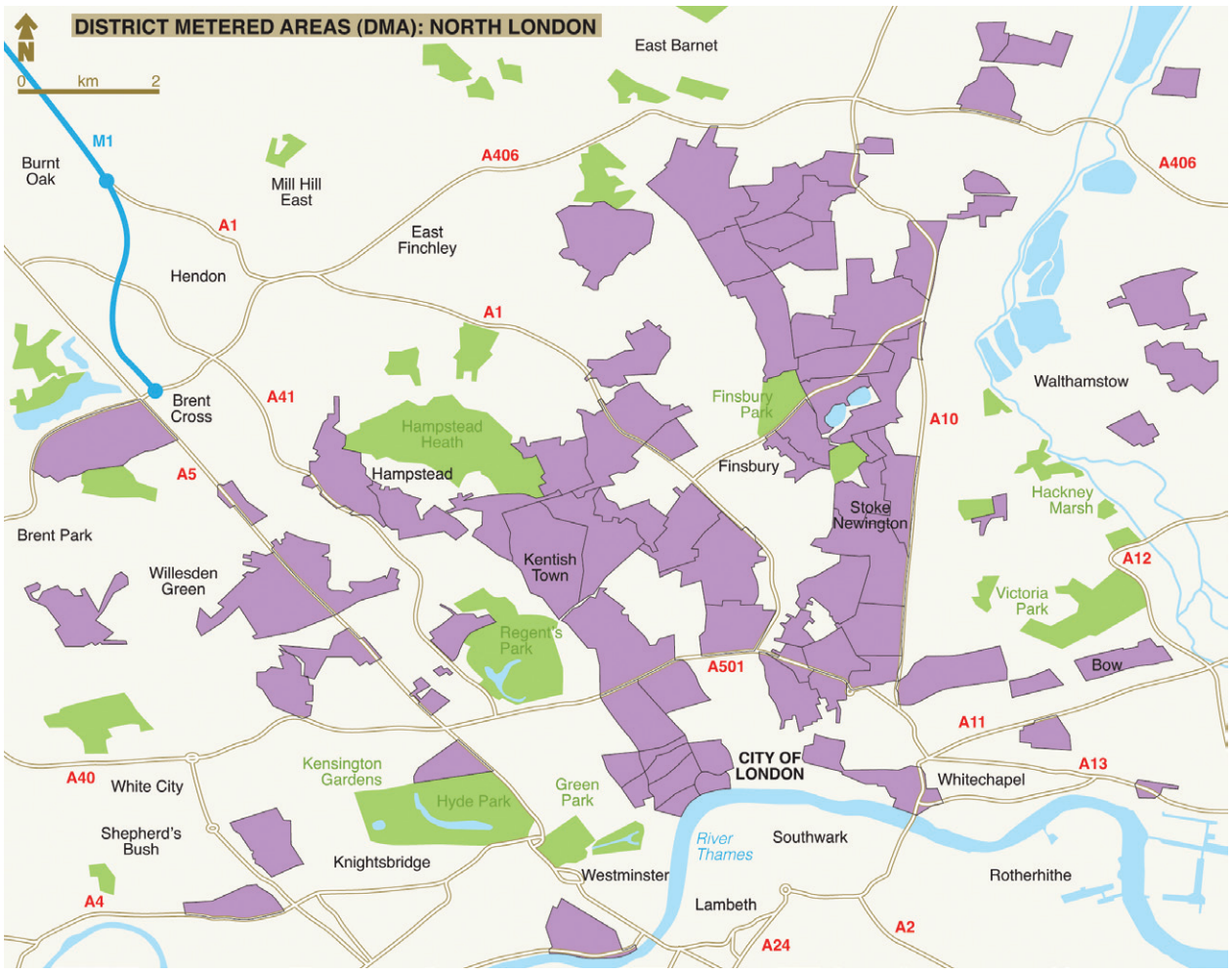
London's Victorian Mains Replacement Programme

Central London's century-old cast iron water mains replaced through one of the biggest, most challenging renewal programmes ever attempted

by David Hayward BSc (Eng) AMICE

Completion this year of arguably the world's largest water mains renewal project will replace Central London's maze of Victorian cast iron distribution pipes with an efficient, cost effective and more reliable Twenty First Century network. With the main driver for the £650m Victorian Mains Replacement (VMR) programme being leakage reduction, Client Thames Water can point to an impressive 270Ml/day saving in the area's water supply since the project began in 2002 - equating to a 36% reduction in leakage. Over the last decade, the water company's engineers have worked alongside its consultants and contractors to oversee not just a major 2,300km pipe laying construction programme, covering 300,000 homes, but also an equally challenging logistics exercise. Below ground, an existing antiquated jungle of water pipes has been decommissioned.



The total work area covered 200km² of North and Central London - Courtesy of J. Murphy & Sons Limited

Background

The current needs of every property in 1,000 streets are analysed before a new polyethylene network is installed using a range of construction techniques. This results in a rationalised network providing greater operational control. Above ground, months of equally complex computer analysis, plus negotiations with countless stakeholders, has led to the safest and least disruptive works' programme. Further impact reductions are achieved through innovative planning of traffic and pedestrian movements, plus the use of temporary water supplies. Overriding all this technical design, the diverse needs of major West End hotels, Leicester Square film premieres, underground Soho recording studios and judges at the Royal Courts of Justice had all to be accommodated.

Until a few years ago, 99% of North and Central London's commercial and domestic customers received their mains water supply through cast iron pipes up to 150 years old.

That such a network has lasted so long is testament to the skills of our Victorian water engineers. However this maze of pipes, laid piecemeal by different companies and regularly duplicated, is now often over or under today's water capacity needs.

UTS ENGINEERING LTD

A True single source for pipeline products & services

Your first point of call for any piping requirement...

SITE SURVEYS

We have experienced engineers located around the UK who can attend site and assess your piping situation. We will provide frank and honest advise and offer the most cost effective solution.

Scan to access our full range of products & services

Couplings, End Caps, Dismantling Joints, Flange Adaptors, Repair Clamps, Tapping Sleeves... and anything else you need!

ON-SITE EXPERTISE

UTS Engineering's site operatives are highly skilled. We can perform a range of services under pressure to avoid any disruption to the current flow.

One last thing...

Did we mention all of this can be achieved within 24 hours of your call...

24-7 EMERGENCY RESPONSE
07730 396 294

Call (0191) 428 4003

BESPOKE DESIGNS

Following an on-site survey, our design and development team can issue 3D drawings for approval. We have the expertise to offer any solution in the piping industry.

Our range of services include hot tapping, wall tapping, flow stopping, in-line valve insertions, pipe cutting, pipeline repair, maintenance & investigation...

DEDICATED TRANSPORT

Once your fabrication is ready, we have a dedicated transport service to deliver on-site at any specified time.

FITTINGS & FABRICATIONS

We can manufacture any pipe fitting or fabrication and tailor them to your individual needs. Our fabrications can suit any size diameter and oval pipes.

All of our products are manufactured in the UK and conform to the most stringent quality procedures.

UTS Engineering Ltd, Connor House, Pilgrims Way, Bede Industrial Estate, Jarrow, Tyne & Wear, NE32 3EW, England.

E: info@uts-ltd.com T: +44 (0) 191 428 4003 F: +44 (0) 191 428 4004 W: www.uts-ltd.com

UTS Engineering @UTS_Engineering 24-7 07730 396 294

In 2002 Thames Water Utilities embarked on an extensive 2,300km renewal programme based on replacement of leaking cast iron pipe sections and a complete reanalysis of every street and every customer's needs. A primary aim was significant reduction in water leakage which, a decade ago, exceeded 900Ml/day over the full Thames Water network.

Over the years a range of consultants and contractors have been employed, and this article highlights the challenges of construction company J. Murphy and Sons Ltd. Murphy has been involved continuously from the programme's 2002 pilot study until the project's planned completion in 2013, replacing 2,000km of the old network's distribution mains and supply pipes, under contracts totalling £225m.

For the first eight years until March 2010, Murphy was contracted to replace some 1,000km of mains and domestic supply pipes. From 2010 until 2013, the company has been lead contractor with Clancy Docwra Ltd in the Optimise joint venture, consisting also of contractor Barhale Construction and specialist consultant MWH.

Existing work

Contracted to cover a total 200km^2 of North and Central London, including the capital's West End, the Murphy-led team divided its programme into some 100 District Metered Areas (DMAs), which had been pre-selected by Thames Water. A typical DMA involved about 10km of distribution mains serving around 2,000 customers. The main criteria was to choose DMAs which were assessed as being the leakiest in the network area. This would result in customers receiving best value.

The contractor's brief is to replace and decommission, but leave insitu, the entire existing cast iron network. These distribution mains, and smaller services supply pipes to individual properties, range in diameter from 12" (305mm) down to 1" (25mm).

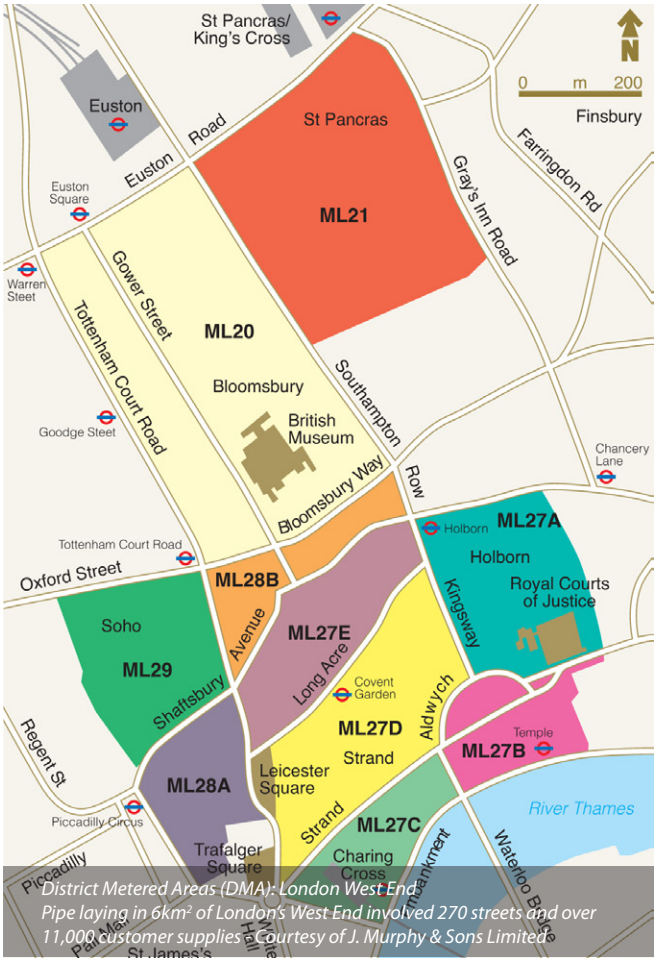
Over a century of below ground installations by numerous separate water companies has introduced uncharted additional pipe runs with some distribution mains duplicated up to five times. To design the replacement network, the team used sophisticated hydraulic computer modelling to determine current and future demand for every property.

The design was then re-analysed to take account of possible differing capacity and property types in neighbouring zones. In some DMAs, new pipe runs are almost half those in cast iron, with rationalisation producing, over the total programme, a 30% reduction in the pipe needed.

With much of the old network laid when the dominant street traffic was a horse and cart, some 25% of the total area's 50,000 operating valves lay beneath the roadway, often in the centre. These valves have now been repositioned either at roadway edges or footways, considerably increasing maintenance safety.

Innovation in design, routing and construction methods has brought increased cost and time savings, with disruption minimised both to customer supplies and to traffic flows. Field investigations and network interrogation enabled design to be optimised. This, along with geographical, topographical and health & safety data, supported the technique selection process.

The customer remained the focus and mitigating impact was the key to expectations being exceeded. On-line techniques were used on mains that could easily be isolated and capped off either end. Temporary by-passes were installed to further reduce interruptions to, and impacts on, customers. The joint venture's 400 strong workforce centres on over 80 (No.) two to five man teams employed in mains laying, lateral service pipe installation or carriageway reinstatement. Outputs averaged 2km of the new network installation every week during the peaks of the programme.



District Metered Areas (DMA): London West End
Pipe laying in 6km^2 of London's West End involved 270 streets and over 11,000 customer supplies Courtesy of J. Murphy & Sons Limited

The team had to cope with the pedestrian congestion of London's West End Courtesy of J. Murphy & Sons Limited

Logistics

Roadworks in 1,000 streets, and supply interruptions to 200,000 customers, translates into inevitable disruption to traffic, parking, pedestrians and upgraded customers ranging from major hotels and hospitals to schools and high rise blocks of flats. Communication is the key with lead personnel attending often three external meetings daily. The project area encompasses twelve different local authorities at any one time, each involving up to five of its own departments with interests varying from street works permits to parking bay suspensions and temporary traffic light arrangements.

Emergency services, Transport for London and representatives from every group of properties or business affected had to be consulted. At key times, over 2,500 letters per week were sent out with mains replacements in individual streets sometimes taking six months to plan. The construction team has been working in up to thirty DMAs at any one time scattered across the region. It aims at minimising supply interruption, with an average two hour supply break per property dependent, for the larger buildings such as hotels and offices, on how much internal water storage capacity they hold.

West End

The most challenging area to upgrade has been London's West End. For three years from early 2007 a dedicated 100 strong workforce replaced 46km of cast iron pipes beneath the key central streets on one of the World's busiest capital cities. On either side of the 270 streets dug up, some 11,000 customer supplies had to be upgraded. But the West End was different to other areas in that a high percentage of London's 8 million daily pedestrians had also to be considered.

Over much of the 6km^2 area from King's Cross Station south to the Embankment, and from Oxford Street and Piccadilly east to Kingsway, minimising inconvenience to pedestrian commuters and visitors was of equal importance to reducing traffic disruption. Along just one short upgraded pedestrian route from Leicester Square to Covent Garden, the safe control of over 250,000 pedestrians every day occupied considerably more planning and focus than the construction work beneath their feet. The team was acutely aware that to cause disruption to Central London's pedestrians – especially its high percentage of visitors – was just not an option.

Murphy had also to satisfy the often conflicting needs of unusually high profile customers. London's theatreland would not tolerate noise or disturbance from road works during evening performances, nor would it allow matinees to be invaded with the sound of adjacent drills. Equally sensitive was the Strand's Royal Courts of Justice or narrow Soho streets alongside which lie 16 below-ground recording studios equally sensitive to external noise or vibration.

Scenarios worked through, but thankfully never experienced, included the implications of a burst water mains flooding basement areas of landmark buildings, or major leakage forcing the closure of an underground tube station.

Some way down the worry list, but more reality than fear, was the temporary removal of high amenity paving; laid more for architectural appeal than for ease of underground utilities maintenance. Chinatown offered the particularly delicate task of disturbing bespoke and ornate hand carved granite setts; replacements for which could only be ordered from China.

As well as infrastructure, major public events proved a constant challenge. Excavation work just a few metres from prestigious Leicester Square film premieres or Royal celebrations, and avoiding disruption to seemingly weekly demonstration marches or London's marathon road race, all passed - thanks to meticulous planning - without any overall impact to the construction programme.

District Metered Areas (DMA): Woodgreen Area - A typical DMA with a range of pipe laying techniques and hundreds of short individual connections

New pipes were needed beneath Central London's Leicester Square Courtesy of J. Murphy & Sons Limited


New water pipes had sometimes to be threaded though a maze of existing other services - Courtesy of J. Murphy & Sons Limited

Construction

Of the four principal construction techniques employed for new pipe installation, the one dominant in London's West End proved the exception rather the rule. Here large diameter distribution mains, coupled with the maze of other often unmapped utility services, led to traditional open cut trench being the most practical method.

Outside this central zone, comparatively expensive conventional or even narrow trenching was avoided where possible in favour of one of three trenchless techniques:

- Directional drilling.
- Pipe insertion.
- Pipe bursting.

Of these options directional drilling was used for only some 15km of pipe run. Though economic in open virgin ground, the method is less practical employed within existing congested routes with lateral water supply pipes and other utility services all at different sometimes irregular levels.

Such dense urban terrain proved more ideal for the other two trenchless methods of in-line replacements, provided the new pipe runs mirrored exactly the alignment of the cast iron routes. These now sacrificial pipes acted as host pipes or guide routes for their replacement network.

Pipe insertion involves a narrow fibreglass nose cone, known as a 'cobra', with the replacement polyethylene pipe run fixed behind it. The cone and new pipes are pulled through the existing slightly larger cast iron pipe which remains insitu though now redundant.

For the larger mains distribution routes, pipe bursting is widely adopted. Relatively new to water mains construction at the start

Open trench construction shows side connections to properties laid at the same time - Courtesy of J. Murphy & Sons Limited


Pipe bursting, using a row of access holes, has proved one of the most effective installation methods - Courtesy of J. Murphy & Sons Limited

of Murphy's project, the contractor has fine-tuned the technique into a cost effective method, especially for replacement pipes larger than their originals.

Here a more robust steel nose cone, sporting splitter blades and again with the new pipe run attached behind it, is employed. This arrangement is also pulled through the cast iron pipes, but with powerful jacks and linked steel rods replacing the insertion technique's rope haulage.

The brittle cast iron is cracked and burst apart opening up a wider diameter bore into which the larger plastic pipe run is positioned. Installation of either of these trenchless methods costs in the range £140 to £480 per metre run, depending on location and service density, offering considerably reduced cost and surface disturbance compared to the open trench alternative.

But the biggest construction saving to be achieved during the 11 year programme has been labelled by the team 'the one hit system'. Instead of the conventional two separate crews, for laying mains and lateral service pipes, operating independently - with the latter gang following after distribution pipes are in place - the two teams have been replaced by one, completing both operations at the same time.

This results in one, rather than two, sets of roadworks and carriageway closures, with a second smaller later team, completing individual house connections and working only in footways. Less disruptive and more efficient, this simple innovation has resulted in 12% savings in both time and cost.

Conclusion

The end of 2013 will mark completion of arguably the largest and most complex replacement programme for an urban water distribution network yet attempted. Central London will then have an efficient, secure and leak-reduced supply network 'fit for purpose' for at least 50 years.

Inconvenience in residential streets is minimised by carefully planned work areas - Courtesy of J. Murphy & Sons Limited

Its success can be summed up by two statistics. Leakage reduction has been the programme's primary aim and Thames Water's total over 900Ml/day loss of water in 2002, throughout its region, is this year down 36% due, in no small part, to its VMR programme.

Secondly, despite the extensive 11 year project causing inevitable disruption and inconvenience to many thousand of drivers, pedestrians and local residents, the work has triggered on average three commendations – and less than one written complaint – per month.

The Editor & Publishers would like to thank David Hayward, a technical journalist commissioned by J. Murphy & Sons Limited, for providing the above article for publication.

Pipe installation outside London's Royal Courts of Justice was particularly sensitive - Courtesy of J. Murphy & Sons Limited