Strategic Regional Water Resource Solutions: Annex A1.2: River Vyrnwy bypass pipeline conceptual design report

Standard Gate Two Submission for River Severn to River Thames Transfer (STT)

Date: November 2022

Severn to Thames Transfer

River Vyrnwy bypass pipeline conceptual design report

STT-G2-S3-331
November 2022

Disclaimer

This document has been written in line with the requirements of the RAPID Gate 2 Guidance and to comply with the regulatory process pursuant to Thames Water's, Severn Trent Water's and United Utilities' statutory duties. The information presented relates to material or data which is still in the course of completion. Should the solution presented in this document be taken forward, Thames Water, Severn Trent Water and United Utilities will be subject to the statutory duties pursuant to the necessary consenting processes, including environmental assessment and consultation as required. This document should be read with those duties in mind.

River Vyrnwy bypass Pipeline Conceptual Design Report

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Vyrnwy Bypass
10 October 2022

Executive Summary

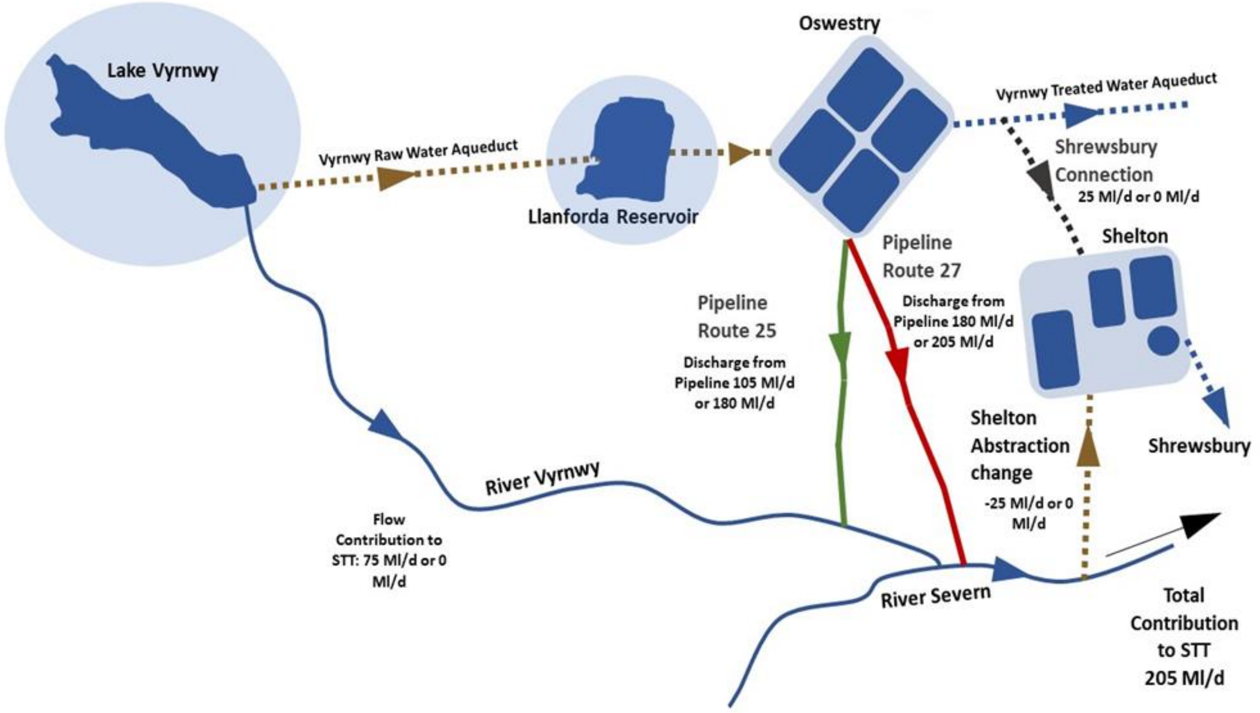
The River Vyrnwy Bypass Pipeline is part of the Severn to Thames Transfer (STT) SRO. The Vyrnwy Bypass was included in Gate 1 submission but was not part of the Price Review 19 Final Determination. The project is now advancing through the Regulators' Alliance for Progressing Infrastructure Development (RAPID) gated process and is proceeding to Gate 2. This document details the concept design of the engineering elements of the project including the gravity pipeline, outfall and flow control facilities.

Lake Vyrnwy discharges raw water into the River Vyrnwy, which eventually joins into the River Severn. Lake Vyrnwy is the sole raw water resource feeding Oswestry. The raw water is transferred from Lake Vyrnwy to Oswestry through the Vyrnwy Raw Water Aqueduct (RWA) system. Oswestry then processes the raw water and supplies treated water to customers in Cheshire and Liverpool via the Vyrnwy Treated Water Aqueduct (TWA).

It is important to highlight that at the time of commencing this work a release of 75Ml/d was assumed into the River Vyrnwy and work proceeded on that basis. However subsequent environmental assessment has now proposed a reduced volume of 25Ml/d to the river and a consequential bypass capacity of 155Ml/d. The consequences of this change will be addressed in Gate 3 and the 180Ml/d bypass has been assumed to characterise the 155Ml/d requirement for the purposes of Gate 2.

The principal purpose of the Vyrnwy Bypass project is to supply between 105 and 205 Ml/d to the River Severn from the RWA as a source option for the STT. Sustained discharges from Lake Vyrnwy directly into the River Vyrnwy (and hence River Severn) are expected to have unacceptable environmental impacts, hence the need for a bypass pipeline.

Figure S-1 Project Overview



As shown in the figure above, the project consists of a pipeline from a point downstream of settlement/filtration processes in Oswestry that ultimately discharges to the lower reach of the River Vyrnwy or the River Severn. Flow control is provided by a flow measurement and a series of flow control valves near the outfall with burst control provided by upstream flow meters, one of which would be used during the filling operation only. Another associated project is the Shrewsbury Redeployment project which allows diversion of 25 Ml/d from Oswestry to the area normally supplied by Shelton, whose principal source of raw water is the River Severn.

The initial review in Gate 1 consisted of seven routes. In Gate 2, Options 1-7 were re-assessed based on the Gate 1 assessments, updated information, and revised design flows, as per the table below leading to optimised versions of these routes that were re-named options 21 to 27.

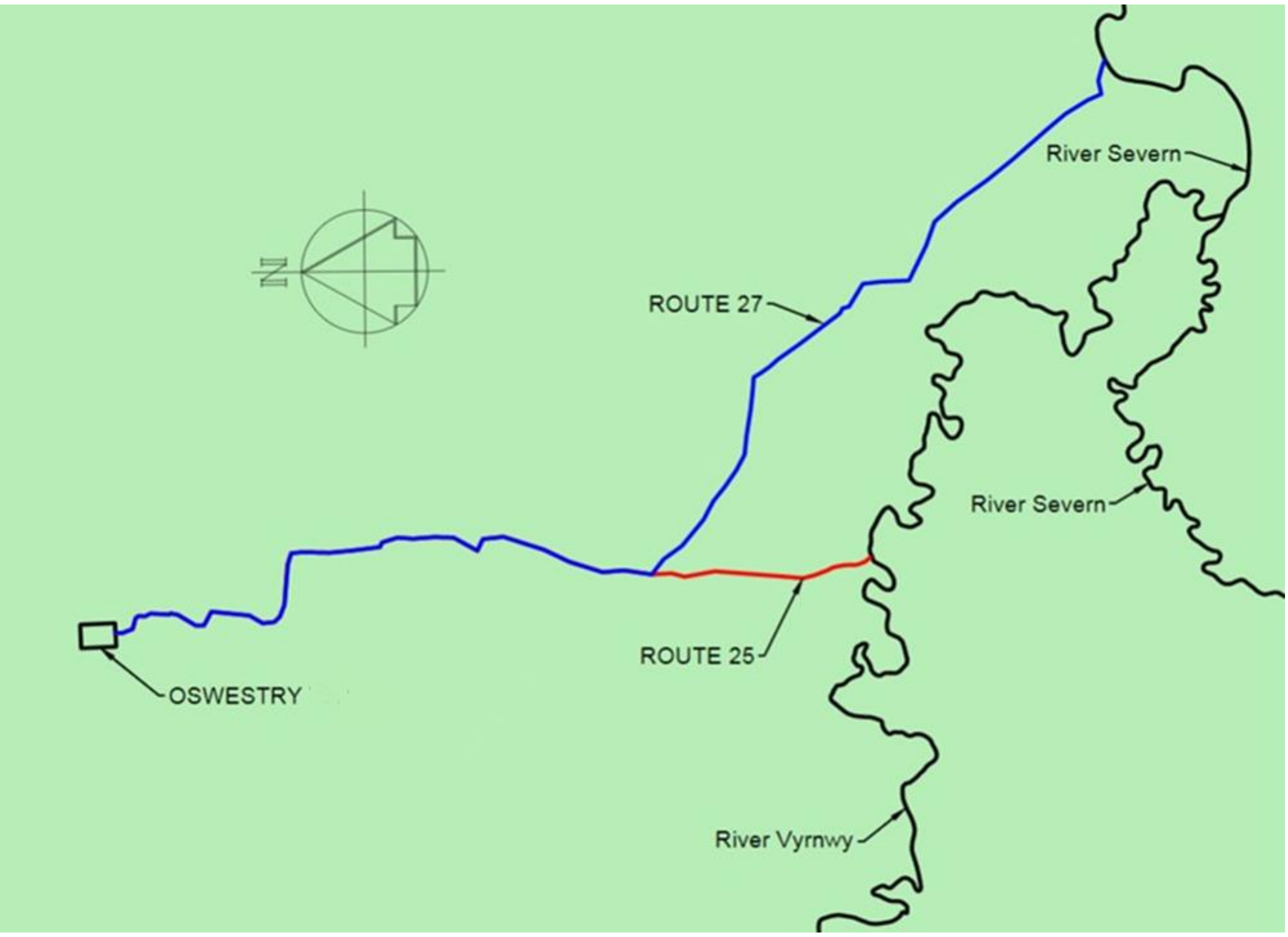
The design flow scenarios are based on a total contribution to STT of 205Ml/d in the scenarios shown in table below which are related to their SRO receptor, either the River Vyrnwy or the River Severn.

Table S- 1 Design Flows Ml/d

River Vyrnwy Flow Contribution to STT	River Vyrnwy Discharge from Pipeline (Route 25)	River Severn Discharge from Pipeline (Route 27)	Shrewsbury Connection	Total Contribution to STT
75	105	0	25	205
0	180	0	25	205
0	0	180	25	205
0	0	205	0	205

In an assessment of constraints, it was concluded that Options 25 (River Vyrnwy discharge) and 27 (River Severn discharge) were the preferred route options. These are shown in the figure below.

Figure S- 2 Plan of Preferred Route Options 25 and 27



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1. Introduction

This concept design report details the concept design of the engineering elements of the Vyrnwy Bypass gravity pipeline and outfall

1.1. Background

Water resources are coming under increasing pressure from population growth, economic development, and climate change. New national water supply resources are urgently needed to avoid water restrictions in the near future, particularly in the Southeast of England. Water companies are working together to develop Strategic Resource Options (SROs) to meet this need.

To support the progression of strategic water resource options, the Regulators' Alliance for Progressing Infrastructure Development (RAPID) has been established to help accelerate the development of new water infrastructure. RAPID is working with the water companies to promote the development of national water resources infrastructure that is in the best interests of water users and the environment. RAPID is comprised of representatives from Ofwat, the Environment Agency and the Drinking Water Inspectorate.

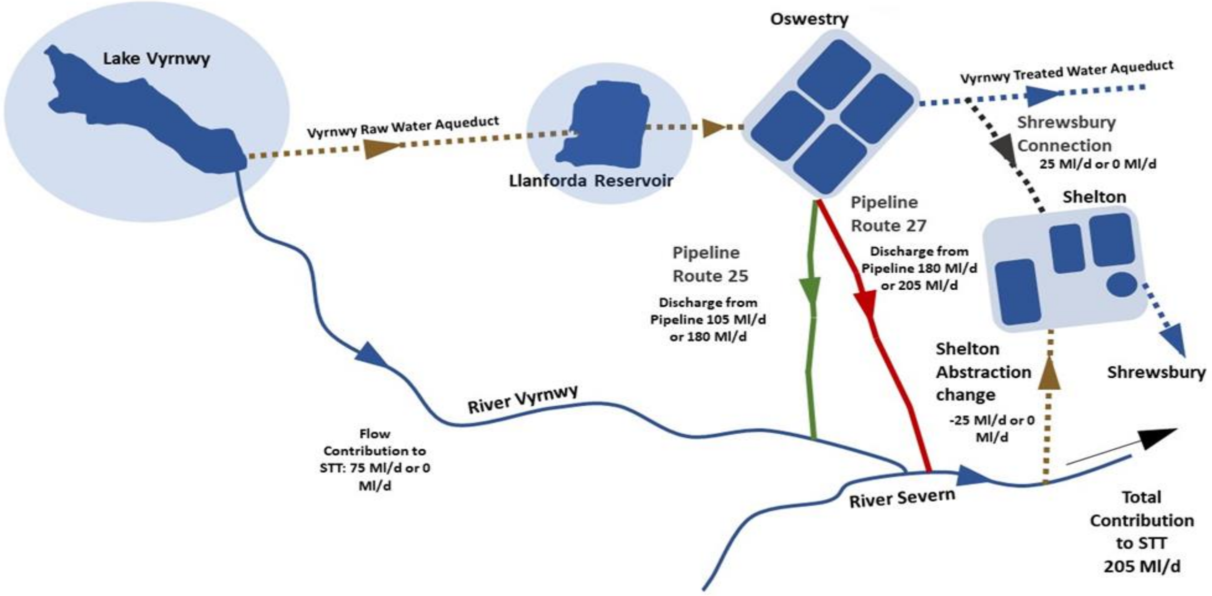
A gated process for SROs has been designed by RAPID to ensure funding to develop the schemes is spent on time and to high quality standards. Water companies exploring agreed strategic solutions need to submit deliverables at each gate to demonstrate their progress. This is in addition to any planning consents. The process is intended to support water companies in progressing the investigation and development of solutions more quickly to the 'construction ready' state.

The River Vyrnwy Bypass Pipeline is part of the Severn to Thames Transfer (STT) SRO. The Vyrnwy Bypass was included in Gate 1 submission but was not part of the Price Review 19 Final Determination. The River Vyrnwy Bypass Pipeline is an alternative (mitigation) to discharging flows directly into the River Severn either directly or via the River Vyrnwy.

1.1.1. Project Details

Lake Vyrnwy discharges raw water into the River Vyrnwy, which eventually joins into the River Severn. Lake Vyrnwy is the sole raw water resource feeding Oswestry. The raw water is transferred from Lake Vyrnwy to Oswestry through the Vyrnwy Raw Water Aqueduct (RWA) system. Oswestry then processes the raw water and supplies treated water to customers in Cheshire and Liverpool via the Vyrnwy Treated Water Aqueduct (TWA).

Figure 1-1 Project Overview



Large releases from Lake Vyrnwy into the River Vyrnwy are expected to have unacceptable environmental impacts as explained in detail in the documents produced by the environmental consultants and available for consultation.

The River Vyrnwy Bypass Pipeline is being developed as a mitigation as part of Gate 2 submission. This will include options for transferring all or part of the Lake Vyrnwy releases into the lower reaches of River Vyrnwy or upper reaches of River Severn via the existing Raw Water Aqueduct (RWA) and from within Oswestry.

It is important to highlight that at the time of commencing this work a release of 75Ml/d was assumed into the River Vyrnwy and work proceeded on that basis. However subsequent environmental assessment has now proposed a reduced volume of 25Ml/d to the river and a consequential bypass capacity of 155Ml/d. The consequences of this change will be addressed in Gate 3 and the 180Ml/d bypass has been assumed to characterise the 155Ml/d requirement for the purposes of Gate 2.

The design flow scenarios examined in this study are based on a total contribution to STT of 205Ml/d. Four scenarios have been assessed based on the flow conveyed by the bypass pipeline and the point of discharge, either the River Vyrnwy or the River Severn.

Three of the four design flow scenarios as shown in the table below are dependent on the Shrewsbury Redeployment project. This latter project allows diversion of 25 Ml/d from Oswestry to Shelton supply, thus enabling a reduction in abstraction at Shelton from the River Severn which would allow a temporary transfer of licence to the STT Interconnector transfer point of abstraction.

Table 1-1 Design Flows Ml/d

River Vyrnwy Flow Contribution to STT	River Vyrnwy Discharge from Pipeline (Route 25)	River Severn Discharge from Pipeline (Route 27)	Shrewsbury Connection	Total Contribution to STT
75	105	0	25	205
0	180	0	25	205
0	0	180	25	205
0	0	205	0	205

1.1.2. Programme

The scheme has passed RAPID's Gate 1, with the project team now focused on developing concept designs. The scheme will be resubmitted to RAPID for Gate 2 review in November 2022 with a decision from RAPID on whether the scheme can commence to Gate 3 in March 2023. Should the scheme be taken forward to construction, the Vyrnwy Bypass Pipeline will be construction ready in AMP8 (2025 to 2030).

1.2. Next Steps

Following Gate 2, the proposals will be developed by commencing a programme of pre-planning activities, including comprehensive community and stakeholder engagement, and developing the mitigations for the potential environmental impacts of each scheme.

Decisions about whether a solution goes ahead will be made through water resources planning and subsequently applications for planning and environmental consents.

Working collaboratively with our SRO partners, we will undertake further data collection to support detailed modelling and engineering feasibility work. These further investigations will allow us to identify the optimum option configuration to meet the need of the Vyrnwy Bypass.

1.2.1. Gate 1 Development

At Gate 1 seven pipeline bypass routes were developed, four were developed originally, then as a result of the initial review another three were developed in an attempt to further mitigate Environmental, Stakeholder and Planning issues. The original routes are shown in Figure 1-2 below.

Two of the routes (i.e., 4 and 7) discharge into the River Severn with its capacity to accept higher flows rather than the River Vyrnwy. Options 5 and 7 were identified as the preferred ones, although option 5 has hydraulic limitations and 7, being longer, has a higher cost. Hydropower was also identified as an opportunity to explore as a component of the pipeline.

At Gate 2 all the routes developed during Gate 1 were re-assessed following receipt of updated information and to account for a change in the position of the pipeline connection point from the Llanforda Reservoir to Oswestry, as per Figure 1-3 below.

To accommodate these changes, the seven routes developed during Gate 1 were refined twice during the options appraisal process in Gate 2. The final route options were renamed Options *21-27. Only these latter series of options are investigated within this study.

In an assessment of constraints, it was concluded that Options 25 (River Vyrnwy discharge) and 27 (River Severn discharge) were the preferred route options. These are shown in Figure 1-4 below.

In each case there is a requirement for a balancing tank within Oswestry at the inlet to the pipeline, and potentially a requirement for dechlorination treatment. It has been agreed with UU that these elements will be outside of the scope of this project and for further details of the proposals in Oswestry please refer to the relevant North West Transfer SRO documents.

* An interim stage of route derivation conceived routes 11 to 17, which are not presented or referred to further.

Figure 1-2 Gate 1 Route Overview

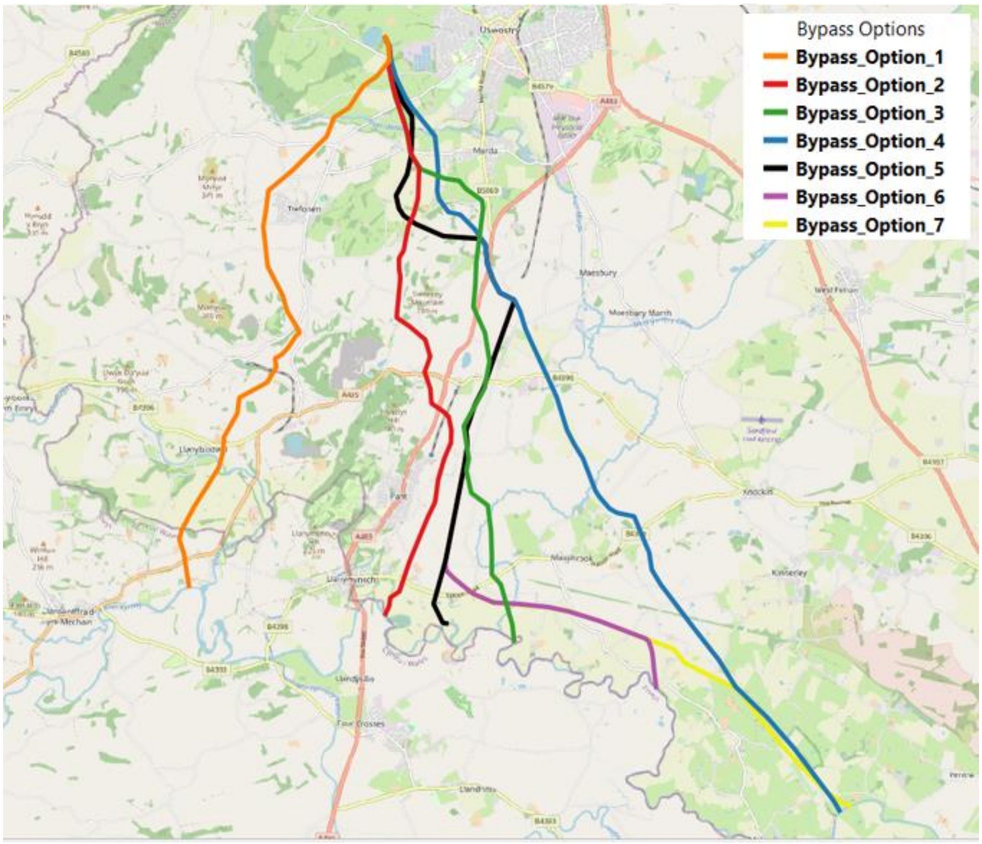


Figure 1-3 Gate 2 routes

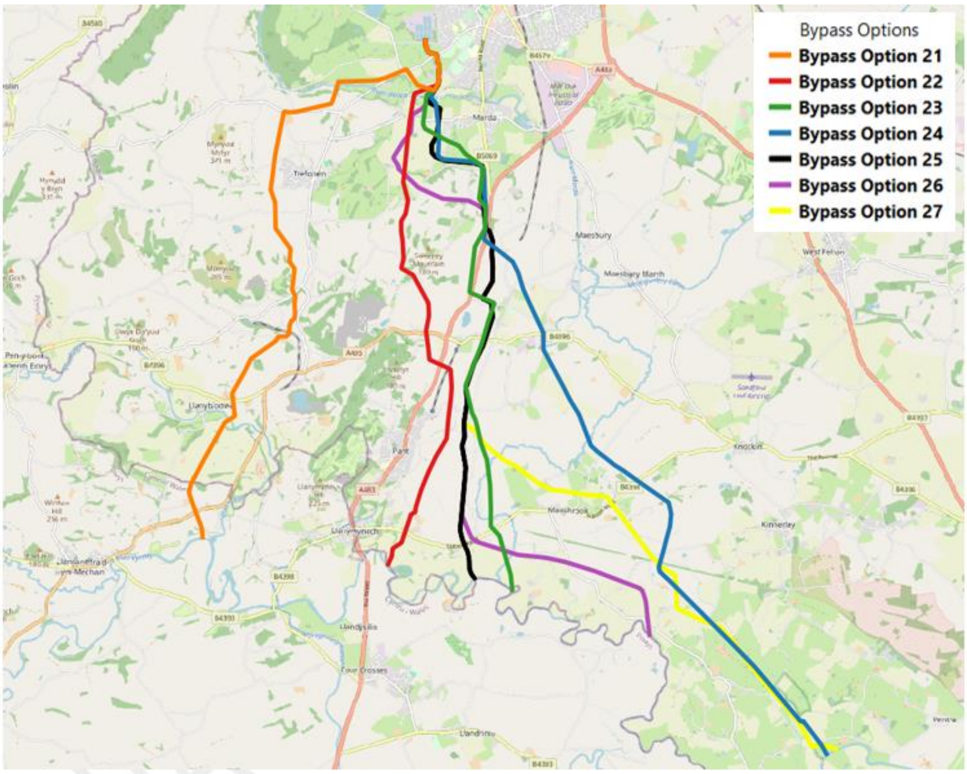
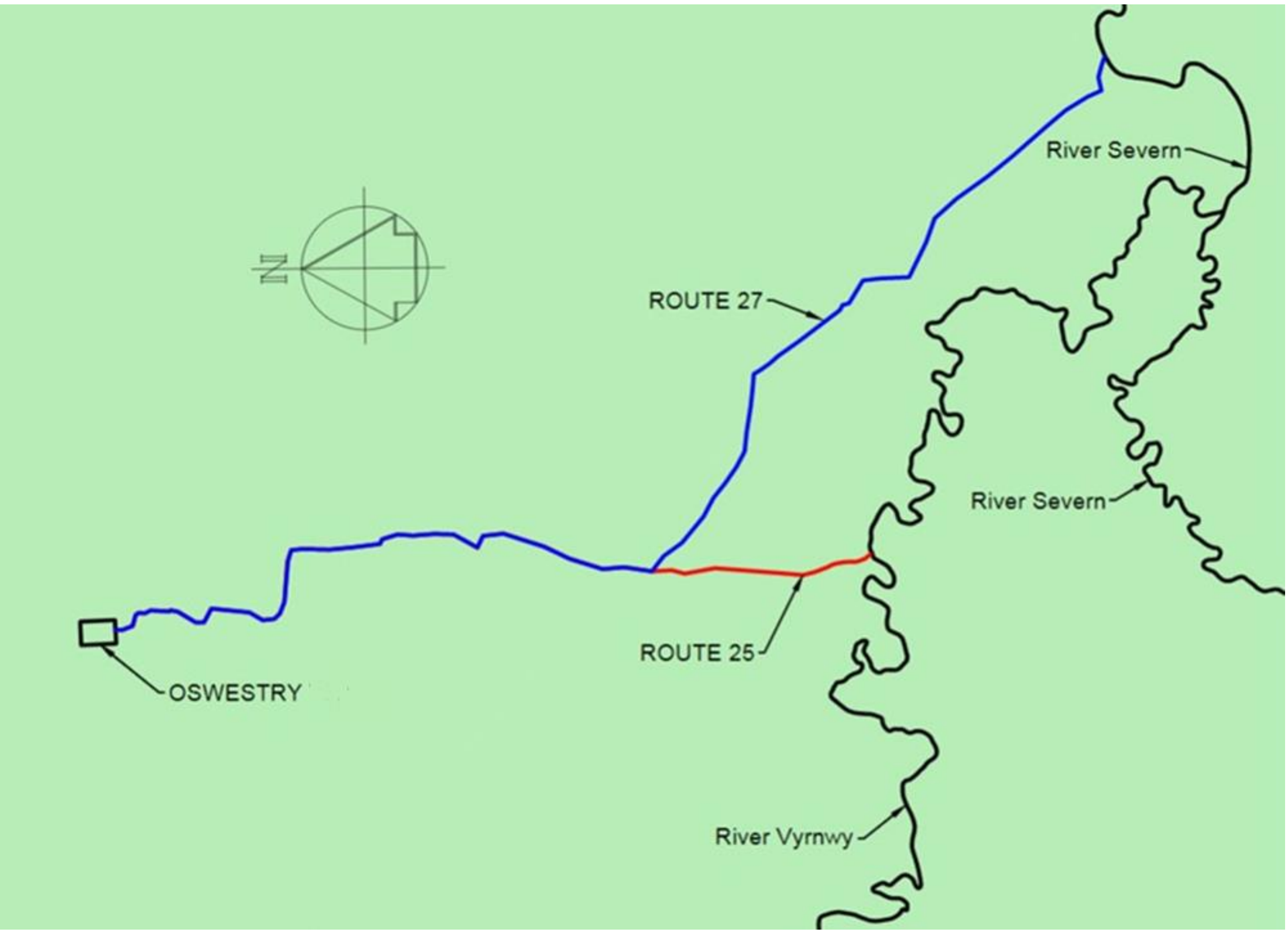


Figure 1-4 Plan of Preferred Route Options 25 and 27



1.2.2. WRSE Regional Modelling Output

Refer to the section below which details the flow quantities required for each of the transfers.

1.3. Sizing and Phasing

This section provides and overview of the sizing and phasing for the concept design of the Vyrnwy bypass pipeline and considers key option constraints.

1.3.1. Pipeline Options

The scope of this concept design includes the Vyrnwy bypass pipeline only, which will be constructed in one phase. The design flow scenarios are based on a total contribution to STT of 205Ml/d as shown in Table 1-1 previously; related to the applicable pipeline option and their SRO receptor, either the River Vyrnwy or the River Severn.

There is some limited potential to construct route 25 first, and to defer construction of the additional section that makes up route 27, thus deferment of investment and, scope to build operational experience to demonstrate that the river channel can accommodate higher flows. The complexity of the outfall and adjacent valve installations for both options, which are specific to each one, mitigate against this. The diameter difference is also a significant issue. Therefore, this possibility is not explored further.

1.4. Links with Other Options, Schemes and Elements

1.4.1. Dependencies

Within the Vyrnwy Bypass, Options 25 is dependent on the Shrewsbury connection and the related SROs in order to fully supplement the River Severn flow to allow full supply to the STT Connector. Whereas option 27 is similar but has no dependency on the Shrewsbury Connection for its 205 Ml/d flow scenario.

1.4.2. Mutual Exclusivities

Except as stated in 1.4.1 above, the solutions listed in 1.2.1are mutually exclusive. By the nature of the choice available, none of the above combined options would be constructed together. However, option 25 is dependent on the Shrewsbury connection as described in 1.4.1 above, for the complete flow contribution to the STT from the Vyrnwy aqueduct. It should be noted that there is considerable commonality between routes 25 and 27 although the proposed diameters differ. Approximately 70% of the route of 25 is common to 27.

2. Conceptual Design

2.1. Design Principles

2.1.1. Cross Cutting Design Principles

#	Principle	Target(s)	Gate 2 Indicators
1	Be specific: Develop project-specific design vision and principles based on an understanding of the objectives of each project and the people and places it will affect.	1.1. Development of project specific vision and principles mapped against the NIC and ACWG Principles. 1.2. Development of a clear, concise narrative describing the story behind your Vision and Principles.	The design vision for this scheme is for efficient but robust concept design with due consideration for the environment in particular to ensure that no detriment is caused to either of the receiving watercourses.
2	Safe and well: Actively and collectively develop designs that can be built, used, and maintained without unacceptable risks to the health and safety of workers - particularly during hazardous construction and operational activity. Manage risks to members of the public thoughtfully with an approach that balances maximising wellbeing benefits with protection from risks that could cause significant harm.	2.1. No accidents, incidents, or harm to people during construction and operation. 2.2. Use of best practice procedures in design risk management following HSE Guidance and CDM Legislation. 2.3. Design informed by understanding potential risks to the public and management of these so far as reasonably practicable. Use of appropriate guidance including but not limited to: a. RoSPA and the National Water Safety Forum's Guiding Principles for Managing Drowning and Water Safety Risks. b. Visitor Safety in the Countryside. 2.4. Consideration of security early in the design of fence, gate, and boundary treatments.	Reference the Outline Designers Risk Assessment which highlights the potential significant and/or unusual risks with potential mitigations. The design has been completed with due consideration of Safety in Design Principles incorporated within the CDM regulations. Safety reviews incorporating members of the consultant design team including constructability experts has been completed during the development of the scheme

2.1.2. Climate

#	Principle	Target(s)	Gate 2 Indicators
1	Nature knows no boundaries: Water is essential to all life and managing our response to climate change is a collective and urgent activity. Projects must be developed to work across companies and/or legislative boundaries to develop sustainable solutions and environmental enhancement for the wider benefit of society.	1.1. Collaborative working across companies and with stakeholders. 1.2. Timely - preparation of proposals ready to construct in 2025-2030 will involve early and rigorous development of design objectives followed by proposals. 1.3. Alignment with other relevant environmental policy, plans and strategies such as Catchment Management and Local Nature Recovery Plans (see also Place 2).	The engineering design has been informed by the emerging environmental consenting requirements being led by the environmental consultants working on STT schemes. The design vision and principles have been informed by this engagement.
2	Resource and carbon efficient throughout: Projects shall seek to reuse existing assets, eliminate waste (including waste of water), and make efficient use of materials	2.1. Lifecycle Carbon: Projects shall support the water industry commitment to achieve Net-Zero in terms of operational carbon in accordance with the industry roadmap. Projects must be efficient in embodied carbon in both construction	The design has considered the minimisation of the works associated to the construction of the new pipeline and reducing carbon.

#	Principle	Target(s)	Gate 2 Indicators
	and transport across the whole of the project lifecycle.	and operation. 2.2. Projects should investigate if existing infrastructure assets could be repurposed and reused. 2.3. Projects should look to avoid unnecessary construction and minimise use of materials. 2.4. Projects should seek to minimise the use and waste of water.	
3	Resilient and adaptable: Design for anticipated future demand at the appropriate scale. Build in the resilience to absorb and recover from the impacts of the extreme events and incremental stresses likely to arise from climate change.	3.1. Designs should be developed to include proportionate measures to anticipate future extreme events and stresses so that they can resist, absorb, recover and, where necessary, be adapted. 3.2. Designs shall support the digitisation of the network at a catchment level using data to inform design, optimise solutions and improve operational efficiency in real time. 3.3. Where proposals add to the resilience of the broader system this should be accounted for in its social value (see Value 3). 3.4. The layout and design of specific elements of infrastructure should be taken in cognisance of planned future development of the immediate area. 3.5. Deploy nature-based approaches to resilience wherever possible (see also Place 2).	This concept design meets the requirements of the flow profiles identified.

2.1.3. **People**

#	Principle	Target(s)	Gate 2 Indicators
1	Understand and respond to your community's needs: Develop a full understanding of the social context that will be impacted by the project over its lifecycle. Design for how local communities will encounter the infrastructure in their everyday lives during both construction and operation.	1.1. Reliable supply of water to customers 1.2. Designs developed to maximise their social value. 1.3. Proposals reflect local community views as to how they interact with and experience the infrastructure as far as possible.	The concept design has been developed with resilience in mind and the source of the water is the water from Oswestry.
2	Engage widely, early and meaningfully: Work with stakeholders and local communities to develop their understanding of the importance of nature and water conservation. Develop co-design approaches to aspects of the design of infrastructure and associated landscape where practicable.	2.1. Stakeholders and communities understand the need for the scheme and the nature/appearance of the proposed solution(s). 2.2. The views of local stakeholders have shaped the design, where possible. 2.3. Engagement and consultation with communities has influenced the design (including but not limited to site selection, layout, materials, detailing) making it more acceptable to them. 2.4. The project provides the public	The feedback from Gate1 has been used to develop this Gate2 proposal Engagement activities will be included within the design programme of the project plan for Gate 3 and beyond showing adequate time for community (public) consultation to inform both site selection (where possible) and developed design. These engagement activities will be supported by the development of tools that will enable successful engagement (e.g., digital models for visualisation/animation, GIS systems,

#	Principle	Target(s)	Gate 2 Indicators
		with information on the importance of water and/or nature conservation (e.g., through information boards, artwork or digital information)).	precedent pictures of similar schemes/components).
3	Improve access and inclusion: Consider how people move around your works. Maximise opportunities to support active travel and improve recreational access to waterside and green spaces that can improve outcomes for wellbeing, health, local economy, social inclusion and education.	3.1. Find opportunities to improve people's health, wellbeing and understanding of the natural environment, through access to waterside and green spaces for recreational and other purposes (see Note 1). 3.2. Maximise opportunities for workers to access sites via sustainable transport during construction and operation. Minimise disruption to travel routes in areas affected by a project during construction and operation.	The STT pipeline route has been developed with public rights of way in mind and tried to avoid them and to cross them efficiently where this is not possible to minimise impact during construction.

2.1.4. Place

#	Principle	Target(s)	Gate 2 Indicators
1	Take care: Develop proposals in the spirit of stewardship looking to both the past and future of each context to understand and develop its landscape, cultural heritage, health and sustainability. Work with partners to secure the long-term success of all measures.	1.1. Achieve Environmental Net Gain (ENG). 1.2. Adopt measures in the design that enhance the environment and help avoid future problems - e.g., adoption of SuDS solutions that improve cooling, attenuate surface water run-off and improve infiltration and biodiversity. 1.3. Have clear and realistic long-term strategies for how operational and mitigation proposals will be managed and maintained. Develop partnerships with local communities where this has a mutual benefit. 1.4. Develop proposals in light of a clear understanding of the area's landscape and history.	The pipeline routing options was carried out to minimise the impact on Place Refer to environmental statements on the SRO approach to achieving Environmental Net Gain within the Design Vision and Principles.
2	Protect and promote the recovery of nature: Focus on the role of landscape, its capacity to accommodate infrastructure and shape places. Work collaboratively and employ holistic, landscape-scale approaches that support and deliver biodiversity net gain as well as multiple other benefits.	2.1. Achieve at least 10% Biodiversity Net Gain (BNG). 2.2. Deploy nature-based approaches to integration and mitigation as the first-choice solution where possible. 2.3. When looking at options to provide compensation or enhancement prioritise measures that support achieving good ecological condition for affected watercourses and bodies as a whole. When making an intervention, mitigate infrequent impacts by developing proposals that keep them local and short lived. 2.4. Work with landowners and land managers to develop mutually beneficial solutions where practicable.	Reference environmental statements for the approach to achieving BNG and aspirations to contribute to the recovery of nature within Design Vision and Principles.

#	Principle	Target(s)	Gate 2 Indicators
3	Design all features beautifully, with honesty and creativity: Our utility infrastructure can be a source of pride and a positive contribution to its context. Develop proposals that reveal and celebrate its importance, provide visual delight and leave a positive legacy.	3.1. Develop a utilities architecture that speaks to its purpose and enhances its context. This applies to buildings, structures and landscape. 3.2. Develop designs and, where appropriate, artworks that bring narrative (meaning), beauty and interest to the proposals. 3.3. Consideration of context in every aspect of design including its location, layout, form, scale, appearance, landscape, materials and detailing.	Reference environmental statements for detail of how this is intended to be accomplished.

2.1.5. Value

#	Principle	Target(s)	Gate 2 Indicators
1	Maximise embedded value: Work collaboratively across specialisms and with stakeholders to maximise the benefits of the scheme by being smart with the location and arrangement of elements and design of mitigation within the project scope and budget.	1.1. Early multidisciplinary input informing a design that solves multiple problems at once. 1.2. Design of infrastructure capable of adaptation to reasonable future demands (see also Climate 3). 1.3. Site selection processes and layouts that assist (or as a minimum, do not prevent) local development except where absolutely necessary. 1.4. Reinstatement, landscape and mitigation proposals that improve the existing situation, - e.g., through better biodiversity, carbon sequestration, surface water infiltration and reduced run-off. 1.5. Deliver benefits efficiently by exploiting the two-way relationship between infrastructure and natural capital to enable multiple benefits to be delivered simultaneously	The impact on the local environment has been considered for the selection of the pipeline route which was developed by a multi-disciplinary team For a statement on the SRO's aspirations and capability to deliver embedded value including Social Value, BNG and ENG reference the environmental statements.
2	Understand how you could provide additional value: Identify opportunities to contribute wider regional benefits outside of the project scope. In particular look for synergies with relevant catchment management plans and proposals that support the delivery and enjoyment of a healthy water environment.	2.1. Strategic project selection is informed by cross-sectoral engagement to maximise social benefit and reduce the use of customers money (see note 3). 2.2. Work closely with partners and focus on landscape scale schemes that improve hydrology, aquatic ecology and reduce/sequester carbon and provide opportunities for access to recreation and visual delight. 2.3. Be honest and realistic with partners as to what you might be able to offer as an organisation.	Both the construction and operation of the scheme will create opportunities for work for the local community – for example as construction workers or plant operators / maintainers. Refer to the environmental statements for details on the SRO's aspirations and capability to deliver additional value.

#	Principle	Target(s)	Gate 2 Indicators
3	Capture and measure embedded and additional value: Have clear narratives about how you are contributing to society beyond the core scope of your project. Quantify these benefits so they can be considered meaningfully in conversations on value, financing and risk. Share your experience and knowledge widely.	3.1. Gathering of project specific data and improvement in the tools we have to measure, and monitor added and additional value across the sector. 3.2. Full consideration of potential benefits in the Cost Benefit analysis and investment case for the SRO. 3.3. Clear communication of value of the scheme to stakeholders, communities and within the industry.	Refer to the environmental statements for the best-value metrics used in determination of the Regional Plans and WRMPs and a clear narrative on how these have influenced option selection so far. Refer to the environmental statements for an initial narrative (description) of the value of the scheme in plain English.

2.2. Scheme Components and Operating Philosophy

2.2.1. Conveyance Components

Due to the favourable topography, no pumping will be required, and the proposed project will comprise:

a) A balancing tank at Oswestry to accept water from the treatment process and allow for small fluctuations in flows (not allowed for under this concept design)

b) A gravity pipeline to the discharge point at the river, with at least one line valve.

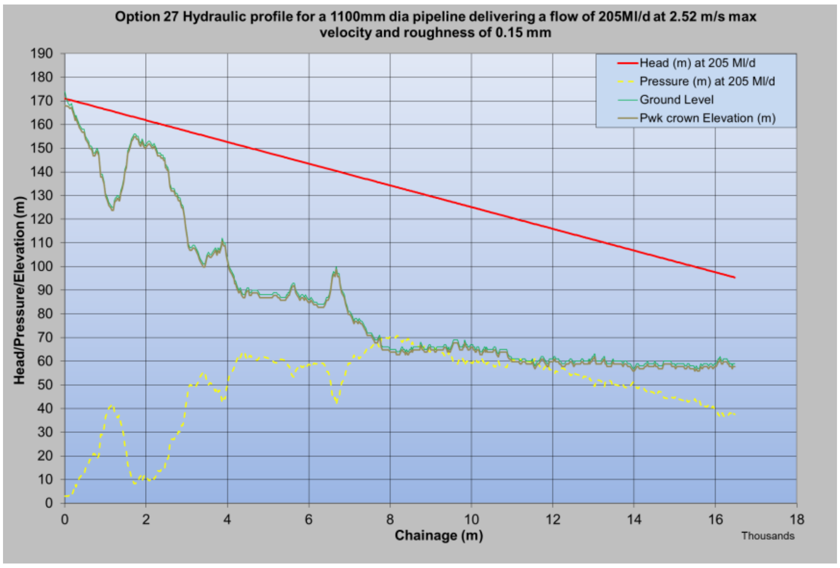
c) A flow control valve installation at the upstream end for burst control and filling control

d) A flow control valve installation at the downstream end close to outfall to the river to control the flows

e) An outfall structure to the river designed to dissipate energy and reduce velocities that might otherwise cause scour and erosion

Pipeline Hydraulics

Figure 2-1 Illustrative steady state hydraulic profile for Option 27



The graphs illustrates: -

- gravity flows are possible

- there are no intermediate high points that would require tunnelling

- there is residual head at the end of the pipeline

The optimised pipe diameters can be found below under the section Pipe Diameters

Flow Scenarios

The table below set out the various flow scenarios being considered for the preferred options. The other 5 pipeline route options considered were eliminated during the options appraisal process.
The pipeline will be entirely drained when not in use (cold standby).

Table 2-1 Design parameters

Route Option	Peak Flow (Ml/d)	Length of Pipeline (km)	*% of the year at Peak flow
25	105	10.3	10%
25	180	10.3	10%
27	180	16.5	10%
27	205	16.5	10%

Surge Analysis

For gravity pipelines transient pressures above the static head are predominantly caused by rapid valve closure or opening. The possibility of unacceptable transients can be eliminated by means of suitable gear boxes on the valve that prevent closure speeds that would be too fast. During detailed design, a full surge analysis would be undertaken to model the system and determine the maximum rate of closure that can be tolerated, and valves and gearboxes selected accordingly. There will be no need for surge vessels at either Oswestry or the river outfall location. Air valves are required at every intermediate high point along the pipeline to allow the pipeline to be commissioned and facilitate drain-down for maintenance.

Initial Flood Risk Assessment

In an initial assessment for route options 25 and 27, the flow control valve installation, falls inside the boundaries of Flood Zone 3. According to Gov.UK a Medium-risk zone, is defined as an area that each year, has a chance of flooding from rivers of between 1% and 3.3%. This considers the effect of any flood defences in the area. These defences reduce but do not completely stop the chance of flooding as they can be overtopped or fail. The control panels should be elevated, and waterproof in case of a flooding event. It will be necessary to carry out a full flood risk assessment at the next stage which is likely to necessitate compensatory flood storage.

2.2.2. Pipeline

The pipeline consists of pressurised gravity pipework falling from Oswestry to the outfall.

Pipe Diameters

The table below identifies the pipe diameters included in the conceptual design. Pipe diameters were chosen on the basis of the pipelines running full at all times with a positive pressure of at least 3m above the crown. Pipeline routes have been carefully selected to avoid intermediate high ground to enable the water to flow from Oswestry to the discharge location without the need for pumping. The diameters proposed for the various options are set out in the table below and are the smallest diameter, hence the cheapest, that satisfy the hydraulics requirements.

To maintain suitable self-cleansing velocities in the pipeline it would be wise, operationally, to 'pulse' at a higher rate for a few hours at a time - rather that a continuous low rate. The hydraulic profiles for each of these options can be found in Appendix A.3

Jacobs

Table 2-2 Pipeline sizing

<table>
<tr><th>Section</th><th>Length (km)</th><th>Pipeline types</th><th>Flow (Ml/d)</th><th>Velocity (m/s)</th><th>Headloss (m)</th><th>Nominal bore (mm)</th><th>Assumed Material</th></tr>
<tr><td rowspan="2">Route 25</td><td rowspan="2">10.3km</td><td rowspan="2">Pressurised gravity main</td><td>105</td><td>2.5</td><td>65.7</td><td>800</td><td rowspan="2">Steel</td></tr>
<tr><td>180</td><td>2.7</td><td>77.5</td><td>1000</td></tr>
<tr><td rowspan="2">Route 27</td><td rowspan="2">16.5km</td><td rowspan="2">Pressurised gravity main</td><td>180</td><td>2.2</td><td>58.6</td><td>1100</td><td rowspan="2">Steel</td></tr>
<tr><td>205</td><td>2.5</td><td>75.6</td><td>1100</td></tr>
</table>

Gravity Main

The gravity main carries the treated water approximately 10. 3 or 16.5 km from Oswestry to the river Vyrnwy or Severn discharge outfall. The Gravity Main is assumed to a be a thin wall steel pipe. However further assessment as to the optimal pipe material is to be undertaken at the next stage of design. Air release, washout, and line valves, located within buried chambers, will be located along the pipeline to enable operation and maintenance. No specific access manway points are included at this stage, as it is anticipated that the direct buried Air release Valve (AV) installations can be used for this purpose. Their occurrence will be at approximately 300m centres, which should allow for use of conventional lengths of jetting hoses. The table below identifies the typical spacing of these assets along the pipeline and provides and indicative total number. The final number of valves will be dependent on the detailed design of the vertical pipeline alignment.

Table 2-3 Gravity Main Valve Requirements Route 25

Asset Type	Typical Spacing	Total Number	Comments
Line Valve	5km	1	
Air Release Valve	300m	34	The number of air valves is dependent on the vertical alignment of the pipeline. Air valves will be located at all high points and intermediate valves on rising sections of pipe greater than 1km. The total number provided is therefore indicative and subject to change at detailed design.
Washout Valve	300m	36	The number of washouts is dependent on the vertical alignment of the pipeline. Washout valves will be located at all low points along the pipeline. The total number provided is therefore indicative and subject to change at detailed design. Washouts will also be provided adjacent to line valves
Access Manway	500m	-	Incorporated into the AVs

Table 2-4 Gravity Main Valve Requirements Route 27

Asset Type	Typical Spacing	Total Number	Comments
Line Valve	5km	2	
Air Release Valve	300m	55	The number of air valves is dependent on the vertical alignment of the pipeline. Air valves will be located at all high points and intermediate valves on rising sections of pipe greater than 1km. The total number provided is therefore indicative and subject to change at detailed design.
Washout Valve	300m	57	The number of washouts is dependent on the vertical alignment of the pipeline. Washout valves will be located at all low points along the pipeline. The total number provided is therefore indicative and subject to change at detailed design. Washouts will also be provided adjacent to line valves
Access Manway	500m	-	Incorporated into the AVs

In open cut sections, it is assumed that the pipeline will be buried at a minimum cover of 1.2m, up to a maximum trench depth of 6m. Without full ground investigation a full assessment of the pipe bedding requirements cannot be undertaken. For the purposes of this Gate 2 design, it is assumed that 90-95% of the as dug material will be recycled for use as pipe bedding with the steel pipe. Where the recycled pipe bedding does not meet the required quality to be used as backfill, imported granular material will be required.

Crossings

Trenchless technique is proposed for the following crossings on the Option 25 gravity main route:

Table 2-5: Trenchless Crossings for Route 25

ID	Length (m)	Crossings
G1	80	Private Road + River Morda
G2	30	Stream/Brook
G3	30	Stream/Brook
G4	30	Private Road
G5	50	A483
G6	40	Stream/Brook
G7	40	Abandoned railway
G8	30	Stream/Brook
G9	30	Stream/Brook
Total	360	

Pipe jack is the assumed trenchless technique in all cases

Table 2-6: Open Cut Crossings For Route 25

No.	Crossing
11	Minor Roads
1 (TBC)	High Voltage
0	Ordinary Watercourses

Table 2-7: Trenchless Crossings for Route 27

ID	Length (m)	Crossings
G1	100	Private Road + River Morda
G2	30	Stream/Brook
G3	30	Stream/Brook
G4	30	Private Road
G5	50	A483
G6	30	Stream/Brook
G7	40	Abandoned railway
G8	30	Private Road
G9	30	River Morda
G10	30	Stream/Brook
G11	30	Stream/Brook
G12	30	Stream/Brook
G13	30	Stream/Brook
G14	30	Stream/Brook

ID	Length (m)	Crossings
G15	30	Stream/Brook
G16	30	Stream/Brook
G17	40	Stream/Brook
G18	30	Stream/Brook
G19	30	Weir Brook
G20	50	Weir Brook
Total	730	

Pipe jack is the assumed trenchless technique in all cases

Table 2-8: Open Cut Crossings for Route 27

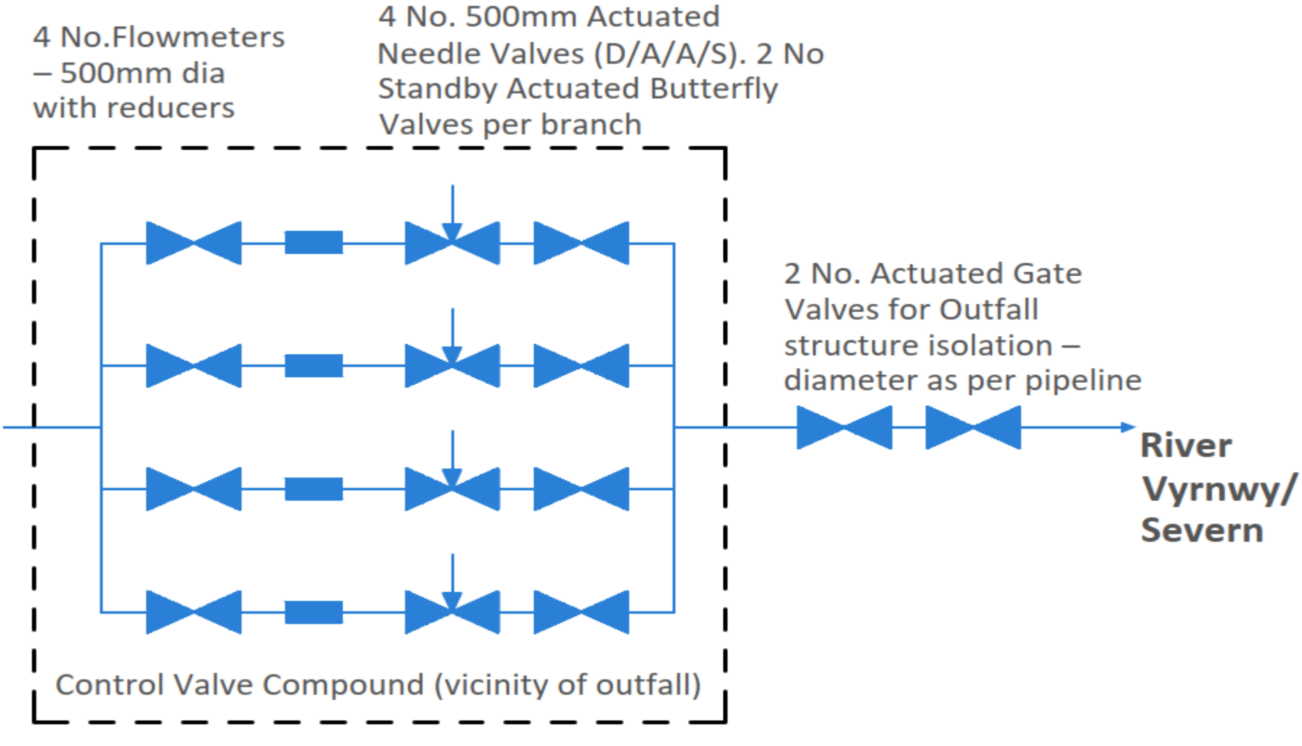
No.	Crossing
20	Minor Roads
2 (TBC)	High Voltage
0	Ordinary Watercourses

2.2.3. Discharge Outfall

The discharge outfall structure would be constructed within the banks of the River Vyrnwy or Severn.

4No. flow control valves are required at a suitable location just upstream of the outfalls to provide control of the outlet flow and ensuring that the gravity pipe remains charged. Due to the range of flow demands, the flow control valves will operate on a duty/assist/assist/standby arrangement. The gravity main will branch into 4No. pipe runs. Each branch will contain a flow meter and a flow control valve, along with 2No. actuated butterfly valves allowing isolation of the branch. The control valve compound will include a control and sampling kiosk and sampling chamber.

Figure 2-2 Flow control valve compound arrangement



Downstream of the flow control compound, a headwall structure allows the pipe to discharge into the River Vyrnwy or Severn. Two actuated control valves (duty / standby) are required to allow isolation of the structure from the pipeline, preventing backflow of river water into the pipe during maintenance.

The headwall structure is an in-situ curved concrete stepped gravity weir, approximately 10m long, based on a broad crested weir with 200mm head over the weir. Detailed consideration of the cascade will be carried out in later design phases to minimise the impact of the discharge on the local environment and river and use of modular construction using prefabricated sections may be applicable.

The proposed outfall site topography is flat at 54mAOD. A review of the EA flood maps indicates that this location sits within a **medium risk** flood zone, meaning that each year this area has a chance of flooding of between 1% and 3.3%. The detailed design for the outfall site shall take this into account and electrical equipment located outside of the flood zone where possible, or above the flood level.

2.2.4. Ground Conditions

Introduction and Resources

The preferred pipeline route options comprise the installation of a shallow buried pipe (≈3.5m average depth) in a trench across open ground, with trenchless crossings (TC) under major third party owned / operated infrastructure, including a railway, major roads (A Roads), rivers, watercourses and private Roads. These will require the pipeline to be installed at depth under the infrastructure, requiring the excavation of entry and exit shafts with the drilling of trenchless crossings between, to install the pipeline.

The trenchless crossings and depths of open cut pipeline greater than 3.5m deep will be the main geotechnical obstacle / risks requiring investigation, due to the variable ground and groundwater conditions expected to be encountered at these locations. Ground investigation at each crossing will be required to enable the most appropriate TC methods to be employed and where these will be applicable.

The installation of the pipeline in open ground will be by shallow trenches installed in a construction corridor. Excavation of shallow trenches will be affected by the ground and groundwater conditions and in some cases, temporary works comprising sheet piles / localized dewatering or benching of the excavations may be required to install the pipelines.

This geotechnical appraisal has been compiled from the following available information:

British Geological Survey (BGS) on-line database http://mapapps.bgs.ac.uk/geologyofbritain/home.html

BGS online Geological Maps #168 Birmingham, #184 Warwick
https://webapps.bgs.ac.uk/data/maps/maps.cfc?method=listResults&MapName=&series=E50k&scale=&getLatest=Y&pageSize=100

Highways England Geotechnical Data Management System (HAGDMS)
https://www.hagdms.co.uk/

Groundsure enviro data viewer
https://www.groundsure.io/#

Geotechnical Analysis Summary

Table 2-9: Geotechnical Analysis Summary

Route	Trenchless Crossings	Geotechnical Issues – Superficial Deposits	Geotechnical Issues – Bedrock	Comments
25	Identified potential individual trenchless crossing locations of rivers, railway, and highways. Horizontal Directional Drilling (HDD) may not be suitable in granular material.	Both granular and cohesive materials are expected along the entire route, the granular material (including alluvial deposits adjacent to rivers), will have potentially high groundwater. These may require groundwater control by trenching (sheet pile cut-offs) and /or dewatering.	Both granular and cohesive materials of the weathered upper layers of the underlying bedrock (Sandstone) along the route, may be encountered as sands or gravel, depending on the depth of the superficial deposits.	The route is generally in open ground with potentially limited buried services, but multiple landowners and potential access issues. However, it crosses large areas of granular glacial material with potential high groundwater, soft / loose ground. However, short route overall.
27	Identified potential individual trenchless crossing locations of rivers, railway, and highways. Horizontal Directional Drilling (HDD) may not be suitable in granular material.	Both granular and cohesive materials are expected along the entire route, the granular material (including alluvial deposits adjacent to rivers), will have potentially high groundwater. These may require groundwater control by trenching (sheet pile cut-offs) and /or dewatering.	Both granular and cohesive materials of the weathered upper layers of the underlying bedrock (Sandstone) along the route, may be encountered as sands or gravel, depending on the depth of the superficial deposits.	The route is generally in open ground with potentially limited buried services, but multiple landowners (long route) and potential access issues. However, it crosses large areas of granular glacial material with potential high groundwater, soft / loose ground.

Geology / Groundwater

Geotechnically, all routes are similar with regard to the underlying near surface ground conditions.

- Alluvium loose granular and / or soft cohesive material mainly located in the vicinity of, and derived from water courses that the routes cross, requiring the construction of trenchless crossings
- Glaciofluvial Deposits, comprising river derived Devensian loose to medium dense Sands & Gravels.
- Glaciolacustrine Deposits, comprising Devensian soft to firm Clays & Silts.

These deposits are likely to have a high, near surface groundwater, which will be potentially variable due to seasonal conditions. This will be a risk during construction and may well require groundwater control. Trenches excavated in loose granular (river gravels) or soft silty sands (alluvium) will need temporary works, to cut off and control the groundwater. These could comprise either sheet piles if route / access corridors are limited, or by the benching of excavations (if corridor width is available), combined with localized dewatering. There is no single route that avoids these potential issues.

Groundwater is not expected to be artesian, however high groundwater may affect floatation of the pipeline if encountered within the open trench.

It is recommended that any intrusive ground investigation will include suitable permeability tests in the alluvium comprising soakaway tests in trial pits, or in situ permeability tests in boreholes / piezometers, to quantify the permeability and determine recharge rates. Existing available boreholes do not have sufficient data with regard to determining permeabilities and / or recharge rates.

In the north and the centre of the routes, there are sections of Glacial Till (Boulder Clay), mainly comprising firm to stiff gravelly Clays with potential for cobbles/boulders. Generally, this stratum will not have groundwater present, or if present, will be limited in its volume and flow, requiring pumping from sumps within the excavation.

2.2.5. Land Requirements

Table 2-10: Land Requirements

Option	Estimated Land Area required (Permanent)	Estimated Land Area required (Temporary)
Route 25 – Upstream Valve Compound	*40 x 40 = 1600 m2	0
Route 25 – Downstream Valve Compound	40 x 60 = 2400 m2	0
Route 25 – Pipeline	0	(135 x 20) + (9,800 x 40) = 394,700 m2
Route 25 – Temporary Compounds	0	6,739 + 6,348 + 8,751 = 21,838 m2
Route 25 Total	4,000 m2	416,563 m2
Route 27 – Upstream Valve Compound	*40 x 40 = 1600 m2	0
Route 27 – Downstream Valve Compound	40 x 60 = 2400 m2	0
Route 27 – Pipeline	0	(250 x 20) + (15,496 x 40) = 624,840 m2
Route 27 – Temporary Compounds	0	6,739 + 6,348 + 4,100 + 11,411 = 28,598 m2
Route 27 Total	4,000 m2	653,465 m2

* The upstream Valve Compound is assumed to be within Oswestry

2.2.6. Operating Philosophy

The means of flow control of a gravity pipeline is by Flow Control Valves (FCVs) designed for handling the high flow rates and the significant reduction in pressure required without causing cavitation and the associated rapid erosion or components. The FCVs and conveyance elements of the project are intended for fully automatic remote operation once commissioned.

It is anticipated that Oswestry will be given a "set point" target flow rate for the bypass project that will be delivered to a new balancing tank. A submerged outlet will feed the gravity pipeline via a suitably sized magnetic flow meter and emergency isolation valve. At the downstream end of the pipeline an arrangement of FCVs will modulate to keep the level in the balancing tank at Oswestry within a tight control band. The FCVs both control flow rate and reduce the pressure safely. They deliver water at a low pressure ready for discharge via the outfall structure to either the Vyrnwy or the Severn. It is expected that basic water quality and pressure monitoring will take place.

As is typical for large diameter trunk mains, burst monitoring will be undertaken by comparing the flow of water leaving Oswestry and that arriving at the flow control valves. Any disparity will flag an alarm to operators and if desired the system can be set to automatically shut off the flow from Oswestry if a burst is suspected. It is envisaged that the four flow control valves will be identical to each other in a duty/assist/assist/standby configuration and the duty valve rotated to even the wear and tear on each valve. Lower flows will be catered for by one or two valves, whilst higher flows by three valves.

In the event of a flow control valve failure or malfunction then an isolation valve upstream of the FCVs can be used to shut down the flow whilst the problem is rectified. During initial filling after a shut down - fill rates would be controlled by a small valve on a bypass at the start of the pipeline allowing the pipeline to fill slowly and for all trapped air to be expelled at each air valve. Only when this air is removed should the pipeline be put into operation.

2.2.7. Inter Site Control System Requirements

Since the level control of the balancing tank at the start of the pipeline is provided by the FCVs at the end of the pipeline, it is necessary for there to be robust broadband and radio communications in place between the FCV complex and Oswestry. This should be provided with full redundancy since loss of communications would inevitably mean that the pipeline would need to be shut down. The communication equipment could also be used for passing pressure, flow, river level and water quality data back to the central control point. Flow data would be required to action the burst monitoring algorithms in the control system.

2.2.8. Power Requirements

The power requirements for the active equipment associated with the project is minimal and, as such, a standalone LV DNO supply for each site will be suitable to provide sufficient capacity for all field power and control requirements. In addition, the available Oswestry available spare capacity will also be used to supply the new equipment at the site.

The active assets associated with the project are highlighted in the table below:

Table 2-11: Project Power Demand

Active Assets	Option 25			Option 27		
	Qty	Power Demand (W)	Current Demand (A)	Qty	Power Demand (W)	Current Demand (A)
Oswestry						
Actuated Gate Valves	2	2,400	6.2	1	2,400	6.2
Actuated Butterfly/Needle Valves	2	800	3	2	800	3
Flowmeters	2	200	1	1	200	1
Total Demand	3,400 kW		10.2 A	3,400 kW		10.2 A
Line Valve Site No. 1						
Actuated Gate Valves	1	1,200	3.1	1	1,200	3.1
ICA Panels	1	250	1.1	1	250	1.1
Telemetry	1	250	1.1	1	250	1.1
Total Demand	1,700 kW		5.3 A	1,700 kW		5.3 A
Line Valve Site No. 2						
Actuated Gate Valves	N/A			1	1,200	3.1
ICA Panels				1	250	1.1
Telemetry				1	250	1.1
Total Demand				1,700 kW		5.3 A
Outfall Compound						
Actuated Gate Valves	2	2,400	6.2	2	2,400	6.2

	Option 25			Option 27		
Actuated Butterfly/Needle Valves	12	4,800	36	12	4,800	36
Flowmeters	4	400	2	4	400	2
ICA Panels	1	250	1.1	1	250	1.1
Telemetry	1	250	1.1	1	250	1.1
Total Demand	8,100 kW		46.4 A	8,100 kW		46.4 A

Regardless of the chosen option the expected power demand across the project is 3.4 kW at Oswestry, 1.7kW at the line valves sites and 8.1 kW at the outfall compound. The additional Oswestry load is assumed to be adequately supported by the existing site power supply. As such, 2 No. (or 3No. for option 27) standard 400V, 3ph, 100A power supplies would be required for the line valve site(s) and outfall compound site. Single-phase supplies could also be considered in later stages of the design should 230V actuators be the preferred solution. A high-level network assessment of the of the DNO (Scottish Power Energy Networks - SPEN) area shows that there is both ample capacity and available distribution infrastructure localised around the target sites to support the project with no additional requirement for enabling works.

2.2.9. Energy Recovery and Renewable Energy Opportunities

There is between 39 and 56m head available within the gravity pipeline which discharges to the River Vyrnwy or Severn – it may be possible to install a turbine in this length to recover this head as electricity.

2.3. Interactions with Other SROs

For STT to be able to utilise the Vyrnwy Bypass Pipeline as a source, other infrastructure must be constructed such as the transfer between the River Severn and the River Thames. The Shrewsbury Connection is also essential for 3 out of the 4 options.

2.4. Opportunities and Future Benefits Realisation

To realise the benefits of this additional water resource for ultimate discharge to STT, STT transfer between the River Severn and the River Thames has to be constructed to transfer water to Thames' catchment. If this is not completed the water will be lost to the River Severn.

3. Scheme Delivery

3.1. Pipeline Construction Strategy

3.1.1. Open Cut Pipe Sections

The typical construction methodology for pipe installation is open cut. This methodology represents a cost-effective solution for pipe installation that can be undertaken at scale with relatively standard construction plant and no specialist construction materials. The typical open cut construction sequence and methodologies are described in Appendix A.4.

3.1.2. Working Corridor

The pipe alignment is in greenfield land which provides few physical constraints to a contractor undertaking the works provided they have a suitable working corridor, and access to it. To facilitate these pipeline construction activities a working width of 40m, 20m either side of the pipe centreline, has been identified along the route. This allows room for pipeline construction activities, buffer zones, and logistics movements up and down the working corridor. Once initial discussion with landowners and operators have taken place there may be additional constraints that need to be applied which may amend these working corridors, and access routes, locally.

3.1.3. Trenchless Pipe Sections

To traverse natural constraints along the route several trenchless crossings are proposed. These crossings are outlined in the previous section for route 25 and 27 respectively. Pipe-jacking has been selected as the preferred method of undertaking the trenchless crossing on the schemes as it offers the ability to mitigate the potentially poor ground and high ground water at each crossing location. For further methodology description refer to Appendix A.4.

The working area required by a contractor to construct the thrust and reception pits generally fits within the 40m wide pipeline working corridor. However, an additional 5m clearance around the perimeter, of the shaft will be required by a contractor to safely install and operate the shaft. This working room has been considered in the length of the proposed pipe-jack to allow shafts to be set back from the crossing.

Throughout installation of the pipe jack-crossings there will be a requirement for HGV deliveries of segment and pipe sections and for removal of shaft and tunnel arisings.

The construction plant requirements to support the pipe-jacking activities should be relatively minor with a small mobile or telescopic crawlier crane to lift equipment, pipe sections and remove arisings from the shaft. Due to the high ground water and poor ground conditions a closed face cutter head is likely to be deployed to provide frontal support to the advancing pipe-jack. Depending on detailed ground investigation a contractor could chose to deploy either an Earth Pressure Balance (EPB) or Slurry Shields (SS) system. If a SS system is utilised slurry cleaning and storage silos will be required in close proximity of the launch shaft.

3.1.4. Open Cut Road Crossings

For crossing minor roads and access tracks a more cost-effective alternative to pipe-jacking is that of open-cut. These crossings are outlined in the previous section for route 25 and 27 respectively. These crossings will require careful planning and advanced warning with the impacted stakeholders. The works should be planned to coincide with periods of low use, and where possible alternative means of access should be provided. The schedule for undertaking these open cut crossings should be as short as practicable with extended working hours permitted to allow the contractor to complete the works with minimal disruption to the impacted stakeholders.

During the works National Roads and Street Works Act NRSWA, Chapter 8 compliant Traffic Management will need to be installed by NRSWA certified personnel. There are two methods of undertaking the open cut crossings that a contractor could deploy. Selection of which will be dependent on subsequent discussion with the impacted stakeholders and the width of crossing to be undertaken.

These methods are:

1. Road closure - Excavation, installation, and reinstatement in a single activity.
2. Lane closure - Excavation, installation, and reinstatement of half the crossing with traffic passing under signalling. The second half of the crossing is then installed with traffic being diverted onto the completed works.

3.1.5. Ground Water Mitigation

Along the pipe route there is expected to be sections with high ground water. The number of locations may increase during the winter months when higher rainfall is expected. For this project pipeline excavations will extend through glaciofluvial, glaciolacustrine and alluvial superficial deposits. Such excavations will require thorough investigation and a carefully considered temporary works design. For further methodology description refer to Appendix A.4.

3.1.6. Poor Ground Mitigation

The design requires pipe installation at an average depth of 3.5m, from ground level. If the ground conditions are not favourable, as anticipated at several points along the route, this will require a departure from the typical construction methodology identified above. For further methodology description refer to Appendix A.4.

3.1.7. Access Points

Efficient supply of labour, plant, and materials to, and from, the works location is essential for a contractor undertaking the works. Generally, access to the works location should be along the working corridor however, where this corridor does not intersect with the Local Road Network (LRN) access needs to be provided.

Access locations have been identified as part of the pipeline design and will need to be considered as part of the project temporary land take requirements. When considering the location of these access points the following has been taken into consideration:

1. Where possible at least two access points to each cut and cover pipe run. Where larger pipe runs are required intermediate access points are proposed to shorten logistics routes.
2. That access points are located as close as practicable to the shaft locations to shorten haul distances for pipe-jacking arisings and delivery of pre-cast concrete products.
3. Grouping access points from the LRN to minimise Temporary Traffic Management requirements and to reduce travel time for the main contractor between sites.
4. Existing access points and routes are utilised to minimise the impact of the work on the local environment and minimise enabling and reinstatement activities.
5. Width of access points is 5.5m to allow two HGVs to pass side by side. Where this is not possible passing places should be utilised. The length of access points between LRN and working corridor should be as short as practicable.

3.1.8. Office and Welfare Strategy

A pipeline contractor will need to provide office and welfare facilities that comply with Schedule 2 of the CDM Regulations 2015, and HSE Guidance Sheet No59.

For Route option 25 these are proposed to be located as follows:

1. Primary site establishment - At the Oswestry.
2. Temporary Compound 1 - At 5km out from Oswestry
3. Temporary Compound 2 - North of the Outfall

For Route option 27 these are proposed to be located as follows:

1. Primary site establishment - At the Oswestry
2. Temporary Compound 1 - At 5km out from Oswestry
3. Temporary Compound 2 - At 11km out from Oswestry
4. Temporary Compound 3 - Northwest of the Outfall

Mobile welfare will also be required at the location of pipe installation. This should be moved along the working corridor as the pipe laying activities advance. A similar mobile arrangement will be required for the trenchless crossing teams. The set up should move from location to location as the works proceed.

3.1.9. Outfall

To facilitate construction of the outfall structure a water excluding temporary works structure may be required. For further methodology description refer to Appendix A.4. Once dewatered a large open excavation will be required to construct the new outfall and weir structures. The landside working area around the excavation should be secured during construction by security hoarding around the site perimeter and access to the site should be controlled. The site area should include sufficient space for offices, vehicle parking, welfare facilities and storage for plant and materials. During construction the riverbank footpath will need to be temporarily closed and diverted around the site.

The timing of in river works and high noise/vibration works should be scheduled, where possible, for the period June to September to avoid lamprey migration and salmon upstream migration and spawning periods.

3.1.10. Valve compound and Washout area construction

The design requires Air Valve and Washout Areas at locations along the route. The location of these assets will be confirmed during the next stage of design.

The typical construction sequence for Air Valves could be as follows:

1. Main pipe installed and location of air valves left exposed.
2. T-junction and reducer cut into pipeline and air valve installed.
3. Access chambers constructed from insitu or pre-cast concrete.
4. Ground around the valve chambers backfilled and compacted. Areas made good with topsoil or hard surfacing installed.
5. Permanent access routes to the valve chambers installed for operation and maintenance.

The typical construction sequence for Washouts could be as follows:

1. Main pipe installed and location of washout left exposed.
2. Offset T-junction and reducer installed.
3. Washout pipework installed to discharge location including washout valve.
4. Access chambers constructed from insitu or pre-cast concrete around the washout valve.
5. Ground around the washout valve chambers backfilled and compacted. Areas made good with topsoil or hard surfacing installed.
6. Construction/installation (if precast concrete) of reinforced concrete Washout Headwall and base. Temporary works may be required to facilitate a safe and dry working environment.
7. Installation of river erosion protection

8. Installation of ancillary elements i.e., Handrails etc

9. Permanent access routes to the discharge and valve chamber installed for operation and maintenance.

3.1.11. Private Landowners

Across the pipeline route there will be an interface with private landowners. These interfaces should be clearly mapped and become the basis for a comprehensive stakeholder management plan. The pipeline contractor should be included in the stakeholder plan to ensure that lines of communication are clearly defined and that any reinstatement or compensatory works are fully understood.

3.1.12. Utilities

There are several utilities in the general vicinity of the pipe alignment however they do not traverse the pipe alignment or encroach into the working corridor. Once the C2 searches have been undertaken during the next stage of the project they should be overlaid on the pipe route to ensure that any utilities that clash with the pipe alignment are considered in the design development. If the clash cannot be mitigated by relocating the pipe, then these interfaces should be clearly identified and communicated as part of the preconstruction information.

3.2. CDM Implementation

In the Gate 2 process, Jacobs was appointed by Severn Trent Water as a designer in accordance with the Construction Design and Management (CDM) Regulations 2015.

Whilst Initial pre-construction information from United Utilities will be requested for Oswestry and potential hazard information extracted, this will only affect the upstream end of the pipeline. Hazard information was also extracted from the geotechnical baseline study. Site visits will be carried out by Designers during the next phase to verify feasibility of the conceptual designs as well as to gather information on site conditions which could potentially cause health and safety hazards.

Measures which could be taken to eliminate the hazards or to mitigate the risks during Gate 2 were incorporated into the conceptual design, and elimination or mitigation actions to be taken at the future design stages were identified. Potentially significant and/or unusual health and safety risks in the Vyrnwy Pipeline project are listed in the table below.

The hazard information collected, the design measures taken in Gate 2, as well as the measures to be taken at the future stages will be handed over to Gate3 Principal Designers and Designers for further “Safety in Design” activities in conformance with the CDM Regulations 2015.

Table 3-1: Outline of Potentially Significant and/or Unusual Health & Safety Risks with Potential Mitigations

Potential significant and/or unusual health and safety risks	Potential mitigations
Risk of drowning in work adjacent to deep water during construction of outfalls and crossings	Appropriate safe system of work to be implemented, which would include appropriate edge protection, life saver rings/ropes, and appropriate use of life jackets.

3.3. Construction Environmental Management Plan

The table below shows potential environmental mitigation measures for identified environmental topic areas.

Table 3-2 - Environmental Mitigation

Topic	Receptor	Specific Construction Mitigation
Ecology	Priority habitat (deciduous woodland, traditional orchards,	Avoidance of any habitat loss/damage by keeping the working area to the minimum practicable required for construction (informed by UK Habitat and site condition surveys along route).

Topic	Receptor	Specific Construction Mitigation
	purple moor-grass and rush pastures).	Best practice dust and pollution prevention measures to avoid damage to habitats/species. Trees protected in line with BS 5837:2012 - Trees in relation to design, demolition, and construction. Habitats, trees, shrubs, grassland reinstated (planted, seeded, relevant aftercare). Species specific mitigation to be informed by protected and notable species surveys along route, scope of these to be informed by UK Habitat and site condition surveys along route. European protected species (e.g., great crested newt, white clawed crayfish, dormouse, otter and bats) and other protected and/or notable species (e.g., badgers, breeding birds, fish, water vole, common reptiles and invertebrates) to be managed as agreed with Natural England, if applicable.
Water	River Morda, stream crossings	Tunnel or directional drilling under main rivers where possible. Minimise removal of riparian vegetation (avoid damage to bank stability, minimise habitat loss). If necessary to remove, reinstate riparian vegetation. Minimise duration of any necessary in-channel working to avoid compaction, disruption of flow processes, bank erosion Minimise impacts on water quality through temporary fluming watercourses, buffer strips, straw bales to stop sediment from the site compounds running off-site untreated. Construction mitigation relating to fine sediment runoff and spills and leaks management to be included as defined as part of any environmental permit applications and may require some route re-alignment. Timing of in river works and high noise/vibration works to avoid salmon upstream migration and spawning periods. Optimal construction period is June to September.
Heritage	Listed buildings	Desk based study of cultural heritage assets within and adjacent to construction works (confirmation of locations, descriptions of assets). Subject to the findings of the desk-based study a further programme of archaeological and heritage investigation may be required to be agreed with Historic England and the local authority. Monitoring by qualified staff prior and during construction if required and as agreed in any further investigation programme, including recording and intervention as appropriate.
Recreation	Public Rights of Way (PRoW)	All closures to be agreed with the relevant regulators and stakeholders. Alternative routes identified if possible, using existing public rights of way or public highways, with appropriate signage. Any public rights of way affected during construction to be reinstated following completion of works. Screening to be used where required in construction locations which are in proximity to public rights of way.

3.4. Transportation of Construction Materials and Spoils

3.4.1. Pipeline and Trenchless Section Construction Materials Delivery

All the pipeline and trenchless work sites will require construction material delivery. These will be transported to site using HGVs, which will have an impact on the surrounding road networks. The number of HGVs for transportation of this material has been estimated for Route options 25 and 27. The pipeline along its whole length will produce a significant quantity of spoil and will require the importation of fill material to support the pipe. However, it is proposed that the required volumes of each can be reduced significantly by the re-use of suitable excavated material

3.4.2. Spoil Disposal

All the work sites will generate spoil from Open Trench excavation, Trenchless construction, Air Valve and Washout installation/construction activities and Outfall construction. The spoil produced during construction would normally be transported along the working corridors using all terrain dump trucks to the access point.

Once at the access point the spoil would be loaded onto HGVs for transport via the LRN (Local Road Network) to point of disposal. These vehicle movements will have an impact on the surrounding road networks.

The quantities of spoil have been estimated based upon assumed depths of the trench excavation, Washout construction excavation and pipe jack diameters stated earlier in the report and readily available ground information. Appropriate bulking factors have also been assumed for the different types of ground anticipated.

No opportunities for rail transport have been identified during Gate 2. Suitable spoil disposal locations would need to be identified.

3.4.3. Vehicle Movements During Construction

Vehicle movements across the scheme have been quantified to give an order of magnitude for each of the chosen route. There are two component parts to the vehicle movements, open cut and trenchless.

Table 3-3 - Summary of vehicle movements for open cut section for Route 25

Chainage Start	Chainage Finish	Estimated number of HGVs for spoil removal.	Estimated number of HGVs for Steel pipe deliveries.	Estimated number of HGVs for pipe bedding import.
0	5150	785	49	532
5150	10300	785	49	532

Table 3-4 Summary of vehicle movements for trenchless crossings for Route 25

ID	Length (m)	Crossings	Estimated number of HGVs for spoil removal.	Estimated number of HGVs for Pre-Cast Concrete Units
G1	80	Private Road + River Morda	40	7
G2	30	Stream/Brook	36	5
G3	30	Stream/Brook	36	5
G4	30	Private Road	36	5
G5	50	A483	38	6
G6	40	Stream/Brook	37	5
G7	40	Abandoned railway	37	5
G8	30	Stream/Brook	36	5
G9	30	Stream/Brook	36	5

Table 3-5 - Summary of vehicle movement for open cut section for Route 27

Chainage Start	Chainage Finish	Estimated number of HGVs for spoil removal.	Estimated number of HGVs for Steel pipe deliveries.	Estimated number of HGVs for pipe bedding import.
0	8250	1257	78	853
8250	16500	1257	78	853

Table 3-6 Summary of Vehicle Movements Trenchless Crossings for Route 27

ID	Length (m)	Crossings	Estimated number of HGVs for spoil removal.	Estimated number of HGVs for Pre-Cast Concrete Units
G1	80	Private Road + River Morda	40	8
G2	30	Stream/Brook	36	5
G3	30	Stream/Brook	36	5
G4	30	Private Road	36	5
G5	50	A483	38	6
G6	30	Stream/Brook	37	5

ID	Length (m)	Crossings	Estimated number of HGVs for spoil removal.	Estimated number of HGVs for Pre-Cast Concrete Units
G7	40	Abandoned railway	37	5
G8	30	Private Road	36	5
G9	30	River Morda	36	5
G10	30	Stream/Brook	36	5
G11	30	Stream/Brook	36	5
G12	30	Stream/Brook	36	5
G13	30	Stream/Brook	36	5
G14	30	Stream/Brook	36	5
G15	30	Stream/Brook	36	5
G16	30	Stream/Brook	36	5
G17	40	Stream/Brook	36	5
G18	30	Stream/Brook	36	5
G19	30	Weir Brook	37	5
G20	50	Weir Brook	36	5

The vehicle movements have been quantified based on the following assumptions:

1. 13m^3 HGVs are used to remove spoil from site and bring in pipe bedding material.
2. 6m^3 Concrete wagons are used to bring in ready mix concrete.
3. Pipes and Pre-cast concrete are brought to site on 27.5tn articulated HGV's

3.5. Delivery Programme

This scheme has passed RAPID's stage Gate 1, with the project team now focused on developing the concept design. The scheme will be submitted to RAPID for stage Gate 2 review in November 2022, with a decision from RAPID on whether the scheme can commence to Gate 3 in March 2023. During stage Gate 3, the proposals will be developed by commencing a programme of pre-planning activities, including comprehensive community and stakeholder engagement, and developing the mitigations for the potential environmental impacts of the project.

Based on the Programme allied to this Concept Design Report, the Vyrnwy Conveyance will be construction ready in AMP8. High level durations and logic have been applied to key elements of the Vyrnwy bypass project to generate a high-level scheme schedule. Refer to Appendix A.1 for the Indicative Implementation Programme.

The schedule has been prepared to Level 2 detail (L2). A Level 2 schedule represents the overall project broken down into its major components and shows the critical path that flows from start to finish. The schedule can be integrated into the Level 1 project schedule to control the overall program, or to compare different options. The following Assumptions and Exclusions apply to this current version of the L2 Programme:

Assumptions:

1. The construction durations were estimated assuming the methodologies identified in the Conceptual Design Report,
2. Productivity is based upon the use of welded steel pipework,
3. All ancillary works, for example valve arrangements and washouts, along both routes can be constructed concurrently with the pipeline installation works,
4. Construction of the Outfall for both routes can be constructed concurrently with the pipeline installation works,

5. Works will be suspended during all Bank Holidays and between Christmas and New Year of each respective year,
6. The calendar for the project was assumed to be based on a 5-day work week with no allowance for night, possession,
7. No financial constraints imposed on the schedule for annualised spend,
8. No seasonal constraints were applied and that outputs were normalised for winter and summer,
9. All necessary access and logistics requirements are achievable.
10. All schemes will need a Development Consent Order (DCO) to proceed to construction. This assumption is being validated by a parallel workflow which could result in a Town and Country Planning Act (TCPA) approach being adopted.

Exclusions:

1. No allowance has been made for works at Oswestry,
2. No allowance for suspension of the works due to Floodplain issues has been allowed for,
3. No planning, ecological, archaeological, environmental, access, traffic management or rail possession constraints were applied,
4. Time Risk Allowance or Terminal Float could not be quantified for each activity at this stage due to limited available design details,

3.5.1. Pre-construction Phase

The pre-construction phase of the project covers everything that facilitates making the project ‘shovel ready’ and allows the contractor to start work onsite. This phase starts at the Tender Award / CAP award for the Contractor and includes the following:

Detailed Design

The design for the pipeline assets is likely to be of a standard/basic nature, whilst the design for the trenchless crossings, and outfall are likely to be more complex. This Detailed Design stage also allows for the completion of associated site Ground Investigation works and incorporation of the findings into the design. An allowance of 18 months has been made for these activities.

Procurement

It is proposed that the main contractor will undertake the detailed design of the scheme. This approach should allow the contractor to identify long lead procurement items and tender key subcontract packages. At this stage of the project the only materials that are considered long lead are the pipes, bends, junctions, and valving. The key subcontract packages that have been identified at this stage of the project are the trenchless crossing sub-contractor and pipe welding sub-contractor. A conservative 12 months has been included on schedule for procurement of these items.

Enabling Works

Enabling works is the final pre-construction activities that prepares the site for construction works. The schedule identifies; Site establishment, archaeological mitigation, environmental mitigation and installation of perimeter fencing as the key activities during this phase. These are also activities that can be conducted prior to award of a DCO. Should one be required for the scheme. The duration of each of these activities will be dependent on further screening work undertaken as the project matures however an allowance of 11 months has been made on the schedule. The works can take place whilst the detailed design and procurement activities are taking place.

The pre-construction duration for Vyrnwy is 30 months for both Route options 25 and 27.

3.5.2. Construction and Commissioning Stages

Construction

The construction works are scheduled to start immediately after site establishment. The critical path then flows through the open-cut pipe laying activities, with trenchless crossings being undertaken in advance and valving work following on. The pipe laying duration is resource driven and therefore deploying more gangs on the activity, will shorten the activity duration. As pipe laying is on the critical path any change in duration will directly impact the planned completion date of the project.

The optimal resource level for pipe laying should be explored and further and agreed in Gate 3 on the required operation date for the scheme. For comparison purposes only one pipe laying gang has been used in both Route 25 and Route 27 schedules. This results in a later end date of Route option 27 when compared to Route option 25 which can be attributed to its longer length. It is feasible that if the level of resource was increased, to two or three gangs, on route option 27 it could finish at the same time or even earlier than route option 25.

The single gang works progressively from Ch0 to Ch10300 on Route 25, and from Ch0 to Ch16500 on Route 27. Ch0 is located at Oswestry at the upstream end.

To aid continuity of the main pipeline installation works, it is proposed that the trenchless crossings are completed progressively in advance of the main route. The programme identifies 1 pipe-jack team is required to achieve this. The pipe-jacking gang would likely consist of two halves: jacking/reception pit team, and pipe-jack team. The first half would work ahead of the second installing pits on a just in time basis so that the pipe-jacking equipment is never underutilised. Once pipe had been jacked the jacking/reception pit team would fall back and make good each location and prepare the connection for the pipe laying gangs to tie into.

It is proposed that the Air Valve and Washout arrangements are constructed by separate dedicated resources. This element of the works is scheduled to commence after the initial pipe laying activities and continue in parallel until the pipeline is complete.

It is proposed that the outfall is constructed by separate dedicated resources. The structure should be completed prior to the date at which the main pipeline construction reaches it and allows the pipe laying team to tie into it as the final construction activity. The timing of construction should also coincide with favourable summer weather when river levels are likely to be lower and salmon spawning and lamprey migration season. This period has been identified as June to September.

The assumed L2 Schedule baseline output rates are shown in the table below

Table 3-7: L2 Schedule Baseline Output Rates

Item	Rate
Pipe laying (800mm to 1100m) – Easy Access	50m/day/gang
Jacking/Reception Shaft Construction	1 ring/day
Pipe Jacking - 1m Diameter	12m/day
Note. There are minor deviations from these rates to account for local constraints	

The overall construction duration for the Vyrnwy pipeline is the following:

- Route option 25: 13 months
- Route option 27: 20 Months.

Commissioning

Based on previous water company experience for an optimised pipeline QA and commissioning regime, an allowance of two months is included on the schedule for this phase of the works. Following commissioning, the system would be handed over to operation and a performance testing period to assess the overall operation of the system would commence. This Performance Testing period would run concurrently with the contractors 12 months defect period.

3.5.3. Summary

The programme dates* for Route option 25 and 27 can be seen in Table 3-8 and Table 3-9 respectively.

*Programmes are based on an 'early as possible' scenario

Table 3-8 - Programme dates for Route option 25

Task Name	Duration (months)	Start Date	Finish Date
Contract Management	81.5	04-Oct-22	08-Oct-29
Pre-Construction	44.5	15-Aug-23	15-Jun-27
Procurement	12	01-May-26	14-May-27
Enabling Works	14	30-Mar-26	15-Jun-27
Construction	13	15-Jun-27	26-Jul-28
System Commissioning Works	2	26-Jul-28	26-Sep-28
Performance Testing	6	26-Sep-28	05-Apr-29
Defects Period	12	26-Sep-28	08-Oct-29

Table 3-9 - Programme dates for Route option 27

Task Name	Duration (months)	Start Date	Finish Date
Contract Management	88.5	04-Oct-22	17-May-30
Pre-Construction	44.5	15-Aug-23	15-Jun-27
Procurement	12	01-May-26	14-May-27
Enabling Works	14	30-Mar-26	15-Jun-27
Construction	20	15-Jun-27	02-Mar-29
System Commissioning Works	2	02-Mar-29	04-May-29
Performance Testing	6	04-May-29	06-Nov-29
Defects Period	12	04-May-29	17-May-30

3.5.4. Integration with Other SRO Programmes

The Vyrnwy bypass pipeline is a source of water for the STT SRO. Its construction will be programmed to be available for operation in line with the Regional Modelling.

4. Water Resources

4.1. Deployable Output

The Vyrnwy bypass project comprises a pipeline conveying flow from Oswestry WTW to the lower reach of the River Vyrnwy or the River Severn, therefore it does not provide any additional water resource or Deployable Outputs (DOs). However, the implementation of the project will release additional water to the River Severn, that once abstracted downstream, including by STT, will provide benefits to the final users.

4.2. Regulation and Licensing

A new discharge licence will be required for the new River Vyrnwy or Severn discharge, and for the washout outfalls and planning permission may be required. However it is noted that a new permitting strategy has been developing of all abstractions and discharges to the River Severn catchment as part of the permitting strategy for the wider STT.

5. Assumptions, Risks and Uncertainty of Benefits

5.1. Key Assumptions

Key assumptions that have been made in this conceptual design report are listed below:

1. Any requirement for dechlorination will be dealt with by the relevant UU Oswestry project team
2. An upstream balancing tank (which may be linked to dechlorination) will be designed by the relevant UU Oswestry project team
3. A discharge consent will be granted by the EA/NRW for discharge into the River Vyrnwy/River Severn for transfer into the STT system
4. It was assumed that there will be no issues with land access for the construction of the pipeline
5. River Vyrnwy Discharge has been assumed as 75Ml/d above any existing compensatory discharge flow. This will need to be further reviewed and in line with feedback from NRW and EA.
6. It was assumed that the Lake Vyrnwy Sustainable Yield is a minimum of 180Ml/d.
7. Discharge locations have been chosen from a desk study exercise. There was an assumption that these discharge locations may alter +/- 1km upstream or downstream on the river once site visits and further detail is understood about the adjacent land, the river and the location of the discharge and any potential impact on the river.

5.2. Key Risks

Key risks associated with this project are listed as follows:

1. There is a risk that unexpected ground conditions increase construction complexity
2. There is risk that service diversions along the route are more numerous or more difficult to incorporate than anticipated.
3. Existing landowners/planning issues cause complications in land purchase/rental for permanent control valve compound and temporary contractor's areas.
4. Additional ecological works for protected species are required that are found.

5.3. Uncertainty of Benefits

Key uncertainties identified that could impact on the realisation of project benefits are listed as follows:

- A long pipeline project will be high profile and high cost. There is a potential to face challenge from approving authorities.
- Discharge consents could be challenged regarding environmental effects.
- There has been no consultation at this stage with local authorities or local communities regarding environmental challenge and associated mitigation.

5.4. Opportunities

Key opportunities identified in the conceptual design are listed in the table below.

Table 5-1: Key Opportunities

Category	Opportunities
Pipeline Design	The pipeline material is assumed to a be a thin wall steel pipe, however further assessment as to the optimal pipe material is to be undertaken at the next stage of design.
Pipeline Design	Smaller pipeline diameters with accompanying economic benefits may be achievable, however, would have hydraulic and operational implications.
Hydro-generation	Energy Recovery opportunities are possible from hydro generation. The economic feasibility of this needs to be studied further in the next stage.

6. Glossary

Acronym	Definition
AMP	Asset Management Period
AV	Air release Valve
AWTP	Advanced Water Treatment Plant
BPT	Break Pressure Tank
CAPEX	Capital Expenditure
Ch	Chainage
CDR	Conceptual Design Report
DCO	Development Consent Order
DO	Deployable Output
DNO	Distribution Network Operator
DWF	Dry Weather Flow
DWI	Drinking Water Inspectorate
dWRMP14	Draft Water Resource Management Plan 2014
EA	Environment Agency
FCV	Flow Control Valve
GIS	Geographic Information System
HGV	Heavy Goods Vehicle
ICA	Instrumentation Control and Automation
kW	kilowatt
LRN	Local Road Network
L2	Level 2 - This refers to the level of detail in the Programme/Schedule
LV	Low Voltage
MEICA	Mechanical, Electrical, Instrumentation, Control and Automation
Ml/d	Mega litres per day
OPEX	Operational Expenditure
NRSWA	New Roads and Street Works Act
NRW	Natural Resources Wales
PS	Pumping Station
RAPID	Regulators' Alliance for Progressing Infrastructure Development
SRO	Strategic Resource Option
STT	Severn Thames Transfer
STW	Severn Trent Water
TC	Trenchless Crossing
TCPA	Town and Country Planning Act
UV	Ultra-Violet
UU	United Utilities
WRMP14	Water Resource Management Plan 2014
WRMP19	Water Resource Management Plan 2019
WwTW	Wastewater Treatment Works

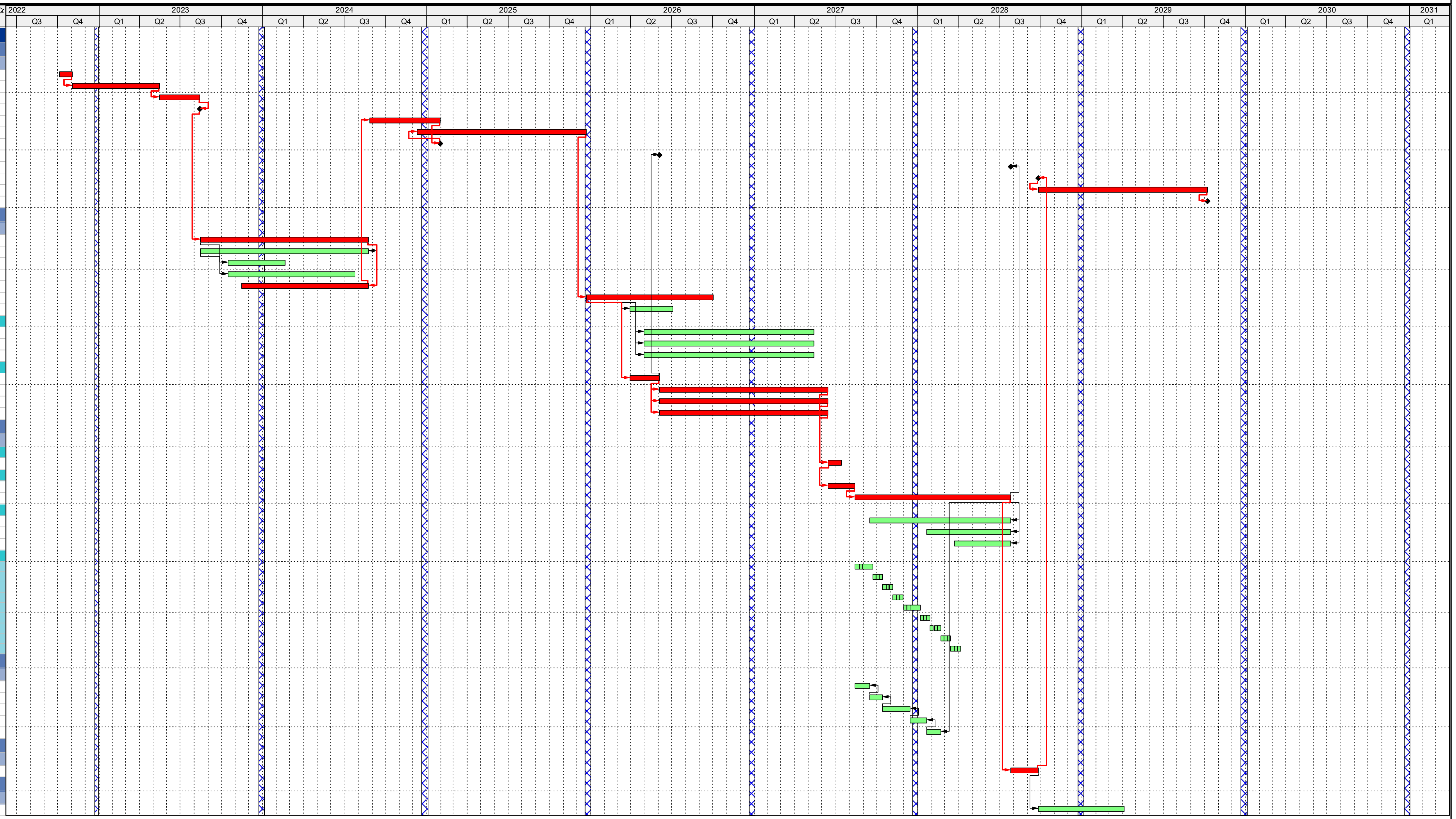
Appendix A. Technical Material

A.1 Indicative Implementation Programme

Vyrnwy Construction Programmes

Jacobs

Activity ID	Activity Name	Original Duration	Start	Finish
Vyrnwy Construction Programmes		81.50m	04-Oct-22	08-Oct-29
Contract Management		81.50m	04-Oct-22	08-Oct-29
Route 25		81.50m	04-Oct-22	08-Oct-29
R25_X1000	Submission to RAPID Gate 2	1.00m	04-Oct-22*	02-Nov-22
R25_X1010	RAPID Decision on Scheme Progression to Gate 3	6.00m	02-Nov-22	15-May-23
R25_X1020	Procure Gate 3 Designer	3.00m	15-May-23	14-Aug-23
R25_X1030	Gate 3 Designer in place	0.00m		14-Aug-23
R25_X1040	TCPA Determination	5.00m	27-Aug-24	31-Jan-25
R25_X1050	Procurement of Delivery Contractor	12.00m	10-Dec-24	22-Dec-25
R25_X1060	TCPA Decision	0.00m		31-Jan-25
R25_X1070	Start Onsite	0.00m	03-Jun-26	
R25_X1080	Construction Completion	0.00m		26-Jul-28
R25_X1090	Commissioning and Handover to TW	0.00m		26-Sep-28
R25_X1100	Defects Period	12.00m	26-Sep-28	08-Oct-29
R25_X1110	Retention Released	0.00m		08-Oct-29
Pre-Construction		44.50m	15-Aug-23	15-Jun-27
Route 25		44.50m	15-Aug-23	15-Jun-27
R25_A1000	Gate 3 Concept Design	12.00m	15-Aug-23	23-Aug-24
R25_A1010	Produce EIA	12.00m	15-Aug-23	23-Aug-24
R25_A1020	Phase 1 GI	4.00m	16-Oct-23	20-Feb-24
R25_A1030	Environmental Survey	9.00m	16-Oct-23	25-Jul-24
R25_A1040	TCPA Submission Production	9.00m	14-Nov-23	23-Aug-24
R25_A1050	Gate 3 Detailed Design	9.00m	22-Dec-25	02-Oct-26
R25_A1060	Phase 2 GI	3.00m	30-Mar-26	03-Jul-26
Procurement		12.00m	01-May-26	14-May-27
R25_A1100	Pipeline Materials and Valves	12.00m	01-May-26	14-May-27
R25_A1110	Power Supplies	12.00m	01-May-26	14-May-27
R25_A1120	Trenchless Crossing Materials and Equipment	12.00m	01-May-26	14-May-27
Enabling Works		14.00m	30-Mar-26	15-Jun-27
R25_A1200	Main Project Office/Site Establishment	2.00m	30-Mar-26	03-Jun-26
R25_A1210	Archaeological Advanced Work	12.00m	03-Jun-26	15-Jun-27
R25_A1220	Environmental Management	12.00m	03-Jun-26	15-Jun-27
R25_A1230	Dispatch TCPA planning conditions	12.00m	03-Jun-26	15-Jun-27
Construction		13.00m	15-Jun-27	26-Jul-28
Main Works - Route 25		13.00m	15-Jun-27	26-Jul-28
Oswestry Treatment Works		1.00m	15-Jun-27	15-Jul-27
R25_B1000	Establish Site Compound	1.00m	15-Jun-27	15-Jul-27
Pipe Laying		13.00m	15-Jun-27	26-Jul-28
R25_B2000	Establish Working Coridor, Access Routes, Compounds	2.00m	15-Jun-27	13-Aug-27
R25_B2010	Pipe Laying (10300m)	11.00m	13-Aug-27	26-Jul-28
Ancillary Infrastructure		10.00m	15-Sep-27	26-Jul-28
R25_B2120	Air Valves, Line Valves and Washouts	10.00m	15-Sep-27	26-Jul-28
R25_B2100	Downstream Valve installation	6.00m	21-Jan-28	26-Jul-28
R25_B2110	Upstream Valve installation	4.00m	22-Mar-28	26-Jul-28
Trenchless Crossings		7.50m	13-Aug-27	05-Apr-28
Private Road & River Morda (80m)		1.25m	13-Aug-27	22-Sep-27
Stream/Brook 1 (30m)		0.75m	22-Sep-27	14-Oct-27
Stream/Brook 2 (30m)		0.75m	14-Oct-27	05-Nov-27
Private Road (30m)		0.75m	05-Nov-27	29-Nov-27
A483 (50m)		1.00m	30-Nov-27	06-Jan-28
Stream/Brook 3 (40m)		0.75m	06-Jan-28	28-Jan-28
Abandoned railway (40m)		0.75m	28-Jan-28	21-Feb-28
Stream/Brook 4 (30m)		0.75m	21-Feb-28	14-Mar-28
Stream/Brook 5 (30m)		0.75m	14-Mar-28	05-Apr-28
Outfall Works		6.00m	13-Aug-27	21-Feb-28
Route 25		6.00m	13-Aug-27	21-Feb-28
R25_C1000	Instal Temporary Works	1.00m	13-Aug-27	15-Sep-27
R25_C1010	Excavate to Formation	1.00m	15-Sep-27	14-Oct-27
R25_C1020	Cast Concrete Structures	2.00m	14-Oct-27	14-Dec-27
R25_C1030	Remove Temporary Works	1.00m	14-Dec-27	21-Jan-28
R25_C1040	Instal access covers, gratings, landscaping, and fences	1.00m	21-Jan-28	21-Feb-28
System Commissioning Works		2.00m	26-Jul-28	26-Sep-28
Route 25		2.00m	26-Jul-28	26-Sep-28
R25_D1000	Conveyance	2.00m	26-Jul-28	26-Sep-28
Performance Testing		6.00m	26-Sep-28	05-Apr-29
Route 25		6.00m	26-Sep-28	05-Apr-29
R25_E1000	Performance Testing	6.00m	26-Sep-28	05-Apr-29



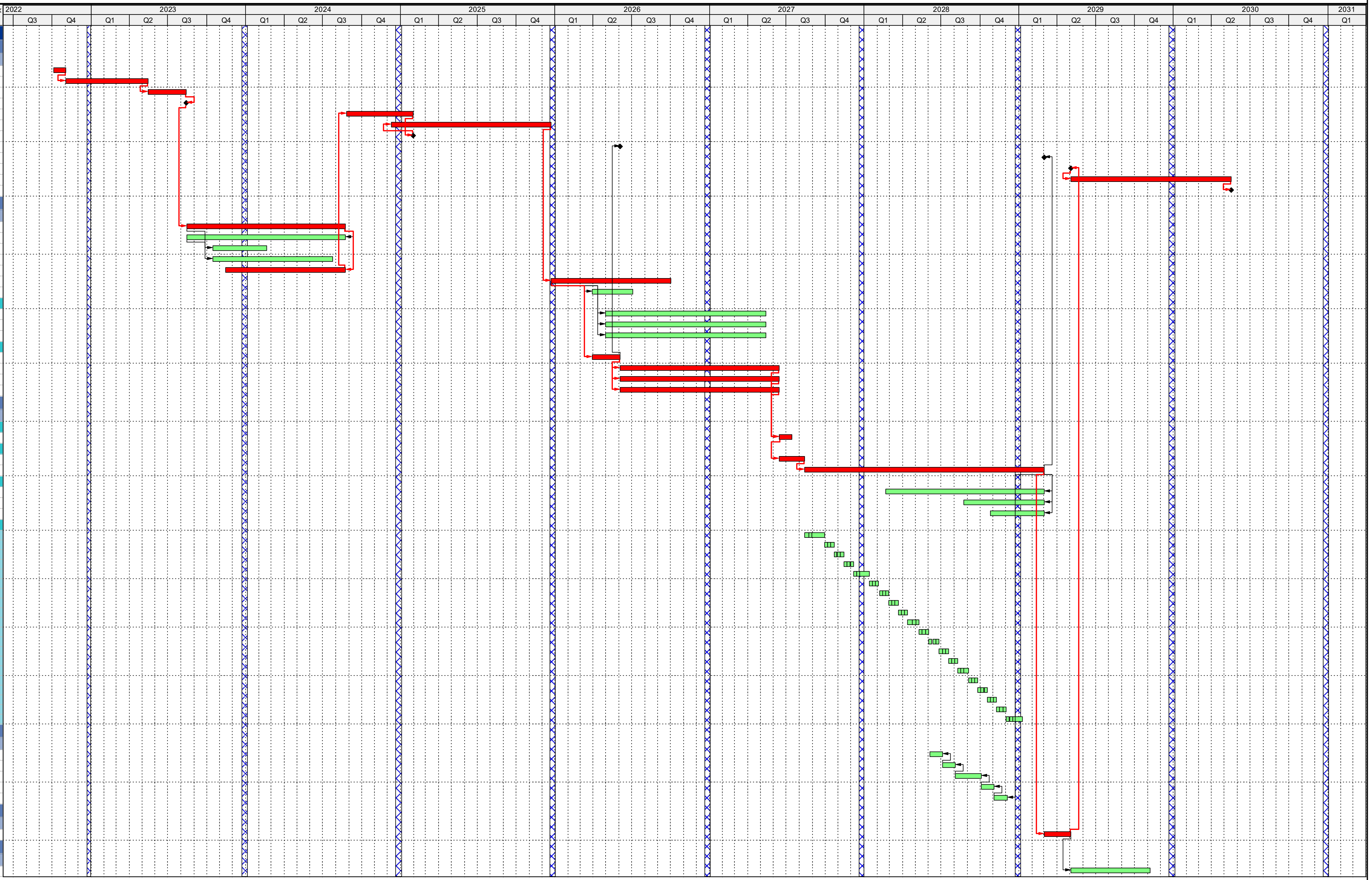
Remaining Level of Effort	Actual Work	Critical Remaining Work
Actual Level of Effort	Remaining Work	◆ Milestone

Date	Revision	Checked	Approved
25-Aug-22	Vyrnwy Construction Programmes - Route 25		

Vyrnwy Construction Programmes

Jacobs

Activity ID	Activity Name	Original Duration	Start	Finish
Vyrnwy Construction Programmes		88.50m	04-Oct-22	17-May-30
Contract Management		88.50m	04-Oct-22	17-May-30
Route 27		88.50m	04-Oct-22	17-May-30
R27_X1000	Submission to RAPID Gate 2	1.00m	04-Oct-22*	02-Nov-22
R27_X1010	RAPID Decision on Scheme Progression to Gate 3	6.00m	02-Nov-22	15-May-23
R27_X1020	Procure Gate 3 Designer	3.00m	15-May-23	14-Aug-23
R27_X1030	Gate 3 Designer in place	0.00m		14-Aug-23
R27_X1040	TCPA Determination	5.00m	27-Aug-24	31-Jan-25
R27_X1060	Procurement of Delivery Contractor	12.00m	10-Dec-24	22-Dec-25
R27_X1050	TCPA Decision	0.00m		31-Jan-25
R27_X1070	Start Onsite	0.00m	03-Jun-26	
R27_X1080	Construction Completion	0.00m		02-Mar-29
R27_X1090	Commissioning and Handover to TW	0.00m		04-May-29
R27_X1100	Defects Period	12.00m	04-May-29	17-May-30
R27_X1110	Retention Released	0.00m		17-May-30
Pre-Construction		44.50m	15-Aug-23	15-Jun-27
Route 27		44.50m	15-Aug-23	15-Jun-27
R27_A1000	Gate 3 Concept Design	12.00m	15-Aug-23	23-Aug-24
R27_A1020	Produce EIA	12.00m	15-Aug-23	23-Aug-24
R27_A1010	Phase 1 GI	4.00m	16-Oct-23	20-Feb-24
R27_A1030	Environmental Survey	9.00m	16-Oct-23	25-Jul-24
R27_A1040	TCPA Submission Production	9.00m	14-Nov-23	23-Aug-24
R27_A1050	Gate 3 Detailed Design	9.00m	22-Dec-25	02-Oct-26
R27_A1060	Phase 2 GI	3.00m	30-Mar-26	03-Jul-26
Procurement		12.00m	01-May-26	14-May-27
R27_A1100	Pipeline Materials and Valves	12.00m	01-May-26	14-May-27
R27_A1110	Power Supplies	12.00m	01-May-26	14-May-27
R27_A1120	Trenchless Crossing Materials and Equipment	12.00m	01-May-26	14-May-27
Enabling Works		14.00m	30-Mar-26	15-Jun-27
R27_A1200	Main Project Office/Site Establishment	2.00m	30-Mar-26	03-Jun-26
R27_A1210	Archaeological Advanced Work	12.00m	03-Jun-26	15-Jun-27
R27_A1220	Environmental Management	12.00m	03-Jun-26	15-Jun-27
R27_A1230	Dispatch TCPA planning conditions	12.00m	03-Jun-26	15-Jun-27
Construction		20.00m	15-Jun-27	02-Mar-29
Main Works - Route 27		20.00m	15-Jun-27	02-Mar-29
Oswestry Treatment Works		1.00m	15-Jun-27	15-Jul-27
R27_B1000	Establish Site Compound	1.00m	15-Jun-27	15-Jul-27
Pipe Laying		20.00m	15-Jun-27	02-Mar-29
R27_B1010	Establish Working Coridor, Access Routes, Compounds	2.00m	15-Jun-27	13-Aug-27
R27_B1020	Pipe Laying (16500m)	18.00m	13-Aug-27	02-Mar-29
Ancillary Infrastructure		12.00m	21-Feb-28	02-Mar-29
R27_B1030	Air Valves, Line Valves and Washouts	12.00m	21-Feb-28	02-Mar-29
R27_B1040	Downstream Valve installation	6.00m	24-Aug-28	02-Mar-29
R27_B1050	Upstream Valve installation	4.00m	25-Oct-28	02-Mar-29
Trenchless Crossings		16.25m	13-Aug-27	10-Jan-29
Private Road & River Morda (100m)		1.50m	13-Aug-27	29-Sep-27
Stream/Brook 1 (30m)		0.75m	30-Sep-27	22-Oct-27
Stream/Brook 2 (30m)		0.75m	22-Oct-27	15-Nov-27
Private Road 1 (30m)		0.75m	15-Nov-27	07-Dec-27
A483 (50m)		1.00m	07-Dec-27	13-Jan-28
Stream/Brook 3 (30m)		0.75m	13-Jan-28	04-Feb-28
Abandoned railway (40m)		0.75m	07-Feb-28	29-Feb-28
Private Road 2 (30m)		0.75m	29-Feb-28	22-Mar-28
River Morda (30m)		0.75m	22-Mar-28	13-Apr-28
Stream/Brook 4 (30m)		0.75m	13-Apr-28	10-May-28
Stream/Brook 5 (30m)		0.75m	10-May-28	02-Jun-28
Stream/Brook 6 (30m)		0.75m	02-Jun-28	26-Jun-28
Stream/Brook 7 (30m)		0.75m	26-Jun-28	18-Jul-28
Stream/Brook 8 (30m)		0.75m	18-Jul-28	09-Aug-28
Stream/Brook 9 (30m)		0.75m	10-Aug-28	04-Sep-28
Stream/Brook 10 (30m)		0.75m	04-Sep-28	26-Sep-28
Stream/Brook 11 (40m)		0.75m	26-Sep-28	18-Oct-28
Stream/Brook 12 (30m)		0.75m	18-Oct-28	09-Nov-28
Weir Brook 1 (30m)		0.75m	09-Nov-28	01-Dec-28
Weir Brook 2 (50m)		1.00m	01-Dec-28	10-Jan-29
Outfall Works		6.00m	05-Jun-28	04-Dec-28
Route 27		6.00m	05-Jun-28	04-Dec-28
R27_C1000	Instal Temporary Works	1.00m	05-Jun-28	05-Jul-28
R27_C1010	Excavate to Formation	1.00m	05-Jul-28	03-Aug-28
R27_C1020	Cast Concrete Structures	2.00m	03-Aug-28	04-Oct-28
R27_C1030	Remove Temporary Works	1.00m	04-Oct-28	03-Nov-28
R27_C1040	Instal access covers, gratings, landscaping, and fences	1.00m	03-Nov-28	04-Dec-28
System Commissioning Works		2.00m	02-Mar-29	04-May-29
Route 27		2.00m	02-Mar-29	04-May-29
R27_D1000	Conveyance	2.00m	02-Mar-29	04-May-29
Performance Testing		6.00m	04-May-29	06-Nov-29
Route 27		6.00m	04-May-29	06-Nov-29
R27_E1000	Performance Testing	6.00m	04-May-29	06-Nov-29



Remaining Level of Effort | Actual Work | Critical Remaining Work
Actual Level of Effort | Remaining Work | ◆ Milestone

Date	Revision	Checked	Approved
25-Aug-22	Vyrnwy Construction Programmes - Route 27		

A.2 Design Hazard Elimination and Risk Register

Jacobs

DESIGN HAZARD ELIMINATION AND RISK REDUCTION REGISTER

Latest Meeting Date	
Phase	
C	Construction
M	Maintain / Clean
U	Use as Workplace
D	Demolish
Project Name:	Vyrnwy and Shrewsbury SRO
Project Number:	A7W13153
Client:	Severn to Thames / United Utilities

Update Critical Risk Table

Probability	Worst Potential Severity (WPS) of Impact	Risk Rating
1: Highly Unlikely 2: Unlikely 3: Possible 4: Likely 5: Highly Likely	1: Nil or slight injury / illness, property damage or environmental issue. 2: Minor injury / illness, property damage or environmental issue. 3: Moderate injury or illness, property damage or environmental issue. 4: Major injury or illness, property damage or environmental issue. 5: Fatal or long term disabling injury or illness. Significant property damage or environmental issue. 10. Multiple fatalities and catastrophic event	NOTE: The purpose of Risk Rating is to determine which risks are significant. It is a subjective assessment and not an absolute or precise determination

LIKELIHOOD	RISK				
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
SEVERITY	1	2	3	4	5

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Risk ID.	Formal Review Description	Phase	Activity	Potential Hazard	Person(s) Most at Risk	Prob	WPS	Initial Risk Rating	Discipline	Design Measures to Eliminate Hazards	Design Measures to Reduce Risk	Residual Prob	Residual WPS	Residual Risk Rating	Residual Risk Description	Included on Drawing No(s) or other doc. (give ref.)	Action By (Name or Role)	Target Date	Revised Target Date	Date Action Complete	Tracker Status	Comments	Primary Legislation
1	4: Routine Design Team Meeting	C	Large vehicles movement through rural areas to access Needle Valve chamber location during construction	Poor manoeuvrability through rural areas to access to all temporary compounds and the needle valve chamber compound (near the outfall) throughout construction. There is a risk of injuring the general public and workers	Public	3	5	15	Civil / Structural	Hazard cannot be completely eliminated.	Consider the location and size Shorten the construction period by considering pre-cast reinforced concrete for the chamber Reduce the requirement for temporary works	2	5	10	Although the risk of injuring general public in residential areas is reduced, it is still possible that large vehicles may injure general public during transportation to site. Appropriate traffic management systems to be in place.								
2	4: Routine Design Team Meeting	C	Construction of shafts for crossings	Operative will be working with shafts around 5 to 10m deep. Risk of operative falling (or being hit by falling object) during installation of services, working platforms or any other activity within drop shafts.	Construction	3	5	15	Civil / Structural	Hazard cannot be completely eliminated.	Minimise number of trenchless crossings hence consequently the number of deep shafts required. Option routes adjusted to improve hydraulic profile which subsequently minimised sections requiring deep trenches	2	5	10	risk still remains but it can be further mitigated during construction by employing Appropriate H&S measures including barriers and edge protection.								
3	4: Routine Design Team Meeting	C	Pipeline/chamber excavation	Accident due to striking of an underground service such as a gas pipeline and HV cables	Construction	4	5	20	Civil / Structural	Hazard cannot be completely eliminated.	carry out utilities survey and try to reduce number of crossing between proposed pipeline and existing services and amendif possible the proposed pipeline route to keep it away from known existing services.	3	5	15	Risk still remain.Adhere to HSG47G Avoiding danger from underground services. Consult Utility Records, visual inspection/surveys along entire route, carry out GPR surveys, trial holes, implement industry standard procedures i.e. activities associated with a Permit to Dig process such as a Cable Scan and 'slit trenches' etc								
4	4: Routine Design Team Meeting	M	mainteinance of valves	Electric shock due to occurrence of faults in electrical system or other accident involving electrical work	Operations	3	5	15	Electrical	Hazard cannot be completely eliminated.	Specify control panel and electrical equipment/system compatible with the correct operation of the proposed valves.	2	5	10	Risk still remains, but reduced if appropriate systems specified, correctly installed and maintained.								
5	4: Routine Design Team Meeting	C	laying of pipeline	Laying pipeline in areas with high aquifer productivity potential. Unstable excavation causing harm to construction personnel. Contamination of aquifer.	Construction	3	5	15	Civil / Structural	Hazard cannot be completely eliminated.	Try to avoid aquifer potential zones as much as possible. Identify any potential areas for further investigation and mitigation measures	2	5	10	Difficult and dangerous construction, poor stability in excavations (appropriate dewatering systems to be in place) and/or potential aquifer contamination.								
6	4: Routine Design Team Meeting	C	Manual Handling	Accident (Musculoskeletal) from Lifting/moving pipes, valves, flow meters, temporary pumps etc	Construction	3	4	12	Civil / Structural	Hazard cannot be completely eliminated.	Minimise as much as possible the weight of units being used. Where possible heavy units to be installed at ground level.	2	4	8	Risk of injury due to falling items or strenuous lifting								
7	4: Routine Design Team Meeting	C	Working in confined spaces	Excavations, work in chambers (e.g. The outfall or in tanks in Oswestry WTW) may present environment for a confined space hazard	Construction	3	5	15	Civil / Structural	Hazard cannot be completely eliminated.	Minimise units and chambers in enclosed spaces. Minimise depths of excavation where possible and incorporate trenchless methods to minimise open excavations	2	5	10	Risk of working in a confined space Adhere to H&S / Confined Space regulation								
8	4: Routine Design Team Meeting	C	working in proximity of unstable slopes	Falling into or collapse of excavations	Construction	3	5	15	Civil / Structural	Hazard cannot be completely eliminated.	Minimised depths of excavation where possible and incorporated trenchless methods to minimise open excavations	2	5	10	Risk still present but manageable by competent Contractor. Correct open excavation design based on ground conditions, appropriate barriers and edge protection to be in place. Ensure trenches/holes are kept covered and or backfilled as soon as is practicable								
9	4: Routine Design Team Meeting	C	Large vehicle movement adjacent to site using the same road access	Traffic incidents including interface with agricultural vehicles Risk of injury for workers	Operations	4	5	20	Civil / Structural	Hazard cannot be completely eliminated.	Consider the location and size	2	5	10	The risk of injuries or traffic incidents is reduced, but not entirely eliminated Appropriate traffic management systems to be in place.								
10	1: Interactive Design Safety Session	C	Construction plant movements	Accidents from poor or waterlogged ground conditions	Construction	3	5	15	Civil / Structural	Hazard cannot be completely eliminated.	Consider the location Reduce the requirement for temporary works	2	5	10	The risk of injuries or traffic incidents is reduced, but not entirely eliminated. Dewatering systems possibly required.								
11	1: Interactive Design Safety Session	C	Construction activity or operational activity	Accident from flooding (electrical or drowning)	Construction	4	5	20	Civil / Structural	Hazard cannot be completely eliminated.	Consider the location and size Reduce the requirement for temporary works Minimise depths of excavation wherever possible	3	5	15	The risk of an accident cannot be eliminated, though it is reduced. Appropriate dewatering systems to be provided.								
12	1: Interactive Design Safety Session	C	Construction/Operational plant movements	Electrocution via Strike or arcing of/from overhead cables	Construction	3	5	15	Civil / Structural	Hazard cannot be completely eliminated.	Consider the location and size Option Routes adjusted to reduce the crossing with OH cables	2	5	10	Risk still remains. Apppropriate use of banksmen Diversion / relocation/protection of cables as appropriate								
13	1: Interactive Design Safety Session	C	Construction activity	Storm damage to HV lines leading to electrocution	Construction	3	5	15	Civil / Structural	Hazard cannot be completely eliminated.	Consider the location and size Option Routes adjusted to reduce the crossing with OH cables	2	5	10	Apppropriate use of banksmen Diversion / relocation/protection of cables as appropriate. Suspend works ahead of forecasted storms.								
14	1: Interactive Design Safety Session	C	Excavation	Injury from Strike of UXO	Construction	2	5	10	Civil / Structural	Hazard cannot be completely eliminated.	UXO search to be carried out and amend route to avoid any areas identified as high risk due to potential presence of UXO	1	5	5	hazard cannot be completely eliminated but its probability reduced via appropriate level of investigation.								
15	1: Interactive Design Safety Session	C	Construction activity or operational activity near outfall or WTW tank	Danger of drowning or falling injury from working adjacent to deep water	Construction	3	5	15	Civil / Structural	Hazard cannot be completely eliminated.	Consider the location and size Shorten the construction period by considering pre-cast reinforced concrete for the chamber Reduce the requirement for temporary works Minimised depths of excavation where possible	2	5	10	Risk still remain. Appropriate barriers and edge protection to be in place.								

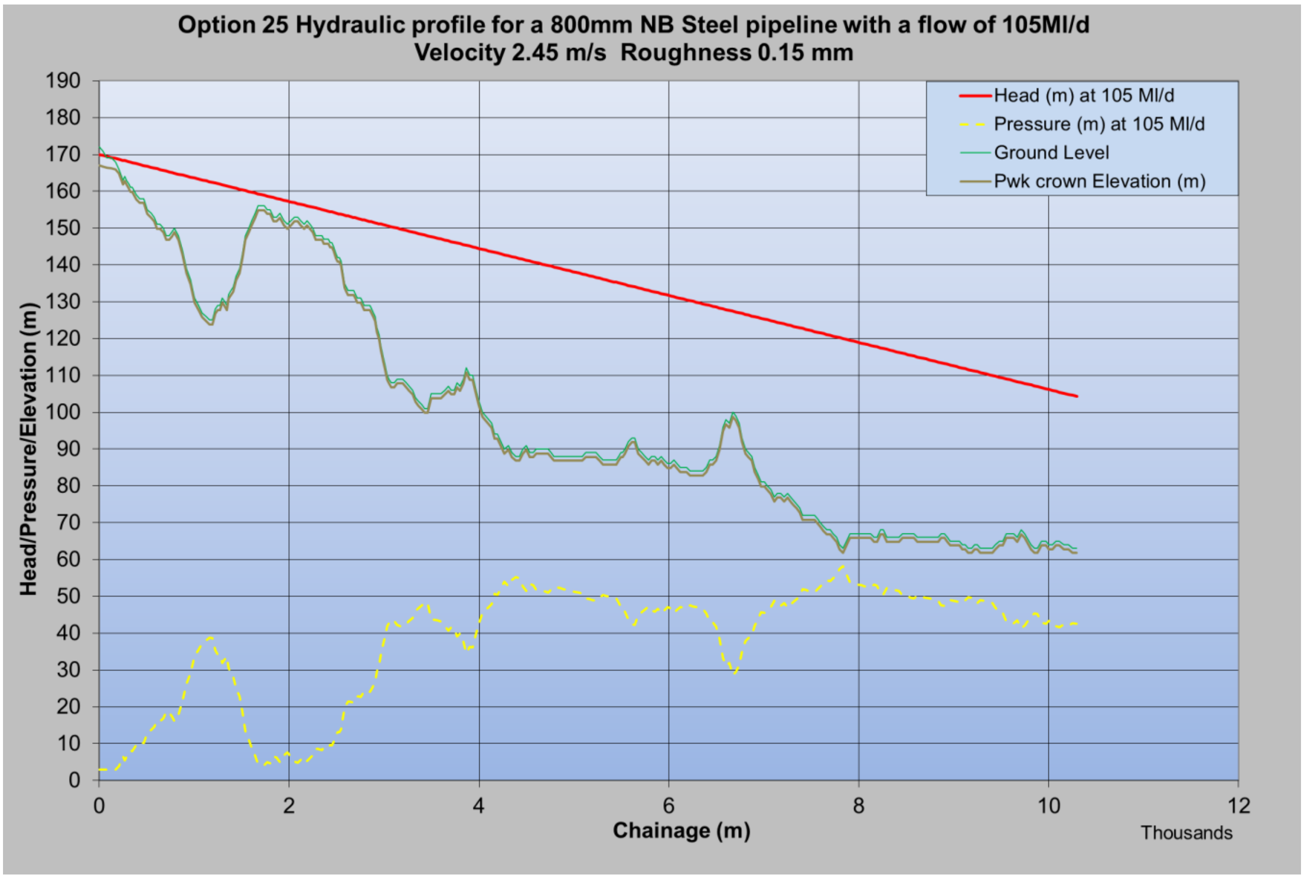
A.3 Steady State Hydraulics

The following graphs illustrate the typical long section associated with each of the flows, pipe diameters and route options shown in section 2 of the main body of the report - repeated here for ease of reference.

Section	Length (km)	Pipeline types	Flow (Ml/d)	Velocity (m/s)	Headloss (m)	Nominal bore (mm)	Assumed Material
Route 25	10.3km	Pressurised gravity main	105	2.5	65.7	800	Steel
			180	2.7	77.5	1000	
Route 27	16.5km	Pressurised gravity main	180	2.2	58.6	1100	Steel
			205	2.5	75.6	1100	

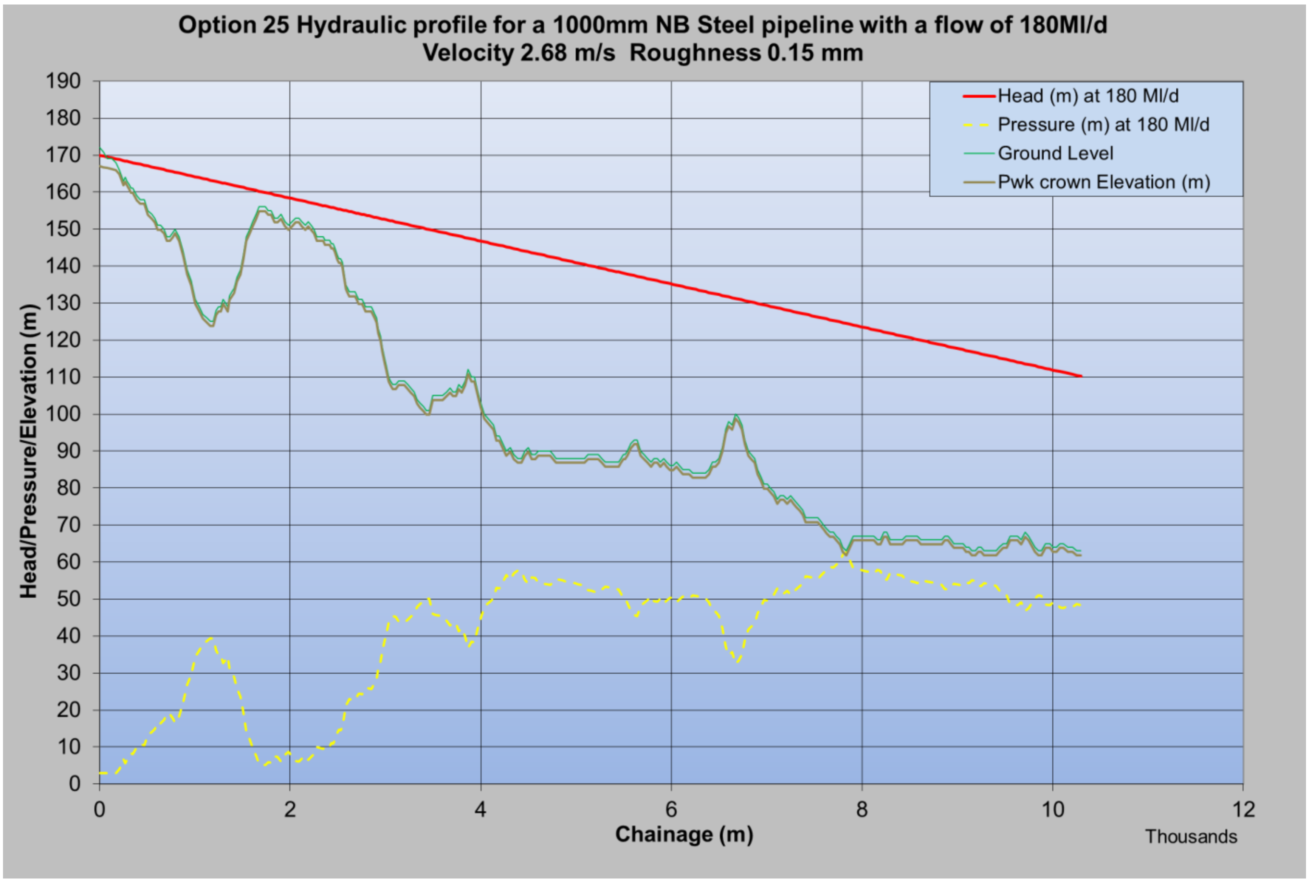
Route 25 - Length 10.3km

Flow 105Ml/d. Optimal diameter 800mm nominal bore. Steel



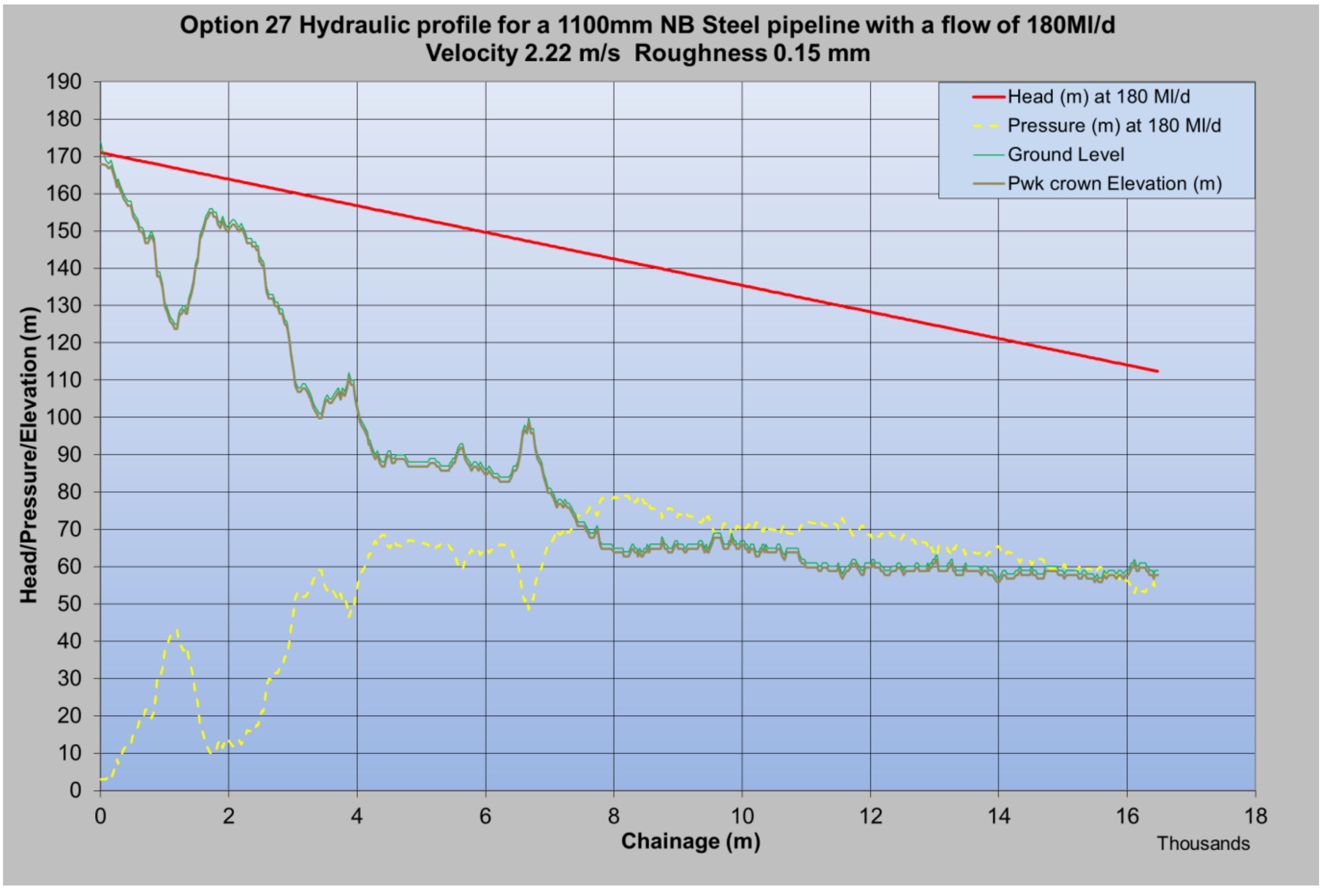
Route 25 - Length 10.3km

Flow 180Ml/d. Optimal diameter 1,000mm nominal bore. Steel



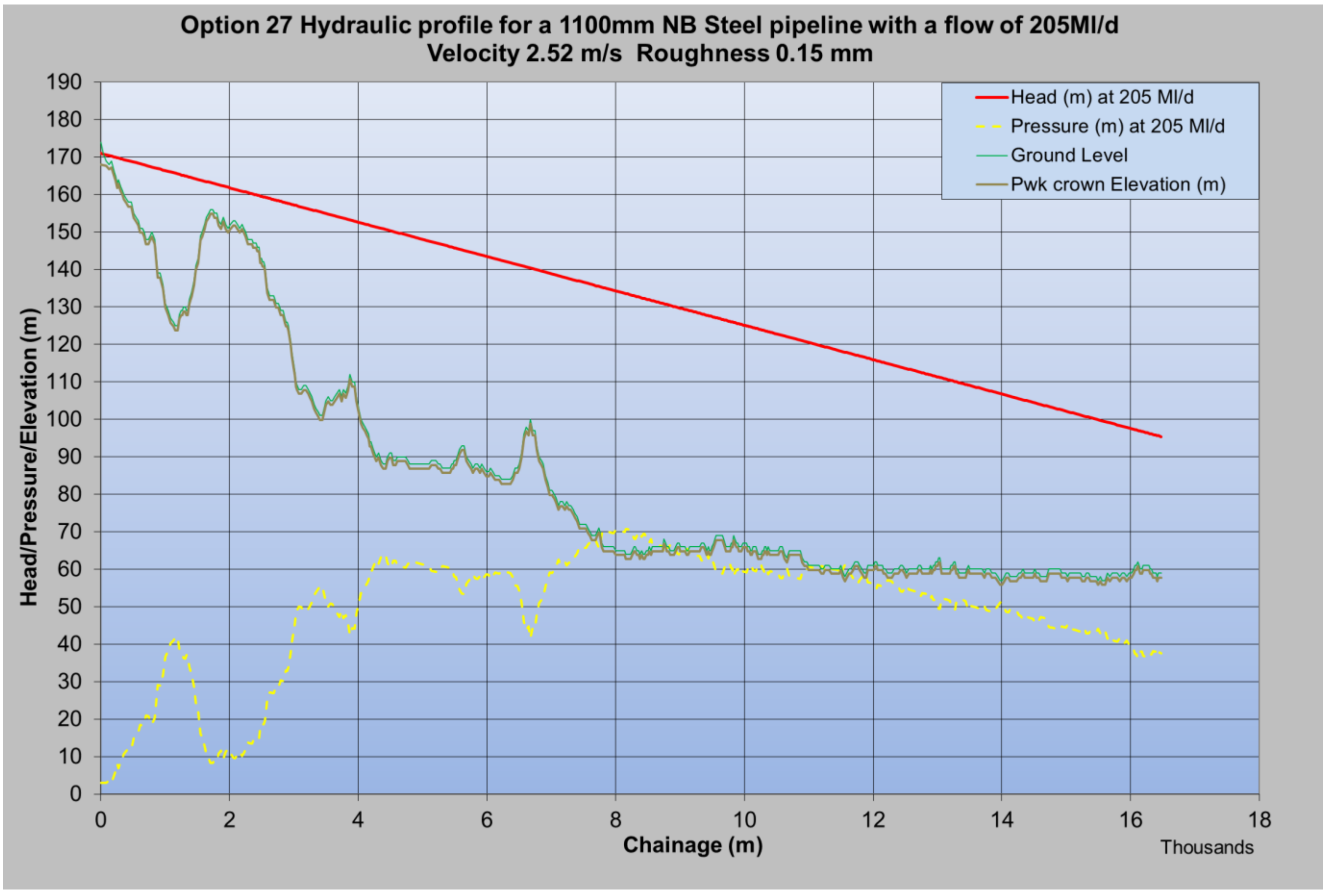
Route 27 - Length 16.5km

Flow 180Ml/d. Optimal diameter 1,100mm nominal bore. Steel



Route 27 - Length 16.5km

Flow 205 Ml/d. Optimal diameter 1,100mm nominal bore. Steel



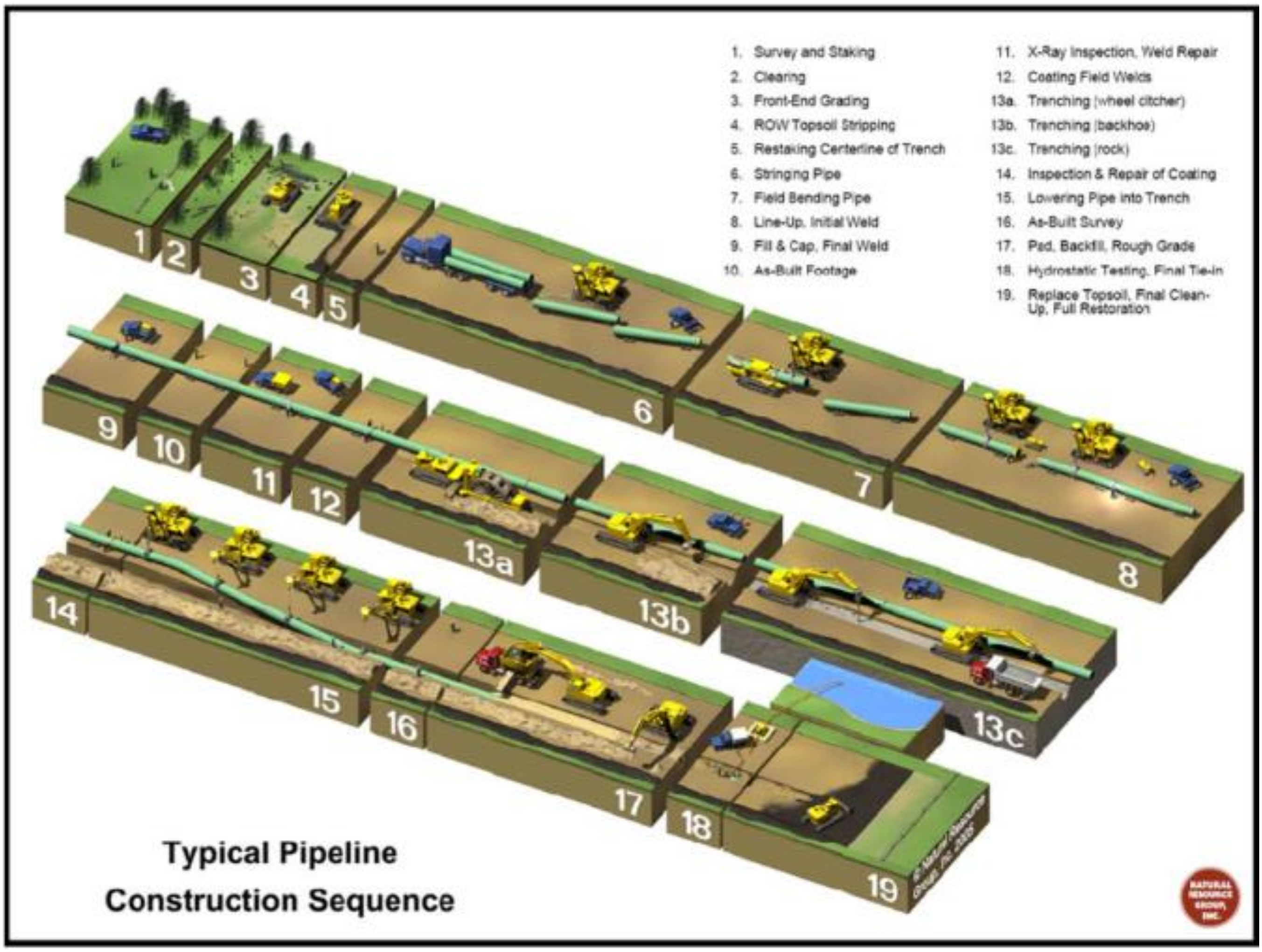
A.4 Construction Methodologies

Open Cut Pipe Sections

The typical construction methodology for pipe installation on the scheme is open cut. This methodology represents a cost-effective solution for pipe installation that can be undertaken at scale with relatively standard construction plant and no specialist construction materials.

The typical open cut construction sequence can be seen in the figure below.

Figure A4 - 1 Typical Pipeline Construction Sequence (Source: Natural Resource Group Inc)



This standard pipelaying sequence would be augmented with best practice from other pipeline projects in the UK. On this project the team have found the following:

Trench arisings should be processed and reused as backfill as much as possible. This minimises the volume of import and export on the project and reduces the HGV movements across the scheme.

Three, 12m steel pipe sticks would be welded together at ground level on pipe rollers prior to being lifted into the trench. This combined shorter length means that excavators could be used to install the pipe length instead of specialist side booms. This minimises the volume of plant required to install pipe and maintains high utilisation.

The insitu connection of 36m pipe lengths is undertaken in a wider section of the trench using a modified manhole box to retain the ground and create a safe working environment for welding.

To mitigate poor weather a mobile weld tent is used to cover the pipe welding and installation activities. This 'factory in a field' approach has maintained production rates, quality, and H&S of the pipe laying operation.

On a recent project hygienic pipe laying processes were deployed to ensure that swabbing and commissioning could be undertaken as quickly as practical. All pipe lengths are delivered from the fabricator with end caps, pipes were stored on chocks, site cleanliness and cleanliness trainings are promoted heavily.

Innovative zero splatter weld systems have been developed to allow welding to be taken place from outside of the pipe without damaging the internal lining. This significantly improves quality and remediation activities needed as part of conventional welded systems.

On the project, developing technology has been trailed that is yielding production and quality benefits over conventional methods. The trial of large diameter pipe ploughs has yielded a significant increase in pipe laying over cut and cover methods. The working corridor has also been reduced from ~40m to ~20m Although this is limited to ~340mm diameter HDPE pipes at present (we are currently proposing steel pipes, but there is an opportunity to review the pipe material at the next stage), further trials are ongoing for larger diameters.

The figure below shows a pipe plough installing HDPE pipe.

Figure A4 - 2 Pipe plough installing HDPE Pipe

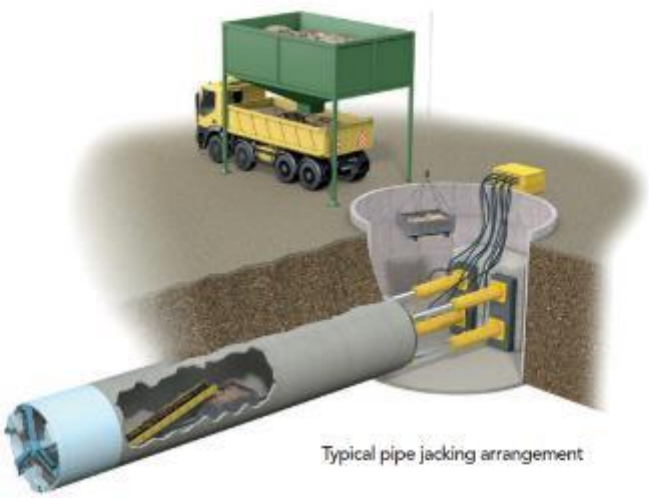
Commissioning on the project has utilised a near waterless system which has reduced the required volume of water significantly over conventional commissioning methodology. The use of digital site QA systems has also improved the commissioning process allowing issues to be identified and closed out quickly and transparently.

Trenchless Pipe Sections

Pipe-jacking is a non-disruptive method of installing utility tunnels and conduits by thrusting pipes through the ground as controlled excavation is undertaken at the face. The figure below outlines the typical arrangement of a pipe jacking site.

It should be noted generally that trenchless installation has a potential requirement for increased depth of cover to pipe crown to control adverse subsidence/heave, and as a result will lower the longitudinal profile overall.

Figure A4 - 3 Typical pipe-jacking arrangement (Source: Pipe Jack Association)



To undertake pipe-jack works thrust and reception pits are required. These would normally be constructed by sinking pre-cast concrete rings into the ground and excavating within them. Alternatively, a sheet pile cofferdam can be driven to facilitate the micro tunnelling activity.

Ground Water Mitigation

In general, to mitigate ground water and provide a suitable excavation to install pipe sections a contractor may need to undertake a dewatering design which could deploy several solutions to suit the expected ground water ingress rate. CIRIA113 - Groundwater in Temporary Works outlines a suitable methodology but in summary there are three cost-effective solutions for varying levels of ground water ingress.

1. Low ingress rates - Sump pump - A sump is dug at one end of the excavated trench. An electric submersible pump is then installed to remove water.
2. Medium ingress - Well points - A well point, or series of well points, is installed into the excavated trench, or alongside it, to lower the ground water level as the works progress. The well points are generally a steel tube with perforations that only allows water to enter the tube. Inside the tube a well pump is installed to remove water.
3. High Ingress - Cut off structure - Generally a temporary sheet pile wall is driven to toe into an impervious underlying stratum. This 'cuts off' and prevents water from penetrating into the excavation. Cut off structures may require propping and other dewater techniques to be implemented in parallel.

Discharge points for ground water pumping systems need to be considered, and possibly consented, as does the secondary impacts of removing ground water from the local area. This could be significant in pipelaying areas adjacent to farmland.

Poor Ground Mitigation

Poor ground can be mitigated by a contractor in several ways:

4. Decrease the angle of the excavated batter so that the material remains stable during the pipe installation process.
5. Increase the number of benches, and therefore the height of each bench, to ensure that the material remains stable during the pipe installation process.
6. Install trench boxes, or sheet piles to retain the poor ground as the pipe is installed.

7. Consider alternatives to cut and cover methodology such as large diameter pipe plough, Horizontal Directional Drilling, or micro tunnelling.

The first two options will increase the volume of excavated material and land take requirements for the pipe laid in poor ground. At this stage of the project, it is felt that the methods could be accommodated within the planned 40m working corridor.

The first three options will have an impact in the production rates for pipe laying as there are additional activities in the pipe laying cycle over and above the typical pipe laying methodology. These options are seen as the most likely techniques that a contractor would deploy to overcome poor ground.

The fourth option is a significant departure from the typical cut and cover solution and would have a significant impact on the scheme cost and delivery programme. The use of HDPE pipe would also need to be considered to facilitate effective use of HDD or large diameter pipe plough solutions. At this stage of the project, it is not anticipated that the ground conditions are poor enough to warrant a change in construction methodology.

Outfall Construction

To facilitate construction of the outfall structure a water excluding temporary works structure may be required. This could take the form of a driven sheet pile cofferdam, or a more lightweight Portadam structure as shown in the figure below.

Figure A4 - 4 Portadam Cofferdam for Outfall Construction (Source: Portadam)

This will likely be installed from the riverbank without the need for working from the river. However, other river users will need to be notified of the works and an exclusion zone placed within the river to segregate construction operations and river users.