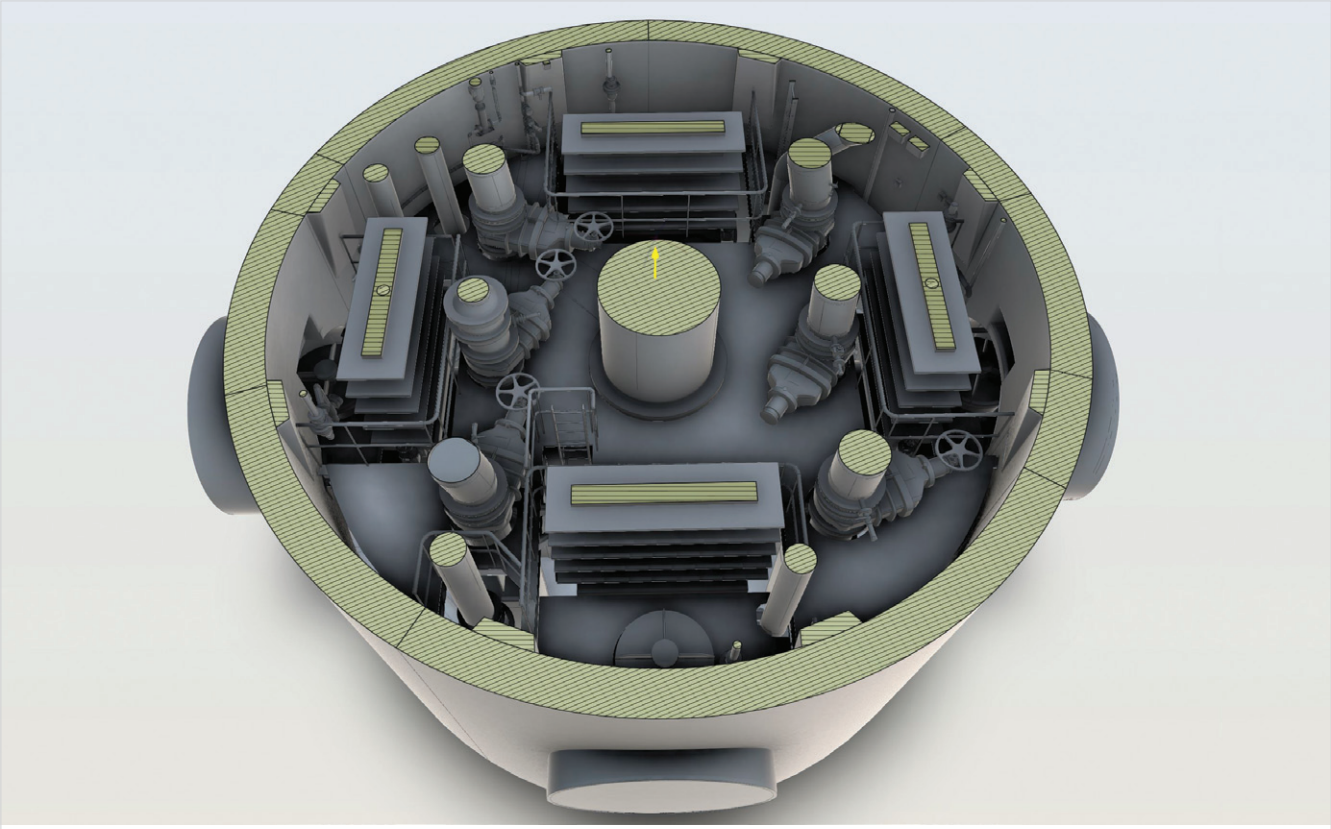
Barrow Hill Shaft

technological innovation at the heart of the deepest shaft of Thames Water's ring main

The Thames Water Ring Main (TWRM) in London is an 80km long, 2.5m diameter tunnel built between 1988 and 1994 to take water from five treatment works and transfer flows via pumping stations housed in shafts along the route. It is a major part of London's water supply infrastructure and carries an average daily flow of 0.3 x10^9 gigalitres; a little under one-sixth of the capital's daily demand. The Barrow Hill Shaft, one of a total of 22 on the ring main, is located at St. Edmund's Terrace on the edge of Primrose Hill in North London. Barrow Hill is the deepest of the shafts at 80m deep and also the biggest with a four-way tunnel connection at its base. Barhale was appointed by Thames Water to carry out refurbishment works at the Barrow Hill shaft.



3D view of the shaft at high integrity valves level - Courtesy of Murphy Surveys

Programme of work

The works at Barrow Hill would not only see a major refurbishment and upgrade of the site but also presented a fantastic opportunity to adopt a forward-thinking technological strategy, simplifying potential future works by digitally modelling the shaft. This would be the 19th shaft to be refurbished for Thames Water under the current programme. The programme of works included upgrading the shaft drainage, access, flooring, electrics and pipework. This work ran from December 2018 to December 2019 and was valued at £1.8m.

First steps

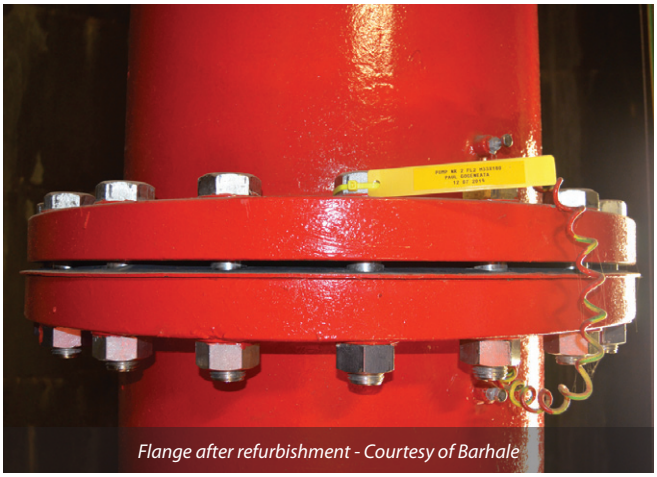
While access to the site was good, Barrow Hill is set in a residential area of north-west London and it was important to ensure early engagement with the community. To that end, a series of letter drops was undertaken advising inhabitants of the proposed programme of works, an outline schedule and contact details for the project managers. The Barhale team also provided assurances that noise and disturbance would be minimal and the works would be undertaken within a regular daily window, with any out-of-hours activity strictly restricted. It is a simple but important step adopted by Barhale across its sites, but it helps to foster positive relationships and understanding with the community.

Water ingress

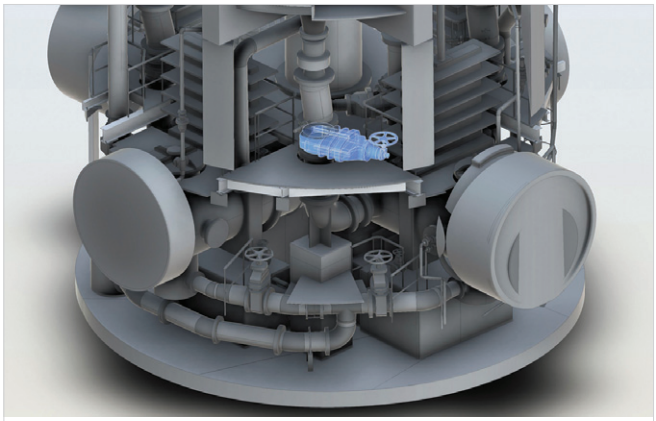
The ring main was constructed between 1988 and 1993. Despite its comparative youth, significant water ingress to the shaft had been caused by climbing average rainfall levels. It meant that when the Barhale team was appointed to conduct the refurbishment they faced a big challenge.

At best, the shaft was damp while at other times significant volumes of water would pour in, making it a difficult working environment. So before work to address any damaged assets such as leaking flanges or burst pipes was possible, it was essential that the shaft was made dry. Working with Tempo PCE, Barhale developed an innovative solution. A series of holes were drilled through the shaft's concrete rings making it possible to insert a lance.

Valves after refurbishment - Courtesy of Barhale



Flange after refurbishment - Courtesy of Barhale



3D BIM of the bottom of the shaft - Courtesy of Murphy Surveys

Barrow Hill Shaft Supply chain - key participants	
Client	Thames Water
Principal contractor/designer	Barhale
BIM 3D surveys	Murphy Surveys
Water sealing	Tempo-PCE
Scaffolding	K Scaffolding
Fabrications	BCS Group
Alarm installation (Covers)	Chubb
Cover installation	EJ UK Fabrication & Access Solutions Ltd
Installation of new ventilation fans	Lee Bullen Engineering
Asbestos purvey & lead paint testing	Alltask
Supply & install pressure switches	Parson Peebles

Normet TamPur 125, a hydrophobic polyurethane was then injected. The chemical reacts when it comes into contact with water to produce a rigid polyurethane foam, sealing and waterproofing the shaft. Effectively, an additional resinous waterproof barrier has been created over the outside of the shaft. More than 300 leaks were dealt with using this approach.

The nuts and bolts

Once the shaft was dry, the Barhale team was able to progress the maintenance and refurbishment work. Scaffolding was erected to the full 80m depth of the shaft enabling the operatives to safely reach all the components as necessary.

The substantial water ingress had taken a significant toll on the metalwork and the works required the checking and replacement of thousands of components. A programme of pipework modifications entailed the removal of old corroded pipe and either installing blanking plates or replacing the pipework with better-quality materials. Existing pipework was tested to ensure no lead paint was present before three coats of paint (primer; base coat; and finish coat) were applied.

When the shaft was originally built it had not been designed with a view to replacing components. Nevertheless, the team was generally able to operate in a live environment with only a few isolations being required; for example when changing a gate valve. In each instance, they replaced the component in such a way that in future it will not be necessary to isolate.

The work also saw the replacement of approximately 8000 corroded mild steel flange bolts with stainless steel equivalents. Each bolt had to be accurately torqued and the loading recorded by the engineer. As with the pipework, the flanges, pumps and valves were cleaned and re-coated with protective paint. Actuators were replaced in the chambers and at ground floor level.

All mild steel elements, such as like platforms, deckings, handrails and brackets, have been replaced with galvanised steel. The fabrications were carried out by Barhale subsidiary BCS Group. Electrical and communications work included an overhaul of the lighting system, removing any redundant systems. The 110V supply and the fixed phone system were both disconnected from the shaft.

The physical structure and landscape above the shaft also required attention. Barhale resealed the shaft cover with waterproofing thereby addressing another long-term source of water entry. The top of shaft was re-paved and new drains were installed so the water ran off the shaft top into the drainage system.

Embracing digital technology

While a key feature of the works programme was the installation of better components, drawing on the experience gained at other TWRM shaft refurbishments, Barhale decided to take the opportunity to create a trial 3D digital model of the lower section of the shaft. At its most basic level, this model enables Barhale to replace paper-based safety and quality records with digital versions. Looking ahead, the model will also bring significant benefits to Thames Water and anyone working in the shaft in future. For example, the model will have details of the shaft components so will remove the need to carry out a pre-survey and eliminates the associated risk of confined space entry prior to the commencement of any future works.

Barhale engaged land and engineering surveying specialist Murphy Surveys to carry out a 3D laser scan survey of the lowest three levels of the shaft. Murphy then built a digital model using Autodesk's BIM 360 Field software. All the existing components within the shaft were picked up in the survey. As Barhale replaced that component with something new, data relating to every new part is attached to the model.

Taking the example of bolts being replaced on a pipe flange. Once the job is finished, a Barhale engineer takes a tablet device down the shaft, carries out all the safety and quality checks (such as the torque on the bolts) and records them electronically. This information, together with the engineer's signature and any photos taken of the work, were automatically attached to that component and then synchronised to the master model online so anyone with access can log in and look at it.

Barhale and Murphy Surveys' scope of work included:

- Murphy Surveys completing a 3D survey using a Leica 3D laser scanner and a NCTech iStar 360 camera; creating the model using BIM 360 Field software; hosting the model data; and provisioning of Apple tablets for the team to complete the post work survey.
- Barhale providing site access and confined space rescue and supervision; making available inspection test plan check sheets to upload to the model; completing post work surveys utilising the Apple tablets; and uploading survey information to the model. Barhale team members are able to view the survey information but not the model using Autodesk BIM 360 Field web browser which requires a license fee. 3D Autocad software is required to view the model.

Timeline creating/using the 3D model, July to December 2019

- ***July 2019***: Barhale and Murphy Surveys agreed scope of works with Murphy completing the 3D survey within 1 day.
- ***August 2019***: On completion of survey, Murphy created 3D model within 1 month.
- ***September-November 2019***: Barhale engineer used a tablet device provided by Murphy to complete post refurbishment work survey throughout the works.
- ***September-November 2019***: On completion of the survey, the tablet once it has internet connection automatically synchronises to the master model online, so anyone with access can log in and look at it.

Client benefits

The main benefits to Thames Water of having the 3D BIM model come from not having to go into the shaft to survey or check information before work commences. The model will be kept live and can be viewed and updated when required through maintenance periods. There is the opportunity to use the model for design, scaffolding, temporary works design and planning isolations.

On this contract, a model was only built for the bottom of the shaft. For future contracts, Barhale plan to complete a model from the start for all the shaft works.

In conclusion

Barhale has developed unparalleled knowledge of refurbishment programmes across the Thames Water Ring Main having worked on nearly all of the 22 shafts. While the conditions at Barrow Hill presented some site-specific challenges it also presented the opportunity to pilot new technology.

The success of the project can be measured through the double benefit it has delivered:

1. In the fulfilment of Thames Water's refurbishment and maintenance objectives.
2. In the implementation of the digital modelling technology which offers the potential to reduce time, cost and risk on this and other projects.

The editor and publishers would like to thank Barhale for providing the above article for publication.

Looking down the shaft - Courtesy of Barhale

TDP actuator after refurbishment - Courtesy of Barhale