

Optimisation in Design



Our Presentations



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Agenda

- **Who and What is SPA?**
- **Required Outcome and Timing**
- **Phasing of Work**
- **Model and Optimiser Setup**
- **Validation and Outputs**
- **Benefits of Optimiser**



Who is SPA?

Project 13
programme
made of 5
partners:

Farrans

Jacobs

Mott MacDonald Bentley

Costains

Anglian Water



Brought together to deliver the Water Resource
Management Plan



strategic
pipeline
alliance



What is SPA?

Strategic Pipeline Alliance set up to address Anglian Water's WRMP19

Water Resource Management Plan needs as follows:

- Drought resistant (1:200) water supply
- Accommodate future Growth, Climate Change and Sustainability Reductions
- Provide Resilience to various water treatment works

How?

Pipeline interconnectors from Elsham to Colchester

Anglian Water's Water Resources Management Plan 2019

Water Resources in the east of England are under increasing pressure from a rapidly growing population, climate change and environmental needs. There is also a significant and growing risk of severe drought. We need to act now to address these challenges.

Population growth

- We serve 20% more properties now than we did in 1998.
- Regional population is expected to increase by 20% over the next 25 years compared with population levels in 2011-12.
- Total impact is 109 Mlrd by 2045.

Climate change

- Climate change is one of the most significant threats we face.
- Total impact is 58 Mlrd by 2045.

Environmental needs

- Our region is environmentally sensitive and home to many internationally important wetland ecosystems that need protecting.
- We need to reduce our abstractions to prevent actual or potential environmental harm.
- Total impact is 85 Mlrd by 2045.

Drought resilience

- Our customers have told us that the use of severe restrictions is not appropriate or acceptable.
- But parts of our system are vulnerable to severe drought, so we need to act now to reduce this risk.
- Total impact is 26 Mlrd by 2045.

Supply-demand balance in 2045 (Mlrd)

Water Resource Zone	Supply	Demand	Balance
1	100	100	0
2	100	100	0
3	100	100	0
4	100	100	0
5	100	100	0
6	100	100	0
7	100	100	0
8	100	100	0
9	100	100	0
10	100	100	0
11	100	100	0
12	100	100	0
13	100	100	0
14	100	100	0
15	100	100	0
16	100	100	0
17	100	100	0
18	100	100	0
19	100	100	0
20	100	100	0
21	100	100	0
22	100	100	0
23	100	100	0
24	100	100	0
25	100	100	0
26	100	100	0
27	100	100	0
28	100	100	0

The scale of the challenge...

- The total impact on our supply-demand balance is 204 Mlrd by 2045.
- There is a total regional deficit of 144 Mlrd by 2045.

Our Preferred Plan

Demand management is our priority:

- Managing demand and reducing leakage is a customer, government and regulatory priority.
- It saves water that would otherwise be abstracted from the environment, treated and pumped through our network.
- It is required to ensure the reliability, sustainability and affordability of water resources over the long-term.

We have developed an ambitious, cost beneficial demand management strategy that will more than offset the effects of growth.

Total estimated demand savings of up to 43 Mlrd by the end of AHP7 (2020-25) and 123 Mlrd by the end of the planning period (2045).

Our strategy consists of:

- Leakage reduction (including 23% decrease by 2025 and 42% decrease by 2045)
- Installing smart meters across our region
- Innovative water efficiency schemes including behavioural change initiatives.

Smart metering

The next step-change in demand management will be achieved through technological innovation, including smart metering.

Smart meters can reduce demand in several ways:

- They allow us to identify customer supply pipe leaks (COPs) and internal plumbing issues. We can then notify customers proactively of the leak so that they can fix it, saving both water and money.
- Customers with a smart meter save 2% more water than those with a dumb meter, but the savings can be much greater if the smart meters are introduced alongside behaviour change initiatives.

There is no supply-demand deficit in Hartlepool and therefore no selection supply-side options.

Our Revised dWRMP is...

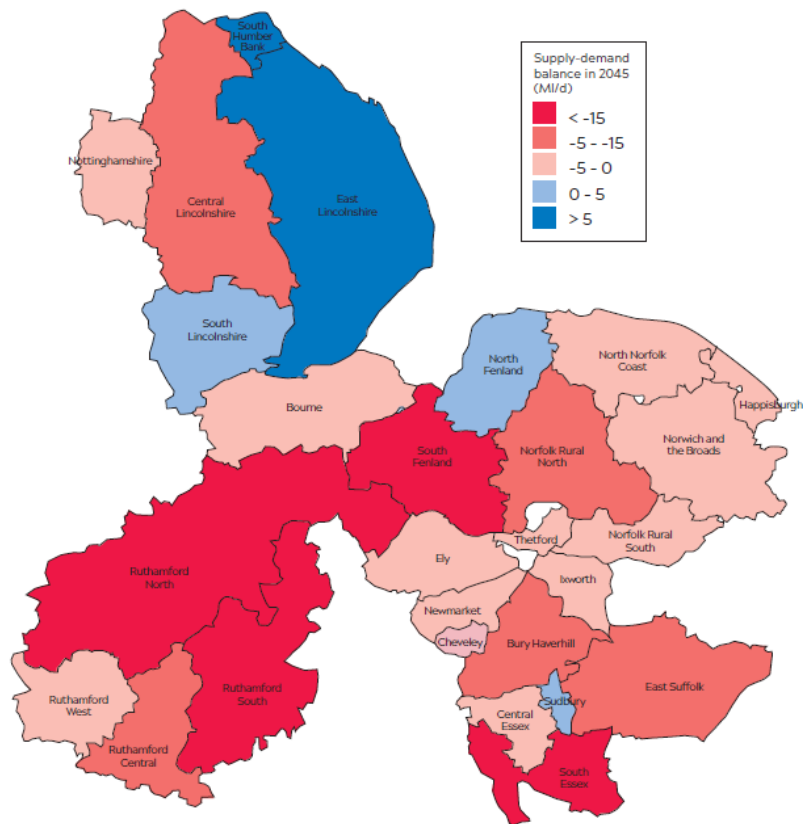
Reliable	Sustainable	Affordable
<ul style="list-style-type: none"> Resilient to severe drought, ensuring no customers would experience stand pipes or rota cuts in a 1 in 200 year drought. Adapting to climate change impacts from 2020. 	<ul style="list-style-type: none"> Prioritises demand management. Makes best use of existing resources. Protects and enhances the environment through sustainability reductions. Supports regional growth. 	<ul style="list-style-type: none"> Identifies the 'best value' solutions to our region's challenges. The majority of our customers think our plan is affordable, and we offer a comprehensive package of support for those who struggle to pay their bills.

<https://www.anglianwater.co.uk/siteassets/household/about-us/wrmp-report-2019.pdf>



Outcomes Requirement

Baseline supply-demand balance in 2044-45 (DYAA scenario)



To meet the deficit in the following zones.

Provide resilience to 20 water treatment works by connecting into them.

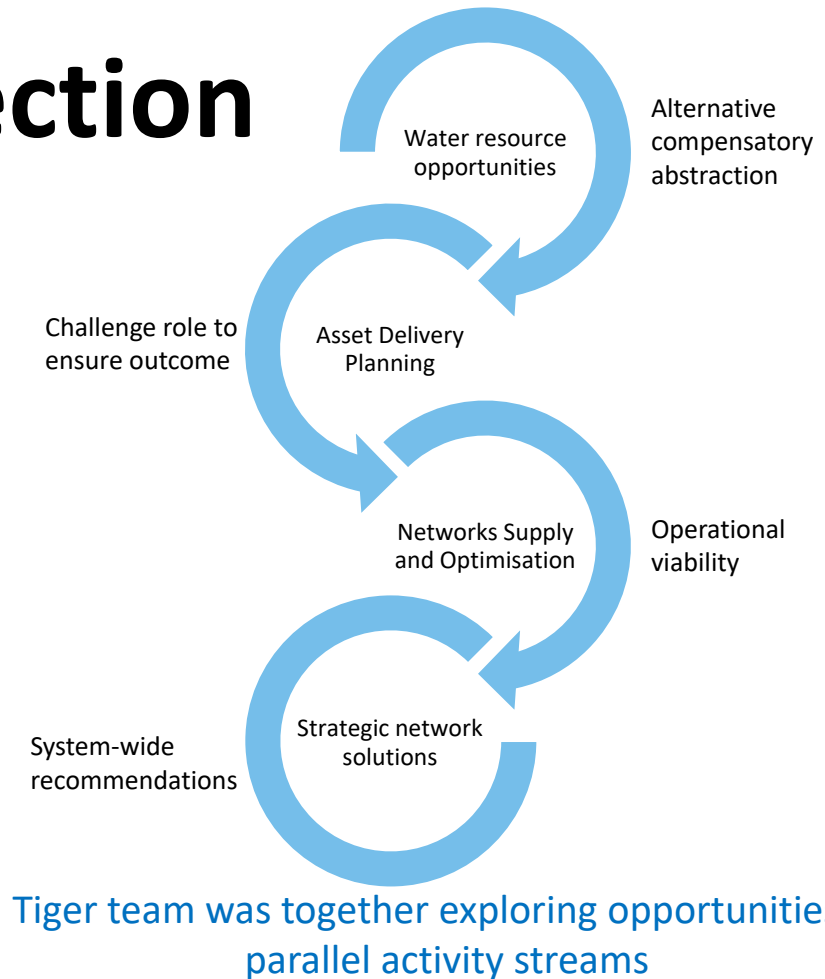
Timeline

- Sprint to construction required an accelerated timeline
- Impossible to achieve using traditional modelling approaches
- 4 months from WRMP flows to recommended sizing

	Owner	Reviewer	Comments	Individual Actions	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Wk13	Wk14	Wk15	Wk16	Wk17	Wk18	Wk19
Model Planning / Strategy	Strategic Modelling Strategy and plan	SC	VA / CR																				
	Change and version control including record of assumptions	SC	VA / CR / ST																				
	Review and check of existing models and all input data	CR																					
	Define Hydraulic design Cases including failure modes	SC																					
	Define network model cases	VA/ CR																					
	Define extents of strategic model	VA/ CR																					
Flow Rates and Demands	Define conditioning Strategy	CR																					
	Confirm existing sites turn down and up	SC																					
	Control requirements	VA/ CR	MC																				
	Aquator / EBSD - System maximum capacity																						
	Aquator - Utilisation levels at various intervals																						
	Aquator Resilience design flow rates																						
Model Prep	Mixer - Resilience design flow rates																						
	QA and Formal Agreement/Signoff	VA/CR																					
	Design Freeze																						
	Extend the strategic model																						
	Update with defined flow scenarios from Aquator																						
	Model conversion, data cleansing and model validation			Optimatics work																			
Model Run in Optimiser	Update model for Control requirements																						
	QA and Formal Agreement/Signoff																						
	Agree Optimiser penalties																						
	Agree pipeline sizing criteria																						
	Agree WR sizing criteria																						
	Model for Controls																						
	Optimatics (strawman runs)																						
	Primal exam answers																						
	Pipe Diameter Manual Calcs																						
	Model runs including validation																						
WR sizing																							
Pipeline sizing																							
System curves for pump selection																							
QA and Formal Agreement/Signoff																							
Flow																							

Phase 1 - Outline Direction

- ✓ Strategic Pipeline Alliance set up to address WRMP19 needs as follows:
- ✓ Drought resistant (1:200) water supply
- ✓ Accommodate future Growth, Climate Change and Sustainability Reductions
- ✓ Provide Resilience to various water treatment works



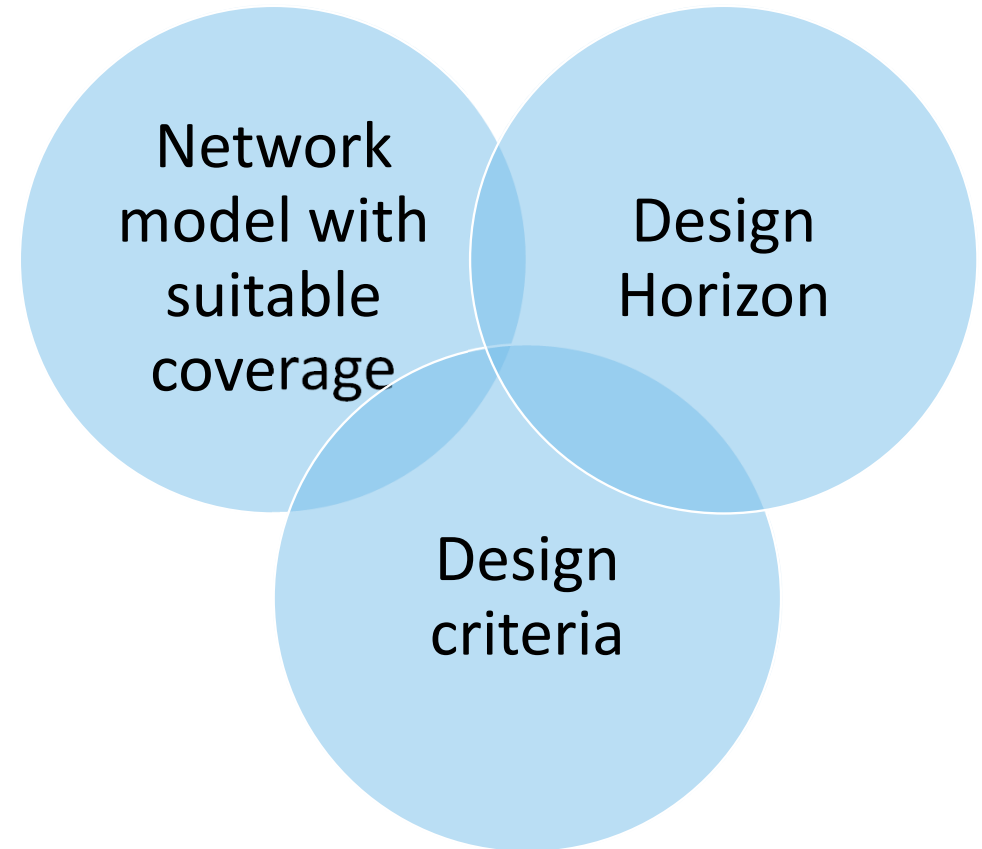
Phase 1 - Outline Direction

- We needed:
 - Aquator modelling
 - Network modelling
 - Operational buy-in
 - Governance procedure
 - Timescales

Phase 2 - Flows, model and formulation

On agreement on the general direction, we now needed:

- Suitable hydraulic network model
- The criteria to make a decision
 - Constraints
 - Costs (financial and carbon)
 - Scenarios
- A design horizon



Design Horizon

Water Resources Flows

Multiple runs to include Average Day demands, peak day demands, Resilience demands and failure modes.

Aquator has output over 130 years of historical hydrological trends against:

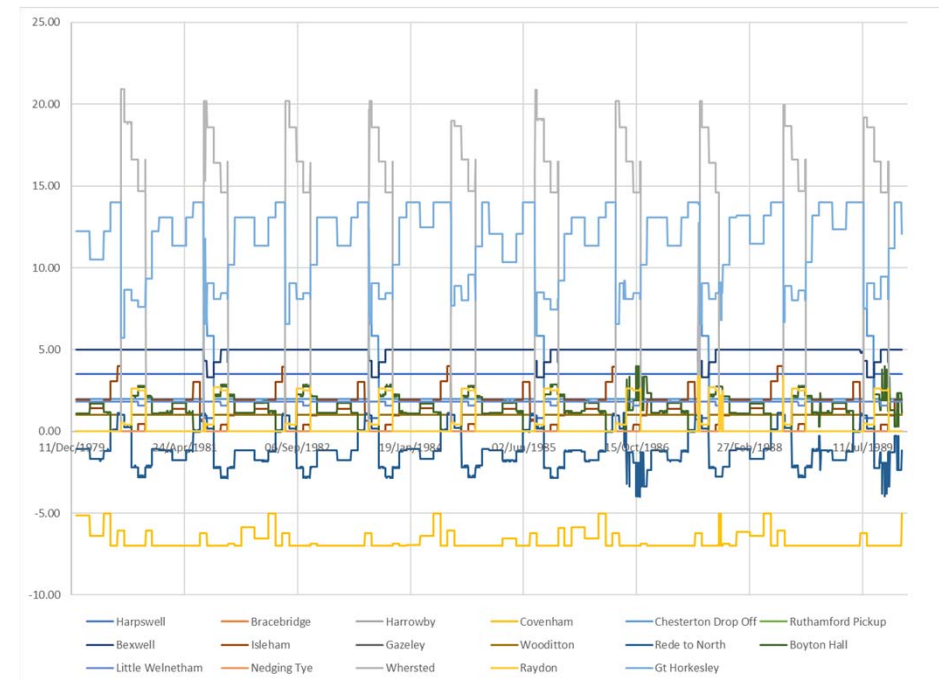
- ✓ DYAA
- ✓ NYAA
- ✓ Drought

Miser has given outputs regarding

- ✓ Resilience

The outputs show that the strategic grid will not be a static system, but rather a dynamic one that operates differently, not least of which time of year due to existing water source availability

Network modelling will need to overlay the above seasonal variations to further operational constraints



Design Horizon

Agreement of Flowrates

Broad mix of operating flows agreed with water resources and supply teams:

- 1:200 drought events
- Dry year and Normal year
- 2025 and 2045
- Seasonal variations
- Resilience scenarios

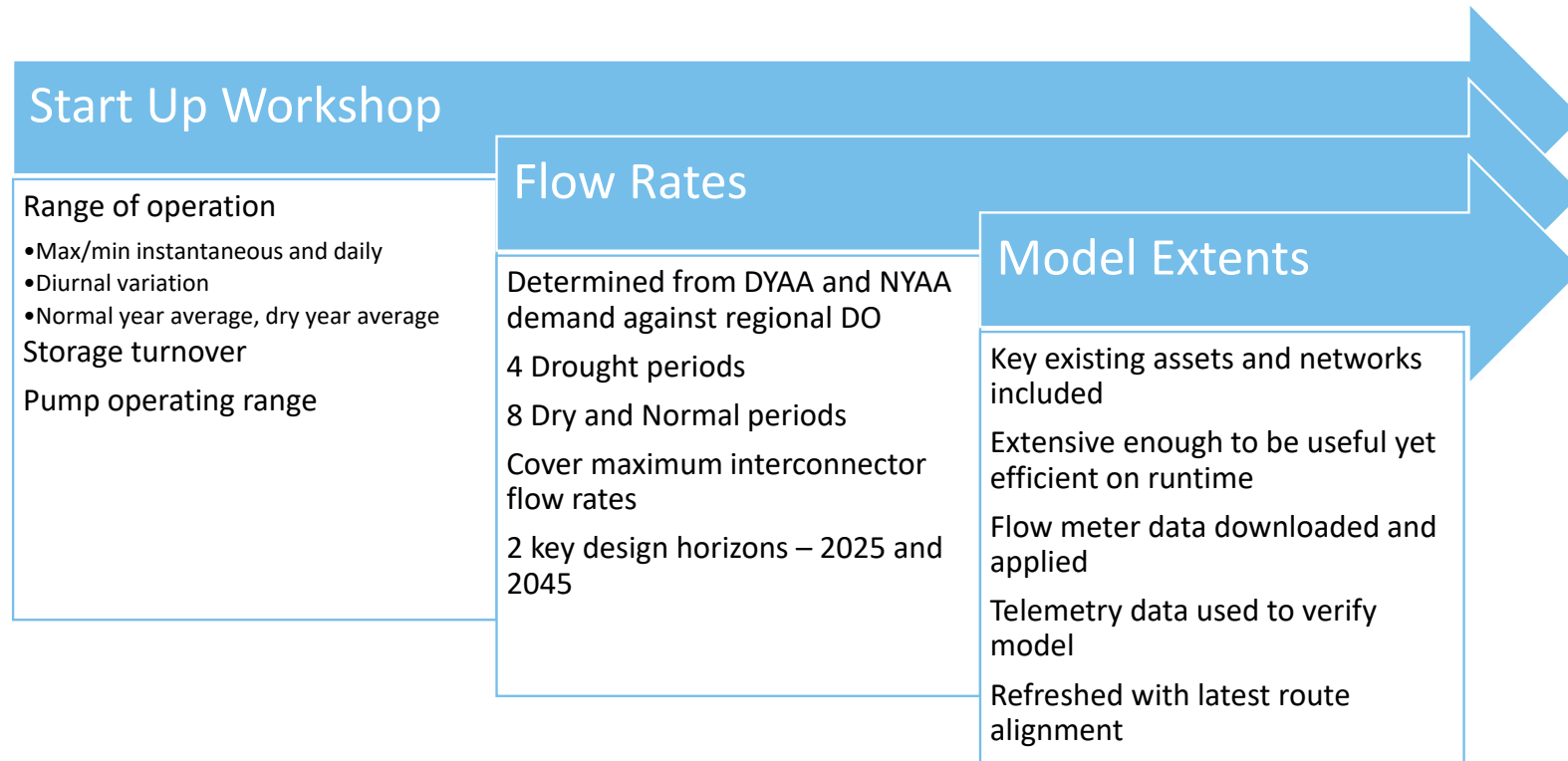
DD	Operational Interconnector Capacity	H5 - NY 2025					H6 - NY 2045					H7 - DY 2025					H8 - DY 2045																
		Demanded	Winter	Spring	Summer	Autumn	Demanded	Winter	Spring	Summer	Autumn	Demanded	Winter	Spring	Summer	Autumn	Demanded	Winter	Spring	Summer	Autumn												
Elisham to Welby		16	15	23	20	15.87	21.53	13	12	20	17	12.67	18.33	55	33	37	54	54.46	34.99	54	33	35	54	53.87	34.20								
Notts	19.3	19.9	0.8	0.8	2.2	0.8	1.1	0.80	1.49	20.1	0.8	0.4	2.4	0.0	0.9	0.61	1.21	21.1	1.8	1.3	3.4	0.5	1.1	1.12	2.38	21.1	1.8	1.4	3.5	0.5	1.1	1.17	2.43
Lincoln		0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
Grantham	31.0	25.8	0.0	0.0	0.0	0.0	0.0	0.00	0.00	23.8	0.0	0.0	0.0	0.0	0.00	0.00	0.00	27.8	0.0	0.0	0.0	0.0	0.0	0.00	0.00	27.8	0.0	0.0	0.0	0.0	0.0	0.00	0.00
Welby to Eton		16	15	23	20	15.07	20.95	13	12	18	17	12.06	17.12	53	32	35	54	53.34	32.60	52	32	32	53	52.71	31.77								
Bourne (Input)	47.7	41.8	-7.0	-7.0	-7.0	-7.0	-7.00	-7.00	40.9	-7.0	-7.0	-7.0	-7.00	-7.00	44.9	-7.0	-6.2	-7.0	43.9	-6.9	-7.0	-6.6	-7.0	43.9	-6.82								
Peterborough		0.0	-2.0	-2.0	-2.0	-2.00	-2.00	1.50	0.0	-2.0	-2.0	-2.0	-2.00	-2.00	1.50	0.0	30.0	10.0	7.0	33.0	20.0	31.50	8.50	31.50	8.50								
Eton to Bexwell	48	25	24	29	22	24.07	25.55	22	21	27	19	21.06	22.67	30	29	32	28	28.84	30.69	29	29	32	27	28.21	30.09								
Bexwell	23.0	29.1	2.9	2.3	5.2	1.2	3.1	2.63	3.21	27.9	1.7	1.2	4.0	0.1	1.7	1.45	2.01	31.0	4.8	4.2	7.3	3.0	3.89	5.75	31.0	4.2	3.6	6.7	2.4	3.32	5.14		
Bexwell to Rede	20	22	21	24	20	21.44	22.31	20	19	23	19	19.63	20.61	25	25	25	25	24.95	24.94	25	25	25	24.95	24.95									
Ely	20.9	18.4	0.0	0.0	0.0	0.00	0.00	18.6	0.0	0.0	0.0	0.00	0.00	20.0	0.0	0.7	0.0	20.0	0.0	1.2	0.0	0.0	0.00	0.58									
Newmarket	15.0	10.9	0.0	0.0	0.0	0.00	0.00	10.9	0.0	0.0	0.0	0.00	0.00	11.9	0.0	0.0	0.0	11.8	0.0	0.0	0.0	0.00	0.00	0.00									
Woodlton	1.6	1.9	0.3	0.2	0.4	0.2	0.36	0.30	1.7	0.1	0.1	0.2	0.1	0.09	0.13	0.0	0.4	0.3	0.5	0.3	0.3	0.31	0.43	1.8	0.2	0.2	0.4	0.1	0.16	0.26			
Haverhill (Rede)	7.0	10.1	3.1	2.9	3.9	2.5	3.1	3.03	3.23	9.7	2.7	2.5	3.5	2.1	2.7	2.63	2.83	10.6	3.6	3.4	4.4	2.9	3.25	3.89	10.6	3.4	3.2	4.2	2.8	3.06	3.69		
Rede to Little Welnehan	20	18	18	18	18	18.16	18.92	17	17	19	16	16.89	17.66	21	21	22	22	21.29	20.29	21	22	19	22	21.67	20.41								
Rushbrooke (Little Welnehan)	13.9	21.1	7.2	7.2	7.2	7.20	7.20	20.0	6.1	6.1	6.1	6.1	6.10	6.10	22.5	8.6	8.6	8.6	8.6	8.6	8.6	8.60	8.60	21.9	8.0	8.0	8.0	8.0	8.00	8.00			
Theford/Ixworth (Little Welnehan)	15.5	15.9	0.0	0.0	0.0	0.00	0.51	15.6	0.1	0.0	1.3	0.0	0.4	0.05	0.67	16.3	0.8	0.5	2.1	0.0	0.8	0.39	1.27	16.0	1.4	1.1	2.8	0.4	0.92	1.94			
Little Welnehan to Raydon / Wharfedale	20	11	11	12	11	10.96	11.11	11	11	11	10	10.74	10.86	12	12	9	13	12.40	10.42	12	13	9	14	12.75	10.48								
Ipswich	65.7	65.5	4.0	4.0	4.0	4.00	4.00	65.4	4.0	4.0	4.0	4.00	4.00	65.5	4.0	0.9	0.0	65.8	0.7	1.00	0.45	0.77	34.1	32.2	32.2	65.9	3.20	4.75					
Raydon (or split between Semer & Raydon)	0.0	0.0	7.5	7.4	8.1	7.1	7.46	7.63	7.8	7.2	7.9	6.9	7.3	7.24	7.38	8.3	7.8	7.7	8.5	7.4	7.69	8.07	8.3	8.0	7.8	8.6	7.5	8.1	7.75	8.23			
Raydon to Gt Horkeley	15	3	3	3	3	2.50	2.50	3	3	3	3	2.50	2.50	3	4	0	5	3.80	1.90	7	7	7	7	7.00	7.00								
South Essex	56.0	56.7	2.5	2.5	2.5	2.50	2.50	57.7	2.5	2.5	2.5	2.50	2.50	57.7	2.8	3.6	0.2	4.8	3.8	3.80	1.90	6.2	7.0	7.0	7.0	7.00	7.00						

Location	Season	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10	Run 11	Run 12
		Whole Life Costs											
1:200 Drought H8 DY2045	Summer												
Drought in Notts, Lincoln, Woodlton, Haverhill, Rushbrooke and Theford	Autumn												
Drought in Ruthamford	Autumn												
Drought in Ipswich	Autumn												
Drought in Colchester	Autumn												
Winter/Spring NY 2025	2025												
Summer/Autumn NY 2025	2025												
Winter/Spring NY 2045	2045												
Summer/Autumn NY 2045	2045												
Spring/Summer DY 2025	2025												
Autumn/Winter DY 2045	2045												
Spring/Summer DY 2045	2045												
Drop Off Locations	Summer												
Notts	2.30												
Lincoln	20.00												
Grantham	-												
Bourne (Input)	-	7.00											
Peterborough	-	40.00											
Bexwell	15.00		2.40										
Ely	2.66												
Newmarket	2.00												
Woodlton	0.50												
Haverhill (Rede)	4.21												
Rushbrooke (Little Welnehan)	10.00												
Theford/Ixworth (Little Welnehan)	2.80												
Ipswich	7.20												
Raydon (or split between Semer & Raydon)	8.63												
South Essex	1.92												
TOTAL (Peterborough to Bexwell)	39.7		21.5										
TOTAL (East: from Bexwell)	24.7		19.1										



Design Criteria

Engagement



Network Model

The hydraulic model has been created from:

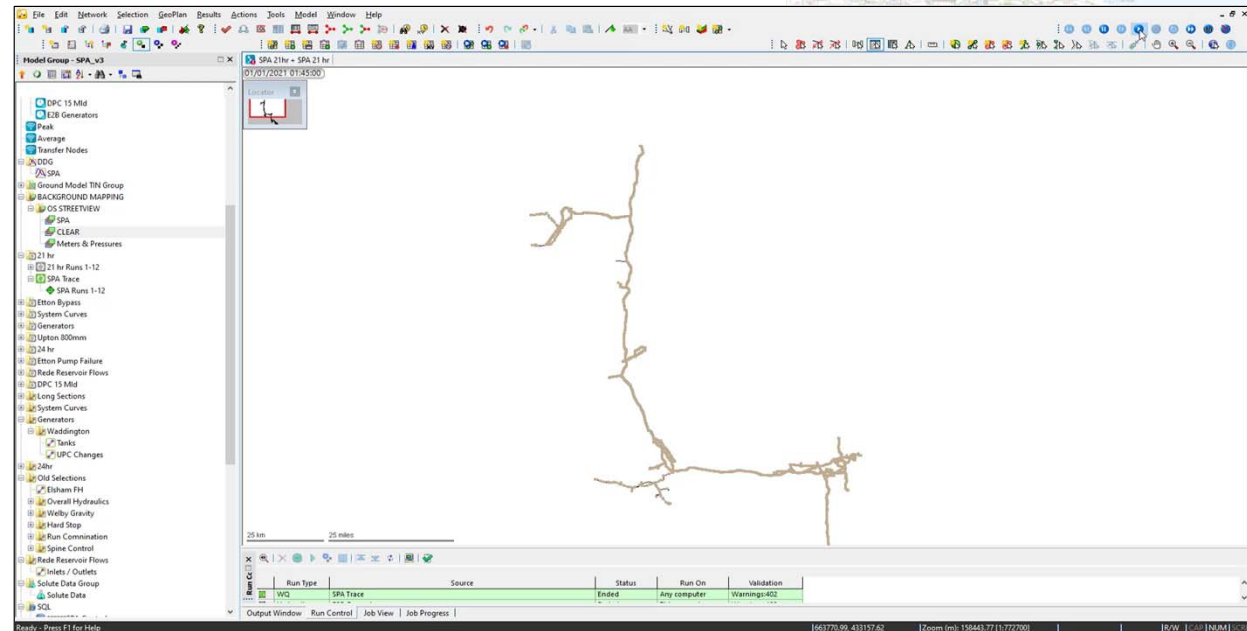
- The latest GIS extract of route alignment
- Existing regional network models captured collaboratively as to agreed extents
- Key existing sites included

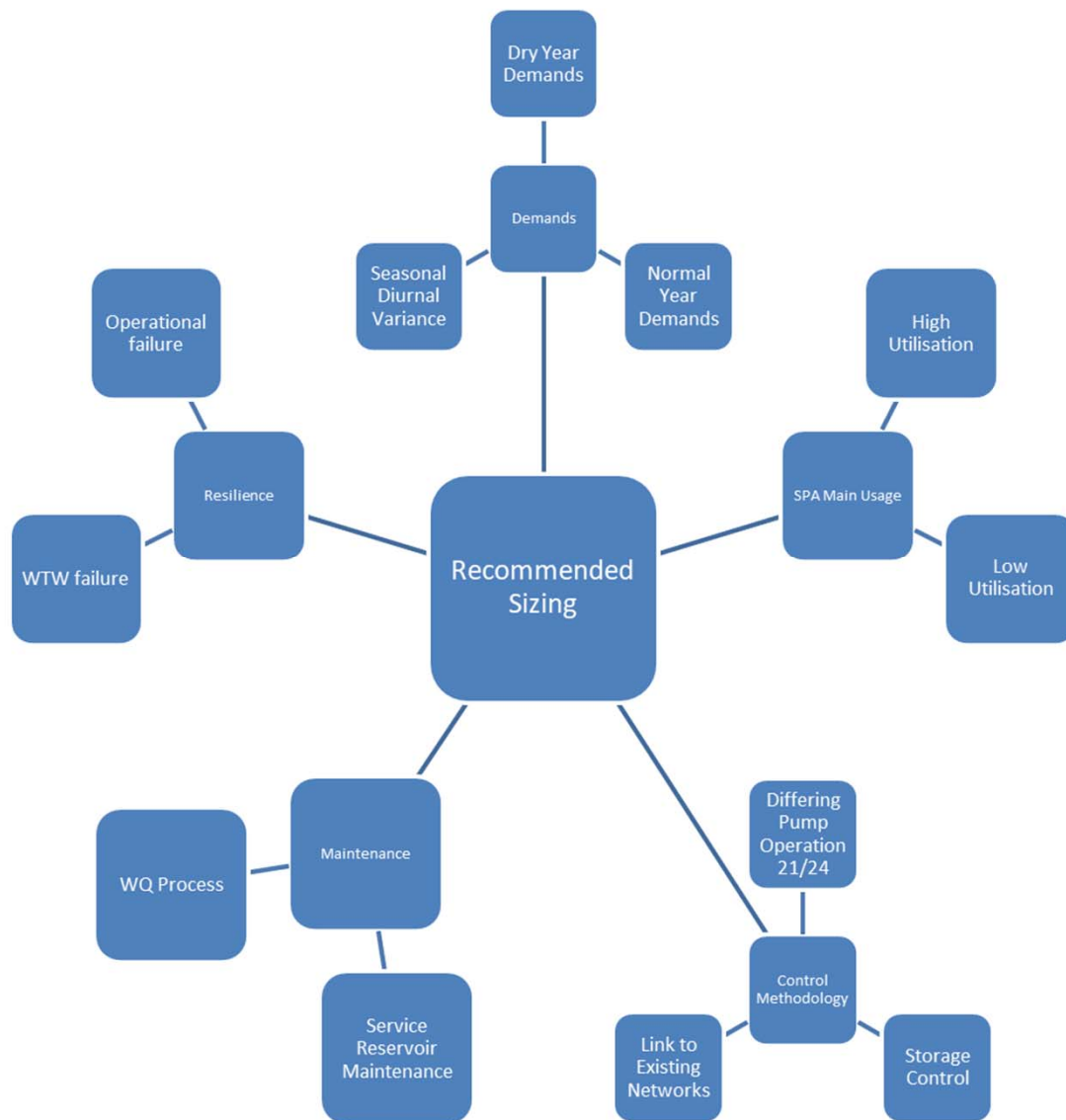
The model has been verified against:

- Telemetry level, flow and pressure data

Existing Schemes Captured:

- Most onerous of options for the existing schemes have been included
- Detailed modelling for each region is a parallel workstream
- Parallel workstreams have been coordinated with





Optimatics

- The definition of this range of scenarios is a multi criteria analysis
- Optimatics has been designed with this MCA in mind
- We can achieve the majority of our sizing through spreadsheets or engineering judgement; however we need to prove it works

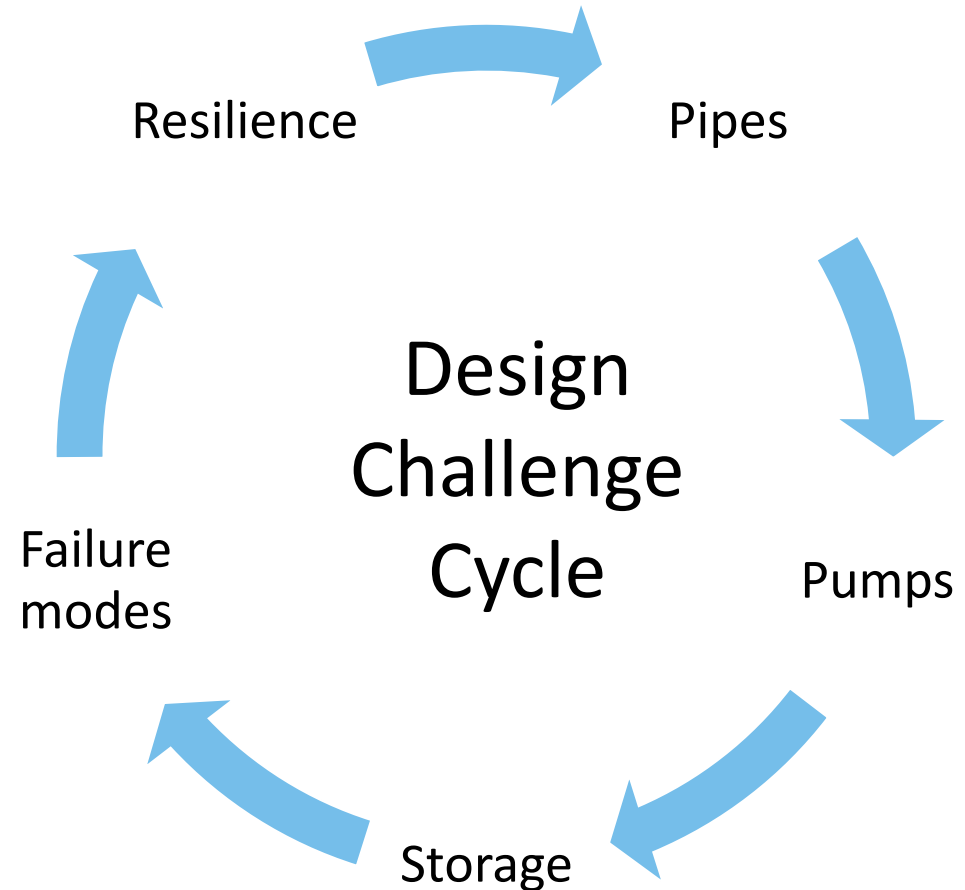
Phase 3 - Application and evolution

We now had:

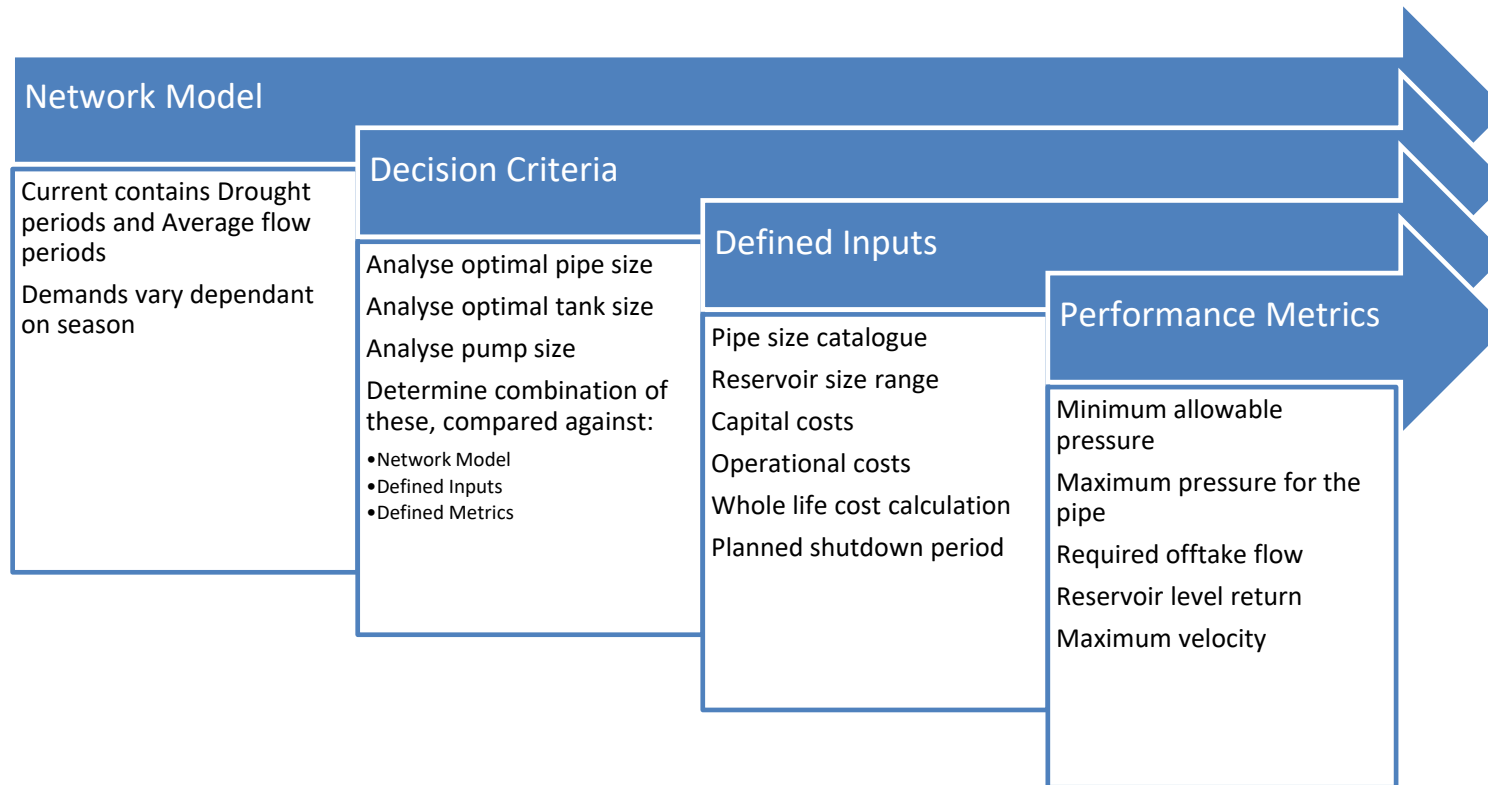
- A dynamic network model
- Cost catalogues
- Penalty ranges
- Sizing criteria

The designs have a natural iterative nature

- Bigger pipes = smaller pumps
- Failure modes = bigger pipes
- Cost drives = smaller pipes



Translation to Optimatics



Whole Life Cost

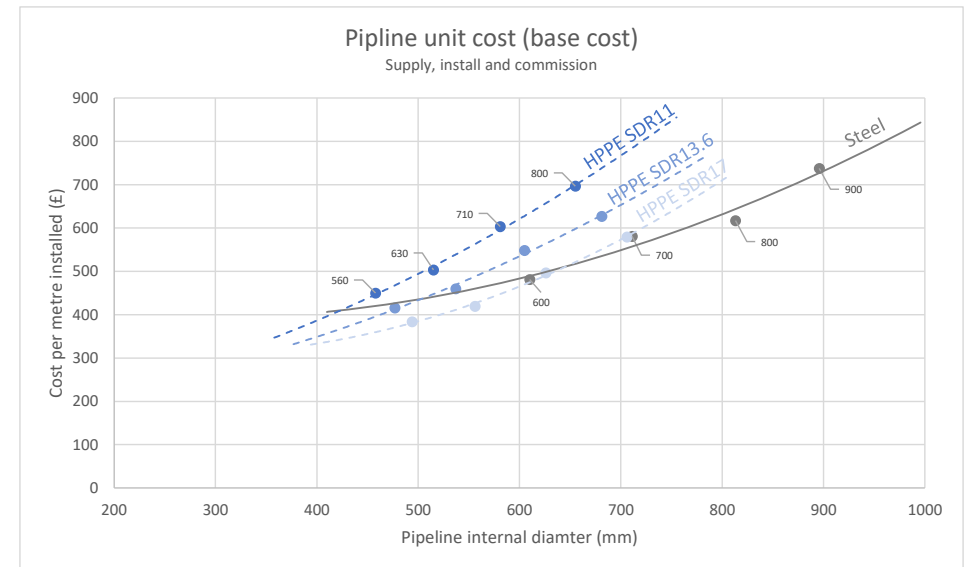
Headline parameters:

- SPA base CAPEX uplifted to outturn costs
- 40 year analysis period, 3.7% discount rate
- 2 days per year conditioning allowance
- Normal year : Dry Year → 2 : 5
- Seasonal variation
- Power cost: 12.1 p/kWh
- Replacement periods:
 - Civil assets: 50 years
 - PS M&E assets: 25 years
 - PS ICA assets: 10 years

Other parameters:

- PLM
- WR cleaning
- Insurance

Conditioning v Other	Cond.	Other								
	0.5%	99.5%								
2025 v 2045	n/a	2025				2045				
	100.0%	25%				75%				
	100.0%	43%				57%				
Normal v Dry year	n/a	Normal year		Dry year		Normal year		Dry year		
	100.0%	71%		29%		71%		29%		
Seasonal	n/a	Winter/ Spring config.	Summer/ Autumn config.	Winter/ Autumn config.	Spring/ Summer config.	Winter/ Spring config.	Summer/ Autumn config.	Winter/ Autumn config.	Spring/ Summer config.	
	100.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	
Proportions within a "representative" year		0.5%	15.1%	15.1%	6.0%	6.0%	20.4%	20.4%	8.2%	8.2%
Conversion of daily energy opex to WLC		365.25				21.71				



Numbers above are not actual and only indicative.

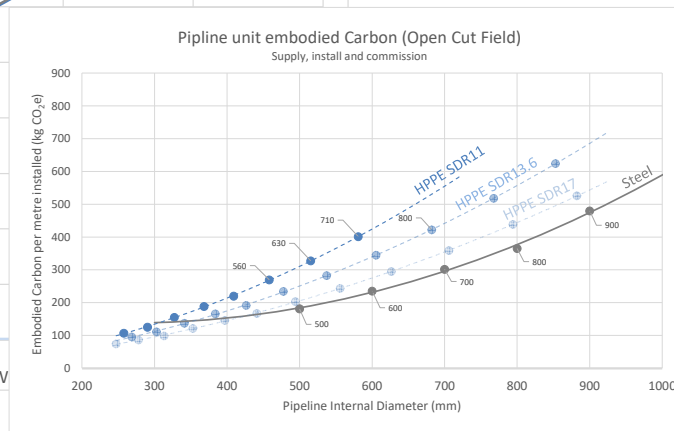
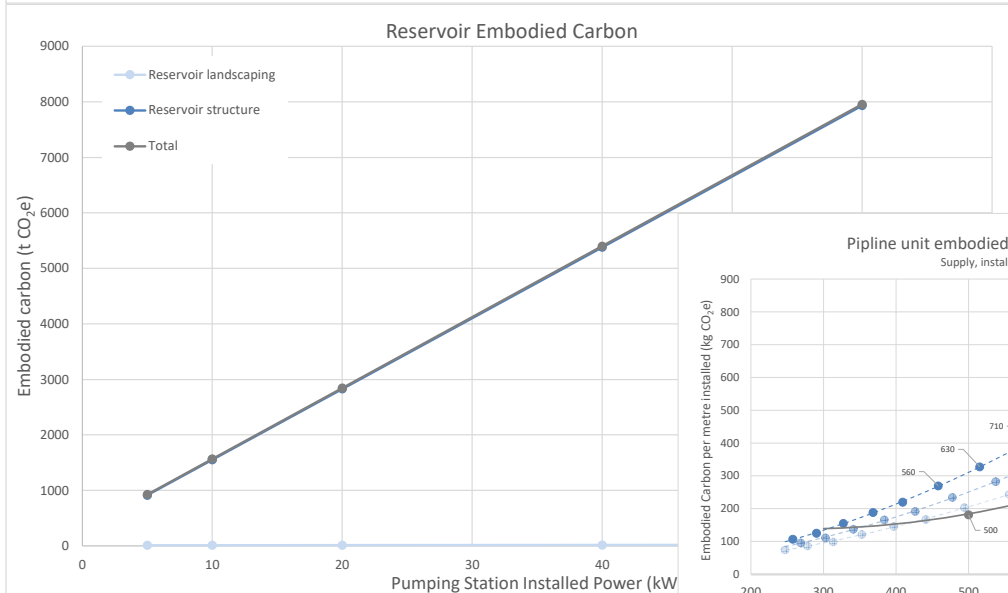
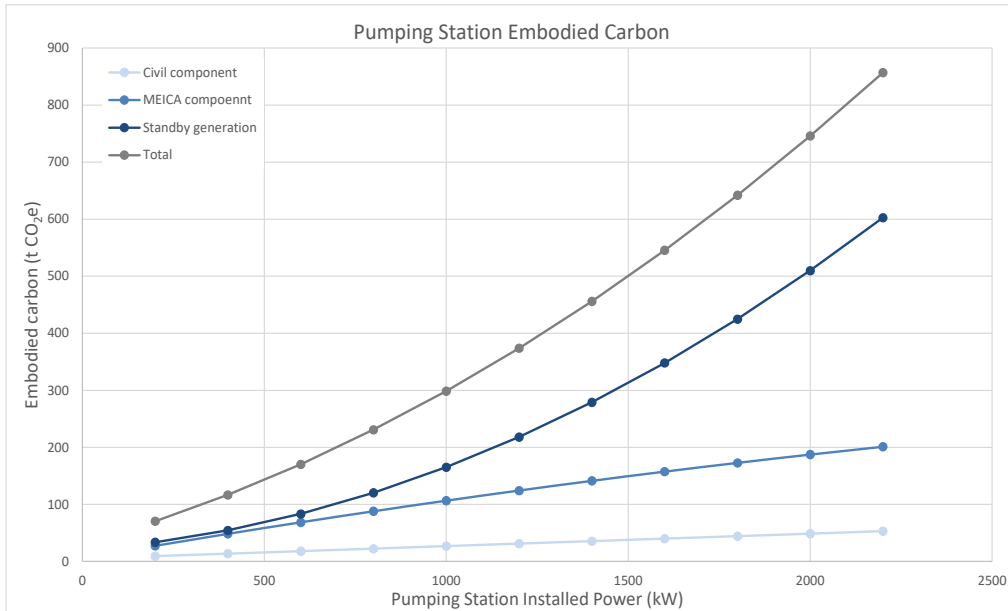


Carbon parameters

- Operational and Embedded Carbon
- Variation on pipe materials

“The entire pipeline has been designed to have the lowest carbon footprint possible in line with Anglian’s pledge to reach net zero carbon by 2030”

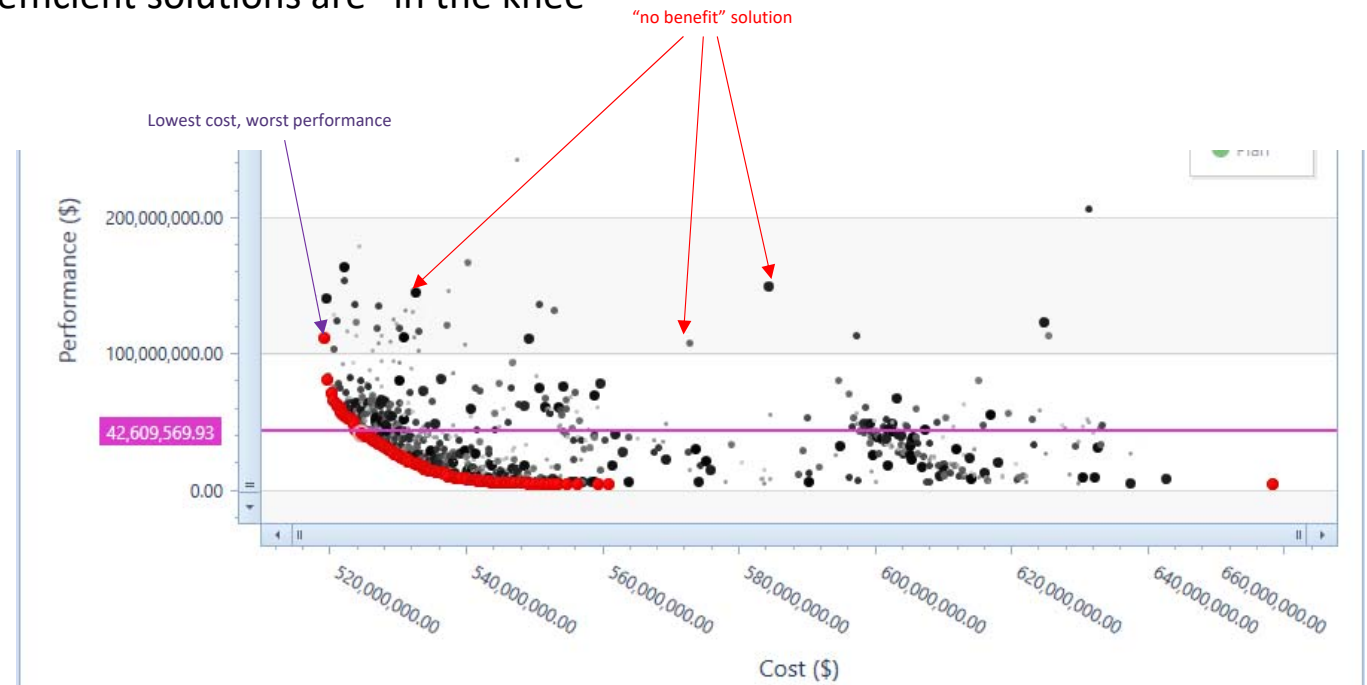
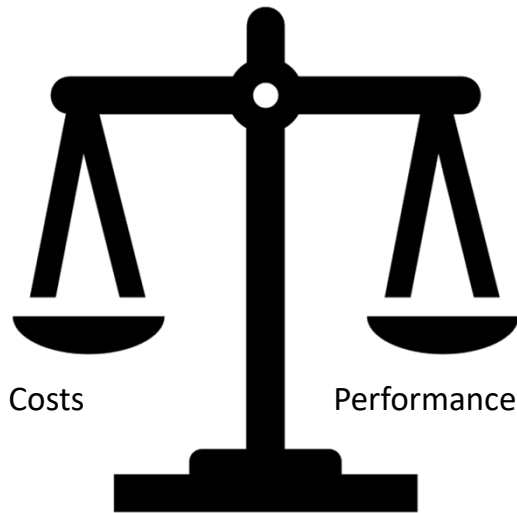
Significant financial saving for Anglian Water as part of their green bonds, requiring them to reach a carbon target of 65%



Optimatics Approach

The Optimatics algorithm will carry out analysis on all these criteria and inform on solution costs against performance within the hydraulic model

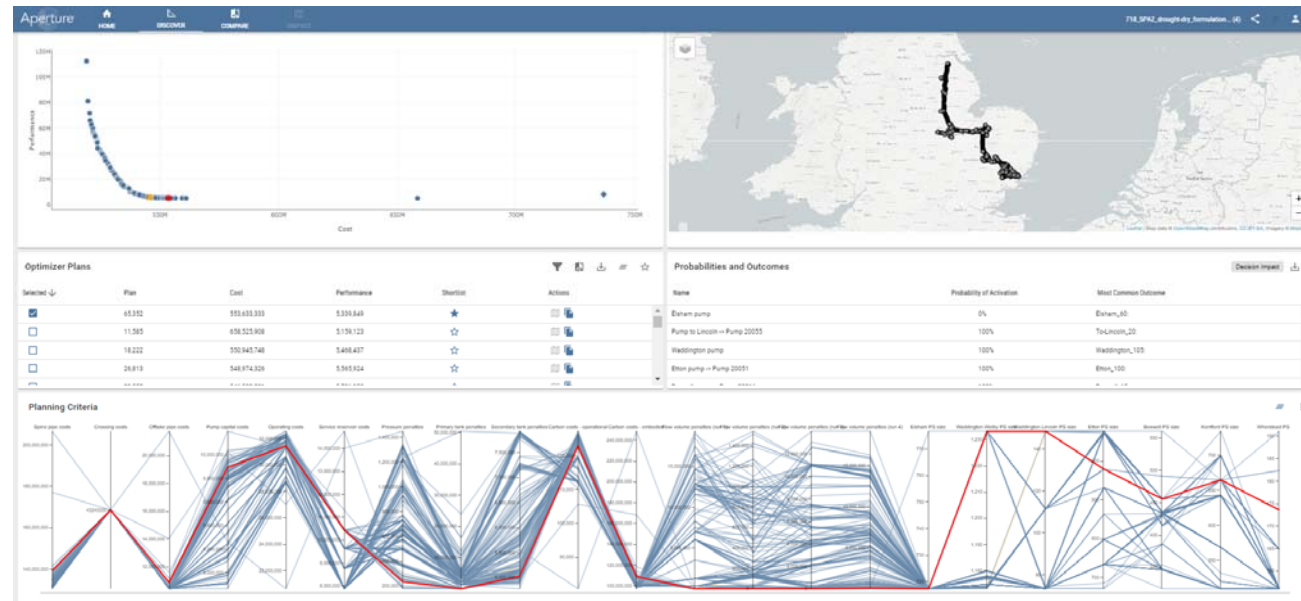
- For instance, the most expensive solution sacrifices nothing, but the cheapest solution doesn't work
- The Pareto curve shows the most efficient solutions are “in the knee”
- Not a “black box”



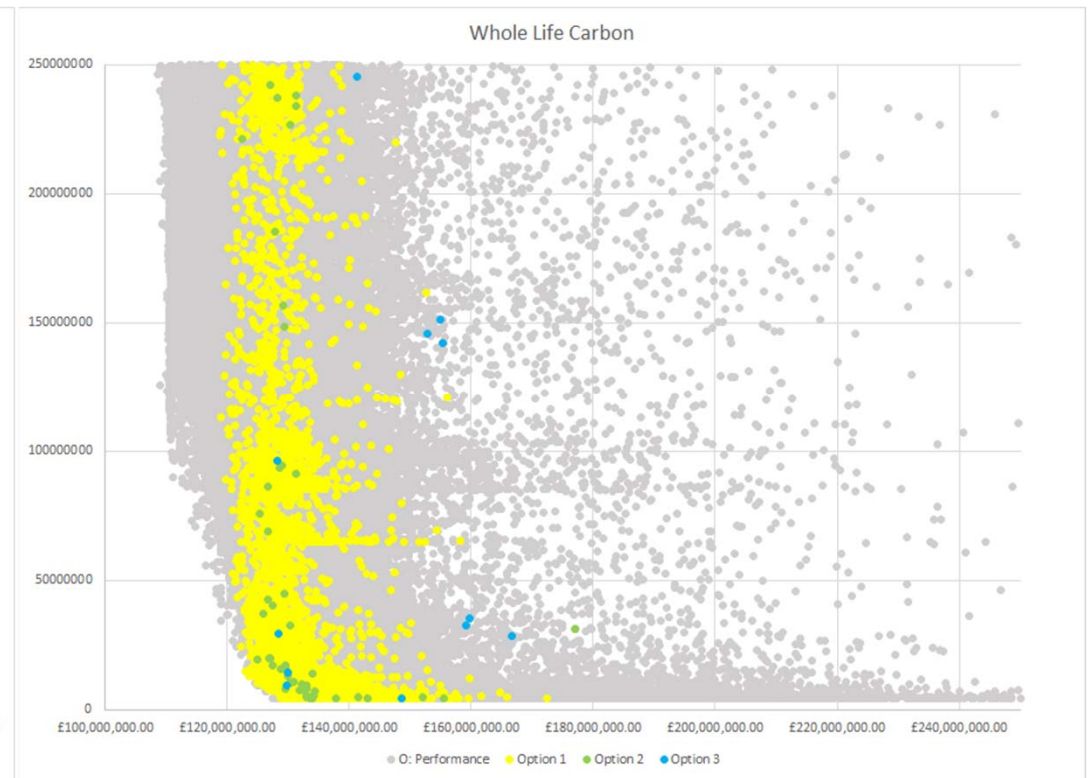
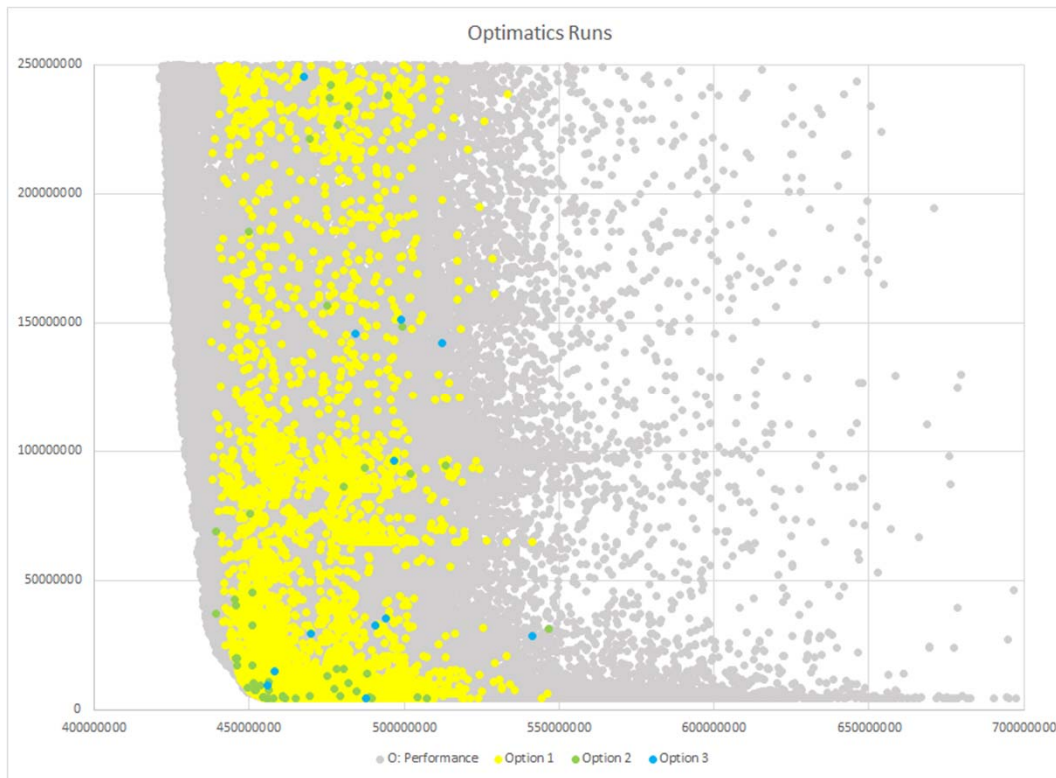
Optimatics – So how do we choose?

We have thousands of runs – how do we choose the right ones?

- Starting with Aperture
- We can decide what we are interested in
- We select those runs that meet it
- We can then dive further into those runs

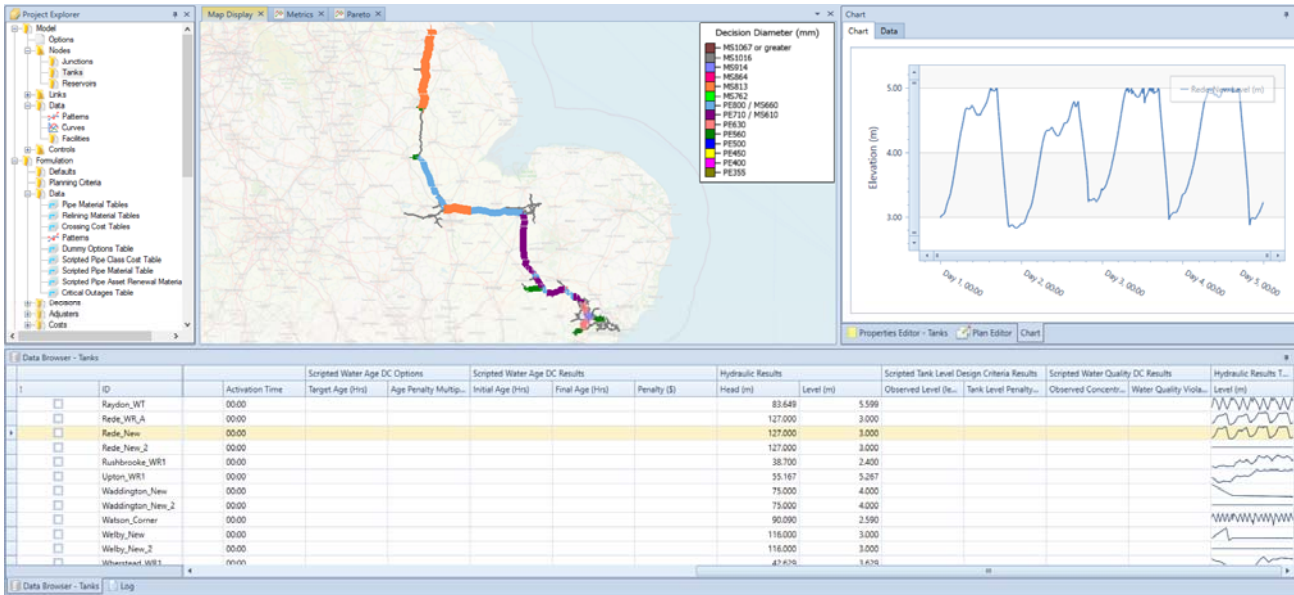


WL Cost and Carbon Pareto Charts of Options



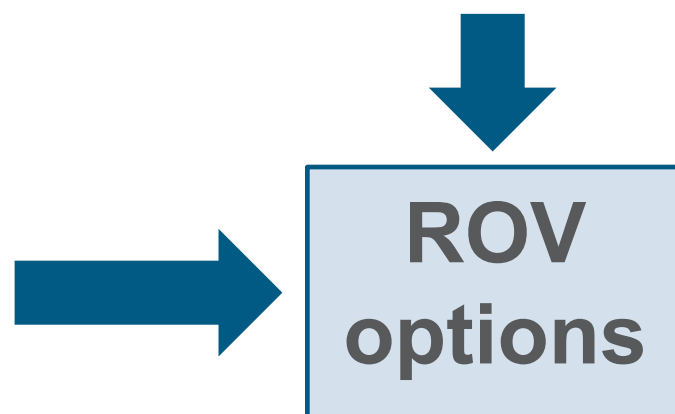
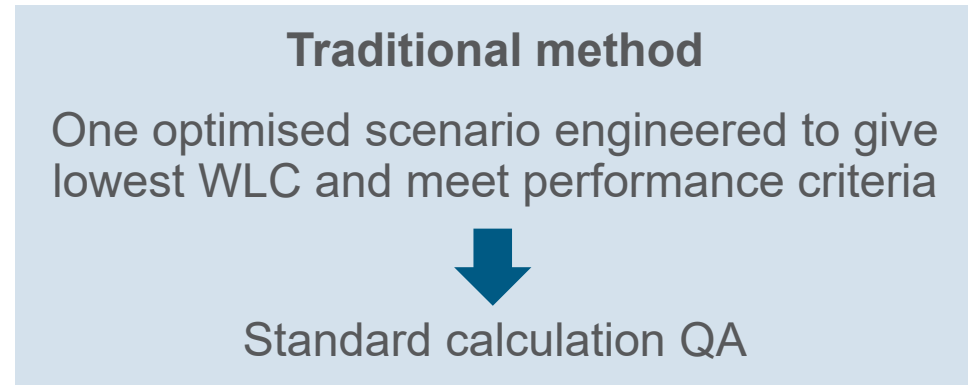
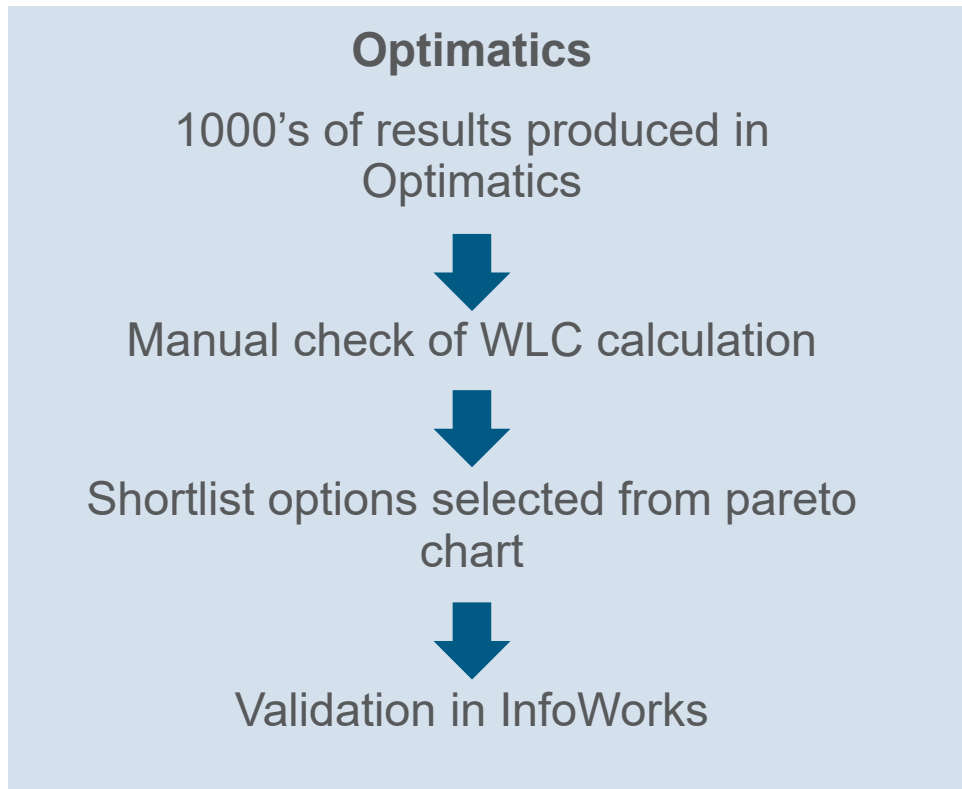
Optimatics – So how do we choose?

The software allows us to look at each plan in detail



	Pareto	Plan002	65352
Decision Outcomes			
Isleham intake -> 20	CT D: 473.2; ND: 300; CT: D: 491.8; ND: 300; CT: D: 597.4; ND: 710; CT:		
Isleham-Kentford -> 13	CT D: 553.2; ND: 630; CT: D: 597.4; ND: 610; CT: D: 597.4; ND: 610; CT:		
Kentford -> Tank Kentford_New	:0 35.7m, \$1311325.20	35.7m, \$1311325.20	35.7m, \$1311325.20
Kentford pump -> Pump 20049	Kentford_95:	Kentford_100:	Kentford_95:
Kentford-Gazeley -> 14	CT D: 597.4; ND: 610; CT: D: 597.4; ND: 610; CT: D: 645.8; ND: 660; CT:		
Gazeley-Woodditon offtake -> 15	CT D: 597.4; ND: 610; CT: D: 597.4; ND: 610; CT: D: 597.4; ND: 610; CT:		
Woodditon offtake -> 31	CT D: 491.8; ND: 560; CT: D: 491.8; ND: 560; CT: D: 491.8; ND: 560; CT:		
Woodditon offtake-Rede -> 16	CT D: 624.6; ND: 710; CT: D: 553.2; ND: 630; CT: D: 696.8; ND: 711; CT:		
Rede-Little Welnetham (1) -> 17	CT D: 553.2; ND: 630; CT: D: 553.2; ND: 630; CT: D: 624.6; ND: 710; CT:		
Rede -> Tank Rede_New	:0 35.7m, \$1311325.20	35.7m, \$1311325.20	35.7m, \$1311325.20
Rede-Little Welnetham (2) -> 18	CT D: 553.2; ND: 630; CT: D: 553.2; ND: 630; CT: D: 624.6; ND: 710; CT:		
Little Welnetham offtake -> 26	CT D: 491.8; ND: 560; CT: D: 491.8; ND: 560; CT: D: 553.2; ND: 630; CT:		
Little Welnetham-Nedging Tye (1) -> 19	CT D: 553.2; ND: 630; CT: D: 553.2; ND: 630; CT: D: 703.9; ND: 800; CT:		
Little Welnetham-Nedging Tye (2) -> 20	CT D: 534.5; ND: 630; CT: D: 491.8; ND: 560; CT: D: 624.6; ND: 710; CT:		
Nedging Tye-Hadleigh -> 21	CT D: 553.2; ND: 630; CT: D: 553.2; ND: 630; CT: D: 553.2; ND: 630; CT:		
Wherstead offtake -> 30	CT D: 475; ND: 560; CT: D: 475; ND: 560; CT: D: 475; ND: 560; CT: I		
Wherstead offtake-Raydon -> 23	CT D: 553.2; ND: 630; CT: D: 553.2; ND: 630; CT: D: 553.2; ND: 630; CT:		
Hadleigh-Wherstead offtake -> 22	CT D: 624.6; ND: 710; CT: D: 553.2; ND: 630; CT: D: 894; ND: 914; CT: I		
Raydon offtake -> 32	CT D: 603.4; ND: 710; CT: D: 475; ND: 560; CT: D: 645.8; ND: 660; CT:		
Raydon-Great Horkesley (1) -> 24	CT D: 475; ND: 560; CT: D: 475; ND: 560; CT: D: 534.5; ND: 630; CT:		
Raydon-Great Horkesley (2) -> 25	CT D: 491.8; ND: 560; CT: D: 491.8; ND: 560; CT: D: 491.8; ND: 560; CT:		
Wherstead pump -> Pump 20022	Wherstead_95:	Wherstead_90:	Wherstead_100:
Crossings -> Valve 31378	Setting: 0.00	Setting: 0.00	Setting: 0.00
Gazeley offtake -> 27	CT D: 650.54; ND: 800; C: D: 491.8; ND: 560; CT: D: 534.5; ND: 630; CT:		
Waddington pump	Waddington_105:	Waddington_100:	Waddington_105:
Waddington -> Tank Waddington_New	:0 50.5m, \$2189730.20	50.5m, \$2189730.20	61.8m, \$2986135.20
Pump to Lincoln -> Pump 20055	To-Lincoln_15:	To-Lincoln_15:	To-Lincoln_20:
Pipe class (offtakes) -> Active	Active	Active	Active
Waddington-Lincoln -> 5	CT D: 491.8; ND: 560; CT: D: 491.8; ND: 560; CT: D: 491.8; ND: 560; CT:		
Notts-Waddington (2) -> 4	CT D: 795.4; ND: 813; CT: D: 795.4; ND: 813; CT: D: 795.4; ND: 813; CT:		
Notts-Waddington (1) -> 3	CT D: 795.4; ND: 813; CT: D: 795.4; ND: 813; CT: D: 795.4; ND: 813; CT:		
Elsham-Notts (2) -> 2	CT D: 795.4; ND: 813; CT: D: 795.4; ND: 813; CT: D: 795.4; ND: 813; CT:		
Pipe class (spine) -> Active	Active	Active	Active
Elsham-Notts (1) -> 1	CT D: 795.4; ND: 813; CT: D: 795.4; ND: 813; CT: D: 795.4; ND: 813; CT:		

Validation



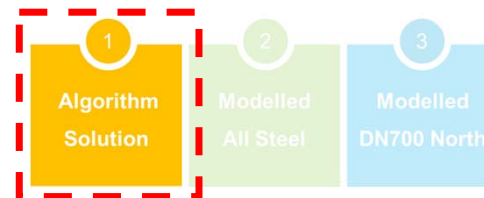
Option 1 – Algorithm Solution

Section	Dia / Material
Elsham to Cadney	DN800 Steel
Cadney to HGG offtake	DN800 Steel
HGG offtake to Waddington	DN800 Steel
Welby to Etton (Part a)	DN800 PE17
Welby to Etton (Part b)	DN800 Steel

Cost component	£m
CAPEX (whole spine, pipeline, PS + WR)	£384.1
OPEX (energy only NPV)	£15.2
OPEX (other, NPV)	£10.6
Whole Life Cost	£409.9

Carbon component	t CO ₂ e
Emb. carbon (whole spine, pipeline, PS + WR)	102,730
Carbon (operational)	22,621
Whole Life Carbon	125,351

Number above are not actual and only indicative.



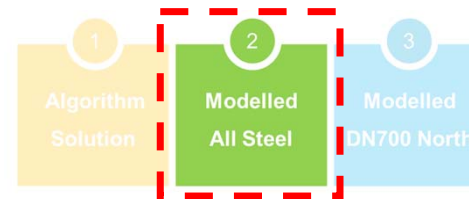
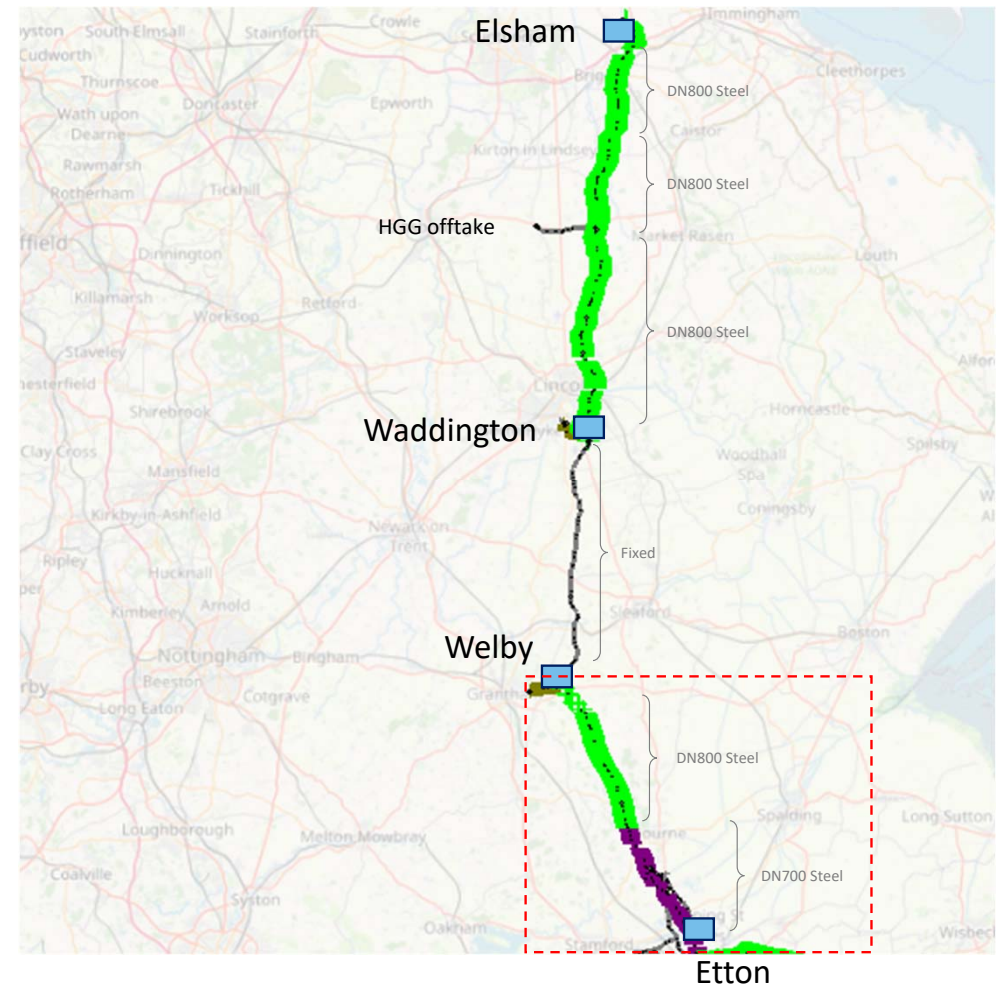
Option 2 – Modelled All Steel

Section	Dia / Material
Elsham to Cadney	DN800 Steel
Cadney to HGG offtake	DN800 Steel
HGG offtake to Waddington	DN800 Steel
Welby to Etton (Part a)	DN800 Steel
Welby to Etton (Part b)	DN700 Steel

Cost component	£m
CAPEX (whole spine, pipeline, PS + WR)	£424.1
OPEX (energy only NPV)	£15.2
OPEX (other, NPV)	£10.6
Whole Life Cost	£449.9

Carbon component	t CO ₂ e
Emb. carbon (whole spine, pipeline, PS + WR)	101,651
Carbon (operational)	23,621
Whole Life Carbon	124,172

Number above are not actual and only indicative.



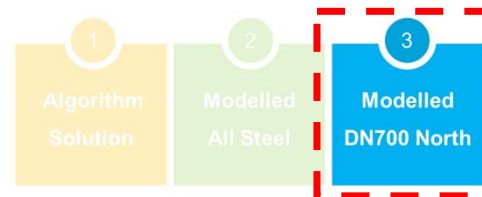
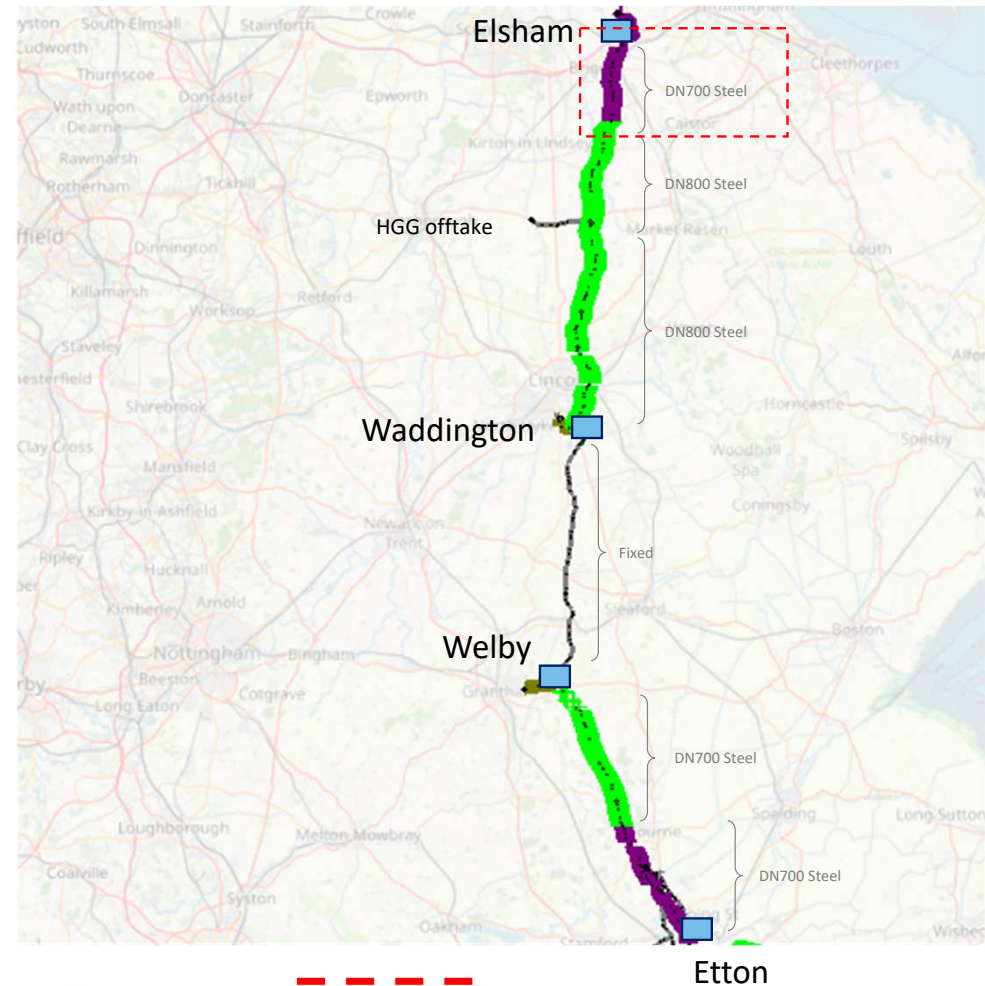
Option 3 – DN700 Steel North

Section	Dia / Material
Elsham to Cadney	DN700 Steel
Cadney to HGG offtake	DN800 Steel
HGG offtake to Waddington	DN800 Steel
Welby to Etton (Part a)	DN800 Steel
Welby to Etton (Part b)	DN700 Steel

Cost component	£m
CAPEX (whole spine, pipeline, PS + WR)	£413.7
OPEX (energy only NPV)	£36.3
OPEX (other, NPV)	£10.8
Whole Life Cost	£430.8

Carbon component	t CO ₂ e
Emb. carbon (whole spine, pipeline, PS + WR)	100,851
Carbon (operational)	24,380
Whole Life Carbon	124,231

Number above are not actual and only indicative.



Option summary – Cost and Carbon

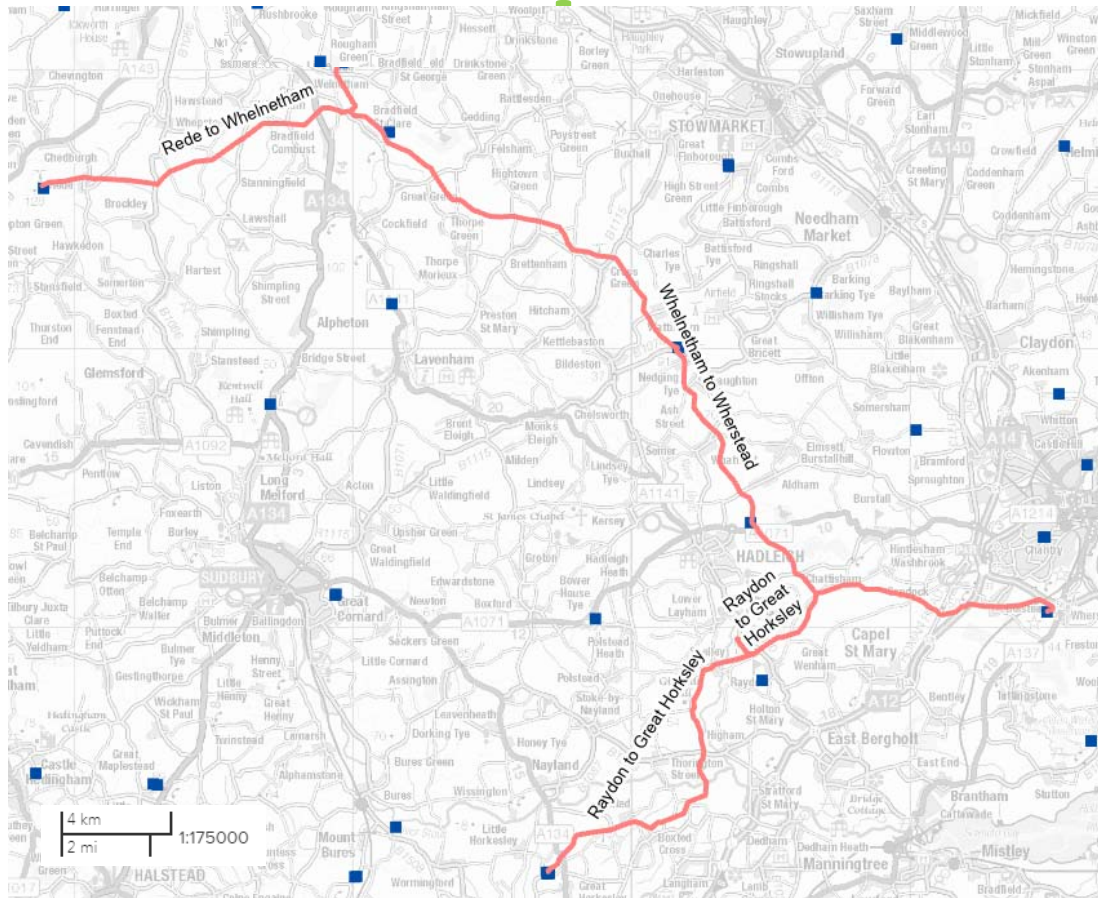
	1 Algorithm Solution	2 All Steel	3 DN700 North
CAPEX	£404.1 m	£424.1 m	£413.7 m
WL Cost	£409.9 m	£449.9 m	£430.8m
WL Carbon	125,351 t CO ₂ e	124,172 t CO ₂ e	124,231 t CO ₂ e

Note: The above table is for the entire scheme, however only the northern scope is being changed between the options.

Number above are not actual and only indicative.



Option 1.1: PS at Rede, Hadleigh



Cost components	£m
CAPEX (whole spine, pipeline, PS + WR)	56.088
OPEX (NPV, 40 years, 3.7%)	2.826
Whole Life Cost	58.914

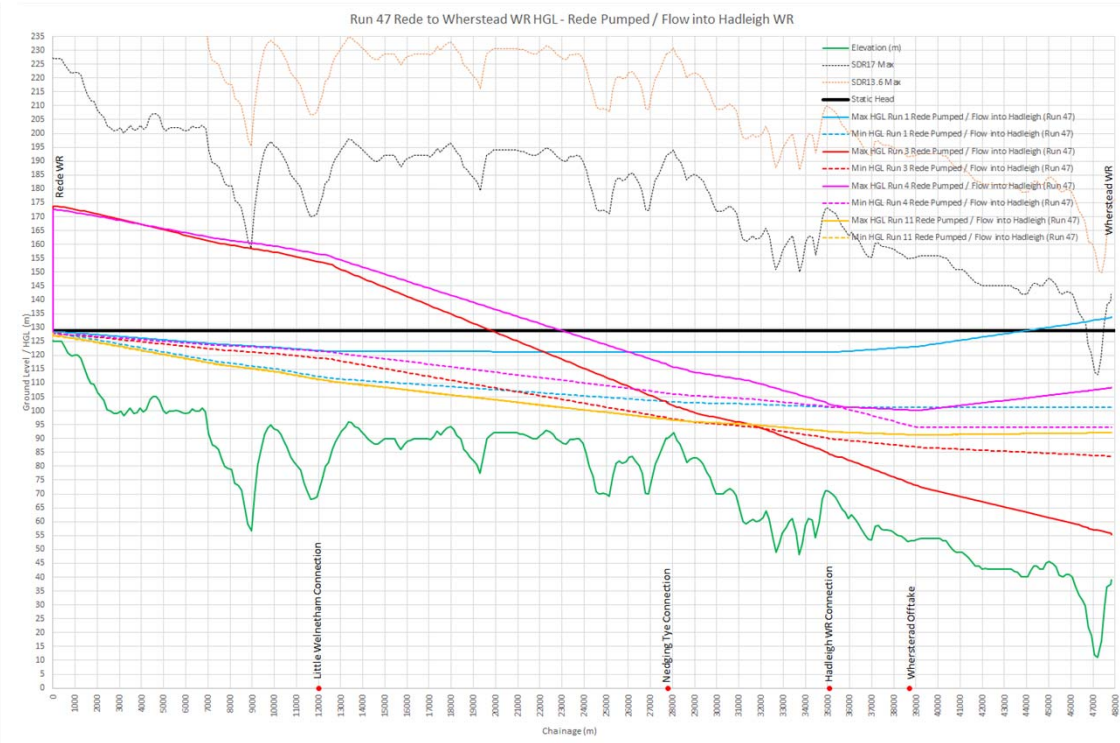
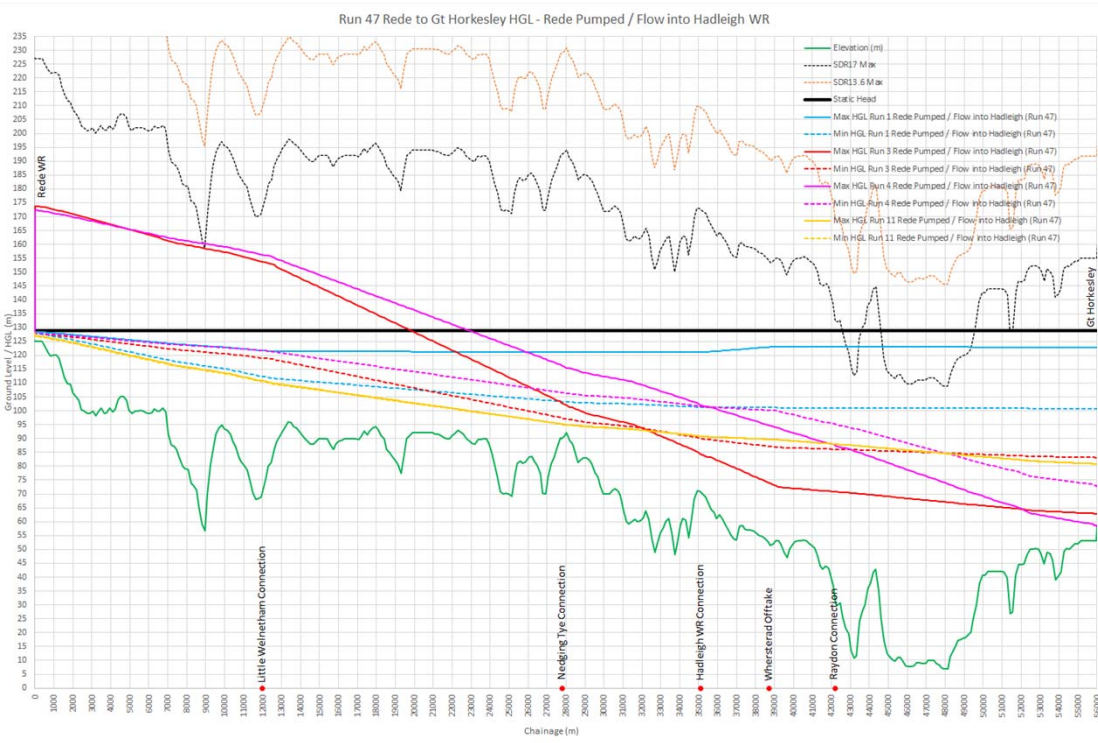
Carbon components	t CO ₂ e
Emb. carbon (whole spine, pipeline, PS + WR)	13,317
Carbon (operational energy, 40 year)	609
Whole Life Carbon	13,926

Number above are not actual and only indicative.

	1.1	1.2	2.1	2.2
PS at Rede	Yes	No	Yes	No
SP connectivity	Hadleigh	Hadleigh	Hadleigh, Raydon & Watsons Corner	Hadleigh, Raydon & Watsons Corner

Option 1.1: PS at Rede, Hadleigh

(run 47)



Pipeline hydraulic profiles

	1.1	1.2	2.1	2.2
PS at Rede	Yes	No	Yes	No
SP connectivity	Hadleigh	Hadleigh	Hadleigh, Raydon & Watsons Corner	Hadleigh, Raydon & Watsons Corner

Benefits – Outputs of the Modelling Optimisation

- Reduced pipe size and length £57.7m
- Reduced storage – total 66ML to 32ML - £7.8m
- Reduced carbon – 13,350 Tonnes of CO₂e
- Reduced pump sizes – £7.4m



Optimatics Benefits

Activities could be carried out traditionally, so why use this software?

- Tight timescales required quick turnaround of options
 - The design challenges meant sizing needed to be robust
 - Did we analyse all options thoroughly?
 - Do we understand the impact on the existing networks?
- The quantity of criteria
 - The system became more complex as we progressed south
 - An estimate of manual effort with the number of options for the south region was equal to 1.1 million modeller hours
- Sizing and costing for carbon and TOTEX were carried out together

Any questions?



Thank you for listening

