Appendix A17.2: Carbon Assessment

1 Introduction

1.1 The need to reduce greenhouse gas (GHG) emissions is enshrined in Scottish and UK law; and in December 2015 at the Paris Climate Conference (COP21), 195 countries adopted the first-ever universal, legally binding global climate deal. The Intergovernmental Panel on Climate Change 5th Working Group report “Climate Change 2013: The Physical Science Basis” includes summaries of recorded observations of the climatic changes that have already occurred, along with projected future climatic changes. While the global climatic system is incredibly complex, this report presents a clear message that “*continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions*.”

1.2 The ultimate receptor of GHG emissions is the global climate system, and climate change caused by GHG emissions which will result in social, environmental and economic impacts felt globally. This is the case regardless of where the GHGs are emitted, whether they be released directly from the combustion of fossil fuels, or associated with the extraction, manufacture and transport of materials. It is for this reason that to reduce the carbon footprint of infrastructure, it is important that the GHG emissions embodied in the materials used are accounted for, and minimised where possible.

1.3 Reporting for this proposed Scheme GHG impact is carried out using mass of carbon dioxide equivalent (CO_2e) emissions, which allows for the emissions of the six key GHG: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6); to be expressed in terms of their equivalent global warming potential in mass of CO_2. The Greenhouse Gas Protocol (Greenhouse Gas Protocol, 2004) is the most widely used accounting system for GHG emissions.

1.4 Key definitions in order to determine the boundary of ownership for emissions include:

- direct emissions: originating from sources that are owned or controlled by the reporter; and
- indirect emissions: emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity.

1.5 Further to this, the GHG Protocol (2004) categorises these direct and indirect emissions into three broad scopes, including:

- Scope 1: Direct GHG emissions – emissions that occur from sources that are owned or controlled by the project;
- Scope 2: Electricity indirect GHG emissions – emissions generated through the purchase of electricity, heat, steam or cooling; and
- Scope 3: Other indirect GHG emissions – emissions from sources not owned or controlled by the project, but occur as a consequence of the project and its activities.

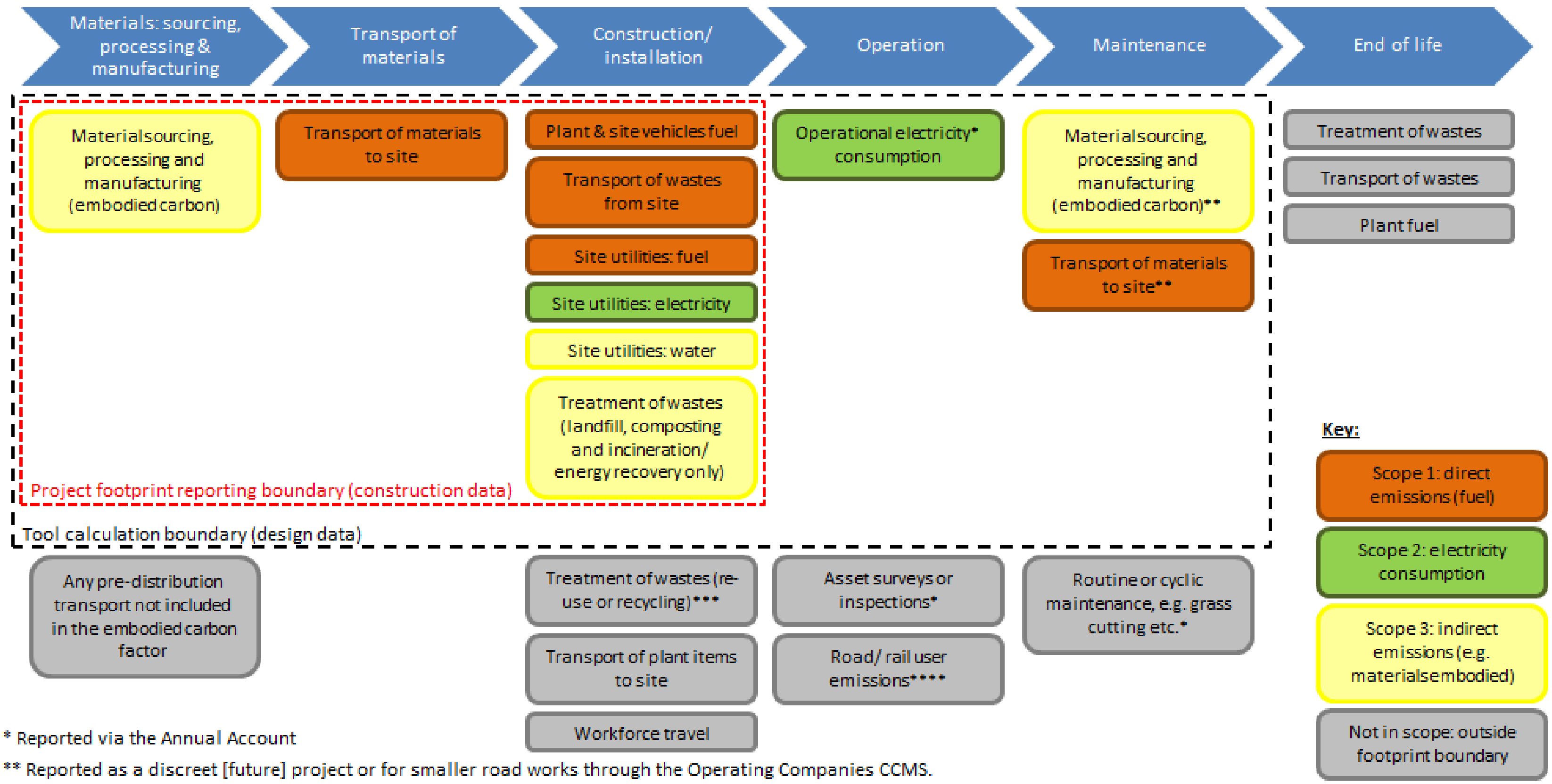
2 Methodology, Assumptions and Notes

Project Boundary

2.1 The initial step towards project carbon management is to identify and map out the emissions sources that can be attributed to a project throughout the project’s life cycle; management and reduction can only occur after this. Whilst the proposed Scheme will aim to identify and account for as much carbon as possible, it is a more efficient approach to prioritise some sources over others, rather than calculating the absolute carbon footprint of the project, as many components will have a negligible impact and offer limited opportunities for mitigation compared to the time, effort and cost involved in determining its carbon impact.

2.3 The Transport Scotland Project Carbon Tool recommends a boundary that varies based on when the carbon assessment is being undertaken, as shown in Diagram 1. As can be seen, this includes embodied carbon (material resourcing, processing and manufacturing), transport of materials to site, transport of waste, and maintenance activities.

Diagram 1: Transport Scotland Project Carbon Tool Boundary



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**** Road and rail user emissions are calculated via STAG (Technical Database - Section 7).

The Transport Scotland Projects Carbon Tool

2.4 Transport Scotland have developed and implemented a Carbon Management System (CMS) as a suite of tools to measure their Scope 1, 2 and 3 carbon emissions associated with their construction and maintenance activities across their road and rail schemes.

2.5 The CMS fulfil two roles.

- It enables consistent, transport and objective measurement and reporting of the carbon emissions from Transport Scotland's construction and maintenance operations and schemes.
- It will aim to support design and construction optioneering for our operations and schemes.

2.6 The 2014 version of Transport Scotland's Projects Carbon Tool is part of the CMS suite of tools. The tool is used to estimate carbon emissions associated with civil and structural engineering projects, including road, rail and buildings. It is intended to be used throughout the design process, from outline design to detailed design, allowing for comparison of design options to be made.

2.7 Whole life carbon options can be estimated for projects based on the embodied carbon associated with the materials used, the transport of materials and waste, site plant energy consumption, any operational energy and emissions associated with structural maintenance.

Source Data

Information Used

2.8 Entries into the tool are based on design information available at the time, and as such present an incomplete picture.

2.9 Design information that was incorporated into this carbon assessment includes:

- information on earthworks required in the project;
- detailed pavement specifications for the different sections of the project;
- structures such as bridges, culverts and underpasses;
- drainage filter material;
- kerbs;
- safety barriers;
- boundary fencing; and
- signage.

2.10 This information allowed for the calculation of material use, which is presented below in Table 1 by broad material type and construction component. Further, each scheme component has an associated replacement frequency, which was used to determine emissions associated with scheme renewal over a 100 year period, and the transport of waste from the site has been calculated in line with the assumptions presented in Chapter 17 (Materials).

Table 1: Carbon Emissions by Broad Material Type and Construction Components

Project elements	Material types	Worst Case Scenario Quantity (Including 10% Contingency) (unit listed)
Earthworks	Soil	5,679,300 m^3
	Of which imported	3,176,800 m^3
Pavement	Surface, binder and base	299,100 m^3
	Sub-base	258,500 m^3

Project elements	Material types	Worst Case Scenario Quantity (Including 10% Contingency) (unit listed)
Structures (civils & buildings)	Precast reinforced concrete	36,410 m^3
	Steel	2,530 tonnes
Drainage	Drainage filter material	59,400 m^3
Kerbs	Concrete, 150mm x 250mm and 50mm x 150mm	1,199 m^3
Safety Barriers	Steel, single sided	605 m^3
	Concrete barriers	14,388 m^3
Boundary Fencing	Timber fencing	3,652 m^3
Signage	Metal-backed signage	2,360 m^2

Transport: Transport of Material to Site

2.11 It has been assumed that materials are to be sourced locally, through procurement in Inverness. This results in an average transport distance of 9.5 km from Inverness to locations along the A96. It may be possible to determine more accurate transport distances, based on individual construction compound locations when these are fully specified.

Exclusions due to incomplete or unknown design information:

- Embodied material: Road Lighting; No details on the number of lighting units has been included.
- Embodied material: detailed information on signals and signage columns is not available and so has not been included.
- Plant and site vehicles fuel.
- Site utilities: fuel.
- Site utilities: electricity.
- Site utilities: water.
- Treatment of wastes.
- Operational electricity consumption.
- Emissions associated with maintenance activities.

3 Results

3.1 Transport Scotland's Projects Carbon Tool was used to estimate the carbon emissions associated with the proposed Scheme. The results are set out below in Tables 2 to 4. The calculations are based on a worst case scenario, including a 10% contingency to cover unknown items.

3.2 Table 2 shows the total carbon emissions anticipated from the proposed Scheme throughout its lifetime, with this figure broken down into construction materials, carbon emissions due to transport of materials and waste, and maintenance.

Table 2: Proposed Scheme Emissions Summary* (Worst Case Scenario including 10% contingency)

Carbon source	tCO_2e
Total project carbon emissions	**1,080,250**
Construction: Materials embodied	266,250
Construction: Transport of material and waste	14,250
Maintenance: Materials embodied	799,750

* Figures are rounded up for reporting purposes

3.3 Tables 3 and 4 provide more detailed information on the carbon emissions for each of the three sub-sections above, by breaking the figures down into the individual project elements, and the carbon emissions for construction materials by type. All volumes shown are based on the worst case scenario figures that include a 10% contingency.

Table 3: Summary by Project Elements (Worst Case Scenario including 10% contingency)

Project elements	Materials embodied (tCO_2e)	Transport of materials (tCO_2e)	Maintenance (materials embodied) (tCO_2e)
Drainage	5,886	1,096	62,837
Earthworks	111,315	9,495	0
Fencing	1,157	14	3,511
Road Pavement	124,781	3,358	721,492
Safety Barriers	3,699	31	11,190
Signs	176	0	702
Structures (civils & buildings)	19,217	169	0

Table 4: Summary by Material Types: Construction Embodied Only (Worst Case Scenario including 10% Contingency)

Material types	tCO_2e
Aggregate	5,886
Aluminium	176
Asphalt and bitumen	81,334
Concrete, cement, and cement substitutes (including steel reinforcement)	64,003
Iron and steel	2,838
Soil	111,315
Timber	679

4 Peat Use – Carbon Sequestration

4.1 Carbon dioxide (CO_2) cycles naturally occurs between the atmosphere, geosphere and biosphere as a result of photosynthesis, respiration, decomposition and combustion. The amount of carbon in an ecosystem changes as it develops and evolves. Globally, soils contain about three times the amount of carbon than in vegetation and twice that in the atmosphere (IPCC, 2000; Smith, 2004).

4.2 Land management choices can either maintain or increase the carbon store for long periods of time or result in net emissions. It has been considered that emissions (or rather reduced sequestration) associated with the change in land use from peatland to a road does not fit within the project footprint carbon calculation boundaries as described in Section 2. However, they are an important consideration.

4.3 Carbon storage by habitat (Natural England Research Report NERR043, 2012) describes the potential carbon sequestration of peatlands as between 0.1 - 0.46 tonnes carbon (t C) per hectare per year or net accumulation of peatland is approximately 0.2 - 0.5 t C per hectare per year.

4.4 There is a considerable quantity of peat land within the proposed Scheme footprint, with an estimated 22.15ha of non-degraded peat land, and a volume of 35,000m3. The removal of peatland due to the proposed Scheme footprint could result in a reduction of carbon sequestration of 4.4 to 11.0 t C per year.

4.5 Over the 100 year assessment period, this land could have sequestered 440 to 1,100 t C, equivalent to 1,614.8 tCO2e to 4,037 tCO2e.

5 Carbon Saving Measures

5.1 Carbon quantification is vital for ensuring an understanding of the greatest carbon impacts for the project, enabling opportunities for reducing carbon to be highlighted.

5.2 Reporting and guidance, such as the Infrastructure Carbon Review (HM Treasury, 2013) and Building a Sustainable Future (ICE, 2011) indicate that the potential to influence carbon emissions decreases as a project progresses, from the most during the planning stage, to more modest reductions during design and construction.

5.3 With this in mind, the key early intervention procedure, as identified in the Infrastructure Carbon Review (HM Treasury, 2013), can be considered to be:

- avoid and/or eliminate or ‘build nothing’: challenge the need; explore alternative approaches to achieve the desired outcome;
- reduce or ‘build less’: maximise the use of existing assets, optimise asset operation and management to reduce the extent of new construction required;
- substitute or replace or ‘build clever’: design in the use of low carbon materials, streamline the delivery process, minimise resource consumption; and
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5.4 In the first instance, the use of significant quantities of high impact materials, (e.g. steel and aluminium), or processes (e.g. large amounts of excavation), should be avoided where practicable through alternative design specification. If this cannot be done, the amount of material or the length/intensity of the process should be reduced where functional specifications allow. Materials or processes should be substituted with lower intensity replacements, if possible within design standards for strength and safety. Finally, compensatory measures, such as carbon offsetting, should be considered where it is felt they would be cost effective.

5.5 Where it would not significantly impact upon engineering, safety and maintenance characteristics, the principle of substitution requires that low carbon alternatives for materials be considered.

5.6 Imported earthworks fill is a significant part of the overall carbon footprint of this project, with only 56% of the required earthworks material currently able to be sourced from planned on-site cuttings. Opportunities to obtain additional earthworks fill on-site or near to the construction area should be maximised and, where it will not significantly alter the safety and driving characteristics of the road, earthworks fill should be reduced. While this assessment does not take into account emissions associated with on-site vehicles, including those that would be used to dig and move earthworks fill material, on-site soil movements will generate lower emissions than long-distance transport.

5.7 The regular maintenance of the road pavement, including the surface course, sub-base and base course contributes a significant proportion of the calculated whole-life emissions, making up 68% of the whole. Investigation of either a more hard-wearing material for the surface course or a material with a lower emissions factor should be a priority for any mitigation measures. It should be noted that the existing A96 would require renewal over this same period as well, and so could be considered as offsetting the maintenance requirements. However, as the road is being detrunked and retained this is not the case and the maintenance requirements are fully additional.

6 Conclusions

6.1 The information provided accounts for emissions associated with the design, as it is currently known. This should be further developed by the appointed contractor going forward, and should be a point of discussion where construction methods may contribute to a reduction or increase in emissions.

6.2 The results of this assessment can be reviewed in comparison to other schemes with published emissions and with industry benchmarks. It should be noted that there are not a large number of published embodied carbon assessments of highways schemes and that the characteristics of those schemes can vary considerably in terms of the required structures. Further, the assessment of embodied emissions will not be fully consistent as it is always based on the available information for the scheme and may differ in terms of exclusions. However, several schemes and a Scottish benchmark are presented in Table 5 below. It can be seen that the proposed Scheme emissions calculated here are comparable to another Scottish highways scheme.

Table 5: Comparison of Emissions from Other Road Schemes

Scheme name	Approximate lane-kilometres and notes	Embodied Emissions (tCO_2e)	Transport Emissions (tCO_2e)	Embodied tCO_2e / lane.km	tCO_2e / lane.km
Proposed Scheme	120 lane.kms	266,231	14,227	2,220	2,340
A14	204 lane.kms Including 30 bridges	740,062	235,979	3,630	4,785
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7 References

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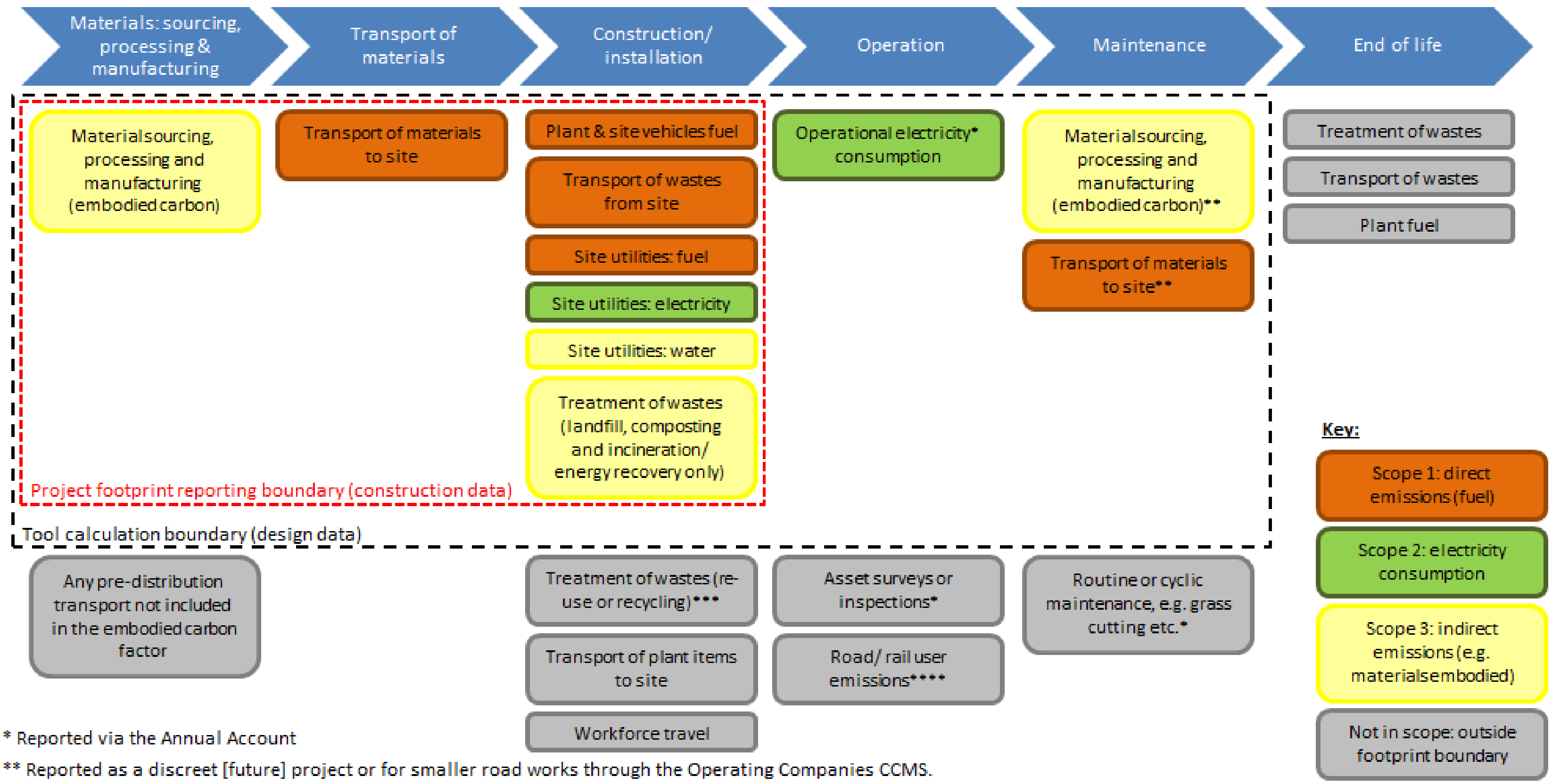

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