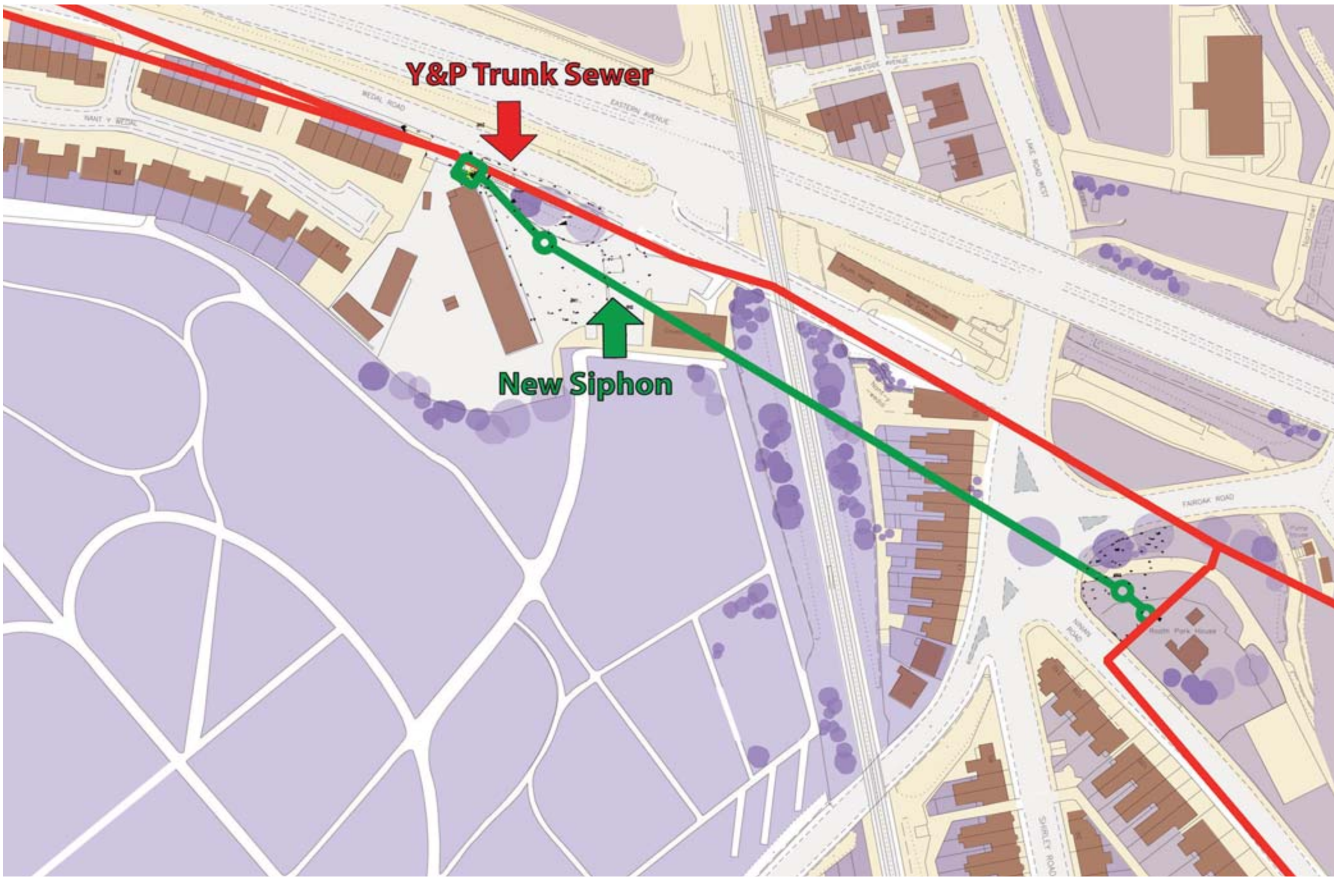
Ystradyfodwg & Pontypridd (Y & P)
trunk sewer duplication - new 250m inverted siphon sewer

The Ystradyfodwg and Pontypridd (Y & P) trunk sewer is a key asset delivering sewage from the Rhondda Valley (including Pontypridd) through central Cardiff to the Treatment Works at Cardiff Bay. This trunk sewer dates back over one hundred years to the Bazalgette era and most of it is still used today with minimal, if any, remedial works since the time it was first constructed. With the passage of time there has been a substantial increase in development in the area; for example the population of Cardiff alone has increased from 160,000 in 1901 to a little over 300,000 in 2001. The increase in population across the catchment has been accompanied by increased surface water run off from developments. This has placed more demand on the sewer network.



Map showing Y&P Trunk Sewer and siphon location *photo courtesy Dwr Cymru Welsh Water*

To improve capacity, parts of the Y & P trunk sewer from south of Pontypridd into the Roath area of Cardiff were dualled during AMP2 (1995-2000). Typically, the trunk sewer is a brick egg shaped sewer that varies in size along the route. In Wedal Road it is 1676 x 1118mm and the duplication sewer is a 1500mm diameter concrete pipe upstream and a 1350mm downstream of this location. However, time and financial constraints meant that the section through the Wedal Road area was not completed during AMP2.

Following long term flow monitoring during AMP3 (12 months continuous) and the results of a "backwater test" (in which the outfall from the catchment was closed and the sewer filling monitored) the hydraulic model analysis showed that this sewer also needed to be duplicated in order to meet the needs of the continuing development within the Cardiff Catchment.

AMEC (now Morgan Est), DCWW's Alliance Partner were responsible for overall management and construction of the scheme. Arup (Cardiff Office) were the Designers).

Options
There were two sets of options. The first was the surface route. This would involve constructing the duplication sewer underneath a railway bridge, then along a busy road and in front of a popular restaurant before crossing a roundabout and connecting with the existing trunk sewer some 300m downstream in a public park.

Whilst feasible, this option would have been difficult because of the need to lay large diameter pipes in a restricted traffic sensitive area which was also congested with underground services.

The second option was to construct an inverted siphon over 250m between the two sections of the existing reinforcement sewers. This is, as far as we know, the only recent example of using an inverted siphon over such a distance in a sewer network. The design parameters included the following:

* The siphon would maintain acceptable daily self-cleansing velocities both in dry weather conditions and when the sewers are operating in storm conditions.

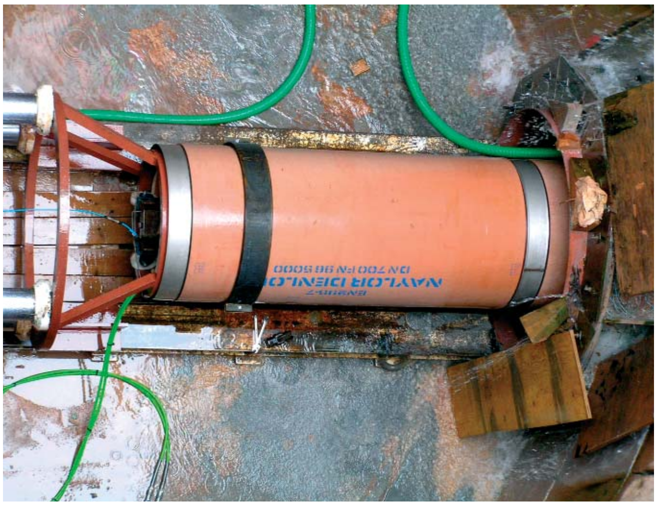


photo courtesy Dwr Cymru Welsh Water

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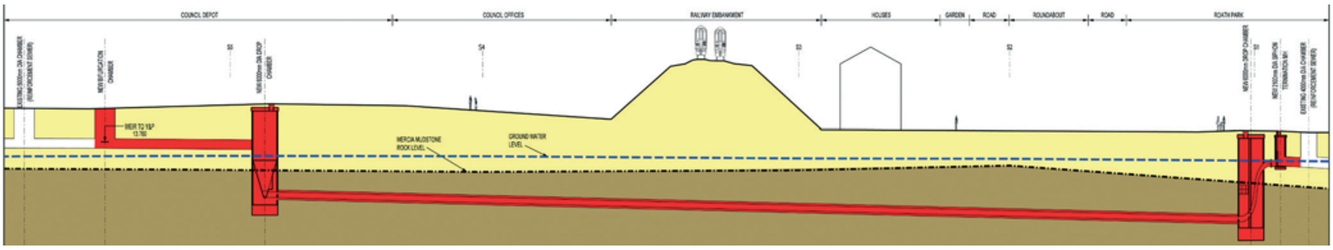

Schematic showing long section through siphon — ***photo courtesy Dwr Cymru Welsh Water***

* There would be a substantial flow at least twice per day generating sufficient velocities to ensure that any incipient accumulation of debris (including larger debris such as small rocks, half bricks and the like) were flushed through the siphon.
* The siphon had sufficient cross-sectional area to prevent the larger debris that night be expected down the sewers to accumulate and ultimately, if not prevented lead to blockages.
* A design life of at least 120 years; this includes both maintenance free operation and the integrity of the materials of construction.
* To be sufficiently deep so as not to cause disturbance to any of the structures at or near ground level including the railway embankment, residential and commercial properties.
* As this was going to be constructed by tunnelling, the ground conditions should facilitate tunnelling operations by minimising the risk of the driving head becoming stuck and also by minimising possible ground water movements and/or adverse pressures on construction equipment.

In addition, the operational requirements for the design had to include means for the following:

* Isolating the siphon for periodic flushing (in the event that this became necessary);
* Preventing large objects (with the potential for causing blockages) from entering the siphon;
* As a final resort, in the unlikely event of a blockage, safe access to the horizontal leg of the siphon.

Planning the Installation

The pipe to suit these parameters was to be 700mm diameter and clayware to meet the durability and flow characteristics. Microtunnelling a 700mm diameter of pipe over 250m was within the bounds of the possible but would be very high risk. It would be on the limit of this technique and because of the proximity of surface structures over the whole of the route of the siphon, it would not have been possible to sink a rescue/recovery shaft should the driving head become stuck. Accordingly, Morgan Est's solution was to construct a larger 1,200mm internal diameter concrete lined tunnel by pipejacking. The 700mm diameter pipeline would be threaded through this and grouted into position.

As the new pipeline was to be installed at a depth of up to 14m, it was necessary to investigate the ground formation in detail. The general stratification comprised up to 8m of alluvial and made ground over Mercia mudstone. The surface of the mudstone was undulating and had been subject to weathering over the upper 2m - 3m. However, the weathered mudstone was found to be somewhat more substantial than might be expected from a reasonably weathered state and during the course of the works, the unconfined compressive strength proved to be as high as 70MP a relatively high for this geological formation.

The pipejack was carried out using an Iseki-manufactured TCC 1200 Unclemole. This unit comprises a remote-controlled tunnelling shield which uses slurry as the spoil removal and ground support system. The TBM was fitted with tungsten carbide tipped cutting teeth to handle the harder than expected ground conditions encountered during the shaft sinking. Shift rates of jacking between 4 and 5 pipes into position were achieved and the tunnel was completed in some 27 days using a 12 hour shift system.

When the pipe jacking was completed, all the driving equipment was removed to allow the installation of the 700mm diameter clay pipe. This pipe was the Denlok jacking pipe system which, incidentally, has developed its reputation as a tunnelling pipe in its own right. The Denlok pipes were supplied in 2.0m lengths with a wall thickness of 75mm. To ensure that the 700mm clay pipe remained central within the 1200mm concrete sleeve pipe, specially designed skid mounts were used. These comprised a steel band with two small skid feet at the 4 o'clock and 8 o'clock positions around the circumference. The leading edge of each skid was upturned to prevent the edges catching on anything in the concrete pipe. The jacking frame from the 1200mm Iseki-pipe jack system was adapted and used to thrust the liner pipe into the casing pipe. When the pipe had been installed and tested, the annulus between the clay and concrete pipes was filled with grout to provide the necessary stability using subsequent operation.

The upstream shaft from the surface pipes was a 6m diameter with a cone at the lower end to 'funnel' the flows into the siphon and to ensure that all debris passes into the siphon at velocities sufficient to the risk of settling and/or causing blockages. The corresponding shaft at the downstream end contained a 700mm stainless steel 'S" pipe which transferred the flows at the same high velocity to the normal trunk sewer pipes at the higher level.

The construction was monitored carefully for any impact on surface features and in particular, the tracks over the railway embankments. No movements were detected during construction; our work was complimented by Network Rail.

The new siphon was connected to the duplication sewer at the downstream end at an existing shaft in Roath Park Gardens. This was fitted with a modulating penstock as part of the Cardiff East Control Strategy to manage the levels during extreme rainfall events in this part of Cardiff.

The upstream end was more complicated and involved constructing an online bifurcation chamber with flow in excess of a 1 m^3/s coming down the existing Y & P sewer. The 1676 x 1118mm brick egg sewer was in good condition, this was verified by CCTV from the inside ahead of the works. The upstream duplication sewer provided some storage which allowed the flow to be stemmed for short durations to facilitate breaking into the sewer.

The chamber was constructed around the existing sewer at a depth of around 5m; and was completed with the brick egg intact. The connection into the existing brick egg was carried out once the flow could pass along the siphon. Breaking into the brick egg and turning the flows had to be carried out during a period of dry weather and between the hours of 9 pm and 6 am when the high flows in the sewer would be at the lowest level.

Note: ***The Editor & Publishers wish to thank Dwr Cymru Welsh Water for preparing the above article for publication.*** ■