RAPID Gate Three Strategic Resource Option Hampshire Water Transfer and Water Recycling Project

Supporting Annex 5: Carbon

July 2024

Contents

5. Carbon

5.1 Background

This annex provides an overview of the current carbon assessment for Southern Water's (SW) Hampshire Water Transfer Water Recycling Project (HWTWRP), as well as a summary of the mitigation opportunities identified at this stage. This supports the Gate Three submission to the Regulators' Alliance for Progressing Infrastructure Development (RAPID). RAPID's strategic water resource solutions guidance for Gate Three[1] and the National Policy Statement for Water Resources Infrastructure[2] have been used to inform this report and ensure its alignment to regulatory requirements.

5.2 Carbon Management Overview

The HWTWRP has the potential to deliver significant water security benefits, however, this involves activities through its construction and operation which will emit carbon. There are seven main Greenhouse Gases (GHGs) that contribute to climate change, as covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). CO_2e is the universal unit of measurement to indicate the global warming potential (GWP) of GHGs, expressed in terms of the GWP of one unit of carbon dioxide[3]. The calculations provided in this report are in units of tonnes of carbon dioxide equivalent (tCO_2e). 'Carbon' is used as a shorthand to reference this value throughout the report.

This report splits the assessment of the whole life carbon into capital carbon and operational carbon (Table 5-1).

Table 5-1 - Definitions of components that make up whole life carbon assessment (in alignment with PAS2080:2023)

Terminology	Definition	Source	Scope Category	Scope Category Detail
Capital Carbon	GHG emissions and removals associated with the creation and end-of-life treatment of an asset, network or system, and optionally with its maintenance and refurbishment. (***Note***: *whilst assets replacements are included within these calculations, decommissioning the project is not; given the whole life period being assessed, methods of decommissioning and disposal are likely to be substantially different to the present day (see Section 5.1 of Chapter 5: Carbon). In addition, a large proportion of the assets have been modelled as having a 100-year asset life (e.g., pipelines, tunnels) would only reach 'end-of-life' after the appraisal period used for this study has passed.*	PAS2080:2023	3	Capital carbon emissions largely associated with the materials supplied for construction, transport of materials and construction activities.
Operational Carbon	GHG emissions and removals associated with the operation of an asset, network and/or system required to enable it to operate and deliver its service	PAS2080:2023	2 (Power) & 3	Operational carbon emissions largely attributed to power consumption from the grid network (Scope 2), the manufacture and supply of chemicals during the scheme's operation, regular operational transport, and regular maintenance activities (Scope 3).
Whole Life Carbon	Sum of emissions and removals from all work stages of a project and/or programme of works within the specified boundaries	PAS2080:2023	n/a	Whole life carbon emissions are typically a mix of all scopes as its

1 RAPID Strategic Regional Water Resource Solutions Guidance for Gate Three Version 3 January 2024
2 National Policy Statement for Water Resources Infrastructure Defra April 2023
3 UK Government GHG Conversion Factors for Company Reporting 2023

Terminology	Definition	Source	Scope Category	Scope Category Detail
				boundaries include both construction and operation.
Carbon Hotspots	An asset / aspect of the project attributed to a significant proportion of the total carbon emissions. This can be used in the context of capital, operational and whole-life carbon totals.	No 'official' definition – informal term	n/a	n/a

The proposed location of the Water Recycling Plant (WRP) partially overlaps an existing landfill site. The Geo-environmental Interpretative Report for the WRP was reviewed in order to determine if there was a risk of increased methane emissions (a greenhouse gas as well as a potential safety risk) as a result of the project (either during construction or operation of the WRP). The review has concluded that the risk of methane emissions from the landfill is very low and furthermore that this risk is not expected to be affected by the proposed project. Therefore, no fugitive emissions from the landfill have been included in the GHG emissions estimates presented in this report.

5.3 Capital Carbon

Under the Greenhouse Gas Protocol, capital carbon emissions from construction are typically categorised as Scope 3 emissions of the sector/organisation. Capital carbon emissions from construction and maintenance activities are the result of materials (extraction and processing), manufacturing effort, transportation, construction effort and any disposal of construction waste. The capital carbon assessments within this section cover lifecycle modules A1-A5 (as per BS EN 15978:2011)[4] and are only associated with the embodied carbon of materials used, their transportation and associated construction activities; therefore not including emissions associated with the HWTWRP's operation. The assessments only considered a cradle-to-built asset boundary (as per UKWIR, 2012).

Quantifying the emissions associated with asset construction for this report has enabled the identification of efficient mitigation opportunities. This section provides an overview of the capital carbon emissions estimate undertaken for the HWTWRP and describes some of the key carbon hotspots.

5.3.1 Capital Carbon: Overview of Approach

A capital carbon assessment has been carried out using the latest design information, as prepared at Gate Three, alongside the breakdown of asset scope inputs used for the Gate Three cost estimate. The asset information for the project cost estimates has been used within the carbon models that have been developed for the project, using industry standard data. This has enabled an estimate of capital carbon to be calculated for the two tunnel options as presented in Chapter 2: Solution Costs and Benefits. These estimates include all assets associated with each tunnel option, as shown in section 2.3.8 of Chapter 2 of this submission.

The assessment for the HWTWRP construction activities has predominantly used carbon emissions rates from the Civil Engineering Standard Method of Measurement (CESMM4)[5]. These cover activities such as topsoil stripping, excavation, stockpiling and placing of excavated materials.

Mott MacDonald's library of industry standard carbon models has been used to determine capital carbon emissions for other types of assets that would be constructed as part of the HWTWRP, such as models for open-cut pipeline installations and below-ground service reservoirs. These models have been developed using typical industry generic designs and supplier information for products and materials, alongside emissions factors data from the Inventory of Carbon and Energy (ICE)[6].

Over time, as more detail is built into material specifications and specific locations of supply, specific to this project, it is expected that more supplier-specific emissions data could be utilised in place of industry standard emissions inventories. It is likely the assessment will become more precise using supplier-specific emissions data, which in turn will better inform future decision making. Hence, through this process the capital carbon assessments will continue to be refined as the project design progresses towards DCO application.

5.3.2 Summary of Capital Carbon Assessment

A capital carbon assessment has been completed for both Preferred and Backup Tunnel Options. Figure 5-1 and Table 5-2 show the breakdown of each option in relation to their capital carbon hotspot areas.

[4] BS EN 15978:2011. Sustainability of construction works. Assessment of environmental performance of buildings 2011
[5] CESMM4 Carbon & Price Book 2013.
[6] ICE (Inventory of Carbon & Energy) V3.0. Dr. C. Jones & Prof. G. Hammond. Circular Ecology & University of Bath. 7 Nov 2019.

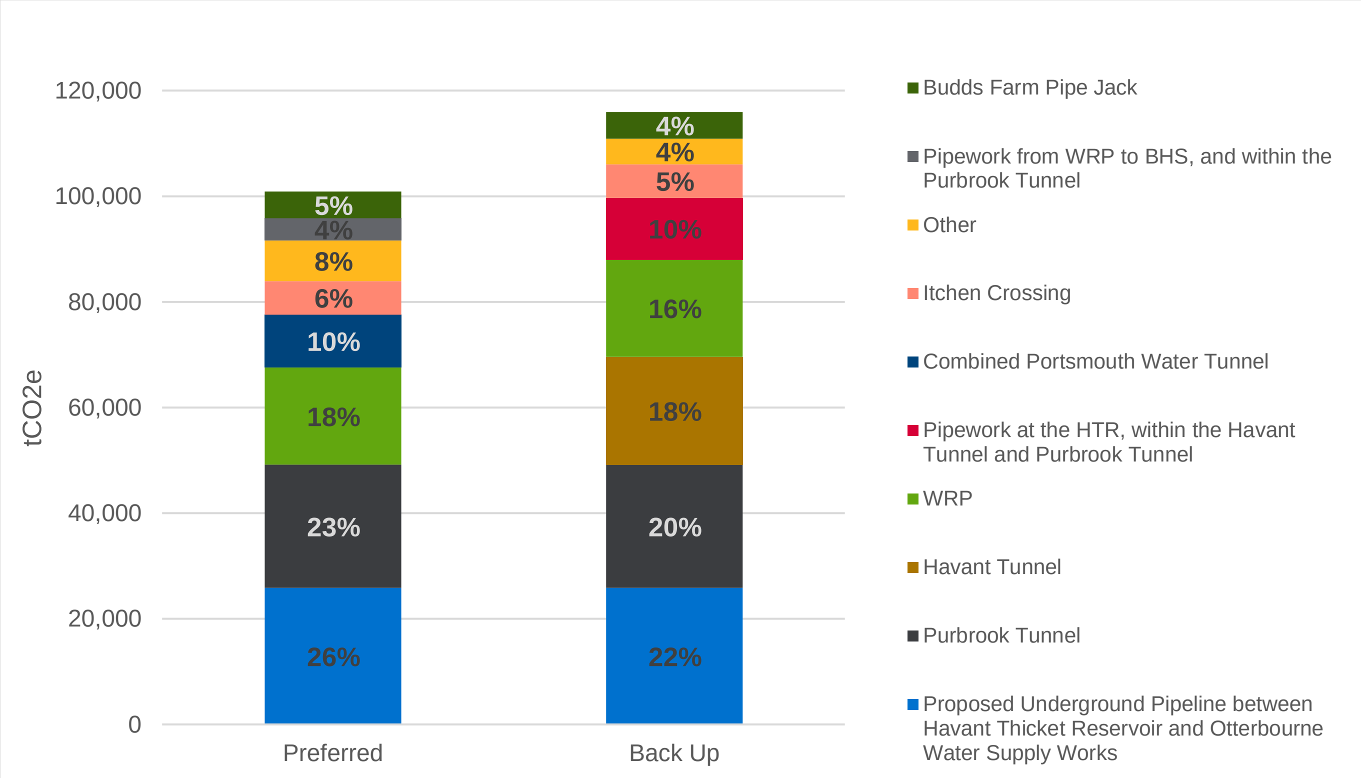

Figure 5-1 - Capital carbon emissions for the HWTWRP tunnel options, split by asset

Table 5-2 - Capital carbon emissions for both the HWTWRP tunnel options, split by asset

Scope Area	Preferred Tunnel Option		Backup Tunnel Option	
	Carbon (tCO_2e)	% of total	Carbon (tCO_2e)	% of total
Underground Pipeline between HTR and Otterbourne WSW	25,800	26%	25,800	22%
Pipework from WRP to BHS, and within the Purbrook Tunnel	4,200	4%	-	-
Pipework at HTR, within the Havant Tunnel and Purbrook Tunnel	-	-	11,700	10%
Havant Tunnel	-	-	20,400	18%
Purbrook Tunnel	23,300	23%	23,300	20%
Itchen Crossing	6,300	6%	6,300	5%
WRP	18,400	18%	18,400	16%
Combined Portsmouth Water Tunnel	10,000	10%	-	-
Other	7,600	8%	4,900	4%
Budds Farm Pipejack	5,000	5%	5,000	4%
Total	**100,800**[7]	**100%**	**115,900**[7]	**100%**

Carbon emissions have been separated into the asset life categories included in the ACWG guidance[8] to help identify the components which provide the greatest contribution to carbon emissions (Figure 5-2).

[7] tCO_2e have been rounded to the nearest 100 and therefore totals presented may result in variance +/-200 tCO_2e.
[8] Cost Consistency Methodology: Technical Note and Methodology, ACWG February 2022

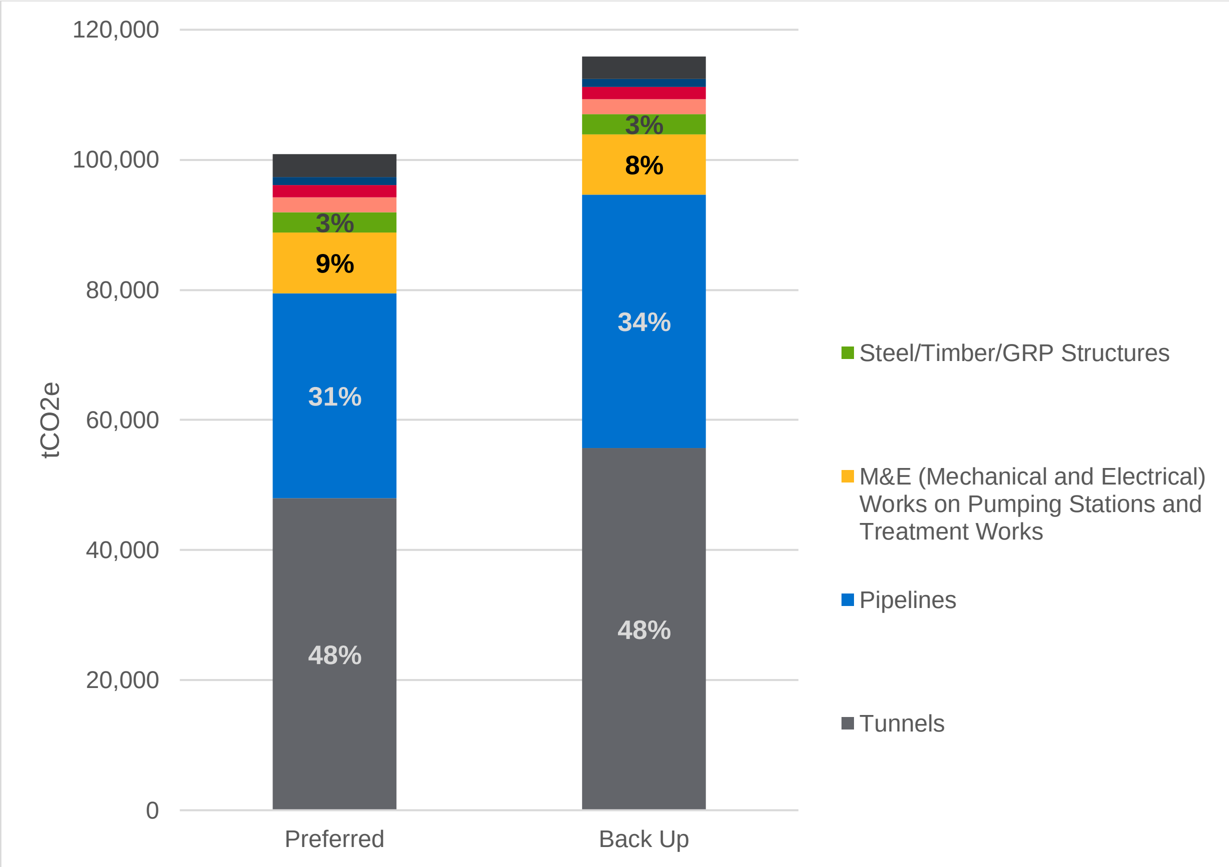

Figure 5-2 - Capital carbon emissions for the HWTWRP tunnel options, split by ACWG asset life category.

Table 5-3 - Capital carbon emissions for the HWTWRP tunnel options, split by ACWG asset life category

Asset Life Category	Preferred Tunnel Option		Backup Tunnel Option	
	Carbon (tCO_2e)	% of total	Carbon (tCO_2e)	% of total
Pipelines	31,500	31%	39,000	34%
Tunnels	48,000	48%	55,700	48%
M&E for Pumping Stations and Treatment Works	9,300	9%	9,200	8%
Steel/Timber/GRP Structures	3,100	3%	3,100	3%
Treatment / Pumping Stations Civils	2,300	2%	2,300	2%
Tanks – other (e.g., chemical)	1,900	2%	1,900	2%
RC Tanks (BPT) / Service Reservoirs	1,300	1%	1,300	1%
Other	3,500	3%	3,500	3%
Total	**100,800**[7]	**100**	**115,900**[7]	**100**

As expected, the capital carbon emissions are higher for the Backup Tunnel Option, being estimated to be ~15,100 tonnes higher (13%) in comparison to the Preferred Tunnel Option. This difference is driven by the Havant tunnel, an additional micro tunnel required from the WRP to HTR that would need to be pursued should the Preferred Tunnel Option not be approved during the planning process.

5.3.3 Capital Carbon Hotspots

The capital carbon emissions associated with the underground pipeline between HTR and Otterbourne WSW is a significant hotspot, ranging between 22% (Backup Tunnel Option) or 26% (Preferred Tunnel Option) of the total tCO_2e respectively. This is consistent with the installation of the tunnels and their associated shafts, accounting for

48% of the total capital carbon for either tunnel option. The significance of these two hotspots is expected, as the installation of both of these assets involves large quantities of typically carbon-intensive materials (ductile iron pipelines, precast concrete tunnel segments and grouting) as well as significant earthworks.

The WRP accounts for a further 16% or 18% of the total capital emissions of the respective tunnel options, with the site civil works being the main source of emissions at the WRP. This includes the various roads, piling, earthworks, plinth / base slabs and buildings, which together make up 41% of the emissions associated with the WRP. Other capital carbon hotspots within the WRP include the High Voltage (HV) and standby generation (9%), the Granular Activated Carbon (GAC) plant (8%), and the microfiltration (MF) / reverse osmosis (RO) plants (6% and 7% respectively). Potential mitigation opportunities associated with these hotspots are discussed within Section 6 of this Annex.

All other categories in the capital carbon assessment contribute less than 4% of the total capital carbon emissions, and include, for example, the interstage pumping stations (IPS) and break pressure tanks (BPT). Whilst these are not identified as major hotspots within this assessment, their emissions impact will continue to be optimised during later stages of design development.

5.3.4 Replacement Capital Carbon

The HWTWRP scope consists of a variety of assets, each with a typical design (or asset) life that is shorter than the forecast operating life of the HWTWRP. These assets will therefore require replacement once they reach the end of their design lives in order to ensure that the HWTWRP can continue to operate. An assessment of the estimated capital carbon emissions associated with these replacements has been completed. This assumes that the carbon emissions of an asset replacement are identical to the capital carbon emissions calculated for a new asset installation. The total of these emissions for each option is summarised in Table 5-3.

The ACWG has provided guidance[8] to all companies developing SROs to ensure consistency with determining the asset life for carbon calculations. This guidance summarises the various ‘asset life categories and their associated asset life that should be considered for all assets that are included with each SRO (Table 5-4). This standard list ensures that all SROs include a consistent assessment of the need to replace certain components at the end of their asset life. Assets are replaced at the end of their asset life, with their estimated capital carbon emissions being forecasted to repeat in full for each replacement. For example, a pump is likely to be categorised as a Mechanical and Electrical (M&E) asset, and therefore the capital carbon emissions of installing that pump are forecasted to repeat every 20 years over their assumed operating period.

Table 5-4 - ACWG Asset Life Categories used for the HWTWRP with Preferred Tunnel Option (rounded to the nearest 100tCO2e)

ACWG Asset Life Category[9]	Asset Life (years)	Total Capital Carbon in Construction, Preferred Option (tCO2e)	Total Capital Replacement Carbon over Whole Life Period, Preferred Option (tCO2e)	Total Capital (in Construction) + Capital Replacement Carbon (tCO2e)	Percentage of Total Capital + Capital Replacement Carbon over Whole Life Period, Preferred Option (%)
Tunnels	100	48,000	0	48,000	34%
Treatment and Pumping Station Civils (incl. Intakes)	60	2,300	2,300	4,600	3%
Pipelines	100	31,500	0	31,500	22%
M&E Works on Pumping Stations and Treatment Works	20	9,300	27,700	37,000	26%
Steel/Timber/GRP Structures	30	3,100	6,300	9,400	7%

As discussed, the majority of capital carbon emissions for the HWTWRP are associated with pipelines, tunnels and shafts. These have long asset lives and are not expected to be replaced within the 80-year appraisal period used for the whole life carbon estimate of the HWTWRP. Of the asset life categories listed, assets categorised as ‘M&E Works on Pumping Stations and Treatment Works’ provide the greatest proportion of capital replacement carbon emissions, accounting for approximately 65-66% (27,700 tCO_2e for the Preferred Tunnel Option) of the total capital replacement carbon emissions over the 80-year appraisal period. 88% of the emissions associated with these asset replacements are related to an asset contained within the WRP scope.

9 all other categories contributed less than 3% of total capital + capital replacement carbon emissions, and are omitted for simplicity

Table 5-4 also aims to compare the sum of the capital and capital replacment carbon emissions for each asset life category over the whole life period. For example, the pipelines category is a significant contributor to the total capital carbon, accouting for 31% of the preferred option (see Table 5-3). However, when taking into account capital replacement carbon emissions over the whole life period, the 'M&E…' category is responsible for more emissions in total, despite only accounting for only 9% of the Preferred Tunnel Option's total capital carbon. This difference is displayed in Table 5-4, as 'M&E…' contributes 26% to the total capital and capital replacement carbon of the Preferred Tunnel Option, whilst pipelines only contributes 22%, as they are not expected to be replaced within the whole life period.

It is important to note that the assumption regarding asset replacement emissions being identical to their initial capital (construction) emissions is likely to be an overestimate, as construction methods are expected to decarbonise in the future.

5.4 Operational Carbon

An operational carbon assessment has been undertaken for the HWTWRP. These emissions are divided between scope 1, 2 and 3 emission categories. Scope 1 emissions are direct emissions from SW-controlled asset operations, Scope 2 emissions are indirect emissions which are a result of SW's purchase and use of grid electricity, and Scope 3 emissions are associated with activities undertaken within SW's value chain (e.g., purchase of chemicals from an external supplier). Under the European Standard Sustainability of Construction Works: Assessment of environmental performance of builds calculation method (BS EN 15978:2011) life cycle modules, the current assessment covers use stages B1-B6 modules.

For the HWTWRP, the major sources of operational emissions are due to chemical usage within the WRP (Scope 3 emissions), and indirect emissions associated with grid power consumption by treatment and pumping equipment (Scope 2 emissions).

5.4.1 Operational Carbon: Overview of Approach

The following aspects for the operation of the HWTWRP have been considered within the operational carbon assessment:

- Emissions due to grid power consumption (excluding solar power generation);
- Emissions due to regular transport activities (e.g., chemical deliveries);
- Emissions due to operational material use (e.g., chemical use in water treatment); and
- Emissions due to operational maintenance (an allowance based on the total capital carbon of the project)

The operational carbon assessment was based on the timescales and required water flows for the latest construction design (Table 5-5). These include the assumption that the Thames to Southern Transfer (T2ST) project will be operational from 2040. T2ST is expected to increase the operational demands on the scheme, and hence the operational carbon emissions. Using this assumption, if the operational start date of T2ST is delayed, the increase in operational carbon emissions of HWTWRP will also be delayed, and hence the whole-life carbon emissions over the period assessed (2025-2104) will be reduced.

The annual average flows derived for the analysis were based on a simplified assumption that 'business as usual' flows would occur for 99% of each year and drought conditions for 1%. The flows for the WRP to HTR transfer are consistent for both tunnel options being developed.

Table 5-5 - Flow regimes used in operational carbon analysis

Flow regime	Business as usual: 99% of time		Drought conditions: 1% of time	
Option component	WRP to HTR Transfer	HTR to Otterbourne WSW Transfer	WRP to HTR Transfer	HTR to Otterbourne WSW Transfer
Pre-T2ST (Ml/d)	30	30	60	90
Post-T2ST (Ml/d)	60	30	60	80

To calculate the GHG emissions associated with power consumption, projected location-based emissions factors from the DESNZ Data Tables 1-19[10] (which supports the 'Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions') are used to forecast grid carbon intensity for future years uses, which assume 'commercial/public sector' values (Figure 5-3).

[10] Electricity emissions factors to 2100, Department for Energy Security and Net Zero

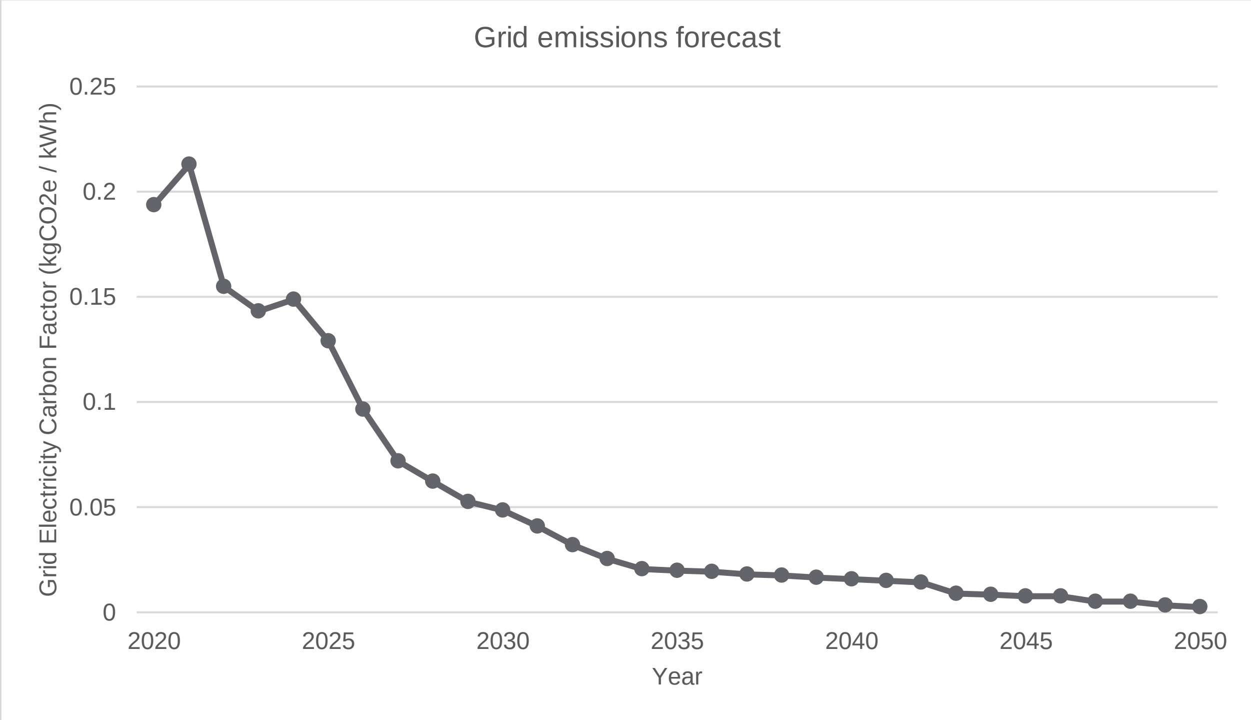

Figure 5-3 - Forecast Grid Carbon Intensity

The impact of the grid decarbonisation on the carbon intensity of the anticipated power consumption is that there will be an 89% decrease in annual power carbon emissions between now (2024) and 2040 and it is predicted that the grid will have largely decarbonised by around 2050.

As information regarding specific maintenance activities is not available in detail at this stage of design development, the carbon emissions associated with operational maintenance have been derived based on specific percentages of the M&E and civil works related capital carbon of the project, following a similar methodology to that used for estimating operational maintenance costs. Although operational maintenance activities are potentially labour and cost intensive, they generally have relatively limited consumables that would have a direct carbon impact. For example, the additional operational maintenance carbon emissions may be associated with:

- Transport fuel consumption for maintenance visits; and
- Embodied carbon associated with small quantities of consumables such as lubrication and minor M&E replacement parts.

Hence, the percentages used are relatively low (0.15% and 0.025%, applied to the total capital carbon of the M&E and civils items respectively). These are significantly lower than the percentages used for assessing operational maintenance costs.

As the design develops in the approach to Gate Four and the DCO application, the scale and frequency of each of the activities such as the above examples shall be reviewed to calculate the emissions associated with operational maintenance using a bottom-up approach.

5.4.2 Summary of Operational Carbon

The annual operational carbon emissions have been compared to reflect four different timeframes using the appropriate DESNZ grid carbon intensity forecast (Figure 5-4). The four timeframes assessed are:

- 2034 (first operational year) using grid carbon intensity forecasts 0.020 kgCO_2e/kWh;
- 2039 (year prior to T2ST) using grid carbon intensity forecasts 0.017 kgCO_2e/kWh;
- 2040 (year after T2ST) using grid carbon intensity forecasts 0.016 kgCO_2e/kWh; and
- 2055 using grid carbon intensity forecasts 0.002 kgCO_2e/kWh

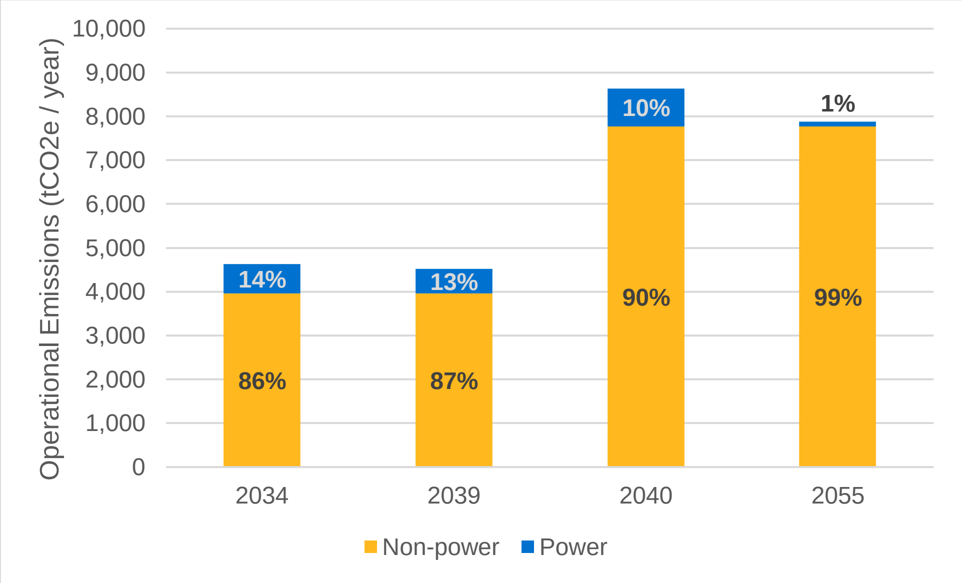

Figure 5-4 - Effect of grid decarbonisation and T2ST on annual operational carbon emissions

Furthermore, the impact of T2ST beyond 2040, demonstrates that the power consumption and non-power operations will increase significantly. This is driven largely by the increase in power required from chemical use as the utilisation of the WRP will increase to maximum capacity after this time.

5.4.3 Operational Carbon Hotspots

The chemical dosing required at the WRP is the most significant contributor to operational carbon emissions, expected to be 82% and 95% of total operational emissions in 2034 and 2055, respectively. Currently there is no decarbonisation trajectory assumed for chemical use within industry, therefore the associated emissions are assumed to stay constant.

The power-related operational carbon emissions are expected to decrease as the power grid decarbonises with increasing use of renewable energy. For example, by 2050 the forecast indicates[8] a reduction to 2% of current levels. The WRP power consumption is the largest contributor to the carbon emissions for grid power use, ranging between 41% and 54% of the total project power-related emissions pre- and post-T2ST, respectively. The interstage pumping stations along the pipeline route to Otterbourne WSW represent a combined 40% and 52% (pre- and post-T2ST) of the total power related emissions, with IPS-3 and IPS-4 being the largest contributors. Power for the high-lift pumping station (HLPS) alongside other miscellaneous power requirements contribute a further 8% to 10% to the total power-related operational carbon emissions pre- and post-T2ST respectively.

The operational emissions associated with transport represent approximately 3% of the total operational emissions in both 2034 and 2055. Operational maintenance is only 1% of the total operational emissions for each year (Figure 5-4) demonstrating the reduction of emissions associated with transport in 2055.

5.5 Whole-Life Carbon Assessment

The outputs from the capital and operational carbon assessments outlined, have been used to inform a whole-life carbon assessment.

To align with the whole-life cost estimates for the HWTWRP, the whole-life carbon has also been assessed over 80 years consistent with ACWG guidance[8]:

- A 4-year planning period (2025-2028) during which it is assumed no carbon emissions are attributed to the project;
- A 5-year construction period (2029 – 2033) during which the initial construction period capital carbon emissions occur. The total capital carbon is split evenly between these five years; and
- A 71-year operation period (2034 – 2104) during which the replacement capital carbon emissions occur alongside the annual operational carbon emissions. During this period (2039/40), the T2ST project is assumed to become operational, increasing the operational demands of the HWTWRP (i.e., an increase in chemical consumption, WRP power demand and operational transport).

Whilst capital carbon associated with lifecycle replacements has been considered with the emissions calculations for capital, the quantified assessment does not include an estimate of the potential impact of decommissioning the project. The operational life is expected to be over 80 years and it is anticipated that the systems in place to re-use, recycle or dispose of assets would be substantially different to present day.

5.6 Summary of Whole-Life Carbon Emissions

A summary of estimated annual carbon emissions included with the whole-life carbon estimate is presented in Figure 5-5 and Figure 5-6 for the two tunnel options. The infrequent 'spikes' in emissions observed are attributed to and consistent with the forecasted asset replacement. For example, the large capital replacement emissions in 2053 are associated with the replacement of the M&E components following a 20-year asset life, which is then repeated in 2073. These are predominantly for replacement of assets associated with the WRP. The increase in operation carbon in 2040 can be attributed to the introduction of T2ST to support the Hampshire Water Resource Zones (discussed in Chapter 2 of the submission document), whereby WRP flows increase from 30 Ml/d to 60 Ml/d for BAU operation.

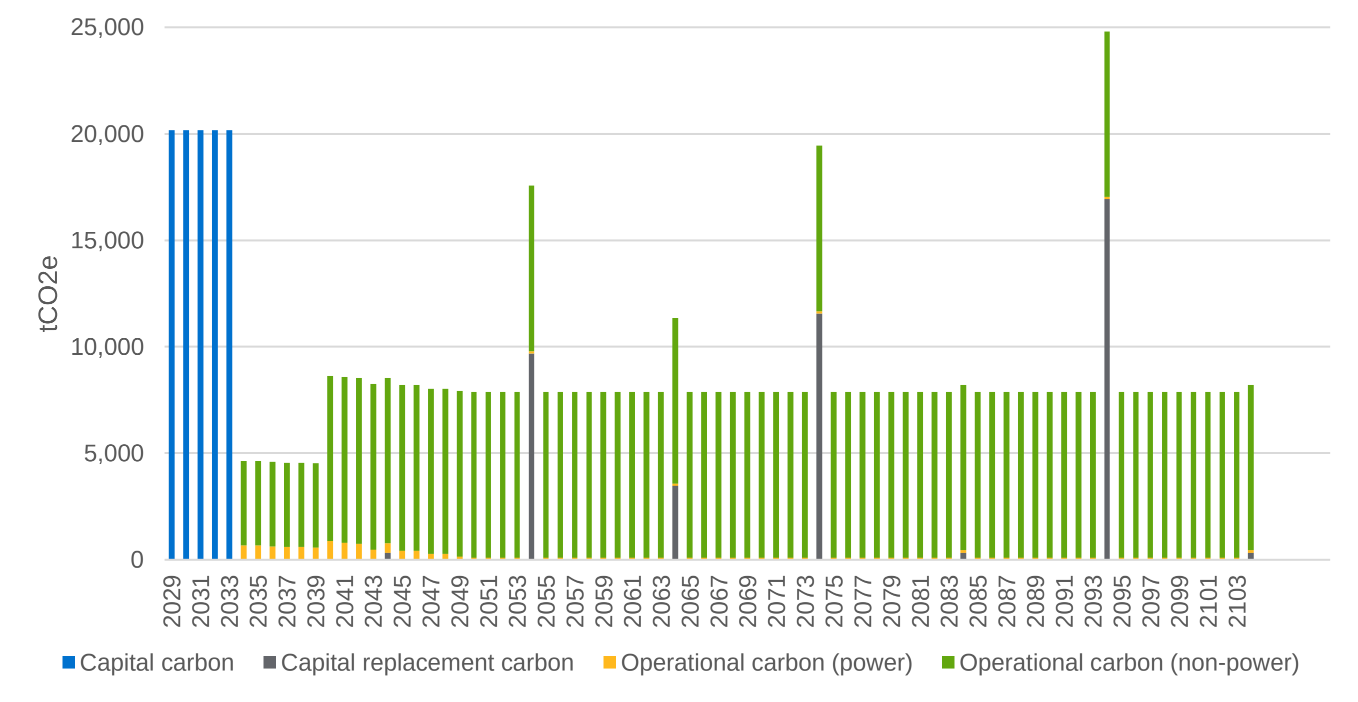

Figure 5-5 - Whole-life carbon emissions profile of the Preferred Tunnel Option

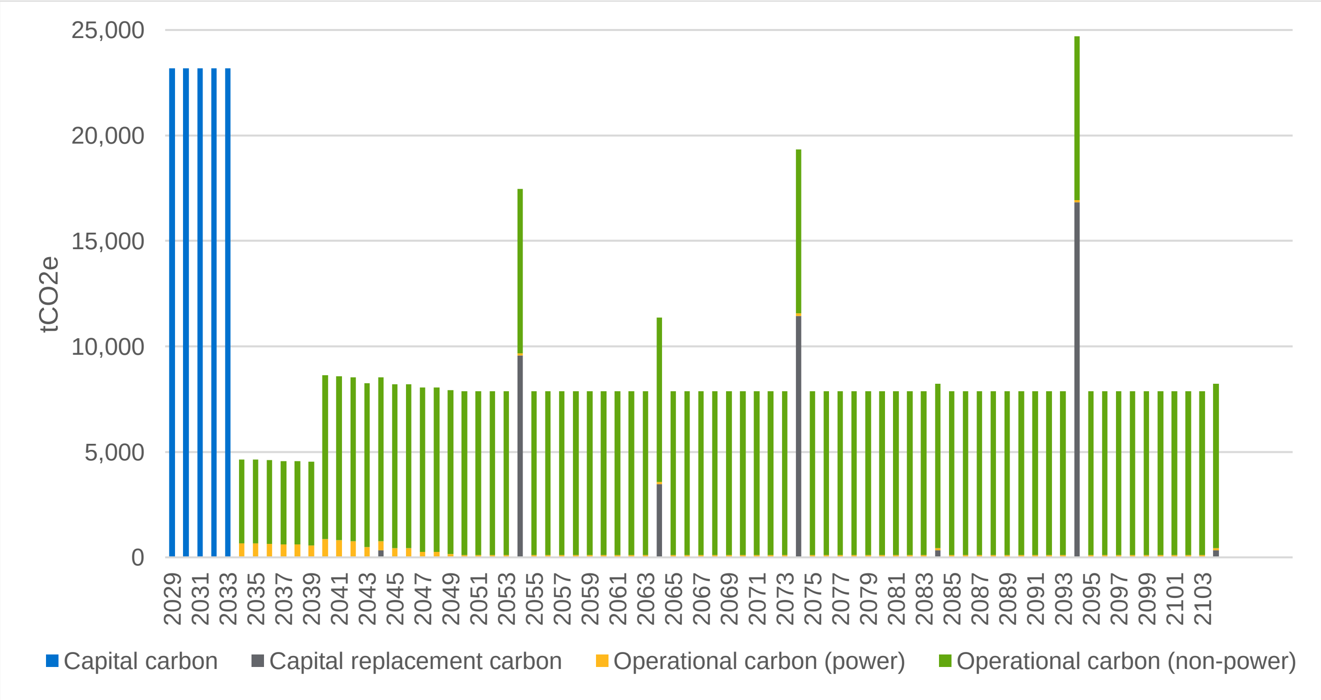

Figure 5-6 - Whole-life carbon emissions profile of the Backup Tunnel Option

A summary of the estimated whole life carbon emissions for the HWTWRP tunnel options has been developed (Table 5-6). These estimates indicate that over an 80-year period, the capital carbon emissions of the project account for ~15-17% of the whole life emissions, with a further 6% associated with capital replacements of the assets.

Table 5-6 - Summary of whole-life carbon emissions over an 80-year period as defined by PAS 2080:23.

Category	Preferred Tunnel Option		Backup Tunnel Option	
	tCO_2e, whole-life period	% of tCO_2e, whole-life period	tCO2e, whole-life period	% of tCO_2e, whole-life period
Capital Carbon	100,800	15%	115,900	17%
Capital Replacements	42,600	6%	42,300	6%
Operational carbon - power	14,600	2%	14,600	2%
Operational carbon - non-power	529,000	77%	529,200	75%
Total	**687,100**[11]	**100%**	**702,100**[11]	**100%**

The majority of whole-life carbon emissions are associated with the chemical dosing at the WRP, accounting for approximately 75 or 77% of the respective tunnel options, whilst the emissions associated with power consumption (of the WRP, HLPS and IPSs) account for the remaining 2%.

Whole life carbon emissions have also been monetised using BEIS Green Book Data Tables 1-19[12], Table 3. The monetisation of carbon has been built into the regional planning appraisal approach to account for the carbon impact of different projects. Table 5-7 summarises the whole life carbon NPV (in £m) over 80 years for both the Preferred and Backup Tunnel Options.

Table 5-7 Summary of the monetised carbon emissions for the HWTWRP with each tunnel option

Tunnel Option	Low Carbon Cost (£m)	Central Carbon Cost (£m)	High Carbon Cost (£m)
Preferred	48.4	96.8	145.2
Backup	50.1	100.1	150.2

5.7 Comparison with Gate Two Baseline

The whole-life carbon assessment completed at Gate Two has been compared to the Gate Three assessment to understand how changes in project design have impacted the potential carbon emissions of the project.

The design and scope of the HWTWRP have significantly changed since Gate Two (Table 5-8). These changes represent the update in the throughput flows modelled for the WRP that is now required at Gate Three.

Furthermore, two tunnel options have now been proposed, the Preferred and Backup, between the WRP and HTR. This change in scope has result in additional capital carbon the number, length and diameter of each tunnel option and the associated pipelines has increased.

The length and diameter of the underground pipeline route to Otterbourne WSW is similar for Gate Three as it was at Gate Two scope, therefore resulting in minimal change to the capital carbon emissions since Gate Two of this element.

Table 5-8 - Key differences in scope used for carbon assessment at Gate Two vs. Gate Three

Aspect	Gate Two	Gate Three
Number of options proposed	4 possible transfer routes within preferred 'HWTWRP'	2 – transfer routes largely agreed, 2 No. tunnelling options from WRP to HTR
Flows	2 scenarios: Minimum - WRP 5 Ml/d, HTR to Otterbourne WSW Transfer 5 Ml/d Drought - WRP 15 Ml/d, HTR to Otterbourne WSW Transfer 75 Ml/d	Pre T2ST: - BAU (99% of time)– WRP 30 Ml/d, HTR to Otterbourne WSW Transfer 30 Ml/d - Drought (1% of time) – WRP 60 Ml/d, HTR to Otterbourne WSW Transfer 90 Ml/d Post T2ST: - BAU (99% of time)– WRP 60 Ml/d, HTR to Otterbourne WSW Transfer 30 Ml/d

[11] tCO_2e have been rounded to the nearest 100 and therefore totals presented may result in variance +/-200 tCO_2e. Note: this is the same table as provided in Submission documents Table 5-1.
[12] Table 3: Carbon values and sensitivities 2010-2100 for appraisal, 2022 £/tCO2e, Department for Energy Security and Net Zero

		- Drought (1% of time) – WRP 60 Ml/d, HTR to Otterbourne WSW Transfer 80 Ml/d
Pipeline routes	~30km 800mm ID open cut pipeline, ductile iron	~30km 800mm ID open cut pipeline, ductile iron.
Tunnels	~3km of 3m ID tunnel	Preferred: ~4km of 3.5m ID tunnel by Tunnel Boring Machine (TBM) and associated shafts Backup: ~1.5km of 2.5m ID micro tunnel by pipe jack and associated shafts

A comparison of the capital, operational and whole-life carbon emissions between the solutions presented at Gate Two and Gate Three (Table 5-9) demonstrates the significant increase in carbon emissions due to the increased capacity required.

Table 5-9 - Difference in emissions reported at Gate Two vs. Gate Three.

Aspect (tCO_2e)	Gate Two ('average' operating regime, 6.69 Ml/d, 100-year operating period)	Gate Three (preferred solution, 80-year whole-life period)
Capital Carbon	71,000	100,800
Capital Replacement Carbon	5,200	42,700
Operational Carbon	118,800	543,600
Whole-Life Carbon	195,000	687,100

The greatest increase in whole-life carbon is driven by the increased flows expected from the WRP to align to the revised draft WRMP24 and Regional plans, increasing both chemical and power consumption.

It is important to note that the carbon assessment at Gate Three has used the latest available emissions factors and, in some cases, these vary from those used at Gate Two. For example, the operational carbon emissions associated with grid consumption now use emissions factors updated in November 2023. For 2035, the grid consumption emissions factor used was 0.056; this has since decreased in the latest revision to 0.020. A full sensitivity analysis to identify the scale of these differences has not been completed; however, from high-level analysis of the key hotspots (capital carbon of pipelines / tunnels, operational carbon from chemicals and power consumption), this impact appears to be small.

Furthermore, the approach to calculating the carbon emissions associated with capital replacements differed at Gate Two, where they were assumed to be proportional to the capital maintenance costs. For example, if capital maintenance costs in one year are 1% total CAPEX, the capital maintenance carbon emissions in the same year were estimated as 1% of total capital carbon emissions. The approach to calculating the capital replacement carbon emissions at Gate Three can be found in Section 5.3 Capital Carbon.

5.8 Carbon Mitigation Opportunities

As described in Chapter 5: Carbon, collaborative workshops between internal stakeholders have been established to identify mitigation opportunities that could be incorporated into project design. These workshops have been informed by work carried out by the ACWG to identify opportunities for mitigation, and the carbon hotspots identified as part of operational and capital carbon assessments The following asset subgroups have been considered:

- Pipelines;
    - *~30km 800mm open cut pipeline (ductile iron).*
- Tunnels and shafts (preferred option);
    - *~4km of 3.5m ID tunnel by TBM and associated shafts;*
    - *~1.5km of 2.5m ID micro tunnel by pipe jack and associated shafts.*
- Above Ground Plant (AGP);
    - *Interstage pumping stations;*
    - *Break pressure tank(s).*
- Water Recycling Plant (WRP);
    - *Process plant;*
    - *Buildings;*
    - *Roads;*
    - *Piling.*

Carbon mitigation opportunities were ranked (qualitatively) based on 'carbon mitigation potential' and technical feasibility. This enabled the exploration of these opportunities to be prioritised in line with the carbon reduction hierarchy (Chapter 5: Carbon) and hence it is likely not all ideas generated will be explored in-depth. Further work to review the highest ranked opportunities will accelerate in the approach to the DCO application.

A RACI matrix has been designed to show opportunities for mitigating carbon in the development of the HWTWRP (Table 5-10). In order to successfully reduce emissions, the asset owner, designer, construction and suppliers involved in the project will need to take some level of responsibility, rather than each mitigation measure being attributed to one stakeholder.

Overall, engagement with the supply chain and policy makers will help develop an environment and marketplace where low carbon alternatives are prioritised; and collaborative efforts are made to ensure the implementation of these alternatives is cost-effective. This type of engagement will continue in the pre-planning stage for DCO application and beyond.

The development of detail on procurement activities and timeframes for engagement with the supply chain, will be key in helping to ensure maximum value can be driven through engagement activities with the wider supply chain at the appropriate time.

Suppliers will be required to follow Southern Water and national policy and legislation. This will be driven through contractual mechanisms which will be refined through the procurement process. At this stage of design iteration, a number of potential opportunities to mitigate carbon emissions have been identified. These opportunities will be viability tested through design development and progress against these will be reported at Gate Four.

Table 5-10 - RACI Matrix (Red = Responsible, Yellow = Accountable, Green = Consulted, Blue = Informed)

HWTWRP Hotspot	Mitigation Measure	Asset Owner	Designer	Constructor	Product Material/Supplier
Pipelines	Low carbon ductile iron used for the pipeline material, or use of another low carbon material if it matches the design requirements.	Incentivise the use of these low carbon materials through identifying and embedding 'no regrets' low carbon alternatives into DCO design. Clearly communicate with supply chain importance of carbon mitigation and any carbon reduction targets. Use appropriate contractual mechanisms to incentivise constructors to deliver carbon reductions beyond DCO design.	Choosing a material which is most efficient for carbon whilst also meeting design requirements. Incorporating the carbon intensity of these products and materials into decision making is key. Engaging with constructors and product material suppliers at the earliest appropriate stage to bring expertise to identify most efficient low carbon materials and construction approaches.	Work with asset owner to also engage with supply chain to understand performance specification, carbon impact and potential limitations to supply of materials. Work with designer to achieve optimal balance between low carbon materials and efficient construction.	Highlighting to asset owners, designers and constructors the availability of low carbon materials that achieve specific performance requirements. Work with asset owner and designer and constructor to adapt existing products to meet carbon performance targets. Understand scale of supply required and provide confidence of availability. Ensure the pipeline material is manufactured using lowest feasible emissions method. Ensure able to consistently supply these materials. The carbon intensity of these materials significantly varies, depending on how it has been manufactured, how and where it is transported from, and the carbon intensity of the energy source used for manufacturing.
All	Electric / hydrogen / biodiesel / hybrid powered plant	As per pipelines, plus: Incentivise the use of low carbon fuels. Setting targets and clearly communicating their importance.	Consider opportunities to share use of this plant with other infrastructure schemes. Need to understand ancillaries, such as how to get hydrogen to site and where it will be stored.	A commitment to use low carbon earth moving equipment for the duration of construction. Research constructability of alternative fuels and feed this feasibility back to designers/asset owners.	Supply lower carbon vehicles, plant, and fuel for the constructor to use. Communicate availability and limitations to constructor, designer and asset owner
All	Automated plant	As per pipelines, plus: Ensure the tender documents require the chosen provider has policies in place to minimise carbon in all site-based activities.	Understand how it impacts the design approach as well as cost. Communicate any issues that may arise from this.	Consider the feasibility of new technologies made available by construction plant suppliers. Provide confidence to asset owners and collate evidence of	Continue to consider efficiency improvements to reduce carbon emissions. Ensure the other stakeholders are onboard

				successful implementation to reinforce this.	with the transition to automated plant.
Chemicals	Procure lower carbon-intensive chemicals	As per pipelines, plus: Collaborate with supply chain to further understand chemical emissions factors. Communicate key hotspots	Consider alternative treatment solutions when high carbon intensity chemicals are used.	Stay informed on the latest chemical decarbonisation trends.	Improve chemical supply chain carbon accounting. Demonstrate actions taken to reduce carbon intensity. Highlight barriers to reducing emissions (e.g., low carbon chemicals may have a higher cost).
Energy	Inclusion of renewable energy generation	As per pipelines, plus: Weigh up the benefits of on-site energy resilience against the fact the energy grid will likely be decarbonised when the project begins operation. Set renewable energy targets. On a systems level, engage other energy demand stakeholders in the region to plan renewable energy delivery as efficiently as possible.	Assess the feasibility of renewable energy sources. Investigate other performance benefits e.g., resilience. Engage renewable energy suppliers to identify most efficient and latest technology. Understand regional policy constraints around renewable infrastructure.	Highlight opportunities for efficient delivery for renewable infrastructure.	Engage and communicate with the other stakeholders upstream and any further downstream providers to ensure they're aware of latest technology and generation potential. E.g., smaller solar panels may be placed in areas not previously thought viable.
Energy	Low carbon power and decarbonised electricity procurement.	As per pipelines, plus: Consider whether this will be necessary when the project goes into operation – will the grid already be sufficiently decarbonised? Procure all power associated with the site through REGO backed green energy tariffs. This would reduce the generation impact of grid power from the grid average to zero (but would still incur the associated transmission and distribution losses associated with grid supply). Understand the importance of a balance between quality and locality of low carbon energy available.	Understand any energy constraints that might be placed on the site from the procurement of low carbon power.	Use of low carbon plant during construction.	Use of low carbonised power in factories/manufacturing.
All	Efficient construction approaches and construction waste minimisation	As per pipelines, plus: Ensure project team has time and resources to consider this. Engage with wider capital delivery programme within organisation or	It is important to understand the type, quantity, and quality of waste likely to be produced. This can help identify opportunities to re-use	Adopt efficient construction techniques, e.g., modular, off-site manufacture options. This can help reduce the amount of waste associated with construction	Manufacturing processes aligned with best practice. E.g., pipeline – need to optimise the quality of bedding required for different

		beyond organisation to see if waste could be reused for another project.	construction waste either within the project site boundary or more locally rather than requiring it to be transported larger distances. Having a robust waste management plan and engaging other potential users of surplus excavation waste can help reduce emissions associated with construction waste disposal. Carry out ground investigations to see if dug material can be used as pipe surround (instead of importing pipe surround). Design in measures for reducing quantities of waste, identifying surplus material to be excavated and opportunities to reuse within site boundary. Investigate any processing needed for material to be reused. Minimise carbon intensity for transport e.g., rail or barge provide lower carbon intensity transport. Maximise beneficial reuse rather than disposal.	projects, whilst potentially reducing carbon emissions, improving health and safety and overall operational performance of assets. Understand what needs to be done with each material (e.g. correct storage) so the quality is maintained. Have a detailed waste management plan interlinked with reuse opportunities	pipe materials where this enables lower emissions, e.g. to reduce use of imported material with its higher carbon intensity.
Energy	Optimising energy efficiency and maintenance activities	As per pipelines, plus: Ensure project team has time and resources to consider this. Follow the principle of minimising whole life carbon even if an increase in capital carbon is required. Monitoring across the whole life of the project, allows understanding of when it becomes less efficient. Understand the potential benefits of spending more on capital expenditure to save on power consumption during the whole life of the project.	Optimise pump selection using latest software to provide the greatest balance between energy efficiency, performance, and resilience. Assess whole life carbon rather than just capital carbon.	Engage with the supply chain to identify the optimal product based on the designer's criteria. Keep maintenance requirements during operation in mind, trying to make access for maintenance as easy as possible. Transition to low carbon van fleets for maintenance activities.	Be able to supply the energy efficient pumps required by the project.

5.9 Renewable Energy

The renewable energy strategy for the HWTWRP is currently being developed. This will cover the key principles of whether the project would benefit from self-generation or whether procurement routes would be more efficient to achieve optimal decarbonisation of power demand. Due to the stage of design development (particularly in regard to the energy demand of the WRP, a significant driver of power demand), quantified analysis has not yet been undertaken. Over the next design phase, the team will carry out the following activities:

- Finalise the scale of power demand and demand profile of the transfer and WRP elements at different utilisation rates;
- Conduct an assessment of scale of renewable generation required to meet this demand and identify optimal sizing, etc;
- Go through a screening exercise to identify feasible renewable generation options (e.g., considering cost, land availability, planning constraints, etc.); and
- Finalise renewable energy strategy following this screening exercise.

It is important to note that this strategy will focus on being location-based in its decarbonisation efforts, i.e., aiming to procure power from a renewable energy source in close proximity to the project.

5.10 Next Steps

The HWTWRP has identified a range of mitigation measures that need to be further assessed for their feasibility and viability which will support the continued maturity of the project, linked to its design development. To enable the HWTWRP to demonstrate the considerations and potential implementations of all viable carbon mitigation opportunities, the following next steps must be achieved:

- Establish a set of criteria to test the viability of embedding the identified mitigation measures in this report into the next phase of design development. This should include, cost, carbon reduction potential, planning constraints, land-use requirements, etc.;
- Continue to engage design teams and other value chain members through further workshops to identify innovative opportunities to mitigate emissions and identify actions needed to remove barriers and increase feasibility of implementation;
- Continue to develop a renewable energy strategy based on the latest options sizing, power demand and links to other projects to ensure the potential renewable energy opportunities are sized optimally. This should include reviewing the benefits associated with solar, wind and hydro-turbines and also expanding to explore other opportunities for energy recovery and test the viability of these against the criteria identified for other mitigation measures;
- Develop a decarbonisation ambition for the HWTWRP for Scope, 1, 2 and 3 emissions based on existing commitments, such as the net zero operational emissions commitment by English companies, the National Policy Statement for Water Resources requirements to demonstrate mitigation measures and alignment to UK Climate Act commitments to achieve net zero emissions across the UK economy by 2050. A clearer decarbonisation ambition statement would help focus and prioritise decarbonisation efforts through future project design development; and
- Develop an offsetting strategy linked to the decarbonisation ambitions of the project that considers best practice in identifying and securing offsets and help deliver value by supporting the wider regional system to decarbonise. This would involve engaging stakeholders, such as local authorities, to see what types of offsetting interventions would drive best value across the region(s) that the HWTWRP serves and passes through.