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Melksham Bypass

Carbon Management Plan

Wiltshire Council

05 April 2022

5205316

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Executive Summary

The purpose of this document is to set out the means by which carbon management will be implemented across the whole lifecycle of the project.

Having good carbon management systems in place is essential to managing and reducing the whole life carbon emissions over the course of the project lifecycle.

1. Introduction

This is the Carbon Management Plan (CMP) for the proposed A350 Melksham Bypass 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].

This CMP summarises the carbon footprint for the scheme and sets carbon reduction targets. It also outlines the process to enable the carbon reduction targets to be achieved.

This is a live document and will be updated through the project to report on the implemented opportunities and any associated carbon reductions achieved.

This document should be read in conjunction with other project specific reports, including the Preliminary Environmental Assessment Report (PEAR).

It includes:

- 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
- Reporting, continual improvement, communication and training
- Next steps for considering scheme carbon emissions

[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. Scheme Description

Wiltshire Council is promoting a scheme for the A350 at Melksham as part of an application to the Large Local Majors fund administered by the DfT. The scheme was one of nine priority schemes identified by the Western Gateway Sub-national Transport Body (STB). In March 2020, the Government awarded funding to further develop the case for the project, having considered an initial Strategic Outline Business Case (SOBC) submission made in July 2019.

The scheme will provide an approximately 9 km long full bypass to the east of Melksham. Construction of the scheme is assumed to start in 2025 with the scheme open to traffic in 2028.

2.1. Need for the scheme

The scheme is intended to improve the current and future transport-related problems and issues relating to the A350 at Melksham including journey times and delays, journey time reliability, collisions and severance.

The A350 in Wiltshire forms part of the Major Road Network (MRN). It connects the M4 corridor (at Junction 17) with the Dorset Coast and Poole port and is the main transport artery serving the A350 Growth Zone identified in the Swindon and Wiltshire Strategic Economic Plan (SEP)[4]. Improvement to the A350 route forms a key part of the Western Gateway Strategic Transport Plan 2020 – 2025[5], which identifies improved north / south connectivity between the Midlands and South Coast as a fundamental priority for the Western Gateway region.

Between Chippenham and Trowbridge the A350 passes through Melksham (a market town with a population of approximately 31,000) and the smaller village of Beanacre to the north. Here, the A350 also serves an important local function providing access to key commercial and retail sites, in addition to the town's railway station. Sections of the route are also fronted by residential properties, with the speed limit restricted to 30 mph. The route suffers from delays and congestion, including at key junctions.

The A350 corridor has experienced significant growth over the last decade, and this trend is expected to continue. Key policy documents including the SEP and Wiltshire Core Strategy (WCS) 2006-2026[6] confirm that population, housing and economic growth in Wiltshire is expected to be concentrated in the A350 corridor, and this is supported by housing allocations and planning permissions that are now in place for the 2017-2026 period. Wiltshire Council is currently undertaking a Local Plan Review which extends the planning horizon to 2036 and establishes a continued high demand for new housing in the A350 corridor linked to economic growth.

Future traffic growth in the A350 corridor, linked to new housing and economic activity, is likely to exacerbate many of the issues identified. Traffic model forecast data predicts average peak period journey times on the A350 through Melksham to increase by approximately 10% to 13% between 2018 and 2036 (equating to approximately 1 to 2 minutes additional journey time per vehicle). Without intervention, this suggests that by 2036 all through-traffic on the A350 at Melksham would incur a total additional 55,000 vehicle hours of journey time on this section over the course of a year.

2.2. The identified problems and issues – need for intervention

Based on the evidence considered in Outline Business Case (OBC) and stakeholder consultations, key transport problems with respect to the A350 at Melksham / Beanacre are: journey times and delays; poor journey time reliability; collisions (road safety); severance; and localised noise, disturbance and emissions. Collectively, these transport problems have the potential to create wider negative impacts on economic, environmental and social outcomes in Melksham and the wider A350 corridor (Figure 2-1).

[4] https://www.lepnetwork.net/media/1128/swindon-wiltshire-sep.pdf

[5] https://westerngatewaystb.org.uk/strategy/2020-2025-western-gateway-strategic-transport-plan/

[6] https://pages.wiltshire.gov.uk/wiltshire-core-strategy-web-version-new-june.pdf

Table 2-1 - Relationship between identified problems, underlying causes and consequences

Causes and drivers

- The A350 at Melksham serves multiple functions, including for north-south and east-west through traffic, access to the town centre, and access to retail and commercial sites.
- High traffic volumes (one of the busiest routes in Wiltshire), with demand remaining relatively high throughout the day. Travel demand exceeds available capacity at some locations, particularly in the peak periods.
- Inconsistent road standard, including various speed limit changes and numerous junctions to be negotiated.
- Sections with property frontages very close to the road and multiple access points.
- Few viable alternative routes (north-south and east-west) without substantial diversion.
- Housing and employment strategy focused on and around the A350 corridor, driving increased traffic growth.

Problems / issues

1. **A350 journey times and delays** – journey times (Semington to Beanacre) up to 50% higher (5 mins) in the peaks compared to 'free-flow' conditions. Journey time increase of up to 2 mins forceast by 2036, across all time periods.
2. **A350 journey time reliability** – significant variation in day to day journey times.
3. **Collisions / road safety** – notable accident clusters along the A350 route at Melksham, particularly at key junctions.
4. **Severance** – the A350 forms a barrier to east-west pedestrian and cyclist movement, including access between the town and the rail station.
5. **Localised noise, disturbance and emissions** – adverse impacts to residents and premises adjacent to the A350.

Consequences (no intervention)

- £ Local and strategic connectivity adversely impacted – increased business / freight transport costs and commuting, resulting in lower productivity and reduced agglomeration impacts.
- The A350 becomes a potential constraint to housing and employment growth in West Wiltshire and regeneration of Melksham town centre.
- Adverse impacts to local communities in terms of physical and mental health and well-being.
- Deteriorating access to the rail station (including by walk / cycle) and increased delays to buses on the A350 adversely impact the attractiveness of public transport options.
- The physical barrier effect of the A350 continues to grow, further discouraging local walking and cycling activity. General deterioration in the quality of the environment in Melksham and Beanacre, making Melksham a less attractive place to live, work and visit.
- Increasing congestion and lower average speeds leads to an increase in carbon emissions.

2.3. The objectives

In response to the problems and issues, three strategic outcomes linked to five pairs of high-level objectives and transport objectives were identified for the scheme. Measures for success were also identified for each of the objectives. The objectives and outcomes have a strong alignment with the MRN / LLM fund objectives.

Strategic outcomes	High-level objectives	Transport objectives
Sustainable population and economic growth in the A350 corridor, with positive impact on regional and national economic productivity; Sustainable population and economic growth around Melksham / Bowerhill, supporting a revitalised town centre; Improved physical and mental wellbeing for users of the A350 and residents of Melksham.	Improve north-south connectivity between the M4 and South Coast, and provide capacity for growth in the A350 corridor between Trowbridge / Westbury and Chippenham / M4	Reduce journey times and delays and improve journey reliability on the A350 through Melksham and Beanacre, allowing for future growth in demand
	Improve connectivity for other through journeys via Melksham (to/from Bath, Calne and Devizes)	Reduce journey times and delays and improve journey reliability on the following routes through Melksham, allowing for future growth in demand: - A350 South - A3102 - A365 West - A365 East - A350 South - A365 West
	Improve connectivity within Melksham / Bowerhill, particularly for walking and cycling journeys to Melksham town centre and along the existing A350 corridor through Melksham	Provide enhanced opportunities for walking and cycling between Melksham town centre and rail station / Bath Road, and along the existing A350 corridor within Melksham
	Reduce personal injury accidents on the road network	Reduce personal injury accident rates and severity for the A350 and Melksham as a whole
	Reduce severance impacts of traffic on communities in Melksham / Bowerhill and Beanacre	Reduce the volume of traffic including HGVs, passing along the current A350 route in northern Melksham and Beanacre, and avoid negative impacts on other existing or potential residential areas

2.4. Options Development and Assessment

Options were assessed against fit with the scheme objectives (including the scale of impact against addressing the underlying issues), fit with wider policy outcomes (such as economy, environment and society), and the likelihood of unacceptable impacts in relation to: economic or environmental impacts; major technical risks, and public / stakeholder acceptability (taking into account feedback from the consultation exercise).

Options taken forward from the initial sift were subject to further assessment across a broader set of criteria and supported by the application of additional evidence and analysis. This included potential impacts in relation to economic, environmental and social criteria in addition to delivery and financial implications. In general, the longer bypass options (to the west and east) demonstrated a higher scale of impact in terms of potential for journey time improvements and traffic relief, although at a higher cost. All options were assessed as likely to result in at least slight adverse environmental impacts.

More detailed assessment was undertaken of the short-list options, including: traffic modelling (through use of the strategic Wiltshire Transport Model); further environmental assessment; delivery and risk review; and initial value for money assessment.

Based on the outcomes of the option generation, sifting and assessment process, it was proposed that the most suitable option to progress to further appraisal as part of the LLM Outline Business Case submission comprises the full eastern bypass option (‘outer’ alignment), plus a package of complementary measures focused on walking and cycling to ‘lock in’ the benefits of the traffic reduction on the existing A350 and other adjacent routes. The A350 Melksham Bypass scheme comprises:

- A full eastern bypass, approximately nine kilometres in length and with four junctions;
- Modifications and enhancements to Public Rights of Way along the bypass route;
- Supplementary highway improvement works to the adjacent network; and

- Complementary walking and cycling measures within Melksham Town and around the existing A350 route.

The current bypass proposal is based on an ‘emerging route’, which was subject to consultation in summer 2021. Potential variants raised are to be considered further by Wiltshire Council.

3. Legislation and Policy Drivers for Carbon Management

Relevant international, national and local policies are provided in Appendix A.

3.1. UK National Policy

3.1.1. Climate Change Act

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.

3.1.2. UK Carbon Budgets

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 $MtCO_2e$

3.1.3. Transport Decarbonisation Plan (TDP) 2021

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] https://www.legislation.gov.uk/ukdsi/2019/9780111187654

3.2. Local Policy

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”.

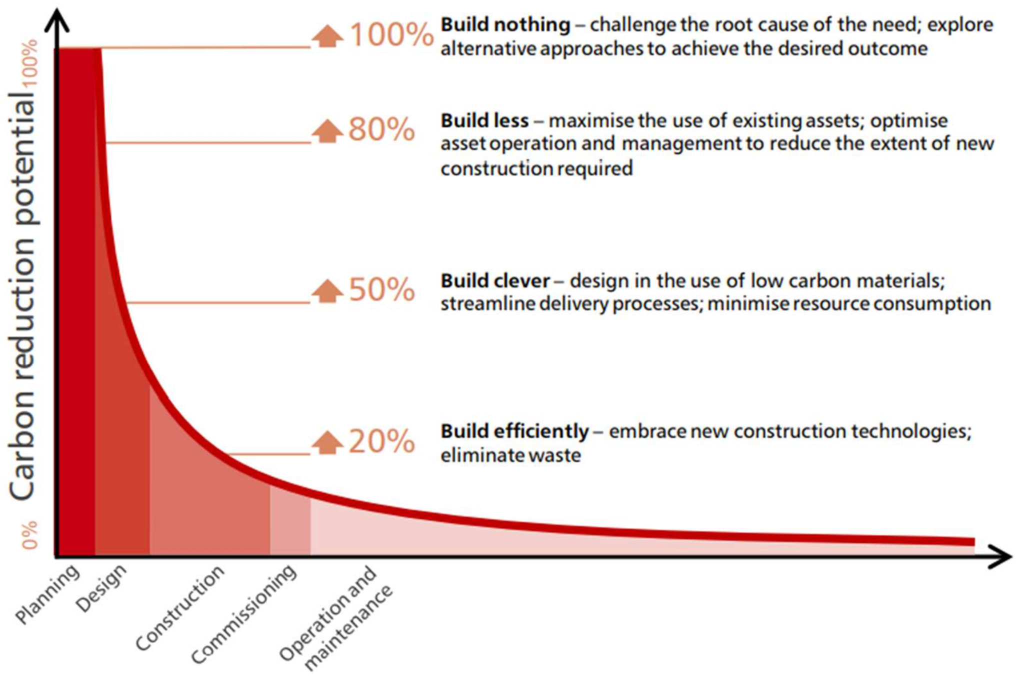
4. Carbon reduction hierarchy

When identifying potential opportunities to reduce carbon emissions, the following carbon reduction hierarchy, as provided in PAS 2080, should be 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.

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

Figure 4-1 - Carbon Reduction Curve

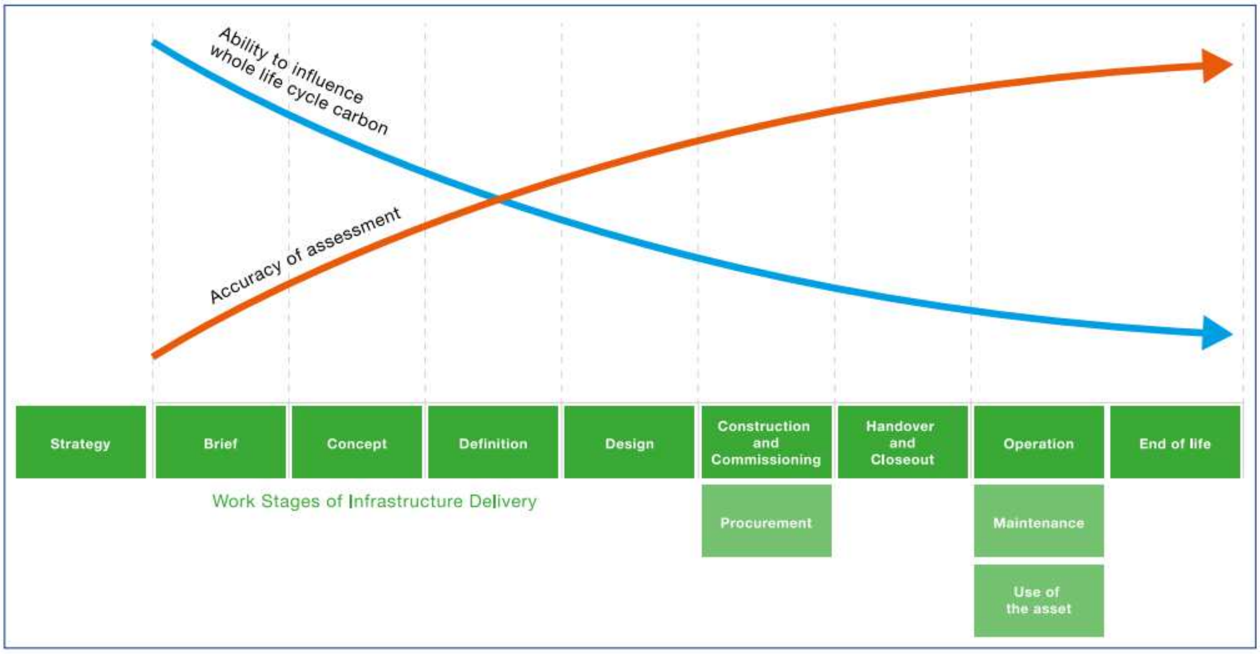


Source: Green Construction Board

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



Within relevant tasks, the hierarchy should be 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.

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.

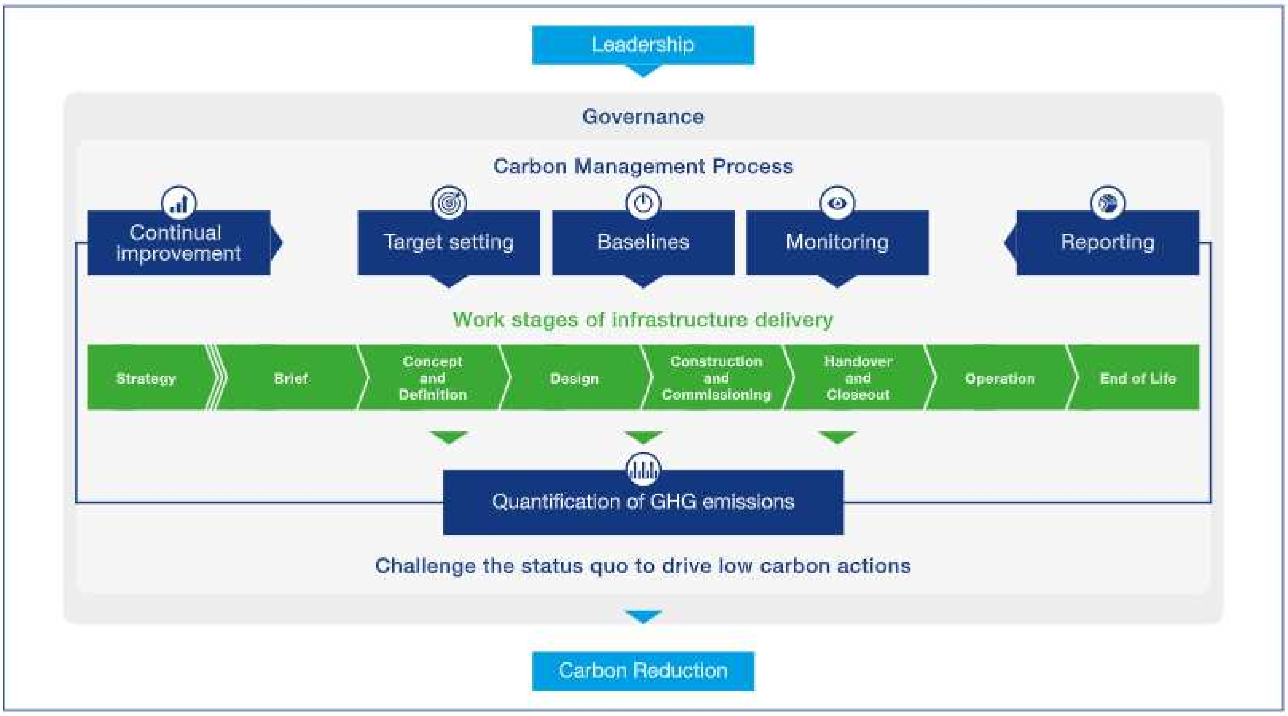
5. Scope of Carbon Management Process

The various components of the carbon management process, in accordance with PAS 2080, are shown in

Figure 5-1. The carbon management process needs to include the following:

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

Figure 5-1 - Carbon Management Process



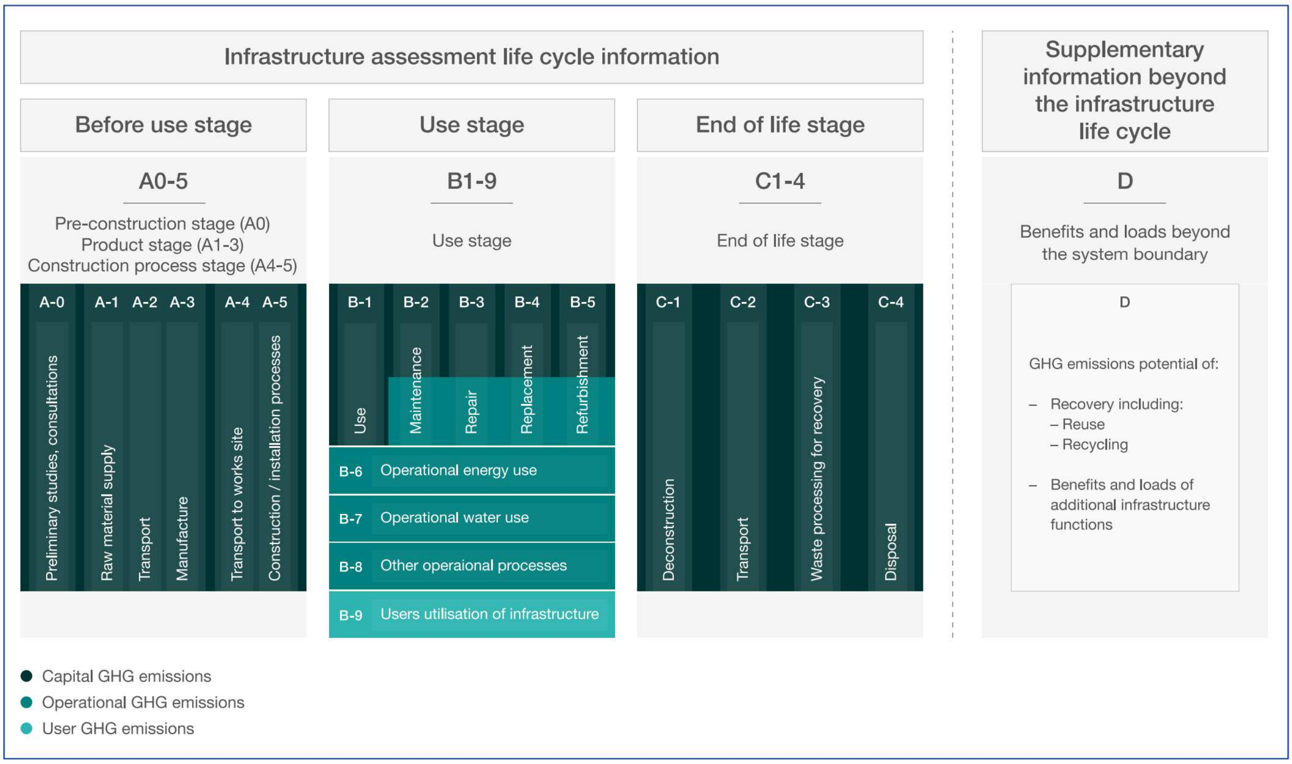
The carbon management process integrated into project delivery processes drives the **value chain**[9], as described in section 6, to collaborate and create a culture of innovation. This supports reductions in carbon and cost during project delivery by driving the use of low carbon solutions.

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.

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

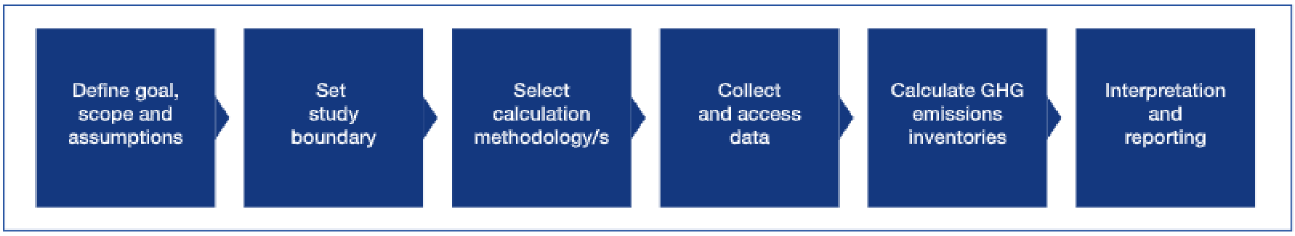


The CMP is a live document which should be updated at each stage of the project, with revisits to the **target setting**, **baselines**, **monitoring** of carbon reduction, **GHG emissions quantification**, and **reporting** to allow for **continual improvement** in the carbon management process in accordance with PAS 2080.

6. Quantification of GHG emissions

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



6.1. Assessments undertaken to date

The method used for quantifying carbon emissions to date is provided in the PEAR. The study area as defined in the climate chapter has been determined based on Design Manual for Roads and Bridges (DMRB) LA 114, the boundaries and scopes of Highways England's Carbon Tool, and PAS 2080.

The life cycle stages and GHG sources presented in Table 6-1 are included within the assessment, with reference to the type of assessment which has been carried out. Emissions have been calculated for the construction and operation stages of the scheme. The operation phase is assumed to cover 60 years from opening year in line with the appraisal period used in the TAG appraisal. The emissions calculated provide the baseline for the scheme.

It should be noted that the data provided here is preliminary only, obtained at the time of undertaking the PEAR. As the scheme progresses, more detail will become available which could mean changes to this dataset.

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)	Details of sources scoped in
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.
Operation stage (in line with appraisal period)	Use of the infrastructure by the end-user (road user).	Vehicles using highways infrastructure.	Traffic count/speed by vehicle type for highway links.
	Operation and maintenance (including repair, replacement and refurbishment).	Energy consumption for infrastructure operation and activities of organisations	Fuel/electricity consumption for vehicles, lighting and plant.

Main stage of project life cycle	Sub-stage of life cycle	Potential sources of GHG emissions (not exhaustive)	Details of sources scoped in
		conducting routine maintenance.	Waste and arisings quantities, transport mode/distance and disposal fate.
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 fate.

Table Source: adapted from DMRB LA 114

6.1.1. Construction Emissions

Construction phase emissions are broken down in Table 6-2. The construction of the scheme will lead to the release of an additional 2,271 tCO_2e, with the majority (96%) arising from material production and processing, and the remaining 4% coming from the transport of materials to site.

Road markings are responsible for the largest proportion of emissions across the entire construction operation at 453.15tCO_2e (19.95%). This is largely due to the thermoplastic markings used on roads and emissions from trucks used for their application and maintaining the material at a constantly high temperature[10].

The use of geotextiles was the second largest contributor to construction carbon, at 346.48tCO_2e (15.25%), due to the strength and quantity of membrane fabrics used to prevent soil damage and improve stability, decreasing soil and erosion rates[11].

The third highest emitter within construction is from kerbs, at 291.87 tCO_2e (12.85%), primarily due to the large quantity of concrete and asphalt required in their manufacture[12].

The fourth and fifth largest contributors to construction emissions are the aluminium lighting columns and plastic high-density polyethylene (HDPE) pipework at 203.63 tCO_2e and 201.64 tCO_2e respectively, which can be attributed to the large quantity of material used.

Data for construction processes including waste, fuel and energy is not available at this stage.

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	Ready mix concrete	41.80	1.84	5.87	0.25
	Fill and aggregate	2.78	0.12	7.24	0.31
Earthworks	Imported soil	10.36	0.45	8.39	0.37
	Geotextiles	346.48	15.25	2.65	0.11

[10] The Carbon Emissions of Line Marking | White Paper | MEON – Meon-UK (meonuk.com)

[11] https://www.aimil.com/blog/importance-of-geotextiles-in-road-constructions-types-of-geotextiles/

[12] Edgings & Kerbs - Road Kerbs | Pavingexpert

Category	Item	Materials		Transport	
		Emissions (tCO_2e)	Percentage of Construction Total (%)	Emissions (tCO_2e)	Percentage of Construction Total (%)
Fencing, barriers & road restraint systems	Timber rail fence (all types-including posts)	67.70	2.98	5.00	0.22
	Steel RRS barrier single sided	132.88	5.85	0.93	0.04
Drainage	Plastic pipework (HDPE)	201.64	8.87	1.55	0.06
	Precast concrete manholes	124.97	5.50	10.58	0.46
	Plastic inspection chambers	67.83	2.98	0.30	0.01
	Gullies	15.45	0.68	0.13	0.00
	Channel & slot drains	22.29	0.98	1.43	0.06
	Petrol interceptor	64.80	2.85	0.15	0.00
Road pavements	Bitumen / surface treatment	9.14	0.40	0.93	0.04
	Kerbs	291.87	12.85	42.95	1.89
	Road markings	453.15	19.95	1.54	0.06
Street furniture & electrical equipment	Road lighting and columns - LED light	17.20	0.75	0.05	0.00
	Road lighting and columns - Aluminium columns 10m	203.63	8.96	0.59	0.02
	Cable	16.27	0.71	0.17	0.00
	Cabinets	84.45	3.71	0.59	0.02
	Marker posts/signs	5.01	0.22	0.01	0.00
Total material		**2179.79**	**95.98**	**-**	**0.00**
Total transport		**-**	**0.00**	**91.10**	**4.01**

6.1.2. Operational Emissions

The emissions provided in the PEAR have been updated here using Defra's latest emissions factors toolkit (v11.0)[13], which provides emission factors up to 2050 to allow for the increasing numbers of electric vehicles into national the 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 2043 design year.

Table 6-3 and Table 6-4 provide the quantification of carbon calculations for the scheme during operation for the opening year (2028), design year (2043) and the 60-year operational appraisal period for both with the Do Minimum and Do Something, i.e. without and with the scheme scenarios. The emissions have been calculated for all roads in the scheme specific traffic model as described in the PEAR, and hence cover a much larger area than just the proposed bypass.

Over the operational period of 60 years the scheme would produce 57,339,755 tCO_2e, with the majority of emissions coming from the road users. There would be a net increase in emissions with the scheme compared to the Do Minimum scenario of 331,543 tCO_2e over 60 years.

Emissions are also provided for operation and maintenance of the roads which is assumed to be a small percentage (0.29%) of road user emissions, and hence cover the same study area as for operational emissions, i.e. roads in the wider area affected by traffic changes. These are again considered to be conservative, given the need to meet the net zero target by 2050.

Table 6-3 – Operational Phase emissions – Do Minimum scenario

Life cycle module	Emissions (tCO_2e)		
	2028 Emissions (tCO_2e)	2043 Emissions (tCO_2e)	60-year operational period (tCO_2e)
Road user carbon (direct)	1,198,117	897,037	56,230,878
Road user carbon (indirect)	12,910	12,963	777,334
Road user carbon (total)	1,211,027	910,000	57,008,212
Operation and maintenance	3,512	2,639	165,324
Total operation	1,214,539	912,639	57,173,536

Table 6-4 – Operational Phase emissions – Do Something scenario

Life cycle module	Emissions (tCO_2e)		
	2028 Emissions (tCO_2e)	2043 Emissions (tCO_2e)	60-year operational period (tCO_2e)
Road user carbon (direct)	1,201,443	899,741	56,398,058
Road user carbon (indirect)	15,635	15,704	941,696
Road user carbon (total)	1,217,079	915,445	57,339,755
Operation and maintenance	3,530	2,655	166,285
Total operation	1,220,608	918,099	57,506,040

6.1.3. Land Use Land Use Change (LULUC) Emissions

The loss of habitats due to construction of new highway and its elements will result in the release of carbon stored in plants. This has been calculated as 554.77 tCO_2e over the 60 year appraisal period, although there is

[13] V11.0 Released in November 2021, available here: Emissions Factors Toolkit | LAQM (defra.gov.uk)

limited data available at this stage. This estimate does not take into account any offsetting of carbon emissions taken up by new planting.

6.1.4. Summary

Table 6-5 provides a summary of emissions considering all life cycle modules for the scheme during construction and operation, including over the 60-year appraisal period.

Table 6-5 – Summary of Emissions with the scheme

Life cycle module	Pre-2028 (tCO_2e)	2028 (tCO_2e)	2043 (tCO_2e)	60-year appraisal period (tCO_2e)
Construction	2,271	-	-	-
Road user carbon	-	1,217,079	915,445	57,339,755
Operation and maintenance	-	3,530	2,655	166,285
LULUC (loss of sequestration potential)*	-	9	9	555
Total	2,271	1,220,618	918,109	57,506,595

*LULUC emissions divided over 60-year appraisal period to obtain indicative annual loss of sequestration potential

The operational emissions for the scheme should be compared with the 'do-minimum' scenario, to show the net change in carbon emissions. Over the 60-year appraisal period the majority of additional emissions associated with the scheme are from road user carbon (98.6% of total) as shown in Table 6-6, however this will reduce as a result of government policies which are not yet taken into account in the methodology.

Table 6-6 - Carbon emission source apportionment over 60 year appraisal period

Life cycle module	Change over 60-year appraisal period (tCO_2e)	Percentage of total
Construction	2,271	0.68%
Road user carbon	331,543	98.87%
Operation and maintenance	961	0.29%
LULUC (loss of sequestration potential)*	555	0.17%
Total	335,330	100.0%

7. Baseline, Target setting and Monitoring

7.1. Baseline

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

A target should be 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.

The GHG 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.

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.

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.

The target for this scheme at this stage is to reduce capital emissions during construction by between 15% and 25%.

Proposals to inform this reduction in carbon emissions are provided in section 9, and will be further developed over the next stages of this scheme.

7.3. Monitoring

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 Wiltshire Council specific requirements and should be compatible with other national policy and regulatory requirements.

Data is expected to be reported as tonnes of carbon dioxide equivalent (tCO_2e). 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.

Appropriate monitoring requires key roles and responsibilities to be established to allow effective implementation of actions. These are discussed further in section 8.

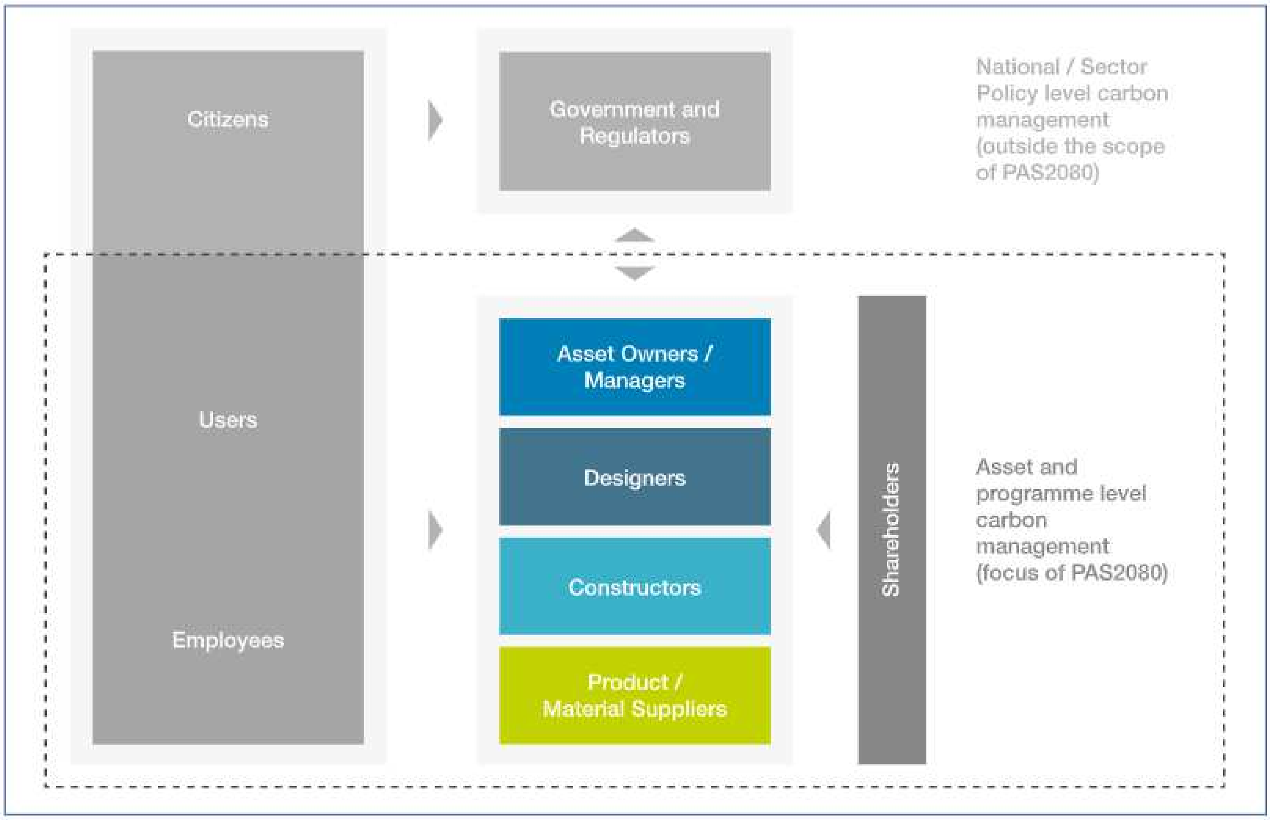
8. Management and Delivery of the Carbon Management Plan

8.1. Value Chain Members responsible for carbon management

Leadership and governance is recognised as a key enabler of a CMP. Wiltshire Council, as **asset owner,** 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.

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

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.

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.

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

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

The responsibilities of those involved within the value chain are included in Table 8-1 which shows the **RACI**[14] 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

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

9. Reporting, Continual Improvement, Communication and Training

9.1. Reporting

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.

9.2. Implementation of Low Carbon Solutions

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

Item No	Summary details of implemented opportunity	Carbon reduction achieved tCO_2	Estimated % reduction
1	Reduce the length of the route by approx.200m in section 2 (between A365 and A3102)	50 (assuming 253 tCO2/km of road)	2.20%
2	Reduce the length of the route by approx. 1.2 km in section 4 (between Lower Woodrow and A350)	303 tCO2 (assuming 253 tCO2/km of road)	13.34%
3	Shorten the span of the viaduct over River Avon	Tbd at next stage	n/a
4	Redesign and reduce length of bridges over Forest book and Clacker brook	Tbd at next stage	n/a
5	No dualling between Littleton roundabout and roundabout 1	Tbd at next stage	n/a
6	Do not improve Littleton roundabout	Tbd at next stage	n/a
7	Ready mix concrete - Use 25% GGBS instead of C32/40	5.5	0.25%
8	Fill and aggregate – use recycled resources, no heat treatment instead of general fill and aggregate	0.5	0.02%
9	Drainage – Use plastic pipework with 225m diameter instead of 300m	59.0	2.71%
10	Road Lighting and Columns - use steel columns instead of aluminium columns	91.5	4.20%
11	Use plastic marker posts	5.0	0.23%
12	Use clay instead of plastic pipework	tbd	n/a

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

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

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

9.4. Communication

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

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.

9.5. Training and Awareness

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.

9.5.1. Asset Owner - Wiltshire Council

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

9.5.2. Designer - Atkins

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)

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

- Engineering Net Zero – An Introduction (Global training introducing key concepts around climate change and net zero)
- Carbon – The Basics
- How to drive reduction through projects
- Carbon Knowledgebase

Appendices

Appendix A. Legislation, Regulatory and Policy Framework

Table A-2 - 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. By April 2016, 190 parties, including the UK, had made voluntary pledges to reduce emissions[15], however the cumulative effect of these would still lead to an estimated 3°C of warming or greater. 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[16]	To support international efforts, the UK Climate Change Act (2008) sets 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 2032.

[15] Nationally Determined Contributions

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

Scale	Legislation/ regulation/ policy	Summary of requirements
		In response to the ambitions of the Paris Agreement, in June 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 Progress to Parliament by the Committee on Climate Change[17] .
	Town and Country Planning (Environmental Impact Assessment) Regulations 2017[18]	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[19]	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[20].
	Department for Transport: Decarbonising Transport – setting the challenge (2020)[21]	The document presents transport modes and their current GHG emissions, the existing strategies and the policies already in place to deliver against current targets. It covers the projected trajectory of the forecast GHG emissions from transport to carbon budget 5 (2028-2032) and beyond based on the firm and funded commitments outlined. The document describes the challenge in meeting carbon budgets and net zero by 2050 and split the challenge into six strategic priorities. The document sets out the work approach through which interested parties and communities around the UK will collaborate to take urgent action on climate change, as well as delivering the substantial co-benefits of decarbonisation.
	Construction 2025 (July 2013) HM Government[22]	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[23]	The Infrastructure Carbon Review sets out carbon reduction action required by infrastructure organisations that have formally endorsed the review; this includes Highways England.

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

Scale	Legislation/ regulation/ policy	Summary of requirements
		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 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 Draft Climate Strategy 2022-2027, published for public consultation in September 2021[24]	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 (Consultation Draft, September 2021)[25]	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)[26]	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

[24] Wiltshire_Council_Draft_Climate_Strategy_Sept21.pdf
[25] 111340-GBIS-Vol1-Strategy-DF-2021-08.indd (wiltshire.gov.uk)
[26] 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
		how the preparation of the Wiltshire Local Plan can, in part, help address the issue.
	Swindon and Wiltshire Local Enterprise Partnership (SWLEP)[27]	The SWLEP has published its emerging Local Industrial Strategy[28] 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.

[27] https://www.wiltshire.gov.uk/green-economy-climate-emergency

[28] 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 - Reducing Carbon: Construction best practice

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 carbon 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.[29] • Reduces 80% of carbon. • 30% more expensive but design life 10 years, compared to 3-5.[30]
		Alternatives to geotextile materials: • Geosynthetics	• Reduces emissions by 64% • Provides the same level of erosional defence and stability.[31]
		• Plastic Kerbing Material	• Reduces emission intensity by 40%**Error! Bookmark not defined.**.

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

[30] 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)

[31] 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

Carbon Reduction Hierarchy	Best Practice	Examples	Further Details
		• Timber alternatives for fencing	• There are opportunities for timber to be carbon negative from certified forests[32] • Potential to eliminate 100% of 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[33].
		• Cooking Oils • Lignin	• Waste cooking oil has been tested to be an effective alternative[34]. • Natural Lignin is also another suitable replacement found in trees and plants[35].
	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[36] • Recycled Aluminium uses 95% less energy[37]. • Using copper cables to increase efficiency, with recycled HDPE casing[38].
		• 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[39].
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

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

33 LED Climate Group (2020). Available:< LED | Climate Group (theclimategroup.org)

34 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).

35 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).

36 Warwick Government Paper on Metal Recycling (2020). Metal_recycling_facts_for_website.pdf

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

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

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

Carbon Reduction Hierarchy	Best Practice	Examples	Further Details
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 – Reduce construction emissions	Optimise construction programme	• Reduce hours of machinery • Plant machinery on site	• Emissions from fuel/energy 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

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