14 Climate change

14.1 Introduction

14.1.1 This chapter of the Environmental Statement provides the context, baseline data, methodology and approach, assessment results and mitigation measures for the three assessments under the climate change topic:

- Greenhouse gas (GHG) emissions assessment;
- Climate change resilience (CCR) assessment; and
- In-combination climate change impact (ICCI) assessment.

14.1.2 The GHG emissions assessment quantifies the potential GHG emissions associated with the construction and operation of the proposed development and identifies mitigation measures to reduce these emissions.

14.1.3 The CCR assessment evaluates the effectiveness and feasibility of adaptation measures integrated into the proposed development to avoid or reduce hazards and increase resilience of the proposed development to climate change impacts.

14.1.4 The ICCI assessment evaluates the combined effect of the proposed development and potential climate change impacts on the environment during construction and operation.

14.1.5 Consideration of the three related but separate climate change assessments within this chapter provides a holistic assessment of climate change aspects related to the proposed development.

14.2 Review of proposed development

14.2.1 The proposed development comprises the construction of a business park and new transport hub facility, and infrastructure associated with; biodiversity, landscape, drainage, walking, cycling and other transport modes. The development proposals for Cardiff Hendre Lakes are described in Chapter 3 of this report.

14.2.2 Each new element of development will contain embodied carbon from the materials used, such as steel and concrete. These elements will also produce carbon to operate, such as the carbon produced to generate the energy each element requires.

14.2.3 It is important to distinguish between elements as different building types will have a different amount of embodied carbon per m^2 and will indirectly produce different amounts of operational carbon.

14.3 Legislation, policy context and guidance

Legislation

International

14.3.1 The Paris Agreement is an international climate agreement aiming to limit global temperature increase this century to less than 1.5 degrees Celsius above pre-industrial levels. It was adopted into UK law in 2015 and was enforceable as of November 2016. Additionally, it is to establish a goal on enhancing adaptive capacity[1], strengthening resilience and reducing vulnerability to climate change. The guidelines for implementing the Paris Agreement were adopted at the 24th Conference of the Parties (COP24), in Katowice, Poland.

14.3.2 The Directive 2014/52/EU states that EIAs shall identify, describe and assess the direct and indirect significant effects of climate change relevant to a project. The Regulations implementing this directive were transposed into UK legislation in May 2017.

National

14.3.3 The Climate Change Act 2008 committed the UK to its first statutory carbon reduction target to reduce carbon emissions by at least 80% from 1990 levels by 2050. The Climate Change Act 2008 (2050 Target Amendment) Order 2019 amended the legislated target to net zero emissions by 2050 in June 2019, following advice from the Committee on Climate Change. The Act requires that five-yearly carbon budgets are set and not exceeded. It also established a requirement to undertake a climate change risk assessment every five years and development of a programme for adaptation action in response to the risks identified.

14.3.4 The Environment (Wales) Act 2016 requires Welsh Ministers to meet greenhouse gas reduction targets for Wales and establishes a 2050 emission target of 80% reduction in net emissions from the baseline year (1990 or 1995 depending in the specific greenhouse gas). Progress to this target is supported by interim emissions targets set for every ten years until 2050 and carbon budgets established for five-yearly periods. In June 2019, Welsh Government committed to adopting the Committee on Climate Change's recommendation to change the emissions reduction target to 95% by 2050, with an ambition to reach net zero emissions by 2050. Regulations to amend the existing 2050 target and related carbon budgets will be brought to Welsh Assembly in 2021.

14.3.5 The Well-being of Future Generations (Wales) Act 2015 requires public bodies to carry out sustainable development, which is the process of improving the economic, social, environmental and cultural well-being of Wales by taking action aimed at achieving the well-being goals. The Act establishes seven well-being goals, which specifically

[1] Adaptive capacity relates to the capacity of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

reference acting on climate change. As such, the Act requires all public bodies to embed climate change into their decision-making.

14.3.6 The Planning (Wales) Act 2015 emphasises that national, strategic and local planning must be carried out in accordance with the sustainable development definition and principle as per the Well-being of Future Generations (Wales) Act 2015.

Policy context

International

14.3.7 Published in 2015, the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report provides evidence that human influence on climate change is clear and growing. Climate change is the largest inter-related cumulative environmental effect which has the potential to lead to significant environmental effects on a wide range of areas. This report outlines potential impacts of climate change in various geographical areas.

14.3.8 In 2018, the IPPC published a Special Report on limiting global temperature increases to 1.5°C above pre-industrial levels. It identifies the need for systems transitions in all sectors including transport infrastructure to limit global warming to 1.5°C and avoid the climate-related risks associated with warming of 2°C or more.

National

14.3.9 The second UK Climate Change Risk Assessment was published in 2017, as required under the Climate Change Act 2008. It establishes the six priority risk areas for action over the following five years. It is based on the independent evidence report published by the Committee on Climate Change.

14.3.10 The UK Clean Growth Strategy is part of the wider Industrial Strategy. It sets out the Government's policies for delivering economic growth that delivers on the UKs legal requirements for reducing carbon emissions. This includes measures that will support green finance, that support businesses to reduce energy consumption by 20% by 2030, increase the energy efficiency of homes, supporting the shift to low-carbon transport, developing flexible energy networks and making better use of natural resources.

Regional

14.3.11 The 10th edition of Planning Policy Wales (PPW10) was published in December 2018. It sets out land-use and planning policy for Wales. The new planning policy incorporates the sustainable development principles of the Well-being of Future Generations (Wales) Act 2015.

14.3.12 Prosperity for all: A low carbon Wales was published in March 2019. It sets out how Wales aims to meet the first carbon budget (2016-2020) and consequently the 2020 interim target through 100 policies and proposals across Ministerial portfolios.

14.3.13 Prosperity for all: A Climate Conscious Wales (2019) to influence partners in Wales to take action. The document aims to raise awareness of climate adaptation and offers knowledge and best practice to improve climate resilience.

Local

14.3.14 Cardiff Council (CC) adopted their Local Development Plan 2006-2026 (LDP) in January 2016. Mitigating against the impacts of climate change and adapting to its impacts are considered in 'Key Policy 15: Climate change'.

14.3.15 Cardiff Local Flood Risk Management Strategy was adopted by CC in 2014. Local authorities are a designated Lead Local Flood Authority (LLFA) under the Flood and Water Management Act 2010, and are required to produce a Local Flood Risk Management Strategy. Schedule 3 to the Flood and Water Management Act 2010 establishes Sustainable Drainage Approval Body (SAB) in local authorities. The legislation gives those bodies statutory responsibility for approving and in specified circumstances, adopting the approved drainage systems.

14.3.16 The Cardiff Public Services Board published their Local Well-being Plan in 2018. 'Well-being objective 2: Cardiff grows in a resilient way' includes an action related to preparedness for extreme weather events associated with climate change. One of the measures of progress is per capita carbon emissions.

14.3.17 Newport County Council (NCC) Local Development Plan (LDP)[2] is the development plan for Newport and is the basis for land use planning within the council's administrative area.

Relevant guidance

14.3.18 The Institute of Environmental Management and Assessment (IEMA) (2017) Environmental Impact Assessment Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance aims to assist EIA practitioners with addressing greenhouse gas emissions assessment and mitigation. It outlines the process for undertaking the carbon assessment as it relates to the EIA stages.

14.3.19 PAS 2080:2016 Carbon management in infrastructure provides a framework on how to manage whole life carbon when delivering infrastructure assets and programmes of work. This assessment broadly follows the principles set out in PAS 2080 for the quantification of greenhouse gas emissions.

14.3.20 IEMA (2015) Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation provides a framework for the consideration of climate change resilience and adaptation in the EIA process, in line with Directive 2014/52/EU.

14.4 Scoping and consultation

Scoping

14.4.1 This chapter has been scoped to include the three climate change assessments (GHG emissions assessment, CCR assessment and ICCI assessment).

14.4.2 There was no scoping response relating to climate change, except for one comment related to flooding (as noted in the Scoping Report, this will be addressed in the water resources assessment). Climate change is considered the largest inter-related cumulative

[2] Newport County Council 2015, Local Development Plan (2011-2026)

environmental effect and therefore was scoped in to assess the developments impacts and how to reduce them, while suggesting mitigation to improve resilience to a changing climate.

Consultation

14.4.3 Internal meetings with the design team and EIA specialists have discussed the impacts of the proposed development on climate change and proposed mitigation measures against increasing GHG emissions. For the GHG assessment, liaison with transport and air quality specialists within Arup was undertaken to ensure consistency of approach between topics. For the CCR assessment, liaison with the water resources specialist was undertaken to understand risks and mitigation measures associated with flooding. Consultation with other EIA topic leads has been undertaken to ensure that the ICCI assessment includes consideration of key issues in all topics.

14.5 Methodology

Methodology for GHG emissions assessment

14.5.1 The GHG emissions are quantified using the principal steps outlined in Publicly Available Specification 2080:2016 Carbon Management in Infrastructure (PAS 2080), as shown in Figure 14.1 .

Figure 14.1: Principal steps of GHG emissions quantification[3]

14.5.2 A lifecycle approach is adopted to capture both direct and indirect GHG emissions arising as a result of the proposed development. The lifecycle stages are defined in Figure 14.2. The GHG emissions assessment scope includes the before use stage (A) and the use stage (B).

[3] Construction Leadership Council & the Green Construction Board (2016) PAS 2080:2016 Carbon management in infrastructure. BSI Limited, London, UK.https://shop.bsigroup.com/forms/PASs/PAS-2080/ [Accessed June 2018]

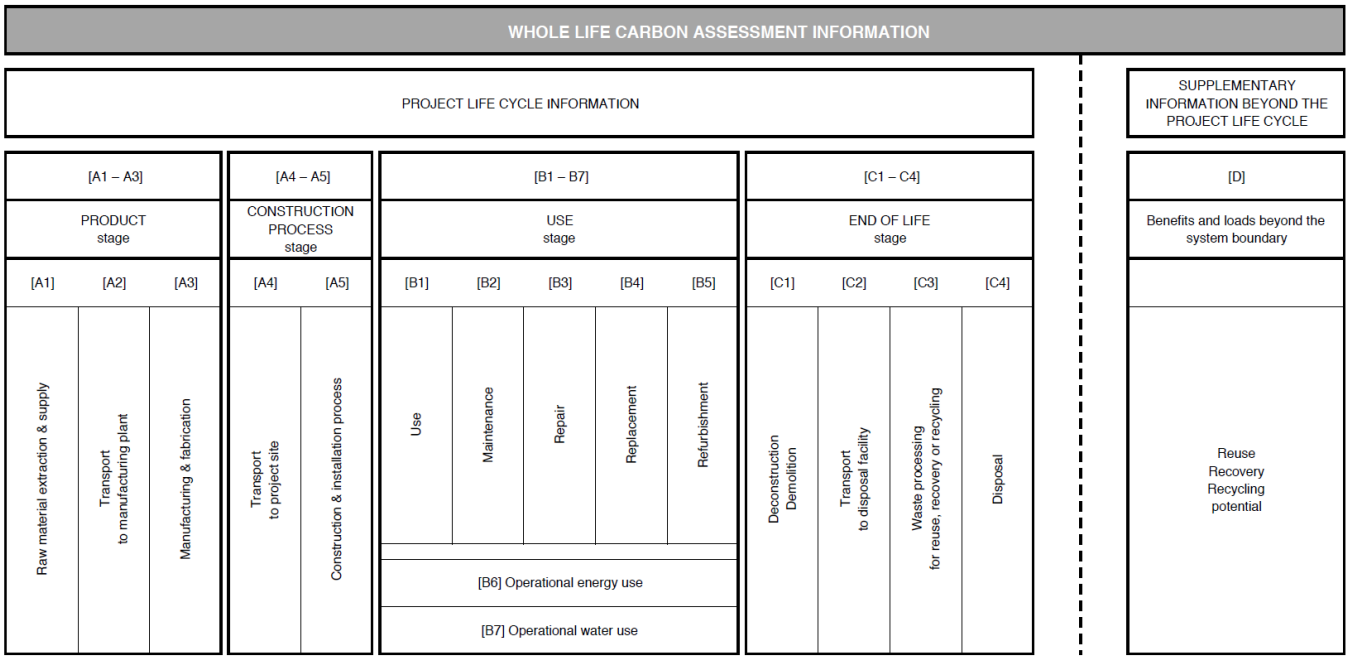

Figure 14.2: Lifecycle stages for a whole life carbon assessment as per EN 159784

14.5.3 For consistency with other chapters in the EIA, the 'before use stage' (A) will be referred to in this chapter as 'the construction phase', and the 'use stage' (B) will be referred to as 'the operational phase'.

14.5.4 The temporal scope of the assessment aligns with the defined design life of 60 years for the development[4].

14.5.5 The study area[5] of the assessments is taken to be the energy and emissions associated with physical elements within the red line boundary of the proposed development, and therefore includes the emissions associated with construction and operation transport. The elements included in this scope are summarised in Section 1.2.

14.5.6 The GHG emissions from the proposed development were calculated by converting 'activity data' (such as land areas, energy consumption and transport kilometres travelled) into quantities of GHG emissions through the application of emissions conversion factors. As this is an outline planning application the 'activity data' is applied to benchmarks to approximately calculate GHG emissions of the proposed development.

14.5.7 The GHG emissions assessment was undertaken on the basis of the information available at the time of assessment. Where assumptions have been made, they have been selected to present the worst-case scenario for the particular item/factor. The outputs of the 90,000m^2 B1 use were the worst-case scenario have been reported in this chapter. A second GHG assessment has been undertaken that splits the 90,000m^2 B1 use into 60,000m^2 B1 and 30,000m^2 B2 use. This has been done to ensure a robust assessment without a detailed design.

[4] RICS (2017) Whole life carbon assessment for the built environment 1st edition http://www.rics.org/Global/Whole_life_carbon_assessment_for_the_BE_PGguidance_2017.pdf [Accessed March 2020]
[5] the area considered by each discipline when undertaking their assessment to determine significant effects

14.5.8 These benchmarks, their data sources and assessment methodology for each aspect of the development included in the GHG emissions assessment are summarised in **Table 14.1**.

Table 14.1 : Methodology for estimating emissions sources included in the GHG emissions assessment

	Assessment methodology	**Data sources**
Stage A – Construction		
Buildings, Station, Public Realm and Parking	These benchmarks use the embodied carbon per unit area for over 1,000 buildings included in the Embodied Carbon Benchmark Study	Carbon Leadership Forum – CO2 Benchmarks Available at: http://carbonleadershipforum.org/data-visualization/
Buildings, Station, Public Realm and Parking	Embodied emissions of building materials have been calculated based on the floor area of each building, using benchmarks for typical buildings of each type. Using data from various design and research projects	Project Embodied Carbon Calculator - v3.5.0 (2019) (Arup tool)
Buildings	Embodied emissions of building materials have been calculated based on the estimated floor area of each building, using benchmarks for typical buildings of each type. Multiple data sources used from 2010 onwards.	Project Embodied Carbon Calculator - v3.5.0 (2019) (Arup tool)
Public realm	Embodied emissions in the pavement materials of footpaths, carparks and recreation areas calculated based on masterplan areas and emissions factors from the Green Guide to Specification. Note that these are calculated over a 60-year life, so additional allowance for maintenance and refurbishment has not been included.	BRE (2008) Green Guide to Specification Available at: https://www.bregroup.com/greenguide/calculator/page.jsp?id=2071
Stage B – Operation		
Buildings – operation	Annual energy consumption calculated based on published industry standard data for energy benchmarks, based on the floor area schedule for each building type. The benchmarks have been adjusted to make allowance for improvements in energy efficiency in order to meet compliance with Building Regulations 'Part L' 2013. Emissions calculated over the 60-year design life using projected emissions intensity of the electricity grid. The Building Energy Efficiency Survey (BEES) 2014–15 sets out to improve and update the evidence of how energy is used, and to provide an assessment of the abatement	CIBSE TM46: 2008 – Energy Benchmarks Available at: https://www.cibse.org/Knowledge/knowledge-items/detail?id=a0q20000008I7evAAC BEES building energy efficiency survey (2016) Available at: https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

	opportunities for all non-domestic premises across England and Wales.	
Buildings – maintenance and refurbishment	The embodied emissions from maintenance and refurbishment over the life of the buildings have been estimated based on the ratio of embodied emissions in the phases 'to practical completion' and 'in use', applied to the benchmarks for calculating embodied emissions of building materials (as described above). Using this method, a benchmark that defined the embodied emissions during the operation phase was developed and applied to each building type.	RICS (2017) Whole life carbon assessment for the built environment Available at: https://www.rics.org/globalassets/rics-website/media/news/whole-life-carbon-assessment-for-the--built-environment-november-2017.pdf
Public realm	Energy requirements have been estimated for footpaths on a linear basis and parking areas on an area basis, using benchmarks developed based on Arup's professional experience. Emissions calculated over the 60-year design life using projected emissions intensity of the electricity grid.	Arup professional experience DECC (2015) Energy and Emissions Projections Available at: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2015
Transport emissions	The methodology for modelling the additional traffic volumes due to the proposed project is included in in the Transport Assessment. Traffic volumes on roads surrounding the proposed development were modelled for the scenarios with and without the proposed project, for the first year of construction (2023) and the first year of operation (2028) The emissions from traffic were calculated using the Emissions Factor Toolkit (EFT) for these scenarios, and linearly interpolated to provide annual emissions over the 60-year design life. These emissions assume no improvement in driving efficiency or uptake of electric vehicles.	DEFRA (2017) Emissions Factor Toolkit Available at: https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html
Habitat emissions	Provides carbon sequestration rates per habitat. This is the carbon per year per hectare absorbed from the atmosphere by a specific habitat type.	Natural England Research Report (2012) Available at: http://publications.naturalengland.org.uk/publication/1412347?category=7005

Significance criteria

14.5.9 IEMA is the industry standard guidance to contextualise the emissions from developments. The IEMA guide to assessing greenhouse gas (GHG) emissions and evaluating their significance[6] uses the following over-arching principle:

"*The GHG emissions from all projects will contribute to climate change; the largest inter-related cumulative environmental effects…as such any GHG emissions or reductions from a project might be considered to be significant…*"

14.5.10 In accordance with this guidance, any carbon emissions associated with the proposed development can be deemed significant. Accordingly, initiatives to mitigate emissions are recommended in Section 14.10.

Methodology for CCR assessment

14.5.11 The approach and methodology for the climate change resilience assessment is as follows:

- analysis of relevant climate change and weather data, emissions scenarios and probability levels;
- assessment of climate hazards, such as heatwaves or flooding;
- identification of potential risks from these climate hazards to the assets and occupants of the proposed development;
- consideration of the resilience of the proposed development within the context of any incorporated mitigation measures, including resilience measures which are embedded within the design due to regulations and design guidelines; and
- identification of need for any further resilience measures to protect the proposed development against the effects of climate change.

14.5.12 The CCR assessment is composed of three main parts: the identification of climate hazards and benefits; the assessment of likelihood and consequences; and the evaluation of significance. These are shown in **Table 14.2** and **Table 14.3**.

Table 14.2 Qualitative five-point scale of likelihood of climate change risks

Level	Descriptor	Description
A	Very unlikely	Event only occurs in exceptional circumstances and would not be expected to occur in the lifetime of the development
B	Unlikely	Based on the current design, engineering and maintenance standards, the event is not expected to occur more than once during the lifetime of the development
C	As likely as not	Event may occur at least once during the lifetime of the development
D	Likely	Event is expected to occur several times during the lifetime of the development

[6] IEMA (2017) Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance

E	Very likely	Event is expected to occur many times during the lifetime of the development

Table 14.3 Qualitative five-point scale of consequences of climate change risks

Level	Descriptor	Disruption	Public Perception	Financial	Safety	Damage
1	Minimal	Minor service disruption within a single day <30 mins	Short-term adverse local stakeholder reaction	Insignificant financial loss.	Minor harm or near miss -no adverse human health effects or complaints.	No damage to assets
2	Minor	Minor service disruption for multiple days or delays up to 2h on a single day.	Adverse local media reports over sustained period; localised stakeholder concern.	Additional operational costs. Minor financial loss.	Lost time injury or medical treatment, short term impact on persons affected	No permanent damage. Some minor restoration work required.
3	Moderate	Service delays of up to 2h for multiple days or major delays (>2h) in a single day	Significant local and /or regional reports including social media. National media interest creating public concern	Moderate financial loss.	Long-term injury or illness, porlonged hospitalisation or inability to work	Widespread damage and loss of service. Damage recoverable by maintenance and minor repair. Partial loss of local infrastructure.
4	Major	Service closed for 1 day or major delays for multiple days	Negative national reporting and public disputes with key stakeholders, utility companies or other government agencies such as the Environment Agency.	Major financial loss.	Single fatality/ multiple long-term injuries- emergency response	Extensive damage requiring extensive repair.
5	Catastrophic	Service closed for multiple days	Extensive and prolonged negative reporting nationally and or public disputes with key stakeholders.	Significantly high financial loss.	Multiple fatalities - emergency response	Permanent damage and/or loss of service Retreat and translocation of development.

14.5.13 For the CCR assessment, the timeframes for the risk assessment have been selected to align with the start and end of the operational life.

14.5.14 Due to the short temporal phase of construction, it is anticipated that these measures will appropriately address climate change risks during the construction phase. The construction phase has therefore been scoped out of the CCR assessments.

Significance criteria

14.5.15 The significance of the risks identified in the CCR assessment is based upon the likelihood of a climate hazard having an impact on the proposed development, and the consequence of the impact. The potential likelihood and consequence of impacts to the proposed development is assessed using a qualitative five-point scale as shown in **Table 14.4**.

Table 14.4 Significance matrix

			Consequence				
			1	**2**	**3**	**4**	**5**
			Minimal	**Minor**	**Moderate**	**Major**	**Catastrophic**
Likelihood	**A**	**Very Likely**	Medium	Medium	High	Very High	Very High
	B	**Likely**	Low	Medium	Medium	Very High	Very High
	C	**As Likely as Not**	Low	Low	Medium	High	High
	D	**Unlikely**	Very Low	Very Low	Low	Medium	Medium
	E	**Very unlikely**	Very Low	Very Low	Low	Low	Medium

14.5.16 Any risk equal to or above "medium" is considered significant.

Methodology for the ICCI assessment

14.5.17 For the ICCI assessment, the timeframes for the risk assessment have been selected to align with the start and end of the operational life.

14.5.18 Due to the short temporal phase of construction, it is anticipated that these measures will appropriately address climate change risks during the construction phase. The construction phase has therefore been scoped out of the ICCI assessments.

14.5.19 The approach and methodology for the ICCI assessment is as follows:

- analysis of relevant climate change and weather data, emissions scenarios and probability levels;
- consideration of potential climate change impacts for all environmental topics;
- assessment of each environmental topic's respective significant effects and the corresponding mitigation measures identified by each topic;
- assessment of any potential in-combination climate change impacts and effects given existing mitigation measures (i.e. mitigation measures identified by each environmental topic);
- assessment of whether there are any significant in-combination climate change effects, based upon whether potential in-combination climate change impacts are assessed to be 'likely' or 'high' consequence;
- consideration of additional mitigation measures to address significant in-combination climate change effects, beyond those existing mitigation measures identified by other environmental topics; and
- inclusion of allowances for future mitigation measures and monitoring, to ensure continued resilience of receiving environment.

Significance criteria

14.5.20 The outcomes of the ICCI assessment will be the categorisation of each environmental topic based on the following significance criteria:

- many potential in-combination climate change impacts with high consequences;
- some potential in-combination climate change impacts with high consequences;
- some potential in-combination climate change impacts with low consequences; and
- no potential in-combination climate change impacts.

14.5.21 The significance of an effect is assessed using the same matrix as the CCR and shown in **Table 14.4**.

14.6 Limitations and assumptions

14.6.1 The limitations of the GHG emissions assessment are as follows:

- The benchmarking tools create an average carbon output for development types by using data from thousands of previous projects. Therefore, the GHG assessment is used to estimate the carbon output of the proposed development and will have a degree of uncertainty.
- Bulk infrastructure has also been excluded, which includes water pipes, energy grid connection, roads and communication lines as this information is currently unavailable at this stage in design.
- The scope of the assessment is limited to the inclusion of the emissions sources summarised in Section 14.2.4.

14.6.2 Assumptions made in the GHG emissions assessment are included in **Table 14.5**.

Table 14.5: GHG emissions assessment assumptions

<table>
<tr><th>Emissions source</th><th>Assumptions</th></tr>
<tr><td colspan="2">Construction</td></tr>
<tr><td>Buildings</td><td>The building areas have been based on the maximum applied for in the outline planning application. This is used as it is the worst-case scenario for emissions.

Buildings have been assigned to a typology which represents most closely the use type of the building.

For the assessment it is assumed to include 90,000m^2 of class B1, B2 and B8 uses.

The benchmarks for embodied carbon in buildings are based on collated life cycle assessment data for the production stage emissions (refer to Figure 2). As the production of materials are typically the largest proportion of before use stage emissions for buildings[7], these have been taken to be the entire construction phase emissions.

Further detail of the benchmarks used to calculate the emissions and the emissions breakdown per asset are included in Appendix L1, GHG Assessment. The alternative assessment can be found in Appendix L2, GHG Assessment alternative design.</td></tr>
<tr><td>Public realm</td><td>The carpark and footpaths are assumed to be constructed as per the elements detailed below:
<table>
<tr><td>Type</td><td>Element for the Green Guide For Specification</td></tr>
<tr><td>Carpark</td><td>Asphalt (85mm) over prepared sub-base</td></tr>
<tr><td>Footpath</td><td>Asphalt paving (75mm) over prepared sub-base</td></tr>
</table></td></tr>
</table>

[7] RICS (2014) Methodology to calculate embodied carbon 1st edition http://www.rics.org/Global/Methodology_to_calculate_embodied_carbon_1st_edition_PGguidance_2014.pdf [Accessed December 2019]

<table>
<tr><td>Transport emissions</td><td>The EFT uses the traffic modelling data collected to calculate carbon emissions. It assumes the predicted fleet mix for construction for one year, which is extrapolated over the 5 year construction period. The calculations assume every year of construction will produce the same amount of emissions.</td></tr>
<tr><td>Habitats</td><td>The sequestered carbon in ecological habitats has been calculated using the Natural England Research Report[8].

Total habitats currently on the site have been measured and their total carbon calculated to give a baseline. The design is then overlaid the baseline to measure retained and proposed habitats, giving a total carbon figure for the proposed development. As habitats absorb carbon at a yearly rate, the total loss of carbon absorbed per year can be added to the total carbo emitted if development goes ahead.

A length of hedgerows has been calculated in metres. It is assumed a 3m width for all hedgerows to give a figure in m^2.</td></tr>
<tr><td colspan="2">Operation</td></tr>
<tr><td>Buildings</td><td>Operational energy consumption benchmarks for buildings have been derived from The Building Energy Efficiency Survey (BEES)[9] reports on the non-domestic building stock in England and Wales in 2014–15. Within this overall scope the stock is split into 10 sectors (retail, for example). These are in turn made up of 38 sub-sectors (Large food shops, for example), each of which was analysed separately. The overarching report describes the results from across the 10 sectors, whilst more detail is provided in 10 separate sector-specific reports.</td></tr>
<tr><td>Public realm</td><td>Street lighting is operated for an average of 12 hours per day, 365 days per year. These are considered the worst case scenario and could be improved by light reduction design measures.</td></tr>
<tr><td>Transport emissions</td><td>The EFT includes assumptions about the predicted mix of vehicles for operation. The calculations assume every year of operation will produce the same amount of emissions. It is also assumes no improvement to fleet emissions during the operation of the development.</td></tr>
<tr><td colspan="2">Maintenance and refurbishment</td></tr>
<tr><td>Buildings</td><td>The ratios for embodied emissions from the phases ‘to practical completion’ and ‘in use’ are as summarised below[10]:
<table>
<tr><th>Building type</th><th>Carbon emissions to practical completion</th><th>Carbon emissions in use</th><th>Ratio</th></tr>
<tr><td>Office</td><td>35%</td><td>32%</td><td>91%</td></tr>
</table>
All buildings are assumed to have a similar embodied emission profile to office buildings.</td></tr>
</table>

[8] Natural England (2012) Natural England Research Report. NERR043_edition_1.pdf [Accessed March 2020]
[9] UK Government (2016) The Building Energy Efficiency Survey. https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees. [Accessed Febuary 2020]
[10] RICS (2017) Whole life carbon assessment for the built environment 1st edition http://www.rics.org/Global/Whole_life_carbon_assessment_for_the_BE_PGguidance_2017.pdf [Accessed December 2017]

14.6.3 The limitations of the CCR and ICCI assessments are as follows:

- there is uncertainty in the climate change projections used – the UKCP18 Weather Generator is subject to certain limitations which are addressed in detail in the Weather Generator Report published by UKCP[11];
- the assessment is qualitative except for the assessment for flood risk and drainage design which is quantitative and takes into account climate change allowances;
- the evidence base relating to climate change impacts for some assets and environmental topics is limited due to material uncertainty in projections for specific climate variables (in particular extreme wind and storm events).

14.6.4 The CCR and ICCI assessments are based on the following assumptions:

- the assessment has assumed that mitigation measures for effects assessed by other topics will be implemented effectively;
- a Construction Environmental Management Plan (CEMP) will be developed for the construction phase that will be effectively implemented and provide appropriate mitigation for extreme weather-related effects during construction. An outline CEMP can be seen in Appendix A2. These mitigation measures have been incorporated in the CEMP and will form part of the planning condition.

[11] UKCP09 (2010) UK Climate Projections science report: Projections of future daily climate for the UK from the Weather Generator, http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87944&filetype=pdf [Accessed December 2017]

14.7 Baseline environment

GHG emissions assessment

14.7.1 Climate change predicts summers will be warmer and drier while winters will be warmer with increased precipitation[12]. There will also be more frequent extreme weather events such as heatwaves and heavy rainfall.

14.7.2 The site is not presently developed however parts of the site are agricultural and the reen network is managed. As the land is not developed the existing habitats will have a store of historic carbon and will be sequestering carbon from the atmosphere.

14.7.3 The existing reen network within the site functions to control water levels, both in summer for supply/irrigation and to improve flood resilience during the winter.

CCR and ICCI assessments

14.7.4 The baseline environment for the CCR and ICCI assessments include consideration of:

- Current climate conditions; and
- Projected future climate conditions.

14.7.5 The current climate conditions have been established for a range of climate variables based on the long-term average of historical weather data for 1981 – 2010. This data is from the UK Climate Projections (UKCP18) gridded observations. These values are presented in Table 14.6 UKCP18 baseline climate **data** (1981-2010) and climate change projections for Cardiff as a baseline for comparison with the projected future climate conditions.

14.7.6 The proposed development is at risk of flooding and designated under a TAN15 Zone C1[13], defined as ‘an area of the floodplain which is developed and served by significant infrastructure, including flood defences’. The Rivers and Sea Flood mapping produced by Natural Resources Wales indicates that the whole site is within Flood Zone 3[14]. The Surface Water Flood Mapping produced by Natural Resources Wales indicates there are areas of Low Surface Water Flood Risk associated with the Gwent Levels reen system.

14.7.7 The future climate conditions are also presented in Table 14.6 and Table 14.7, based on projections of different probability levels and emissions scenarios. These are presented over two timescales; ‘the 2020s’ (which is defined by the Met Office as the period 2010-2039) and ‘the 2070s’ (which is defined as the period 2060-2089). These periods have been selected as they align with the construction and operational phases of the proposed development, based on the 60-year design life.

14.7.8 Future climate conditions are given for both a medium emissions and high emissions scenario at the 50% probability level. A reference range is also provided in each case,

[12] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[13] Planning Policy Wales: TAN15: Development and Flood Risk.
[14] Natural Resources Wales: Long term flood risk map.

using the 10% probability level medium scenario as a lower limit and the 90% probability level high scenario as an upper limit.

14.7.9 An indication of the directional trend for each of the climate variables is also included in **Table 14.7**. Overall, the trends in climate variables are summarised as:

- **High temperatures** – Increase in mean daily temperatures in the summer and winter, increase in the number of hot days (days when daily mean temperature is >25°C) and increased insolation;
- **Low temperatures** – Decrease in the number of frost days (days when daily minimum temperature <0°C);
- **High precipitation** – Increase in mean daily rainfall in the winter, increase in the number of days with heavy rain;
- **Low precipitation** – Decrease in mean daily rainfall in the summer, increase in the annual number of dry spells;
- **Extreme wind** – Increase in extreme wind events[15]; and
- **Lightning** – Increase in the number of lighting days, particularly in Autumn[16].

[15] IPCC (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, https://ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap23_FINAL.pdf [Accessed December 2017] page 1279

[16] Future changes in lightning from the UKCP09 ensemble of regional climate model projections, http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87950&filetype=pdf [Accessed December 2017]

Table 14.6 : UKCP18 baseline climate data (1981-2010) and climate change projections for Cardiff

Parameter		**Observed Baseline**	**Anomalies from 1981 – 2010 baseline**			
			2020s (2010 - 2039)		***2070s (2060 – 2089)***	
			50% probability	*Range (10% - 90% probability)*	*50% probability*	*Range (10% - 90% probability)*
Temperature (°C)	Winter mean temperature	4.5	5.1	4.4 to 5.9	7.4	5.5 to 9.4
	Summer mean temperature	15.6	16.5	0.2 to 17.2	20.5	17.5 to 23.6
	Winter mean daily minimum temperature	1.6	2.2	1.5 to 3	4.6	2.6 to 6.9
	Summer mean daily maximum temperature	20.1	21.2	20.4to 22.2	25.6	22.2 to 29.2
Precipitation (%)	Winter mean precipitation rate	5.1	5.4	4.9 to 6	6.4	5.3 to 7.9
	Summer mean precipitation rate	3.2	2.9	2.3 to 3.4	2	1 to 2.9

Table 14.7 UKCP18 baseline climate data (1981-2010) and climate change event projections for Cardiff.

Parameter		**Observed Baseline**	**2020s (2010-2039)**			**2060s (2050-2079)**		
			RCP 8.5 Min	**RCP8.5 Mean**	**RCP 8.5 Max**	**RCP 8.5 Min**	**RCP8.5 Mean**	**RCP 8.5 Max**
Temperature	Number of frost days (daily minimum temperature equal or lower than 0°C)	46.5	28.0	36.4	49.1	19.9	23.2	28.9
	Heatwaves (2 days with maximum temperature higher than 29°C and minimum temperature higher than 15°C)	0.2	0.5	1.5	3.6	2.6	7.6	14.0
	Number of hot days (daily maximum temperature higher than 25°C)	9.1	9.4	19.4	39.4	27.4	51.8	77.3
Precipitation	Dry spells (10 days or more with no precipitation)	3.8	3.0	4.0	5.0	3.9	5.1	6.8
	Annual number of days per year when precipitation is greater than 25mm per day (Met Office definition of 'heavy rain')	9.8	6.1	10.7	13.5	9.5	13.0	15.5

14.8 Design mitigation

GHG emissions assessment

14.8.1 The benchmarks used to undertake the GHG emissions assessment are assumed to reflect a development built and operated according to standard practice. Therefore, it is recommended that opportunities for mitigation should be regularly reviewed and integrated where practicable as the design develops.

14.8.2 Suggested mitigation to reduce GHG emissions during the construction and operational phases are summarised in Section 14.9.10 and the Design and Access Statement.

CCR assessment

14.8.3 The CCR assessment uses the allowances that are made for future climate impacts on the severity of fluvial and tidal flooding events. These are detailed in the Flood Consequences Assessment.

14.8.4 In the near term, the changes in climate variables are expected to be small enough to not impact the operation of the infrastructure and building equipment.

14.8.5 Detail of the embedded mitigation measures associated with each identified climate change risk are included in the risk register in Appendix L3, CCR assessment. These include building standards which consider climate change, the operational (climate) ranges of equipment and maintenance standards for roads. Beyond these legal standards it is also suggested the proposed development be connected to the mains water supply in case of droughts and a Landscape Management Plan be developed which includes procedures for irrigation during establishment and ongoing maintenance. These will be secured via planning conditions.

ICCI assessment

14.8.6 Design mitigation measures for all of the environmental topics are detailed in their ES chapter.

14.8.7 Detail of the embedded mitigation measures associated with each identified in-combination impact are included in the risk register in Appendix L4, ICCI assessment. These include the sustainable drainage system (SuDS) designed to retain water onsite during dry weather, developing a storm water drainage strategy and designing flood mitigation to ensure no dewatering of the existing reen system.

14.8.8 When landscaping tree and plant selection should incorporate a wider range of drought tolerant species and contain a diverse range of species from regions with similar climatic conditions. All of the mitigation contained in Appendix L4, ICCI assessment, will be secured via planning condition.

14.9 Assessment of effects

GHG emissions assessment

14.9.1 The GHG emissions resulting from the construction and operation of the proposed development are summarised in Table 14.8.

Table 14.8: Total CO^2 emissions by emission sources

Emissions source	Emissions over appraisal period (tCO_2-e)	Annual emissions in opening year (tCO_2-e/year)
Construction		
Buildings	62,569	n/a
Public realm	1,928	n/a
Transport	4,075	679
Habitats	18,937	n/a
Operation		
Buildings	94,143	5,610
Public realm	1,264	289
Habitats	12,948	80
Transport	192,462	3,262
Maintenance and refurbishment		
Buildings	33,366	n/a
Total		
	335,558	9,325

14.9.2 Further detail of the benchmarks used to calculate the emissions and the emissions breakdown per asset are included in Appendix L1, GHG Assessment.

Assessment of effects from construction

14.9.3 The construction phase of the development will result in 87.5 ktCO2e of GHG emissions, based on the scope of the assessment outlined in this chapter. For context, the emissions from the proposed development can be compared to the annual emissions from the Cardiff region. In 2017, the total reported emissions for all sectors was 1,665 ktCO2e[17]. Construction is over five years and therefore equates to approximately 1% of emissions of the Cardiff region. This is significant as any increase in GHG is considered significant.

[17] National Atmospheric Emissions Inventory (2017) Local Authority CO2 interactive maps (2015), http://naei.beis.gov.uk/data/local-authority-co2-map [Accessed December 2017]

Assessment of effects from operation

14.9.4 The operational phase of the development will result in 333.4 ktCO2e of GHG emissions over the 60-year appraisal period, based on the scope of the assessment outlined in this chapter. This is comprised of:

- 286.6 ktCO2e from the annual energy consumption of buildings and transport-related emissions during operation;
- 12.9 ktCO2e from the loss of habitat carbon sequestration; and
- 32.6 ktCO2e from embodied emissions due to maintenance and refurbishment activities over the 60-year period.

14.9.5 In the first year of operation (2028), the annual emissions from energy consumption and transport will be 9.2 ktCO2e, this is considered significant.

CCR assessment

Assessment of effects from construction

The impacts of climate change are already being experienced, particularly in terms of increased frequency and severity of extreme weather events such as storms and heatwaves. The measures set out in the Construction Environmental Management Plan should be set within the context of the current climate. Due to the short temporal phase of construction, it is anticipated that these measures will appropriately address climate change risks during the construction phase. The construction phase has therefore been scoped out of the CCR assessments.

Assessment of effects from operation

14.9.6 Over the near-term (the 2020s), the risks identified in the CCR assessment have a ‘Low’ or ‘Very low’ risk rating due to the mitigation measures embedded in design. These measures are outlined in Section 15.8.2 and Appendix L3, CCR Assessment.

14.9.7 Over the long-term (the 2070s), several risks identified have a ‘Medium’ risk rating. These include:

- Risks associated with decreased precipitation leading to a reliance on water mains for landscape management and loss of vegetation during the summer; and
- High winds lead to increased stress and damage to above ground utility infrastructures.

14.9.8 These risks identified in the CCR assessment have been classified as significant.

ICCI assessment

Assessment of effects from construction

14.9.9 The impacts of climate change are already being experienced, particularly in terms of increased frequency and severity of extreme weather events such as storms and heatwaves. The measures set out in the Construction Environmental Management Plan should be set within the context of the current climate. Due to the short temporal phase of

construction, it is anticipated that these measures will appropriately address climate change risks during the construction phase. The construction phase has therefore been scoped out of the ICCI assessments.

Assessment of effects from operation

14.9.10 Over the long-term (the 2070s), several risks have been identified as being significant. These include:

- Variation in temperature and rainfall patterns exceed thresholds for certain habitats and species. Could change the growing season of species. Changes in precipitation patterns may have an effect on pollution caused by runoff;
- Hot and dry (drought-like) conditions lead to habitat degradation, including potentially drying out of waterbodies and therefore making less suitable for otter/water vole; and
- Increased temperature and occurrence of heat waves may change the suitability of habitat conditions, potential for increase in spread of non-native species if native species/plants can't survive.

14.10 Mitigation and enhancement

GHG emissions assessment

14.10.1 The GHG emissions assessment provides an indication of the emissions associated with the construction and operation phases of the proposed development. As all emissions from the development are considered significant under the definition in Section 14.5.2, mitigation actions should be implemented to reduce GHG emissions from the development.

14.10.2 PAS 2080 provides a framework for the management of carbon in projects in the built environment. The use of PAS 2080 to guide the approach to reducing GHG emissions associated with the proposed development is recommended, along with further mitigations measures which are outlined below.

14.10.3 At this stage in the project programme, when the details of construction are in outline only and no contractor has yet been appointed, mitigation measures which are outlined in the sections below **are only recommendations** to be evolved during detailed design stage. These mitigation measures are therefore not accounted for in the assessment of significance of effects and the outcomes of the assessments remain as stated in Section 14.9 of this ES chapter.

Recommended mitigation of effects from construction

14.10.4 To mitigate GHG emissions during the construction phase it is recommended that targets are set for carbon reduction and passed through the supply chain. This should include a

clear plan as to how targets will be passed to developers of individuals plots over time (this could e.g. be a plot guide).

Recommended mitigation of effects from operation

14.10.5 The following measures are recommendations for design interventions to mitigate the impact of GHG emissions during the operation of the proposed development:

- Consider opportunities for meanwhile uses on the site in terms of the site the programme for development
- Take a 'fabric first' approach to building design in order to improve the thermal efficiency of buildings and reduce heating and cooling energy requirements during operation. Including consideration of orientation and design;
- Select energy efficient infrastructure, equipment and fittings in order to reduce energy demand during operation;
- Assess energy supply options, and develop an energy strategy for the proposed development, which focuses on the installation of renewable energy generators and connections to low carbon energy sources where possible, in order to reduce the emissions intensity of the energy consumed;
- Develop strategies to encourage the use of low carbon transport modes, including active and public transport, in order to reduce emissions from transport. This should include an EV charging strategy for cars parking at the station.
- Provide segregated infrastructure for walking and cycling, and sufficient bicycle parking at the station, as well as in the wider development, aligned to the building uses;
- Develop a strategy to support building occupiers to develop a circular economy, reducing consumption and waste;
- Design for operation, consider service-based material and selection of durable materials with low requirements for maintenance and replacement over the operational life of the development, with consideration of appropriate selection of materials.

CCR assessment

Mitigation of effects from operation

14.10.6 No risks identified in the CCR assessment have been identified as significant and therefore no further recommendations for mitigation are needed.

14.10.7 However, due to the uncertainties involved in adapting to future climate change, an adaptive pathway approach[18] is recommended for monitoring and managing climate risks into the future. A clear plan, with climate related trigger points for review should be

18 Adaptation pathways is a planning approach addressing the uncertainty and challenges of climate change decision-making. It enables consideration of multiple possible futures and allows analysis/exploration of the robustness and flexibility of various options across those multiple futures.

developed to support this, including an understanding of interdependencies and the requirements for developers of individual plots.

14.10.8 During detailed design, green infrastructure[19] on site will be designed to reduce heat exposure, in tandem with the carbon sequestration opportunities.

ICCI assessment

Mitigation of effects from operation

14.10.9 No risks identified in the ICCI assessment have been identified as significant and therefore no further recommendations for mitigation are needed.

19 Green Infrastructure refers to a strategically planned and managed network of green spaces and other environmental features vital to the sustainability of any urban area. Green Infrastructure also encompasses river systems and coastal environments