Keynsham Requisition Sewer

constructing infrastructure in the built environment
a £1.7m requisitioned sewer serving a 560-property development

by Thomas Shenton MEng

This report describes problems of constructing in the built environment and how existing infrastructure constrains design and construction. The £1.7million requisition sewer was designed by Mouchel to fulfil Wessex Water's obligation to provide a foul sewer connection for a phased 560-property development in Keynsham, a town between Bristol and Bath. It was paid for by the developer so the scheme was principally designed to Sewers for Adoption 6 (SFA6), but Wessex Water design standards were also applied. Phase 1 of the development was granted planning permission in 2011 and consists of 283 properties, a population equivalent (PE) of 708. Delivery of the requisitioned sewer was required by the end of 2013 to coincide with the first properties being occupied. The scheme was designed to convey the combined flows of Phases 1 & 2, with a PE of 1,400.

Land south of Keynsham requisitioned sewer - Courtesy of Mouchel

The Keynsham Requisition Sewer, involving the construction of a new 1.5km long sewer, a sewage pumping station (SPS) and real-time pump control, illustrates the challenges those looking to construct in the sub-urban jungle might expect:

- Existing utilities.
- The demands of private landowners.
- Land contaminated from past-use.
- Standards & Specifications of the undertaker.
- Limitations of connecting infrastructure.

Innovative design solutions, together with an integrated sewer flood alleviation scheme, demonstrate how 21st century sewerage network design must do more than address inadequacies in isolation.

Routing for success

Because of incapacity in the receiving sewerage network, the initial proposal was to route the sewer directly from the development to siphons at the head of Keynsham STW. Online storage would then be provided at the downstream connection point to prevent overloading during storm conditions. This direct route involved pipe-laying through the land of a number of third parties, see Figure 1 (next page), which was unattractive for the reasons outlined in Table 1.

Table 1: Risks of working in third party land

Third party land-use	Risks
Caravan park	Maintaining access, disruption & compensation to residents
Cricket club	Ensuring satisfactory reinstatement of cricket pitch
Primary school	Disruption to school drop offs etc. Consideration of pupils' health & safety
Electricity sub-station	Specific working and access arrangements for constructing adjacent to critical infrastructure assets
Planned secondary school building	Disrupting an existing planning process

Through computer modelling, Mouchel demonstrated that a more effective design could be achieved by connecting the development to a sewer on the eastern side of Keynsham in conjunction with the provision of storage at the SPS. As shown in Figure 1 (below), by connecting the development in this way Mouchel was able to change the route of the sewer to avoid the risks in Table 1, and reduce the sewer length by 300m to 1.5km. Providing storage at the SPS is estimated to have offered savings circa £100k on alternative measures to increase sewer capacity all the way to the STW or construct storage elsewhere.

The sewer had to cross the Chew River Valley via a 0.5km long rising man and Wessex Water standards stipulated that twin pipes were required to cross the EA-designated Main River. It was found that there would be a number of operational benefits to twinning the entire main at minimal increased cost over laying a single pipe.

The twin main enabled hydraulic optimisation of the system for two design flows associated with the phased development. The Phase 1 main was 90mm diameter (delivering 7l/s) and the second main for Phases 1 + 2 was 130mm diameter (delivering 11l/s).

Only one rising main would be operational at any time, with isolation of each main via gate valves within the new SPS. The spare main provides operational flexibility so that the SPS could continue pumping in the event of failure or cleaning of one of the mains.

A washout was provided at the low point of the pumped system on the eastern side of the river to enable each main to be separately emptied. Having the smaller main also meant that retention times within the pumped system could be minimised during the initial low flows from Phase 1, thus reducing the likelihood of septic conditions arising and the associated odour problems at the discharge point in a residential area.

St Clements Road Sewage Pumping Station

The new SPS was required to pass flows across the Chew River Valley and as there was no provision for a SPS within the housing development, a new site had to be found. A site at the top of the valley was prioritised for the reasons shown in Table 2.

Table 2: Parameters on which the location of the new SPS were assessed

Parameter	Assessment of St Clements Road SPS
Hydraulic performance	The SPS location at the top of the Chew River Valley made it possible to have a continuously falling profile to the watercourse and then a continuously rising one to the discharge point. This simplicity meant only one air valve, at the SPS, was required. By being lower than the discharge point, the pumps operated against a positive static head thus avoiding cavitation and siphon-inducing conditions
Energy	Constructing the SPS at the top of the valley rather than at the river resulted in a longer rising main but a reduced net lift. Two 7.4kW-rated Flygt submersible centrifugal pumps were arranged in duty – standby to operate against a static head of +16m and a total system head of 21m. These pumps were selected as their impellor size could be increased to deliver the additional flow through the larger rising main when occupation of Phase 2 begins
Access	SPS was located immediately adjacent to St Clements Road, meaning a new access road was not required
Minimisation of green-field construction	SFA6 require a SPS to have off-road tanker parking, so the wet well can be emptied any time. Whilst this is often achieved by having an off-road turning circle, this would have meant construction on green-field land. Instead, the new SPS was designed with a lay-by, reducing land-take by 400% compared to the turning-circle arrangement and limiting construction to brown-field land on the site of an in-filled quarry

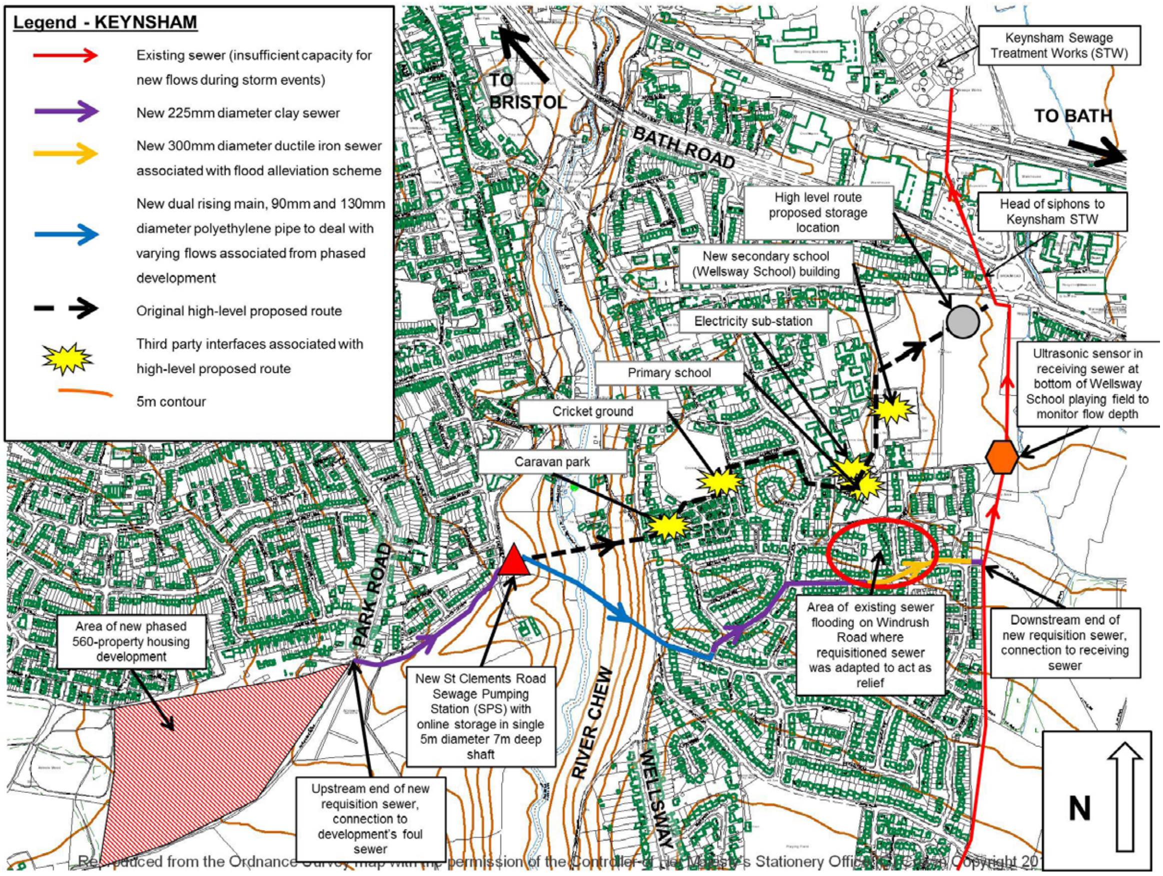

Figure 1: Route of the pipeline - Courtesy of Mouchel

The receiving combined sewer in the eastern side of Keynsham becomes surcharged during storm events. To ensure flows from the development did not increase this surcharge to the point of flooding, an ultrasonic flow-monitor was installed in the receiving sewer at the bottom of Wellsway School field to communicate, via general packet radio service (GPRS), this level to the control panel of the SPS.

A multi-network subscriber identity modul (SIM) card was specified so that, in the event of one network provider failing, the one providing the next strongest signal would be used.

Once a critical level, determined by computer modelling, has been reached within the receiving system the pumps at the SPS are stopped and 90m^3 of online storage is mobilised to deal with flows from the development, see Figure 2 (below).

SFA6 required the SPS to have 45m^3 of emergency storage that would mobilise in the event of SPS failure. This, together with the 90m^3 determined in the model, meant 135m^3 was required. In the event that this storage is fully mobilised, the pumps will run to prevent flooding at the SPS, instead resulting in flooding of fields just upstream of the STW.

Shaft construction

Wessex Water's standard of providing storage at the SPS via an offline tank with a gravity return to the wet well meant two 6m deep shafts were required. A cost saving was achieved by having the storage online in an enlarged 5m diameter 7m deep wet well, with 1:1 benching specified to prevent ragging.

The principal contractor, Clancy Docwra, opted to construct the chamber by underpinning using Buchan shaft liners. Initially a 1m thick thrust ring was cast around the outside of the 5m diameter shaft. Shaft segments were then hung off of this thrust ring and each progressive depth of section excavated before the next section attached. Once the shaft was excavated to depth, a reinforced concrete base was poured.

Anthrax contamination

During the planning process for the housing development, local residents raised concern that the ground might be contaminated with anthrax. A local-press publication in 2010 claimed mules that worked a quarry became infected with anthrax during WWI and were buried somewhere in the vicinity.

Although there were no records of an anthrax outbreak or of such a burial, the Council became sufficiently concerned about the potential release of anthrax spores into the atmosphere that the housing development was initially refused planning permission. 13 (No.) boreholes subsequently undertaken on the site were negative for anthrax resulting in planning consent being granted in 2011.

Because the requisitioned sewer and SPS were within this potentially contaminated area, Mouchel had to satisfy the Planners and themselves that the anthrax hazard was not present. This was achieved by intrusive site investigation above and beyond what would normally be commissioned, in conjunction with interpretation and risk assessment by Mouchel's contaminated land specialists.

This additional site investigation cost approximately £6k and required particular H&S measures including contamination suits and wash-down facilities. No anthrax was found within the worksite and it remains to be seen whether infected mules were ever buried or whether spores would have survived their 100yr burial.

It does demonstrate that building on developed land carries a cost in time and money and that ground contamination can be a legacy for generations.

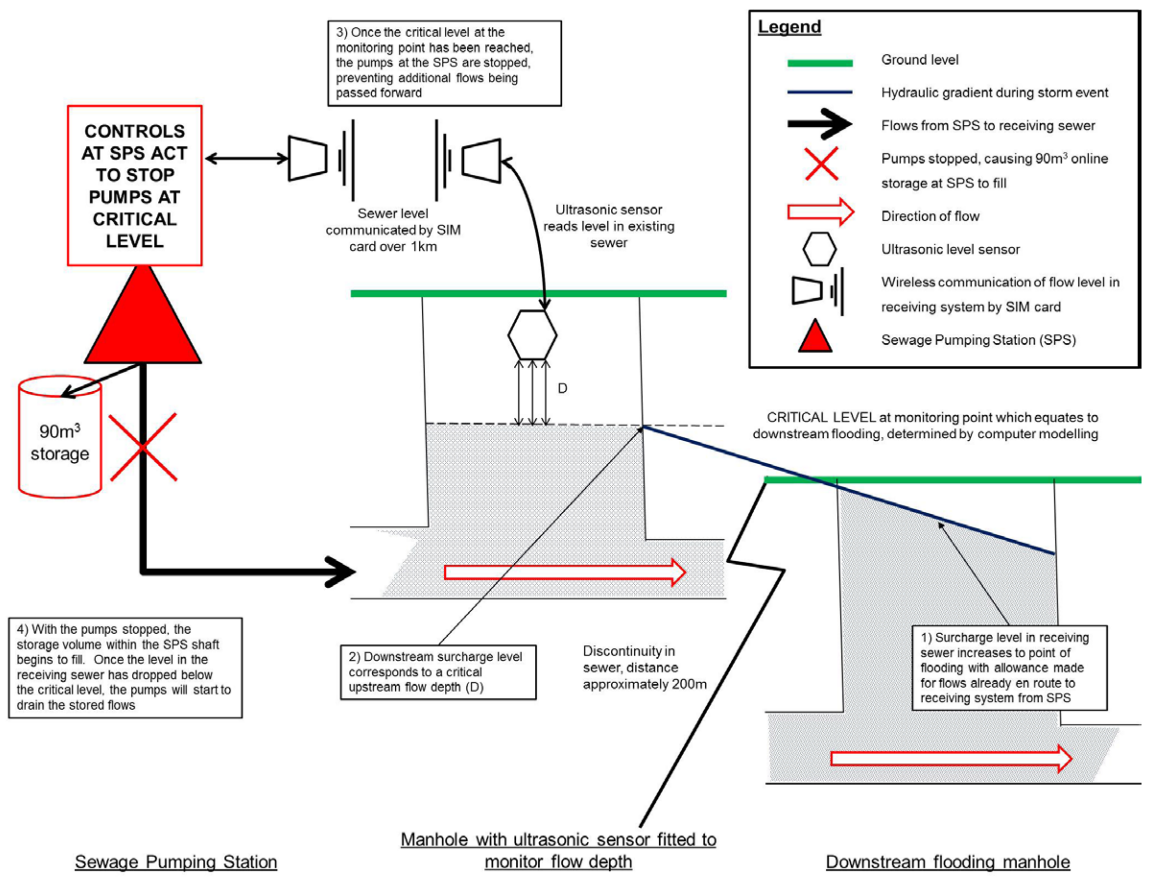

Figure 2: Pump Control concept diagram - Courtesy of Mouchel

Flood alleviation

An opportunity to reduce existing sewer flooding was taken by adapting the requisitioned sewer to act as a relief pipe to a flooding area identified in a soon to be released project brief.

This enabled a flood alleviation scheme identified by Wessex Water to be delivered for approximately 10% of the estimated stand-alone cost of £270k.

The flood alleviation scheme was in Windrush Road, a residential area which had five locations on the National Flood Register. A float-controlled flap-valve designed by Hydrok UK was installed on the existing 150mm diameter sewer which was at the upstream end of the flooding.

This valve is capable of staying closed against a positive upstream head and this was the first such application of the valve on the Wessex network.

Once flows in the 150mm diameter sewer are closed-off they backup a short distance before overflowing into the requisitioned sewer. The surcharge level in the existing system downstream of the valve is thus limited to that at which the float operates to isolate the 150mm diameter pipe, see Figure 3 (below).

Downstream from this overflow point, the size of the requisitioned sewer was increased from 225mm to 300mm diameter to a second overflow point where there was spare sewer capacity. Although flows diverted to the requisitioned sewer could not be controlled, their impact would be to cause flooding in fields which was preferable to flooding residential areas.

Sub-urban jungle

Sewers are normally constructed sufficiently deep to minimise conflict with other underground services. Due to uncommonly hard rock found on the eastern side of Keynsham, a compromise was reached between sewer depth and the risk of clashing with utilities. Pipe protection measures, such as using ductile iron pipe and overlying concrete slabs, were employed where depths were reduced.

The requisitioned sewer was constructed upstream from its connection point to the receiving sewer. Before pipe-laying reached the first upstream manhole the line and level of the requisitioned sewer was obstructed by a 750mm diameter surface water sewer which was lower than expected based on a survey undertaken during the design stage.

This problem was overcome by moving the connection point of the requisitioned sewer 50m downstream and using this additional potential head to vertically drop the requisitioned sewer below the obstruction.

Conclusions

This scheme demonstrates some of the challenges with constructing new infrastructure in the built environment. Some risks, such as utility clashes, are known and can be mitigated with site investigation and adaptable designs but others, such as anthrax contamination, are less foreseeable.

Through value engineering during detailed design and an efficient 10 week civils construction programme through the summer of 2013, the total scheme was delivered £200k below budget and in time to receive flows from the housing development.

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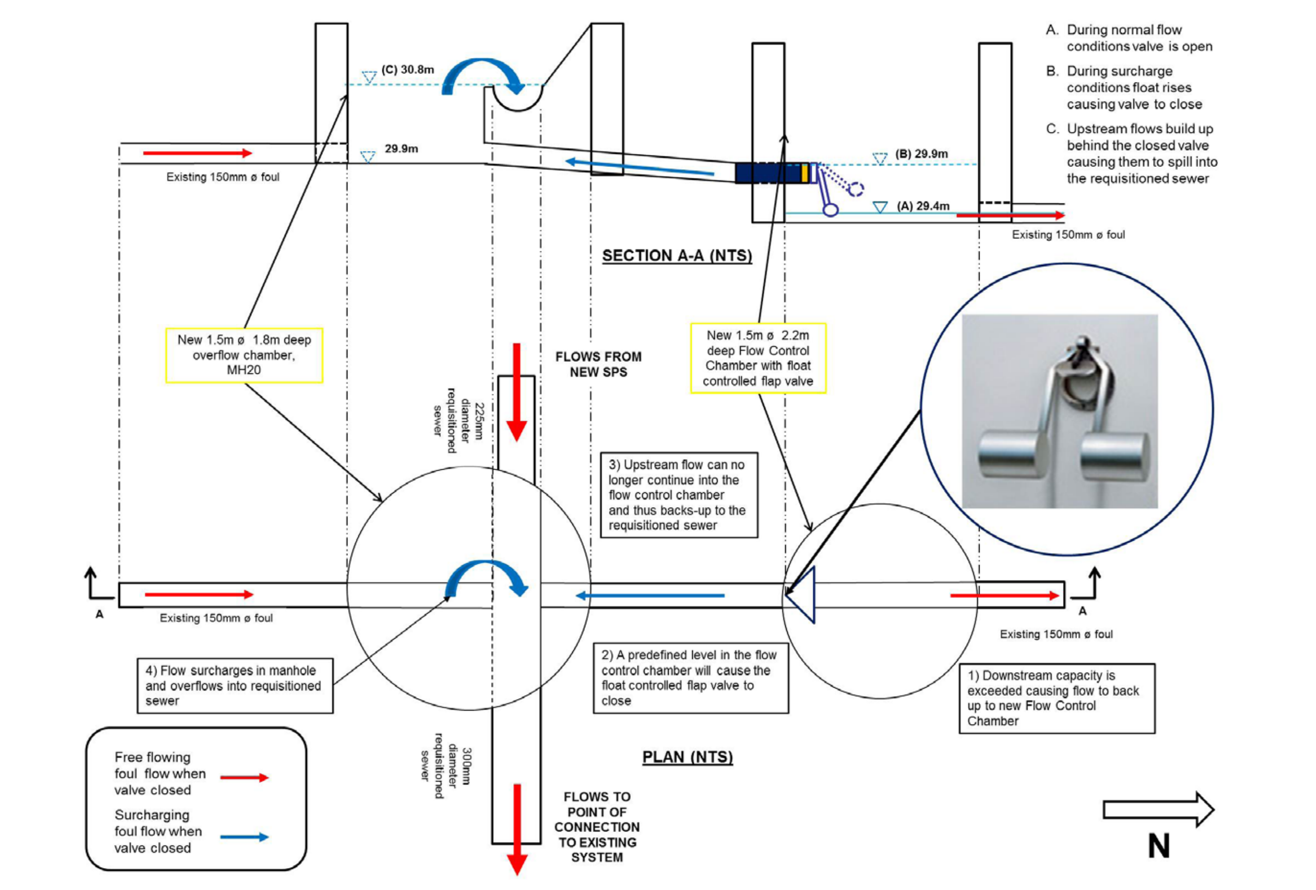

Figure 3: Relief sewer concept diagram - Courtesy of Mouchel