

Mythe WTW Flood Alleviation Scheme

Severn Trent Water invests £5.5m to secure Gloucestershire's water supply

Flooding in Gloucestershire in July 2007 was a civil emergency involving major disruption to the transportation and utilities infrastructure including Severn Trent's Mythe Water Treatment Works (WTW). Mythe WTW supplies 160,000 properties and over 350,000 customers in Gloucester, Cheltenham, Tewkesbury and large parts of rural Gloucestershire. Due to the flooding, Mythe WTW was shut down resulting in the majority of these customers being without mains drinking water for up to two weeks. Anecdotal reports from site staff indicated that the WTW flooded from rising groundwater levels beneath the site, before floodwater from the River Avon and River Severn inundated the site further.



Mythe WTW July 2007 - Courtesy of Severn Trent Water

Mythe WTW lies on an area of land that is bounded to the west by the River Severn and to the east and south by the River Avon. The site lies at an elevation of between 13m OD and 10.3m OD with levels falling from north to south. Prior to 2007 it is understood that there had not been a flooding incident which had resulted in loss of supply from the works.

During emergency works following the flood, a temporary flood defence barrier was installed around the site. This project replaces the temporary defence barrier with a permanent defence.

Scope of work

The outline and feasibility design was carried out by Mouchel and handed over to Costain-MWH to complete the detail design and construct the project. This involved the following flood defences:

- A sheet pile wall along the boundary with the River Severn, connecting into existing sheet piling around the two river intakes. The sheet piles were driven into the impermeable mudstone as a cut-off along the river.
- A 3.5m high reinforced earth embankment along the

southern and eastern boundaries of the site linking into the southernmost section of sheet piling and a reinforced concrete wall on the eastern boundary.

- Infill reinforced concrete walls at various locations tying into existing buildings, sheet piles and existing masonry walls.
- Demountable barriers and flood defence proofing works to existing buildings.
- A groundwater (borehole) lowering system to prevent upward internal site flooding and manage risks associated with structural protection from floatation.

These measures ensure a continuous permanent barrier around Mythe WTW, with the exception of the main gate area where the barriers are put in place only during a flood.

The measures provide protection to 13.62m AOD, the agreed river flood level with the Environment Agency based on the July 2007 flood of 13.02m AOD plus 0.6m freeboard. The 2007 flood is the highest since records began for this area. The 0.6m freeboard was chosen due to the mix of hard and soft flood defence barriers.



Mythe WTW looking from the south-east with the River Avon in the foreground and the River Sever to the rear - Courtesy of Severn Trent Water



Completed timber clad sheet piles along River Sever adjacent to footpath (Section A-B) - Courtesy of Costain Ltd



Section G-H brick clad RC wall looking south alignment specified to avoid existing services - Courtesy of Costain Ltd



Completed reinforced earth embankment (Section E-F) with environmental mitigation pond in foreground - Courtesy of Costain Ltd

An original feasibility undertaken by Mouchel in 2009 indicated that as well as protection from overland flooding from the Severn and Avon rivers, there is a risk that flooding would occur from conduits between the underlying river terrace gravels and the ground surface, and that groundwater lowering is needed for both structure protection and to prevent site flooding.

Allowable groundwater levels

The ages of the main structures on the site vary from the 1930s forward. Typically they are brick, concrete and steel frame structures. A review of the available documents on site indicated that the structures had been designed to resist floatation by various means including underslab drainage, self-weight and reinforced concrete heels activating soil wedges. For the purposes of the evaluation it was assumed that the drainage for older structures with underslab drainage was ineffective. From the review, the structures were categorised dependent on their safe groundwater level. These levels determined the target design groundwater level for the site.

The design groundwater level across the site is 11.45m which equates to a 1:5 year return period. This low return period is required due to the lack of information for some of the site structures. Higher groundwater levels are accepted at the intake works due to their high structural mass and lower design groundwater levels for the structures in the south-east of the site (10.3m AOD).

Site geology, hydrogeology and hydrology

The geology is fairly consistent across the site, with Made Ground and Alluvium to a typical depth of 6m. These are underlain by River Terrace Gravels with thicknesses of 2 to 6m. The River Terrace Gravels are further underlain by weathered Mercia Mudstone; a red, stiff clay. The alluvium is a silty clay whilst the gravels comprise brown sandy gravel with sub-angular to rounded gravels of quartz, quartzite, sandstone and mudstone.

The top of the gravels generally range from 4 to 8m AOD, with the base 2 to 6m lower. River bed surveys undertaken as part of the flood alleviation scheme revealed that the bed of the River Sever is at approximately 4 to 5m AOD immediately adjacent to the site. This indicated that the gravels were likely to be in direct connection with the River Severn.

The River Terrace Gravels are a minor aquifer with heads between 8.5m AOD and 12m AOD (measured by datalogger beneath the site between April 2009 and May 2011), compared to non-flood River Severn levels of 8m AOD. This indicates that across the site the gravels are confined by the overlying lower permeability alluvium.

The River Avon levels are around 9.6m AOD above the weir in normal non-flood conditions. Therefore there is a gradient from east to west from the River Avon across to the River Severn. The time series of river levels and groundwater levels indicates that groundwater levels respond rapidly to changes in River Severn levels, with a lag of around 2 hours.

Groundwater modelling

The original feasibility study developed an initial steady state, finite difference model using Visual MODFLOW v4.3. The model domain comprises an area of 1.7 x 2.0km incorporating the area between the Rivers Severn and Avon from the confluence north. With additional data collected during the design and construct phase, Costain-MWH developed a transient model, to firstly model a selected calibration event (November-December 2009 high river level event) followed by the design flood.

Pumping tests were carried out pre and post installation of the sheet piles, to determine the efficiency of the sheet piles for cut-off along the River Severn. The model results were used to determine the number and location of further groundwater lowering boreholes, and to estimate the abstraction rates. The groundwater lowering



Mythe WTW looking from the west with the River Sever in the foreground - Courtesy of Severn Trent Water

boreholes were drilled and tested by WB & AD Morgans Ltd for Costain-MWH. A group test was then carried out on the in-place boreholes to determine draw down characteristics and confirm model conductivities across the site.

Borehole operating system

To effectively control the groundwater levels for structural safety during flood events, six boreholes were required across the site. For shorter return period floods only three would operate, which would protect the more at risk structures on the south-east of the site which have existing underslab drainage, and are at risk from high groundwater levels should the drainage fail.

For longer return periods, all boreholes operate maintaining the groundwater levels below 11.4m AOD across the site, with lower groundwater levels on the south-east and localised higher groundwater levels at the intakes.

The boreholes have been tested and commissioned and are operable. However, final commissioning awaits higher groundwater level, closer to a flood design event to validate the pump settings and drawdown characteristics between boreholes.

Summary

A continuous flood defence barrier surrounds the Mythe WTW, which prevents flooding from over land sources with borehole groundwater lowering preventing structural damage from high groundwater levels and upward flooding of the site. The works were constructed by Costain, with detail design by MWH for the client Severn Trent Water. The construction start was March 2010 and completed May 2011, with an overall project cost of £5.5m and construction costs of £4.65m.

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Piling trial to monitor noise and vibration with the Grade II listed Mythe Bridge in the background - Courtesy of Costain Ltd



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