

Retro-fit Green Infrastructure in Llanelli

implementing the UK's first large scale retrofit green infrastructure strategy providing sustainable flood risk management and pollution reduction

by Chris Ellis BEng MSc

Llanelli, a large coastal town of 58,000 people, has a highly impermeable response to rainfall due its urbanised nature and aging combined sewer network. The town lies adjacent to the Loughor Estuary, a tidal water body protected by environmental designations including the Shellfish Waters Directive. 56 (No.) combined sewer overflows (CSOs) from the sewer network discharge into the estuary, up to 2.36 million cubic metres of combined sewage annually from a single asset. Since 2002, a mass decline in cockle numbers within the Loughor Estuary came to the attention of the European Commission, who responded with the threat of infraction proceedings against the UK for a breach of the Urban Waste Water Treatment Directive (UWWTD). In 2010 Arup, in partnership with Morgan Sindall, was commissioned by Welsh Water to develop and implement a catchment strategy with the following key aims; reduce CSO spill frequency to ten per annum, address flooding of 115 properties, and to deliver resilient critical sewer infrastructure able to withstand the pressures of climate change and population growth.



Setting the scene

Following extensive catchment wide investigations, data collection and hydraulic modelling undertaken between 2010 and 2011, a suite of over one hundred green infrastructure (GI) schemes was identified for implementation as part of a long term catchment strategy to address flooding and river pollution in Llanelli (see *Burry Inlet Investigations, UK Water Projects 2012*).

At the beginning of 2011 Welsh Water announced a £15m investment, funded through its flooding and pollution budgets, to target the top ten highest priority schemes collectively capable of reducing peak storm water runoff entering the combined sewer

by 25%. Implementation of the strategy is now underway with three constructed GI schemes showing the benefits resulting from a new integrated, sustainable and resilient approach to water management.

Timetable

	Stage	Dates
1	Data Collection and Modeling	May 2010 – April 2011
2	Solution Development	Jan 2011 – Sept 2011
3	Strategy Implementation	Sept 2011 – 2014+



Construction of the new Bioswale at Queen Mary's Walk
Courtesy of Morgan Sindall plc



Bioswale inlet and outlet – Courtesy of Morgan Sindall plc



Bioswale during heavy rainfall - Courtesy of Morgan Sindall plc



Playground at Stebonheath School after scheme implementation
Courtesy of Arup

Key roles and responsibilities

The use of green infrastructure interventions by a water company for this purpose is unique of its kind in the UK. The project team, which comprised Dŵr Cymru Welsh Water (the client), Arup (the designer) and Morgan Sindall plc (the capital delivery partner), worked collectively to address key challenges such as planning policy, a lack of real life examples and design guidance, delicate construction within an existing Victorian built environment and long term adoption and maintenance agreements with Carmarthenshire County Council.

Strategy implementation

The selection of three priority schemes was based on a multi-criteria analysis comprising key indicators such as surface water reduction, resolution of flooding, whole life costing, ease of construction and carbon footprint. Queen Mary's Walk, Stebonheath School and Glevering Street are all located in central Llanelli and are each serviced by a public combined sewer network.

The sites are typical of the urban environment that has evolved within the catchment resulting in a highly impermeable response to storms where rainfall quickly arrives within the sewer network.

Retrofit GI is the foundation for all three schemes; principally intercepting storm discharge and directing it away from the combined sewer network via pipes and overland channels. Innovative attenuation basins and planters then utilise specially selected soils, plants and trees to slow the flow whilst improving water quality and encouraging evapotranspiration.

Placement of the bespoke attenuation units, all of which adopt the same hydraulic principles, has been carefully considered to blend into and enhance the existing local built environment. The desire was to provide wider community benefits which go beyond flood alleviation by providing open green space in otherwise dull environments, improving local air quality, encouraging local biodiversity enhancement, and promoting health and wellbeing.

Queen Mary's Walk

Queen Mary's Walk (QMW) is a suburban street located between a residential estate and public playing fields. Previously the roofs, roads and other hard standing areas within this subcatchment drained to a 225mm combined sewer running along QMW, contributing 129l/s to the network during a 1 in 5 Annual Exceedance Probability (AEP) rainfall event. Consequently, the scheme was identified as a key contributor to pollution and flooding.

The basis of the design at Queen Mary's Walk involves conveying storm flows into a 100 metre long bioswale located alongside local playing fields. This required diversions of storm and road drainage into a new storm sewer feeding the new swale.

The swale controls pass forward flow via a perforated underdrain which sits beneath the swale topsoil surface, allowing a maximum of 4l/s to enter the combined sewer downstream. The swale also provides water quality benefits through natural processes such as filtration.

Historical mining activities, contamination and the presence of clay rich Glacial Till within the vicinity of QMW limited the potential for infiltration into underlying soil layers and bedrock. To mitigate the risk of local subsidence & contaminant mobilisation, an impermeable geosynthetic clay liner (GCL) was used. The process of evaporation and evapotranspiration allows the system to completely remove some flow from the combined sewer network in the absence of infiltration.

Stebonheath School

Stebonheath Primary School previously contributed 59l/s into the combined sewer network (1 in 5 AEP). The school grounds offered

little in the way of green space, and localised flooding was common. A GI scheme at the school brought with it the potential to turn an otherwise bland playground into something green and vibrant, creating an exciting place and educational resource to encourage children to come and learn in the centre of Llanelli.

Design proposals for Stebonheath were refined through interactive sessions with the staff and pupils at the school. The final design consisted of a selection of basins and planters, whereby attenuation volume was maximised through the use of innovative storage products, such as Silva Cell, designed to increase soil void ratios. Collectively, 100m³ of sustainable attenuation volume has been constructed at the site, limiting peak flows into the sewer system to just 6 l/s (1 in 5 AEP).

A key challenge faced at Stebonheath School was the programme. Construction was limited to just six weeks to fit within the summer holiday period, which in turn presented design challenges. This lent itself to off-site fabrication; for example bespoke downpipe timber planters which were delivered to site in two halves, generating 14m³ of attenuation volume within a matter of hours on site. The innovative design avoids the need for excavation whilst providing aesthetic benefits. In addition the planters are maintainable by the school pupils themselves instilling a sense of ownership whilst benefiting both the school and Welsh Water alike.

Glevering Street

Glevering Street is the largest scheme in the strategy to date, with construction work spanning nine highly urbanised streets. The dense nature of housing and streetscape within this area, which feeds solely into a combined sewer system, meant that previously peak flows leaving the catchment were in excess of 800l/s (1 in 5 AEP). In addition seven properties in the immediate vicinity of this scheme were on Welsh Water's Definitive Flood List.

The scheme ethos at Glevering Street is based on the conveyance of surface water using overland routing, combined kerb drainage and dish channels; all of which direct runoff towards a network of roadside basins and planters. Collectively this will reduce peak storm flows by over 300l/s (1 in 5 AEP).

A challenge faced in the design of this scheme, recognised through engagement with the local community, was the potential loss of parking caused by roadside GI.

The solution was to strategically place the planters and basins in locations less frequently used for parking, such as side streets, re-engineered junctions and in areas with existing parking restrictions in place.

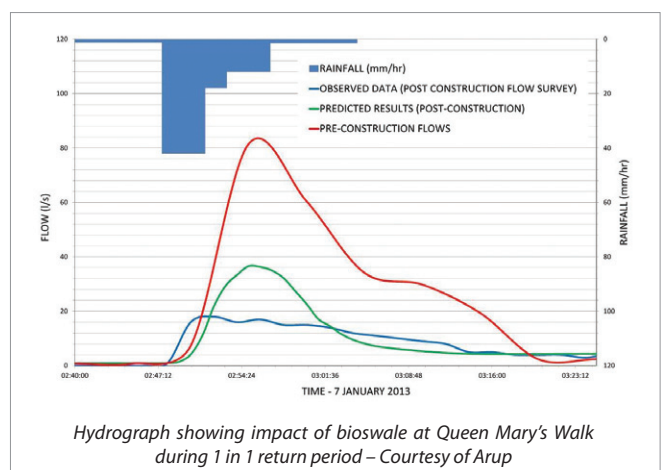
Construction of retro-fit GI in highways is likely to involve interaction with existing below ground services. The design approach taken in Glevering Street was to supplement significant up front trial trench information with flexibility in design and materials/products; this has allowed for significant on-site modifications to suit local conditions.

Adoption

Adoption can be a critical barrier for many retro-fit GI projects; cost, responsibility and maintenance are often the three key issues. This was overcome in Llanelli by working with Carmarthenshire County Council (CCC) from inception stage. Discussions and agreements started with the GI overall strategy; this then progressed to agreeing individual detailed site layouts and the use of bespoke technologies.

Performance of Retro-Fit Green Infrastructure

The peak flow reduction impact of each of the GI schemes is being monitored and assessed using rain gauges, pipe flow monitors and water depth monitors.



To date it has been shown that the GI systems are not only meeting, but surpassing targets set within the solution development stage. For instance during a typical annual storm event at Queen Mary's Walk (1 in 1 AEP) an additional 20% peak flow reduction has been achieved beyond that predicted.

This additional hydraulic benefit can be attributed to the green elements; the process of soil retention properties and evapotranspiration brought about by plants and trees.

Through infiltration, evaporation and evapotranspiration, it is estimated that 32,000m³ of water will be removed from the combined sewer network annually from these three schemes; this is water which now simply returned to the water cycle rather than being pumped and treated at great energy and cost.

The immediate observed performance is promising; as the plants and trees mature the system will improve further; trees will intercept, capture and store even more rainfall, and plant growth will increasingly slow and treat stormwater runoff.

Long term monitoring will provide Welsh Water with a more comprehensive understanding of how the climate and seasons affect the performance of the green infrastructure assets.

Costs

The early green infrastructure schemes implemented in Llanelli provide an effective, sustainable method of reducing peak flows from urbanised subcatchments. GI has offered a significant cost benefit over traditional hard engineering solutions.

The combined whole life cycle cost of Stebonheath School, Queen Mary's Walk and Glevering Street is projected to be approximately £3.5m; delivering a peak flow removal of 477l/s.

The cost of delivering an equivalent traditional 'storage and upsize' solution, approximately 1,092m³ plus local pipe upsize, was estimated at £7.5m.

Conclusion

The GI systems are proving to be hydraulically effective, physically robust, cost effective, sustainable, carbon efficient and providing community benefit. Post monitoring indicates that additional hydraulic benefits have been achieved beyond those originally targeted.

Planters which have been installed for over six months are now flourishing and seeing an improvement in performance as smaller rainfall events never actually reach the receiving sewer downstream of the GI elements.

The cost effective delivery of flow removal and subsequent flood alleviation and pollution reduction has led Welsh Water to adopt the Llanelli strategy as best practice approach for implementation across Wales. Community benefits have been achieved including the creation of unique learning environments, improved recreational spaces and enhanced biodiversity.

Collaboration with the community and key stakeholders has ensured all requirements and concerns have been addressed from planning through to on-going maintenance.

The award winning approach adopted in Llanelli has been recognised as a blueprint for sustainable and affordable water management by Welsh Government and the water industry as a whole.

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