

Flood Alleviation Works for Critical Infrastructure

Dŵr Cymru Welsh Water's works at four assets in Wales identified as being 'at risk'

by Martin Masters, MRIN AMICES and Raff Whitehead, BSc (Hons) CEng MICE MEPS

The Welsh Government's Technical Advice Note 15: Development and Flood Risk (TAN15) gives indicative guidance that the annual probability of flooding of general infrastructure from fluvial events should be no greater than 1% AEP (annual exceedance probability) and no greater than 0.5% AEP from tidal events. In line with Dŵr Cymru Welsh Water's commitment to respond to climate change and to protect public water supplies, the company undertook to assess the risk at sites which may be vulnerable to flooding and to provide mitigation if necessary.



Pedestrian access over the flood wall at Llechryd Pumping Station - Courtesy of Dŵr Cymru Welsh Water

Introduction

Of the eight assets assessed, works were approved to proceed at the four sites listed in the table below. Assessment reports for the Canaston and Nantgaredig Pumping Stations, Crowhill WTW and Llanerch boreholes identified no immediate requirements and the results were used to inform wider strategic reviews of these assets.

This paper presents the details of the flood alleviation works arising from the detailed flood risk assessment of eight water assets in Wales in 2011. For details of the approach, methodology and findings of the hydraulic modelling which preceded these works, reference should be made to the [separate paper](#) available at www.WaterProjectsOnline.com.

Site name	Description	Benefit £k = Loss avoided	Cost £k	Benefit/cost ratio
Bryn Aled	Water Pumping Station	35	9	3.9
Bryn Cowlyd	Water Treatment Works	1,000	150	6.6
Llechryd	Water Pumping Station	3,000	650	4.6
Pontsticill	Water Treatment Works	1,000	250	4



Flood barrier across maintenance access at Bryn Aled Pumping Station
Courtesy of Waterco Consultants



'Up and over' steps to the main entrance of Bryn Aled Pumping Station
Courtesy of Waterco Consultants



Plastic sheet piles installed in the existing flood embankment at Bryn Cowlyd WTW - Courtesy of Waterco Consultants



Access steps over the raised wall at Bryn Cowlyd WTW
Courtesy of Waterco Consultants

Bryn Aled Water Pumping Station

The flood risk assessment carried out for the WPS highlighted the potential for flooding, as the building is situated in the flood plain of the River Aled. The Environment Agency held no information on predicted flood levels.

The predicted 1% + CCA flood flow occurring within the River Aled at the WPS was calculated in accordance with EA guidance and the derived peak flows and flood event hydrograph used as input data into the model. This modelling showed the WPS slab to be 300mm below the 1% plus CCA flood level. Adding a further 300mm freeboard to this level, as recommended by the EA, provided a design protection level of 600mm for the WPS.

Raising equipment within the building was discounted on the basis of cost. Another option considered was to build a flood defence wall around the building. This would have reduced flood storage within the functional floodplain which would have led to the need for compensation storage which would have proved difficult to provide. The defence wall was also an expensive option for dealing with the relatively low flood depth.

The substantial (375mm thick) walls were reasonably watertight and found to be structurally sound, so attention was focused instead on preventing water from entering the building in a flood event.

Initially, water would enter the building through two intake channels, which lie beneath the building and run from the adjacent river containing the pump intake pipework. Water would flow through the open concrete channels into the building, allowing flood waters to rise up, flooding the building and in particular the electrical control panels. Flood water would also enter the building via the main entrance door and the maintenance access doors.

The solution adopted was to construct 'up and over' steps to the main entrance doorway, which is used on a frequent basis, which also means that the building can be entered during a flood event if necessary. An automatic pump, located in a sump on the downside of the steps, prevents any water ponding outside the doorway. A flood barrier was specified across the maintenance access doorway, which was rarely used and could be removed as and when required.

The open concrete channels containing the intake pipes were not necessary for the operation of the pumping station. Sealing around the pipes within these channels and other incoming ducts removed the risk of water entering beneath the building and rising within. A second sump pump was provided within the building to protect against the risk of seepage during a flood event.

A flood barrier was installed across the doorway to an external electricity substation that is situated at a slightly higher level than the pumping station, and to which access is rarely required. Incoming below ground electricity ducts were also sealed and low level louvre vents either side of the access doors and in the side walls were bricked up with the approval of the electricity utility.

Bryn Cowlyd WTW

The works were constructed in the 1990s and protected by a flood defence bank which was constructed at the same time as the works to protect against both fluvial and tidal flooding from the nearby River Conwy.

The WTW buildings were constructed with raised floor levels, however, if the embankment were to be overtopped, any flood waters would be contained within the embankment and would have to be pumped away, thereby delaying the works returning to normal. Therefore, the flood bank level assessed as being appropriate in the 1990s was considered inadequate, particularly when account was taken of climate change.

The E.A. was consulted and concurred with the view that the site was at greatest risk from tidal inundation with there being only 230mm freeboard between the predicted tide level and top of the embankment. To provide protection against the 0.5% tidal event with an allowance of 100 years sea level climate change plus freeboard meant raising the flood protection by some 1,000mm.

Geotechnical investigations confirmed the bank had been properly constructed, but the option to simply widen and raise it with bulk earthworks was ruled out for two reasons: landscape planting on the outside of the bank would be destroyed; while on the inside, operational plant and equipment and the security fence constrained the available footprint. Plastic sheet piles were used instead to increase the protection level. The APE plastic piling system (using 2m long hollow hexagonal piles with 3m long posts) was chosen as the light weight material meant that relatively small plant could be utilised and the piles and posts more easily handled in the confined space available; the exposed pile needs no maintenance; and the posts cause less damage to tree roots than from continuous piling.

The method employed was to choose the route to minimise tree damage; dig a nominal 600mm deep trench and place the piles to achieve the required top level. Then drive support posts to depth through the piles every other hole so as to be flush with the pile tops; concrete the trench and then use surplus fill to back up the pile line where there were any low spots.

Bridging techniques and additional posts were used where services crossed through the bank. Steps were fabricated to allow for operatives to pass over the raised wall safely to access external valves and sampling points. The works were carried out with minimal disruption to the landscaping and the operational works.

Llechryd Water Pumping Station

The WTW is located to the north of the A484 while two associated pumping stations are located on the lower lying land between the road and the river, which is prone to flooding. Consideration was given to relocating the pumping stations within the WTW site, which is flood free but there was little space available and the intake from the river would have had to come under the road in a deep tunnel with the pump well extending down some 14m to receive gravity flow. It was therefore decided to protect the two pumping stations.

In the case of the low lift raw water pumping station the pump motors were raised within the building and a new control building was built on higher ground. Raising the pump motors was achieved using extension spindles which required new platforms to be installed.

Moving the motor control centre to the new control building required new ducts to be core-drilled through the foundation wall. The completed project provided updated controls in a secure, accessible building.

The high lift treated water pumping station was protected by constructing a flood defence wall around the perimeter with a 3m wide flood gate to provide access. The substantial plan area of the building and perimeter wall meant that flotation had to be investigated. Archive records showed that mass foundations had been used in the construction providing an adequate safety factor. As an additional precaution, bentonite matting was installed against the existing foundations. This will swell in the event of the ground becoming saturated to prevent groundwater seeping through existing joints.

The retaining wall was designed to BS8110 as it is only intended to withstand water on infrequent occasions and does not need to be drop tight. The maximum height of the wall is 2.5m above ground level which was set following the hydraulic modelling of the 1%



Inside the low lift raw water pumping station at Llechryd
Courtesy of Dŵr Cymru Welsh Water



New control building at Llechryd Pumping Station
Courtesy of Dŵr Cymru Welsh Water



The high lift treated water pumping station at Llechryd
Courtesy of Dŵr Cymru Welsh Water



Llechryd Pumping Station before installation of flood wall
Courtesy of Waterco Consultants



River gauging weir at Pontsticill - Courtesy of Waterco Consultants

flood including an allowance for climate change. The buoyancy factor was also kept low on the basis that the water design level was the top of the wall - which if overtopped, the water would start to balance.

In order to maintain operational access to two sets of main plant doors, it was decided to enclose the external access area within the flood wall. Two options were considered for the flotation protection of this courtyard area. One was to prevent saturation of the ground below the courtyard by providing a cut off wall using the bentonite matting. The other was to supplement the self-weight of the slab by using ground anchors. This was considered to be the most robust and safest solution.

Platipus ground anchors were used for the external slab to overcome the risk of the slab lifting due to hydrostatic pressure. A total of 41 (No.) ground anchors were installed as far as possible at

1m spacing. The ground was tested and found to have a minimum pull out load of 60kN in dry conditions. This formed the basis of design, and on installation each anchor was proofed to 60kN and then locked off at 10kN.

The location of the flood wall was a key consideration, taking into account the number of access doors and vents as well as services and the main water delivery pipes. Just one flood gate was included to allow vehicular access. The other means of access to the inside of the flood wall is a set of steps up and over the flood wall. The existing access doors are now inside the flood wall around three sides of the building. These include fire escapes which are well within industry guidelines and building regulations (max. distance to place of safety 60m and min. width 800mm). The flood wall is positioned against one face of the pumping station to avoid building over the water mains.

This required specific detailing including the relocation of a fire door and sacrificial shuttering to allow for the future replacement of a glass wall. Surface water drainage from the building and pathways within the flood wall is dealt with by drainage channels, a small pumping station and anti-flood valves. All services passing under the flood wall have been sealed.

Pontsticill WTW

The predicted 1% + CCA event is 80 cumecs. A hydraulic constraint is created by an Environment Agency measurement weir alongside the WTW which raises the riverbed and elevates the water level. The modelling showed that removal of this weir would lower water levels sufficiently for no other works to be necessary. However the cost and logistics of relocating the weir made this a relatively expensive solution.

It was observed that revised operating levels for the impoundment could provide the additional storage needed in an extreme event,

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but this would effectively reduce the storage capacity of the impoundment. Given that climate change is also having the effect of more frequent and longer periods of drought this was felt to be an acceptable solution, although it was recommended that operating levels be kept under review so that this approach could be used in the future if necessary.

Building a new wall alongside the river was a high cost option and also meant that future maintenance of the waterway would be difficult. The option chosen was to construct a bypass channel on the land on the opposite side of the river from the WT W. This land had been used in the past as a storage lagoon and was still in Welsh Water ownership.

A new wall, parallel with the river, upstream of the measurement weir is set to overtop into the new channel during an extreme event. Low flows remain in the existing channel allowing the measurement weir to function properly (high flow conditions are not presently measured by the weir). Space for the bypass channel was limited by trees and a second lagoon which is still in use; so a compromise was to reduce the side channel from its optimum length and carry out some limited (3-500mm high) bank raising upstream to contain the flow. Finally, as part of the scheme, an access bridge is to be raised to remove the risk of blockage which would elevate flood levels unacceptably.

As the land had become overgrown and was surrounded by mature trees, ecology surveys and mitigation works have delayed construction of this bypass channel. The completed bypass channel will enhance the biodiversity of the area, offsetting the removal of overhanging trees posing a blockage risk to the structures.

Flood barriers across doorways will also protect against flood risk due to operational flooding within the works.



*Bellmouth overflow at the reservoir at Pontsticill
Courtesy of Waterco Consultants*

Construction

The works at Bryn Aled and Bryn Cowlyd were carried out by Dawnus Construction Ltd. Construction at Llechryd WTW was carried out by Lewis Civil Engineering Ltd. with mechanical and electrical works by Lloyd Morris Electrical Ltd. and the ground anchor installation by Dawnus Construction Ltd. At Pontsticill, preparation works have been carried out ahead of the expected planning permission approval, with the main works planned for completion in 2012.

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Pontsticill WTW from the dam - Courtesy of Waterco Consultants

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FloodGuard UK Ltd

3 - 7 Ormskirk Road, Newtown, Wigan, WN5 0XD

Website: www.floodguarduk.co.uk

E-mail : admin@floodguarduk.co.uk

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