Barry West UID Scheme

1. Introduction

This paper describes a scheme carried out by MWH as part of the Virtual Design House (VDH) for the Dwr Cymru Welsh Water Capital Alliance - South East Team. The scheme is being implemented as part of the AMP3/4 Barry Bathing Waters Project.

The scheme demonstrates the benefits that can be gained by challenge, focus on environmental benefit, enhanced hydraulic modelling, and integrated solution development.

2. Catchment Area Description

The Barry West catchment comprises the western half of Barry, Barry Island, Rhoose, Fontygary and Tredogan. The catchment has a total area of approximately 531ha and population of 33000. The southern edge of the catchment is bounded by the Bristol Channel with the Barry East catchment to the east. Barry West comprises five areas / subcatchments:

- Porthkerry & Rhoose
- Inland Barry
- Knap
- Barry Island & Docks
- Barry Town & Broad St

The sewerage network within Barry is fully combined although newer developments around the town are utilising separate surface water systems. The systems in Rhoose and Fontygary are separate but there is a considerable storm response within the catchments due to misconnections, poor workmanship etc.

There are 23 CSOs and 27 pumping stations in the Barry West catchment. They range from small unscreened “hole in the wall” type structures to large complex pumping stations with associated off-line storage tanks and mechanical screens.

The catchment drains to the Terminal Pumping Station at Barry Town, this in-turn pumps to Cog Moors STW for treatment. The pass forward flow to Cog Moors from Barry Town PS is approximately 770 l/s. There are 4 main receiving waters in the Barry West catchment, Nant Talwg, Bristol Channel, Old Barry Harbour and Barry Docks. All the assets either spill directly to or via surface water systems to these receiving waters.

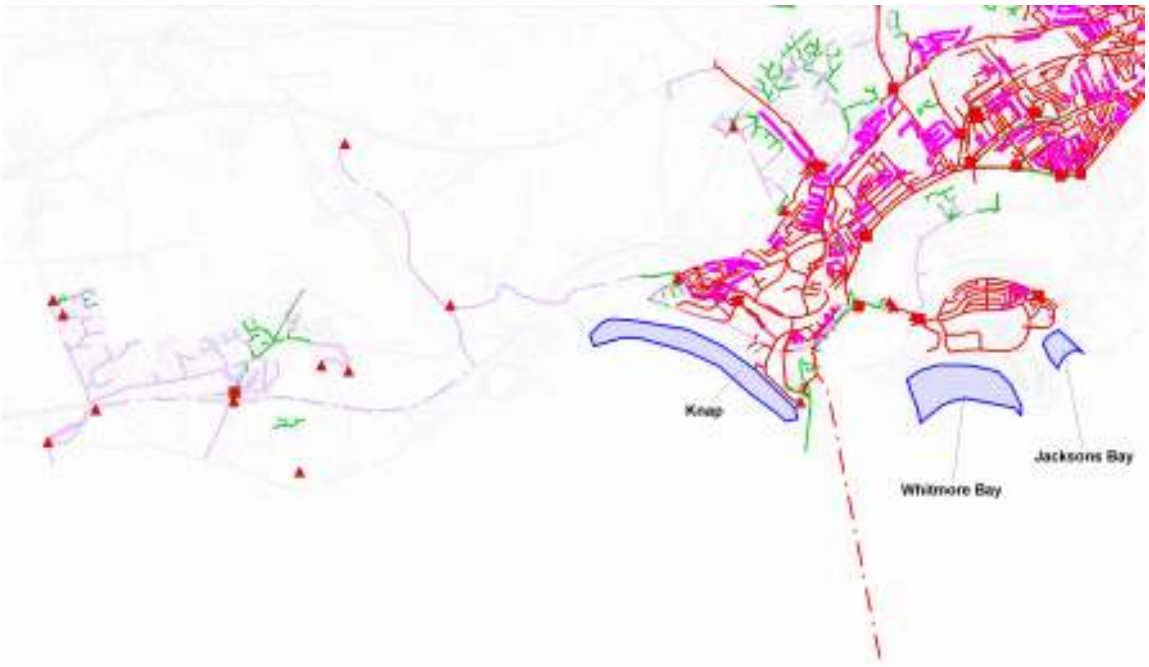


Figure 1. Plan of Catchment, Showing key assets and bathing beaches

3. Environmental Standards

Bathing Waters

There are three EU designated bathing waters in the Barry area – Jackson Bay and Whitmore Bay are immediately off Barry Island; Cold Knap is a short distance to the west. Other "non-identified" bathing waters are located around the adjoining coastline, from Penarth in the east to Limpert Bay in the west.

The spills from these assets plus the assets in Aberthaw, Barry East, Penarth and Cardiff, where initially perceived to cause impact on the three bathing beaches above. Thus the default solution criteria was to restrict each of the spills to 3 spills / bathing season agglomerated over the wider catchment area.

Service Drivers

The project also needed to provide solutions to 38 DG5 flooding properties plus a further 10 SEF locations. All solutions needed to meet 1 in 30 return period flooding.

Maintenance Drivers

Many of the pumping stations in the catchment had maintenance issues, and the operation of some assets (in particular Barry Town PS) was overly complex thus increasing operational risk.

Development Drivers

The catchment also has significant growth predicted to in the Porthkerry catchment and in the brownfield areas around the docks. The dock area has been earmarked for residential and commercial development equalivent to 10,000 population.

4. AMP3 Catchment Strategy

A delivery was set up for this project loosely referred to as the Virtual Design House (VDH). This consisted of designers from MWH, ARUP, Hyder Consulting Ltd (HCL) and Black and Veatch Consulting (BV). This team would agree the overall strategy and manage the delivery of the project. The setting up of the VDH was a subject of a previous paper given by Mike Jones of AMEC.

In order to delivery this project for the best value against a tight budget and timescale the VDH catchment strategy had three main thrusts:

Enhanced Hydraulic Modelling

Hydraulic models for all the VDH catchments had been developed in Hydroworks. These models had been verified using asset and flow survey data obtained in 1999. The VDH agreed that a full review of each of the models be implemented, the review was undertaken by MWH.

The main recommendations of the review were:

- Each model needed to be reverified utilising the New UK Runoff model
- The Ground Infiltration model should be used to represent any shortfall in infiltration
- The resolution of each model be improved

Regulatory Challenge & Coastal Modelling

The default environmental driver for not this catchment but all the VDH catchments (Barry West, Barry East, Penarth and Cardiff) was the standard bathing waters driver. The 3 spills / Bathing Season driver would have forced onerous solutions and the agglomeration of this driver across multiple catchments would constrict the project delivery and possibly drive up the solution size even further.

In order to challenge the driver, use was made of the existing Severn Estuary Coastal dispersion model to undertake an impact analysis using the results of the reverified hydraulic models. This has been documented in Nick Barcock's and Mike Jones's earlier papers on the subject.

The result of the impact analysis was to stratify the assets in terms of impact on the bathing waters:

Category of Significance	Impact significance	Revised Driver
Non Significant	No impact on the beaches (<10fc)	local drivers apply, Formula A, Screening, outfall to MLWS
Intermediate / Undetermined	Possible impact on the beaches (possible failure in combination with other discharges)	further analysis needed,
Significant	Definite impact on beaches (single event could fail, >100fc)	Full bathing water drivers, 3 spills / BS agglomerated across wider catchment, Formula A, Screening, outfall to MLWS

By classifying each asset in terms of its environmental significance we could pin point the assets that caused real impact to the beaches and thus target the investment to maximise the environmental benefit. This strategy was agreed with the Environment Agency and a revised list of assets and drivers developed.

Integrated Solution Development

Each of the designers working for the VDH were empowered to develop integrated solutions that met not only the environmental drivers but also tackled the flooding, rehabilitation and future development needs of each catchment.

In terms of Barry West the need for integrated solutions was clearly apparent, there was significant existing in catchment flooding, development drivers and limited construction space at a number of key assets.

5. Implementation of the Strategy, Barry West

As part of the VDH, MWH were tasked with delivering Barry West. The other catchment, Barry East and Penarth fell to HCL and BV to complete, with ARUP tasked to resolve Aberthaw (and key assets in Cardiff).

Enhanced Hydraulic Modelling

To enhance the Barry West model an asset data collection exercise was undertaken. The data collected was from a number of sources:

- Dwr Cymru Welsh Water's AIS system
- Existing & New asset surveys
- As built drawings from key locations
- Local operator knowledge
- Original Linen sewer record plans

The data was managed through MWH's Data Manager software and used to amend the original model database. The significant number of pumping stations in the catchment required particular attention to be paid to pump performance over the head ranges in each sump. The model build exercise added significant detail to the model and increased the confidence for solution development.

In addition the existing 70 monitor flow survey a new flow and impermeable area survey was procured. These where targeted at areas of high infiltration, slow response and "opportunity".

For example, a large section of Barry Island had been redeveloped for housing since the first survey. These developments had new separate systems, whilst the original land use had been combined. Further flow monitoring confirmed the net effect of the redevelopment was a reduction of 500l/s storm runoff contribution during the critical 1 in 5 event.

Once the enhancement and verification exercise was completed the verification reports were submitted to the EA for approval.

Impact Analysis

The reverified hydraulic model was rerun in Infoworks over the 11 bathing seasons contained in a rainfall dataset recorded at Rhoose (Cardiff Airport). The results were then input in the coastal model with all the other VDH catchments to allow the impact analysis to be undertaken. A summary of the assets and revised initial drivers is given below:

Site Name	Sub Catchment	Receiving Water	Impact on Bathing	Revised Driver
Porthkerry P.S.	Porthkerry	Inland (Nant Talwg)	Non-Significant	Local
Tredogan P.S.	Porthkerry	Inland (Nant Talwg)	Non-Significant	Local
Rhoose P.S.	Porthkerry	Coast	Non-Significant	Local
Station Road CSO	Porthkerry	Coast	Non-Significant	Local
Fontygary P.S.	Porthkerry	Coast	Non-Significant	Local
Lower Fontygary P.S.	Porthkerry	Coast	Non-Significant	Local
Fonman Park P.S.	Porthkerry	Coast	Non-Significant	Local
Nant Talwg P.S.	Inland Barry	Inland (Nant Talwg)	Non-Significant	Local
Nant Talwg Way P.S.	Inland Barry	Inland (Nant Talwg)	Non-Significant	Local
Cwm Barry P.S.	Inland Barry	Inland (Nant Talwg)	Non-Significant	Local
Pontypridd Road / Salisbury Road CSO	Inland Barry	Inland (Nant Talwg)	Non-Significant	Local
Colcot Road / Claude Road CSO	Inland Barry	Inland (Nant Talwg)	Non-Significant	Local
Knap PS	Knap	Coast	Significant	Bathing Waters
Westwood Rise PS	Knap	Inland (Nant Talwg)	Non-Significant	Local
Marine Drive CSO	Knap	Inland	Non-Significant	Local
Dyfrig Street	Barry Island & Docks	Barry Docks	Undetermined	Further Analysis Necessary
Barry Island PS	Barry Island & Docks	Coast	Significant	Bathing Waters
Broad St CSO	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Butrills Rd / Gladstone Rd CSO	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Broad St / Holton Rd CSO	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Woodlands Rd CSO1	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Woodlands Rd CSO2	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Woodlands Rd CSO3	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Woodlands Rd CSO4	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Rear of Gladstone Rd CSO	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Dock View Rd CSO 1	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Ty Newydd Rd / Holton Rd CSO	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Ty Newydd Rd	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Rear of Flats, Lombard Street	Barry Town & Broad St	Barry Docks	Undetermined	Further Analysis Necessary
Barry Town P.S. SSO	Barry Town & Broad St	Coast	Significant	Bathing Waters
Barry Town P.S. LSC	Barry Town & Broad St	Coast	Undetermined	Undetermined

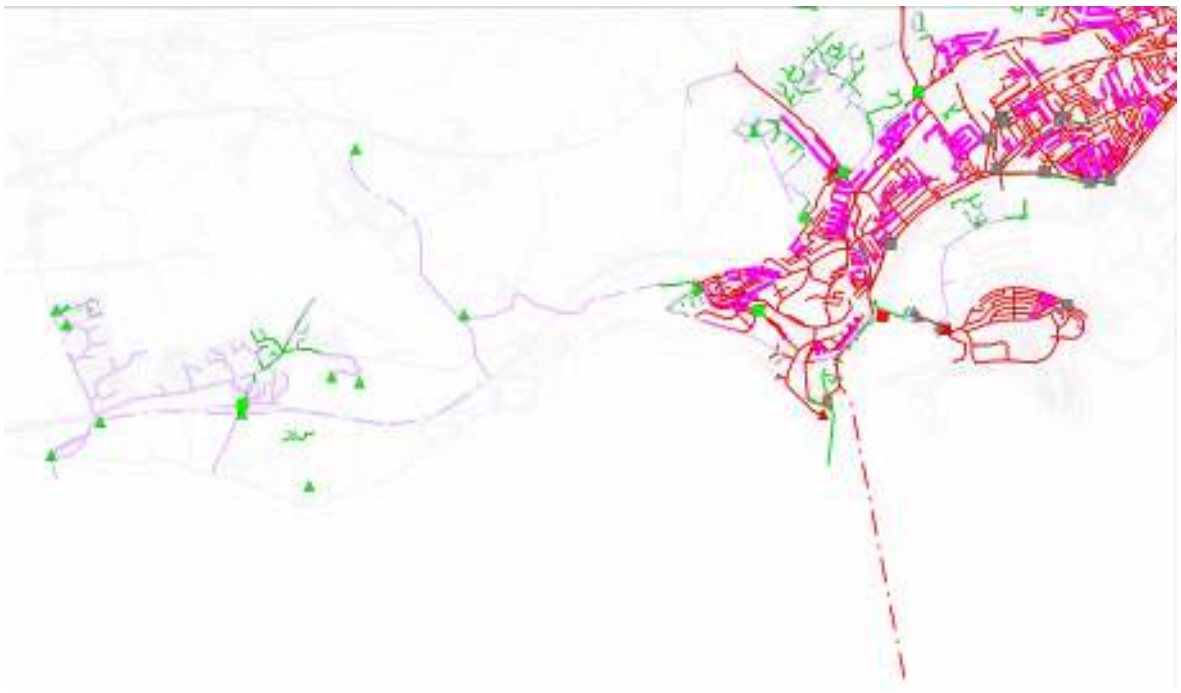


Figure 2. Plan of catchment showing assets and drivers (green - Local drivers, Grey - Undetermined, Red - Bathing waters drivers)

Out of the 30 assets needing improvement, only 3 retained their original Bathing Waters driver, 14 were reduced to local drivers and the remaining 14 would require further work to determine an appropriate driver.

This split allowed an early release of "unagglomerated" local driver work that could be progressed immediately. These schemes could be designed and implemented whilst schemes were being developed for the more tricky undetermined and bathing water assets.

6. Integrated Solution Development

With the reclassification of the assets schemes could be developed for the assets in the Porthkerry and Inland Barry sub-catchments, these consisted mainly of pumping stations. The key considerations of the revised drivers was that each would need to meet Formula A compliance, DWF failure protection and have adequate aesthetic control. In all cases we were able to meet these drivers by optimising the operational levels, fitting power generators (where needed) and retrofitting 6mm bar screens on the overflows. The larger integrated schemes are documented below:

Knap Subcatchment

Knap PS serves a subcatchment of 3500 pop and had a Formula A/PFF of 65/100l/s. It drains a steep catchment that is partially separate. Within the catchment there were 4 DG5 properties and another CSO located within an environmentally sensitive wood. The discharge from the Knap was directly onto one of the bathing beaches and thus a bathing waters driver was appropriate. Model runs indicated that the asset would require approximately 1200m^3 to meet the agglomerated 3 spills requirement.

Within this subcatchment two key improvements where made to the model. The first was the inclusion of a 380m long, twin 300dia inverted siphon with a fall of approximately 1 in 14. This serves the Porthkerry subcatchment to the west; the pumped flows from this area pass by gravity though this siphon directly to the Barry Town the terminal pumping station. The second was a bifurcation that also set flows directly to Barry Town; it had become abandoned due to a downstream sewer collapse causing all flows to pass to the Knap PS. The inclusion of both these assets in the model allowed us to utilise them in the solution. The resulting scheme consisted of relatively minor works:

Firstly, we assessed the available capacity of the inverted siphon and disconnected the incoming sewer from an in catchment CSO at Marine Drive. This allowed us to completely decommission the CSO without the need o undertake any significant construction work in the protected woodland. We took advantage of this new connection and diverted the maximum allowable flow into the new sewer from other parts of the upstream systems thus maximising the benefit at both the Knap PS and the DG5 properties in the catchment.

Secondly, we rehabilitated the abandoned bifurcation. By doing this we allowed flows upto 1 in 1 year storms to pass directly to Barry Town PS rather than the Knap PS. Again taking advantage of the new connection and upsizing to divert flows upto 1 in 1 year storm events to the bifurcation.

The above works halved the population acting at Knap PS and reduced the storage needed there from 1200m^3 to 450m^3.

Thirdly, to design out the storage completely we optimised the station's operation. This was achieved by changing the impellers in the foul pumps to pump approximately 140l/s from 84l/s. The solution also utilised the 200m^3 storage available in the storm sump by raising the storm pump on levels as high as possible and repairing a broken scavenger pump. Thus flow would enter the storm sump but only be pumped to the bathing waters when the sump was full, if during a storm the sump did not fully fill the scavenger pump would return it to the foul sump.

The above packages of works reduced the spills at this asset from 46 annually to <1 thus meeting the bathing drivers, reduced DWF pumping volume by 40% and solved a number of DG5 flooding problems without the construction of any additional storage.

Holton Road

Holton Road is Barry's main shopping street. In this area we where tasked to deal with 11 CSOs and 36 DG5 properties. This area has experienced serious flooding for over 20 years due to the condition of both the foul and surface water sewers and the steepness of the catchment. The CSOs in the area all spilt to a surface water system that drained into the dock.

A major difficulty in this scheme was finding available sites to locate any new CSO chambers. We considered multiple new assets and pump away schemes however both were unviable. Thus we chose to build a single new overflow with major resewering to allow the abandonment of all the others. Significant disruption would be caused to the businesses and extensive negotiation with the council, third parties and the public were required to progress the scheme on site. However, as the scheme removed significant flooding, it was supported by both the council and residents.

The PFF flow from the new structure was designed to offer protection to the downstream system so that during extreme events its throttle pipe would become submerged reducing PFF. This offered significantly more flood protection for the downstream system. The performance of the new overflow was more efficient in terms of passing more DWF forward before spilling than the old assets, so despite passing less peak flow forward the volumes and frequencies of spill also dropped:

Asset	Average Annual Agglomerated Spill Frequency	Average Annual Spill Duration (mins)	Average Annual Spill Volume (m^3)
Existing 11 CSOs	93	3556	9243
New CSO	3	135	2749

We achieved a low spill (<3 spills per bathing season) regime at this site, and still reduced the pass forward flow. This approach avoided the need to negotiate further with the EA regarding the undetermined impact status of this assets spill to the dock. However since we where passing forward significantly more flow that Formula A 750l/s Vs 108l/s, we designed the CSO screen with redundancy to allow future operators to restrict the pass forward flow if the catchment required it and environmental drivers with regard to the docks permitted it.

Barry Town PS

Barry Town is the terminal pumping station for the catchment and the centre of the integrated catchment approach; it is due for improvement in AMP4. The site has a complex of 6 individual pumping stations either lifting flows into the site, pumping forward to treatment, or pumping to sea via the long sea outfall or short sea outfall.

The site was earmarked as a location for any required storage due to the availability of land and existing facilities at the site, for example, an existing 2600m^3 storage tank.

The nature of the incatchment works had increased the volume and peak flows arriving at the site and thus its spills, initially via the LSO then the SSO. This was accepted by the EA as a temporary case due to the large reductions at other more sensitive in catchment sites like the Knap.

In order to develop solutions for this complex asset the strategy needed several approaches:

- Increase flow to treatment to meet future Formula A, 770 to 820l/s
- Integrate scheme with Broad St and development needs around docks
- Optimise the sites assets and controls
- Develop a strategy to allow best use of existing Long Sea Outfall

In order to achieve an integrated solution with Broad St we are proposing to construct a new tank sewer draining either to a new overflow to the dock or to Barry Town. This allows us to offer capacity for the new development, resolve the flooding and "peak lop" the flows arriving at Barry Town reducing the need for storage at that site by approximately 2000m^3. The new sewer is required to convey the flow anyway and had to be a large diameter to meet the required capacity, by oversizing this piece of work we achieve the required volume to offer either a new 3 spills / bathing season CSO spilling to the dock or to sea. The actual route will be agreed by the VDH team with Dŵr Cymru Welsh Water, Associated British Ports (ABP) and the developers.

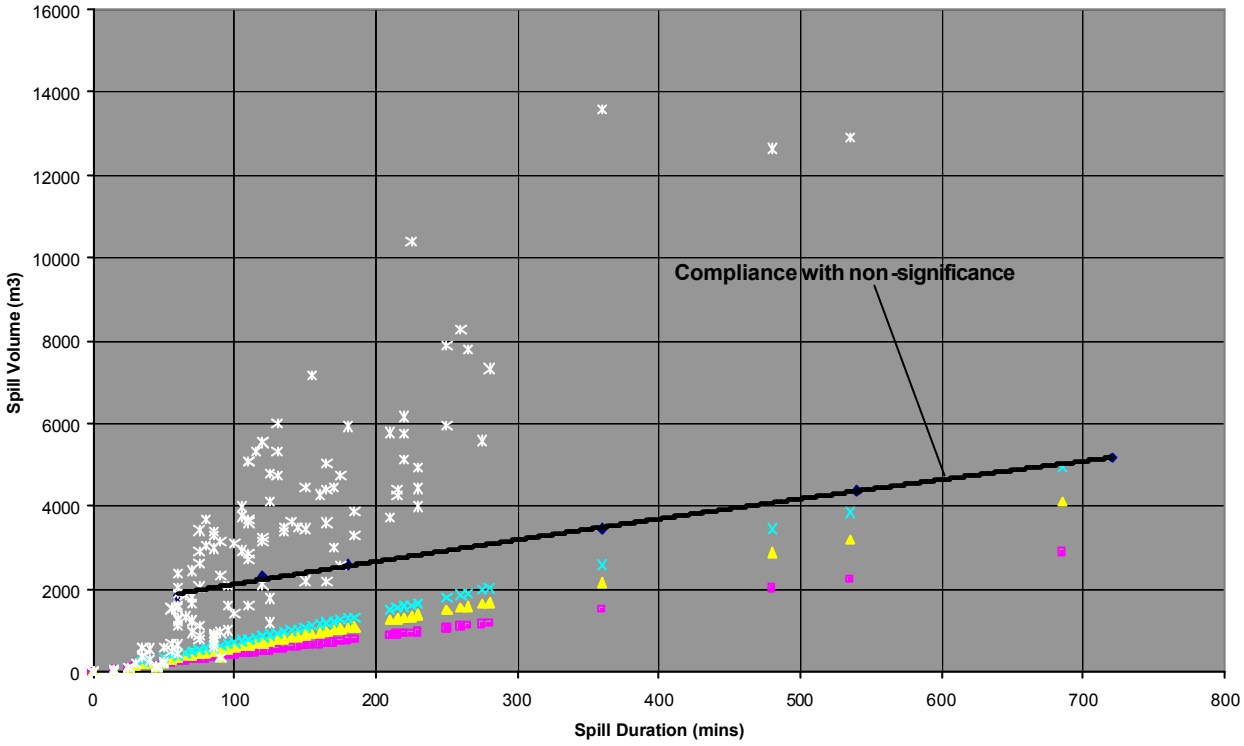
There was significant scope to improve the existing operation at Barry Town. For example, the existing tank on the site was designed to drain continuously which caused the flow to recirculate around the site until it could find a way out either to treatment or to sea. The simple addition of a motorised penstock on the tank to control its emptying will smooth the flows significantly. Additional

works also include the construction of a weir wall at the SSO high point; this utilised the 800m^3 storage available in the SSO rising main that needs to be filled before spillage to sea.

The 1.5km long sea outfall at Barry Town had been designated an undetermined impact on the bathing waters, whilst the SSO was significant due to its discharge proximity to the beach. We could construct additional volume at the site to limit the spills down the LSO to 3 / BS however the asset would become redundant since its use would be in parallel with the SSO. So rather than provide the conventional 3 spills solution, we chose to rerun the impact analysis to determine whether a reduced pump rate could achieve a non-significant impact.

This rate was determined to be approximately150l/s. At 150l/s the LSO could operate in it current configuration without any limit to its spills. The proposed arrangement provides a non-significant solution for the LSO and a 3 spills solution for the SSO.

Figure 3. Graph showing Impact of Barry Town LSO (White Existing pump rate, Pink pumping at 70l/s, Yellow pumping at 100l/s, Cyan pumping at 150l/s)



Conclusion

The Barry West UID Project represents an excellent example of the scheme benefits that can be achieved through the use of detailed hydraulic models, impact analysis and integrated solution development.

The time invested in improving the detail in the hydraulic model allowed us to determine solutions that would simply not be available without such investment with confidence.

The use of the coastal model to determine each assets impact, allowed an early release of low risk work that could be achieved whilst solution development priority was given to the more complex assets.

Had these schemes been developed in isolation with no regard of the bigger catchment picture the solutions would had cost Welsh Water significantly more, both in capital and operational terms, and increased risk, but delivered less environmental benefit that the solutions in this paper.

Acknowledgements

This paper has been produced with the permission of the MWH, AMEC construction and Welsh Water. The views expressed are those of the authors and not necessarily of those organisations.

Contact details

david.j.brook@mwhglobal.com