MAIDA VALE & THE TALE OF THE THROTTLE PIPE – PASSIVE CONTROL TO ELIMINATE FOUL PUMPING

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ABSTRACT

A client outcome-based approach delivered an innovative, sustainable solution to flooding, while embracing safety in design at the outset.

Maida Vale, a suburb of Central London, is served by three of the original 'Bazalgette' brick sewers approximately 2m in diameter and built in the late 19th Century. Whilst these sewers highlight the excellent quality of Victorian design and construction, there are a number of areas where they no longer have the capacity to transfer flows. In Maida Vale this resulted in around 200 basement properties suffering from combined sewer flooding during a 1 in 10 year ARI storm event, with some properties being flooded in more frequent events. Consequently, Optimise, a design & construction joint venture between MWH (now Stantec), and Murphy, Barhale, and Clancy Docwra, received instruction from Thames Water to undertake the £21m Maida Vale Flood Alleviation Scheme. This outcome-based project looked to resolve the flooding problem for up to the 1 in 30 year ARI storm event with a demanding contractual deadline of less than three years from initial issue investigation, through full design, with construction completion by March 2015.

Property flooding was found to be in two main clusters, this paper focuses on the Formosa Street sub-catchment where the flooding mechanism was identified as surcharging from Bazalgette's trunk sewer into the local network.

A traditional approach to the problem would be to isolate the flooding area and pump all flows. In a typical year, this would have resulted in pumping 241,500m^3 when the storm flows – the cause of the flooding – was only 21,500m^3. As a result of extensive hydraulic modelling to understand the flows within the local and trunk sewers, we developed a means of allowing the base / foul flow to remain connected to the existing sewer network, the source of the flooding problem, whilst managing the risk of storm flows backing up from the trunk sewer and causing flooding.

This was achieved by installing a weir in Formosa Street designed to direct foul flows by gravity to a hydraulically designed throttle pipe into the trunk sewer, and in storm events limiting the reverse flows back from the trunk sewer, over the now-drowned weir into a 20m diameter, 26m deep storage shaft located in nearby Westbourne Green park. Flows are dynamically pumped back into to the receiving sewers as level conditions allow.

This solution is essentially maintenance free, and eliminates the need for foul pumping with the associated savings of capital and maintenance costs. It also minimises the health and safety risks during construction and maintenance of the assets in very deep infrastructure. In addition, the solution minimised cost and disruption to Thames Water's customers.

This approach was made possible by Thames Water allowing their trusted delivery partners to develop an effective solution to a problem, not just an instruction to construct expensive infrastructure.

KEYWORDS

Gravity over pumped, residential flooding, Combined sewers, foul flooding, United Kingdom/international, Thames Water

PRESENTER PROFILE

Hannah Breeds is a Senior Water and Waste Engineer for Stantec New Zealand. Hannah has recently returned from working in the UK water industry for the past 10 years where she headed up the complex flooding team and led a number of high-profile flooding projects in and around London. Hannah’s passion centres around stormwater management and water sensitive urban design as she looks to make a real difference here in New Zealand

1 INTRODUCTION

The Maida Vale Flood Alleviation Scheme is a project to resolve combined sewer flooding to almost 200 properties in central northwest London. The project has been undertaken on behalf of Thames Water by Optimise, a joint venture with Murphy, Barhale and Clancy Docwra, where Stantec (previously MWH) are the design partners.

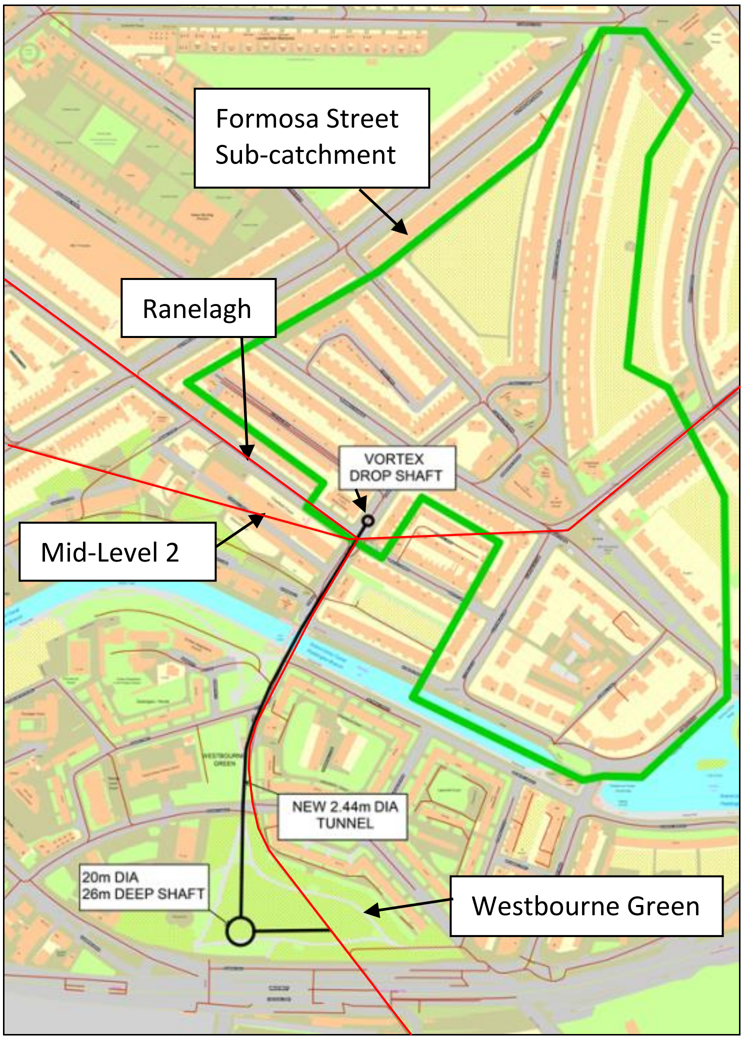
The Maida Vale area is served by three of the original "Bazalgette" brick sewers all about 2m in diameter and built in the late 19th century. These sewers are the Ranelagh and Mid-Level 2 which run from west to east through the catchment along with the King Scholars Pond which runs from north to south. Photograph 1 below shows the Ranelagh sewer and its connection point with the Mid-Level 2 sewer below.

Photograph 1: Bazalgette's 19th Century Ranelagh Sewer

Whilst these sewers highlight the excellent quality of Victorian design and construction, there are a number of areas where they now do not have the capacity to transfer the flows. This is a consequence of an ageing network receiving ever greater flows derived from urbanisation, property creep, conversion to flats, and changes in climate. The result is that around 200 basement properties suffer from flooding during severe storm events in the Maida Vale catchment.

This flooding occurs in both residential and retail premises located into two main clusters, namely around Formosa Street and Shirland Road. This paper focuses on the solution developed around the Formosa Street sub-catchment area, bounded in green in Figure 1.

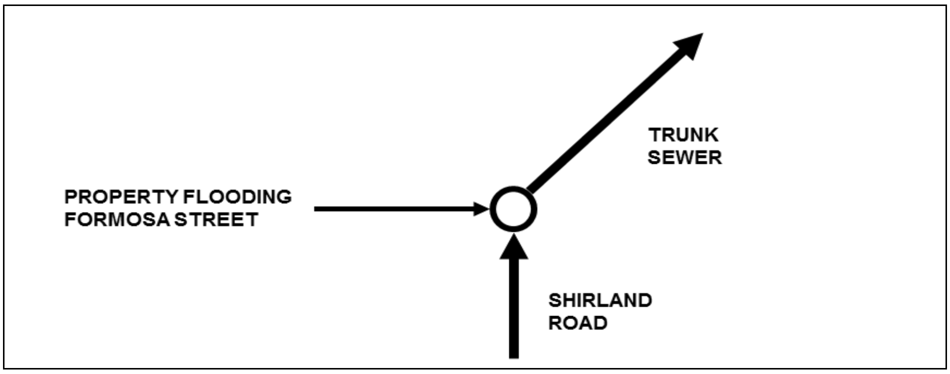
Figure 1: Formosa Street Sub-catchment Boundary & Solution



2 OPTIONEERING

The primary mechanism for flooding in the Formosa Street sub-catchment is the lack of capacity in the receiving Ranelagh and Mid-Level 2 trunk sewers, causing stormwater to back up and enter the basements of certain properties.

Figure 2: Existing Sewer Network



There were three types of solution that could resolve this problem:

1. Build bigger sewers to convey the flow away from the problem area, which would entail laying 13km of sewer across the heart of central London to the Abbey Mills Pumping Station in the east (Figure 3). This option was immediately discounted on the grounds of cost, constructability, and the timescale.

2. Maximise any spare capacity within other sections the network. This was able to be achieved to a limited extent by redistributing flows into the Mid-Level 2 sewer where possible. However, it did not solve the flooding risk in the Formosa Street sub-catchment.

3. Physically isolate the flooding area from the flooding source. Requiring storage flows and provision to pump flows back into the sewer as the level conditions allowed.

Figure 3: Plan showing the approximate locations of Maida Vale and Abbey Mills Pumping Station

2.1 TRADITIONAL APPROACH

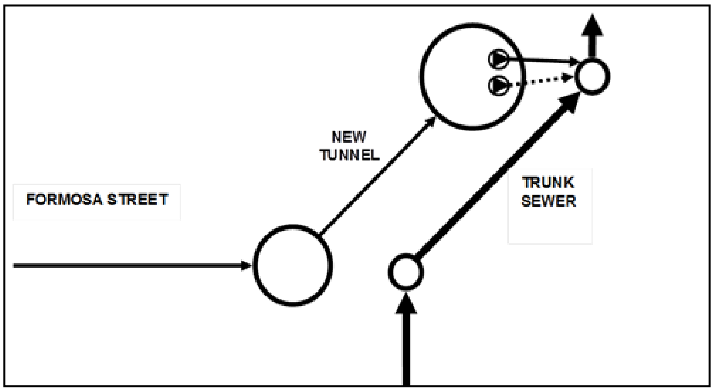
Maida Vale is busy part of London and because of this urbanisation and the time constraints of the contract, it was not envisaged that it would be possible to develop anything other than a standard type of solution. The trunk sewer network, developed by Bazelgette in the late 19th century, is complex with many deep large sewers.

The traditional solution would be to isolate the flooding area. This would be achieved by dropping all flows into a 400m long tunnel and transferring it to a 7,300m^3 storage shaft in Westbourne Green. Flows are then pumped back into to the Ranelagh sewer, as level conditions allow. See Figure 1 above. There are a number of issues with this approach:

- The maximum gradient the tunnel could be laid was around 1 in 250, however this would not allow self-cleansing velocities to be achieved with the foul flows. Mitigation options considered included:
    - Forming a dry weather channel in the tunnel. This was discounted because the velocities would still be poor, forming the channel would occupy a large

part of the tunnel storage and require either an increase in reception shaft depth or tunnel diameter. Additionally, maintenance would be difficult.
    - Suspending a separate pipe within the tunnel. This was the preferred option, as it was considered to provide better hydraulics conditions than a dry weather flow channel, though installing and maintaining this pipe would be a difficult operation.
- Maintenance of the reception shaft would be more frequent because of the foul element.
- Maintenance of pumps and chains within a deep tank in a public area.

Figure 4: Traditional Approach



Working through the pump and storage deign, it was determined that the average annual pumping rate at the station was 241,500m^3 of which only 21,500m^3 was the stormwater element. As a result, the delivery team were driven to reduce operational costs and eliminate or reduce risks by removing the foul pumping and associated maintenance.

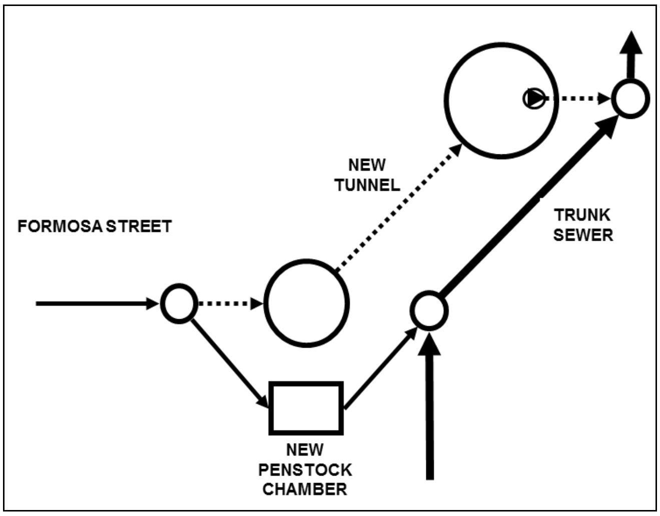
2.2 INTERIM SOLUTION

A revised solution was developed whereby the foul flow continued to the trunk sewer by retaining the existing connection to it. An actuated penstock isolated Formosa Street from the trunk sewer in storm conditions.

Whilst this eliminated the need for foul pumping there were new problems created:

- Risk that in the event of power failure or operator error the penstock could be left open, and properties would be at risk of flooding.
- Maintenance of penstock and actuator within carriageway.
- Additional construction risk due to additional service diversions and provision of a power supply.
- Planning permission for control panel located in a conservation area.

Figure 5: Interim Solution with Actuated Penstock



2.3 FINAL SOLUTION

Whilst it appeared that eliminating pumping or active management of the foul flow was not an option; it had always known that management or separation of the foul flow was only required during times of extreme rainfall events that caused flooding. These only occurred for storm events of around 1 in 10 years ARI or greater.

To understand the cause of the overall flooding problem it had been necessary to develop a very detailed hydraulic model. In addition to being able to understand the flooding problem and develop an appropriate solution, using the hydraulic model together with a specialist hydraulic software package “HADES” allowed for an in depth assessment of the hydraulic characteristics of the network and develop options that would reduce construction and operational risk.

Figure 6: Flow conditions Formosa Street Area

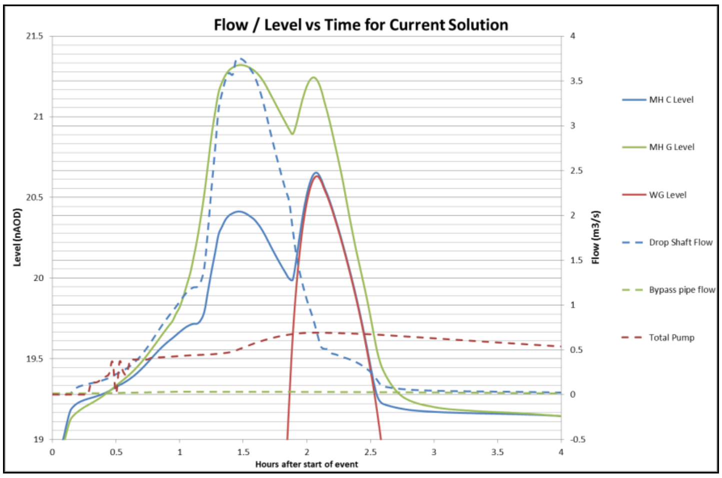
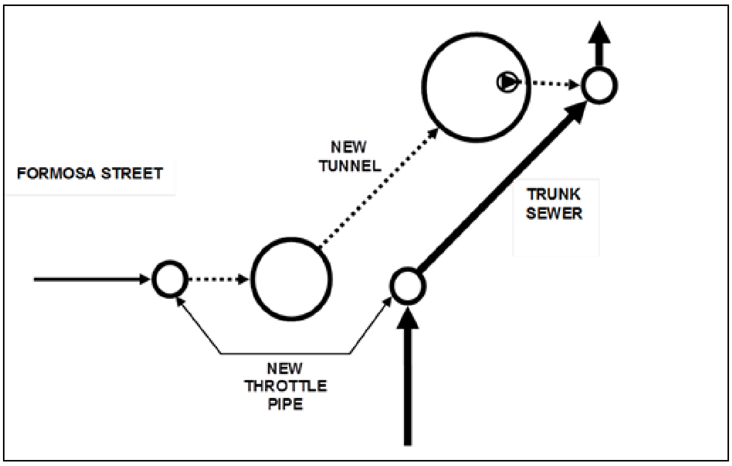
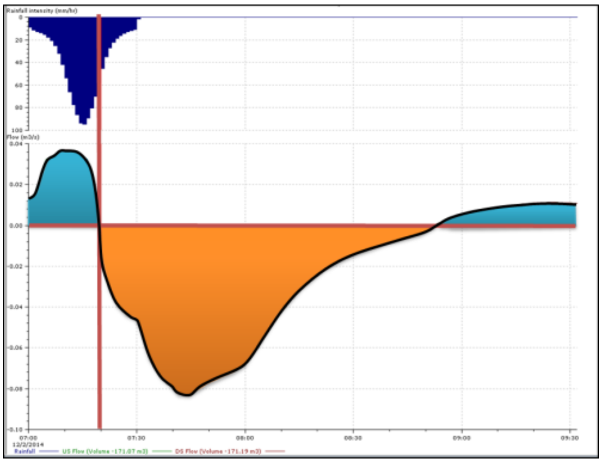


Figure 6 shows the flows in the Formosa Street area, with the red line depicting the level in the Westbourne Green storage tank, blue the level in Formosa Street, red dashed the pumping rate from the storage tank and the remainder flows in adjacent parts of the network.

Understanding these characteristics allowed the design team to identify what would happen if we simply allowed the foul sewer to continue to be connected to the existing trunk sewer that caused the flooding problem. Understanding that reverse flow would occur in extreme events, we were able to develop a design with a "passive" control throttle pipe which would allow flow to pass in two directions, as shown in Figures 7a. In exceptional events reverse flow is passed to the storage tank.

Figure 7: (a) Final Solution with Throttle Pipe (b) Throttle pipe flows showing reverse flows





The throttle pipe controlling the flow between the trunk sewer and the Formosa Street sub-catchment was designed to be 200mm dia pipeline, complying with Thames Water standards for minimum pipe sizes and to be maintenance free. This throttle pipe is big enough to allow dry weather flow (foul flow) to gravitate to the trunk sewer via provision of a small weir in the upstream manhole; and small enough to minimise the back flow from the trunk sewer during storm events. The back flow is directed to the 20m diameter, 26m deep storage shaft located in nearby Westbourne Green along with the storm flows from the Formosa Street catchment. Flows are dynamically pumped back into to the receiving trunk sewers as level conditions allow.

The flow configuration through the throttle pipe during a storm event is demonstrated by Figure 7b. The positive flow, shown in blue, shows that the initial flows from the Formosa Street catchment are able to discharge to the trunk sewer. As the levels in the trunk sewer elevate, the flow reverses through the throttle pipe, shown in orange. This flow shows the volume of flow directed to the storage tank in Westbourne Green. Once the trunk sewer levels subside, flow from Formosa Street can gravitate to the trunk sewer again.

3 CONCLUSION

"Allowing limited flow to reverse back from the trunk sewer without compromising the operation of the system"

The industry standard for solving a problem of this nature is to isolate flows from the source of the flooding. This is achieved by providing physical assets, normally pumping stations or penstocks, to respond to the flows in the sewer network in real time.

Either of these approaches requires installation of moving parts in the sewer system that have to be maintained. Whilst water companies' operational teams are prepared and resourced to do this, it still entails operatives having to enter hazardous, potentially dangerous, confined spaces. In the case of Maida Vale, pumps and a tunnel are located in a public park that are in excess of 26m deep.

Accordingly, the key differentiator of this solution is that the passive control allows reverse flow to pass back to the new system during extreme storm events. This incurs extra pumping by the storm pumps, but it is negligible compared with the pumping that would be required if dry weather pumps were used, or compared to the Health & Safety and maintenance issues that would be required to maintain either a pumping station or a penstock.

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