Gate two query process

Strategic solution(s)	Anglian to Affinity Transfer
Query number	AAT001
Date sent to company	18/11/2022
Response due by	22/11/2022

Query

A2AT Main Report, section 6.5 "An assessment of the carbon impact of the selected pipeline options and opportunities to minimise embodied and operational carbon within the selected scheme was undertaken. The assessment is summarised here."

Please can the full carbon assessment be provided.

Solution owner response

The full carbon assessment which was undertaken for the A2AT has been uploaded to the RAPID SharePoint site (report title '*A2AT Gate 2 Carbon Report_FINAL*'). The report provides detail around the methodology and the outcomes of the carbon assessment as well as describing the main opportunities to minimise both embodied and operational carbon within this SRO.

Date of response to RAPID	22/11/2022
Strategic solution contact / responsible person	Andrea Farcomeni andrea.farcomeni@agilia.co.uk 07376 000023

Anglian Water & Affinity Water

Anglian to Affinity Transfer (A2AT)

A2AT Carbon Report

Reference: A2AT Carbon

Version 2 | November 2022

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 286840-00

Ove Arup & Partners Limited
Admiral House Rose Wharf
78 East Street
Leeds
LS9 8EE
United Kingdom
arup.com

ARUP

Document Verification

Project title	Anglian to Affinity Transfer (A2AT)
Document title	A2AT Carbon Report
Job number	286840-00
Document ref	A2AT Carbon
File reference	

Revision	Date	Filename			
Version 1	November 2022	**Description**	A2AT Carbon Report		
			Prepared by	**Checked by**	**Approved by**
		Name	Ayisha Paw	Ritchie Carruthers / Philip Songa.	Fred Mukonoweshuro
		Signature		[signature]	[signature]
Version 2	November 2022	**Filename**			
		Description	Amends as per client internal QA.		
			Prepared by	**Checked by**	**Approved by**
		Name	Ayisha Paw	Ritchie Carruthers	Fred Mukonoweshuro
		Signature			[signature]
		Filename			
		Description			
			Prepared by	**Checked by**	**Approved by**
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

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1. Background

1.1 Context

Anglian Water and Affinity Water both aim to be operationally carbon net zero by 2030. Anglian Water currently generates around 30% of its energy requirements from renewable resources, and their target over the next five years is to increase this to 44%. Affinity Water use 100% green electricity from the grid, have an energy efficiency programme in place, and have made a commitment to make carbon a key part of all investment decisions going forward.

In 2020, Water UK published their Net Zero 2030 Route map, which provides water companies with a framework on which to develop and cost their own net zero action plans. Water UK expects to see the following by 2030:

Low emissions vehicles: 100% of fleet passenger vehicles are electrified and 80% of commercial vehicles (LGVs and HGVs) converted to alternative fuels to cut carbon and air pollution.

Water and energy saving: New strategies to tackle leakage and help customers save water, alongside smarter and more efficient networks and catchments.

Process emissions: Targeting a reduction of up to 60% from the 2018-19 baseline by 2030, with monitoring of emissions to inform research and detailed pathways ahead of PR24.

Renewable power: Up to 3GW of new solar and wind power coupled with energy efficiency measures and suitable storage to provide up to 80% of sector demand, relieve pressure on grid generators, and minimise the need for offsets.

Green gas: Biomethane from sewage waste is injected into the grid to heat up to 150,000 homes, use in hard to decarbonise sectors, or to generate low-carbon power when generation from renewables is low

Figure 1. Water UK expectations by 2030

To aid Anglian Water and Affinity Water in meeting their low carbon and net zero targets, an assessment of carbon for the Anglian to Affinity Transfer (A2AT) has been conducted. The assessment includes opportunities to minimise embodied and operational carbon within the selected scheme, and the outcomes are summarised in this report.

1.2 Methodology

Four aims have been identified from the partner water companies for this carbon assessment. These are listed in Table 1, along with the methodology for meeting these aims.

Table 1. Aims and methodology for the carbon assessment

Aim	Description	Methodology	Output
1	Interrogate the whole life carbon baseline for the selected pipeline route	A bespoke calculator for whole life carbon was created for the Gate 2 Eastern and Western Routes	The findings are summarised in Section 2.2 of this report
2	Understand the views of representatives to gauge their views on low carbon opportunities	This was carried out via a virtual workshop facilitated by Arup and attended by the Client, and representatives from the Environment Agency and Natural England.	The outputs of the workshop were intended to be used to short-list low carbon, renewable and sequestration opportunities. These fed into the recommendations.
3	Identify carbon considerations into the	Hotspots for carbon reduction were identified in collaboration with the design team.	See Section 2.2 of this report.

Aim	Description	Methodology	Output
	procurement, construction, and operation phases	Assumptions were made for the construction and operation of the pipeline, to inform carbon considerations.	
4	Review the potential for embedding renewables and sequestering carbon into the design of the proposed solution	Using the results from the carbon baseline calculation and workshops with the design team, a list of recommendations, including carbon sequestration was made using the Carbon Reduction Curve principles. Renewable energy potential has been considered elsewhere in the Gate 2 submission.	

For the selected design routes, a whole life carbon assessment has been carried out. The scope of the assessment is based on BS EN 15978:2011 stages, identified below.

- Before use stage: A1-A5
- Use stage: B1-B7
- End of life stage: C1-C4

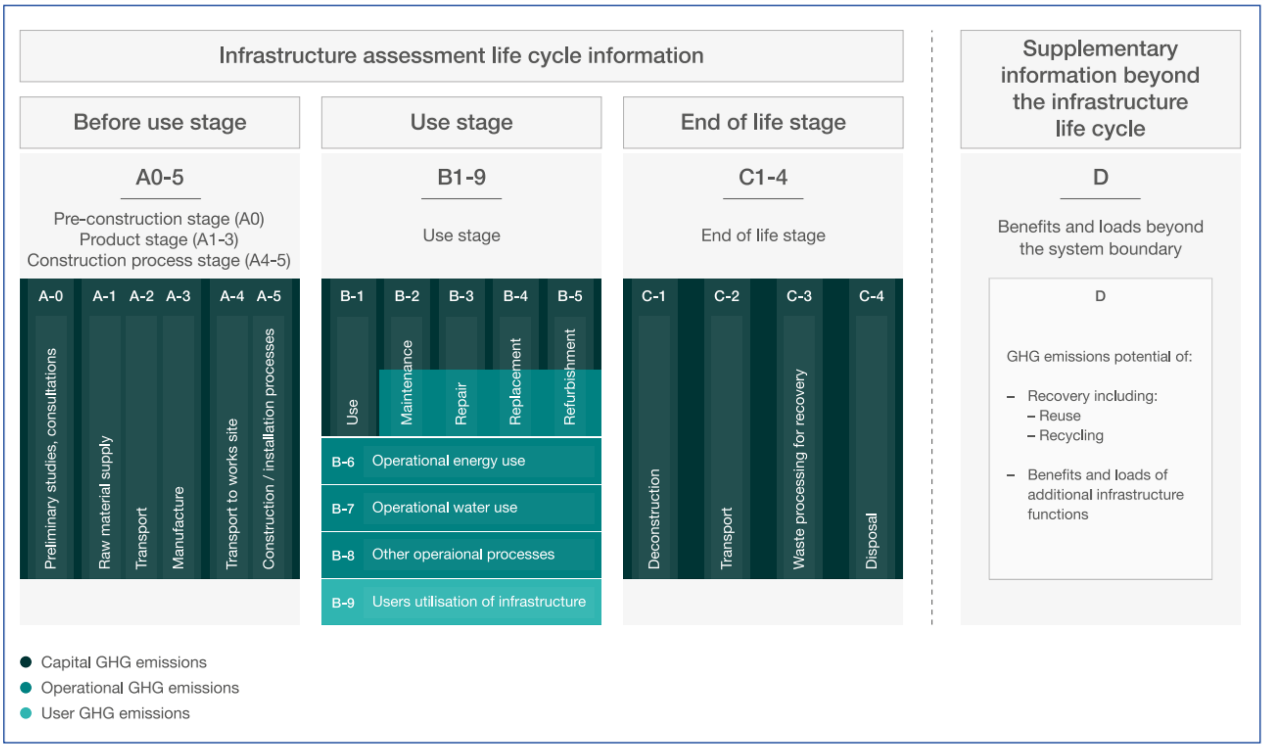


Figure 2. Modular approach to asset lifecycle, BS EN 15978: 2011

2. Carbon Assessment

2.1 Summary of Gate 1 findings

The Gate 1 technical assessments for A2AT analysed four different options for the scheme. One of the four options was the South Lincolnshire Reservoir (SLR) to WRZ5 Hub which is the option progressed at Gate 2 stage.

As stated in the *Gate 1 Concept Design Report*, the SLR options which deliver water to Affinity Water were considered as 50 Ml/d or 100 Ml/d. This is because the proposed SLR is being sized for 150 Ml/d deployable output, and up to 100 Ml/d could be transferred to Affinity Water, and so the Gate 1 options considered both 50 Ml/d and 100 Ml/d alternatives.

Table 2. Gate 1 summary of SLR transfer route (by Mott MacDonald)

	Gate 1 Route – SLR to WRZ5 Hub
Pipe diameter	Peterborough to Intermediate break tank • 800 mm (50 Ml/d) • 1,000 mm (100 Ml/d) Intermediate break tank to WRZ5 • 800 mm (50 Ml/d) • 1,000 mm (100 Ml/d)
Route length	Peterborough to Intermediate break tank • 64 km Intermediate break tank to WRZ5 • 31 km Total • 95 km
Power of pumping station	Peterborough to Intermediate break tank • 2.0 MW (50 Ml/d) • 4.5 MW (100 Ml/d) Intermediate break tank to WRZ5 • 2.0 MW (50 Ml/d) • 4.0 MW (100 Ml/d)

The carbon estimate for the Gate 1 option 'SLR to WRZ5 Hub' is summarised in Table 3 and Figure 3.

Table 3. Gate 1 carbon calculations (calculated by Mott MacDonald)

Route	50 Ml/day		100 Ml/day	
Gate 1 - SLR to WRZ5 Hub	Operational Carbon emissions at full capacity* (tCO2e/year)	Capital Carbon Emissions (tCO2e)	Operational Carbon emissions at full capacity* (tCO2e/year)	Capital Carbon Emissions (tCO2e)
	5,688	71,626	13,177	156,633

*Estimated based on calculated power used at full capacity in MWh/yr and using the Carbon Accounting Workbook v14 grid power emissions factor of 0.277 kg/kWh including transmissions and distribution losses

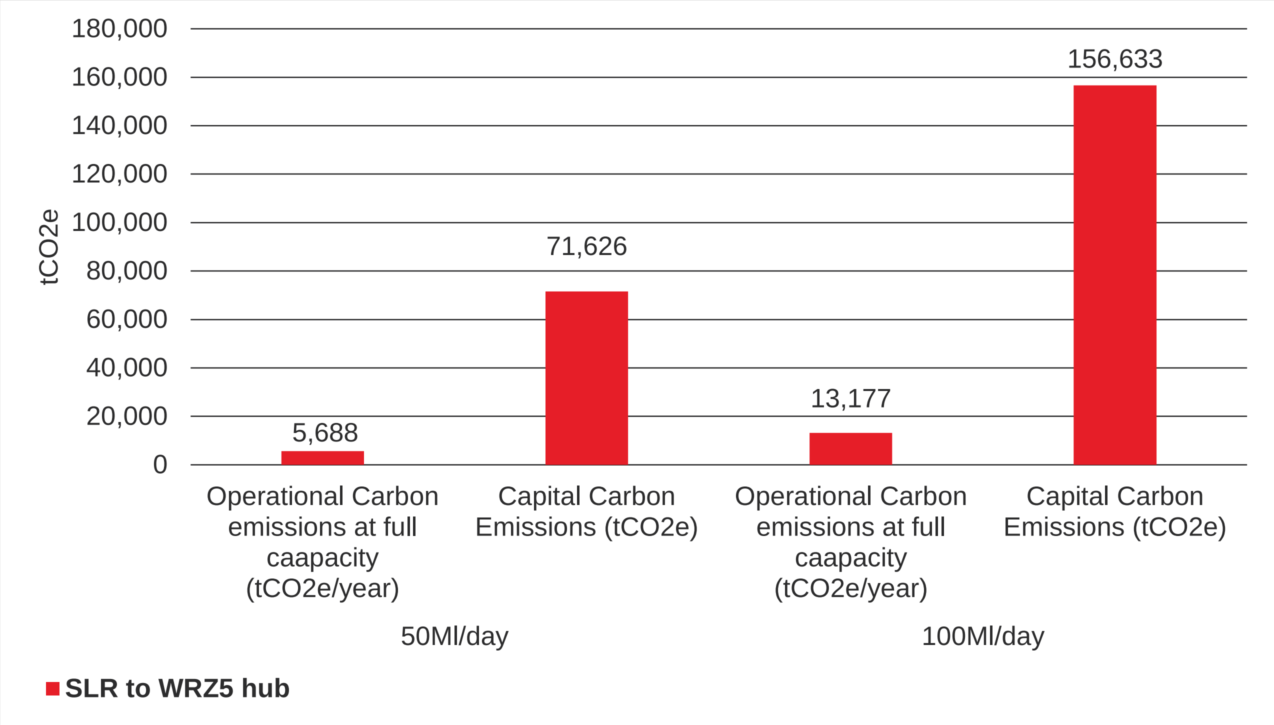


Figure 3. Gate 1 embodied and operational carbon (calculated by Mott MacDonald)

The Gate 1 capital (embodied) carbon was calculated using Mott MacDonald's Carbon Portal and operational carbon was calculated using Affinity Water Long Run Marginal Cost (LRMC) tool.

The Gate 1 assessment was used as a baseline to compare the Gate 2 carbon assessment with.

2.2 Gate 2 Assessment

2.2.1 Assumptions

The following assumptions were used in the Gate 2 carbon analysis:

Embodied (A1-4)	Pipe material	Ductile iron*
	Pipe diameter	50 Ml/d: 900 mm 100 Ml/d: 1200 mm
	Pipe lengths	Eastern Route: 105,000 m Western Route: 115,000 m
	Butterfly valves and chambers	Every 2km
	Break tanks (including Peterborough service reservoir)	Eastern Route: 2 no. Western Route: 3 no. Reinforced concrete tanks at 500 mm wall thickness
	Thrust blocks	Every 1 km Reinforced concrete 2 m x 2 m x 2 m each
	Surge vessels	Eastern Route: 18 no. Western Route: 14 no. Each 100 m^3 constructed of steel carbon
Construction (A5)	Construction method	Open cut excavation
	Trench width and cover depth	Width: pipe diameter + 300 mm either side Cover depth: 0.9 m
	Percentage of excavated material going to landfill / hazardous waste	10%
	Vehicle movements	HGVs, and rigid vehicles travelling 50 km/day

	Construction timeline	5 years
Operational (B1-B7)	Deployable output	112%
	Power source	UK grid electricity
	kgCO2e per kWh based on UK Government 2021	0.21233
	kgCO2e per kWh for Transmission & Distribution based on UK Government 2021	0.01879
	Chemicals for treatment required	Sodium hydroxide, CO_2 gas, Sodium hypochlorite and Chloramines
	Vehicle movements	Hybrid car travelling 50 km/day
End of life (C1-C4)	Pipe will remain in situ and no deconstruction works are associated with decommissioning	

*Assumption to be reviewed at detailed design stage

For details that are unknown at this stage of design, exclusions have been made from the Gate 2 carbon assessment. These include the following:

- Air valves and washout valves
- Pipe bends
- Tunnel boring of the pipeline
- Pumping equipment associated with chemical treatment
- Power requirements associated with chemical treatment
- Pump station building
- Roads and access to the pump stations and treatment works
- Employee travel to site during construction and operation
- Site accommodation and welfare during construction
- Mechanical plant during construction for excavation

However, these should be included at a later stage of the design process once more information is available.

2.2.2 Results

Results of the Gate 2 carbon assessment are shown in Figures 4, 5, 6 and 7 and are split into capital carbon, construction carbon and operational carbon.

In Figure 7, operational carbon has been shown for 20 years, as this is the assumed asset life for pumping; however, it is recognised that the design life for the pipeline is much longer.

Whole life Carbon

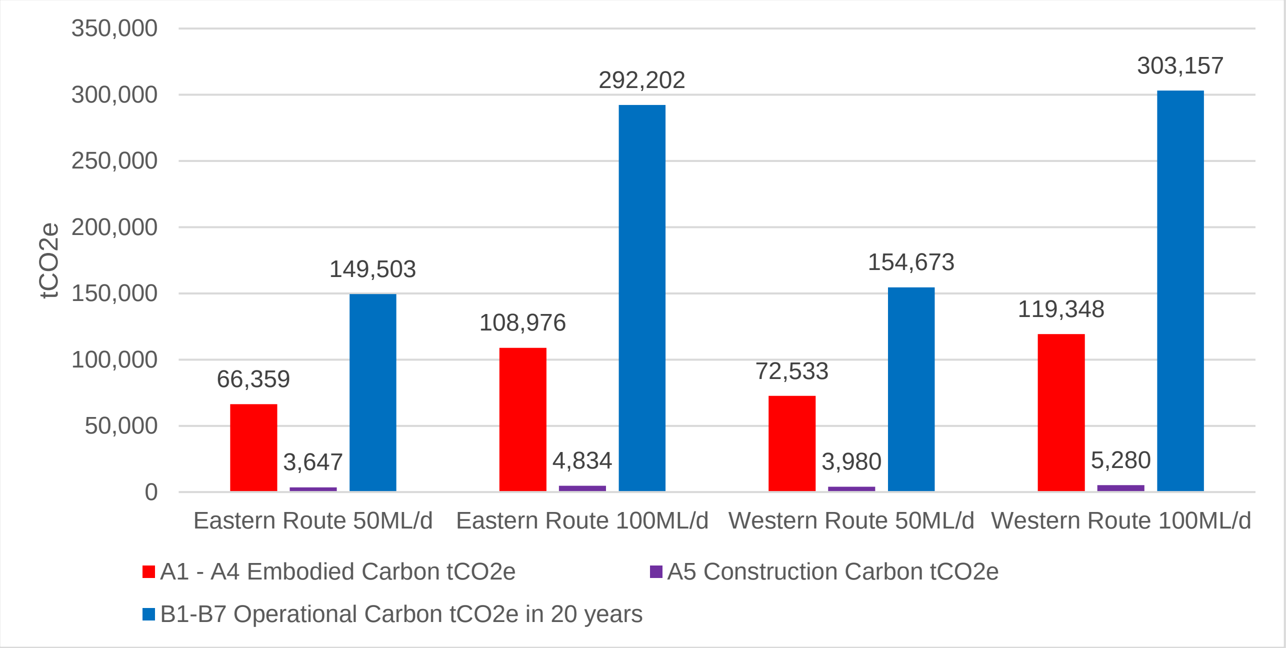


Figure 4. Whole life CO2e estimates for Eastern and Western routes (50 Ml/d and 100 Ml/d)

Embodied Carbon

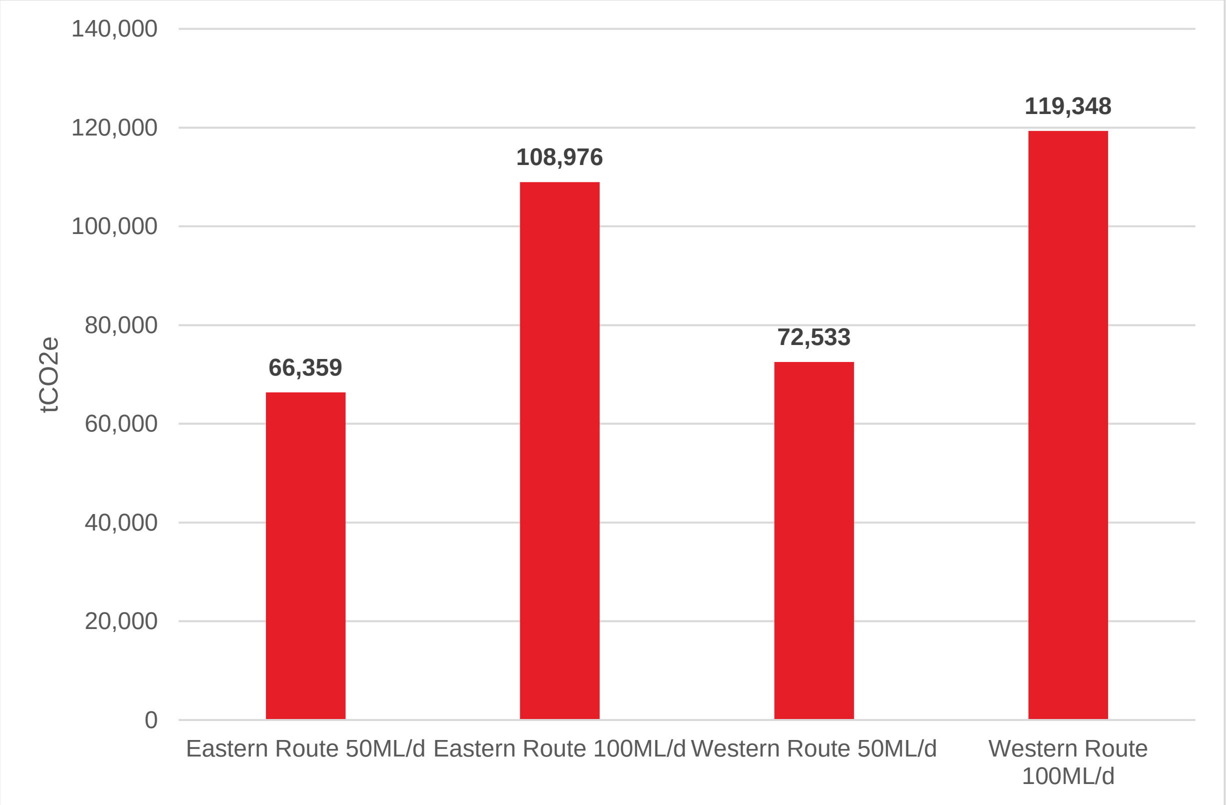


Figure 5. Embodied CO2e for Eastern and Western routes (50 Ml/d and 100 Ml/d)

The majority (97%) of embodied carbon for all routes is associated with the pipework. This means that the largest reductions achievable with respect to embodied carbon would be from reducing the mass of pipe work, i.e., shortening the pipeline route, reducing pipe thickness and/or diameter. Comparing the Eastern Route (100 Ml/d) to the Gate 1 SLR to WRZ5 Hub (100 Ml/d) route, the Gate 2 embodied carbon is 30% lower, despite the Gate 2 Eastern Route having a longer pipeline length. This is due to differences in material density and carbon factors used.

Construction Stage

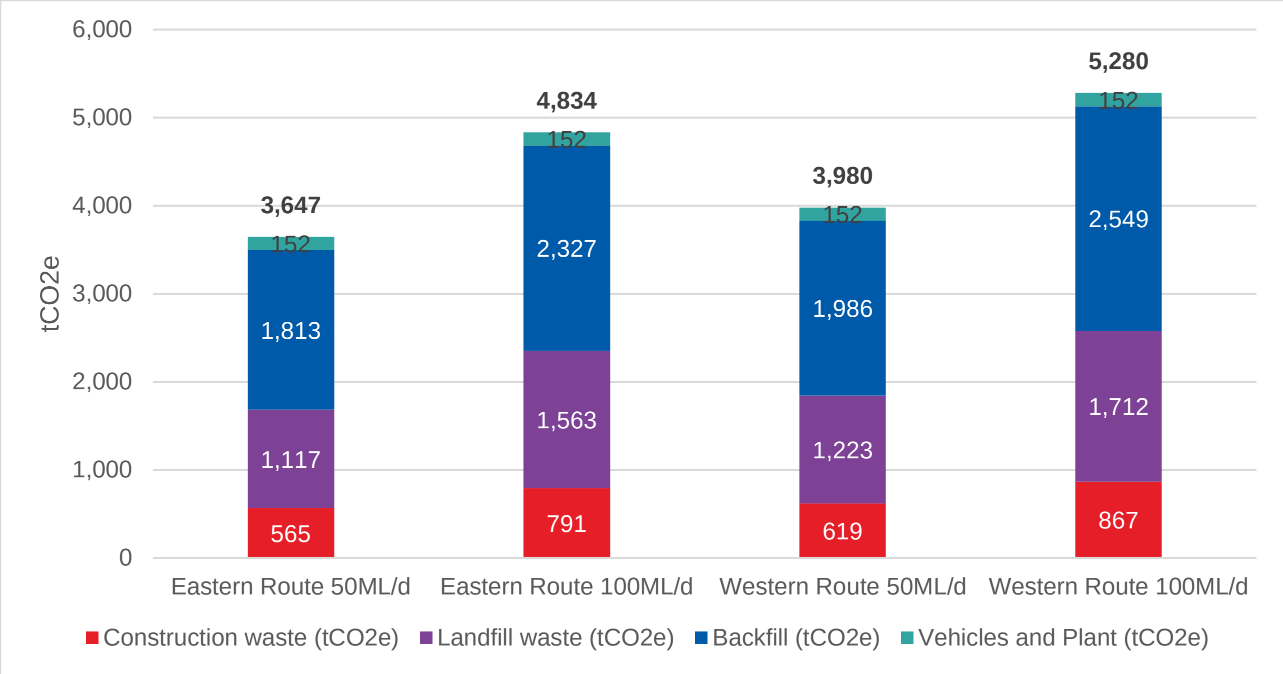


Figure 6. Construction-related CO2e for Eastern and Western routes (50 Ml/d and 100 Ml/d)

Assumptions have been made for the construction method, construction timeline, volume of excavated spoil, backfill quality and vehicle movements. It is recommended that this exercise is repeated once the construction sequence is known for a more accurate assessment.

Operational Carbon

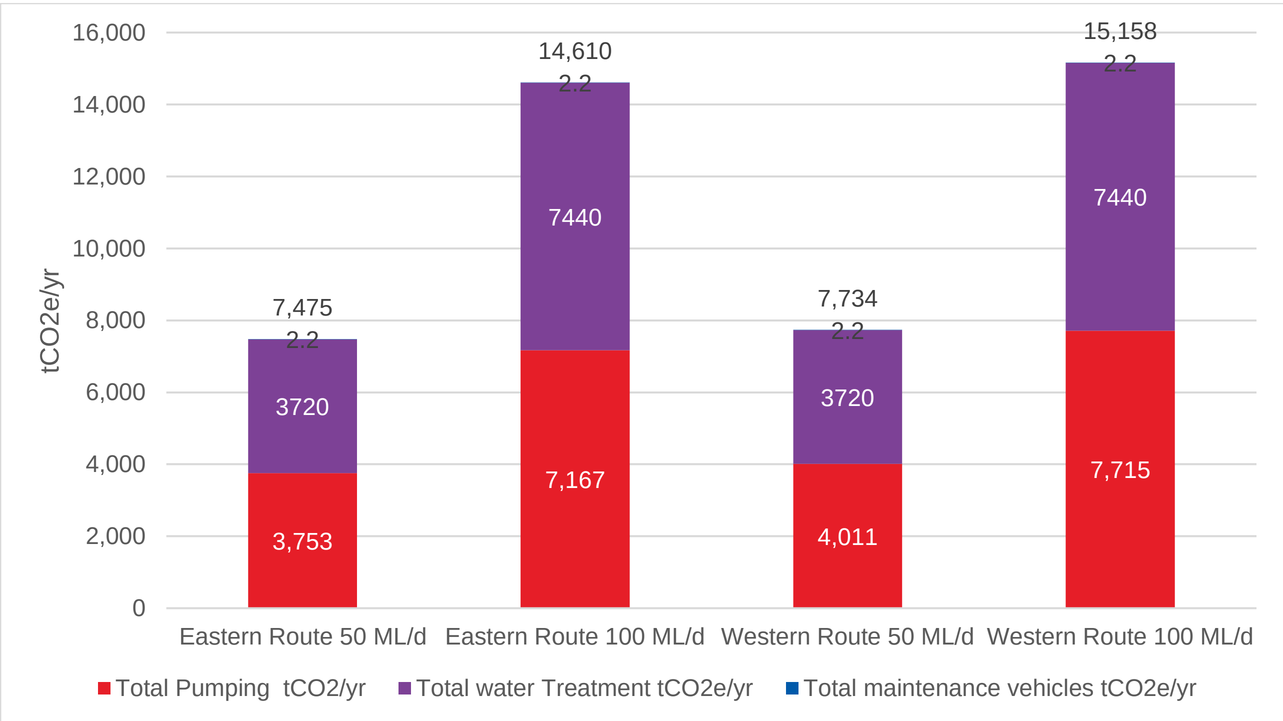


Figure 7. Operational CO2e for Eastern and Western routes (50 Ml/d and 100 Ml/d)

The largest proportion of operational carbon per annum is associated with pumping and water treatment using chemicals. Comparing the Eastern Route (100 Ml/d) to the Gate 1 SLR to WRZ5 Hub (100 Ml/d) route, the Gate 2 operational carbon per year is approximately 11% higher. This is possibly due to more accurate pumping and chemical dosing information being available at Gate 2 but will need verification if the design progresses.

It is assumed that the UK grid is used as a power source for pumping but given Anglian Water and Affinity Waters' aspirations for relying on green electricity from the grid, and proposed use of renewable energy, this could be lowered significantly. Similarly to the construction phase, assumptions have been made for vehicle movements during the operational phase, as these are not yet known.

For the end-of-life stage of this scheme (C1-C4), it is assumed that the pipeline would remain in-situ. Therefore, no CO_2 emissions have been associated with the deconstruction phase of the project.

2.2.3 Western Route with 150 Ml/d option

Affinity Water's draft Water Resources Management Plan (WRMP) and regional modelling by Water Resources East (WRE) and Water Resources South East (WRSE) concluded that a transfer from the Anglian region to Affinity Water does not represent best value for customers. However, Anglian Water's dWRMP and WRE's regional plan confirmed that the full output of SLR is now required within the WRE region and that SLR water will be used locally in south Lincolnshire, as well as across the Anglian Water Ruthamford system. Therefore, an additional 150 Ml/d capacity sub-option for the Peterborough to Grafham Water route was also developed and assessed. The carbon assessment for this sub-option is presented here as a standalone section because it is not directly comparable with the other, much longer routes, and therefore direct comparison would not yield accurate assumptions, given the differences in key parameters such as pumping distances and length of pipework laid.

The following assumptions were made for this route.

Embodied (A1-4)	Pipe material	Ductile iron*
	Pipe diameter	1,400 mm
	Pipe length	45,000 m
	Butterfly valves and chambers	Every 2 km
	Break tanks	1 no. Reinforced concrete tanks at 500 mm wall thickness
	Thrust blocks	Every 1 km Reinforced concrete 2 m x 2 m x 2 m each
	Surge vessels	12 no. Each 100 m^3 constructed of steel carbon
Construction (A5)	Construction method	Open cut excavation
	Trench width and cover depth	Width: pipe diameter + 300 mm either side Cover depth: 0.9 m
	Percentage of excavated material going to landfill / hazardous waste	10%
	Vehicle movements	HGVs, and rigid vehicles travelling 50km/day
	Construction timeline	5 years
Operational (B1-B7)	Deployable output	112%
	Power source	UK grid electricity
	kgCO2e per kWh based on UK Government 2021	0.21233
	kgCO2e per kWh for Transmission & Distribution based on UK Government 2021	0.01879
	Chemicals for treatment required	Sodium hydroxide, CO_2 gas, Sodium hypochlorite and Chloramines
	Vehicle movements	Hybrid car travelling 50 km/day
End of life (C1-C4)	Pipe will remain in situ and no deconstruction works are associated with decommissioning	

* Assumption to be reviewed at detailed design stage

The findings for embodied, construction and operational carbon are outlined in Table 4 and Figure 8.

Table 4. Whole life carbon 150 Ml/d Western Route

	A1 - A4 Embodied Carbon tCO2e	A5 Construction Carbon tCO2e	B1-B7 Operational Carbon tCO2e in 20 years
Western Route 150 Ml/d – Peterborough to Grafham	65,444	2,532	351,061

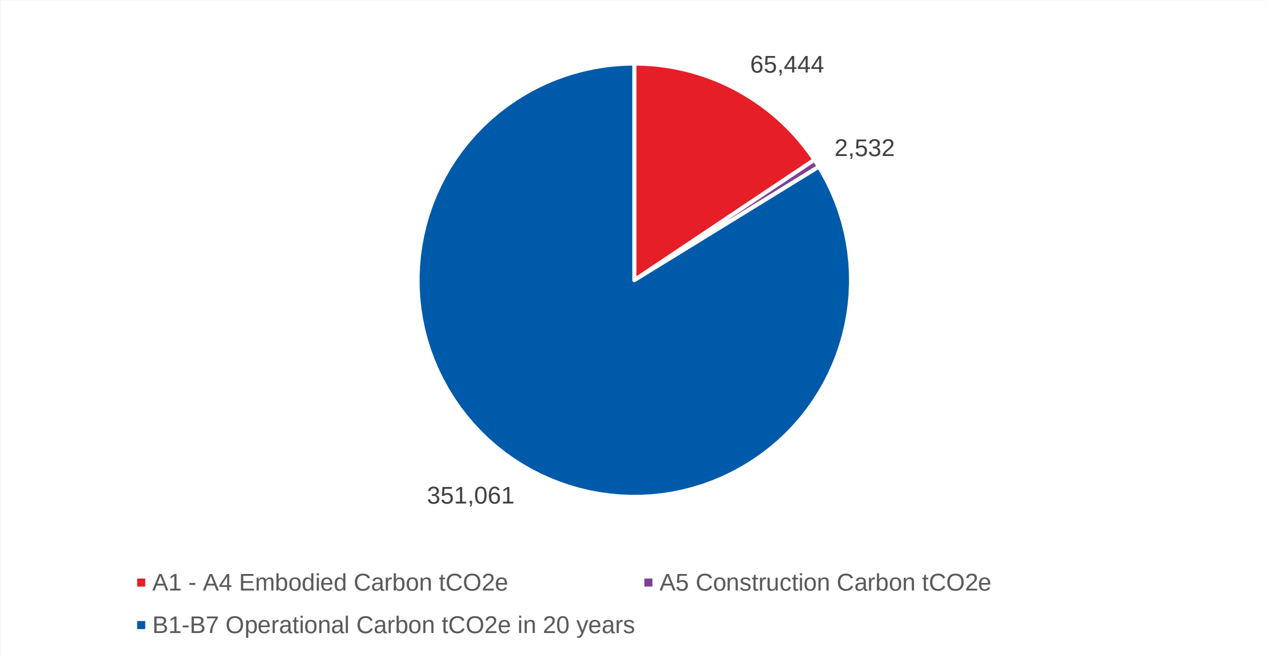


Figure 8. Whole life carbon for 150 Ml/d option

For this route, 95% of embodied carbon is associated with the pipework. Less than 5% of embodied carbon is associated with valves, pumps, break tanks, thrust blocks and surge vessels. Note that exclusions for air valves, washout valves and pipe bends/elbows and specific items for the pump station buildings have been made, as the exact number of these items is unknown at this stage of the design.

Assumptions have also been made for the construction method, construction timeline, volume of excavated spoil, backfill quality and vehicle movements. Construction associated with pump stations, temporary buildings and roads have not been included. It is recommended that this exercise is repeated once the construction sequence is known for a more accurate assessment.

Operational carbon has been shown for 20 years, as this is the assumed asset life for pumping. However, it is recognised that the design life for the pipeline is much longer. This assessment includes pumping, chemical dosing, and movement of maintenance vehicles.

It is assumed that the UK grid is used as a power source for pumping but given Anglian Water and Affinity Waters' aspirations for relying on green electricity from the grid, and proposed use of renewable energy, this could be lowered significantly.

For the end-of-life stage of this scheme (C1-C4), it is assumed that the pipeline would remain in-situ. Therefore, no CO_2 emissions have been associated with the deconstruction phase of the project.

2.2.4 Identifying hotspots

The infographic in Figure 9 summarises the principles through which potential carbon reduction solutions have been categorised.

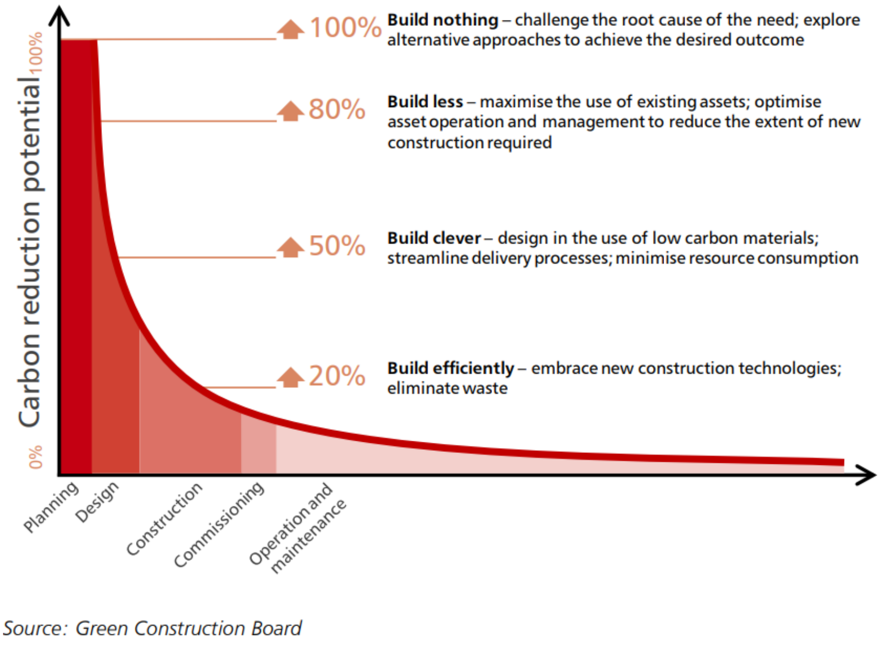


Figure 9. Carbon reduction curve

A 'hot spotting' workshop was held with the Gate 2 design team to identify areas of carbon reduction on the project. The following options were discussed.

Build Nothing

- There is a need to construct the A2AT scheme to secure water for England's future. Therefore, the option to build nothing was discounted.

Build Less

- There are no known existing pipe routes between Peterborough and WRZ5 Hub that can be reused.
- Reusing the pump stations and break tanks at Grafham for the 'Western Route' would not be appropriate as the infrastructure at Grafham would need to be upgraded for the flows associated with the A2AT scheme. Therefore, it was concluded that new infrastructure (pipes, pump stations and tanks) is necessary.
- Reducing the length of pipeline would reduce the embodied carbon of the project, however other factors such as flood zones, protected areas, rivers, habitats, access, and ease of construction needed to also be equally considered. The Eastern and Western routes selected have undergone an environmental constraints assessment to optimise the route as far as practicably possible.

Build Clever

- Pipe material and diameter have been selected to deliver optimum hydraulic conditions.
- Ductile iron has a lower embodied carbon factor compared to steel and HDPE using the Inventory of Carbon & Energy (ICE) database. It is recommended that at detailed design and procurement stage, the material of the pipeline is reviewed once again, and the most carbon efficient is selected.
- Reducing the pipe diameter was considered; however, there was acknowledgement that this decision would increase head losses and increase pumping requirements.
- For the 'Western Route', a portion of the pipeline, between the break pressure tank and WRZ5 hub, does not require energy for pumping as the elevations allow for gravity flow.

Build Efficiently

- During construction stage, the use of electric plant should be maximised, and local manufacturers should be selected to minimise transport to site.
- No-dig construction techniques should be considered to eliminate open cut trenching and backfilling.

Operational carbon

- Variable frequency pumps have been selected for optimum operational conditions, given the varied utilisation throughout the year
- Assuming Anglian Water and Affinity Water are successful in becoming net zero by 2030, the operational carbon emissions should decrease annually as they reduce their reliance on the UK grid and increase the uptake of renewable energy and electric vehicles.
- Solar photovoltaic (PV) panels and other renewable energy systems have been considered as part of the concept design.

2.3 Offsetting

Organisations that wish to offset residual carbon emissions can purchase carbon offsets. Offsetting is usually the last resort, once emissions have been reduced as much as practicably possible by building less, building cleverly and/or efficiently. Research indicates that as land available for sequestration and renewable energy generation becomes scarce, and the demand for organisations to offset emissions increases, the cost of purchasing carbon offsets is set to drastically increase. BloombergNEF (2022) predicts if the market is restricted to just offsets that remove, store, or sequester carbon to achieve net zero targets, there would be insufficient supply to keep up with demand, causing significant near-term price hikes and damaging liquidity. Prices could reach $224 per tonne by 2029, up from just $2.50 on average in 2020[1]

Therefore, a more cost-effective and resilient option for the A2AT scheme is to maximise the use of renewable energy and carbon sequestration.

2.3.1 Renewable energy

To offset the energy requirements for the scheme, renewable energy options have also been considered. Initial case studies have been compiled as part of the concept design of the A2AT at Gate 2, into what level of investment and technical consideration may be required.

2.3.2 Sequestration using nature-based solutions

Sequestering carbon can occur using biological or geological techniques. The former is where carbon is stored in vegetation, soils and oceans, and the latter refers to carbon from industrial sources being stored in underground porous rocks for storage. For utility companies such as water companies which own land, options for carbon sequestration are primarily biological and can include reforestation, afforestation and wetland creation. These are sometimes referred to as nature-based solutions.

Given that the A2AT scheme would involve installing pipelines across multiple land typologies, including private land, an easement would be necessary so that the asset owner can maintain the pipeline during the operational phase. Sequestration options have been excluded from the easement strip as this is to be left for access and maintenance purposes only.

To maximise sequestration options for this scheme, the options are:

- **Option A**: Utilise other land owned by Anglian Water or Affinity Water to develop nature-based solutions to offset the emissions
- **Option B**: Enter into agreements with local landowners and farmers who may be affected by the route, to use their land to sequester carbon for an agreed price.

[1] Long-Term Carbon Offset Outlook 2022, BNEF

Option A – Utilise land owned by Anglian Water and Affinity Water to offset emissions

In order to estimate the land area required to offset embodied carbon for the A2AT scheme, sequestration values for various land uses are shown in Table 5, with an estimate of the land required in hectares. These values are high-level estimates using values from '*Carbon storage and sequestration by habitat: a review of the evidence (second edition) Appendix A, Natural England, Oct 2021*'.

Table 5. Sequestration potential for different land uses

Land use	Carbon Sequestered soil and vegetation (tC/ha^{-1})*
100-year mixed native broadleaved woodland on mineral soil (to 1 m)	354
100-year mixed native broadleaved woodland (to 15 cm soil depth)	258
30-year mixed broadleaved native woodland on mineral soil (to 1 m)	255
30-year mixed broadleaved native woodland (to 15 cm soil depth)	169
Minimal/ Unmanaged hedgerows	144.5
Traditional orchards (30 cm soil depth)	95.15
Upland and lowland heathland (15-30 cm soil depth)	100
Neutral grassland (15 cm soil depth)	60
Floodplains	109.4

**Using Carbon Storage and Sequestration by Habitat: A Review of The Evidence (Second Edition) Appendix A, Natural England, Oct 2021*

The embodied carbon values for the Eastern and Western routes were divided by the sequestration values above. The results are shown in Figure 10, and give an indication of the approximate land take, in hectares, required for each option.

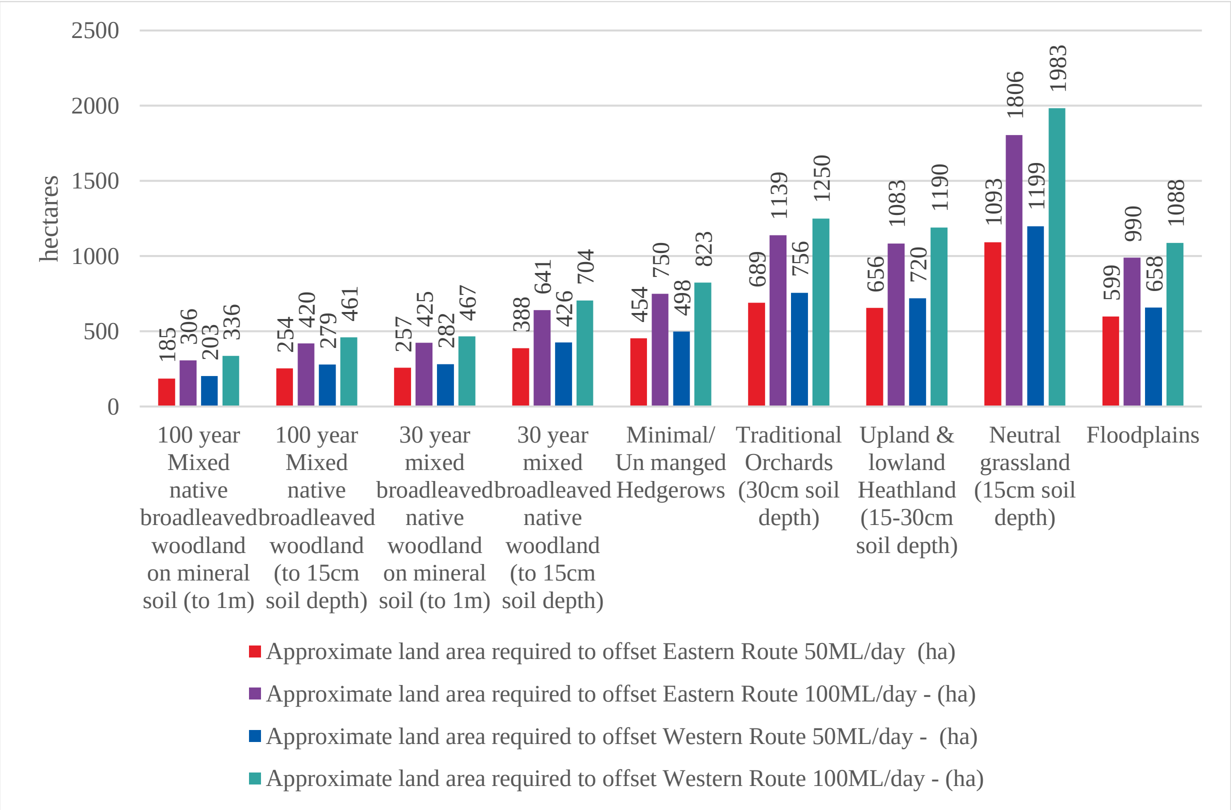


Figure 10. Approximate land area required to offset the Eastern and Western routes.

Option B – Use local landowners and farmers to offset emissions

Option B requires the use of land owned by Affinity Water and Anglian Water, and therefore both companies would need to conduct an exercise internally to assess the viability of using their land assets to sequester carbon.

Once this review has taken place, and if Option A is not feasible, then a viable alternative would be to use land not owned by Affinity Water or Anglian Water to offset the emissions, for example local farmers. Co-benefits of this approach are that it provides an alternative source of income for farmers to allow them to diversify their incomes and, as part of the pipeline route may go through their land or interrupt their farming practices, paying them to use their land for sequestration allows them to be compensated for inconvenience caused by the scheme.

Platforms such as EnTrade, through which Affinity Water have previously collaborated to pay farmers to reduce the use of Metaldehyde on land, could be a viable method to pay farmers to capture carbon. Should this approach be selected, there would need to be a robust monitoring regime over an agreed timeframe, and long-term contractual agreements with landowners. This option should be explored during the stakeholder engagement stage should the scheme proceed.

3. Recommendations for Next Design Stages

- Conduct an analysis to assess whether reducing pipe diameters and increasing energy for pumping - due to increased head loss - results in a lower carbon solution.
- Include the use of low carbon materials, particularly pipe material in the procurement stage.
- Assess how renewable energy produced (solar, biogas etc.) by Anglian Water and Affinity Water can be used to offset the carbon on the A2AT scheme.
- Consider working with local landowners to create opportunities for carbon sequestration.
- Refine the carbon calculations as the design becomes more detailed (e.g., air valves, vehicle movements, telemetry, flowmeters, access roads, ancillary equipment in buildings etc.).
- Continually add to and update the carbon calculations as the construction and operation methods become clearer. Carbon calculations associated with vehicle movements should account for both outward and return journeys.

Gate two query process

Strategic solution(s)	Anglian to Affinity Transfer
Query number	AAT002
Date sent to company	02/12/2022
Response due by	06/12/2022

Query

Please clarify why there are different values provided in *Section 8.1 Solution cost estimates* in the report submitted to RAPID when compared to the report published on the Affinity Water website. This includes the values for the costs range, and the values for Table 9 and Table 10.

Solution owner response

The values provided in *Section 8.1 Solution cost estimates* in the A2AT gate two report submitted to RAPID are correct. An incorrect version of the report containing draft cost figures was accidentally uploaded to the Affinity Water website, apologies.

We have now uploaded the correct version.

Date of response to RAPID	02/12/2022
Strategic solution contact / responsible person	Andrea Farcomeni andrea.farcomeni@agilia.co.uk 07376 000023

Gate two query process

Strategic solution(s)	Anglian to Affinity Transfer
Query number	AAT003
Date sent to company	06/12/2022
Response due by	08/12/2022

Query

Procurement:

1. In section 7.5.1 you identify the A2AT as suitable for delivery by DPC. Please provide:
    a. Your technical discreteness assessment
    b. The results from the value for money analysis including confirming modelling assumptions used. Where these deviate from the prescribed Ofwat assumptions please explain the rationale for using different assumptions and evidence to support the alternative approach.

2. Please provide an assessment of risks & issues associated with the preferred delivery route for example, risks around capacity in the market, procurement timelines, SIPR etc.

3. In section 7.5.2 the submission states that the "operating arrangements used to develop the emerging commercial strategy are set out in section 7.5.1 above." However section 7.5.1 sets out the results of the assessment of eligibility for competitive delivery and doesn't explain the operating arrangements. Please briefly explain the likely operating arrangements and they may impact on the commercial arrangements for the A2AT. In addition, please confirm whether you are intending to procure the A2AT assets separately to the South Lincolnshire Reservour assets or include in the same procurement.

Solution owner response

1. In section 7.5.1 you identify the A2AT as suitable for delivery by DPC. Please provide:
    a. Your technical discreteness assessment

Ofwat's technical guidance sets out a potential framework for identifying DPC projects against four key criteria: Stakeholder interactions and statutory obligation; Interactions with the network; Contributions to supply/capacity and ability to specify outputs; Asset and Operational failure.[1] Table 1 presents the potential framework for identifying DPC projects as set out in Ofwat's technical guidance, published alongside PR19.

Table 1: DPC Discreteness Methodology

Criterion	High discreteness	Low discreteness
Stakeholder interactions and statutory obligations	• Limited or marginal impact on the appointees' ability to meet its statutory obligations (e.g. non-potable or raw water sources).	• Asset materially contributes towards appointee meeting statutory obligations.
Interactions with the network	• Assets where there are limited economies of scale and scope with the rest of the appointee's network system OR where those economies of scale or scope could be maintained through contracts. • Simple or limited, well understood and manageable interactions with the appointees' network. • Separate non-contiguous networks or assets within the appointee's area. • Assets where capacity is shared by multiple appointees. • More 'passive' assets (e.g. network enhancement pipes) that are not actively managed as part of the overall system.	• Assets where there are material economies of scale and scope with the rest of the appointee's network system OR where economies of scale or scope cannot be maintained through contracts. • Significant, complex and frequent interactions with the appointees' network. • Assets that are actively managed as part of the overall system operation of the network.
Contributions to supply/capacity and ability to specify outputs	• Assets where capacity is regularly needed and contracting requirements can be more easily defined and priced. • Schemes where outputs can be clearly defined and are not subject to substantial change from other factors or difficult to predict in the future (e.g. around asset condition at asset hand back).	• Assets where capacity is rarely needed (e.g. resilience schemes) and contracting requirements difficult to specify. • Assets where capacity requirements are not well understood/highly uncertain. • Schemes where outputs cannot be clearly defined.

1 https://www.ofwat.gov.uk/wp-content/uploads/2017/12/DPC-A-technical-review-FINAL_08.12.17.pdf

Asset and operational failure	• Assets where operational failure risk is well understood, and mitigations well established for similar assets. • Well-developed market or technical supply chains with strong experience of similar project delivery.	• Assets where operational failure risk is not well understood with limited track record of effective mitigations. • Weak market or technical supply chains with limited experience of similar project delivery. • Assets where there are no alternative back-up supplies.

The scoring system adopted for the purpose of the Gate 2 submission (and consistent with our Gate 1 submission) is a three-grade scale (high, medium and low). High and low discreteness when the asset information is clearly in line with the methodology above. A factor is given a medium discreteness score when the asset information is neither clearly a high or low level of discreteness. The final score for each scheme is the mean of all the scores assigned to each of the four categories and rounded to the first decimal point to assign the grading as per the scoring system below.

High = 3, high/medium = 2.5, medium = 2, medium/low = 1.5 and low = 1.

We have assumed that each of the four criteria are equally weighted and that the overall score is based on an average of the scores. An overall medium score indicates that the scheme is broadly suitable for DPC.

Anglian to Affinity Transfer (A2AT) Discreteness Assessment

This section sets out the results of the discreteness assessment based on the methodology and approach set out in Sections **Error! Reference source not found.** and **Error! Reference source not found.**.

Error! Reference source not found. 2 below sets out the detailed assessment of the suitability of the A2AT alternative solutions for delivery under a DPC model.

Table 2: A2AT Discreteness Assessment

Key Criteria	Asset information	Discreteness assessment
Stakeholder interactions and statutory obligations	Solution requires interactions with multiple stakeholders including EA and DWI, Natural England, the Canals and Rivers Trust (or the equivalent navigation authority on the River Trent) and Local Planning Authorities.	**Medium (2)** – consenting, planning and construction process will require careful negotiation with the local communities and multiple conservation groups.
Interoperability considerations	The Western Route transfer will interact with major utilities, motorway crossings and railway crossings including River Nene, River Great Ouse, A1, A14, A421, A505, M11, East Coast main line. Active assets including pumping stations will require some monitoring to ensure correct quantity, but it is not expected that these will require	**Medium/High (2.5)** – interactions of the transfer with major utilities and transport infrastructure will make construction more contractually complex. The operation of the asset will not require complex contractual arrangements to manage.

Key Criteria	Asset information	Discreteness assessment
	complex contractual arrangements to manage. The Eastern Route will face similar risks, with interactions at major utilities, motorway crossings and railway crossings including River Nene, River Great Ouse, A1, A11, A14, M11 and local railway lines.	
Output type and stability	The output required from SLR is expected to be 166Ml/d while A2AT will be sized between 50-150Ml/d. The AFW region is forecast to be in significant supply deficit over the next decade and therefore AFW will be highly reliance on this scheme.	**High (3)** – The well understood output and high level of stability will not require detailed contractual arrangements for ramping up and down and associated maintenance costs. AFW will want high levels of assurance that the asset is being operated correctly as any failure may materially limit its ability to serve customers.
Asset and operational service failures	Projected AFW demand is around 1000Ml/d. Hence, failure of the A2AT could take out 10% of the supply (assumign a transfer capacity of Ml/d at full utilisation) causing some outage but not a failure of the supply system. However, transfers are a well-tested technology so low level of risk	**Medium/High (2.5)** – Large proportional impact on AFW customers but risks can be well managed.
Summary	Overall key asset information for the discreteness analysis is (1) interaction with multiple stakeholders (2) interactions with existing infrastructure will make construction more complex (3) output type and stability is fairly well understood and constant. (4) key operational failures should be manageable, and the highest risk is highly unlikely	**Medium/High (2.5)** – Overall A2AT is broadly suitable for DPC. It is not a highly discrete asset due to the scale, impact on wider network and high level of scrutiny. But based on the limited network interface and stable output type it can be viewed as broadly discrete.

b. The results from the value for money analysis including confirming modelling assumptions used. Where these deviate from the prescribed Ofwat assumptions please explain the rationale for using different assumptions and evidence to support the alternative approach

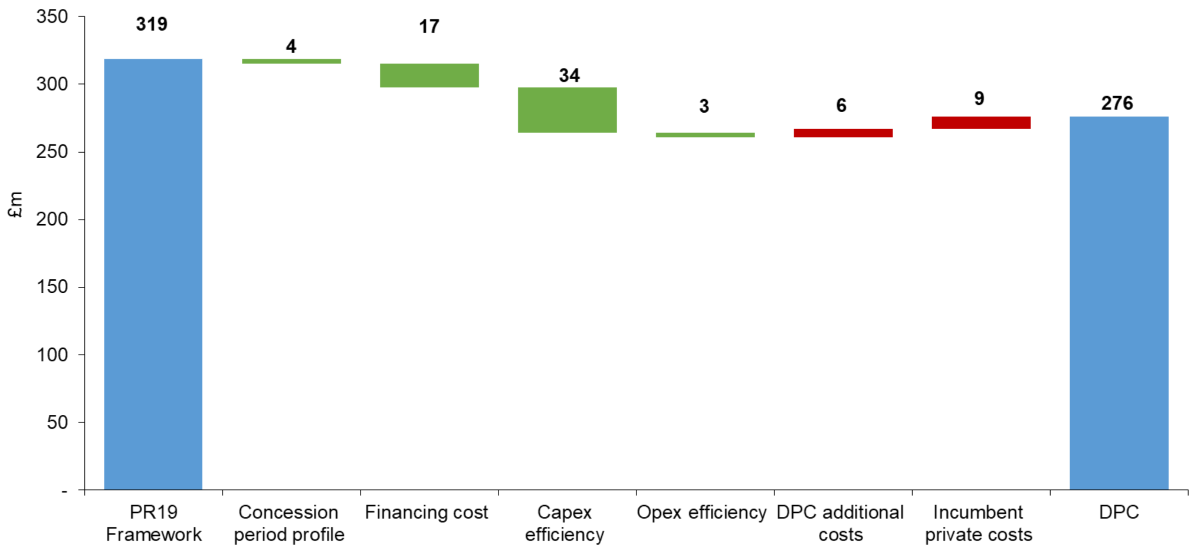
In order to assess VfM for A2AT, the gate 2 cost estimate for both the Eastern and Western route options have been run through the VfM model. The model compares the net present value (NPV) of the factual (DPC) against the counter-factual (in-house). The project sponsors have not sought to adjust any of the standard assumptions set out by Ofwat, with the exception of forward rates which have been smoothed over a 2-year period given the recent volatility in debt markets[2].

These assumptions are subject to the development of project risks and views of the market and will be updated as part of subsequent gate and control point submissions with project-specific assumptions. Sensitivity analysis has been conducted using the high and low ranges from Ofwat's standard assumption to ensure the project offers best value under a range of scenarios and therefore represents a low regret option under DPC. The higher financing costs are driven by the current market rates which are not reflected in the PR19 WACC. For example, when doing VfM analysis for Middlegate DPC the overall cost of capital for DPC was lower than PR19.

The VfM analysis for this submission is based on a 4-year construction period followed by a 25-year operations period and periodic renewal capex. Under this scenario, delivering the project under DPC would result in lower costs to customers than if the project was delivered by AWS under the PR19 framework. The cost to customers in NPV terms, for the Eastern and Western options, under the factual scenario (DPC) is £276m and £293m compared with £319m and £339m respectively, under the counterfactual (PR19). The difference in the costs to customers is £43m (Eastern) and £46m (Western). The benefits from opex and capex efficiencies are partially offset by the higher financing costs and additional procurement costs incurred under the DPC model.

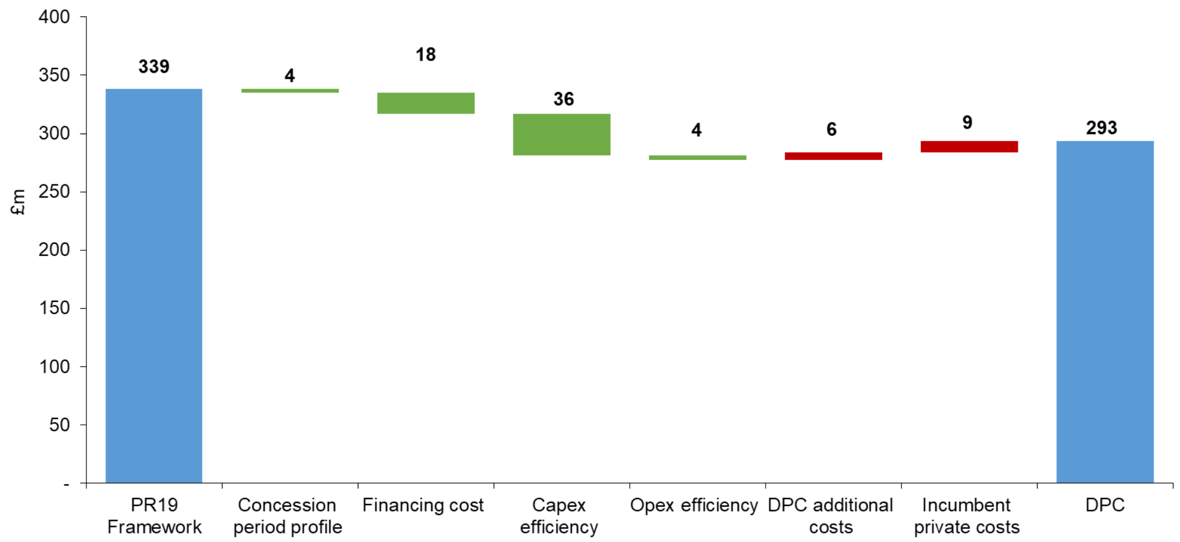
Figures 1 & 2 below represent the results of the VfM analysis under the Mid case assumptions, for the Eastern and Western routes, highlighting the various value drivers between the two delivery models (hereinafter all figures represent £ million net present value of costs to the customers, lower value is better).

Figure 1: Eastern A2AT VfM analysis results (mid case)



2 Anglian-Water-Direct-procurement-for-customers-detailed-actions.pdf (ofwat.gov.uk)

Figure 2: Western A2AT VfM analysis results (mid case)



Tables 3 & 4 below show the results of the sensitivity analysis for both routes. Under all scenarios, delivery of A2AT is shown to have greater value for customers under DPC delivery model based on Ofwat's framework and assumptions.

Table 3: Eastern A2AT scenario testing results

Variables		Assumptions under different cases*			DPC compared with in-house NPV (£m)	
		Low	Mid	High	Low	High
0	Base case				IH: 319, DPC: 276, Diff.: 13%	
1	Contract length (years)	20	25	40	IH: 283 DPC: 245 Diff.: 13%	IH: 393 DPC: 355 Diff.:9%
2	Equity IRR, real (%)	10	8	7	IH: 319 DPC: 304 Diff.: 5%	IH: 319 DPC: 262 Diff.: 18%
3	Gearing (%)	80	85	90	IH: 319 DPC: 300 Diff.: 6%	IH: 319 DPC: 252 Diff.: 21%
4	Depreciation rate (%)	+25% faster	Company policy		IH: 319 DPC: 276 Diff.: 13%	
5	Capex efficiency (%)	5	10	15	IH: 319 DPC: 293 Diff.: 8%	IH: 319 DPC: 259 Diff.:19%
6	Opex efficiency (%)	5	10	15	IH: 319 DPC: 278 Diff.: 13%	IH: 319 DPC: 274 Diff.: 14%

7	Procurement costs (% of Capex)	2	1	0.5	IH: 319 DPC: 282 Diff.: 12%	IH: 319 DPC: 273 Diff.: 14%
8	Bidder costs (% of Capex)	3	2	1	IH: 319 DPC: 279 Diff.: 12%	IH: 319 DPC: 273 Diff.: 14%
9	Contract 7gmt.. costs (annual)	300k	150k		IH: 319 DPC: 279 Diff.: 12%	

DPC worse than in-house
DPC slightly better than in-house (<5%)
DPC definitely better than in-house (>5%)

*Scenarios as specified in Ofwat assumptions within IAP 'Direct Procurement for Customers detailed actions'

Table 4: Western A2AT scenario testing results

Variables		Assumptions under different cases*			DPC compared with in-house NPV (£m)	
		Low	Mid	High	Low	High
0	Base case				IH: 339, DPC: 293, Diff.: 13%	
1	Contract length (years)	20	25	40	IH: 300 DPC: 260 Diff.: 13%	IH: 417 DPC: 378 Diff.: 9%
2	Equity IRR, real (%)	10	8	7	IH: 339 DPC: 323 Diff.: 5%	IH: 339 DPC: 278 Diff.: 18%
3	Gearing (%)	80	85	90	IH: 339 DPC: 319 Diff.: 6%	IH: 339 DPC: 268 Diff.: 21%
4	Depreciation rate (%)	+25% faster	Company policy		IH: 339 DPC: 293 Diff.: 13%	
5	Capex efficiency (%)	5	10	15	IH: 339 DPC: 312 Diff.: 8%	IH: 339 DPC: 275 Diff.: 19%
6	Opex efficiency (%)	5	10	15	IH: 339 DPC: 295 Diff.: 13%	IH: 339 DPC: 291 Diff.: 14%
7	Procurement costs (% of Capex)	2	1	0.5	IH: 339 DPC: 299 Diff.: 12%	IH: 339 DPC: 290 Diff.: 14%
8	Bidder costs (% of Capex)	3	2	1	IH: 339 DPC: 296 Diff.: 13%	IH: 339 DPC: 290 Diff.: 14%

9	Contract mgmt. costs (annual)	300k	150k	IH: 339 DPC: 297 Diff.: 12%	

*Scenarios as specified in Ofwat assumptions within IAP 'Direct Procurement for Customers detailed actions'

(red)	DPC worse than in-house
(yellow)	DPC slightly better than in-house (<5%)
(green)	DPC definitely better than in-house (>5%)

The high-case used in the scenario testing was 40 years. However, rates used for the bullet bond are for a 30-year tenor, this is due to rates for over 50 years in the future not being available at this time. A 40-year operation period has still been used in the model to show a long contract term as it is assumed the difference between rates for 30 years and 40 years is likely to be minimal.

In all scenarios DPC showed value for money however, in the low case for equity IRR the difference was less than 5%. This could suggest the project is particularly sensitive to movements in this variable.

Whilst the cost of debt assumptions under the DPC model have been updated, the WACC as per Ofwat's PR19 Final Determination has been applied throughout the contract period for the in-house delivery model and has not been updated for cost of debt indexation or future price controls. given that the PR19 methodology was finalised when the market rates were significantly lower and less volatile than the current environment, AWS believe that if we were using updated WACC figures, the difference between DPC and PR19 would be greater than currently shown in the results, meaning DPC would be greater value for money.

Overall, based on Ofwat's IAP standard VfM assumptions, and current cost projections for FR, DPC would deliver greater value for customers from a VfM standpoint.

Note that we have not sought to model the VfM of delivery of the scheme via SIPR rather than DPC but instead undertook an assessment similar to TTT of VfM as presented in the note to Ofwat. We would expect many of the benefits of DPC to be achievable under a SIPR model.

2. Please provide an assessment of risks & issues associated with the preferred delivery route for example, risks around capacity in the market, procurement timelines, SIPR etc

A2AT was assessed against the three tests of Ofwat's PR19 DPC eligibility framework: size, discreteness and VfM. The scheme meets the size test, can largely be described as discrete and using Ofwat's standard assumptions and sensitivities is in most cases better value for customers than in-house delivery.

The project sponsors also assessed A2AT against the SIPR conditions which are (1) that the project is of size and complexity to threaten the undertaker's ability to provide services to its customers and (2) the specification of the infrastructure project would result in better value for money that would be the case if delivered in-house. The conclusion reached was that A2AT was not of sufficient size of complexity to meet the SIPR tests.

In addition, the overall recommendation for A2AT is to not continue it to Gate 3 as a preferred SRO for Affinity.

As part of the detailed analysis assessing the eligibility for competition, commercial strategy and procurement strategy for Gate 2 a number of key risks and issues with the SIPR and DPC model were identified. These were presented in either the Gate 2 submission or the note to Ofwat on SIPR suitability. A summary of the key risks and issues are presented below.

Packaging

As mentioned above a key area that the project sponsors need to determine is what the scope of the SIPR tender is. There are several dimensions to this including (1) market appetite and capacity (2) value for customers (3) interoperability (4) overall allocation of risk and (5) DCO alignment. The transfer is made up of several components and key interfaces with the project sponsors. Determining the exact boundary between different parties is key to ensuring timely delivery and value for customers.

Current market conditions

As part of the early market engagement undertaken to support the Gate 2 submission, we engaged with several construction contractors in the market. They noted a number of major challenges facing construction in the water sector currently including supply chain vulnerability, price volatility, a tight labour market and competition with other sectors which are prioritising delivery speed over efficiency e.g. energy and transport. As part of the design of the detailed commercial and tender arrangements we will need to continually engage with the market to ensure that they reflect the current market conditions and are sufficiently attractive to create competitive tension in the market.

Water trading arrangements

The scope of the A2AT commercial arrangements will likely be for the infrastructure and not include the water trading elements. However, a DPC CAP Agreement would need to be designed in alignment with any water trading arrangements as there may still be some points of interdependencies such as responsibilities for water quality or impact of supply interruptions.

Water trading between the parties will be a central component of the overall contractual and legal arrangements. It is not currently envisaged that AFW or any other water company would want to benefit from the supply of SLR but if that changed prior to the tender launch that would need to be taken into account in the overall contractual arrangements.

Under the preferred SIPR framework, AWS could hold the BSA+ with the IP. It would also be possible for the IP to hold a BSA+ with both AWS and another appointee if it has sufficient capacity. The optimum commercial arrangements will require further analysis and engagement with the market.

The structuring of the water trading arrangements between the two (or more) parties need to also develop an approach to bulk supply charges, water trading incentives and set robust, fair and prescriptive operational procedures for drought and operational events. This is particularly complex for SLR as the overall scheme involves raw water abstraction, INNS treatment, raw water transfer, reservoir operations, drinking water quality treatment and transfer of treated water across a wide geographical area. A limitation on the water which can be abstracted may have knock on effects across the asset.

Another component to this is which party holds and manage the water abstraction licences, what the contractual provisions are for changes to those licences and how the risk is managed.

Procurement timeline interdependencies

Tender launch is dependent on the time required to complete pre-tender activities, which are subject to a variety of factors including the capacity of the market, Secretary of State approval of SIPR designation, potential design changes, review and acceptance of submissions to Ofwat, delays to the DCO process, or land purchase and other enabling works (e.g. ground investigations).

There are two hard dependencies with the DCO process (1) tender launch and DCO submission (as the bidders will require certainty of the scope of the project) and (2) contract award, financial close and sufficient discharge of DCO conditions to provide comfort to lenders.

It also assumes that a similar gated process to the DPC control point process would be in place for SIPR. The key interdependency in the process with the RAPID programme is the DCO award, discharge of conditions and the preferred bidder stage.

The project sponsors are also considering the alignment between the FR, SLR and A2AT tenders, as all projects are assumed to be delivered under similar arrangements and at similar times. Although due to the shorter construction time A2AT could be tendered at a later point in time.

Across the pre-tender activities for SLR/FR and A2AT, synergies can be obtained but it will be highly dependent on the timing/effort (e.g. being able to submit joint proposals to the same management board), and ability to reuse thinking/analysis (e.g. apply the same approach to manage and mitigate geological complications risk for both schemes).

Impact of DPC on accounting treatment and credit ratings

There has not yet been a DPC project which has reached financial close, so the accounting treatment and formal views of the credit rating agencies are not available. To assess the impact of DPC on appointees' ability to service debt, the final allocation of risk needs to be understood. Credit rating agencies are not beholden to the accounting treatment if they view the arrangements as being a risk to the appointee's ability to service debt.

Initial work undertaken by the project sponsors suggest that DPC is likely to be treated as debt on the balance sheet even if delivery is by a third party. The impact on the appointees' credit rating of the reservoirs will depend on the allocation of risk between AWS, the CAP, customers and any multi-sector parties. It will be dependent on several complex contractual arrangements.

Recognition as debt on the sponsors' balance sheet will have serious implications for their ability to raise and service debt. The scale of this project relative to the RCV's of AWS or AFW means that any risk will have a huge impact on credit ratings. This may also be of concern to the bidders who will want to understand the contract counterparty risk of the arrangement.

DWI enforcement powers

As noted by Ofwat in the 'Stocktake for competition' an issue with the DPC framework is that the DWI do not have the legal authority to take enforcement action against the CAP. The incumbent appointee would be the only party the DWI could take enforcement action against. Therefore, the DWI may be apprehensive of a DPC arrangement that would weaken the accountability of the appointee.

There is less scope for DWI interest in a transfer that a water treatment works or asset with high operational complexity. However, there is still opportunity for the CAP to impact water quality (e.g. through pumping stations) so there is a residual risk that will sit with the incumbent appointee.

3. In section 7.5.2 the submission states that the "operating arrangements used to develop the emerging commercial strategy are set out in section 7.5.1 above." However section 7.5.1 sets out the results of the assessment of eligibility for competitive delivery and doesn't explain the operating arrangements. Please briefly explain the likely operating arrangements and they may impact on the commercial arrangements for the A2AT. In addition, please confirm whether you are intending to procure the A2AT assets separately to the South Lincolnshire Reservour assets or include in the same procurement

Please note that the reference to 7.5.1 in section 7.5.2 is an error and was intended to say 4.1 to refer to the detailed section on utilisation. For the purpose of developing the commercial and tender strategy for A2AT it is envisaged that the operating regime will be variable based on seasonal demand of AFW. The transfer system will need to operate as a single fully automatic system to achieve the desired daily volumetric transfer flowrate. The concept design considers 50 and 100 Ml/d transfer sizes based on A2AT partially and solely meeting the long-term supply deficit. AFW's current recommendation is that A2AT as a solution to satisfy Affinity Water's forecast demand will not progress beyond RAPID gate two. As detailed in our A2AT gate two submission report, the Peterborough to Grafham transfer (up to 150 Ml/d option) will instead be taken forward by Anglian Water for further investigations into gate three. The scheme will be integrated into the SLR SRO as it relies on the SLR as a source and provides strategic resources into Anglian Water's southern supply area. Over the course of G3, the proposed incorporation of the Peterborough to Grafham transfer will be brought into the broader assessment of suitability for DPC/SIPR for that SRO.

Date of response to RAPID	08/12/2022
Strategic solution contact / responsible person	Andrea Farcomeni andrea.farcomeni@agilia.co.uk 07376 000023

Gate two query process

Strategic solution(s)	Anglian to Affinity Transfer
Query number	AAT004
Date sent to company	14/12/2022
Response due by	16/12/2022

Query

Your submission is lacking several points with regards to costs that we would expect to be included at this stage:

1. Has fixed and variable opex been considered?
2. Have you considered annual operational maintenance costs by considering common assumptions used across the water industry for such infrastructure? E.g. with civil maintenance being calculated as 0.30% of the infra and non-infra civil costs, whilst mechanical and electrical (M&E) maintenance being calculated as 1.5% of infra and non-infra M&E costs.
3. Has Asset Life been aligned to ACWG guidance?
4. Can you update tables showing how costs have evolved since Gate 1?
5. Can you explain the factors driving changes in costs since Gate 1?
6. Could you please provide us with your quantiative risk register as well as some description of your calculations?
7. Are tables available for optimism bias, NPC and AIC calculations?
8. Why has Opex risk not been included at this stage within Optimism Bias?
9. How have indirect costs been considered?
10. Have you engaged in any cost benchmarking for the solution?

Solution owner response

1) Has fixed and variable opex been considered?

Both variable and fixed opex have been considered when estimating the solution cost and have been estimated for a full and a minimum utilisation scenario. Variable opex has been used when presenting costs associated with energy and chemicals, whereas fixed opex has been used when considering costs associated with staff or hired/contract maintenance. Please refer to Table 1 below.

Table 1 Variable and fixed opex of the A2AT solution

			Eastern Route		Western Route		Peterborough to Grafham
Cost Item	**Utilisation**	**Unit**	**50 Ml/d**	**100 Ml/d**	**50 Ml/d**	**100 Ml/d**	**150 Ml/d**
Fixed opex	n/a	£/yr	377,344	377,344	377,344	377,344	330,695
Variable opex	100%	£/yr	2,020,330	3,937,390	2,099,749	2,968,130	4,567,270
Variable opex	25%	£/yr	381,716	762,580	411,177	821,651	997,810

2) Have you considered annual operational maintenance costs by considering common assumptions used across the water industry for such infrastructure? E.g. with civil maintenance being calculated as 0.30% of the infra and non-infra civil costs, whilst mechanical and electrical (M&E) maintenance being calculated as 1.5% of infra and non-infra M&E costs.

We have developed assumptions on the amount of resource required to derive annual maintenance costs, proportionate to the level of design development undertaken at gate two. For 'Staff Maintenance', we have assumed 2x maintenance providers each at 0.5 days/week, each per pumping station. For 'Contract/Hired Maintenance', we have assumed 4 persons, each 4 weeks per year. We have used rates from previous projects to cover the day rate cost associated with these maintenance roles.

These assumptions have been developed based on equivalent schemes; they reflect the relatively simple nature of this pipeline SRO and avoid the inadvertent over estimation of maintenance costs. Noting the proposals to promote the northern section of this SRO into the SLR SRO at gate three, any maintenance assumptions relevant to the northern section will be revisited at gate three and aligned with the proposed maintenance programme for that SRO.

3) Has Asset Life been aligned to ACWG guidance?

Yes, the asset life information provided in Table 4-2 of the All Company Working Group (ACWG) guidance on cost consistency has been used in the A2AT costing exercise for gate two. Table 2 shows the relevant asset types for A2AT with their respective asset life taken from the ACWG guidance document.

Table 2 Asset life for relevant asset classes

Asset class	**Asset life**
Land	Non depreciating
Planning and development	Non depreciating
M&E (Mechanical and Electrical) Works on Pumping Stations and Treatment Works	20
Underwater assets	60
Treatment and Pumping Station Civils (incl. Intakes)	60
Pipelines	100

4) Can you update tables showing how costs have evolved since Gate 1?

Table 3, Table 4, Table 5 and Table 6 below show the evolution of costs from gate one to gate two. We have provided a brief narrative for each table; in summary, each table shows cost elements that have increased or decreased between gate one to gate two, together with the respective increase or decrease, the total change in cost value and commentary on each line.

50 Ml/d capacity Eastern Route

For the 50 Ml/d capacity Eastern Route, cost increases between gate one to gate two are due to scope changes, inflation and risk, each representing about a third of the total cost increase. Cost reductions are attributed entirely to Optimism Bias (OB), which at gate one included risk elements that were separated out as ‘costed risk' in the gate two assessment. Overall, excluding inflation, the gate two estimate was £1.4m (0.4%) higher than the gate one estimate.

Table 3 Eastern Route, 50 Ml/d

Cost Element	Change in Value (£m)	Comments
Cost Increases		
Scope changes	13	Updates to the model based on incrementally more detailed route assessments
Inflation	13	Costs are provided in Sep '20 price base per RAPID's request vs 2017/18 prices at Gate 1
Risk	14	This is a new line that has been separated from OB at Gate 2, and developed within the costed risk register
Cost Reductions		
OB	-25	Risk was included within the OB calculation at Gate 1 (31.2% OB) but has been separated in Gate 2 OB per Risk line above. OB has been further refined in Gate 2 through design development (resulting in lower OB of 19.7%)
Net Change	**15**	**Overall narrative: excluding inflation, the Gate 2 estimate was £1.4m (0.4%) higher than the Gate 1 estimate**

100 Ml/d capacity Eastern Route

For the 100 Ml/d capacity Eastern Route, the cost increases are due to inflation and risk, with inflation representing over half (53%) of the total increase. Cost reductions are due to scope changes and OB, with the change in OB between gate one and gate two representing about 90% of the reduction. Overall, excluding inflation, the gate two estimate was £31.8m (7.1%) lower than the gate one estimate.

Table 4 Eastern Route, 100 Ml/d

Cost Element	Change in Value (£m)	Comments
Cost Increases		
Inflation	16	Costs are provided in Sep '20 price base per RAPID's request vs 2017/18 prices at Gate 1
Risk	14	This is a new line that has been separated from OB at Gate 2, and developed within the costed risk register
Cost Reductions		
Scope changes	-5	Updates to the model based on incrementally more detailed route assessments

OB	-40	Risk was included within the OB calculation at Gate 1 (31.2% OB) but has been separated in Gate 2 OB per Risk line above. OB has been further refined in Gate 2 through design development (resulting in lower OB of 19.7%)
Net Change	**-15**	**Overall narrative: excluding inflation, the Gate 2 estimate was £31.8m (7.1%) lower than the Gate 1 estimate**

50 Ml/d capacity Western Route

For the 50 Ml/d capacity Western Route, the cost increases are due to scope changes, inflation and risk, each representing about one third of the total increase. Cost reductions are due entirely to OB, which at gate one included risk. Excluding inflation, the gate two estimate was £7m (2.1%) higher than the gate one estimate.

Table 5 Western Route, 50 Ml/d

Cost Element	Change in Value (£m)	Comments
Cost Increases		
Scope changes	17	Updates to the model based on incrementally more detailed route assessments
Inflation	14	Costs have been deflated to Sep '20 as per RAPID's request vs 2017/18 prices at Gate 1
Risk	16	This is a new line that has been separated from OB at Gate 2, and developed within the costed risk register
Cost Reductions		
OB	-26	Risk was included within the OB calculation at Gate 1 (31.2% OB) but has been separated in Gate 2 OB per Risk line above. OB has been further refined in Gate 2 through design development (resulting in lower OB of 19.7%)
Net Change	**21**	**Overall narrative: excluding inflation, the Gate 2 estimates was £7m (2.1%) higher than the Gate 1 estimate**

100 Ml/d capacity Western Route

Finally, for the 100 Ml/d capacity Western Route, cost increases are due to inflation and risk, with inflation representing over half (53%) of the total increase. Cost reductions are due to scope changes and OB, with the change in OB representing the majority (60%) of the reduction. Overall, the gate two estimate was £72.m (13.8%) lower than the gate one estimate, excluding inflation.

Table 6 Western Route, 100 Ml/d

Cost Elements	Change in Value (£m)	Comments
Cost Increases		
Inflation	18	Costs have been deflated to Sep '20 as per RAPID's request vs 2017/18 prices at Gate 1
Risk	16	This is a new line that has been separated from OB at Gate 2, and developed within the costed risk register
Cost Reductions		
Scope changes	-35	Updates to the model based on incrementally more detailed route assessments
OB	-53	Risk was included within the OB calculation at Gate 1 (31.2% OB) but has been separated in Gate 2 OB per Risk line above. OB has been further refined in Gate 2 through design development (resulting in lower OB of 19.7%)
Net Change	**-54**	**Overall narrative - without inflation, the Gate 2 estimate was £72m (13.8%) lower than the Gate 1 estimate**

The 150 Ml/d capacity version of the Peterborough to Grafham section was not considered at gate one, hence no comparison with gate one has been made here.

5) Can you explain the factors driving changes in costs since Gate 1?

As outlined in our response to point n.4 above, the primary factors driving the cost differences between gate one and gate two are scope changes, risk, OB and inflation, albeit to differing extents and impacts across the route and capacity options. Of the above factors, inflation is straightforward and does not constitute a change per se.

Regarding OB and risk, at gate one risk was included within OB, whereas at gate two the two items were separated in accordance with ACWG guidance around cost estimation. On average, OB at gate one was about 31% (including risk) and about 19.7% at gate two (excluding risk). Risk at gate two represents about 4.3% of costs. Combined, this would be 24%, which is a 7% reduction from gate one. This is reflective of the increased level of confidence gained through the design development.

For scope changes, the key items and factors have driven changes in scope are summarised in the bullet points below:

- Level of treatment assumed: depending on the option, £14-19m was estimated at gate one, whereas this is much lower at at gate two, reducing to circa £5m. This is a result of increased engagement with Affinity Water's treatment strategy lead at gate two, and a more refined cost estimate on the level of conditioning required.

- Crossings: the estimate at gate one was £3.5 – 10m, whereas this range is much higher at £26 – 34m at gate two for the options considered. The cost increase is due to the design development being progressed to a more advanced stage of design at gate two. An example is the route revision at gate two (Eastern Route) to avoid an environmentally designated site. It is worth noting that this increased level of scope to accommodate the risks encountered, is countered by the optimisim bias decreasing due to an increased level of design maturity (see above).

- Pipework: there are more differences for the 50 Ml/d capacity options than the 100 Ml/d capacity options:

    - For the 50 Ml/d options at gate one, a design diameter of 800 mm was used, generating £188m in pipework costs. At gate two, the equivalent is £194m with a larger diameter (900 mm).
    - For the 100 Ml/d options, the respective costs were similar, i.e £254m at gate one and £255m at gate two.

- Other scope changes: There are other scope changes with a smaller magnitude of difference than the items identified above. For example, land cost for the 100 Ml/d scheme was assumed to be £2.8m at gate one, but less than £1m at gate two, due to the reduced treatment requirements and also to opprtunity identified to utilise land owned by Affinity Water for treatment requirements.

6) Could you please provide us with your quantiative risk register as well as some description of your calculations?

We produced a number of analyses to support the A2AT. Two of these relate to risks:

- Quantitative risk register.
- Construction, Design and Management (CDM) risk register.

Both the Quantitative risk register and the CDM risk register have now been uploaded to the RAPID submission portal. The Quantitative risk register is an excel file with all the relevant calculations available for review.

7) Are tables available for optimism bias, NPC and AIC calculations?

As part of our response to this query, we have uploaded a revised version of Table 5a and 5b to the submission portal which includes NPC and AIC calculations. The file name is '*A2AT_AIC_RevG Tool UploadTemplate_Table5a&b.xlsm*'.

We have also provided a separate excel file which shows the optimism bias template that has been completed for this solution.

8) Why has Opex risk not been included at this stage within Optimism Bias?

We do not typically apply Optimism Bias to opex estimates. Optimism bias is based on capex costs, as developed for gate two, and is consistent with the approach taken for the other SROs.

We do recognise that there are risks associated with opex estimates; these relate predominantly to the cost of electricity. These estimates will be refined over the course of gate three and beyond, to ensure the opex used in AIC calculations continue to be reflective of forecast market conditions.

9) How have indirect costs been considered?

The indirect cost element included within the capex construction costs have been calculated as:

- 38% Contractor Costs
- 24% Client Costs

The total indirect cost element is 62%. This aligns with Anglian Water's business-as-usual capex forecasts within the C55 unit cost platform.

10) Have you engaged in any cost benchmarking for the solution?

We have undertaken a cost benchmarking exercise using both Affinity Water's and Anglian Water's cost models. Solution costs were firstly estimated using the Affinity Water's cost models. These cost models did not provide sufficient granularity for large diameter pipelines, given the absence of historic data on such large infrastructure projects. Therefore, this analysis was supplemented and refined by using Anglian Water's cost models benchmarked by cost data from Anglian Water's SPA project. This further step has allowed the project team to derive a more robust estimate for the upper end of the pipeline diameters being considered for A2AT.

Date of response to RAPID	20/12/2022
Strategic solution contact / responsible person	Andrea Farcomeni andrea.farcomeni@agilia.co.uk 07376 000023

RAPID

Gate two query process

Strategic solution(s)	Anglian to Affinity Transfer
Query number	AAT005
Date sent to company	15/12/2022
Response due by	19/12/2022

Query

Is there any difference between the best value solution option and the least cost solution option? If yes, please indicate where we can find the comparison between best value and least cost solution option.

Solution owner response

The option selection assessment exercise that was undertaken at the outset of gate two concluded that the SLR was the preferred source for the A2AT, while the WRZ5 was the preferred delivery point. The subsequent concept design stage resulted in two routes being developed which would fulfil the objective of delivering water from SLR to WRZ5. Of these two routes, the Eastern Route could be considered the least cost option as it is less capital intensive than the alternative Western Route. The Western Route was identified as an alternative pipeline route that could fully realise the additional strategic benefits, in terms of added resilience and strategic value, that this scheme would provide to both Affinity Water and Anglian Water. As the difference in capital cost was only 7%, from a regional perspective and within the context of the full scope A2AT SRO, the Western Route could offer better value than the Eastern route.

The best value and least cost plans were determined through regional (WRE and WRSE) and draft WRMP best value planning processes. Neither the best value nor the least cost iterations of these plans included the A2AT solution in its entirety

(Eastern or Western route), hence the recommendation in the A2AT gate two submission report that this SRO is not progressed into gate three.

Rather, it is proposed that a revised solution comprising the northern section of the A2AT is progressed by Anglian Water as a single company solution for the remainder of the gates, by merging it into the SLR SRO scope. The scope of this northern section of the A2AT includes a transfer of water from Peterborough to Grafham, in order to service Anglian Water's Ruthamford zones from the proposed SLR.

This Peterborough to Grafham transfer is the one section of A2AT that features in Anglian Water's draft WRMP, in both the least cost and best value plans. It is thus considered the best value solution that has been assessed within the A2AT SRO and is likewise the least cost solution option. In this respect, there is therefore no difference between the best value solution option and the least cost solution option being promoted as part of the A2AT SRO in future gates.

Date of response to RAPID	19/12/2022
Strategic solution contact / responsible person	Andrea Farcomeni andrea.farcomeni@agilia.co.uk 07376 000023

Gate two query process

Strategic solution(s)	Anglian to Affinity Transfer
Query number	AAT006
Date sent to company	16/12/2022
Response due by	20/12/2022

Query

The spend for EA and Natural England contributions is listed as £28k but EA estimates that EA and NAU costs for this solution are £80k. Please explain how these costs have been calculated and provide details around or reason for the differences. Please note – the estimated costs from the EA, do not include contributions to Natural England.

Solution owner response

The efficient spend table for A2AT was collated prior to the formal gate two submission in order to go through internal quality assurance checks. At that time, the best known information was used to collate a forecast of gate two expenditure. Table 1 and

Table 2 below show the value of all the Environment Agency (NAU) and Natural England invoices received and approved for payment as of 14 November 2022. The A2AT team also included their own forecast of what contribution costs might have been in Q3 2022/23 based on previous months' invoices.

Table 1 Breakdown of efficiency of spend submission for NAU gate two costs

		Environment Agency (NAU) Gate 2 costs (£)	Deflation metric	2017/18 pricing (£)
Invoiced	Q2 2021/22	0.00	0.92793594	0.00
	Q3 2021/22	0.00		0.00
	Q4 2021/22	8,661.00	0.86127168	7,459.47
	Q1 2022/23	8,401.00		7,235.54
	Q2 2022/23	0.00		0.00
Invoiced total		**17,062.00**		**14,695.02**
Estimated	Q3 2022/23	8,400.00		7,234.68
	Q4 2022/23	0.00		0.00
Total		**25,462.00**		**21,929.70**

Table 2 Breakdown of efficiency of spend submission for Natural England gate two costs

		Natural England Gate 2 costs (£)	Deflation metric	2017/18 pricing (£)
Invoiced	Q2 2021/22	0.00	0.92793594	0.00
	Q3 2021/22	0.00		0.00
	Q4 2021/22	5,780.00	0.86127168	4,978.15
	Q1 2022/23	0.00		0.00
	Q2 2022/23	958.00		825.10
	Q3 2022/23	848.00		730.36
Invoiced total		**7,586.00**		**6,533.61**
Estimated	Q4 2022/23	0.00		0.00
Total		**7,586.00**		**6,533.61**

Table 3 shows the total (£28,463.31), in 2017/18 pricing, that was reported in our efficient spend table for costs and contributions to the Environment Agency and Natural England.

Table 3 Total costs for EA and NE contributions in today's and 2017/18 pricing

Activity	Today's pricing (£)	2017/18 pricing (£)
NAU	25,462.00	21,929.70
Natural England	7,586.00	6,533.61
Total	**33,048.00**	**28,463.31**

Since our gate two submission, two additional costs have been incurred as shown in Table 4. These costs relate to one NAU invoice received after the gate two submission and another invoice dated August 2022 which has only been approved for payment in early December 2022. These two additional costs have increased the total expenditure of the project by £8,569 (today's pricing). No change has occurred to the previously reported expenditure for contributions to Natural England.

Table 4 Revised breakdown of efficiency of spend for NAU gate two costs

		Environment Agency (NAU) Gate 2 costs (£)	Deflation metric	2017/18 pricing (£)
Invoiced	Q2 2021/22	0.00	0.92793594	0.00
	Q3 2021/22	0.00		0.00
	Q4 2021/22	8,661.00	0.86127168	7,459.47
	Q1 2022/23	8,401.00		7,235.54
	Q2 2022/23	0.00		0.00
	Q3 2022/23	16,969.00		14,614.92
Invoiced total		**34,031.00**		**29,309.94**
Estimated	Q4 2022/23	0.00		0.00
Total		**34,031.00**		**29,309.94**

Table 5 shows the revised expenditure for contributions to the Environment Agency and Natural England. The revised total, in 2017/18 pricing, is £35,843.55.

Table 5 Revised total costs for EA and NE contributions in today's and 2017/18 pricing

Activity	Today's pricing (£)	2017/18 pricing (£)
NAU	34,031.00	29,309.94
Natural England	7,586.00	6,533.61
Total	**41,617.00**	**35,843.55**

Whilst this updated post-gate two spend does show an increase in the total anticipated gate two expenditure to £34,031.00 (today's pricing, NAU only), this does not yet align to c.£80k referenced in the RAPID query above.

Based on Table 4, the current view of expenditure relating to this category is shown in Table 6, along with the variance between the gate two costs and the updated position.

Table 6 Comparison of gate two and updated spend (2017/18 pricing)

Activity	Gate two (£)	Updated (£)	Variance (£)
NAU	21,929.70	29,309.94	7,380.24
Natural England	6,533.61	6,533.61	0.00
Total	**28,463.31**	**35,843.55**	**7,380.24**

For clarity, the variance identified between the gate two costs for this category and the current view, in 2017/18 pricing, is £7,380.24. We recognise that this results in a higher spend than quoted in our gate two submission and plan to undertake a full reconciliation once all the invoices have been received and approved.

Date of response to RAPID	20/12/2022
Strategic solution contact / responsible person	Andrea Farcomeni andrea.farcomeni@agilia.co.uk 07376 000023

Gate two query process

Strategic solution(s)	Anglian to Affinity Transfer
Query number	AAT007
Date sent to company	16/12/2022
Response due by	20/12/2022 extended to 22/12/2022

Query

Please indicate in your plan where we can find information on:

Whole life carbon costs (£m).

A discussion on the range and impact of uncertainties and a plan to mitigate any uncertainties.

A discussion on how a focus on carbon has helped to mitigate the solution costs.

Solution owner response

Whole life carbon costs (£m)

We have revised the A2AT carbon report submitted as part of query AAT001 and added the text below to section 2.3 to provide the requested detail.

The outputs from the capital and operational carbon assessments have been used to inform a whole-life carbon assessment. The whole-life cost assessment ensures consistency with other WRE and Anglian Water SRO processes, particularly the South Lincolnshire Reservoir (SLR) SRO which the 150 Ml/d A2AT option is proposed to align with.

In order to align with whole-life cost estimates, whole-life carbon for A2AT has been assessed over 80 years (from 2025/26 to 2104/05) with the following assumptions:

- A 4-year construction period (2025/26 to 2028/29) during which the capital carbon emissions, as described in Section 2, are applied.
- A 76-year operation period (2029/30 to 2104/05) during which the replacement capital carbon emissions have been estimated based on ACWG cost consistency report asset life categories and applied alongside the annual operational carbon emissions. Electricity emissions account for estimated grid decarbonisation (using *BEIS Green Book Data Tables 1-19, Table 1*)

Whilst capital carbon associated with replacements have been considered, the quantified assessment does not include for estimating the potential impact of decommissioning the scheme. Noting that the operational life is assessed over 80 years, it is anticipated that the systems in place to re-use, recycle or dispose of assets would be substantially different to present day.

Whole life carbon emissions have also been monetised using *BEIS Green Book Data Tables 1-19, Table 3*. The monetisation of carbon has been built into the regional planning appraisal approach to account for the carbon impact of different schemes. Table 1 and Table 2 below summarise the whole life carbon assessment and monetised carbon cost (NPV over 80 years) for each of the A2AT SRO sizes at a 100% (dry year maximum) and a 25% (minimum operational turnover) utilisation rate. The NPV has been calculated by multiplying the estimated emissions in each year by the carbon cost in each year and applying the green book standard discount rate. The sum of these values then provides the carbon NPV over 80 years.

Table 1 Carbon assessment summary, including whole life carbon and carbon costs over 80 years at 100% utilisation

	100% Utilisation				
	Eastern Route 50 Ml/d	**Eastern Route 100 Ml/d**	**Western Route 50 Ml/d**	**Western Route 100 Ml/d**	**Western Route 150 Ml/d**
Capital (tCO2e)	70,010	113,810	76,510	124,630	67,980
Capital replacements (tCO2e)	2,460	2,460	2,460	3,570	2,430
Operational - power (tCO2e)	16,330	31,190	17,450	33,570	27,810
Operational - chemicals (tCO2e)	284,600	569,190	284,600	569,190	853,790
Operational - maintenance (tCO2e)	170	170	170	170	170
Land use change (tCO2e)	-	-	-	-	-
Whole life carbon (tCO2e)	373,570	716,820	381,190	731,130	952,180
Net present value (£m)	**£ 53.00**	**£ 99.30**	**£ 54.7**	**£ 102.20**	**£ 120.70**

Table 2. Carbon assessment summary, including whole life carbon and carbon costs over 80 years at 25% utilisation.

	Variable Utilisation (25%)				
	Eastern Route 50 Ml/d	**Eastern Route 100 Ml/d**	**Western Route 50 Ml/d**	**Western Route 100 Ml/d**	**Western Route 150 Ml/d**
Capital (tCO2e)	70,010	113,810	76,510	124,630	67,980
Capital replacements (tCO2e)	2,460	2,460	2,460	3,570	2,430
Operational – power (tCO2e)	4,080	7,800	4,360	8,390	6,950
Operational – chemicals (tCO2e)	71,150	142,300	71,150	142,300	213,450
Operational – maintenance (tCO2e)	170	170	170	170	170
Land use change (tCO2e)	-	-	-	-	-
Wholelife carbon (tCO2e)	147,870	266,540	154,650	279,060	290,980
Net present value (£M)	**£ 26.10**	**£ 45.80**	**£ 27.7**	**£ 48.40**	**£ 42.70**

The Western Route 150 Ml/d has the lowest capital carbon (tCO2e) due to its shorter length (c.50 km) compared with the alternative options. Whilst this means the northern 150Ml/d option is not directly comparable with the other route capacities presented, it is nonetheless included for completeness, not least because this section is being recommended for incorporation into the SLR SRO. It is also noted that the chemical usage required to support the 150Ml/d capacity and associated significant carbon emissions over the course of its operational life, results in the Western Route 150 Ml/d option showing the highest NPV carbon. Again, whilst this is not directly comparable to the alternative options given the higher yield, it is included here given that this is the preferred option for onward development with the SLR SRO.

A discussion on the range and impact of uncertainties and a plan to mitigate any uncertainties

We have revised the A2AT carbon report submitted as part of query AAT001 and added the text below to paragraph 2.2.2 to provide the requested detail.

There is inherent uncertainty in carbon estimating due to the developing maturity of carbon accounting practices and associated data. There is also additional uncertainty driven by scope uncertainty associated with level of design information available at given stages of the project lifecycle.

There is currently no standardised or established guidance to assess uncertainty in carbon estimates in a consistent way, and directly applying the range of uncertainty associated with cost estimates and optimism bias would likely overstate the level of uncertainty associated with the gate two carbon estimate.

Whilst further ongoing work is required at a carbon estimating and accounting discipline level and within the infrastructure sector to establish a more formalised approach to assessing carbon uncertainty, an estimated range of +/-30% has been considered based on expert judgement for the gate two estimate. This uncertainty range accounts for:

- Uncertainty in carbon factors related to the quality and representativeness of industry level emissions factors to the specific activities undertaken and materials used on the A2AT scheme.
- Scope uncertainty related to whether the carbon estimate has captured all scope requirements to fully deliver the scheme.

These uncertainty estimates will be reviewed and refined at future stages of design development to build on any further industry wide efforts to assess uncertainty in carbon estimating.

A discussion on how a focus on carbon has helped to mitigate the solution costs.

This is discussed in section 6.5.3 of the A2AT gate two submission document and more detail is provided in section 2.3.2 of the updated carbon report which we are submitting as part of our response to this query. The carbon report explains how the carbon reduction hierarchy and a focus on identifying carbon hotspots helped the design team mitigate some of the solution costs.

Date of response to RAPID	22/12/2022
Strategic solution contact / responsible person	Andrea Farcomeni andrea.farcomeni@agilia.co.uk 07376 000023

Anglian Water & Affinity Water

Anglian to Affinity Transfer (A2AT)

A2AT Carbon Report

Reference: A2AT Carbon

Version 3 | December 2022

Job number 286840-00

Ove Arup & Partners Limited
Admiral House Rose Wharf
78 East Street
Leeds
LS9 8EE
United Kingdom
arup.com

ARUP

Document Verification

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Job number	286840-00
Document ref	A2AT Carbon
File reference	

Revision	**Date**	**Filename**			
Version 1	November 2022	**Description**	A2AT Carbon Report		
			Prepared by	**Checked by**	**Approved by**
		Name	Ayisha Paw	Ritchie Carruthers / Philip Songa.	Fred Mukonoweshuro
		Signature			
Version 2	November 2022	**Filename**			
		Description	Amends as per client internal QA.		
			Prepared by	**Checked by**	**Approved by**
		Name	Ayisha Paw	Ritchie Carruthers	Fred Mukonoweshuro
		Signature			
Version 3	December 2022	**Filename**			
		Description	Amends to include Mott MacDonald whole life carbon values, supporting text & client amends.		
			Prepared by	**Checked by**	**Approved by**
		Name	Ritchie Carruthers	Philip Songa	Philip Songa
		Signature			

Issue Document Verification with Document ✓

Contents

Tables

Figures

1. Background

1.1 Context

Anglian Water and Affinity Water both aim to be operationally carbon net zero by 2030. Anglian Water currently generates around 30% of its energy requirements from renewable resources, and their target over the next five years is to increase this to 44%. Affinity Water use 100% green electricity from the grid, have an energy efficiency programme in place, and have made a commitment to make carbon a key part of all investment decisions going forward.

In 2020, Water UK published their Net Zero 2030 Route map, which provides water companies with a framework on which to develop and cost their own net zero action plans. Water UK expects to see the following by 2030:

Low emissions vehicles: 100% of fleet passenger vehicles are electrified and 80% of commercial vehicles (LGVs and HGVs) converted to alternative fuels to cut carbon and air pollution.

Water and energy saving: New strategies to tackle leakage and help customers save water, alongside smarter and more efficient networks and catchments.

Process emissions: Targeting a reduction of up to 60% from the 2018-19 baseline by 2030, with monitoring of emissions to inform research and detailed pathways ahead of PR24.

Renewable power: Up to 3GW of new solar and wind power coupled with energy efficiency measures and suitable storage to provide up to 80% of sector demand, relieve pressure on grid generators, and minimise the need for offsets.

Green gas: Biomethane from sewage waste is injected into the grid to heat up to 150,000 homes, use in hard to decarbonise sectors, or to generate low-carbon power when generation from renewables is low

Figure 1. Water UK expectations by 2030

To aid Anglian Water and Affinity Water in meeting their low carbon and net zero targets, an assessment of carbon for the Anglian to Affinity Transfer (A2AT) has been conducted. The assessment includes opportunities to minimise embodied and operational carbon within the selected scheme, and the outcomes are summarised in this report.

1.2 Methodology

Four aims have been identified from the partner water companies for this carbon assessment. These are listed in Table 1, along with the methodology for meeting these aims.

Table 1. Aims and methodology for the carbon assessment

Aim	Description	Methodology	Output
1	Interrogate the whole life carbon baseline for the selected pipeline route	A bespoke calculator for whole life carbon was created for the Gate 2 Eastern and Western Routes	The findings are summarised in Section 2.2 of this report
2	Understand the views of representatives to gauge their views on low carbon opportunities	This was carried out via a virtual workshop facilitated by Arup and attended by the Client, and representatives from the Environment Agency and Natural England.	The outputs of the workshop were intended to be used to short-list low carbon, renewable and sequestration opportunities. These fed into the recommendations.
3	Identify carbon considerations into the	Hotspots for carbon reduction were identified in collaboration with the design team.	See Section 2.2 of this report.

Aim	Description	Methodology	Output
	procurement, construction, and operation phases	Assumptions were made for the construction and operation of the pipeline, to inform carbon considerations.	
4	Review the potential for embedding renewables and sequestering carbon into the design of the proposed solution	Using the results from the carbon baseline calculation and workshops with the design team, a list of recommendations, including carbon sequestration was made using the Carbon Reduction Curve principles. Renewable energy potential has been considered elsewhere in the Gate 2 submission.	

For the selected design routes, a whole life carbon assessment has been carried out. The scope of the assessment is based on BS EN 15978:2011 stages, identified below.

- Before use stage: A1-A5
- Use stage: B1-B7
- End of life stage: C1-C4

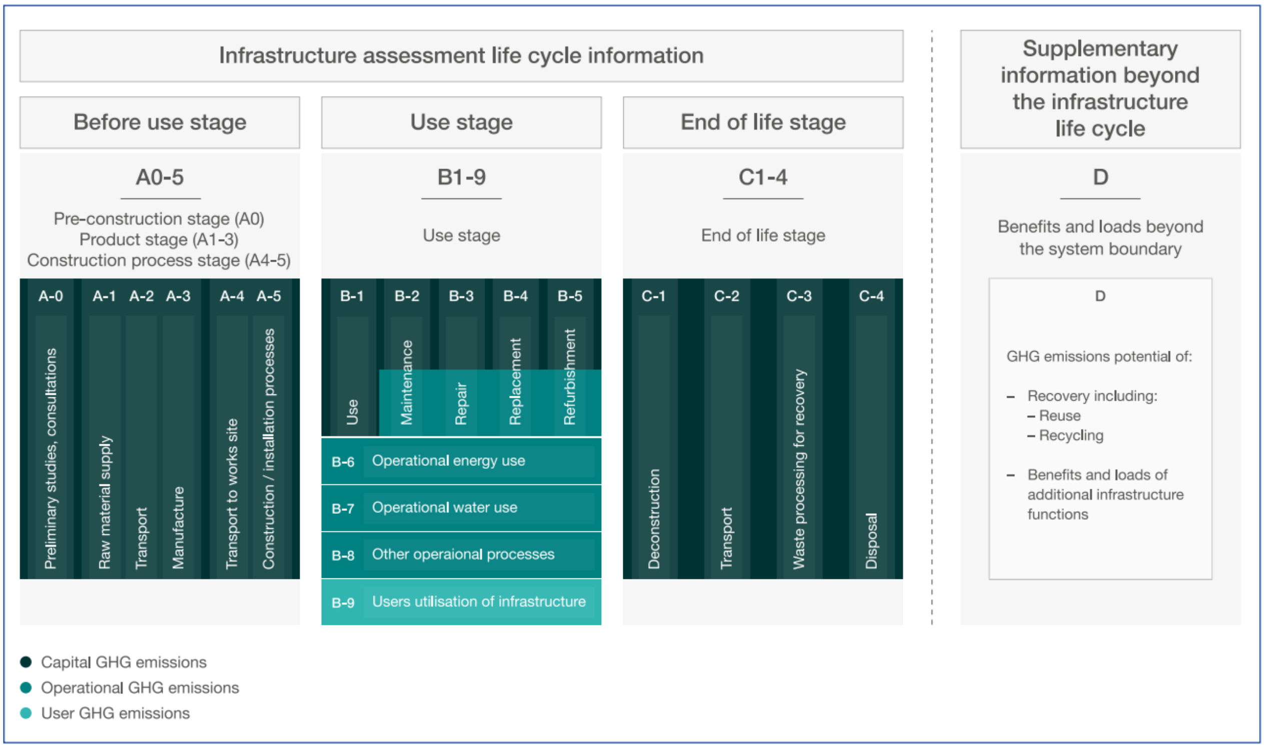


Figure 2. Modular approach to asset lifecycle, BS EN 15978: 2011

2. Carbon Assessment

2.1 Summary of Gate 1 findings

The Gate 1 technical assessments for A2AT analysed four different options for the scheme. One of the four options was the South Lincolnshire Reservoir (SLR) to WRZ5 Hub which is the option progressed at Gate 2 stage.

As stated in the *Gate 1 Concept Design Report*, the SLR options which deliver water to Affinity Water were considered as 50 Ml/d or 100 Ml/d. This is because the proposed SLR is being sized for 150 Ml/d deployable output, and up to 100 Ml/d could be transferred to Affinity Water, and so the Gate 1 options considered both 50 Ml/d and 100 Ml/d alternatives.

Table 2. Gate 1 summary of SLR transfer route (by Mott MacDonald)

	Gate 1 Route – SLR to WRZ5 Hub
Pipe diameter	Peterborough to Intermediate break tank • 800 mm (50 Ml/d) • 1,000 mm (100 Ml/d) Intermediate break tank to WRZ5 • 800 mm (50 Ml/d) • 1,000 mm (100 Ml/d)
Route length	Peterborough to Intermediate break tank • 64 km Intermediate break tank to WRZ5 • 31 km Total • 95 km
Power of pumping station	Peterborough to Intermediate break tank • 2.0 MW (50 Ml/d) • 4.5 MW (100 Ml/d) Intermediate break tank to WRZ5 • 2.0 MW (50 Ml/d) • 4.0 MW (100 Ml/d)

The carbon estimate for the Gate 1 option 'SLR to WRZ5 Hub' is summarised in Table 3 and Figure 3.

Table 3. Gate 1 carbon calculations (calculated by Mott MacDonald)

Route	50 Ml/day		100 Ml/day	
Gate 1 - SLR to WRZ5 Hub	Operational Carbon emissions at full capacity* (tCO2e/year)	Capital Carbon Emissions (tCO2e)	Operational Carbon emissions at full capacity* (tCO2e/year)	Capital Carbon Emissions (tCO2e)
	5,688	71,626	13,177	156,633

*Estimated based on calculated power used at full capacity in MWh/yr and using the Carbon Accounting Workbook v14 grid power emissions factor of 0.277 kg/kWh including transmissions and distribution losses

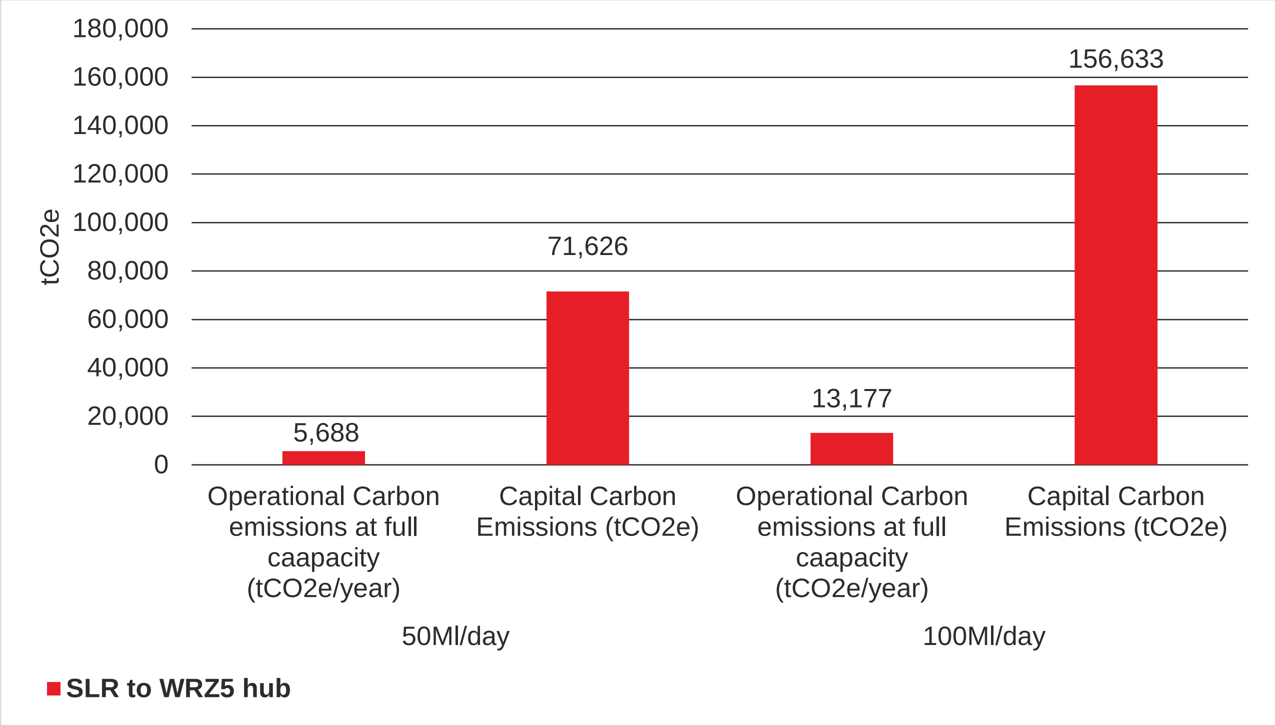


Figure 3. Gate 1 embodied and operational carbon (calculated by Mott MacDonald)

The Gate 1 capital (embodied) carbon was calculated using Mott MacDonald's Carbon Portal and operational carbon was calculated using Affinity Water Long Run Marginal Cost (LRMC) tool.

The Gate 1 assessment was used as a baseline to compare the Gate 2 carbon assessment with.

2.2 Gate 2 Assessment

2.2.1 Assumptions

The following assumptions were used in the Gate 2 carbon analysis:

Table 4. Gate 2 assumptions for carbon analysis.

Embodied (A1-4)	Pipe material	Ductile iron*
	Pipe diameter	50 Ml/d: 900 mm 100 Ml/d: 1200 mm
	Pipe lengths	Eastern Route: 105,000 m Western Route: 115,000 m
	Butterfly valves and chambers	Every 2km
	Break tanks (including Peterborough service reservoir)	Eastern Route: 2 no. Western Route: 3 no. Reinforced concrete tanks at 500 mm wall thickness
	Thrust blocks	Every 1 km Reinforced concrete 2 m x 2 m x 2 m each
	Surge vessels	Eastern Route: 18 no. Western Route: 14 no. Each 100 m^3 constructed of steel carbon
Construction (A5)	Construction method	Open cut excavation
	Trench width and cover depth	Width: pipe diameter + 300 mm either side Cover depth: 0.9 m
	Percentage of excavated material going to landfill / hazardous waste	10%

	Vehicle movements	HGVs, and rigid vehicles travelling 50 km/day
	Construction timeline	5 years
Operational (B1-B7)	Deployable output	112%
	Power source	UK grid electricity
	kgCO2e per kWh based on UK Government 2021	0.21233
	kgCO2e per kWh for Transmission & Distribution based on UK Government 2021	0.01879
	Chemicals for treatment required	Sodium hydroxide, CO_2 gas, Sodium hypochlorite and Chloramines
	Vehicle movements	Hybrid car travelling 50 km/day
End of life (C1-C4)	Pipe will remain in situ and no deconstruction works are associated with decommissioning	

*Assumption to be reviewed at detailed design stage

For details that are unknown at this stage of design, exclusions have been made from the Gate 2 carbon assessment. These include the following:

- Air valves and washout valves
- Pipe bends
- Tunnel boring of the pipeline
- Pumping equipment associated with chemical treatment
- Power requirements associated with chemical treatment
- Pump station building
- Roads and access to the pump stations and treatment works
- Employee travel to site during construction and operation
- Site accommodation and welfare during construction
- Mechanical plant during construction for excavation

However, these should be included at a later stage of the design process once more information is available.

2.2.2 Uncertainty within carbon estimates and assessment

There is inherent uncertainty in carbon estimating due to the developing maturity of carbon accounting practices and associated data. There is also additional uncertainty driven by scope uncertainty associated with level of design information available at given stages of the project lifecycle.

There is currently no standardised or established guidance to assess uncertainty in carbon estimates in a consistent way, and directly applying the range of uncertainty associated with cost estimates and optimism bias would likely overstate the level of uncertainty associated with the gate two carbon estimate.

Whilst further ongoing work is required at a carbon estimating and accounting discipline level and within the infrastructure sector to establish a more formalised approach to assessing carbon uncertainty, an estimated range of +/-30% has been considered based on expert judgement for the gate two estimate. This uncertainty range accounts for:

- Uncertainty in carbon factors related to the quality and representativeness of industry level emissions factors to the specific activities undertaken and materials used on the A2AT scheme.
- Scope uncertainty related to whether the carbon estimate has captured all scope requirements to fully deliver the scheme.

These uncertainty estimates will be reviewed and refined at future stages of design development to build on any further industry wide efforts to assess uncertainty in carbon estimating.

2.2.3 Results

Results of the Gate 2 carbon assessment are shown in Figures 4, 5, 6 and 7 and are split into capital carbon, construction carbon and operational carbon.

In Figure 7, operational carbon has been shown for 20 years, as this is the assumed asset life for pumping; however, it is recognised that the design life for the pipeline is much longer.

Whole life Carbon

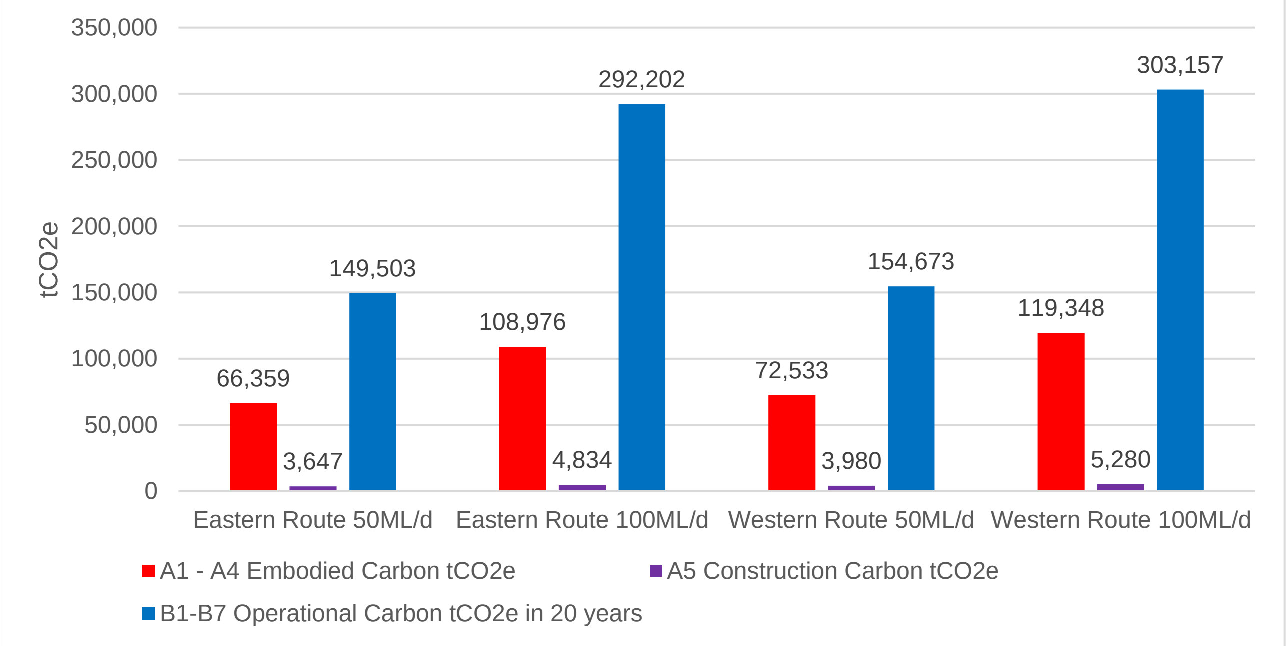


Figure 4. Whole life CO2e estimates for Eastern and Western routes (50 Ml/d and 100 Ml/d)

Embodied Carbon

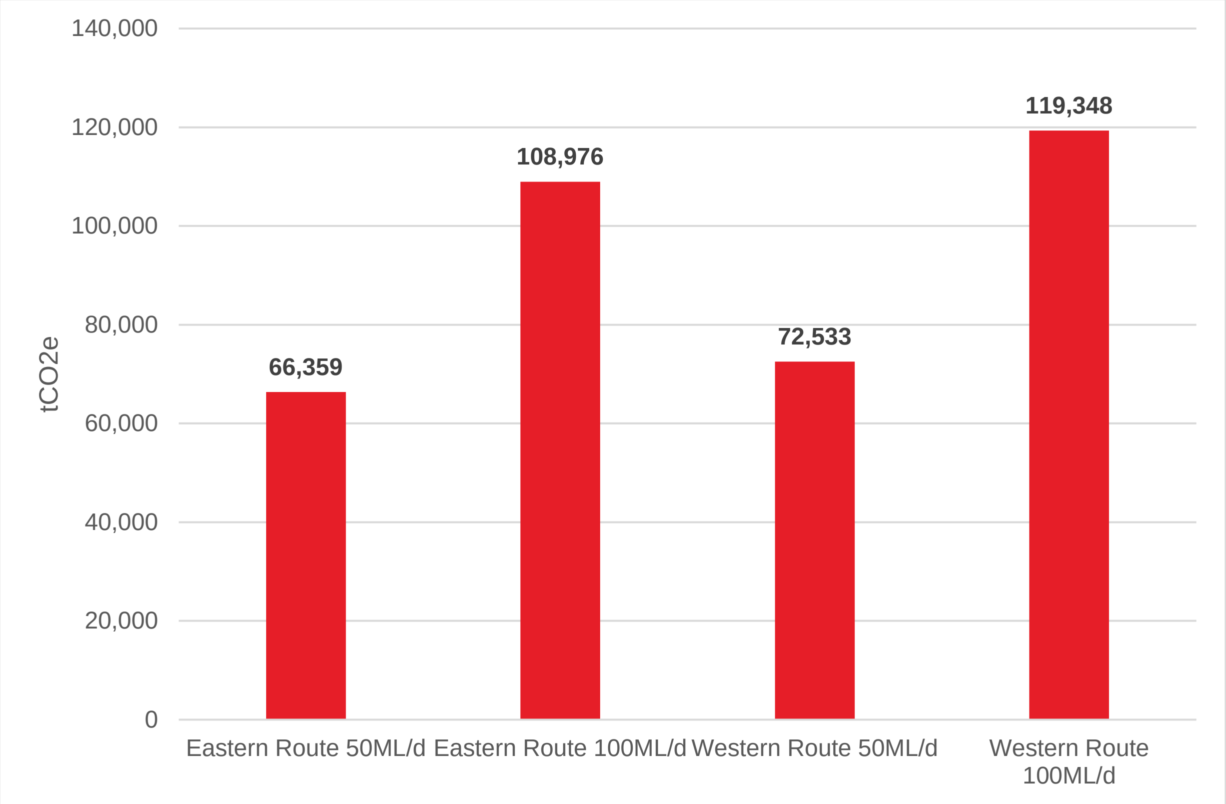


Figure 5. Embodied CO2e for Eastern and Western routes (50 Ml/d and 100 Ml/d)

The majority (97%) of embodied carbon for all routes is associated with the pipework. This means that the largest reductions achievable with respect to embodied carbon would be from reducing the mass of pipe work, i.e., shortening the pipeline route, reducing pipe thickness and/or diameter. Comparing the Eastern Route (100 Ml/d) to the Gate 1 SLR to WRZ5 Hub (100 Ml/d) route, the Gate 2 embodied carbon is 30% lower, despite the Gate 2 Eastern Route having a longer pipeline length. This is due to differences in material density and carbon factors used.

Construction Stage

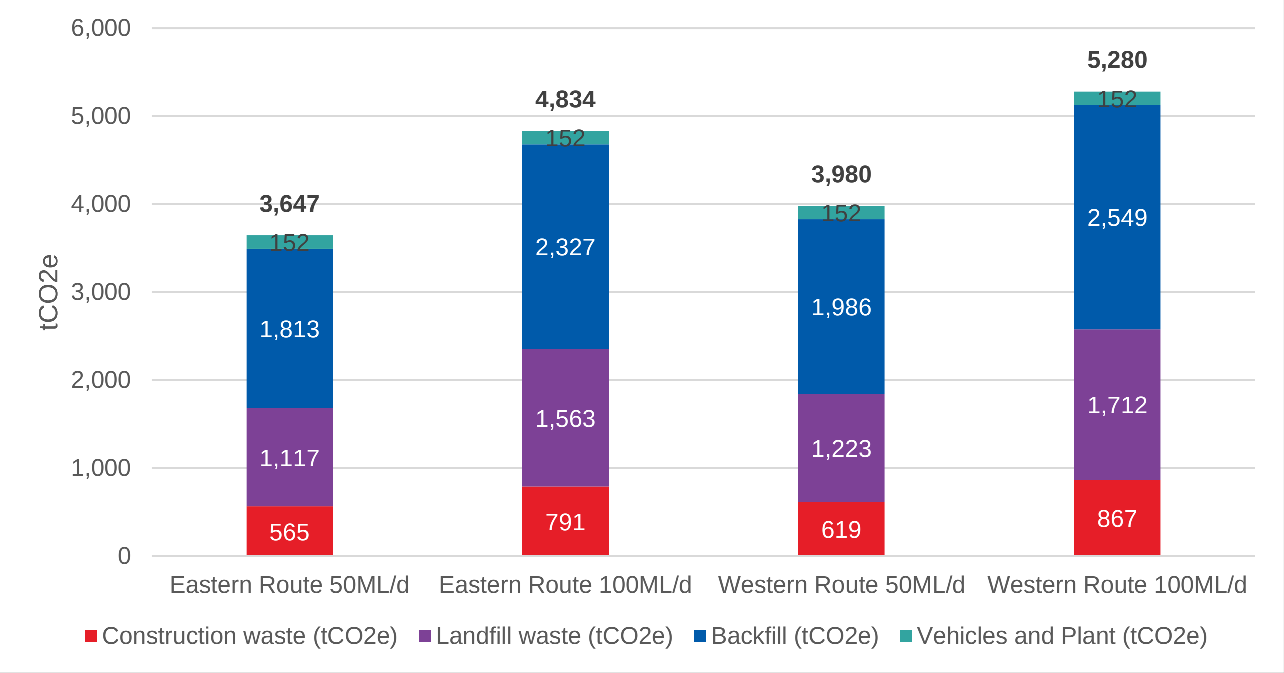


Figure 6. Construction-related CO2e for Eastern and Western routes (50 Ml/d and 100 Ml/d)

Assumptions have been made for the construction method, construction timeline, volume of excavated spoil, backfill quality and vehicle movements. It is recommended that this exercise is repeated once the construction sequence is known for a more accurate assessment.

Operational Carbon

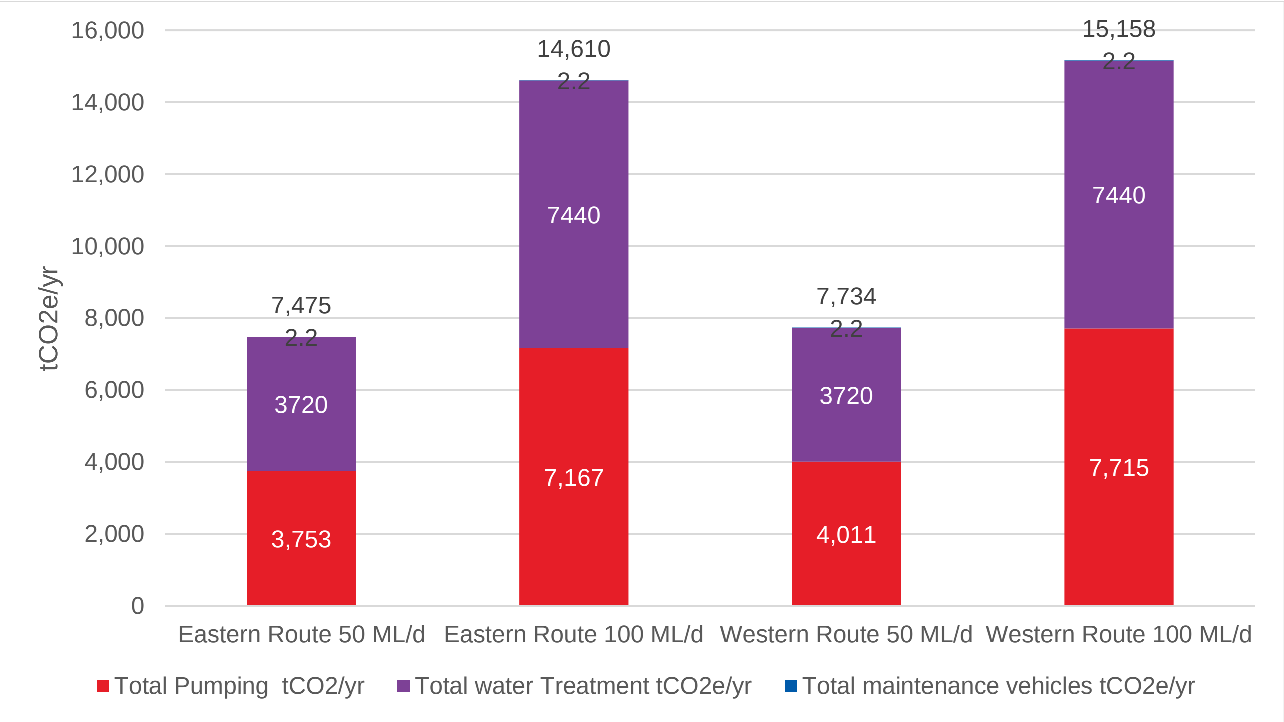


Figure 7. Operational CO2e for Eastern and Western routes (50 Ml/d and 100 Ml/d)

The largest proportion of operational carbon per annum is associated with pumping and water treatment using chemicals. Comparing the Eastern Route (100 Ml/d) to the Gate 1 SLR to WRZ5 Hub (100 Ml/d) route, the Gate 2 operational carbon per year is approximately 11% higher. This is possibly due to more accurate pumping and chemical dosing information being available at Gate 2 but will need verification if the design progresses.

It is assumed that the UK grid is used as a power source for pumping but given Anglian Water and Affinity Waters' aspirations for relying on green electricity from the grid, and proposed use of renewable energy, this could be lowered significantly. Similarly to the construction phase, assumptions have been made for vehicle movements during the operational phase, as these are not yet known.

For the end-of-life stage of this scheme (C1-C4), it is assumed that the pipeline would remain in-situ. Therefore, no CO_2 emissions have been associated with the deconstruction phase of the project.

2.2.4 Western Route with 150 Ml/d option

Affinity Water's draft Water Resources Management Plan (WRMP) and regional modelling by Water Resources East (WRE) and Water Resources South East (WRSE) concluded that a transfer from the Anglian region to Affinity Water does not represent best value for customers. However, Anglian Water's dWRMP and WRE's regional plan confirmed that the full output of SLR is now required within the WRE region and that SLR water will be used locally in south Lincolnshire, as well as across the Anglian Water Ruthamford system. Therefore, an additional 150 Ml/d capacity sub-option for the Peterborough to Grafham Water route was also developed and assessed. The carbon assessment for this sub-option is presented here as a standalone section because it is not directly comparable with the other, much longer routes, and therefore direct comparison would not yield accurate assumptions, given the differences in key parameters such as pumping distances and length of pipework laid.

Table 5. Assumptions made for 150Ml/d route carbon analysis.

Embodied (A1-4)	Pipe material	Ductile iron*
	Pipe diameter	1,400 mm
	Pipe length	45,000 m
	Butterfly valves and chambers	Every 2 km
	Break tanks	1 no. Reinforced concrete tanks at 500 mm wall thickness
	Thrust blocks	Every 1 km Reinforced concrete 2 m x 2 m x 2 m each
	Surge vessels	12 no. Each 100 m^3 constructed of steel carbon
Construction (A5)	Construction method	Open cut excavation
	Trench width and cover depth	Width: pipe diameter + 300 mm either side Cover depth: 0.9 m
	Percentage of excavated material going to landfill / hazardous waste	10%
	Vehicle movements	HGVs, and rigid vehicles travelling 50km/day
	Construction timeline	5 years
Operational (B1-B7)	Deployable output	112%
	Power source	UK grid electricity
	kgCO2e per kWh based on UK Government 2021	0.21233
	kgCO2e per kWh for Transmission & Distribution based on UK Government 2021	0.01879
	Chemicals for treatment required	Sodium hydroxide, CO_2 gas, Sodium hypochlorite and Chloramines
	Vehicle movements	Hybrid car travelling 50 km/day
End of life (C1-C4)	Pipe will remain in situ and no deconstruction works are associated with decommissioning	

* Assumption to be reviewed at detailed design stage

The findings for embodied, construction and operational carbon are outlined in Table 6 and Figure 8.

Table 6. Whole life carbon 150 Ml/d Western Route

	A1 - A4 Embodied Carbon tCO2e	A5 Construction Carbon tCO2e	B1-B7 Operational Carbon tCO2e in 20 years
Western Route 150 Ml/d – Peterborough to Grafham	65,444	2,532	351,061

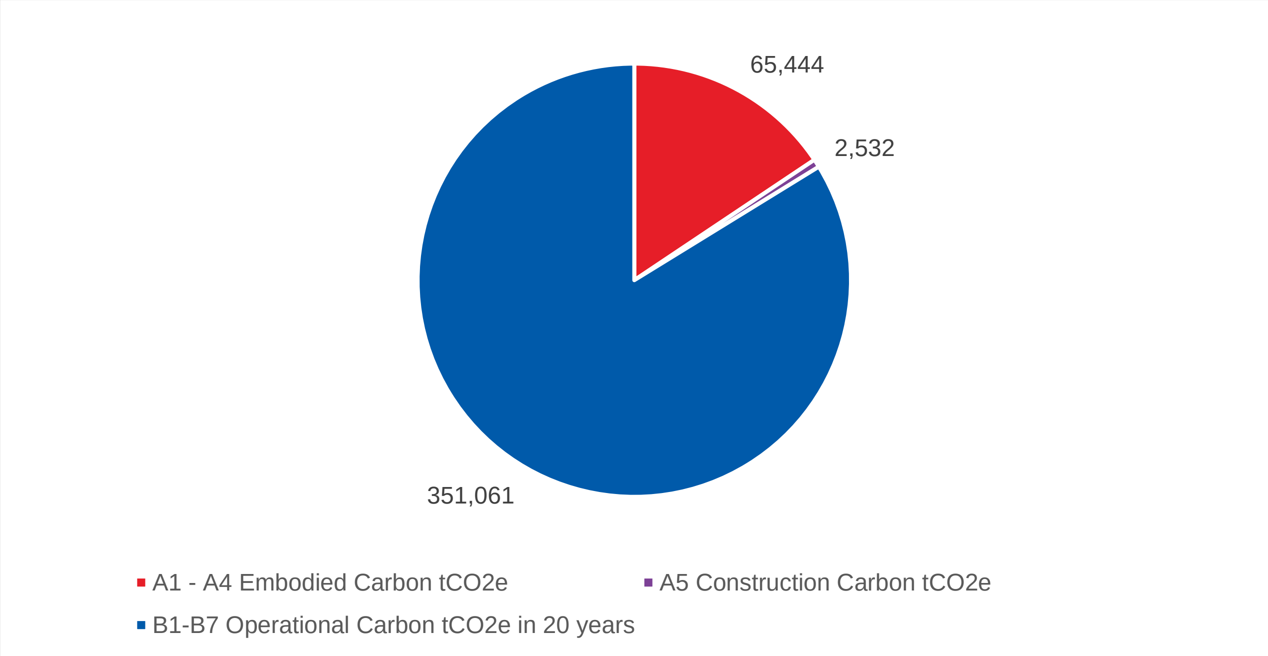


Figure 8. Whole life carbon for 150 Ml/d option

For this route, 95% of embodied carbon is associated with the pipework. Less than 5% of embodied carbon is associated with valves, pumps, break tanks, thrust blocks and surge vessels. Note that exclusions for air valves, washout valves and pipe bends/elbows and specific items for the pump station buildings have been made, as the exact number of these items is unknown at this stage of the design.

Assumptions have also been made for the construction method, construction timeline, volume of excavated spoil, backfill quality and vehicle movements. Construction associated with pump stations, temporary buildings and roads have not been included. It is recommended that this exercise is repeated once the construction sequence is known for a more accurate assessment.

Operational carbon has been shown for 20 years, as this is the assumed asset life for pumping. However, it is recognised that the design life for the pipeline is much longer. This assessment includes pumping, chemical dosing, and movement of maintenance vehicles.

It is assumed that the UK grid is used as a power source for pumping but given Anglian Water and Affinity Waters' aspirations for relying on green electricity from the grid, and proposed use of renewable energy, this could be lowered significantly.

For the end-of-life stage of this scheme (C1-C4), it is assumed that the pipeline would remain in-situ. Therefore, no CO_2 emissions have been associated with the deconstruction phase of the project.

2.3 Whole Life Carbon

2.3.1 Whole Life Carbon Assessment

The outputs from the capital and operational carbon assessments outlined above have been used to inform a whole-life carbon assessment. This whole-life cost assessment has been compiled by Mott MacDonald and included in this Arup report alongside the wider Arup carbon assessment. The whole-life cost assessment ensures consistency with other WRE and Anglian Water SRO processes, particularly the South Lincolnshire

Reservoir (SLR) SRO which the 150 Ml/d A2AT option is proposed to align with. The Mott MacDonald cost assessment is reported in Section 2.3.1 of this report.

In order to align with whole-life cost estimates, whole-life carbon for A2AT has been assessed over 80 years (from 2025/26 to 2104/05) with the following assumptions:

- A 4-year construction period (2025/26 to 2028/29) during which the capital carbon emissions, as described in Section 2, are applied.
- A 76-year operation period (2029/30 to 2104/05) during which the replacement capital carbon emissions have been estimated based on ACWG cost consistency report asset life categories and applied alongside the annual operational carbon emissions. Electricity emissions account for estimated grid decarbonisation (using *BEIS Green Book Data Tables 1-19, Table 1*)

Whilst capital carbon associated with replacements have been considered, the quantified assessment does not include for estimating the potential impact of decommissioning the scheme. Noting that the operational life is assessed over 80 years, it is anticipated that the systems in place to re-use, recycle or dispose of assets would be substantially different to present day.

Whole life carbon emissions have also been monetised using *BEIS Green Book Data Tables 1-19, Table 3*. The monetisation of carbon has been built into the regional planning appraisal approach to account for the carbon impact of different schemes. Tables 7 and 8 below summarise the whole life carbon assessment and monetised carbon cost (NPV over 80 years) for each of the A2AT SRO sizes at a 100% (dry year maximum) and a 25% (minimum operational turnover) utilisation rate. The NPV has been calculated by multiplying the estimated emissions in each year by the carbon cost in each year and applying the green book standard discount rate. The sum of these values then provides the carbon NPV over 80 years.

Table 7. Carbon assessment summary, including whole life carbon and carbon costs over 80 years at 100% utilisation.

	100% Utilisation				
	Eastern Route 50 Ml/d	**Eastern Route 100 Ml/d**	**Western Route 50 Ml/d**	**Western Route 100 Ml/d**	**Western Route 150 Ml/d**
Capital (tCO2e)	70,010	113,810	76,510	124,630	67,980
Capital replacements (tCO2e)	2,460	2,460	2,460	3,570	2,430
Operational - power (tCO2e)	16,330	31,190	17,450	33,570	27,810
Operational - chemicals (tCO2e)	284,600	569,190	284,600	569,190	853,790
Operational - maintenance (tCO2e)	170	170	170	170	170
Land use change (tCO2e)	-	-	-	-	-
Whole life carbon (tCO2e)	373,570	716,820	381,190	731,130	952,180
Net present value (£m)	**£ 53.00**	**£ 99.30**	**£ 54.7**	**£ 102.20**	**£ 120.70**

Table 8. Carbon assessment summary, including whole life carbon and carbon costs over 80 years at 25% utilisation.

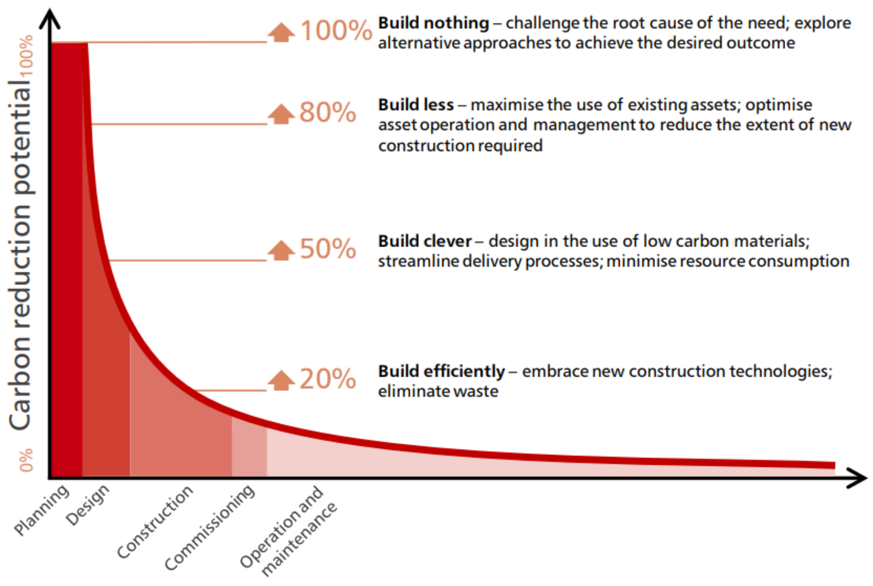
	Variable Utilisation (25%)				
	Eastern Route 50 Ml/d	**Eastern Route 100 Ml/d**	**Western Route 50 Ml/d**	**Western Route 100 Ml/d**	**Western Route 150 Ml/d**
Capital (tCO2e)	70,010	113,810	76,510	124,630	67,980
Capital replacements (tCO2e)	2,460	2,460	2,460	3,570	2,430
Operational - power (tCO2e)	4,080	7,800	4,360	8,390	6,950
Operational - chemicals (tCO2e)	71,150	142,300	71,150	142,300	213,450
Operational - maintenance (tCO2e)	170	170	170	170	170
Land use change (tCO2e)	-	-	-	-	-
Wholelife carbon (tCO2e)	147,870	266,540	154,650	279,060	290,980
Net present value (£M)	**£ 26.10**	**£ 45.80**	**£ 27.7**	**£ 48.40**	**£ 42.70**

The Western Route 150 Ml/d has the lowest capital carbon (tCO2e) due to its shorter length (c.50 km) compared with the alternative options. Whilst this means the northern 150Ml/d option is not directly comparable with the other route capacities presented, it is nonetheless included for completeness, not least because this section is being recommended for incorporation into the SLR SRO.

It is also noted that the chemical usage required to support the 150Ml/d capacity and associated significant carbon emissions over the course of its operational life, results in the Western Route 150 Ml/d option showing the highest NPV carbon. Again, whilst this is not directly comparable to the alternative options given the higher yield, it is included here given that this is the preferred option for onward development with the SLR SRO.

2.3.2 Identifying hotspots

The infographic in Figure 9 summarises the principles through which potential carbon reduction solutions have been categorised.



Source: Green Construction Board

Figure 9. Carbon reduction curve

A 'hot spotting' workshop was held with the Gate 2 design team to identify areas of carbon reduction on the project. The following options were discussed.

Build Nothing

- There is a need to construct the A2AT scheme to secure water for England's future. Therefore, the option to build nothing was discounted.

Build Less

- There are no known existing pipe routes between Peterborough and WRZ5 Hub that can be reused.
- Reusing the pump stations and break tanks at Grafham for the 'Western Route' would not be appropriate as the infrastructure at Grafham would need to be upgraded for the flows associated with the A2AT scheme. Therefore, it was concluded that new infrastructure (pipes, pump stations and tanks) is necessary.
- Reducing the length of pipeline would reduce the embodied carbon of the project, however other factors such as flood zones, protected areas, rivers, habitats, access, and ease of construction needed to also be equally considered. The Eastern and Western routes selected have undergone an environmental constraints assessment to optimise the route as far as practicably possible.

Build Clever

- Pipe material and diameter have been selected to deliver optimum hydraulic conditions.
- Ductile iron has a lower embodied carbon factor compared to steel and HDPE using the Inventory of Carbon & Energy (ICE) database. It is recommended that at detailed design and procurement stage, the material of the pipeline is reviewed once again, and the most carbon efficient is selected.
- Reducing the pipe diameter was considered; however, there was acknowledgement that this decision would increase head losses and increase pumping requirements.
- For the 'Western Route', a portion of the pipeline, between the break pressure tank and WRZ5 hub, does not require energy for pumping as the elevations allow for gravity flow.

Build Efficiently

- During construction stage, the use of electric plant should be maximised, and local manufacturers should be selected to minimise transport to site.
- No-dig construction techniques should be considered to eliminate open cut trenching and backfilling.

Operational carbon

- Variable frequency pumps have been selected for optimum operational conditions, given the varied utilisation throughout the year
- Assuming Anglian Water and Affinity Water are successful in becoming net zero by 2030, the operational carbon emissions should decrease annually as they reduce their reliance on the UK grid and increase the uptake of renewable energy and electric vehicles.
- Solar photovoltaic (PV) panels and other renewable energy systems have been considered as part of the concept design.

2.4 Offsetting

Organisations that wish to offset residual carbon emissions can purchase carbon offsets. Offsetting is usually the last resort, once emissions have been reduced as much as practicably possible by building less, building cleverly and/or efficiently. Research indicates that as land available for sequestration and renewable energy generation becomes scarce, and the demand for organisations to offset emissions increases, the cost of purchasing carbon offsets is set to drastically increase. BloombergNEF (2022) predicts if the market is restricted to just offsets that remove, store, or sequester carbon to achieve net zero targets, there would be insufficient supply to keep up with demand, causing significant near-term price hikes and damaging liquidity. Prices could reach $224 per tonne by 2029, up from just $2.50 on average in 2020[1]

Therefore, a more cost-effective and resilient option for the A2AT scheme is to maximise the use of renewable energy and carbon sequestration.

2.4.1 Renewable energy

To offset the energy requirements for the scheme, renewable energy options have also been considered. Initial case studies have been compiled as part of the concept design of the A2AT at Gate 2, into what level of investment and technical consideration may be required.

2.4.2 Sequestration using nature-based solutions

Sequestering carbon can occur using biological or geological techniques. The former is where carbon is stored in vegetation, soils and oceans, and the latter refers to carbon from industrial sources being stored in underground porous rocks for storage. For utility companies such as water companies which own land, options for carbon sequestration are primarily biological and can include reforestation, afforestation and wetland creation. These are sometimes referred to as nature-based solutions.

Given that the A2AT scheme would involve installing pipelines across multiple land typologies, including private land, an easement would be necessary so that the asset owner can maintain the pipeline during the operational phase. Sequestration options have been excluded from the easement strip as this is to be left for access and maintenance purposes only.

To maximise sequestration options for this scheme, the options are:

- **Option A**: Utilise other land owned by Anglian Water or Affinity Water to develop nature-based solutions to offset the emissions
- **Option B**: Enter into agreements with local landowners and farmers who may be affected by the route, to use their land to sequester carbon for an agreed price.

[1] Long-Term Carbon Offset Outlook 2022, BNEF

Option A – Utilise land owned by Anglian Water and Affinity Water to offset emissions

In order to estimate the land area required to offset embodied carbon for the A2AT scheme, sequestration values for various land uses are shown in Table 9, with an estimate of the land required in hectares. These values are high-level estimates using values from '*Carbon storage and sequestration by habitat: a review of the evidence (second edition) Appendix A, Natural England, Oct 2021*'.

Table 9. Sequestration potential for different land uses

Land use	Carbon Sequestered soil and vegetation (tC/ha^{-1})*
100-year mixed native broadleaved woodland on mineral soil (to 1 m)	354
100-year mixed native broadleaved woodland (to 15 cm soil depth)	258
30-year mixed broadleaved native woodland on mineral soil (to 1 m)	255
30-year mixed broadleaved native woodland (to 15 cm soil depth)	169
Minimal/ Unmanaged hedgerows	144.5
Traditional orchards (30 cm soil depth)	95.15
Upland and lowland heathland (15-30 cm soil depth)	100
Neutral grassland (15 cm soil depth)	60
Floodplains	109.4

**Using Carbon Storage and Sequestration by Habitat: A Review of The Evidence (Second Edition) Appendix A, Natural England, Oct 2021*

The embodied carbon values for the Eastern and Western routes were divided by the sequestration values above. The results are shown in Figure 10, and give an indication of the approximate land take, in hectares, required for each option.

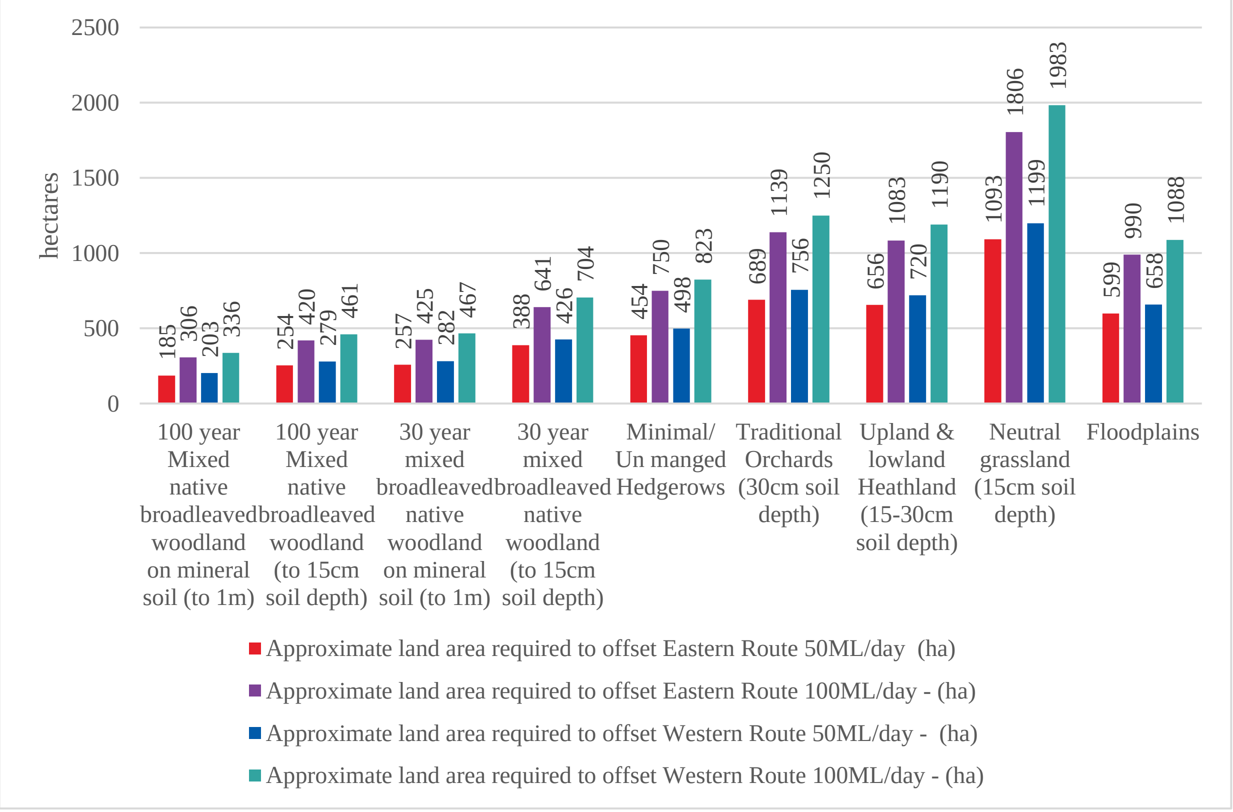


Figure 10. Approximate land area required to offset the Eastern and Western routes.

Option B – Use local landowners and farmers to offset emissions

Option B requires the use of land owned by Affinity Water and Anglian Water, and therefore both companies would need to conduct an exercise internally to assess the viability of using their land assets to sequester carbon.

Once this review has taken place, and if Option A is not feasible, then a viable alternative would be to use land not owned by Affinity Water or Anglian Water to offset the emissions, for example local farmers. Co-benefits of this approach are that it provides an alternative source of income for farmers to allow them to diversify their incomes and, as part of the pipeline route may go through their land or interrupt their farming practices, paying them to use their land for sequestration allows them to be compensated for inconvenience caused by the scheme.

Platforms such as EnTrade, through which Affinity Water have previously collaborated to pay farmers to reduce the use of Metaldehyde on land, could be a viable method to pay farmers to capture carbon. Should this approach be selected, there would need to be a robust monitoring regime over an agreed timeframe, and long-term contractual agreements with landowners. This option should be explored during the stakeholder engagement stage should the scheme proceed.

3. Recommendations for Next Design Stages

- Conduct an analysis to assess whether reducing pipe diameters and increasing energy for pumping - due to increased head loss - results in a lower carbon solution.
- Include the use of low carbon materials, particularly pipe material in the procurement stage.
- Assess how renewable energy produced (solar, biogas etc.) by Anglian Water and Affinity Water can be used to offset the carbon on the A2AT scheme.
- Consider working with local landowners to create opportunities for carbon sequestration.
- Refine the carbon calculations as the design becomes more detailed (e.g., air valves, vehicle movements, telemetry, flowmeters, access roads, ancillary equipment in buildings etc.).
- Continually add to and update the carbon calculations as the construction and operation methods become clearer. Carbon calculations associated with vehicle movements should account for both outward and return journeys.