Fibre in Water Project
Telecoms And Water Combined Operations (TAWCO)
Final Public Report

Document Control	
Authors	David Crawford, University of Strathclyde Gareth Makarek, Arcadis Mark Harrop, Arcadis Sarah Gledhill, Yorkshire Water Willie Turney, CommsWorld
Checked by	Alex Cleaves, DSIT Daniel Oxley, Yorkshire Water Danielle Hankin, Yorkshire Water Steve Methley, DSIT Steve Wood, CommsWorld
Version	V2.1
Date last updated	04/01/2024

Contents

Contents

Tables and Figures

Glossary of terms

Table 1: Glossary of terms

Altnets	Smaller broadband providers that either own their own broadband network or offer broadband that isn't supplied via Openreach or Virgin Media
ATI	Access to Infrastructure
Backhaul	The backhaul part of a telecoms network comprises the intermediate links between the core network and smaller subnetworks such as base stations.
BAU	Business as usual
CBS	Cost Breakdown Structures
CommsWorld	Telecoms operator
DCMS	Department for Digital, Culture, Media and Sport
DEFRA	Department for Environment, Food & Rural Affairs
DSIT	Depart for Science, Industry and Technology
DWI	Drinking Water Inspectorate
ECC	Electronic Communications Code
EIRP	Effective Isotropic Radiated Power
eMBB	Enhanced Mobile Broadband
EoI	Expressions of Interest
FiW	Fibre in Water
Fronthaul	The fronthaul part of a telecoms network that connects remote radio units to associated baseband units when they are not physically co-located.
FTTH / FTTP	Fibre to the Home / Fibre to the Premise
GDPR	General Data Protection Regulation
Geo (Zayo)	Fibre network operator

Gigabit	Project Gigabit is the government's flagship £5 billion programme to enable hard-to-reach communities to access lightning-fast gigabit-capable broadband
IoT	Internet of Things
LTE	Long Term Evolution – a standard for wireless broadband communication for mobile devices and data terminals (typically associated with '4G').
Ml	Mega-litre (a million litres)
MLUHC	Department for Levelling Up, Housing and Communities
(NB)-IoT	(Narrow Band) Internet of Things
NDA	Non-disclosure agreement
NISR	Network and Information System Regulations
NR	New Radio - a global standard for a unified, more capable wireless air interface (typically associated with '5G').
NUAR	National Underground Asset Register
ODI	Outcome Delivery Incentive (Water Industry)
PIA	Physical Infrastructure Access to allow communications service providers access to existing telecoms infrastructure
PR14 /19	Periodic Review 2014 or 2019 – the 5 year planning and approval cycle used in the water industry
PSTN	Public Switched Telephone Network
RF	Radio Frequency
SAL	Shared Access Licence
SCADA	Supervisory Control and Data Acquisition
SSE telecoms	A fibre network operator
TAWCO	Telecoms And Water Combined Operations
Telcos	Telecommunication companies
Telecoms	Telecommunications
vBBU	Virtual Baseband Unit
WaSC	Water and Sewerage Company
Wayleaves	A right of way granted by a landowner, generally in exchange for payment; may be used for the purposes of either telecommunications or water infrastructure.
WBS	Work Breakdown Structures
YW	Yorkshire Water

Section 1: Executive Summary

The Telecoms and Water Combined Operations (TAWCO) project was delivered by a consortium of four organisations: Yorkshire Water, Arcadis Consulting, University of Strathclyde and CommsWorld. The delivery of Phase 1 was completed as planned to carry out research and investigations to de-risk and inform the detailed scope, costs, and benefits for a Fibre in Water installation. This work culminated in a gateway decision point where the success criteria were not sufficiently met to allow the project to continue into the Phase 2 build.

The original project budget for all three phases was £5.4m, with a grant contribution of £3.2m from DSIT. The project expenditure at the end of an extended Phase 1 was £2.3m, with grant contribution of £1.6m, and the £700k balance coming from in-kind contributions from the consortium partners.

The ambition of the TAWCO project was to install fibre optic telecommunication cables within a section of the potable water pipe network. These cables would serve a twofold purpose:

1. To take advantage of the wide coverage of the drinking water network to supply high speed internet cabling to remote locations without having to have a separate telecommunication ducting system.
2. To use some of the strands of the fibre optic cables to detect and locate leaks within the drinking water network.

The benefits of combining the two services are explained at length in this report but principally, installing these two systems in situ would significantly improve the ability to detect leaks in the water supply, thus reducing water consumption, whilst telecoms operators decrease their cost of installation by taking advantage of a readily available duct.

The publicly funded nature of the project, combined with the complexity of the problem meant there were a high number of stakeholders from different industries and organisations including:

- Water companies
- Telecommunications operators
- Technology startups
- Universities
- Multiple Government departments and inspectors
- Regulation authorities

Each interested party had their own motivations for wanting the project to be a success but fundamentally the benefits were a shared cost model (potentially supportive of scale adoption) and the reduction in excavation to reduce carbon emissions alongside an improved service to the end consumers of both water and broadband connectivity.

The technology has been developed to be able to draw telecom cables through a live water main, as a further innovative step from the techniques used to successfully install fibre cables in the wastewater network. A trial route was selected to install a Fibre in Water system on the drinking water network as there is increased coverage to consumers compared with wastewater. More importantly the distribution layout of the clean water network mimics more closely how the telecom cables need to be installed i.e., via trunk mains interconnecting towns and cities with smaller diameter pipe networks reaching out to populations such as villages and towns, and down to individual property level.

Combining two industries meant there was a lack of clarity when it came to industry approved standards which meant certification became a challenge. An important aspect of using the clean water network is that anything installed within the network first needs Regulation 31 (Reg 31) approval from the DWI. For this project, approvals were needed for the installation method and the finished installed product. At the time of writing, almost 2 years after the TAWCO project was awarded funding, approval for the finished product remains outstanding and subsequently there is a barrier to adoption until this issue is resolved.

In addition to the enabling technology, alignment of the operational processes of two very disparate industries – from design and construction to ownership and operation, including 'break-fix' – presented a significant challenge. TAWCO successfully defined aligned processes and as such has created a useful template that can be adopted once the technology approval process is resolved.

The decision was made to stop the live build trial for project TAWCO. Despite the obvious benefits to interested parties, there remains uncertainty around the best commercial model to adopt to make a viable solution. There is also a financial risk that only one small start-up has the capability of installing the cables using their yet to be approved technology. When combined with the lack of Reg 31 approval, the project was unable to continue under the originally agreed scope, timescales, and financing.

Should the Fibre in Water technology receive Reg 31 approval, the commercial models, business processes and detailed designs produced by project TAWCO could still be used to implement the Fibre in Water solution at either the planned location, or elsewhere with some additional effort to translate the designs. Yorkshire Water remains in contact with other members of the consortium and will consider the opportunity for Fibre in Water implementation in the event that the regulatory barrier is overcome.

Section 2: Background

Using water industry infrastructure as an alternative to dedicated telecommunications ducting or 'new dig' has been around as a concept for some time. Fibre operators such as Geo (now part of Zayo) and SSE Telecoms (now Neos Networks) began to install fibre in sewers as early as 2004 and there is over 400 km already installed under London and other major UK cities. The timing was significant in that Openreach were yet to open up their pervasive duct infrastructure to competitors, which left competing new entrant operators (known as 'altnets') with few other options other than slow and expensive duct construction projects. Water industry infrastructure - and particularly wastewater pipes (which presented a lower operational risk than drinking water mains) - became a viable alternative.

The potable water network does however offer some significant advantages over the wastewater equivalent:

- The potable water network has greater reach, connecting over 99% of UK properties[1] whilst the figures for the wastewater network are lower at 96% (many rural properties are served by a septic tank, for example).
- The topology of wastewater networks tends to be very localised 'hub and spoke' infrastructure serving a wastewater treatment works. By contrast, the potable water network includes long spans (often resilient pairs) which can provide the trunk routes between towns that telecoms operators are interested in.

Telecoms operator interest in sewer networks declined as operators gained more experience of the Physical Infrastructure Access (PIA) process, which gave access to Openreach ducting. This meant that potentially the window of opportunity for Fibre in Water infrastructure had closed. But innovation – both in terms of technology and new demand scenarios began to re-ignite market interest:

- A small UK start-up had developed innovative technology to insert fibre optic cable safely and efficiently into live potable water mains, first gaining approval for an earlier iteration of their product from the England and Wales Drinking Water Inspectorate (DWI) in 2019.
- Several technology companies had developed fibre-based sensing solutions (known as Distributed Acoustic Sensing – or DAS) for the oil and gas industry. Faced with the challenge to achieve a 50% reduction in leakage by 2050 (from a 2017 baseline)[2], water companies had begun to see the potential of real time and highly accurate leak detection information that these solutions could provide.
- At the same time, the Government had set an ambitious target to deliver Gigabit broadband services to 85% of the UK population by 2025 and 99% by 2030[3], providing

---

[1] https://www.gov.uk/government/publications/drinking-water-quality-in-england-2017-to-2019#:~:text=Around%2099%25%20of%20the%20population,or%20borehole%20on%20private%20land.

[2] https://www.ofwat.gov.uk/leakage-in-the-water-industry/

[3] https://www.gov.uk/guidance/project-gigabit-uk-gigabit-programme

subsidies to telecoms operators willing to extend their networks into areas that were not commercially viable, particularly rural areas.

- With the PSTN copper-based network due to be switched off in 2025, TAWCO also presented a real opportunity to explore how 5G might be used to connect remote assets belonging to a water company, and at the same time bring more options for fixed-wireless broadband to 'very hard to reach' premises.
- UK Government and water companies have stated carbon neutral ambitions. Fibre in potable water mains uses water flow to install fibre optic cable into a pipe using a parachute-type device, so offers a potential green solution and the opportunity to avoid extensive civil construction work and associated disruption.

Another water company began an independent live trial of fibre-based leak detection and at the same time Yorkshire Water (YW) conducted a desk-based benefits case analysis to understand the economic rationale for Fibre in Water deployment. The YW analysis concluded that whilst the technology was seen as viable (albeit with outstanding operational challenges), the leak detection-driven economics did not justify the cost of installing the required fibre optic cable solely for leak detection. To make the solution viable, an additional commercial driver outside the Water sector would be required.

As an 'anchor institution' of the economy of the region, YW had been involved in discussions about digital infrastructure strategies for the region. Whilst these discussions centred around the 'Internet of Things' (particularly connectivity for smart meters), Yorkshire Water saw a potential opportunity for the predicted investment in fibre broadband from commercial operators and the Government's Project Gigabit to create a multi-sided business case, combining revenue from commercial operators with leak detection benefits to make the Fibre in Water business case work. Yorkshire Water began to create a consortium with the objective of bidding for funding.

DSIT (previously DCMS) were at the same time reaching a similar conclusion. The 2021 launch of the 'Shared Outcomes Fund' by HM Treasury – designed to fund innovation in areas of mutual interest to multiple Government departments – presented an ideal funding opportunity. Fibre in Water had the potential to support DSIT's Project Gigabit and also reduce leakage and improve asset management for the water companies that sat within DEFRA's remit. DSIT were successful in securing Shared Outcomes funding and launched a £4M 'Fibre in Water' competition in August 2021.

Section 3: Project details

Project Conception

Following the launch of the DSIT 'Fibre in Water' competition in August 2021, Yorkshire Water focussed its Fibre in Water activities towards this new potential source of funding and won the award through a competitive process. The proposal was expanded to address the additional priorities required by the structure of the DSIT competition. One area that DSIT were rightly focussed on, for example, was supply chain diversification in both the fibre installation and sensing technology, which were both seen as constrained. DSIT were also understandably keen that the commercial and operational insight gained was not a bespoke solution for CommsWorld and Yorkshire Water but would be a viable template for any operator-water company partnership to adopt. To that end, Thames Water and Severn Trent became advisors to the consortium.

The YW consortium won the competition, and the Grant Funding Agreement was signed in July 2022, following a 'soft start' on project work from April 2022. There were three stages to the project. Phase 1 was the Research and Investigation stage, where operational and commercial models were developed, detailed route survey and build costs completed along with a commercial assessment of the revenue potential of the chosen route. Following a 'go / no-go' decision, phase 2 - the actual construction work – would begin, followed by Phase 3 to evaluate the benefits in operation. A 5G build and innovation competition would also be part of this build phase.

Yorkshire Water considered the commercial and operational alignment between two very different industries (telecoms and water) to be the fundamental challenge, rather than the Fibre in Water and sensing technologies themselves. There were however always some concerns that the single supply market created cost and supply risks within this project and also for future expansion of fibre in water.

The Yorkshire Water consortium included telecoms operator CommsWorld, the University of Strathclyde, and engineering consultancy Arcadis. Central to the project was the selection of a candidate Fibre in Water build route from Barnsley to the village of Penistone.

The route selected by the early-stage consortium was chosen with input from various stakeholders, identifying Penistone as an area unlikely to attract commercial operator fibre investment and yet to be confirmed as being part of the South Yorkshire project Gigabit procurement 'lot' and therefore eligible for state investment. The candidate route also met the criteria of encompassing as many engineering challenges as possible, to represent BAU environments across the YW portfolio and the wider water industry in general. It should be noted that the ultimate telco partner, CommsWorld, was not part of the consortium at the time of route selection[4]. This route was then presented to the design and build Partners where they not only validated the route but identified mitigations for each engineering issue.

[4] A different telco partner was part of the consortium during the bid phase, with CommsWorld joining the consortium between funding award and signing of the Collaboration Agreement.

To create real commercial incentives and operational focus, Yorkshire Water was willing to offer its telecoms partner a thirty-year exclusive 'right to use' so that the operator would be able to commercially exploit the route rather than simply run a time-bound pilot. The thirty-year duration also meant that Yorkshire Water's own operational teams would need to be satisfied that the implications of installing fibre into a potable water main and leaving it there for thirty years were fully understood and appropriate mitigations adopted; this was more than a trial that could be waved through on a temporary basis. As with all water companies, the PSTN switch-off (as per Government policy published 6 January 2023 and updated 25 January 2023) has prompted Yorkshire Water to seek a replacement of connectivity for SCADA systems and the exploration of the wider potential of the evolving connectivity landscape, particularly private 5G networks.

Project Aims

The key objectives of the Fibre in Water (FiW) project as defined by DSIT were to:

1. Execute a Research and Investigation phase to de-risk and inform the detailed scope, costs, and benefits of the pilot implementation. Sign-off of this study would form the gate for progression with the rest of the Pilot.
2. Deploy a FiW pilot solution in the UK at sufficient scale to explore the technical, security, operational, regulatory, and commercial challenges, and benefits to all stakeholders and to give confidence that the solution could be scaled nationally.
3. Deploy a rural 5G testbed, addressing water industry SCADA (Supervisory Control and Data Acquisition) applications and enabling fixed-wireless broadband connectivity options for 'very hard to reach' rural premises.
4. Support DSIT in building a community or ecosystem around the pilot that will ensure wide adoption of FiW, sharing key learning in the form of case study, technical reports, and other project outputs.
5. Collaborate with DSIT, DEFRA and their partners to inform and test regulatory, commercial, operational, and cultural barriers to widespread adoption of FiW.

In responding to the objectives of the pilot, a research and innovation study was undertaken by a project team comprised of experts from across the Telco, Water and 5G industries. The team brought together the skillsets, expertise and experience that blended and balanced the direction, discussion, and decision-making process key to driving the research and investigation stage to conclusion.

The team defined and agreed a set of milestones and associated deliverables which, if successfully achieved, would allow the project to progress through the agreed gateway and phased review processes. As this was an innovation project it was accepted that deliverables would and could be subject to change and the appropriate change control processes were adopted throughout the project lifecycle. The agreed milestones and associated deliverables were owned by the team and split against individual partner businesses' area of expertise being brought together/integrated by the project management lead.

The initial fibre in water route was planned over a distance of 17.5km and offered a wide range of geographic, engineering and operational challenges; this route was later reduced to 8.1km but still maintained the high level of engineering difficulty. Whilst most of the build appeared to be a "business-as-usual" type design and build there were several areas that required review, discussion, and development of existing solutions to fit and new solutions to enable the high-level designs to be drafted.

The challenge was not simply to identify the route, but also to agree a design configuration for breakouts and utilisation of existing infrastructure, to break new barriers in delivery (specifically in gaining approval to run fibre through "clean water" mains), and also to change the Water Company approach to asset strategy related to operational valves.

From initial high-level design, the project team addressed not only the elements of design for 5G, telco (including PIA), and FiW, but also addressed each challenge not only to provide a solution but also look to offer an alternate solution.

Project Plan

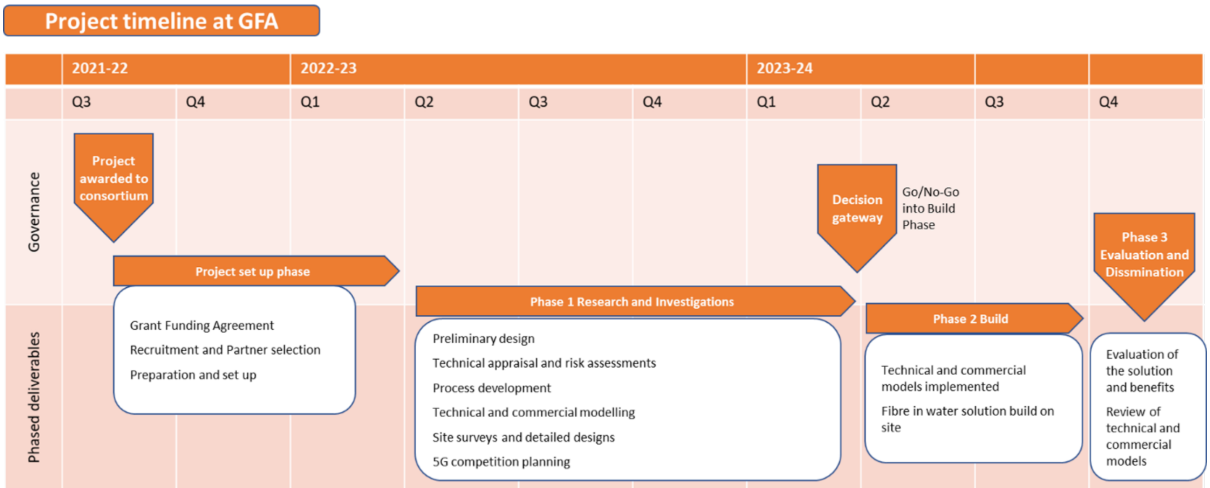

Figure 1 - High Level Project Plan

The project was to be split into 3 Phases:

- Phase 1 – Research and Investigation

To carry out Research and Investigation into the viability of deploying Fibre in Water Technology. This phase would include reviewing the technology, understanding the operational risk of employing the technology, security risk assessment, agreement of design, ownership and maintenance principles, route design, commercial understanding and benefits of Fibre in Water, cost modelling, technical, operational and commercial viability assessments.

- Phase 2 – Detailed Design and Build

Delivery of a FiW pilot to explore the challenges and demonstrate the benefits to all stakeholders. This would cover the 17km between Barnsley and Penistone and connection via PIA to the Exchange. A private 5G shared spectrum standalone network would be installed at two remote locations demonstrating neutral hosting. FiW would be used for back-haul connectivity to a 5G core and the internet.

- Phase 3 – Operation and Evaluation

Benefits of the FiW solution would be evaluated and winners of the '5G in water' competition would be commissioned.

End of Phase 1 Decision Gateway

Between Phases 1 and 2 there was a gateway decision point for project partners and stakeholders to decide if agreed success criteria (gateway criteria) would allow the project to proceed to Phase 2, the detailed design and build. Given the greater costs of the build phase and the intended 30 year asset life installation, it was considered appropriate that exacting criteria were set before this second tranche of spending was to be released.

Table 2: End of Phase 1 Gateway Criteria

Gateway Criteria Heading and Reference	Key Questions	Achievement Criteria
Commercial viability: GW1.1	Is FiW commercially viable when compared against existing fibre deployment and leak detection methods?	A full cost/benefits case is completed, considering alternative solutions, and it projects a return on investment on various future FiW installations.
Commercial viability: GW1.2	Is there appetite for scaling FiW within the water industry?	Engagement with Water Companies leads to positive stance towards FiW at various water companies that together cover >50% of UK customers.
Commercial viability: GW1.3	Is there a commercial agreement in place for the Penistone project?	A draft commercial agreement is in place with notional approval from the relevant legal teams.
Technical viability: GW2.1	Are all necessary regulatory approvals in place?	A review of regulatory approvals has been completed and formal legal advice is in place. Recommended progression to next phase.
Technical viability: GW2.2	Is the solution safe to install?	An Operational Risk Assessment is in place and approved as per YW processes.
Technical viability: GW2.3	Is a viable process for operation and maintenance agreed between the Telco/Water industries?	O&M processes have been established and agreed between all project partners (NB. This includes the secondary validation from Severn Trent and Thames Water that these are transferable to their regions). A plan is also in place to develop the capability required within the various organisations to deliver these processes.
Technical viability: GW2.4	Is the market capable of scaling to enable FiW to be expanded?	An assessment of the market has been completed and it concludes that industry can scale to >5 deployments over 10km per year within a timescale capable of contributing to enabling Gigabit Britain.
Project Delivery: GW3.1	Is a project plan in place to meet the remaining	A project plan for the remaining phases is in place and agreed between the project team.

	outcomes identified at the start of the project?	
Project Delivery: GW3.2	Is funding in place to achieve Delivery of the plan?	An updated fully funded cost plan is in place and agreed to by all partners. (NB. This includes the closing of the funding gap for Phases 2 and 3).

Once the gateway criteria were understood and approved, the team aligned around sub-workstreams to progress the work and identify opportunities and challenges. These work streams were:

1. Governance – Manage programme of activities, produce reports for programme board, produce documentation needed for grant management.
2. Communications - Develop communications strategy, deliver briefing events and website.
3. Business Case - Investigation into FiW benefits case.
4. Technology- Installation and sensing technology to allow FiW to work.
5. Design - Support to design the specific route and scalable routes, with agreed standards.
6. Build & Operate - The build and operate processes for the products sets defined in this project.
7. Customer, Regulation and Legal - Voice of customer and regulatory compliance.
8. Commercial - Build a wholesale commercial model that is acceptable to Water and Telecoms companies current offering.
9. 5G - Build a wholesale commercial model that is acceptable to Water and Telecoms companies current offering.
10. Build Partner Scope – Carry out pre-work studies looking at design and installation scopes, route assessment and suitability.

The workstreams were designed to generate answers to the questions in the Gateway Criteria, which were reviewed at the end of Phase 1. All Gateway Criteria were met except for those outlined in Table 3 below.

Table 3: Review of unmet Gateway Criteria conducted in May 2023

Gateway Criteria Ref	Heading	Key Questions	Justification for not meeting Gateway Criteria
GW2.1	Technica l viability	Are all necessary regulatory approvals in place?	**Reg 31 Approval** – Required water quality testing of the fibre in water technology still not complete along with documentation required to submit for approval under Reg 31. Uncertainty in the timescale for approval means the March 2024 project completion deadline is unachievable.

GW2.2	Technical viability	Is the solution safe to install?	**Water Quality** – initial modelling did not provide convincing evidence about the way that the installed messenger pipe may behave in turbulent water flow, and the potential impact on the pipe and sediments contained within it. Although the results of the modelling are not correlated with any information from live network installations, it would be prudent to carry out further, more complex modelling or observations of a live installation to draw a conclusion on this issue.
GW3.2	Project Delivery	Is funding in place to achieve Delivery of the plan?	**Funding Gap -** The gap has been reduced to £300k by re-engineering solutions, this does not include allowances for reduced deployment times and ECO benefits. Options continue to be progressed: ● Additional development partners. ● Alternative funding options.

Due to the three unmet criteria the project board voted not to proceed to Phase 2 (the build). The uncertainty surrounding the Reg 31 approval had some influence on the other two unmet criteria; more concerted and decisive action could have been taken to resolve the funding gap had the Reg 31 approval been in place.

Benefits Management

During Phase 1 of the TAWCO project a baseline of benefits was established with predicted target values identified for each benefit where possible. Some of the key benefits are outlined below:

- 50% annual reduction (18.1ML) in water lost to leakage.
- 49% reduction (96 working days) in construction time by using FiW deployment to deliver gigabit broadband to the target area.
- 100% reduction (3 months) in landowner time required for construction-related wayleave discussions and agreements by using FiW deployment.
- 90% reduction (42.6 tonnes) in carbon dioxide equivalent emissions for the network's construction by using FiW deployment.
- Technology Readiness Level increases from 2 to 7 for the maturity in understanding of FiW deployment.

These values represent significant benefits realised for the water and telecoms sectors, natural environment, and UK's research knowledge were they to be confirmed in Phases 2 and 3.

Additionally, informal feedback from Yorkshire Water and local business stakeholders indicated a high likelihood of strong, positive customer and business stakeholder responses if significant benefits were to be realised on a range of local economy and social value topics. These would include increased: asset management efficiencies (remote telemetry, reduced site visits, crime detection/deterrence); Cloud computing demand; job opportunities; travel journey efficiencies; online access to community and commercial services; social inclusion, and climate change mitigation.

The Technology

Use Cases for Water and Sewerage Companies and Fibre Providers

Leak Detection

The water industry's economic regulator in England and Wales (the Water Services Regulatory Authority, known as Ofwat) manages companies' performance through Performance Commitments and Outcome Delivery Incentives (ODIs). Failure to deliver on performance commitments can result in financial penalties or fines and impact company reputations.

Leakage is a key focus for the UK water industry due to its economic and reputational impact. There is a requirement to reduce the overall leakage level by 16% by 2025, and a 50% reduction in leakage levels by 2050 (compared to 2017-18 leakage levels).

Existing leakage monitoring technologies are limited to localised level sensing or battery powered noise sensors. Using fibre sensing technology provides water and sewerage companies with the capability to monitor tens of kilometres of networks with activity being reported every few seconds - a seismic shift in asset monitoring capability. A key objective of Project TAWCO was to explore by means of a live deployment how the use of fibre technologies might contribute to the delivery of leakage reduction targets.

Distributed fibre sensing

Distributed fibre sensing (DFS) is a technology that enables continuous, real-time measurements along the entire length of a fibre optic cable without the need for additional transducers in the optical path.

Table 4: Distributed Fibre Sensing

Functionality	Derived Measurements	Application/s
Distributed Temperature Sensing (DTS)	Temperature transition point	Leak detection
Distributed Acoustic Sensing (DAS)	Acoustic signature Eddy speed Speed of sound	Leak detection Flow monitoring Ground movement

Distributed Strain Sensing (DSS)	Direct strain	Pipe integrity Ground movement Pressure fluctuation
Displacement or integrated strain Sensing (DDS)	Fibre elongation between two reference locations	Pipe integrity Ground movement

How might the FiW innovation support key water industry objectives?

Tactical - Provides enhanced visibility of piped networks providing real time information and supporting digital analytics pre-empting network issues.

Regulatory - Tangible demonstration of dedication to reducing leakage in the water network using innovation to meet performance commitments.

Political – A tangible demonstration of water companies supporting local communities by enabling broadband connectivity, particularly in 'hard to reach' rural areas, and supportive of the Government's Project Gigabit ambitions.

Strategic – Demonstrates the potential for transformational change in line with regulators' initiatives supporting the digital transformation of the UK water industry and de-risking the withdrawal of PSTN (Public switched telephone network) by 2025.

In addition to the obvious attraction of utilising existing regulatory assets for non-regulated revenue streams and commercialising fibre deployment for reinvesting into the business (core and non-core), the potential for water and sewerage companies to take their networks from being largely passive to smart networks with the ability to understand what is going on in a buried asset has the potential to be transformative, addressing key performance areas such as efficiency, customer satisfaction and environmental protection.

Increased Efficiency	Customer Satisfaction	Revenue Generation	Protect the environment
Digitalise new and existing asset - real time 24/7 monitoring	Minimise customer impacts	Commercialise fibre deployment	Leakage reduction
Focussed CAPEX investment	Potential to integrate with FiS to combine benefits	Increased collaboration and evolution of shared asset model	Contribution to net zero carbon target
Proactive and predictive operation is 40% more efficient than reactive	High-speed broadband connection available	Possibility for non-regulated revenue stream	Reduction in number of mains bursts

Figure 2: Key water company objectives for fibre in water

How might the FiW innovation support key telecoms industry objectives?

Grow the Network - Use FiW as a unique alternative delivery method to support network expansion programmes, complementary to PIA.

Cost Reduction - Reduce capital spend on deployment to increase profitability and competitiveness.

Market Share - Increase telecoms market share in the water sector.

Revenue Generation - Create additional revenue streams via new products and services such as sensing technologies.

Commercial Opportunity - Commercialisation of fibre within the pipes, partnering with AltNets to support FTTP and 5G roll-out to support Government ambitions.

As is the case with many new innovations, the key to widespread adoption is finding the correct commercial model. FiW is no different. From the work carried out by the TAWCO project team and previously by others, it's clear that the economics of FiW do not stack up individually for either water companies or telcos. The option to use PIA is also not necessarily a straightforward option in all circumstances. Although PIA is not directly comparable to FiW, it is generally a more economic deployment. A smart infrastructure approach that combines the build-out of telecommunications networks together with a water network monitoring capability is the collective solution to the FiW economic challenge.

The significant mutual benefits of fibre in piped networks

- Enhanced visibility of piped networks providing real time information and supporting digital analytics.
- Facilitates the densification of fibre for Smart Cities initiatives.
- Extends connectivity to rural locations as part of the Governments Project Gigabit initiative and FTTH through channel partners.
- Delivery of a high capacity, low latency, highly resilient, secure network supporting IT/OT convergence and service improvements.
- Supports digital transformation of the UK water sector and de-risks the withdrawal of PTSN by 2025.
- Accelerates 5G roll-out, especially in rural locations.
- Reduces consequential impact of traditional civils build (e.g., traffic management, road closures)

5G Connectivity

An important aspect of the TAWCO FiW network was the design of a 5G radio network, the purpose of which was to explore and demonstrate how 5G Fixed Wireless Access (FWA) and Internet-of-Things (IoT) services can contribute to the commercial model and business case. This work package also explored how 5G and IoT networks could help the water sector to operate more efficiently and lower the carbon cost of drinking water. The network design comprised two masts, located such that they could be connected to the fibre-in-water backhaul network and could provide the coverage and connectivity that is needed for the target applications and use cases.

The fibre route that was originally planned for the project was to run between Barnsley and Penistone in the shape of a ‘hockey stick’ via Ingbirchworth, as illustrated in Figure 3. Two mast sites were selected for the 5G network: 1) Champany Hill and 2) Ingbirchworth.

The fibre route was subsequently changed, resulting in a new proposed route from Barnsley to Penistone, missing out Ingbirchworth (as illustrated in Figure 3.) The Ingbirchworth mast site was no longer close to the fibre route, but discussions were held with YW regarding an alternative means of connecting the mast site to the fibre.

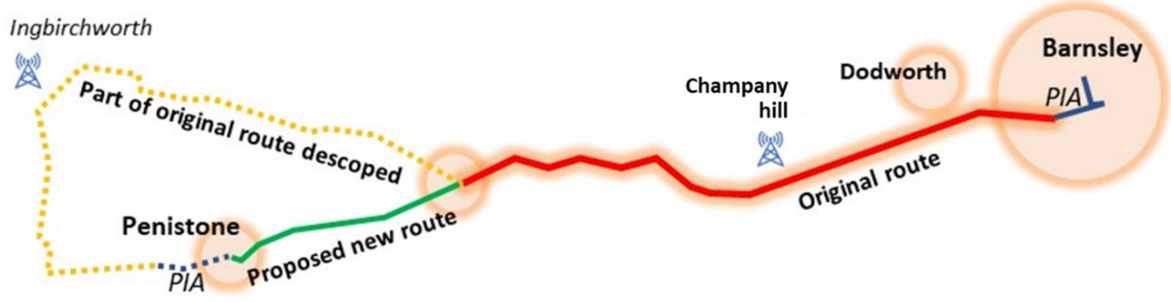

Figure 3: Fibre route and locations of mast sites at Champany Hill and Ingbirchworth

Champany Hill Mast Site

The mast site at Champany Hill was chosen for NB-IoT/LTE and NR coverage using shared access spectrum in Band 3 (1800 MHz) and Upper n77 (3.8-4.2 GHz), respectively. Following RF coverage simulations and conversations with site stakeholders, a suitable location was selected to host the mast and an equipment layout was planned.

The radios would connect via a front-haul fibre link to the vBBU baseband unit software running on a server in the Barnsley telephone exchange. The front-haul fibre link (two pairs of single-mode fibre) runs directly from the vBBU to the radios, passing through various FiW splice chambers and the fibre patch panel in the cabinet at the Champany Hill site.

The server at the Barnsley telephone exchange containing the vBBU also hosts the 5G user plane, therefore giving low-latency on-site breakout. The 5G control plane lives on a separate server located at the University of Strathclyde. WAN/Internet access is required between the two parts of the core, and this is provided via a router installed in the rack at the Barnsley telephone exchange.

Ingbirchworth Mast Site

A mast at Ingbirchworth was included in the network design to support NB-IoT coverage in that area for the testing of automated environmental monitoring equipment.

The NB-IoT baseband software runs on a server installed locally at the Ingbirchworth site. The network core for the NB-IoT cell lives on a server located at the University of Strathclyde, with connectivity provided by the router installed in the rack at the Barnsley telephone exchange.

Spectrum Licences

Spectrum licences for the mast sites at Champany Hill and Ingbirchworth were granted by Ofcom and were valid until 30th December 2023. Details are presented in Table 5.

Table 5: Spectrum licences for Champany Hill and Ingbirchworth.

Base station Site	Associated Frequency Band	Licence Requested	Licence Granted
Champany Hill	SAL 3800-4200MHz	100MHz TDD bandwidth in 3800-4100MHz range (Max. EIRP[1]: 19.5 dBW)	3800-3900 MHz (Max. EIRP: 4.5 dBW)
Champany Hill	SAL 1800MHz	3MHz FDD bandwidth (Max. EIRP: 7 dBW)	1877-1880 MHz (EIRP: 7 dBW)
Ingbirchworth	SAL 3800-4200MHz	100MHz TDD bandwidth in 3800-4100MHz range (Max. EIRP: 19.5 dBW)	3800-3900 MHz (Max. EIRP: 4.5 dBW)
Ingbirchworth	SAL 1800MHz	3MHz FDD bandwidth (Max. EIRP: 7 dBW)	1877-1880 MHz (Max. EIRP: 7 dBW)

5G in Water Innovation Competition as part of TAWCO

As part of the project, a £250k ‘5G in Water’ Innovation Competition was designed, with the aim of engaging innovative SMEs and community organisations to accelerate digital innovation in the water sector via practical use cases in areas such as agri-tech, asset security, environmental sensing, operational and performance optimisation, product quality monitoring, connectivity for social impact, etc. This competition would be organised and administered by the University of Strathclyde on behalf of the consortium.

Competition Focus and Aims

The ‘5G in Water’ Innovation Competition would aim to stimulate a range of small projects using the main project’s infrastructure, enabling SMEs and other relevant organisations to develop, evaluate, and/or commercialise new and emerging technologies. Competition winners would have access to grant funding and technical resources, including the TAWCO network and consortium expertise. This could be across use cases in the community – for example: agri-tech, asset security, environment sensing, operational and performance optimisation, product quality monitoring, or connectivity for social impact and also further engineering design, such as working with Mobile Network Operators (MNOs) to demonstrate Neutral Hosting, vendors offering national roaming support, or novel edge solutions for AI or other applications.

Competition Prize and Funding Breakdown

The ‘5G in Water’ Innovation Competition design would provide grant funding of up to 70% of eligible costs, depending on organisation size and status. From a total budget allocation of

£250,000, the competition would have aimed to fund up to 5 projects, with matched funding prize awards as per Table 6. Successful applicants would be asked to provide contributions in cash or in-kind, such as staff time, expertise, resources, and facilities A discretionary £5,000 ‘Funder’s Prize’ would have been made available to encourage and motivate participation in each project to a satisfactory conclusion.

In addition to the grant funding, each successful project would receive an ‘in-kind’ support package from the TAWCO consortium including access to a customisable private 5G network, technical consultations, and industry guidance to adapt solutions towards the targeted application.

Table 6: Summary of Innovation Competition Funding and Project Budgeting

	Per Project Amount	Total Budget Allocation
Grant Funding	up to £40,000	£200,000
Funder’s Prize	£5,000	£25,000
Funding Total	**£45,000**	**£225,000**
Support Package Equivalent Value (in-kind support)	£10,000*	£50,000
Total Value	**£55,000**	**£275,000**
* Estimated value of products and services supplied by TAWCO consortium		

Section 4: Security Considerations associated with Fibre in Water Methodology

As part of the TAWCO project, there was a need to ensure that within the operational and commercial models employed, cyber and physical security is maintained to ensure safe and secure operation.

A cyber-physical risk assessment was undertaken on the detailed design, concluding that there are some risks that will need particular attention during construction and operational phases of the project. The assessment found common ground on needs across all three FiW use cases: water leakage detection, telecommunications and 5G wireless.

Risk Assessment scope and boundaries:

Sweco were commissioned to document cyber and physical risk profiles for three use cases and to map these to the different appetites for risk across the participating organisations. A standard risk assessment methodology was used to identify, qualify, and quantify security risks, and then highlight those which require further actions for treating residual risk post existing countermeasures.

The following three diagrams provide a high-level perspective of system in scope for each use case:

Water Leakage Detection:

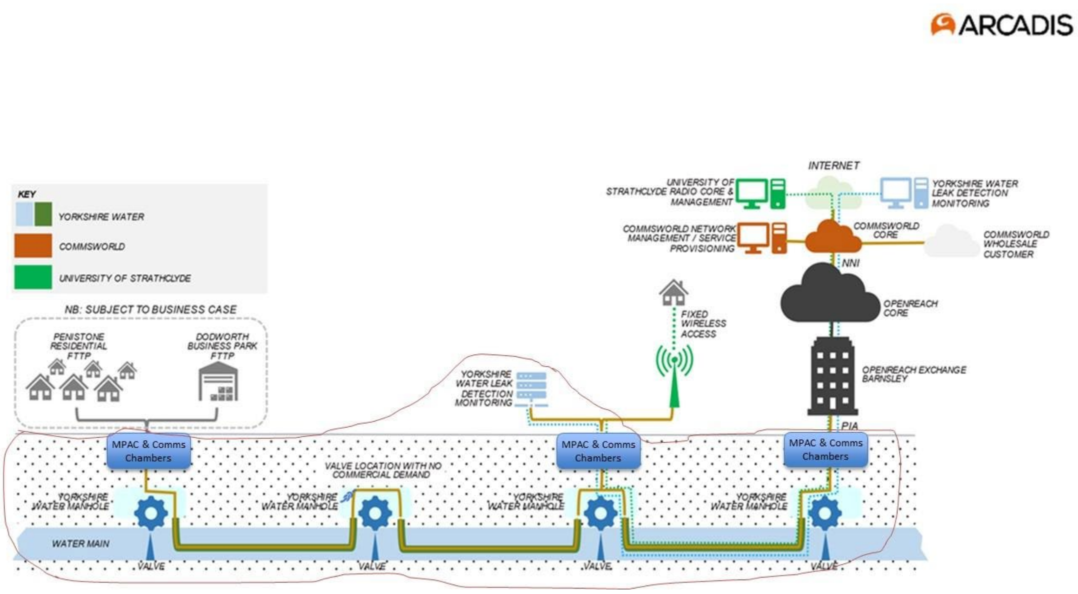

Figure 4: FiW use case water leakage detection scope.

The primary function of this use case is water leakage detection monitoring. There is also potential for operational control of network assets (e.g., valves, PRVs etc) in the future; this potential was not risk assessed.

Telecommunications:

ARCADIS

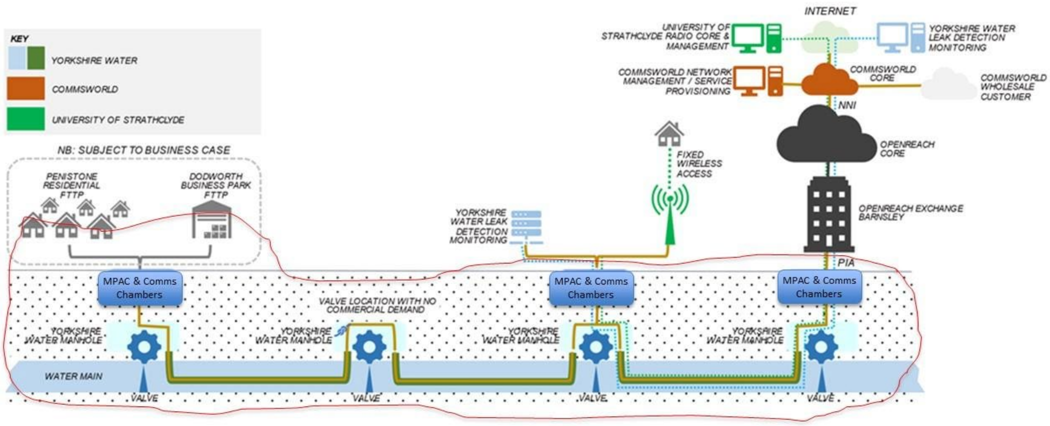

Figure 4: FiW use case telecommunications scope.

The primary function of this use case is to provide fast internet connections to communities and businesses along the route.

As Yorkshire Water comply with the Security & Emergency Measures Directive (SEMD) and Network Information Systems Regulation (NISR) for risks to essential services, the Yorkshire Water security framework (countermeasures) was used in this exercise; it largely reflects the risk matrix used by CommsWorld and is aligned to DEFRA's & DWI's cyber assessment framework (CAF).

The risks identified in all three use cases as needing further attention were related to risk management alignment, which changes with the introduction of fibre into water.

Further information on the findings of the risk assessment cannot be shared in this report for security reasons. However, a key recommendation was that if a FiW installation is initiated, the Water Company and telco involved should set up a joint risk management and governance group to manage risk mitigations identified in each use case risk log, and then to identify changes to the risk landscape throughout the operation of the joint service provision.

Section 5: Key Findings

Project TAWCO has completed the planned investigations into the potential of installing fibre optic broadband in drinking water mains. It has developed a commercial model to show how this can play a role in deploying fibre to hard-to-reach properties, whilst at the same time contributing to reducing drinking water loss due to leakage by using the fibre as a real-time distributed sensor.

There are obvious potential advantages in using existing water infrastructure:

- The UK's water network reaches 99% of properties in the UK compared to only 72% within reach of Gigabit via Openreach's current network.
- Fibre cables running within the buried pipes that make up the water network are much less vulnerable than some of the alternatives available to fibre operators. This is particularly true in rural areas, where Openreach poles are the primary option. Pole based networks are vulnerable to accident and storm damage, as well as vandalism.
- Installation of fibre into live, pressurised water pipes is facilitated by the flow of water, avoiding significant construction effort so is 'greener' and less disruptive than digging new ducting. Provision of leak detection capability also adds to FiW's green credentials.
- Water infrastructure already enjoys existing wayleave arrangements, to grant a temporary right of passage over, or through, land in order to install or maintain water infrastructure. Whilst wayleaves are restricted to water sector applications, there are existing landowner relationships that can be extended rather than requiring operators to start from scratch. All water companies are registered by Ofcom as Code Power providers, reflecting their operation of private radio solutions for more remote locations.
- In addition to trunk routes between towns and villages, water infrastructure crosses many obstacles that can thwart fibre build-out such as motorways, railways, rivers, and canals. Whilst these 'short hop' solutions offer little scope to water companies for leak detection, they can be commercially very lucrative if they can help an operator to reach target communities without a lengthy diversion or expensive construction work.

Technology Findings

At the time of the DSIT Fibre in Water competition for funding and subsequent award of funding to the TAWCO consortium, the technology to safely and efficiently install a fibre optic cable inside drinking water mains was considered to be largely a proven technology. In 2019, a provider had achieved the all-important 'Reg 31' approval for the first iteration of their solution. This in theory meant that a solution was ready to deploy, and some UK water companies had begun to run limited field trials and to model a business case based on leak detection alone.

Reg 31 approval for the latest FiW technology is required for installations in England and Wales to progress. The Reg 31 approval granted to a FiW technology in 2019 was unfortunately not applicable to the intended TAWCO FiW design and has since been withdrawn.

From an operational perspective, Yorkshire Water identified all the operational risks that needed to be addressed before approving the project. These issues ranged from regulatory and safety implications of working on potable pressurised pipelines to the increased risk of service interruptions. The majority of the risks were successfully addressed by the TAWCO project investigations, with the remainder to be closed as a result of the on-site experience expected to be gained from the TAWCO pilot installation.

From a telecoms perspective, TAWCO sought to address the "what happens if there is a major burst?" question. The immediate answer is that major bursts that might necessitate removal of the fibre are a rare occurrence. Wherever possible, bursts are repaired using a clamp method, rather than cutting out and replacing a section of pipe, so the fibre optic cable may not be impacted at all. It is also important to understand what the alternative is; for example, pole-based PIA in rural areas will potentially experience more failures than a fibre in a water main over its service life. The TAWCO team recognised that telecoms operators are all familiar with Openreach ducts and associated processes, so the FiW major burst process mirrors the major event process defined by Openreach. This process gives an initial exclusive period of access to the water company before the telecoms company is allowed to begin their service restoration.

Route Selection Findings

There are a number of complexities relating to route selection. For the combined fibre commercialisation and leak detection benefit business case to work, it stands to reason that a route should be commercially viable for the telecoms company, offering access to potential customers and aligning with the commercial priorities of the operator. At the same time, water companies will have a clear view of which routes offer the greatest potential leak detection benefit. An attractive FiW route should therefore be both commercially attractive and offer good leak detection benefits. There will be scenarios where a route required by an operator is commercially attractive but it offers little leak detection upside for the water company - and of course vice versa. Water companies may be reluctant to install fibre and increase operational risks if there is no real leak detection upside for its operations. By the same measure, telecoms companies may not see the value in a route that offers significant leak detection benefits for the water company but does not touch commercially attractive locations in the operators target markets.

Pipe material and diameters as well as pipe condition will impact the suitability of a route for the installation of fibre in water. During the design phase the Risk Assessment identified a section of pipe along the route that caused unacceptably high risks to both cost and time frame for the build phase. This necessitated a redesign of part of the route. Pipe condition must also be considered; for example ageing cast iron pipes will typically have developed over time an internal layer of tuberculation so that the actual internal diameter is reduced. Surveys must be carried out to ensure that pipes are in sufficient condition to allow a smooth installation of fibre in water using the parachute method.

Route information sharing is a challenge. Water mains are a critical national asset and require assurances to share route information with telecoms operators. The ideal scenario would be a 'PIA-like' portal, where suitably approved operators can see what infrastructure exists and where it goes. The routes presented by the water company should ideally have already been filtered to remove pipes that are not considered suitable by the Water Company (for example material type, age and condition or diameter). For the Penistone pilot a specific NDA was set up to allow route sharing inside the consortium, but this is not a scalable solution. Initiatives like the Geospatial Commission's National Underground Asset Register (NUAR) could be a potential solution but would still need to address the critical national asset concerns of the water companies.

Water companies use valves to control their networks, allowing sections to be isolated and water rerouted. We found that one of the key cost drivers for FiW is the cost of circumnavigating valves on the chosen pipe route. To allow the valves along a chosen Fibre in Water route to operate properly, the fibre must be brought out of the pipe before the valve and reinserted after it. FiW technology providers suggest that single runs of up to 2km are achievable. This may be possible in rural areas, where water companies can have up to 2km gaps between valves, but water company 'asset standards' may drive towards valve spacings of around 1km. In urban areas, valves are more common – typically 3 per km – so costs and complexity for FiW are higher in areas where PIA is a favoured option - and where water company sewer networks may be a better option than water pipes.

Water companies are understandably operationally conservative; we found that many valves on our chosen route had not been required operationally for many years. These included buried valves (where only a 'keyhole' is visible at the surface) in the middle of farmers' fields which would be unlikely to be used in an emergency situation. Yorkshire Water did make concessions and allow the FiW design to route straight through some of these long-term dormant valves rather than requiring them to be circumnavigated, which significantly reduced the estimated cost of the build. Every water company would need to make similar choices which could potentially push out approval and build timescales – at least for initial requirements.

Commercial Findings

Yorkshire Water's own modelling exercise suggested that the cost of installing and operating Fibre in Water could not be justified on the basis of leak detection benefits alone. For Yorkshire Water, the obvious answer was to work with a commercial fibre broadband provider to complement the leak reduction benefits and create a positive consolidated business case. But the consolidated case needs to have both a quantifiable telecoms opportunity and quantifiable leak detection benefits. Without both of these components, the model will be compromised. Either the water company ends up with an unaffordable leak detection solution, or – for a route where there is little leak reduction benefit – will have to make operational compromises with the full weight of expectations sitting on what the telecoms operator is willing to pay.

The focus of TAWCO was to create a realistic commercial opportunity and alleviate operational pressures. The central tenet of the project was to make the chosen route available for a thirty-year period, so that a telecoms operator could deliver commercial services to clients along the route. TAWCO would also demand the full attention of Yorkshire Water's operational teams, given that FiW would be there for the long term rather than simply a typical 'install then remove' six-month trial. This model was developed in some detail between YW and CommsWorld as part of the project, illustrating that Fibre in Water did present an investible opportunity giving a return within a range that would be required by investors in fibre network infrastructure.

The investigations and modelling that were carried out in Phase 1 demonstrated that FiW as a concept has the potential to be a viable proposition from an investment perspective. The commercial modelling showed that alternative routes could show a higher rate of return, if selected within the design parameters indicated by the investigation phase and located in areas with sufficient commercial and domestic broadband customer opportunity.

Telecoms operators do have viable alternative build models (PIA within the Openreach footprint and efficient civils options beyond). Cost is therefore a significant determining factor for Fibre in Water adoption because telecoms operators will make economically driven decisions and will also favour the model that they're familiar with (and where they can drive scale), so natural gravity is towards PIA and civils work. To be attractive to operators, Fibre in Water will therefore need to be available in areas where there is no PIA (typically but not limited to rural areas) or the PIA option available is only pole-based (which can be prone to storm and accident damage and is not quick to repair) and the operator is seeking a more resilient option. Alternatively, Fibre in Water may offer speed of build (simplified wayleave process, for example) and a cost advantage over traditional build options – which remains to be proven and will require a live build to fully explore.

Civil engineering costs are a significant component of PIA related build costs and of FiW. Valve site circumnavigation is not the only driver of the need to bring the fibre optic cable out of the water main; the telecoms operator will require 'breakouts' so that it can serve clusters of business and residential customers. Often there will be valve sites close to these clusters as part of the supporting water infrastructure these premises require but may in some instances require a dedicated breakout build. Water companies rightly will control any civils activity directly impacting water infrastructure but have no telecoms experience. FiW introduces the need for two parallel civils activities which could drive costs and increased disruption for landowners if poorly co-ordinated.

The focus on commercial viability – primarily cost – was an area of focus for TAWCO investigation. The pragmatic approach adopted for this project (and a potential template for wider industry adoption) is for water company approved and appointed civils contractor to take responsibility for both installing the fibre cable in the water mains and for constructing any telecoms specific requirements. For example, this could include ducting from a buried valve in the middle of a field to highways land adjacent to a nearby road and the construction of a telecoms specific chamber or cabinet. Whilst this arrangement saves cost and time, it may be off-set by the reduced cost control by the Telco, who may usually use smaller, lower-cost civils companies.

Commercial viability of the chosen route (rather than FiW technology itself) proved to be one of the key issues that prevented TAWCO from moving into the build phase. Fibre operator Commsworld assessed the residential and commercial opportunity along the route and concluded that providing FTTP into Penistone was essential to the viability of the route. The Barnsley – Penistone route had been chosen because Penistone village appeared to be at risk of not having access to Gigabit broadband services as the boundaries of Lot 21 (the Project Gigabit procurement lot for the South Yorkshire area) evolved in response to successive Open Market Reviews. This uncertainty impacted CommsWorld's valuation to the point where TAWCO failed to meet the Commsworld investment gate threshold. The current situation is that Penistone is outside of Lot 21 boundaries and the commercial operator who had said they were going to build in the village has now withdrawn, leaving Penistone once again without committed Gigabit delivery.

Wayleave findings

There are wayleave implications in combining water and telecoms builds into a single activity; water industry wayleave rights are granted under the Water Act and are restricted to activities related to core services of the water sector. Whilst arguably leak detection sensing is directly relevant to core water sector services (and can therefore make use of existing wayleaves), commercialisation of fibre is not. In theory, most – if not all - water companies are listed by Ofcom as being 'Code Power' operators, which also gives water companies the rights to use the provisions of the Electronic Communications Code (ECC) which gives telecoms operators right to access land to build their networks and sets out an expectation that costs should be 'opportunity cost' based rather than a market rate. A telecoms operator could reasonably argue that unless civils for breakout work is required at a location, a fibre running through a water pipe under existing land has no impact on the landowner and therefore would attract no incremental wayleave payment.

For TAWCO, we adopted a more conciliatory approach. Yorkshire Water were keen to maintain good relationships with landowners on the route and given the use of their contractor to lead combined build activity, opted to proactively engage and offer landowners an incremental payment in recognition of the additional telecoms usage of the fibre, but particularly to ease agreement for any telecoms specific construction that might be required – for example for breakouts. The TAWCO delivery phase was under significant time pressure due to the late start for the project, so proactive and incentivised landowner engagement was considered an appropriate expedient. Time pressures obviously exist in commercial fibre builds using PIA or civils, so the pragmatic water company led approach used for TAWCO is to our mind the right approach for other water companies and telecoms companies seeking to exploit FiW.

Market and Suppliers Findings

One concern for DSIT at the outset of the Fibre in Water competition (and subsequent award to the TAWCO consortium) was the paucity of supplier options. The TAWCO team shared this concern, recognising that dependency on one small supplier could result in higher input costs and bring significant capacity constraints making scaling up a real challenge. Whilst there is a degree of choice in the suppliers of fibre-based sensing solutions, Craley was perceived as the sole provider of FiW installation technology and was certainly the only Reg 31 'approved' supplier. The TAWCO team has engaged with six fibre sensing providers and three FiW installation providers.

Options for Next Steps

Abandoned water company assets are plentiful and avoid the operational considerations and route sharing restrictions that come with using live mains. TAWCO identified a significant number of disused water mains in the proposed pilot area. Abandoned routes do not carry water so whilst FiW technology itself is not suitable and there is no operational leak detection upside for the water company, an abandoned route has value in its wayleaves and landowner agreements, so could be a viable option for telecoms operators.

Openreach PIA is not necessarily ubiquitous even in urban areas; operators told us they are finding ducts full or in poor condition. BT's historical build practices mean there are parts of suburbia where telecoms cables were direct buried rather than installed in ducts that could be re-used. FiW might not be the first choice solution, but wastewater assets like sewers could potentially offer better economics – and there are precedents in several UK cities including London. As with FiW, fibre in sewers technology has moved on and several companies are offering hydrodynamic solutions that avoid the snagging risk usually inherent with sewer installation. There is also no need for Reg 31 approval.

Lack of operational upside for the water company on a given route is not necessarily a showstopper if there is a strong commercial rationale for the route and the telecoms operator is willing to pay accordingly. Operators have identified canal crossings in North London and in Manchester as constraints to their networks and the same logic might apply to other obstacles such as motorways and main roads, rivers, and railways. There are also potentially strategically important routes that could offer significant cost advantages over traditional cabling activities. Scottish Water has a number of drinking water pipes to islands, for example.

Section 6: Lessons Learned

Lesson Learned sessions with partners and stakeholders were held regularly throughout the project to record both positive and negative learnings. In summary, if a similar project were to be delivered in the future, the following lessons should be considered:

- Create more detailed Partner frameworks prior to commencement.
- Appoint a build partner to the Partnership team to ensure early contractor engagement.
- Appoint a technology partner to the partnership or subcontract to a main partner in order to ensure that the testing process is prioritized.
- It is understood that a route may be chosen ahead of time, but we must allow a process for better due diligence and opportunities for commercialisation before accepting that the chosen route is the one to proceed with.
- Make sure that our product portfolio has accreditation for use and deployment in the UK; or if not possible, then engage with Drinking Water Inspectorate at the early stages to ensure they were part of the stakeholder group.
- While FiW is beneficial on trunk mains, FiW would complement PIA – where PIA was not available.
- A more detailed process needs to be carried out on route selection when valves and break outs are involved. The more breakouts needed the higher the costs.
- Water companies would need to review their engineering and maintenance policies about valves to reflect valve condition and whether they need bypassing or can run through.
- A thorough costing exercise to be carried out in the early phases to understand any funding issues and set mitigations earlier.

Section 7: Conclusions and Future for Fibre in Water

Conclusions

A live build is not now part of project TAWCO but is still required to prove the commercial and operational frameworks that have been developed in the first phase of the project, and to test the cost model. Using water flows to deploy fibre in pipes offers the potential of a much more carbon neutral build option compared to new civils work or even to using Openreach PIA. Again, a live build project would allow this assumption to be properly tested.

The TAWCO team see FiW as a potential complementary solution to Openreach PIA rather than as direct competition. Phase 1 of TAWCO has shown that FiW can be economically viable, where valve count (an important cost driver) is low and PIA options are limited.

However, the need to find the sweet spot where there is a commercial telecoms opportunity and operational upside coupled with the challenges of information sharing in a critical national infrastructure environment (not to mention the further complexities of pipe material, and diameters and condition) adds layers of complexity, which will need to be resolved if FiW is to scale.

Even then, altnets are very familiar with both PIA and micro-trenching techniques, so adopting another less familiar and potentially low volume build methodology may not be attractive, particularly in a fast moving 'build' environment, where first-mover advantage is critical.

The overriding issue is the continuing uncertainty about the approval status of the FiW technology. Installing fibre in the potable water infrastructure needs to be done with the appropriate level of care given the potential consequences, and the TAWCO team recognise the primacy of this issue and the role of the DWI in ensuring that water quality and safety are not compromised.

It should be recognised that the Reg 31 approval process can be costly and time consuming, particularly for SMEs, who may also choose to prioritise their activity across other markets outside of the UK where approvals may be simpler to achieve.

Not including the technology provider as part of the TAWCO consortium created a disconnect between them and the project team. The formal relationship with the technology provider would have been established in the build phase, but this did not support good communication between the parties in Phase 1, making it challenging for the team to fully understand and evaluate the risk associated with the timing of the Reg 31 approval. Ultimately, insufficient confidence that the technology would receive approval within the timescales of the TAWCO project funding meant that the build phase could not proceed.

The Future for Fibre in Water

From a pragmatic perspective, abandoned pipe routes are plentiful and come without the baggage of operational risk and approvals that working in live potable water mains entails. Combining FiW and FiS into a ‘Fibre in Pipes’ (FiP) proposition is another natural progression. All the benefits and opportunities that the relevant organisations derive from one of the applications exist in the other. FiP has the potential to improve the overall economics and open wider commercial opportunities for a water/telco partnership e.g., the densification of fibre for Smart Cities initiatives. Obstacle avoidance ‘hops’ and strategic routes might be the best FiW-proper requirement once Reg 31 approval is secured.

FiW (and FiS) development work to date has mainly involved water and sewerage companies and technology providers. Other potential stakeholders such as local authorities, and the MoD, should not be overlooked and may open other potential opportunities for deployment, such as all-encompassing Smart Cities or dedicated fibre for military uses.

The ATI regulations are written with an emphasis on intra-sector asset sharing but with little attention afforded to cross-sector collaboration. The project team believes that the latter will promote strong, longstanding inter-sector relationships. Reasonable volumes of cross sector asset sharing will only be achieved if interested parties have a real aspiration to drive a mutually acceptable solution. Perhaps a way forward might be a review of the more prescriptive sections of the regulations to be redrafted considering recent technical and strategic developments e.g., recent technological developments where the telecoms installation incorporates the ability to deploy a sensing fibre for the purposes of network monitoring.

To encourage collaboration and to incentivise the evolution of shared asset development and smart infrastructure a greater collaboration between relevant regulatory bodies as well as with telcos and water companies is required. The aim would be to remove barriers and establish a broadly recognised business model upon which mutually beneficial smart infrastructure projects can be delivered with less complexity and more clearly defined responsibilities. The creation of a temporary joint sector operating group could be considered, and in the interests of consistency and expediency, it would seem sensible for the incumbent project team to drive this initiative with support from existing DSIT members.

Annex A: Fibre in Sewers

As part of project TAWCO, a stand-alone desktop work package was delivered to evaluate the potential for a viable, replicable, and proven delivery model for Fibre in Sewers (FiS) that might support the objective of the overarching Fibre in Water (FiW) project. This work packaged focused on how fibre can be used for the purposes of smart infrastructure in a sewer environment.

Water and Sewerage Companies (WaSCs) are facing increasing pressure from regulators to reduce flooding and pollution from sewers. In England and Wales step changes of over 25% reduction must be delivered between 2020 and 2025 with material penalties and rewards applying. Fibre-in-sewers (FiS) has the capability to change passive sewerage systems into smart wastewater networks and directly contribute to realising customer and financial outperformance.

A detailed report was written to summarise the current position in terms of existing information, previous findings, technology, and the scale of the potential opportunity for both WaSCs and telecommunication companies. This was achieved by completing interviews with various parties and analysis of available data sources.

In 2019 a Technical User Group (TUG) was set up to investigate the potential for FiS and whilst this did carry out some live trials of the installation and sensing systems, it was ultimately halted in 2021. The TUG found that there was merit in the installation systems trialled and that further investigation was worthy. The sensing benefit that could be realised by FiS was deemed to be a potential step change in asset management capability for sewers.

Nuron has an installation system that was used in live trials in Northumbria Water's sewer network. It was able to be installed in sewer grades 1-5 between DN225mm and DN300mm. The trial was a success with minimal disruption noted.

Outside of the UK there were found to be other potential installation systems available, with FiS being installed in Japan, Germany, Austria, Spain, and the US utilising robotics. At this point it is unclear if those systems would be compatible with any sensing technology that we would like to see incorporated into a FiS system. A multitude of sensing companies exist and have proven technology that may be applicable to this project.

To evaluate the scale of the potential opportunity various data sources from Yorkshire Water and the government were processed to generate heat maps of network and sewer suitability. This mapping exercise suggested that rural areas are the most suitable for FiS; however, they have a low population density, and any potential business case should take this into account. Whilst urban areas performed well in terms of download speeds and ability to receive decent broadband, a gap was seen in superfast and gigabit availability. This suggests that urban areas are suitable for FiS, although a different business case from rural areas would be required. Semi-rural areas performed well in terms of broadband connectivity and were considered unsuitable for FiS.

There are benefits to be had for WaSCs by utilising a distributed sensing network. These include proactive maintenance, identification of hot spots and precursors to events. With 5,671

Internal Sewer Flooding (ISF) and 33,377 External Sewer Flooding (ESF) events, 158,968 sewer blockages and 1,487 sewer collapses recorded between 2016 and 2021, and the associated penalties (£36k for each ISF, £7.69k loss from reward pool for an ESF, and £130k for pollution events) there are financial gains to be made by reducing these events.

For telcos the benefits are primarily around the construction phase of installation with potentially reduced costs, increased delivery speeds and a greener footprint. FiS would also increase network safety as sewers tend to be the deepest utility and so safer from third party activity.

Deployment costs for FiS are relatively high in comparison to other deployment methodologies for fibre, although one supplier indicated that they may be comparable to PIA. In comparison to other monitoring solutions, FiS offers a step change in the amount of data collected and coverage of the network. This comes at a cost, both monetary and flexibility, with existing solutions being cheaper and easier to deploy on an ad hoc basis.

The right commercial model is perhaps the key to unlocking the adoption of FiS as it does not make sense from an economic standpoint for WaSCs and telcos acting separately (reflecting the similar conclusion for FiW). There are numerous options that may be implemented, from the WaSC acting as a “silent landlord”, passively hosting the fibre, to providing an active service. There is a balance of risk and return with ownership of ducts, fibre and service, which would require further investigation.

The greatest risks to FiS currently are the availability of a proven installation system, complex business models and unproven sensing technology deployed on such a large scale. Installation suppliers have voiced their concerns around the market and the potential business models to make the development and installation of these systems viable. Models for both the WaSCs and telcos also need to be explored and deemed suitable before FiS can be employed. The sensing technology is not new; however, it is unclear if it has been employed on such a large scale and whether any perceived benefits can be drawn out.

There are opportunities to be had with potential gains in reputation and a smart sewer network, capable of meeting future demands, reducing incidents and increasing performance.

The conclusion of this work package is that there is merit in FiS, perhaps as a combined Fibre in Pipes system to utilise the benefits of both approaches in a partnership between water and telecoms industries. The next steps would be to conduct live trials, in-depth commercial and business modelling, development of industry standards and engagement with stakeholders.

Contact Us

If you have any questions about this project or report, please contact us by email at:

InnovationTeam@yorkshirewater.co.uk