, UK extreme events, 2018, https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-extreme-events-_heavy-rainfall-and-floods

²⁹ Met Office. (2019). Extreme Weather . [online] Available at: www.metoffice.gov.uk/weather/learn-about/met-office-for-schools/other-content/other-resources/extreme-weather

³⁰ Thornton, H. (2010) Future UK circulation and wind projections and their relevance for the built environment. Met Office Hadley Centre, Exeter, UK. Crown copyright

³¹ Brown, S., Boorman, P., McDonald, R., and Murphy, J. (2012) Interpretation for use of surface wind speed projections from the 11-member Met Office Regional Climate Model ensemble. Post-launch technical documentation for UKCP09. Met Office Hadley Centre, Exeter, UK. Crown copyright

³² Ibid

³³ Met Office, UKCP18 Factsheet: Wind,

www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-wind.pdf

suggest that climate-driven storm changes are less distinct in the northern than southern hemisphere³⁴. There is some agreement of a projected poleward shift in storm tracks across the Atlantic Ocean³⁵. However, for mid-Atlantic storms, such as those that affected the UK in early 2014 projections are less certain³⁶. Potentially, those mid-Atlantic storms may become more intense, particularly with the long-term warming of the sub-tropical Atlantic that could increase the amount of moisture that those storms carry³⁷. However, such is the wide range of inter-model variation, robust projections of changes in storm tracks over the UK are not yet possible and there is low confidence in the direction of future changes in the frequency, duration or intensity of storms affecting the UK.

Scope of assessment

- 17.59. Chapter 17.4 of the Scheme's Environmental EIA Scoping Report Addendum (November 2019) sets out the extent of potential impacts to be considered in the climate vulnerability assessment. This scope is summarised in this section.

Climate hazards

- 17.60. The principle climate hazards that have the potential to impact the Scheme are summarised below:
- An increase in average temperatures;
 - An increase in maximum temperatures;
 - Heavier rain and it's in combination impacts with wetter winters;
 - Increasingly severe extreme weather - in particular more frequent and intense storms with strong winds and more regular lightning strikes.

Potential climate vulnerabilities

- 17.61. This section summarises the potential vulnerabilities of the Scheme to climate change that are associated with the climate hazards identified above.
- 17.62. Climate vulnerabilities are presented based on the Scheme phase they could affect, i.e. construction or operation. They are also split into climate change risks (CCRs) and in-combination climate change impacts (ICCI) (see the Assessment Methodology section of this Chapter for details about these two assessments).

Potential construction climate change risks:

- Extreme weather events or climatic events that compromise the viability of the construction site, including access to it. For example, heavy rain resulting in closure of local roads and power cuts due to flooding or flood inundation of the construction site itself.

Potential operational climate change risks

Climate risks affecting water resources, i.e. the supply of and demand for water:

- The reservoir will provide a regional benefit with regard to the resilience of regional water resources.
- Climate change will increase and change the nature of demand for water. This may result in changes in the way the reservoir needs to operate in the future.
- Climate change could alter aquifer recharge affecting the reservoir's supply.

³⁴ Bengtsson, L., Hodges, K. I. (2005). Storm Tracks and Climate Change. Journal of Climate, 19: 3518-3543. <http://dx.doi.org/10.1175/JCLI3815.1>

³⁵ Bengtsson, L., Hodges, K. I. (2005). Storm Tracks and Climate Change. Journal of Climate, 19: 3518-3543. <http://dx.doi.org/10.1175/JCLI3815.1>

³⁶ Slingo, J., Belcher, S., Scaife, A., McCarthy, M., Saulter, A., McBeath, K., Jenkins, A., Huntingford, C., Marsh, T., Hannaford, J. and Parry, S. (2014). The recent storms and floods in the UK, Met Office, Exeter, 29pp

³⁷ Ibid

Climate risks affecting the reservoirs water quality and treatment of raw water from it:

- Climate change will intensify and extend periods of warm weather during which the reservoir could be prone to thermal stratification.
- Climate change induced changes to the catchment upstream of the reservoir could affect the quality of inflows to the reservoir.
- Water treatment processes may need to adapt in response to changes in climate as well as in response to changes in raw water quality due to climate change.
- Changes in seasonal patterns of rainfall could affect the quality of water in the reservoir.

Climate risks affecting structures (including reservoir embankments):

- Extreme weather could be a contributing factor in an embankment failure and subsequent widespread flooding.
- Increasingly severe soil moisture deficits and altered groundwater levels could affect the stability of soils affecting structures.
- Climate change could alter rates of erosion (scour) around structures.

Climate risks affecting drainage infrastructure:

- Climate change could increase erosion and so increase sedimentation within drainage infrastructure – potentially reducing its capacity to cope with flood events.

Climate risks affecting recreation:

- Climate change could affect the comfort of visitors using the site during hot weather.
- Climate change could affect recreational uses of the reservoir site.

Climate risks affecting landscaping:

- Climate induced water level fluctuations in the reservoir could cause a deterioration in marginal vegetation conditions.
- Hotter summers may increase the risk of fires around the site.
- Hotter drier weather could degrade planted landscape features. These have aesthetic benefits as well as preventing excessive aeolian soil erosion.
- More severe storms could uproot trees around the site.

Climate risks affecting materials and equipment (mechanical and technological):

- General impacts on exposed infrastructure from extreme heat could decrease asset lives and/or maintenance cycles.
- Hotter weather could reduce the operating efficiency of pumps.
- Warmer winters may reduce cold weather operational issues, for example frozen sample pipes, slip and trip hazards and freeze thaw damage to underground assets.
- Extreme hot temperatures may increase thermal loadings on electrical and control equipment reducing their life.
- More regular and intense storms in the future could increase the regularity of lightning strikes on infrastructure which could damage electrical equipment.
- An increase in the severity and or regularity of extreme weather could impact the reliability of essential infrastructure, e.g. control and communication equipment.

Potential in combination climate change impacts during construction

Climate risks affecting flood risk:

- Increased groundwater levels following wetter winters or extreme weather could impact excavation.
- Extreme weather during construction could cause soil erosion impacts or even inundation of the construction site.
- The construction requires new culverts that need to be sized with consideration of extreme weather.

- The construction requires watercourse crossings. The construction methodologies for these need to consider extreme weather.

Potential in combination climate change impacts during operation

Climate risks affecting groundwater flood risk:

- Increased groundwater levels following wetter winters or extreme weather could impact the pipeline.

Climate risks affecting fluvial flood risk:

- The visitor centre could be vulnerable to flooding after extreme weather.
- The reservoir itself could flood following extreme weather, e.g. wind causing waves that overtop the embankments.
- Flood risk directly downstream of the reservoir following extreme weather could be altered.

Climate risks affecting surface water flood risk:

- Surface water flooding after extreme weather from new areas of hardstanding.

Climate risks affecting tidal flood risk:

- Increased tidal flood risk brought about by sea level rise and extreme weather.

Climate risks affecting Langstone Harbour SPA:

- In combination with the Scheme's operation climate change could further reduce inflows to Langstone Harbour.

Climate risks affecting coastal aquifers:

- The operation of the Scheme in combination with climate change could have hydrogeological implications that make coastal aquifers more exposed to saline intrusion.

Design, mitigation and enhancement measures

- 17.63. To understand the resilience of the Scheme's design to potential climate change vulnerabilities, information has been gathered from the design team and the environmental team throughout the design process. The iterative climate vulnerability assessment method has then enabled the development of appropriate adaptation measures that are now part of the design, i.e. they are embedded mitigation.
- 17.64. The embedded mitigation first seeks to avoid climate vulnerabilities, where this is not possible it tries to minimise them and where this is not an option it reduces their adverse consequences to acceptable levels. In addition to this, opportunities for enhancement have been sought during design.
- 17.65. Embedded mitigation relevant to climate vulnerability is set out in the Assessment of effects section. The assessment of the Scheme's vulnerability to climate change has been undertaken after consideration of embedded mitigation.

Assessment of vulnerability to climate change

- 17.66. This section presents an evidence-based analysis of the extent to which the Scheme, and its surrounding environment, could be affected over its design life by climate variability and climate change.
- 17.67. The likelihood of each potential impact, with embedded mitigation in place, has been assessed along with the consequence of that impact if it occurred. All consequences are adverse unless otherwise stated. These assessments along with the resulting significance of each impact are presented in two tables, one for the CCR assessment (Table 17-5 below) and one for the ICCI assessment (Table 17-6 below).

Table 17-5 - Climate change risk assessment

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
CONSTRUCTION					
Receptor: construction site viability					
Extreme weather	Heavy rainfall events can cause pluvial flooding. This may result in surface water flooding of local roads and other essential infrastructure that could impact construction, for example sources of power supply. Note – climate change considerations for potential flood risk impacts to the construction site itself are assessed in the ICCI assessment, Table 17-6.	There are multiple access points to the main construction sites. There are multiple routes to most of the construction sites. Most construction equipment will not be dependent on grid supply. The contractor will have a surface water management plan in place.	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather in the future. Construction will be complete before there are significant changes to extreme weather expected under the prevailing climate. Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the likelihood of impact is low. Likelihood score - low	Magnitude – low Delays to construction schedule could have an economic cost. Timing – low Consequences would be short term and unlikely to occur regularly. Consequence score - low	Not significant (minor)
OPERATION					
Receptor: water resources (supply & demand)					
Hotter drier summers	The reservoir will provide a regional benefit with regard to the resilience of water resources by securing the long-term continuity of a safe and secure drinking water supply in the face of climate change induced supply and demand pressures.	The reservoir design will enable the delivery of a sustainable yield of 21MI/d to Southern Water Services in a 1 in 200 year drought scenario. To achieve this the operating capacity of the reservoir will be 8,700MI and the supply rate to Farlington via Bedhampton booster pumps will be 21 MI / day. Portsmouth Water's supply resilience will	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89	Magnitude – high A water resources deficit could bring about water supply shortages in the future. Timing – high The beneficial impact of the reservoir on water resources will persist for the	Significant beneficial (major)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
		be improved by the operation of the reservoir.	summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - high The main purpose of the reservoir is to provide a beneficial impact on the resilience of regional water resources. Likelihood score - medium	life of the Scheme. Consequence score - high	
Hotter drier summers	The reservoir has a fundamental role to play in protecting flows in two designated chalk streams in Hampshire – the River Test and River Itchen – inter-regional transfers will allow Southern Water to reduce the amount of water abstracted from the rivers In the future, flows in both streams are likely to be adversely impacted in summer by climate change.	NA	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme’s lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - high A key driver for the project is to protect the River Test	Magnitude – high Over abstraction could otherwise harm chalk streams in Hampshire – the River Test and River Itchen. Timing – high The beneficial impact will persist for the life of the Scheme. Consequence score - high	Significant beneficial (major)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
			and River Itchen from environmental impacts resulting from reduced flows that could intensity under climate change. Likelihood score - medium		
Hotter drier summers and warmer wetter winters	Climate change will alter the nature of supply and demand for water. This may change the way it is operated in the future.	The capacity of the reservoir is sufficient to accommodate the potential for increased volumes that might be transferred in the future through its operation in conjunction with existing sources, successful demand management by Portsmouth Water, and from the development of new sources.	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the likelihood of impact is low. Likelihood score – medium	Magnitude – low Changes to operational management plan Timing – negligible Consequences would be unlikely to occur. Consequence score - negligible	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
Wetter winters	Increased aquifer recharge during wetter winters may increase the security of the reservoir's winter groundwater supply (benefit).	This potential benefit is uncertain since as the UK climate becomes warmer, evaporation and transpiration by plants will increase and, even though winters are expected to become wetter, this may on net result in a reduction in recharge and an increase in stress on our groundwater resources. Due to this uncertainty and the disconnection of this potential impact from the construction and operation of the scheme this impact is not assessed. It is noted that through the Water Resources Management Planning process Portsmouth Water regularly reports on the long-term security of its sources.	NA	NA	NA

Receptor: reservoir water quality and treatment processes

Hotter drier summers	During periods of warm weather, with light winds, large water bodies are prone to thermal stratification. These conditions will become more intense and more regular with climate change. Thermal stratification is associated with water quality risks to drinking water safety (e.g. solubilisation of metals compromising treatment) and environmental water quality deterioration (e.g. increased algal blooms).	In order to mitigate the risks associated with thermal stratification the design includes an air-type mixing system, with perforated pipes at low level in the reservoir, through which compressed air will be pumped to create regions of lower density water which will rise and create circulation currents. The reservoir temperature will be monitored at various depths identify the potential onset of thermal stratification. This system will be complemented by dissolved oxygen monitoring at depth. The live monitoring system will be used to initiate the mixing system to achieve efficient destratification	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - negligible With specific embedded	Magnitude – high Reduced water quality could give rise to risks to human health and have cost implications associated with remedial treatment. . Timing – negligible With embedded mitigation in place consequences would be unlikely to occur. Consequence score - low	Not significant (minor)
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Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
			mitigation in place the likelihood of impact is negligible. Likelihood score - low		
Hotter drier summers and warmer wetter winters	Climate change within the catchment upstream of the reservoir could affect the quality of inflows. For example, altered land cover (e.g. drying out grasslands leaving exposed earth vulnerable to erosion (more sediment sources) or extended growing seasons [generating more nutrients]), or changing catchment land-use practices (e.g. shifting farming types toward those that could increase diffuse pollution).	Additional treatment is proposed at Farlington WTW to manage reservoir water quality including microbiological risks, turbidity, algae and soluble metals. Abstraction monitoring and control will mitigate hydrocarbon and nitrate risks.	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the likelihood of impact is low. Likelihood score – medium	Magnitude – high Reduced water quality in the reservoir could give rise to risks to human health and have cost implications associated with remedial treatment . Timing – negligible With embedded mitigation in place consequences would be unlikely to occur. Consequence score - low	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
Wetter winters and heavier rain	Changes in the quality of water in the reservoir could impact water treatment requirements. For example, it could be associated with the accelerated depletion of chlorine in warm water.	There is adequate flexibility and capacity to alter treatment processes at Farlington WTW as required by any changes in raw water quality brought about by climate change.	Climate hazard – medium In line with the UKCP18 projections and the precautionary principle it is considered that there is medium certainty that winter rainfall will increase over the Scheme's lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter precipitation change is an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. Likelihood of climate hazard effecting receptor - negligible With embedded mitigation in place the likelihood of impact is negligible. Likelihood score - low	Magnitude – negligible Cost implications, for example associated with increased chlorine dosing in hot weather, are negligible. Timing – low Consequences would be short term (following extreme events) and infrequent. Consequence score - negligible	Not significant (negligible)
Extreme weather (heavier rainfall)	Changes in seasonal patterns of rainfall could affect the quality of water in the reservoir. For example, first flush impacts could increase in magnitude and become more regular as longer hotter spells of weather are followed by heavier rain that transports large quantities of contaminants into the reservoir in a short period of time. Large quantities of	Existing water in the reservoir will dilute any contaminated surface water inflows. The majority of the reservoirs source water will be from uncontaminated groundwater. Additional treatment is proposed at Farlington Water Treatment Works (WTW) to manage water quality including microbiological risks, turbidity, algae and soluble metals. Additional treatment will include dissolved air flotation treatment which is particularly well-suited to waters at risk of algal	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather. Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the likelihood of impact is low. Likelihood score - low	Magnitude – high If water quality in the reservoir was affected the impact could have safety risks and large financial costs to correct. Timing – negligible With embedded mitigation in place consequences would be unlikely to occur. Consequence score - low	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
	nutrient rich surface water inflows could increase microbiological growth in the reservoir (algae & microorganisms).	blooms, such as reservoirs.			
Extreme weather (heavier rainfall)	The projected climate trend of increasing frequency and intensity of heavy summer rainfall could cause flooding that disrupts the delivery of chemicals to Farlington WTW that are needed for the treatment process (additional chemical deliveries will include bulk liquid supplies of coagulant and acid and dry powder bags of polymer). (note the works at Farlington WTW will be subject to a separate planning application).	Farlington WTW will have storage capacity for 14 days' worth of use, at maximum design consumption, for most chemicals required by the treatment process. At maximum consumption coagulant deliveries would need to be every three to four days. At maximum design conditions a tanker would need access to the site to collect waste from dissolved air filtration treatment processes twice daily. There are two access routes to Farlington WTW. The works will include a new access road to provide vehicular access to the basin floor level for construction and maintenance traffic and also for new chemical deliveries and sludge tanker access. This road will have drainage installed along it which will be sized with consideration of a climate change allowance (note the works at Farlington WTW will be subject to a separate planning application).	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather. Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the likelihood of impact is low. Likelihood score - low	Magnitude – medium Interruptions in supply. Timing – low Consequences would be short term and irregular. Consequence score - medium	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
Receptor: structures (including reservoir embankments)					
Drier summers	The expected reduction in summer average rainfall could intensify and extend soil moisture deficits and impact groundwater levels. This could impact soil stability, for example by increasing earth pressures, which would affect structures such as the embankments.	Risk will be managed by best practice design, for example, the reservoir embankments will be designed through slope-stability analysis using site specific soil parameters, and be compacted and constructed in line with best practice. Chapter 10 Ground Conditions in ES Volume 2 sets out in further detail how these risks will be controlled, this includes completing stability assessments, undertaking ground investigations and inclusion of a drainage blanket and filter zones within the embankment and foundation, to manage the downstream pore water pressures in the embankment. The reservoir will be operated and managed by Portsmouth Water in line with the requirements of the Reservoirs Act 1975. The Act ensures that reservoir operators are legally responsible for ensuring the stringent safety measures are met through regular inspections and maintenance of the reservoir assets (i.e. embankment, spillway, control system and drawdown infrastructure). With these measures in place, the risk of embankment failure and reservoir beach are highly unlikely. The embankments will be designed to withstand rapid drawdowns, which may become more common with climate change.	Climate hazard – medium In line with UKCP18 projections and the precautionary principle it is considered that there is medium certainty that summers will get drier over the Scheme's lifetime. The central estimate of change in mean summer precipitation by 2071-89 is -21% under RCP 8.5. However, the uncertainty around this estimate ranges from -71% to -2% (represented by the 10th and 90th percentile respectively). Likelihood of climate hazard effecting receptor - negligible With embedded mitigation in place the likelihood of impact is negligible. Likelihood score - low	Magnitude – high Drier summers could damage assets and increase maintenance works. If unmaintained embankment stability could be compromised with large safety risks and financial consequences. Timing – low Short duration repairs may be needed infrequently. Consequence score - medium	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
Extreme weather	Increased regularity of more intense storms could increase the rate of erosion around the edges of the reservoir by wave action.	In accordance with current guidance from the ICE and Defra, the design includes freeboard (from the top water level to embankment crest) to contain the water level rise from wave action and the design flood (defined as a 1 in 10,000 year annual exceedance probability flood). Wave action would therefore be contained below the embankment crest during the design flood. Embankment slopes will be protected from erosion by rip-rap (rock armour). Additionally there will be regular inspections as required by the Reservoirs Act (1975).	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather. Likelihood of climate hazard effecting receptor - negligible With embedded mitigation in place the likelihood of impact is negligible. Likelihood score - negligible	Magnitude – low Wave erosion could damage assets (rip-rap) that can be easily maintained or replaced. Timing – low Consequences would be short term and irregular. Consequence score - low	Not significant (negligible)
Wetter winters and heavier rain	Extreme weather could be a contributing factor in an embankment failure and subsequent widespread flooding.	The reservoir has a discharge facility that can reduce the water level in the reservoir within the requirements of the Environment Agency's Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning (Environment Agency, 2017). Following a reservoir inspection by a Panel Engineer, if an imminent breach is considered likely, the draw down strategy would be implemented. The maximum emergency draw down rate from the reservoir would allow the reservoir level to be drained down by 900mm over a 24-hour period, allowing the reservoir to be lowered by a third of its water depth in 6 days. In line with the requirements of the Reservoirs Act (1975), and the Environment Agency Guidance for Drawdown Capacity (Environment Agency, 2017), full testing of the discharge valves will be undertaken	Climate hazard – medium In line with the UKCP18 projections and the precautionary principle it is considered that there is medium certainty that winter rainfall will increase over the Scheme's lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter precipitation change is an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. Likelihood of climate hazard effecting receptor – low With embedded mitigation in place the impact likelihood will be low	Magnitude – high The consequence of a worst-case scenario breach has been modelled to understand the flood risk associated with a failure of the reservoir embankment. The results show that if a breach were to occur then there will be a wide-ranging flood extent that covers most of the urban centre of Havant, Leigh Park and Langstone. Timing – negligible This scenario is never anticipated as the reservoir is designed and maintained never to breach. Consequence score – low	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
		twice per year. For further details see Appendix A15.2 FRA in ES Volume 4. The reservoir will be operated and managed by Portsmouth Water in line with the requirements of the Reservoirs Act 1975. The Act ensures that reservoir operators are legally responsible for ensuring the stringent safety measures are met through regular uinspection and maintenance of the reservoir assets (i.e. embankment, spillway, control system and drawdown infrastructure). With these measures in place, the risk of embankment failure and reservoir beach are highly unlikely.	Likelihood score – medium		
Receptor: drainage infrastructure					
Hotter drier summers	Drier summers combined with the projected increase in summer temperatures could lead to increased erosion as soils and their substrates dry out. This could affect the capacity of drainage infrastructure.	The embankments will be compacted and seeded. Sustainable urban drainage systems will be used where possible e.g. swales. These allow sediment to settle out of the main flow. The detailed design will assist operational maintenance by including accessible sediment traps as required. Existing trees and vegetation are being retained where possible to reduce erosion risks.	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - negligible	Magnitude – low Increased maintenance to preserve drainage capacity. Timing – medium Maintenance may need to become more regular. Consequence score - medium	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
			With embedded mitigation in place the likelihood of impact is negligible. Likelihood score - low		
Receptor: recreation					
Hotter summers	In extreme hot weather visitors may be less comfortable if there is insufficient provision of shading in and around the main visitor areas.	Method to control temperature of the visitor centre will be determined at detailed design. There will be two picnic areas in the north west corner of the reservoir site. The first, to the south of the visitor centre overlooking the reservoir will be open but the second, closer to the playground, will provide some shaded areas as it will be set amongst large trees offering refuge from the sun in times of hot weather.	Climate hazard - high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the impact is low. Likelihood score – medium	Magnitude – low Embedded mitigation will reduce consequences. In extremely hot weather visitors are expected to avoid open spaces so consequences will remain low. Timing – negligible Consequences are unlikely to occur or will be reduced by embedded mitigation. Consequence score - negligible	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
Hotter drier summers	Hotter weather may increase demand for outdoor recreation but increasingly low water levels in the reservoir due to climate change effects on the supply demand balance could cause recreational impacts. This could include reducing the area's aesthetics.	The areas aesthetics, particularly around the visitor centre will be maintained by the wetland water level controls described previously. The viewing area near Warren Park will have reed beds planted at the edge of the reservoir to screen the dried-out reservoir edge in times of draw down.	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - negligible With embedded mitigation in place the impact negligible. Likelihood score - low	Magnitude – low Reduced aesthetic appeal of the landscape during periods of draw down could reduce visitor numbers. Timing – medium Consequences likely to become more regular in the future but only during prolonged hot dry weather. Consequence score - medium	Not significant (minor)

Receptor: Marginal Planting and Wetland Habitat

Hotter drier summers	Climate induced fluctuations in reservoir levels could cause a deterioration in marginal vegetations. Modelling presented in Chapter 15 Water Environment in ES Volume 2 show that a prolonged drought (1 in 10 years) is expected to result in a draw down of 4-5m below TWL to around 35m, after which it will not likely be	The most valuable marginal vegetation will be in the wetland area (see Chapter 2 Description of the Development in ES Volume 2). The design of the wetland area is such that water levels can be managed separately to the main reservoir, with:: - a water retention structure and concomitant retained wetland area; - spillways for passive water level management control;	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C	Magnitude – negligible Temporary loss of planted marginal landscaping in less valuable areas . Recovery expected. Timing – medium Consequences likely to become more regular in the future but would still only materialise in extreme weather.	Not significant (minor)
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Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
	topped up to TWL until the end of the following winter period. In an extreme drought (1 in 200 years) the water level will be as low as the minimum level of 27m – 28m for extended periods over multiple seasons.	• piped controls with penstocks or gate valves to facilitate active water level management. These measures will improve the resilience of the retained wetland area and provide the means by which water level, water quality and habitat management could still be achieved under a wide range of water level scenarios. Outside of the wetland area marginal planting would be more vulnerable to water level changes.	warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the impact will be restricted to areas of lower conservation value, i.e. away from the wetland. Likelihood score - medium	Consequence score - low	
Hotter drier summers	Hotter summers may increase the risk of fires at the facilities and around the site.	Access for emergency vehicles is provided to the north of the visitor centre. This hard-landscaped area provides sufficient room to accommodate a turning circle and paving specification to support all emergency vehicles. There will also be some access around the site, along maintenance roads, that could be utilised by emergency vehicles if the need arose. The detailed design will include a fire strategy providing details such as the location of fire hydrants and the design of fire suppression systems in the buildings on the site. During operation there is likely to be additional measures in place, for example, in extreme hot weather the site is likely to have a no BBQ policy.	Climate hazard - high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the impact is low. Likelihood score - medium	Magnitude – high Fire could endanger life, inhibit water company operations and cause significant financial damage. Timing – negligible Risk of consequences is reduced by embedded mitigation. Consequence score - low	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
Hotter drier summers	Hotter drier summers will increase soil moisture deficits in the future which could negatively impact the planting and vegetation around the site. The landscaping has aesthetic benefits but also prevents excessive soil erosion.	The landscape design will provide for a diversity of species, including drought tolerant species, whilst still having regard to the local character, and the requirement to plant only native species.	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the impact will be low. Likelihood score - medium	Magnitude – negligible Degradation or temporary loss of vegetation. Recovery expected. Timing – high Consequences may occur many times during the life of the Scheme, e.g. in the future they could occur seasonally. Consequence score - low	Not significant (minor)
Extreme weather (high winds)	Climate change may increase the frequency and intensity of storms capable of uprooting trees.	There will be no planting of large trees on the exposed crest of the reservoir or in close proximity to essential assets.	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather. Likelihood of climate hazard effecting receptor - negligible With embedded mitigation in place the likelihood of impact is low. Likelihood score -	Magnitude – negligible Consequences would have little economic cost or affect individual assets that can be easily repaired or replaced Timing – low Consequences would be short term and irregular. Consequence score - negligible	Not significant (negligible)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
			negligible		
Receptor: materials and equipment (mechanical and technological)					
Hotter summers	General impacts on exposed infrastructure from extreme heat, for example: - Over expansion and buckling (e.g. of culverts or kerbs); - Fading of materials and painted surfaces; - More extreme wetting and drying cycles leading to accelerated asset deterioration; - Softening and deformation of bitumen in asphalt on the access road and in the car park; and - Shrinkage and expansion that leads to cracking of concrete structures.	Best practice construction techniques and appropriate material quality standards will be followed to ensure the design lives specified can be met. Details will be confirmed during detailed design, this may include using polymer modified bitumen.	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the impact likelihood will be low. Likelihood score - medium	Magnitude – negligible More regular maintenance interventions may be required, in response to changes in deterioration rates Timing – negligible Consequences are unlikely to occur or will be reduced by embedded mitigation. Consequence score – negligible	Not significant (minor)
Hotter summers	Extreme temperatures may reduce the operating efficiency of pumps.	In accordance with best practice essential pumping locations will have duty and standby pumps in case of failure.	Climate hazard – high In line with UKCP18 projections and the precautionary principle it is considered that there is a high likelihood that mean summer temperatures will increase over the Scheme's lifetime. By 2071-89 summer mean daily	Magnitude – negligible Reduced operating efficiency that could result in the need for more frequent maintenance. Timing – negligible Consequences are unlikely to occur or will be reduced by embedded mitigation.	Not significant (negligible)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
			maximum temperatures could be up to +5.4°C warmer (central estimate under emissions scenario RCP8.5). Likelihood of climate hazard effecting receptor – negligible With embedded mitigation in place the impact likelihood will be negligible. Likelihood score - low	Consequence score – negligible	
Warmer winters	Warmer winters may reduce cold weather operational issues, for example frozen sample pipes, slip and trip hazards and freeze thaw damage to underground assets.	NA - benefit	Climate hazard – medium In line with the UKCP18 projections and the precautionary principle it is considered that there is high certainty that winter mean temperatures will increase over the Scheme's lifetime (in winter, under RCP 8.5, mean temperature is likely to increase by approximately 3°C [central estimate]). However, projected changes to snowfall and the number of nights below freezing are less certain so the likelihood is found to be medium. Likelihood of climate hazard effecting receptor - low The impact likelihood will	Magnitude – negligible Less regular maintenance interventions may be required. Timing – low Consequences are not expected to be regular. Consequence score – negligible	Not significant (minor beneficial)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
			be low. Likelihood score - medium		
Extreme weather	Extreme weather impacts on electrical equipment: • Extreme hot temperatures can increase thermal loadings on electrical and control equipment reducing their life; and • More regular and intense storms in the future could increase the regularity of lightning strikes on infrastructure which could damage electrical equipment.	A control room is proposed to house operating equipment for the control of the reservoir, including emergency discharges, sampling instrumentation and mixing equipment. The control house will have forced thermostatic ventilation with at least 2 points of access/egress. In addition to the primary secure network, and secondary public switched telephone network, a direct system using a mobile network connection will provide system control resilience by ensuring that each site (Farlington WTW, Havant Thicket reservoir and Bedhampton pump station) stays connected and operational. Requirements for protection against main electrical supply surge and transient overvoltage (lightning current) using surge protection devices will be confirmed at the detailed design stage in accordance with best practice. Critical electrical components will be regularly tested by their operators, and replacement cycles may be shortened if deterioration rates increase.	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather. Likelihood of climate hazard effecting receptor – negligible With embedded mitigation in place the impact likelihood will be negligible. Likelihood score - negligible	Magnitude – high Outages of control equipment could have large safety consequences. Timing – negligible Consequences are unlikely to occur or will be reduced by embedded mitigation. Consequence score – low	Not significant (negligible)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood (assessment stages 1&2)	Consequence (assessment stages 3&4)	Significance (assessment stage 5)
Extreme weather (storms)	In the future an increase in the severity and or regularity of extreme weather could impact essential infrastructure, for example stopping mixing that prevents stratification or disabling the ability to draw down the reservoir in an emergency.	No permanently installed standby generation will be provided in the control house as: • Process implications of loss of reservoir mixing can be tolerated for a number of days; • Critical valves at the reservoir (e.g. to facilitate emergency drawdown) will be manually operable and a portable battery supply for actuators will be available if necessary; • Provision will be made in the motor control centre (within the control house) for a plug-in standby power generator and an uninterrupted power supply for critical equipment.	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather. Likelihood of climate hazard effecting receptor – negligible With embedded mitigation in place the impact likelihood will be negligible. Likelihood score - negligible	Magnitude – negligible Control equipment and plant could be brought back online before consequences occurred. Timing – negligible Consequences are unlikely to occur. Consequence score – negligible	Not significant (negligible)

Table 17-6 - In-combination climate change impact assessment

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood	Consequence	Significance
CONSTRUCTION					
Receptor: Flood risk - to be read in conjunction with the Chapter 15 Water Environment in ES Volume 2 and Appendix A15.2 Flood Risk Assessment in ES Volume 4					
Hotter drier summers	An assessment of potential soil erosion impacts during construction, with consideration of extreme, weather, is already undertaken in Chapter 10 Ground Conditions in ES Volume 2. It is therefore not discussed here.	NA	NA	NA	NA
Wetter winters and heavier rain	Storms could impact construction. Prolonged periods of excessive precipitation during wetter winters could lead to a raised water table, which may result in groundwater flooding affecting construction processes, e.g. excavations and the laying of foundations.	Following assessment of the hydrogeological baseline the projects FRA concludes that groundwater flood risk presents a negligible risk to the project. Although wetter winters are projected the construction is planned to be sufficiently soon that the wetter winter impacts presented in the baseline section will not yet have materialised.	Climate hazard – low In line with the UKCP18 projections and the precautionary principle it is considered that there is medium certainty that winter rainfall will increase over the Scheme's lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter precipitation change is an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. Since construction is planned in the near future the hazard is reduced to low. Likelihood of climate hazard effecting receptor - low With embedded mitigation in place the likelihood of impact is low.	Magnitude – low Delays to construction schedule could have an economic cost. Timing – low Consequences would be short term and unlikely to occur regularly Consequence score - low	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood	Consequence	Significance
			Likelihood score – medium		
Wetter winters and heavier rain	Fluvial flooding of the main construction site during wetter winters or extreme weather.	Although wetter winters are projected the construction is planned to be sufficiently soon that the wetter winter impacts presented in the baseline section will not yet have materialised. The wetland retaining structure will be constructed in the first phase of construction, and the area will be used to intercept and manage inflows from the three headwater streams of the Riders Lane Stream. This will prevent flooding in the working area and control surface water flow. Water stored behind this structure will be attenuated and conveyed downstream to the reservoir embankment. The conveyance capacity will be for a flood with an AP of 3.33% (i.e. 1 in 30 or 4.6m³/s).	Climate hazard – low In line with the UKCP18 projections and the precautionary principle it is considered that there is medium certainty that winter rainfall will increase over the Scheme's lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter precipitation change is an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. Since construction is planned in the near future the hazard is reduced to low. Likelihood of climate hazard effecting receptor – low With embedded mitigation in place the impact likelihood will be low. Likelihood score - low	Magnitude – medium If the construction site floods it could lead to delays in the construction schedule and could have an economic cost Timing – low Consequences would be short term and unlikely to occur regularly. Consequence score - low	Not significant (minor)
Wetter winters and heavier rain	Fluvial flooding of other vulnerable construction areas during wetter winters or following extreme weather; including Middle Park Way and the area for construction use between Ellisfield Road and Riders Lane which spans the Riders Lane Stream.	Although wetter winters are projected the construction is planned to be sufficiently soon that the wetter winter impacts presented in the baseline section will not yet have materialised. Flood-related mitigation measures will be implemented by the drainage management plan, construction environment management plan and flood risk activity permits.	Climate hazard – low In line with the UKCP18 projections and the precautionary principle it is considered that there is medium certainty that winter rainfall will increase over the Scheme's lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter precipitation change is	Magnitude – medium If other vulnerable construction sites flood it could lead to delays in the construction schedule and could have an economic cost. Timing – low Consequences would be short term and unlikely to occur regularly.	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood	Consequence	Significance
			an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. . Since construction is planned in the near future the hazard is reduced to low. Likelihood of climate hazard effecting receptor – low With embedded mitigation in place the impact likelihood will be low. Likelihood score - low	Consequence score - low	
Extreme weather (heavy rain)	To facilitate construction access two culverts on the headwater streams will need to be replaced. Extreme weather during construction could increase flood risk around these.	The construction methodology will include consideration of the sizing of the new culverts with regard to extreme weather impacts.	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather. Likelihood of climate hazard effecting receptor – negligible With embedded mitigation in place the impact likelihood will be negligible Likelihood score - negligible	Magnitude – low Could lead to delays in the construction schedule and have an economic cost if access is blocked. Timing – low Consequences would be short term and unlikely to occur regularly throughout the construction period Consequence score – low	Not significant (Negligible)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood	Consequence	Significance
Extreme weather (heavy rain)	The pipeline corridor has three watercourse crossings (see Chapter 15 Water Environment in ES Volume 2). Extreme weather during construction of these crossings could increase flood risk if not managed correctly.	Construction will require temporary damming of the watercourses. The construction design has assumed installation of a flume to ensure the downstream conveyance of flood flows up to and including the 1% (1 in 100) AP for each site. This correlates to flows of 6.7m³/s, 0.7m³/s and 14.5m³/s at the Riders Lane Stream, The Lake Stream, and Hermitage Stream crossings respectively. No change in fluvial flood risk is therefore expected.	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather. Likelihood of climate hazard effecting receptor - negligible With embedded mitigation in place the impact likelihood will be low. Likelihood score - negligible	Magnitude – low Could lead to delays in the construction schedule and have an economic cost if there is extreme weather which exceeds the capacity of the flume. Timing – low Consequences would be short term and unlikely to occur regularly throughout the construction period Consequence score – low	Not significant (Negligible)
OPERATION					
Receptor: Groundwater flood risk (to be read in conjunction with Chapter 15 Water Environment in ES Volume 2 and Appendix A15.2 Flood Risk Assessment in ES Volume 4)					
Wetter winters	Flood risk impacts on the pipeline brought about by wetter winters which could alter groundwater levels.	The pipeline will be underground when operational and there is no risk to it from groundwater. Rising ground levels would have no impact on the bedding or stability of the pipeline. Therefore, no climate change allowance is necessary. It is therefore not assessed here.	NA	NA	NA
Receptor: Fluvial flood risk (to be read in conjunction with Chapter 15 Water Environment in ES Volume 2 and Appendix A15.2 Flood Risk Assessment in ES Volume 4)					
Wetter winters and heavier rain	The visitor centre is built within the wetland, and is therefore at potential risk of flooding following extreme	The visitor centre is classified as a “Less Vulnerable” development, and as such is designed with a finished floor level above the 1% (1 in 100 year) annual probability	Climate hazard – medium In line with the UKCP18 projections and the precautionary principle it is	Magnitude – medium Closure of the visitor centre and repairs would cause financial impacts	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood	Consequence	Significance
	weather that could causes an unusually high rise in the water level of the reservoir.	flood event, plus an allowance for climate change (35% and 45% for the “central” and “higher central” estimates respectively). The 1% (1 in 100 year) annual probability flood event gives reservoir peak water levels of 39.65 and 39.67m AOD for the “central” and “higher central” estimates. When an allowance for wave height is included (0.1m, due to the limited fetch distance from the wetland retaining structure) and freeboard (0.3m), the recommended finished floor level for the visitor centre is 40.1m AOD. Further details are provided in Appendix A15.2 FRA in ES Volume 4.	considered that there a medium likelihood that winter rainfall will increase over the Scheme’s lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter precipitation change is an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. Likelihood of climate hazard effecting receptor – negligible With embedded mitigation in place the impact likelihood will be negligible Likelihood score – low	Timing – negligible Impact would be short term and irregular. Consequence score – low	
Wetter winters and heavier rain	Reservoir flooding during wetter winters of following extreme weather.	Reservoir inflow hydrographs were derived and routed through the reservoir to evaluate the flood surcharge for the design storm (10,000 year return period flood). For reservoir safety, the current guidance does not include climate change allowances for the extreme events. However, the wave action was also assessed for an extreme wind scenario which included an allowance for climate change. The modelling showed that the design is able to discharge flood flows under normal conditions with a safety margin provided by an accepted freeboard limit.	Climate hazard – medium In line with the UKCP18 projections and the precautionary principle it is considered that there is a medium likelihood that winter rainfall will increase over the Scheme’s lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter precipitation change is an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. Likelihood of climate hazard effecting receptor – low With embedded mitigation in place the impact likelihood will be low	Magnitude – medium Overtopping of the reservoir could cause economic and safety issues. Timing – negligible Consequences would be short term and irregular. The reservoir is designed and will be maintained so that it does not overtop. Consequence score – low	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood	Consequence	Significance
			Likelihood score – medium		
Extreme weather (heavy rain)	Flood risk directly downstream of the reservoir following extreme weather.	Modelling presented in the FRA shows that during both 1% AP flood and 0.1% AP flood there is generally a reduction in flood risk downstream of the reservoir (lower peak flows and peak levels). This modelling exercise included climate change allowances that were created following Environment Agency guidance (Environment Agency, 2016). The uplift values applied to the fluvial inflows were taken from the South East River Basin guidance for the 2080s epoch.	Climate hazard – low Climate projections show there is low certainty of how climate change will alter extreme weather. Likelihood of climate hazard effecting receptor - high The beneficial impact has been modelled and is expected to occur. Likelihood score - medium	Magnitude – medium A beneficial reduction in flood risk downstream of the reservoir. Timing – medium The beneficial impact would be observed after extreme weather events that, without the Scheme, would have otherwise increased flood risk. Consequence score – medium	Significant beneficial (moderate)
Receptor: Surface water flood risk (to be read in conjunction with Chapter 15 Water Environment in ES Volume 2 and Appendix A15.2 Flood Risk Assessment in ES Volume 4)					
Wetter winters and heavier rain	Surface water flooding after extreme weather from new areas of hardstanding or saturated ground within the new drainage catchments.	The Scheme's drainage management plan will provide details of how increased surface water runoff from new areas of hardstanding (i.e. access roads, visitor centre, car parks etc) will be managed to ensure no increase in flood risk with a climate change allowance. Sustainable Drainage Systems (SuDS) will be included in the drainage design where possible. The drainage design will follow the SuDS manual, and guidance from the Local Plans/Strategic Flood Risk Assessment (SFRA) will be incorporated. It is noted that in some instances surface water flood risk is likely to reduce due to	Climate hazard – medium In line with the UKCP18 projections and the precautionary principle it is considered that there is medium certainty that winter rainfall will increase over the Scheme's lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter precipitation change is an increase of 0.5 mm by 2071-89. Likelihood of climate hazard effecting receptor –	Magnitude – low Restrictions on access across the site could have small impacts on visitors. Timing – low Impacts are likely to be small and short term. Consequence score – low	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood	Consequence	Significance
		the reduction in peak levels and flow within local watercourses providing more capacity for the surface water network to discharge into the channel.	negligible With embedded mitigation in place the impact likelihood will be negligible Likelihood score – low		
Receptor: Tidal flood risk (to be read in conjunction with Chapter 15 Water Environment in ES Volume 2 and Appendix A15.2 Flood Risk Assessment in ES Volume 4)					
Extreme weather and sea level rise	Increased tidal flood risk brought about by sea level rise and extreme weather.	Various tidal scenarios with climate change allowances have been tested to observe the impact of the reservoir on tidal flood risk (see FRA). This has included modelling tidal flood risk for the baseline and with-scheme for the 50% fluvial and 0.5% AP tidal scenarios for 2125 Upper Estimate Climate Change. The results show that there is no change in extent between the baseline and With-Scheme results under the current climate or with inclusion of climate change. The construction of the reservoir, therefore, does not affect tidal flood risk and so this impact is not assessed.	NA	NA	NA
Receptor: Langstone Harbour SPA					
Drier summers and wetter winters (altered hydrological conditions)	Reduced inflows to Langstone Harbour. The reservoir will store surplus water from groundwater springs at Havant and Bedhampton that, during the winter and spring, would otherwise flow into Langstone Harbour. This could have implications for the quantity and quality of water in the SPA.	The abstraction licence at Havant and Bedhampton includes flow conditions that protect the environment. These are set by the Environment Agency and if required could be amended in the future in response to climate change pressures. Modelling in Chapter 15 Water environment in ES Volume 2 shows the Scheme's operation will result in improved water quality in Langstone Harbour.	Climate hazard – high Climate change is widely expected to alter hydrological flow regimes Likelihood of climate hazard effecting receptor – low With embedded mitigation in the place the impact likelihood will be low Likelihood score – medium	Magnitude – low Changes to water quality and quantity in Langstone Harbour due to the Scheme's effects in combination with climate change impacts are not expected to be observable. Timing – low Adverse impacts would be irregular.	Not significant (minor)

Climate hazard	Description of climate vulnerability	Embedded mitigation	Likelihood	Consequence	Significance
				Consequence score – low	
Receptor: Coastal aquifers					
Drier summers and wetter winters (altered river flow regimes)	Filling the reservoir with water from the aquifers in combination with climate change induced sea level rise could increase the risk of saline intrusion impacts on coastal aquifers.	When the reservoir is filled, it will use flow captured from the Havant and Bedhampton springs. Unlike most groundwater abstractions, the supply is not pumped. The chalk aquifer naturally discharges groundwater through springs which would otherwise then flow through surface water channels out to the sea. There are therefore no associated changes to groundwater quantity.	NA	NA	NA

Significant and residual effects

- 17.68. No significant adverse vulnerabilities of the Scheme to climate change have been identified and accordingly no adaption measures are required beyond the embedded mitigation identified in Table 17-5 and Table 17-6 above.

Monitoring

- 17.69. No significant adverse vulnerabilities of the Scheme to climate change are identified however, it is recommended that monitoring and evaluation of the Scheme's major assets resilience to climate be part of regular asset inspections to inform climate change adaptation decision-making in the future.

Summary

- 17.70. This chapter has presented the Schemes climate change vulnerability assessment. The assessment considers impacts of extreme weather and future climatic conditions on the Scheme during both its construction and operation.
- 17.71. Climate projections from UKCP18 have been examined. They confirm that the study areas climate is expected to change in the future. The assessment finds that the Scheme could be vulnerable to impacts linked to these changes in the climate. Mitigation measures built into the design (i.e. embedded mitigation) that either avoids these impacts, minimises them or reduces their consequences are presented. After consideration of this mitigation none of the potential climate vulnerability impacts are found to be significant adverse.

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