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Wiltshire Council

M4 Junction 17 OBC

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M4 J17 Carbon Management Plan

22/08/22

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This document has 84 pages including the cover.

Document history

Revision	Suitability	Purpose description	Originated	Checked	Reviewed	Authorised	Date
C02	A1	Revised operation data	**CP**	**AR**	**AR**	**AM**	**22**/08/22
C01	A1	First draft	CP	VS	AR	AM	15/08/22

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1. Introduction

1.1.1. This is the Carbon Management Plan (CMP) for the proposed M4 Junction 17 scheme, which is currently at Outline Business Case (OBC) stage. The Department for Transport (DfT) require a CMP to be submitted at each business case stage for schemes requiring government approval as best practice. The CMP has been developed following guidance issued by the DfT in November 2021, which includes reference to the Construction Playbook[1], PAS 2080[2], and Transport Appraisal Guidance Unit A3[3].

1.2. Purpose of this report

1.2.1. This CMP summarises the carbon footprint for the Scheme and proposes an aspirational carbon reduction target. It also outlines the process to enable the carbon reduction target to be achieved.

1.2.2. This is a live document and will be updated through the project lifecycle to report on the implemented opportunities and any associated carbon reductions achieved, as well as identifying opportunities which would need to be implemented through the various project stages.

1.2.3. This document should be read in conjunction with other project specific reports, including the Outline Business Case (OBC) and Environmental Appraisal (EA).

1.3. Structure of this CMP

1.3.1. Following this introduction, the remainder of this report is delivered as follows:

- A brief description of the scheme
- Legislation and policy with reference to carbon emissions
- Carbon reduction hierarchy
- Scope of Carbon Management Process
- Roles and Responsibilities
- Quantification of carbon emissions
- Target setting, baseline, and monitoring
- Management and delivery of the carbon management plan
- Reporting, continual improvement, communication, and training

[1] HM Government (2020). The Construction Playbook - Government Guidance on sourcing and contracting public works projects and programmes. Version 1.0. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/941536/The_Construction_Playbook.pdf

[2] The British Standards Institution (2016). Carbon Management in Infrastructure PAS 2080:2016. Available at: PAS 2080 Carbon Management in Infrastructure verification | BSI (bsigroup.com)

[3] Department for Transport (2021). Transport Analysis Guidance (TAG) Unit A3. Available at: https://www.gov.uk/government/publications/tag-unit-a3-environmental-impact-appraisal

2. Background to the Scheme

2.1. The Major Road Network

2.1.1. The proposed Major Road Network (MRN) improvements at M4 Junction 17 are part of Wiltshire Council's progressive improvements to the A350, which have been delivered since 2004. The Scheme is considered a top nine priority MRN Scheme by the Western Gateway Sub-National Transport Body (STB) due to its ability to improve north-south connectivity in the area. The Scheme will build upon the partial signalisation of M4 Junction 17 that was completed in May 2018, where the eastbound and westbound off-slips were signalised to reduce instances of queuing on the M4.

2.2. Need for the Scheme

2.2.1. The A350 is a key north-south route between the M4 corridor and South Coast and is part of the MRN comprising the UK's busiest and most economically important local authority 'A' roads. It forms a key strategic route in the Western Gateway area and underpins the A350 Growth Zone identified in the Swindon and Wiltshire Strategic Economic Plan (SEP)[4]. The route provides connections between the two Principal Settlements[5] of Chippenham and Trowbridge along with the Market Towns of Corsham, Bradford-on-Avon, Westbury, and Warminster.

2.2.2. It has been a longstanding priority for Wiltshire Council to improve north-south connectivity via the A350 corridor, which includes alternatives to road travel such as rail. This reflects the significant role of the A350 in supporting economic activity and growth at a local and regional level. Strong local connectivity in the West Wiltshire area as well as effective north-south links to the M4 are a pre-requisite to support further growth and in order to open up new business opportunities by making it easier to transport freight from the south coast ports and improve road access to London and the rest of the Western Gateway area.

2.2.3. Wiltshire Council is taking a strategic approach to the planning and delivery of improvements and upgrades to the A350. This has drawn upon various funding opportunities within the last 10 to 20 years to deliver necessary improvements to the corridor. This has included improvements to M4 Junction 17 and upgrades to the A350 route around Chippenham (link and junction improvements). Further south, the proposed Yarnbrook and West Ashton Relief Road Scheme (to be delivered by developers) will provide a new route for the A350 east of Trowbridge and facilitate the development of the Ashton Park urban expansion. Wiltshire Council is also likely to seek funding to improve the A350 at Westbury, but this will fall into a further round of government funding which is unlikely to begin until 2025.

2.2.4. M4 Junction 17 is located at the intersection of the M4 and A350, north of the A350 Growth Zone identified in the Swindon and Wiltshire SEP. It provides access to Cirencester (Gloucestershire) to the north via the A429, and Chippenham (Wiltshire) to the south via the A350 MRN. The MRN was adopted by the DfT in 2017 as part of the Transport Investment Strategy and implemented towards the end of 2018[6]. It was introduced to form a middle tier of roads sitting between the national Strategic Road Network (SRN) and the rest of the local road network, covering the UK's busiest and most economically important local authority 'A' roads.

2.2.5. To unlock new business opportunities, need for an effective north-south link between the M4 and the south coast has been identified. This will make freight transport from the ports on the south coast easier, as well as improve road access to London as well as the rest of the Western Gateway area. The Western Gateway STB prioritised the M4 Junction 17 Scheme for MRN funding in its Regional Evidence Base submitted to the DfT in July 2019.

[4] Swindon and Wiltshire Strategic Economic Plan (Swindon and Wiltshire Local Enterprise Partnership, Jan 2016)
[5] Principal Settlements as defined within the Wiltshire Council Core Strategy (2015)
[6] https://www.gov.uk/government/publications/major-road-network-and-large-local-majors-programmes-investment-planning

2.3. Scheme objectives

2.3.1. The Scheme includes increasing the number of traffic lanes on the M4 Junction 17 circulatory carriageway and widening of entries and exits, with full signalisation. These improvements will contribute to the five main objectives of the Scheme:

- Reduce delay and improve journey time reliability at M4 Junction 17, supporting journeys on the SRN;
- Support the overall success of the A350 improvements programme (including MRN) by delivering complementary improvements at M4 Junction 17.;
- Improve north-south connectivity on the A350 through improvements to M4 Junction 17, the gateway to the A350 from the SRN;
- Ensure that M4 Junction 17 has the capacity to accommodate planned and future growth in the A350 Corridor and in the A350 and Swindon M4 SWLEP Growth Zones, including the Chippenham Urban Expansion and the Wiltshire Local Plan Review; and
- Improve existing safety levels at M4 Junction 17, taking into account forecast traffic growth.

3. Legislation and Policy Drivers for Carbon Management

3.1.1. Relevant international, national and local policies are provided in Appendix A. Key policies, plans and guidance documents are described below.

3.2. UK National Policy

Climate Change Act 2008

3.2.1. The UK has made commitments to tackle the root cause of climate change by reducing greenhouse gas (GHG) – also termed 'carbon' – emissions, as well as to increase the resilience of development and infrastructure to the changing climate. The Climate Change Act 2008 (as amended in 2019)[7] sets a target to reduce net GHG emissions by at least 100% from 1990 levels by the year 2050 (Net Zero). Relevant policies include the UK's 'Nationally Defined Contributions' (NDC) which are respectively agreed and submitted to the United Nations as a commitment in the Conference of the Parties (COP), the most recent being Glasgow COP26 in November 2021.

UK Carbon Budgets

3.2.2. Table 3-1 contains the UK's defined 'carbon budgets' as required by the Climate Change Act, from 2008-2037. The carbon budgets are set by the UK government and quantify the maximum level of emissions that may be released in the UK in million tonnes whilst still meeting its obligatory climate change targets. The UK government has met all its carbon budget targets to date, but it should be noted that to meet future carbon budgets and the Net Zero target by 2050 will require more challenging measures.

Table 3-1 - UK carbon budget reduction targets

UK carbon budget period	UK carbon budget emissions
1st carbon budget (2008 to 2012)	3,018 $MtCO_2e$
2nd carbon budget (2013 to 2017)	2,782 $MtCO_2e$
3rd carbon budget (2018 to 2022)	2,544 $MtCO_2e$
4th carbon budget (2023 to 2027)	1,950 $MtCO_2e$
5th carbon budget (2028 to 2032)	1,725 $MtCO_2e$
6th carbon budget (2033 to 2037)	965 $MtCO_2e$

Transport Decarbonisation Plan (TDP) 2021

3.2.3. In response to the UK's Net Zero emissions target, the Department for Transport (DfT) published "Decarbonising Transport: A Better, Greener Britain" referred to as the Transport Decarbonisation Plan (TDP) in 2021. The TDP outlines a number of commitments by the Government to remove all emissions from road transport to achieve Net Zero by 2050. Commitments that will have a direct impact on road user emissions from the Scheme include:

- An end to the sale of new petrol and diesel cars and vans by 2030
- All new cars and vans must by 100% zero emission at the tailpipe by 2035
- An end to the sale of all non-zero emission road vehicles including HGVs by 2040

[7] The Climate Change Act 2008 (2050 Target Amendment) Order 2019. Available online at: https://www.legislation.gov.uk/ukdsi/2019/9780111187654. Accessed May 2022.

3.3. Local Policy

3.3.1. In February 2019 Wiltshire Council resolved to acknowledge a climate emergency and to seek to make the county of Wiltshire carbon neutral by 2030. Cabinet subsequently committed to also make the council carbon neutral by 2030. The Climate Strategy was adopted at Full Council in February 2022 and sets out how this will be achieved. The 2030 commitment applies to direct emissions (Scope 1 and 2). The Climate Strategy contains the following commitment on indirect (Scope 3) emissions: “Work to understand and reduce scope 3 emissions (supply chain and outsourced operations) for wider impact”.

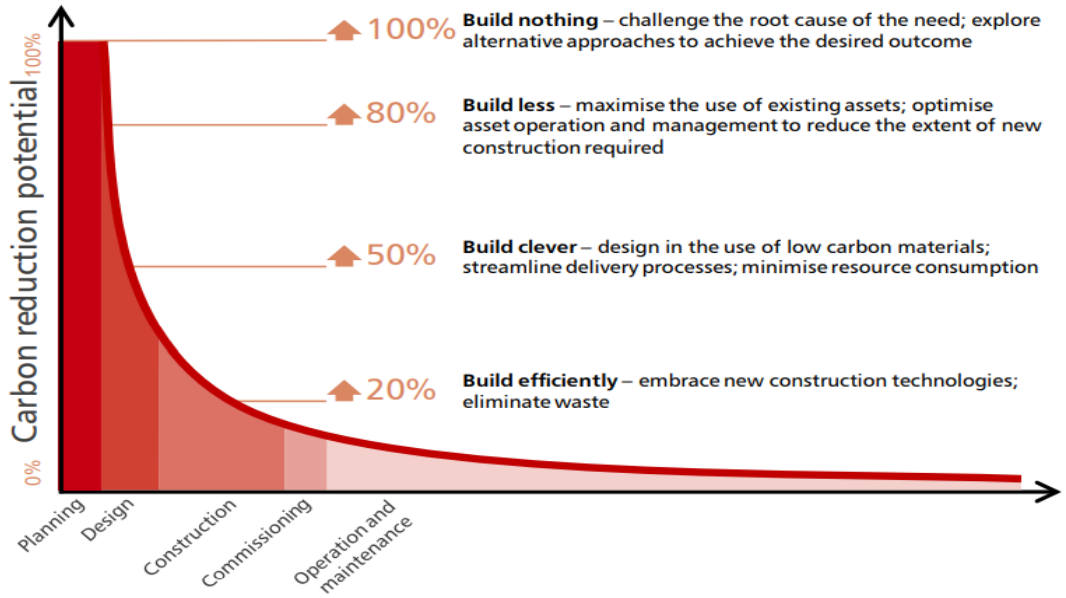
4. Carbon Reduction Hierarchy

4.1.1. When identifying potential opportunities to reduce carbon emissions, the following carbon reduction hierarchy, as provided in PAS 2080, has been used:

- **Build nothing**: evaluate the basic need for an asset and/ or programme of works and explore alternative approaches to achieve outcomes set by the asset owner/ manager[8]
- **Build less**: evaluate the potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required
- **Build clever**: consider the use of low carbon solutions (including technologies materials and products) to minimise resource consumption during the construction, operation and user's use stages of the asset or programme of work; and
- **Build efficiently**: use techniques (e.g. construction, operational) that reduce resource consumption during the construction and operation phases of an asset or programme of work.

4.1.2. An example of the potential reductions that can be saved is shown in Figure 4-1 below.

Figure 4-1 - Carbon Reduction Curve

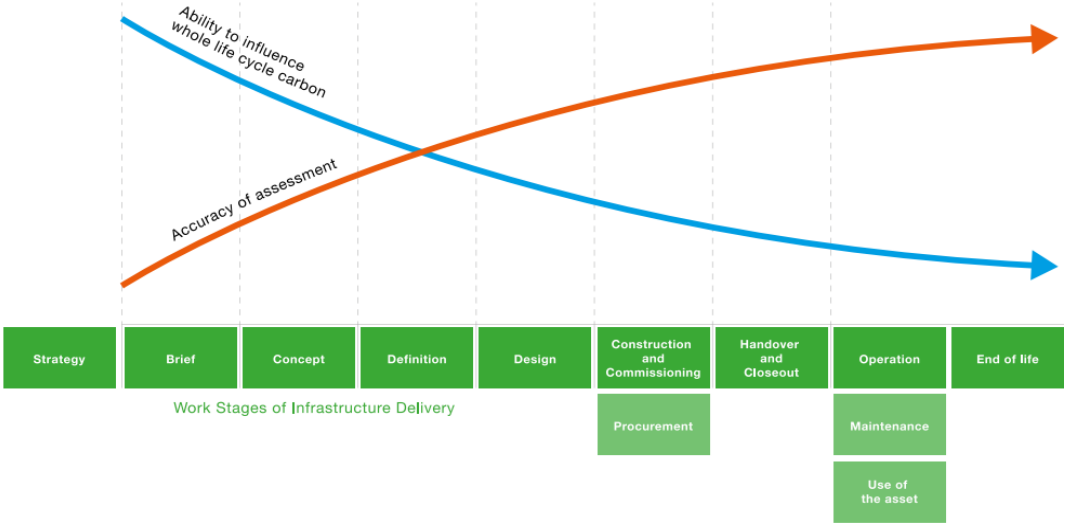


Source: Green Construction Board

4.1.3. The scope for reducing carbon emissions is greater during the initial work stages (stages Brief to Definition) than in the later work stages (stages Design to End of Life), as shown in Figure 4-2. However, the degree of knowledge of the types of assets required to deliver the desired outcomes is smaller at these initial work stages and increases over time. Accuracy requirements for the assessment (or quantification) of whole life cycle carbon emissions also vary in different work stages (e.g. for data and modelling assumptions that are needed for assessing whole life carbon emissions). The degree of accuracy becomes important when it affects decisions in each work stage to select the lowest whole life carbon option.

[8] Organization that manages and is responsible for providing, operating and maintaining infrastructure assets

Figure 4-2 - Conceptual diagram showing ability to influence carbon reduction across the different work stages of project delivery



4.1.4. Within relevant tasks, the hierarchy has been applied through any techniques that generate new ideas, ranging from:

- Individual desk-based working and light-bulb moments; to
- Extensive collaboration across the supply chain as both on-going discussion and specific innovation and value engineering exercises; to
- Identifying transferable solutions external to the scheme, e.g., through learning from other projects, or CPD training.

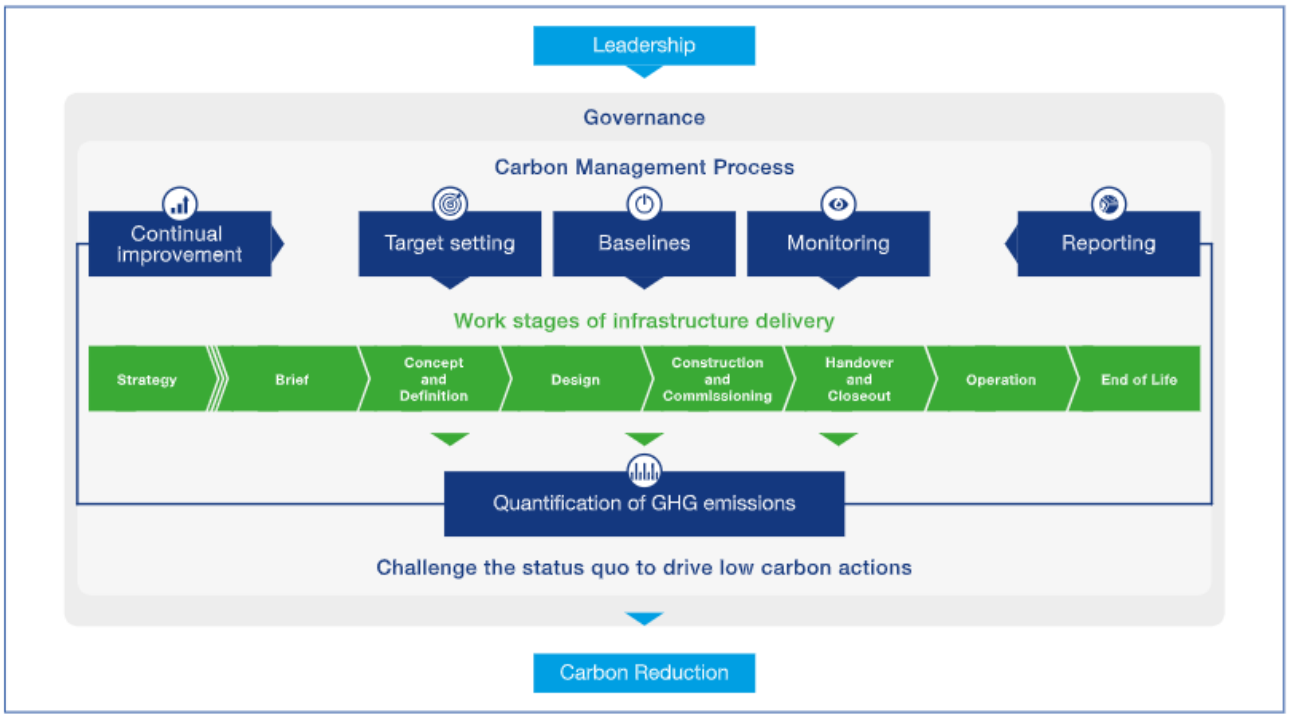
4.1.5. In summary, any new design or construction idea that is generated, through whatever means, that can lead to lower carbon solutions should be used, and this plan has been developed to enable and accommodate this.

5. Scope of Carbon Management Process

5.1.1. The various components of the carbon management process, in accordance with PAS 2080, are shown in Figure 5-2 and includes the following:

- Quantification of GHG emissions
- Target setting, baselines and monitoring
- Reporting
- Continual improvement

Figure 5-1 - Carbon Management Process



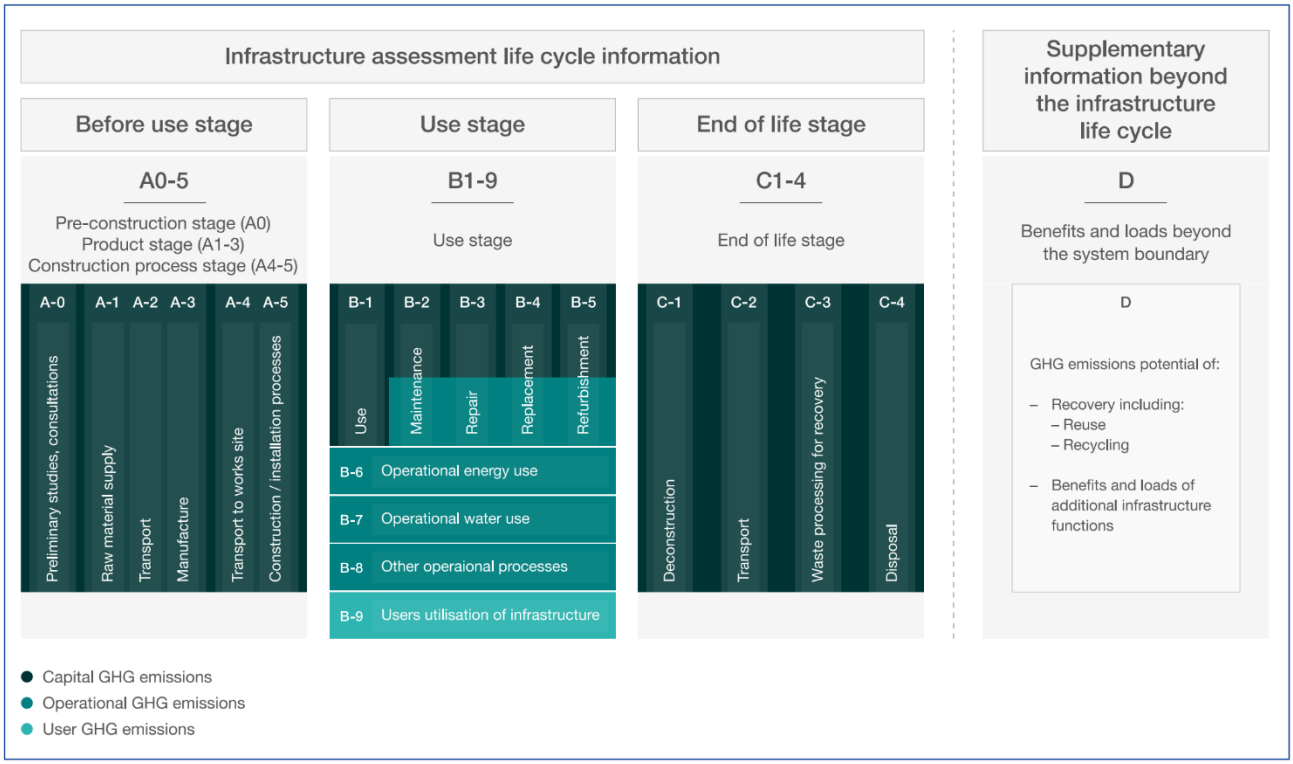
5.1.2. The carbon management process integrated into project delivery processes drives the value chain[9], as described in section 6, to collaborate and create a culture of innovation. This supports reductions in carbon and cost during project delivery by driving the use of low carbon solutions.

5.1.3. PAS 2080 applies a whole life cycle-based approach to GHG emissions, as shown in Figure 5-2 below. The purpose of this is to avoid un-intended consequences, helping to ensure a balanced perspective by showing the gross size/scale of emissions and when they occur. In this way, informed decisions can be made supporting optimum low carbon outcomes.

5.1.4. Each life cycle stage includes boundaries, which further identify specific emissions sources applicable within each life cycle stage and are critical to defining the full scale of emissions to be considered. The stages that have been quantified for the baseline of this Scheme are explained further in section 6.

[9] Organisations and stakeholders involved in creating and managing infrastructure assets. These include asset owners/managers, designers, constructors and product/material suppliers.

Figure 5-2 - PAS 2080 and Project Carbon Emissions Scope

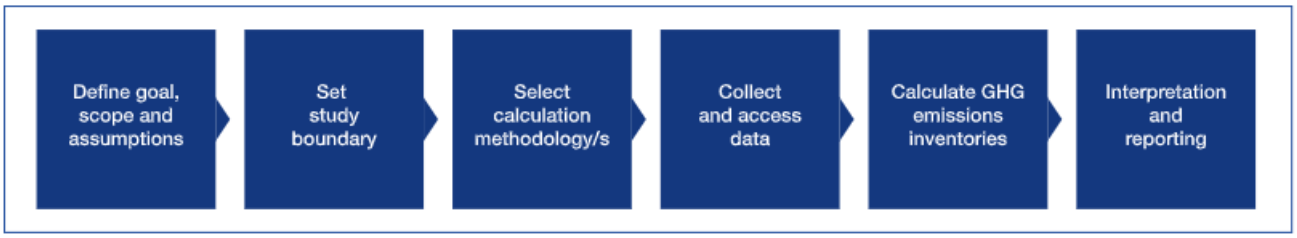


5.1.5. The CMP is a live document which should be updated at each stage of the project, with revisits to the target setting, baselines, monitoring of carbon reduction, GHG emissions quantification, and reporting to allow for continual improvement in carbon management.

6. Quantification of GHG Emissions

6.1.1. The quantification of GHG emissions allows carbon hotspots to be identified and informs carbon reduction strategies. The quantification of GHG emissions follows the steps shown in Figure 6-1 in line with PAS 2080 and will need to be revised based on available information at each stage.

Figure 6-1 - Principal steps of GHG emissions quantification



6.2. Assessments undertaken to date

6.2.1. The method used for quantifying whole life cycle carbon emissions to date has been determined based on guidance within Design Manual for Roads and Bridges (DMRB) LA 114 and the boundaries and scopes of National Highways' Carbon Tool, and PAS 2080.

6.2.2. The life cycle stages and GHG sources presented in Table 6-1 are those that are usually included within an assessment, although exclusions at this stage have been noted. Emissions have been calculated for the construction and operation stages of the scheme. The operation phase is assumed to cover 60 years from the opening year in line with the appraisal period used in the TAG appraisal. The emissions calculated provide the baseline for the scheme.

6.2.3. It should be noted that the data provided here are preliminary only, obtained at the time of undertaking the OBC. As the Scheme design progresses, more detail will become available which is likely to result in a re-assessment of the carbon emissions of the project and the carbon management processes associated with the scheme.

Table 6-1 - Sources and lifecycle stages for Scheme GHG emissions

Main stage of project life cycle	Sub-stage of life cycle	Potential sources of GHG emissions (not exhaustive)	Activity Data
Construction stage	Product stage; including raw material supply, transport and manufacture.	Embodied GHG emissions associated with the required raw materials.	Materials quantities
	Construction process stage: including transport to/from works site and construction /installation processes.	Activities for organisations conducting construction work	Fuel/electricity consumption. Construction activity type/duration. Transportation of materials from point of purchase to site, mode/distance.
	Land use change. [**Excluded at this stage**]	GHG emissions mobilised from vegetation or soil loss during construction.	Type and area of land subject to change in usage.
Operation stage (in	Use of the infrastructure by the	Vehicles using	Traffic count/speed by

Main stage of project life cycle	Sub-stage of life cycle	Potential sources of GHG emissions (not exhaustive)	Activity Data
line with appraisal period)	end-user (road user).	highways infrastructure.	vehicle type for highway links.
	Operation and maintenance (including repair, replacement and refurbishment).	Energy consumption for infrastructure operation and activities of organisations conducting routine maintenance.	Fuel/electricity consumption for vehicles, lighting and plant. Waste and arisings quantities, transport mode/distance and disposal fate.
	Land use and forestry **[Excluded at this stage]**	Ongoing land use GHG emissions / sequestration each year.	Type and area of land subject to change in usage. Net change in vegetation.
Opportunities for GHG reduction throughout project life cycle (construction, operation and decommissioning)	GHG emissions potential of recovery including reuse and recycling GHG emissions potential of benefits and loads of additional functions associated with the study system.	Avoided GHG emissions through substitution of virgin raw materials with those from recovered sources.	Waste and arisings material quantities and recycling/reuse rate.

Table Source: adapted from DMRB LA 114

6.3. Predicted construction emissions

6.3.1. Construction phase emissions and construction process emissions are broken down in Table 6-2 and Table 6-3 respectively. Full details are provided in Appendix D. Conservative assumptions have been used, including:

- All materials are brought to site by HGVs travelling a distance of 100km; and
- All plant machinery used on site will be powered by diesel fuel.

6.3.2. As the design progresses and preliminary design begins, all data displayed in Table 6-2 and Table 6-3 will be revised. A full assumption list provided by the expert judgement of the Atkins Quantity Surveyor team can be found in Appendix C. Preliminary design is currently expected to commence in January 2023.

6.3.3. The construction of the Scheme will lead to an additional 7681.15 tCO_2e with the majority (76.02%) arising from material production and processing, with 13.67% from transportation of materials to site and a further 10.31% from the construction processes of plant machinery.

6.3.4. Bitumen surface treatment is responsible for the single largest source of emissions (4,368tCO_2e) which equates to 56.87% of construction emissions, followed by asphalt which produced 849.13CO_2e (11.05%). This is largely due to the high carbon content of bitumen and asphalt surfacing, which are applied at high temperatures.

6.3.5. As shown in Table 6-3, within the construction plant data, the ‘Other Machinery’ which accounts for smaller plant operating across the site accounted for the largest proportion of construction process carbon at 247.28CO_2e (3.22%) followed by the Bull Dozer which accounts for 179.84 CO_2e (2.34%) and the Dump Truck which accounts for 151.36CO_2e (1.97%).

Table 6-2 – Construction Phase Emissions

Category	Item	Materials		Transport	
		Emissions (tCO_2e)	Percentage of Construction Total (%)	Emissions (tCO_2e)	Percentage of Construction Total (%)
Bulk Materials and Pavements	Bitumen/ Surface Treatment	4,368.12	56.87%	102.33	1.33%
	Asphalt	849.13	11.05%	299.30	3.90%
	Kerbing	16.33	0.21%	2.41	0.03%
	Road Marking	49.65	0.65%	0.17	0.00%
Earthworks	Imported Soil	305.69	3.98%	248.27	3.23%
Street Furniture and Electrics	Traffic Signs	18.91	0.25%	0.13	0.00%
	Road Lighting and Columns	36.99	0.48%	0.24	0.00%
	Cable	1.72	0.02%	0.02	0.00%
	Plastic cable ducting	8.80	0.11%	0.07	0.00%
	Cabinets	3.86	0.05%	0.03	0.00%
	Chambers	21.53	0.28%	0.15	0.00%
	Signals	1.33	0.02%	0.00	0.00%
Drainage	Plastic pipework (HDPE)	123.78	1.61%	0.96	0.01%
	Precast concrete manholes	38.38	0.50%	3.14	0.04%
	Gullies	2.40	0.03%	0.02	0.00%
	Filter Drain	2.20	0.03%	5.74	0.07%
Fencing and Barriers	Fence	4.10	0.05%	0.03	0.00%
	Road Restraint System/ Safety Barrier	218.83	2.85%	1.54	0.02%
Construction Waste	Bituminous Mixtures	0.00	0.00%	90.33	1.18%
	Mixed Metals	0.57	0.01%	0.52	0.01%
	Aggregate and Soil	0.00	0.00%	299.32	3.90%
Total material		**5839.33**	**76.02%**	**-----**	**----**

Category	Item	Materials		Transport	
		Emissions (tCO_2e)	Percentage of Construction Total (%)	Emissions (tCO_2e)	Percentage of Construction Total (%)
Total transport		**---**	**----**	**1050.03**	**13.67%**
Construction process emissions		**791.80**	**10.31%**	**----**	**----**
Construction phase total		**7,681.16**	**100%**		

Table 6-3 – Construction Process emissions

Plant Type	Litres of Diesel Consumed	Emissions (tCO_2e)	Percentage of Construction Total (%)
Bulldozer/ Ripper	57,600	179.84	2.34%
Tipper truck	32,000	99.91	1.30%
Pavers -Base layer	3,000	9.37	0.12%
Rollers – Base layer	2,160	6.74	0.09%
Pavers	5,000	15.61	0.20%
Pavement Roller	3,600	11.24	0.15%
Roller – Type 1	7,200	22.48	0.29%
Excavator	15,360	47.96	0.62%
Dump Truck	48,480	151.36	1.97%
Other Machinery	79,200	247.28	3.22%
Total	**253,600**	**791.80**	**10.31%**

6.4. Predicted operational emissions

6.4.1. Operational emissions are calculated separately from the National Highways Carbon Tool, which is focused specifically on construction-phase emissions. Road user carbon emissions have been estimated using National Highways speed band emissions factors based on Defra's Emissions Factors Toolkit (v11)[10], which provides emission factors up to 2050 to allow for the increasing numbers of electric vehicles into the national vehicle fleet. Emissions are broken down into direct emissions from the tailpipe, and indirect emissions from battery charging. The future emissions are however still conservative, as no further decrease is assumed post the 2036 future year. The calculations used traffic data from the Scheme specific traffic model and considered the full road network included in this traffic model, for the opening and future years (2026 and 2036 respectively), and over the 60-year appraisal period.

6.4.2. Operational emissions for the Scheme have been calculated for two separate scenarios, the 'Do Minimum Scenario' which represents the emissions which would occur if the Scheme was not constructed. The second scenario is the 'Do Something Scenario which represents the operational emissions that would arise if the Scheme were constructed.

10 Defra Emissions Factors Toolkit (V11) released November 2021 and the associated Highways England speed band emission rates which account for the November 2021 DEFRA Emissions Factors Toolkit update.

6.4.3. There is no project-specific data available for operational energy use, or maintenance and refurbishment during the Scheme's operational life, so emissions cannot be calculated using a standard tool. Instead, they have been estimated using published data from other highways schemes of a similar scale to this Scheme, based on the assumption that emissions from the operational and maintenance of similar highways is broadly consistent across the UK network. Published data from three other highway schemes[11] (M4CaN new relief road, A14 improvement scheme, A465 embankment works) shows that proportionately, annual emissions from operational energy use and maintenance works equate to between 0.05% and 0.29% of in-use traffic emissions. As a reasonable worst case therefore, operational and maintenance emissions have been assumed to be 0.29% of the road user emissions in each case, and to cover the same study area as for operational emissions, i.e. roads in the wider area affected by traffic changes. These emissions are considered to be conservative, given the need to meet the net zero target by 2050.

6.4.4. The results of the Do Minimum Scenario are presented in Table 6-4. Table 6-4 shows that in the opening year of 2026 there would be a total operational emission release of 1,620,060tCO_2e, and 1,426,132tCO_2e in the future year of 2036 and 86,830,987 tCO_2e over the 60-year appraisal period under the Do Minimum Scenario. Table 6-5 presents the Do Something Scenario.

Table 6-4 – Operational emissions in the Do Minimum Scenario

Life cycle module (Do Minimum Scenario)	Emissions (tCO_2e)		
	2026 Emissions (tCO_2e)	2036 Emissions (tCO_2e)	60-year operational period (tCO_2e)
Road user carbon (direct)	1,620,060	1,426,132	86,830,987
Road user carbon (Indirect)	10,838	19,851	1,141,513
Operation and maintenance	473	419	25,512
Total operation	1,631,371	1,446,402	87,998,011

Table 6-5 – Operational emissions in the Do Something Scenario

Life cycle module (Do Something Scenario)	Emissions (tCO_2e)		
	2026 Emissions (tCO_2e)	2036 Emissions (tCO_2e)	60-year operational period (tCO_2e)
Road user carbon (direct)	1,620,379	1,426,715	86,864,272
Road user carbon (Indirect)	10,840	19,861	1,142,070
Operation and maintenance	473	420	25,522
Total operation	1,631,693	1,446,996	88,031,864

6.4.5. The results of the Do Something Scenario show that in the opening year of 2026 there would be a total operational emission release of 1,620,379 tCO2e, with 1,426,715 tCO2e of operational carbon emitted in the future year of 2036 and 86,864,272tCO2e over the 60-year appraisal period.

[11] Welsh Government (2016) M4 Corridor around Newport, Environmental Statement: Volume 3, Appendix 2.4 Carbon Report

6.5. Land use and land-use change (LUC) emissions

6.5.1. The loss of habitats due to construction of new highway and its elements will result in the release of carbon stored in plants. There is limited data available at this stage, as such, calculations have not been included.

6.6. Summary

6.6.1. Table 6-6 shows the overall net emission of the proposed Scheme whereby the Do Minimum Scenario has been subtracted from the Do Something Scenario, to give the total net operational emissions. There are no construction emissions in the Do Minimum Scenario and therefore the construction of the Scheme is considered to have a net increase in emissions.

6.6.2. The construction of the Scheme will have a net increase in emissions of 7,681.16 tCO2e, with a net operational emission impact of 322 tCO2e in the opening year of 2026, 594 tCO2e in the future year of 2036 and 33,852 tCO2e over the 60-year appraisal period.

Table 6-6 – Net emissions of the Scheme for Construction and Operation

Life cycle module Net emissions (DS-DM)	Emissions (tCO_2e)			
	Construction Period	2026 Emissions ($tCO_2e_)$	2036 Emissions ($tCO_2e_)$	60-year operational period ($tCO_2e_)$
Construction	7,681.16	-------	--------	--------
Road user carbon (direct)	---------	320	583	33,286
Road user carbon (Indirect)	---------	2	10	557
Operation and maintenance	----------	0.1	0.2	9.8
Total emissions	7,681.16	322	594	33,852

7. Baseline, Target Setting and Monitoring

7.1. Baseline

7.1.1. The baseline for the Scheme is presented in Section 6 of the CMP, as informed by the quantification of GHG emissions with the Scheme during construction and over the 60-year appraisal period during operation, before any carbon reduction measures have been applied. At the time of writing this CMP there are limitations for setting the baseline for the first time due to the limited data available at this stage. The baseline GHG emissions should be updated and documented as additional design details are available as the CMP is revisited.

7.2. Target setting

7.2.1. A target has been set against the baseline so that performance against it can be determined. The Scheme should aim to reduce carbon emissions as much as possible throughout the life cycle of the project. Given the need to revisit the baseline at each stage of the scheme, as more accurate data becomes available, then it is also possible that the target may need revisiting.

7.2.2. The carbon emissions which make up the construction phase for the baseline at this stage are informed by best estimates by the designers, without any constructor on board. There is potential for scope for further carbon reductions once a constructor is appointed.

7.2.3. Given that the operational phase emissions are largely outside the control of the value chain and will be reduced over time with the decarbonisation of the vehicle fleet, as a proportionate approach, it is recommended that the focus on setting a target is for the capital emissions associated with the construction phase only at this stage. However, solutions to reduce carbon emissions during operation, both from road users and from operation and maintenance will continue to be logged and included within this CMP.

7.2.4. Given that at this stage there are also no constructors contracted for this scheme, the target should be revisited once they are on board, given their ability to be able to have a greater understanding of where carbon savings can be made through construction rather than just purely from the design.

7.2.5. **The aspirational target for this Scheme at this stage aims to reduce capital emissions during construction by a proposed 15 to 25%.** This target will be revisited once a better understanding of options for reducing carbon emissions and proposed construction methods takes place.

7.2.6. Proposals to inform this reduction in carbon emissions will be further developed over the next stages of this scheme.

7.3. Monitoring

7.3.1. Monitoring is a key and mandatory element of carbon management. Progress against targets and in relation to the carbon baseline should be monitored in line with PAS 2080 and other specific requirements by GCC/ NH and should be compatible with other national policy and regulatory requirements.

7.3.2. Data is expected to be reported as tonnes of carbon dioxide equivalent (tCO2e). Monitoring and reporting is expected to be carried out at each stage of the scheme, and also on an annual basis once construction commences. This could be undertaken more frequently during construction to ensure the capital carbon target is met.

7.3.3. Appropriate monitoring requires key roles and responsibilities to be established to allow effective implementation of actions. These are discussed further in Section 9.

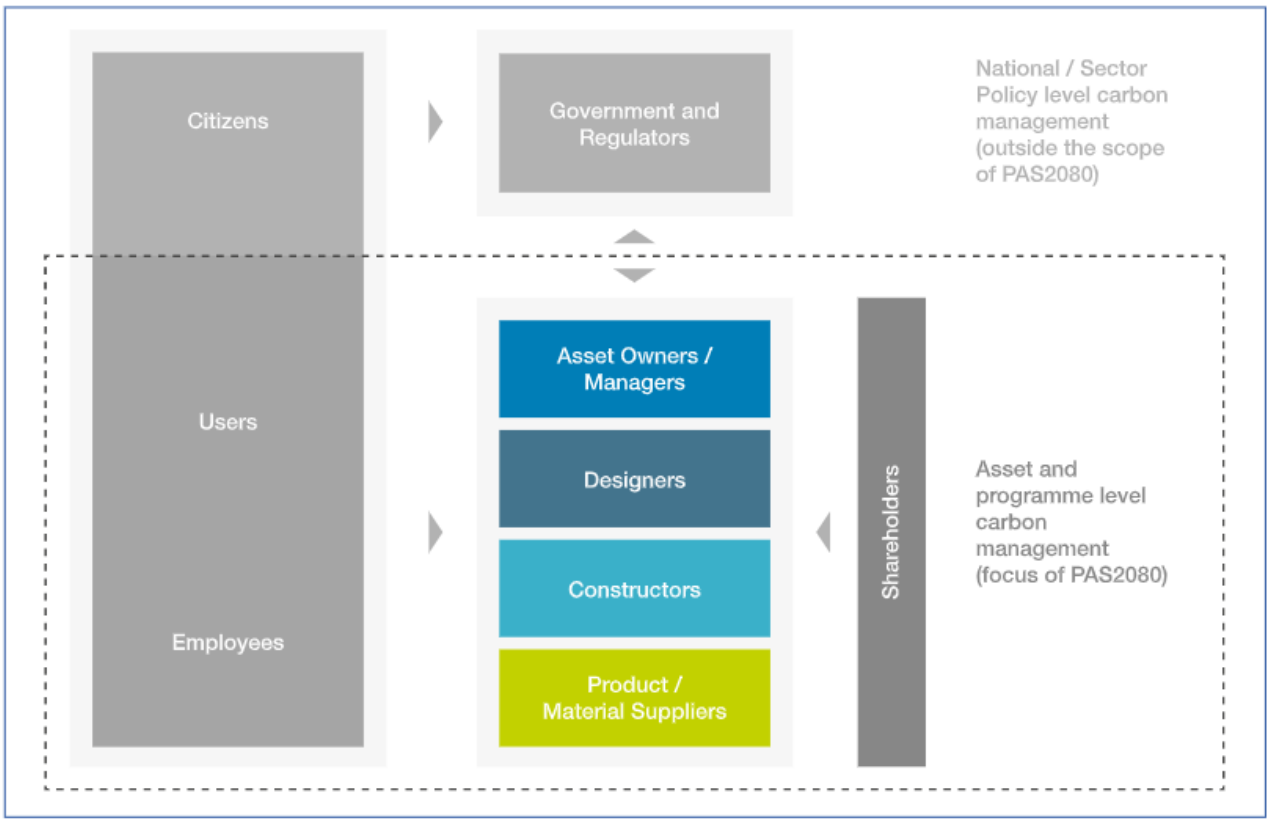
8. Management and Delivery of the Carbon Management Plan

8.1. Value chain members responsible for carbon management

8.1.1. Leadership and governance are recognised as a key enabler of a CMP. Wiltshire Council has overall responsibility for the implementation of the CMP, and for encouraging the value chain to challenge the existing 'business as usual' approach of infrastructure delivery, to reduce carbon and cost in assets and programmes of work.

8.1.2. Figure 8-1 presents the value chain members responsible for carbon management for the scheme. These include the following: Asset Owner/ Manager; Designer; Constructor; and Product/ Material Suppliers – also termed as "suppliers".

Figure 8-1 - Infrastructure value chain members responsible for carbon management



8.2. Project team roles and responsibilities

8.2.1. This section sets out the outline roles and responsibilities across the project team. Every project team member is responsible for contributing to improving the carbon performance of a project. As the Scheme progresses specific requirements of all value chain members will be included.

8.2.2. Collectively the project team is required to:

- Adopt the carbon reduction targets set by Wiltshire Council as a minimum
- Communicate and share the carbon targets with other value chain members
- Collect data relevant to their activities and roles within infrastructure delivery for carbon baselines

- Take into account limitation in the accuracy of baselines when making comparisons against their activities during delivery and report these against any claims of reductions achieved
- Undertake design development and construction planning according to the requirements specified in the project carbon management plan;
- Apply the carbon reduction hierarchy, using unlimited design and construction thinking and project planning;
- Ensure that carbon management is embedded throughout each stage of the scheme;
- Work with suppliers to identify, assess and develop new design proposals that may improve the carbon performance of the scheme; and
- Understand the overall purpose and requirements of this plan and communicate it to project stakeholders as necessary to assist with implementation.

8.2.3. Specific roles and associated responsibilities applicable to the asset owner, Wiltshire Council, are detailed below.

- Set the overall carbon management direction including targets and governance systems
- Ensure staff have adequate carbon management skills through training or recruitment
- Ensure strategic plans for new and existing assets incorporate clear carbon objectives and targets
- Procure products/ materials/ services using agreed criteria to achieve carbon objectives
- Engage across the value chain to ensure that technologies and solutions proposed and implemented are in line with carbon targets
- Ensure assets are operated to achieve carbon targets
- Ensure asset maintenance and replacement strategies incorporate carbon objectives
- Managing carbon throughout the life of an asset

8.2.4. Specific roles and associated responsibilities that apply to the designer, Atkins, are detailed below.

Project director

- Ensures that a project carbon management plan is implemented into project delivery
- Engages with key stakeholders and make them aware of the responsibility to participate in the delivery of the carbon management plan
- Ensures competent resource is provided to support the delivery of the carbon management plan, and support the development and skills/ awareness throughout the team
- Supports options assessment and correct prioritisation of carbon performance

Project manager:

- Responsible for implementation of the project carbon management plan on the project
- Agrees a RACI Matrix of Carbon Management Responsibility
- Ensures that carbon management is documented in the project programme
- Supports discipline leads with realising carbon reduction opportunities and minimising risks
- Has a communications plan in place that supports collaboration between the value chain members

Project technical lead:

- Ensures appropriate technical assurance, capability and techniques are applied
- Prepares and updates the project carbon management plan to reflect the overall needs of the project, in accordance with relevant guidance
- Reviews the competencies of the discipline leads and their teams to ensure appropriate skills and training/ support are mapped
- Reviews and reports on the implementation of the requirements of the CMP
- Puts a system in place for recording decisions and ensures they are recorded.

- Ensures that carbon is a consideration throughout the project's technical delivery processes and co-ordinates this within the wider team
- Assists team in assessment of carbon performance/ options and brings a consistent approach

Discipline leads:

- Ensure designers, engineers and specialists in their team are aware of their responsibilities, and have the knowledge to carry them out, and can apply the carbon reduction hierarchy
- Challenge designers, engineers and specialists to apply innovation and assess carbon reduction potential opportunities

8.2.5. The responsibilities of those involved within the value chain are included in Table 8-1 which shows the RACI12 matrix for the Scheme at this stage. The constructors and suppliers for the Scheme are not yet known, however they will be informed of the various activities once they are involved. The terms for the RACI matrix are defined as follows:

- Responsible – The doer of the activity
- Accountable – The value chain member accountable for ensuring the activity is completed to the level required
- Consulted – Value chain member who is actively engaged and contributes input to the doer of the activity
- Informed – Value chain member who is kept aware of how and when the activity is being completed and ready to provide inputs if necessary

Table 8-1 – RACI matrix for the CMP at OBC stage

Carbon Management Process activity	Asset Owner (Wiltshire Council)	Designer (Atkins)	Constructor (tbc)	Product / Material Supplier (tbc)
Set objectives for carbon management	A	R	I	I
Set measurable target to achieve objectives	A	R	I	I
Obtain baseline data by calculating GHG emissions	A	R	I	I
Compare emissions against baseline	A	R	I	I

R= responsible A=accountable C=consult I=inform

[12] Responsible, Accountable, Consulted, Informed (RACI)

9. Reporting, Continual Improvement

9.1. Reporting

9.1.1. Reports on whole life carbon emissions will be provided at each stage of the scheme, or as required by Wiltshire Council. The reports will allow progress of monitoring against targets and continuous improvement over the duration of the project and inform decision-making in managing whole life carbon. An extensive carbon reduction innovation list that could be utilised through ongoing discussion with Atkins designers is included in Appendix B.

9.2. Implementation of low carbon solutions

9.2.1. Table 9-1 provides the current log of ideas to reduce carbon emissions. These can be further developed during the next stages of preliminary and detailed design, with those ideas that are implemented, recorded and noted.

Table 9-1 – Log of Carbon Management Opportunities

Log Number	Summary details of implemented opportunity	Carbon reduction achieved tCO_2	Estimated % reduction
1	Procuring steel with an increased recycled content.	TBC	TBC
2	Exploring the use of low carbon asphalt.	TBC	TBC
3	Exploring the use of low carbon concrete.	TBC	TBC
4	Design change implemented avoiding bridge works, which has reduced the volume of material required for the scheme, reducing construction carbon footprint. Additional carbon benefit of reducing congestion.	TBC	TBC
5	Avoiding defining a pavement excavation depth, which reduces the amount of excavation needed, and also reduced material/ asphalt use.	TBC	TBC
6	Design change for the westbound merge, means less carriageway is now required, reducing the volume of material needed and subsequent carbon footprint.	TBC	TBC
7	Explore the use of materials travelling to site via rail.	TBC	TBC
8	Explore the use of low carbon plant machinery, through Hydrotreated Vegetable Oil or diesel plant.	TBC	TBC
9	Explore use of plastic marker posts	TBC	TBC
10	Use clay instead of plastic pipework	TBC	TBC

9.2.2. This table will be updated throughout the project at the various stages.

9.2.3. Other examples of low carbon solutions which could be implemented during the construction and operational phases are provided in Appendix B, and these will be explored over the next stages of the project.

9.3. Continual Improvement

9.3.1. To allow continual improvement, the following key points should be followed by all value chain

members:

- Establish a process of continual improvement and embed in the relevant carbon management process components
- Seek the input of all value chain members to the process of continual improvement of their own activities during infrastructure delivery
- Capture carbon emissions information and share with other value chain members in order to facilitate benchmarking and continual improvement in future carbon management between organizations within infrastructure sectors
- Capture carbon reduction solutions and share learning with other value chain members to inform future current good practice.

10. Communication and Training

10.1. Communication

10.1.1. The project team will be kept informed about carbon targets and the carbon management plan through appropriate communications.

10.1.2. Carbon reduction opportunities will also be discussed and recorded at meetings for designers, engineers, construction specialists and key subcontractors where relevant. Carbon reduction achievements will also be communicated.

10.2. Training and awareness

10.2.1. Training requirements for the key roles will be identified by the management teams and will vary according to role. This section will be updated for the constructors and suppliers once they are involved in the scheme.

Asset owner - Wiltshire Council

10.2.2. Training requirements for Wiltshire Council will be ascertained during preliminary and detailed design stages.

Designer - Atkins

10.2.3. Training resources are provided to all staff on the following topics:

- Design for Life: Carbon and energy use
- Whole Life Carbon Management (WLCM)
- Net Zero Carbon Introduction (course content provided by UK Green Building Council)
- Engineering Net Zero – An Introduction (Global training introducing key concepts around climate change and net zero)

10.2.4. Atkins are also developing further courses to be made available to all staff on:

- Carbon – The Basics
- How to drive reduction through projects
- Carbon Knowledgebase

Principal Contractor

10.2.5. The Principal Contractor will need to implement the Carbon Management Plan and ensure that key personnel and suitability trained to be able to embed and identify further carbon reduction measures.

Appendix A. Legislation, Regulatory and Policy Framework

Table A-1 Legislation, regulatory and policy framework for effects on climate

Scale	Legislation/ regulation/ policy	Summary of requirements
International	Kyoto Protocol (1997)	The first international agreement to mandate greenhouse gas emission reductions. Under the United Nations Framework Convention on Climate Change (UNFCCC) treaty, industrialised nations pledged to cut their annual emissions by 5% on a 1990 baseline by 2012. Although the target was met successfully, it was insufficient to offset the increase in emissions from industrialising countries. Total global emissions continued to grow over the period, by 40% between 1990 and 2009.
	COP 21 Paris Agreement (2015)	Strengthened negotiations at COP 21 led to the 2015 Paris Agreement, the aim of which is to maintain the increase in global average temperature at 'well below' 2°C and 'pursue efforts' to limit the temperature increase even further to 1.5°C. In 2018, the International Panel on Climate Change (IPCC) published a special report in response to the Paris Agreement, to present the impacts of the targeted 1.5°C temperature rise. The report highlighted that to achieve this, global emissions must decrease by 45% by 2030 (against a 1990 baseline), and that net zero global emissions (where emissions and removals from the atmosphere are balanced) must be achieved by 2050. This is noted to require rapid and far-reaching transitions for every sector on an unprecedented scale.
	COP 26 Glasgow (2021)	Negotiations have strengthened further at COP 26 in Glasgow in 2021, with countries agreeing to 'phase down' unbated coal power and 'phase out' inefficient fossil fuel subsidies. Additionally, 40 countries signed up to ending coal consumption by 2030. Whilst, 140 countries vowed to end deforestation, including $19 billion of international financial support. Further, the conference concluded with the first commitment on methane emission release, with 100 countries pledging to reduce methane emissions by 30% compared to 2020 levels, by 2030. The final message of the conference concluded the world must 'secure global net-zero by mid-century, to keep the 1.5 degrees target alive'.
National	Climate Change Act (2008) as amended in 2019[13]	To support international efforts, the UK Climate Change Act (2008) set a legal reduction target of 80% against 1990 levels by 2050. It also introduced a series of carbon 'budgets' for five-year periods, to act as stepping-stones to the overall reduction. There are budgets currently set up to 2037. In response to the ambitions of the Paris Agreement, in 2019 the Climate Change Act was amended to set the overall reduction target by 2050 to at least a 100% reduction in net emissions against 1990 levels, i.e. 'net zero carbon'. The UK has so far outperformed its budgets, but progress is slowing, and the country is not on track to meet its future budgets or the overall reduction target, according to the most Recent 2021

[13] http://www.legislation.gov.uk/ukpga/2008/27/contents

Scale	Legislation/ regulation/ policy	Summary of requirements
		Progress to Parliament by the Committee on Climate Change[14] .
	Town and Country Planning (Environmental Impact Assessment) Regulations 2017[15]	Schedule 4 of the Regulations requires a description of the factors likely to be significantly affected by the development which includes climate (for example GHG emissions and impacts relevant to adaptation).
	National Planning Policy Framework (NPPF) 2021[16]	Paragraph 152 outlines its support for transitioning to a low carbon future, by way of reducing greenhouse gas emissions and supporting renewable and low carbon energy and associated infrastructure. Building on the NPPF, planning practice guidance first published in June 2014 and revised in March 2019, advises on how to identify suitable measures in the planning process to mitigate for and adapt to climate change[17].
	Transport Decarbonisation Plan (TDP)[18]	In response to the UK's Net Zero emissions target, the Department for Transport published its Transport Decarbonisation Plan (TDP) in 2021. The TDP outlines a number of commitments by the Government to remove all emissions from road transport to achieve Net Zero by 2050. Commitments that will have a direct impact on road user emissions from the Scheme include: an end to the sale of new petrol and diesel cars and vans by 2030; all new cars and vans must be 100% zero emission at the tailpipe by 2035; an end to the sale of all non-zero emission road vehicles including HGVs by 2040.
	National Highways Net Zero Highways Plan (2021)	National Highways' Net Zero Plan is aligned with the TDP, and sets out aspirational greenhouse gas reduction targets and a roadmap with targets to cut corporate emissions (100% of corporate emissions to be net zero without purchased offsetting by 2030), maintenance and construction emissions (40-50% reduction in emissions compared to 2020 by 2030, and 100% of schemes net zero by 2040) and road users (100% of the network will be net zero by 2050).
	Construction 2025 (July 2013) HM Government[19]	Construction 2025 (2013) sets out how efficiency improvements will be created in construction covering sustainability and carbon and including a target to reduce emissions by 50%. The emissions reduction target of 50% is not Scheme specific, and the efficiency improvements are broad. In terms of the Scheme and emissions reduction, the reduction target should be taken into account when developing Scheme specific mitigation measures, where relevant.
	Infrastructure Carbon Review (2013) HM Treasury[20]	The Infrastructure Carbon Review sets out carbon reduction action required by infrastructure organisations that have formally endorsed the review; this includes Highways England. The Review shows that the infrastructure industry controls 16% of the UK's total carbon emissions, covering construction (A1-5), and operation and maintenance of assets (B1-8). It also highlights

[14] 2021 Progress Report to Parliament - Climate Change Committee (theccc.org.uk)
[15] The Town and Country Planning (Environmental Impact Assessment) Regulations 2017 (legislation.gov.uk)
[16] National Planning Policy Framework (publishing.service.gov.uk)
[17] Climate change - GOV.UK (www.gov.uk)
[18] Decarbonising Transport: Setting the Challenge (publishing.service.gov.uk)
[19] https://www.gov.uk/government/publications/construction-2025-strategy
[20] https://www.gov.uk/government/publications/infrastructure-carbon-review

Scale	Legislation/ regulation/ policy	Summary of requirements
		that a further 37% of carbon emissions are related to the use of infrastructure assets (B9), over which the industry can have some influence.
Local	Wiltshire Climate Strategy 2022-2027, published for public consultation in September 2021[21]	In February 2019, Wiltshire Council resolved to acknowledge a climate emergency to seek to make the county of Wiltshire (and the Council itself) carbon neutral by 2030. A Global Warming and Climate Emergency Task Group was set up to gather evidence and develop recommendations on achieving net zero. Government data gathered in 2019, shows that the key sources of CO_2 emissions in Wiltshire are: transport (45%); industry, commercial and agriculture (29%); and homes (26%). The Wiltshire Draft Climate Strategy is structured around seven delivery themes: Transport; Homes and the Built Environment; Natural Environment, Food and Farming; Energy; the Green economy; Waste; becoming a Carbon Neutral Council; and Working Together. The Strategy includes a number of proposed strategies, targets and timelines for delivery. The delivery theme for Transport includes a number of commitments and proposed initiatives, based on the following objectives: • To achieve a transport system in Wiltshire that has zero carbon emissions, acknowledging the different solutions for our towns and city versus rural villages. • Creating the infrastructure for increased walking, cycling, shared and public transport and use of alternative fuels, including electric vehicle charging points • Achieving high-quality, bus-based, public transport and transport hubs that offer a pleasant and convenient way to get around, and seamless combined journeys • Locating and designing new developments to reduce the need to travel and provide more opportunities for people to travel by zero or low carbon transport modes, for work, leisure and errands.
	A Green & Blue Infrastructure Strategy for Wiltshire, February 2022)[22]	The draft Green & Blue Infrastructure Strategy was shaped in consultation with local nature, health and enterprise partnerships and neighbouring authorities. The Strategy is supported by an evidence base and has links to planning guidance on green and blue infrastructure (GBI) and settlement frameworks. It is a high-level strategic document which sets out the vision, goals and principles for GBI across Wiltshire and considers 'what' is needed and 'how' it is to be delivered.
	Wiltshire Council Local Plan, Looking to future (January 2021)[23]	In February 2019, Wiltshire Council acknowledged a climate emergency and agreed to seek to make the county of Wiltshire carbon neutral by 2030. This plan outlines the challenge of climate change in a national and local context and describes how the preparation of the Wiltshire Local Plan can, in part, help address the issue.
	Swindon and Wiltshire	The SWLEP has published its emerging Local Industrial

[21] Wiltshire_Council_Draft_Climate_Strategy_Sept21.pdf
[22] 111340-GBIS-Vol1-Strategy-DF-2021-08.indd (wiltshire.gov.uk)
[23] https://www.wiltshire.gov.uk/media/5622/Addressing-Climate-Change-and-Biodiversity/pdf/Wiltshire_Local_Plan_Addressing_Climate_Change_and_Biodiversity_FINAL.pdf?m=637469175263630000

Scale	Legislation/ regulation/ policy	Summary of requirements
	Local Enterprise Partnership (SWLEP)[24]	Strategy[25] 2020-2036 which includes commitments to improving the strategic energy infrastructure, decarbonising the economy and helping to deliver the national climate change targets.
	Wiltshire Core Strategy (Adopted in January 2015	Core Policy 41 identifies how sustainable construction and low-carbon energy will be integral to all new development in Wiltshire. In doing so, this policy sets the framework for meeting a number of national and local priorities that seek to achieve sustainable development and conserve natural resources. The policy aims to help reduce Wiltshire's contribution to climate change through improved design and construction methods.

[24] https://www.wiltshire.gov.uk/green-economy-climate-emergency
[25] https://static.swlep.co.uk/swlep/docs/default-source/strategy/industrial-strategy/emerging-lis-v0-1-master-31032020.pdf?sfvrsn=4fe0ce5e_14

Appendix B. Reducing Carbon During Construction

Table B-1 - Legislation, regulatory and policy framework for effects on climate

Carbon Reduction Hierarchy	Best Practice	Examples	Further Details
Build Less – Reduce built structures	• Reduce size/number of structures/assets.	• Find design efficiencies to design out structures/assets • Substantially reduce their size e.g. use NFM instead of built structures	• Largest potential to reduce overall project carbon
Build Less – Reduce quantities of materials	• Challenge standards / business as usual • Minimise the quantities of materials required to provide the solution	• Avoid over-engineering and over-designing • Prioritise lower-carbon materials over ca rbon intensive materials	• High potential to reduce overall project carbon. • Also reduces quantities of materials that need to be transported – further reducing emissions
Build Clever – Use Alternative materials	Low carbon / alternative materials: • Cement • Plastics • Timbers • Road Markings • Kerbside Installations • LED Street Lighting and road studs • Surface treatments	Alternative Cementitious options: • Alkali activated materials – CemFree	• Low-stress structures/uses 60 – 80% carbon reduction • 15-20% more expensive
		Cement replacements options: • GGBS • Fly Ash	• 15-70% carbon reduction (depending on % replacement)
		Thermoplastic Marking replacement options: • Methyl Methacrylate • Solvent-water based acrylics	• These alternatives can also be transported via LGVs • Consume less energy as they can be applied at cold temperatures • Require no gasses or primers.[26] • Reduces 80% of carbon. • 30% more expensive but design life 10 years, compared to 3-5.[27]
		Alternatives to geotextile materials: • Geosynthetics	• Reduces emissions by 64% • Provides the same level of erosional defence and stability.[28]
		• Plastic Kerbing Material	• Reduces emission intensity by 40%**Error! Bookmark not defined.**.
		• Timber alternatives for fencing	• There are opportunities for timber to be carbon negative from certified forests[29] • Potential to eliminate 100% of

[26] https://www.aexcelcorp.com/blog/mma-vs-thermoplastic-paint

[27] CHAPTER 3. COST EFFECTIVENESS - Pavement Marking Demonstration Project: State of Alaska and State of Tennessee-Report to Congress, April 2010 - FHWA-HRT-09-039 (dot.gov)

[28] Aimil (2018) Importance of Geotextiles in Road Constructions& types of geotextiles. Available at:< Importance of Geotextiles in Road Constructions & types of geotextiles - Aimil Corporate Blog> Accessed: 02/12/2021

[29] Accoya (2020) Sustainable Timber Production Sustainable timber, what is FSC certified wood, FSC timber (accoya.com)

Carbon Reduction Hierarchy	Best Practice	Examples	Further Details
			timber related emissions with electric machinery and transport.
		• LED lighting technology	• Uses 70% less energy. • Substantially reduces running and maintenance costs through increased design life[30].
		• Cooking Oils • Lignin	• Waste cooking oil has been tested to be an effective alternative[31]. • Natural Lignin is also another suitable replacement found in trees and plants[32].
	Recycled Materials: • Road lighting columns • Steel RRS barrier • Plastic inspection chamber • Precast Concrete Gullies • Road Cabinets • Cabling • Marker Posts and Signs	• Recycled steel and aluminium and copper	• 80% carbon reduction for steel[33] • Recycled Aluminium uses 95% less energy[34]. • Using copper cables to increase efficiency, with recycled HDPE casing[35].
		• Recycled plastics (e.g., for piling / planks and HDPE materials)	• 50% capital carbon reduction. Additional potential benefits due to longer lifespan • Tested by EU to reduce emissions by 28% • Utilizing recycled concrete gullies will lower carbon emissions.
	Site won materials	• Borrow pits/ • Reuse of excavated materials • Road Gully Waste	• Emissions from sourcing and transportation substantially reduced • By collecting road gully waste, it can be transformed into topsoils and aggregates which can be used for other road schemes[36].
Build Clever – Design-in efficiencies for later project stages	DfMA / Off-site manufacture	• Precast concrete slabs / blocks etc.	• Reduced materials and construction time (less fuel burnt on site)
	Design for EOL	• Ensuring products are as recyclable as possible at EOL	• Reduced emissions for manufacturing of future products
Build Efficiently – Reduce transportation emissions	Locally sourced materials	• Source from local manufacturers / suppliers	• Reduced journey distance of product transport (less fuel burnt)
	Zero Emission Freight	• Battery EV • Hydrogen Fuel Cell HGVs	• Up to 100% carbon reduction (if renewable energy used) (Green Hydrogen from windfarms in future)
Build Efficiently –	Optimise construction	• Reduce hours of	• Emissions from fuel/energy

[30] LED Climate Group (2020). Available:< LED | Climate Group (theclimategroup.org)

[31] Azahar, W.N.A.W., Bujang, M., Jaya, R.P., Hainin, M.R., Mohamed, A., Ngad, N. and Jayanti, D.S., 2016. THE POTENTIAL OF WASTE COOKING OIL AS BIO-ASPHALT FOR ALTERNATIVE BINDER â€“AN OVERVIEW. *Jurnal Teknologi*, *78*(4).

[32] Van Vliet, D., Slaghek, T., Giezen, C. and Haaksman, I., 2016, June. Lignin as a green alternative for bitumen. In *Proceedings of the 6th Euroasphalt & Eurobitume Congress, Prague, Czech* (pp. 1-3).

[33] Warwick Government Paper on Metal Recycling (2020). Metal_recycling_facts_for_website.pdf

[34] Alupro Environmental Benefits (2021) There are significant environmental benefits to recycling aluminium (alupro.org.uk)

[35] Copper and Carbon (2020) Copper Development Association Copper and Carbon - Copper's Contributions Towards Reducing Greenhouse Gas Emissions (copperalliance.org.uk)

[36] Gullies go Green (2015) The Construction Index. Available at: Gullies Go Green (theconstructionindex.co.uk)

Carbon Reduction Hierarchy	Best Practice	Examples	Further Details
Reduce construction emissions	programme	machinery • Plant machinery on site	consumption substantially reduced
	On-site renewables	• Solar Generators (e.g. Solar Pod / Solatainer)	• Up to 100% carbon reduction compared to diesel generators
	Electric / Hybrid Plant	• Electric excavators, loaders, rollers etc.	• Up to 100% carbon reduction (if renewable energy used)
Operate Efficiently – Reduce operational emissions	Design in renewables	• Design in solar panels for operational energy requirements	• Up to 100% carbon reduction
	Design in EV infrastructure	• Design in EV chargepoints	• Reduced emission from infrastructure users
Operate Efficiently – Emissions Sequestration	Design in sequestration measures	• Identify opportunities for tree planting within the design	• Capture / remove residual emissions

Appendix C. Assumption's list

C.1. Material Assumptions

Table C-1 Showing Assumptions used for National Highways Carbon Tool, provided by Atkins Quantity Surveyors

Asset	Assumption
RRS length	VRS length is assumed to be similar to the VRS provided currently.
Fencing (m)	Fencing is assumed to be provided 30m on each arm on approach to junction and along the length of proposed and on existing lay-bys on A429 arm.
Filterdrain (m)	It is assumed based on Google Street view that approximately 296m of filter drain will be provided on Eastbound Off-Slip, 457m on Eastbound On-Slip 209m on Westbound On-Slip. No filter drain is observed on westbound on-slip.
Narrow Filterdrain (m)	Assumed narrow filter drains length throughout Scheme for sub-base drainage.
Gullies (No)	It is assumed that number of gullies provided will be similar to the existing gullies as seen on Google Street view.
Manholes (No)	Assumed manholes at a spacing of 150m over a total pipe length of 4399m within the Scheme extents
Carrier Pipes (m)	Assumed pipe length through out Scheme is approximately equal to verge length. Assume 450mm diameter
"Chambers (No) comms and signals	Assumed signal connection to SDP-5Chambers. Considered length of slip roads-4 new chambers on slip roads NRTS ca bles added on one side of the carriageway for the backbone.
Signals (heads)	Assumed 5 signal locations at the roundabout. 2 roads at each location 2 heads at each road 20 heads in total
Cable length (m)	Assumed cable length approximately equal to length of gyratory. 20% added for contingency. Communication cables added on one side on the mainline
Along the verges	Assumed 10m wide earthworks on along all slips and arms and 0.2m fill required on an average.
Common earthworks (Ex. Between ML and Slip)	Measured area of common earthworks between slip road and mainline. Assumed 0.2m fill required on an average.
Slip Roads	Measured the paved area within the Scheme extents from design model.
Gyratory	Measured the paved area within the Scheme extents from design model.
A429+B4122+A350 arms	Measured the paved area within the Scheme extents from design model.
Maintenance Hardstanding	5 Maintenance hardstandings, one for each arm, with 12.5m length and 5.5m wide considered.

Asset	Assumption
Surface course, 40mm thick	Assumed 0.04m thick surface course and 2.65 specific gravity of material, required for widening portion and existing paved area to be resurfaced.
Binder course, 60mm thick	Assumed 0.06m thick binder course and 2.65 specific gravity of material, required for widening portion and existing paved area.
Base course, 200mm thick	Assumed 0.2m thick base course and 2.4 specific gravity of material, required only for widening portion.
Sub-Base, 200mm thick	Assumed 0.2m thick sub-base surface course and 2.4 specific gravity of material, required only for widening portion.
A429	Assumed 100m of friction surfacing to be provided on approach to junction (Width of carriageway is measured as 12.45m) as mitigation measure to sub standard entry path radius. Assumed 0.04m in depth 2.65 specific gravity of material
B4122	Assumed 100m of high friction surfacing to be provided on approach to junction (Width of carriageway is measured as 12.00m) as mitigation measure to sub standard entry path radius. Assumed 0.04m in depth 2.65 specific gravity of material
A350	Assumed 100m of high friction surfacing to be provided on approach to junction (Width of carriageway is measured as 11.00m). Assumed 0.04m in depth 2.65 specific gravity of material
Eastbound off-slip	Assumed 100m of high friction surfacing to be provided on approach to junction (Width of carriageway is measured as 11.15m). Assumed 0.04m in depth 2.65 specific gravity of material
Westbound off-slip	Assumed 100m of high friction surfacing to be provided on approach to junction (Width of carriageway is measured as 11.02m). Assumed 0.04m in depth 2.65 specific gravity of material
Kerbs	Length of all kerbs measured comparing the design model and streetview. All kerbs observed on streetview are kerbs with gullies. It is assumed that the same arrangement would be carried forward to next design stage
Center/Warning Lines	Total length of warning lines are measured from design 2D model and multiplied value by (4/6) as they are dashed markings with 4m mark and 2m gap. Assumed 0.2m wide markings
Edge Lines	"Total length of edge lines is measured from the design 2D model.
Stop Line	Assumed 0.2m wide markings"
Hatches	"Length of all stop lines in design 2D model are added.
Arrows (35)	Assumed 0.2m wide stop lines at all locations."
Others	Calculated areas of hatch marking regions and assumed 20% of area to be painted for hatches.
Traffic Signs	Counted number of signs from street view. Assumed 1m wide and 1.5m wide signs on an average.
Street Lights (No.)	Assumed that similar number of street lights will be provided as seen in Google street view.
Lighting Ducts (m)	Lighting duct length is assumed to run between lighting columns plus 10m in advance of a lighting column and 10m beyond other lighting column in series
Lighting cabinets (No)	Assumed one for each arm

Asset	Assumption
Lighting Chambers (No)	Assumed two for each arm
Landscaping Area	It is assumed that traffic islands in A429, B4122 and A350 arms are landscaped.

C.2. Construction plant Data

Table C-2 Construction plant data and assumptions

Plant	Fuel	Number	Litres per hour	Duration (days)	Total Hours on site physically	Litres Consumed each machine	Total Litres Consumed	(tco2)	Assumptions
Bulldozer/ Rippers	Diesel	2	36	80	800	28,800	57,600	179.84	
Tipper Trucks for pavement materials	Diesel	10	32	10	100	3,200	32,000	99.91	
Pavers- Base Layer	Diesel	2	25	10	60	1,500	3,000	9.37	Assumed 6 hour operational days
Rollers - Base layer	Diesel	2	18	10	60	1,080	2,160	6.74	Assumed 6 hour operational days
Pavers	Diesel	2	25	10	100	2,500	5,000	15.61	
Pavement Roller	Diesel	2	18	10	100	1,800	3,600	11.24	

C.3. Construction Plant Assumptions

- Construction plant data was not readily available at OBC stage and therefore was based on a pro-rata calculation of the construction programme of Motorway M5 Junction 9 and was subsequently scaled based on size to produce high level estimates of the amount of construction plant needed and for how many hours.
- The M5 J9 Scheme size was 67,160m^2 and lasted for 682 days with plant in operation for 262 days of the construction programme. Therefore, the overall plant operation time was 38%.
- The Scheme size paved area of the M4 J17 Scheme was 52,461m^2, with a construction programme of 434 days and therefore applying the 38% calculation from J9 produced a maximum of 165 days of machine on time across the scheme.
- However, expert technical judgment from Atkins designers through interpreting the size of the Scheme concluded that many constructions plant would be operational for a considerably lower quantity of time, as displayed in Table C-1.

Appendix D. Evidence from the National Highways Carbon Tool

D.1. Surface Treatment and Pavements

Material / Product								Transport			
Item	Type	Unit	This Return Quantity	Carbon Factor Value	Carbon Factor Unit	Conver -sion Factor	This Return tCO2e	Transport mode	Transport distance value (km)	Carbon Factor (tCO_2e/t.km)	This Return tCO2e
Bitumen / surface treatment	Straight-run bitumen	tonnes	4634.1	0.191	tCO2e/t	1.000	885.115	HGV	100.0	0.0000975	90.328
Bitumen / surface treatment	High friction surfacing	tonnes	611.0	5.700	tCO2/t	1.000	3482.700	HGV	100.0	0.0000975	11.910
Kerb	Pre-cast concrete 125x150mm	metres	2870.0	0.132	tCO2e/t	0.043	16.328	HGV	100.0	0.0000975	2.411
Road markings	Thermoplastic road marking	tonnes	8.7	5.700	tCO2/t	1.000	49.647	HGV	100.0	0.0000975	0.170
Asphalt	General Asphalt	tonnes	15355.0	0.055	tCO_2e/t	1.000	849.132	100.00%								HGV	100.0	0.0000975	299.301	

D.2. Street Furniture and Electrics

Marker posts/signs	Aluminium marker sign	no.	20.0	6.670	tCO2e/t	0.010	1.334	HGV	100.0	0.0000975	0.004
Traffic signs	Steel	m2	137.0	2.760	tCO2e/t	0.050	18.906	HGV	100.0	0.0000975	0.134
Road lighting and columns	LED light	no.	48.0	6.670	tCO2e/t	0.012	3.842	HGV	100.0	0.0000975	0.011
Road lighting and columns	Steel columns 8m	no.	91.0	2.760	tCO2e/t	0.132	33.153	HGV	100.0	0.0000975	0.234
Cable	Miscellaneous cable	metres	2172.0	1.860	tCO2e/t	0.000	1.717	HGV	100.0	0.0000975	0.018
Plastic cable ducting	150mm diameter	metres	1478.0	2.520	tCO2e/t	0.002	8.796	HGV	100.0	0.0000975	0.068
Cabinets	Average roadside cabinet type	no.	7.0	2.760	tCO2e/t	0.200	3.864	HGV	100.0	0.0000975	0.027
Cabinets	Average roadside cabinet type	no.	39.0	2.760	tCO2e/t	0.200	21.528	HGV	100.0	0.0000975	0.152

D.3. Drainage and Fencing

Plastic pipework (HDPE)	450mm diameter	metres	4399.0	2.520	tCO2e/t	0.011	123.775	HGV	100.0	0.0000975	0.957	
Precast concrete manholes	1200mm diameter, up to 3m depth	no.	50.0	0.238	tCO_2e/t	3.220	38.381	HGV	100.0	0.0000975	3.138	
Gullies	Plastic gully pots - PE	no.	50.0	2.296	tCO2e/t	0.021	2.399	HGV	100.0	0.0000975	0.020	
Fence	Steel/wire/chain fence (includes posts)	metres	389.0	2.760	tCO2e/t	0.004	4.101	HGV	100.0	0.0000975	0.029	
Road Restraint System/ Safety Barrier	Steel RRS barrier single sided	metres	3401.0	2.760	tCO_2e/t	0.022	209.231	HGV	100.0	0.0000975	1.478	
Fill, aggregate and sand	General mixture	tonnes	72.7	0.007	tCO2e/t	1.000	0.543	100.00%								HGV	100.0	0.0000975	1.417	
Fill, aggregate and sand	General mixture	tonnes	221.7	0.007	tCO2e/t	1.000	1.656	100.00%								HGV	100.0	0.0000975	4.322	

D.4. Earthworks

Imported Soil	General soil/top soil	tonnes	12737.0	0.024	tCO2e/t	1.000	305.688	HGV	100.0	0.0000975	248.270

D.5. Waste

Material / Product									Transport			
Item	Type	Unit	This Return Quantity	Carbon Factor Value	Carbon Factor Unit	Conver -sion Factor	This Return tCO2e	Methodology	Transport mode	Transport distance value (km)	Carbon Factor ($tCO_2e/t.km$)	This Return tCO2e
Bituminous mixtures	Reuse off site	tonnes	4634.1	0.000	tCO2e/t	1.000		The carbon emissions factor is zero and no direct carbon emissions will be accounted for. Transport emissions should still be captured.	HGV	100.0	0.0000975	90.328
Mixed metals	Recycled	tonnes	26.6	0.021	tCO2e/t	1.000	0.566	Carbon factor taken directly from Government Carbon Factors 2021. Waste disposal > Metal	HGV	100.0	0.0000975	0.518
Aggregate and soil exported off-site	Re-use off site	tonnes	36329.7	0.000	tCO2e/t	1.000		The carbon emissions factor is zero and no direct carbon emissions will be accounted for. Transport emissions should still be captured.	HGV	100.0	0.0000975	708.141
Aggregate and soil exported off-site	Re-use off site	tonnes	15355.8	0.000	tCO2e/t	1.000		The carbon emissions factor is zero and no direct carbon emissions will be accounted for. Transport emissions should still be captured.	HGV	100.0	0.0000975	299.316

D.6. Construction Processes

Site offices, site vehicles and plant energy	Diesel	Litres	128304.0	3.122	kgCO2e/l	0.001	400.589
Site offices, site vehicles and plant energy	Diesel	Litres	126720.0	3.122	kgCO2e/l	0.001	395.644
Site offices, site vehicles and plant energy	Diesel	Litres	22000.0	3.122	kgCO2e/l	0.001	68.688
Site offices, site vehicles and plant energy	Diesel	Litres	31680.0	3.122	kgCO2e/l	0.001	98.911
Site offices, site vehicles and plant energy	Diesel	Litres	39600.0	3.122	kgCO2e/l	0.001	123.639
Site offices, site vehicles and plant energy	Diesel	Litres	28512.0	3.122	kgCO2e/l	0.001	89.020
Site offices, site vehicles and plant energy	Diesel	Litres	72072.0	3.122	kgCO2e/l	0.001	225.022
Site offices, site vehicles and plant energy	Diesel	Litres	49896.0	3.122	kgCO2e/l	0.001	155.785
Site offices, site vehicles and plant energy	Diesel	Litres	77440.0	3.122	kgCO2e/l	0.001	241.782
Site offices, site vehicles and plant energy	Diesel	Litres	239976.0	3.122	kgCO2e/l	0.001	749.251
Site offices, site vehicles and plant energy	Diesel	Litres	28160.0	3.122	kgCO2e/l	0.001	87.921
Site offices, site vehicles and plant energy	Diesel	Litres	95990.4	3.122	$kgCO_2e/l$	0.001	299.700

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